

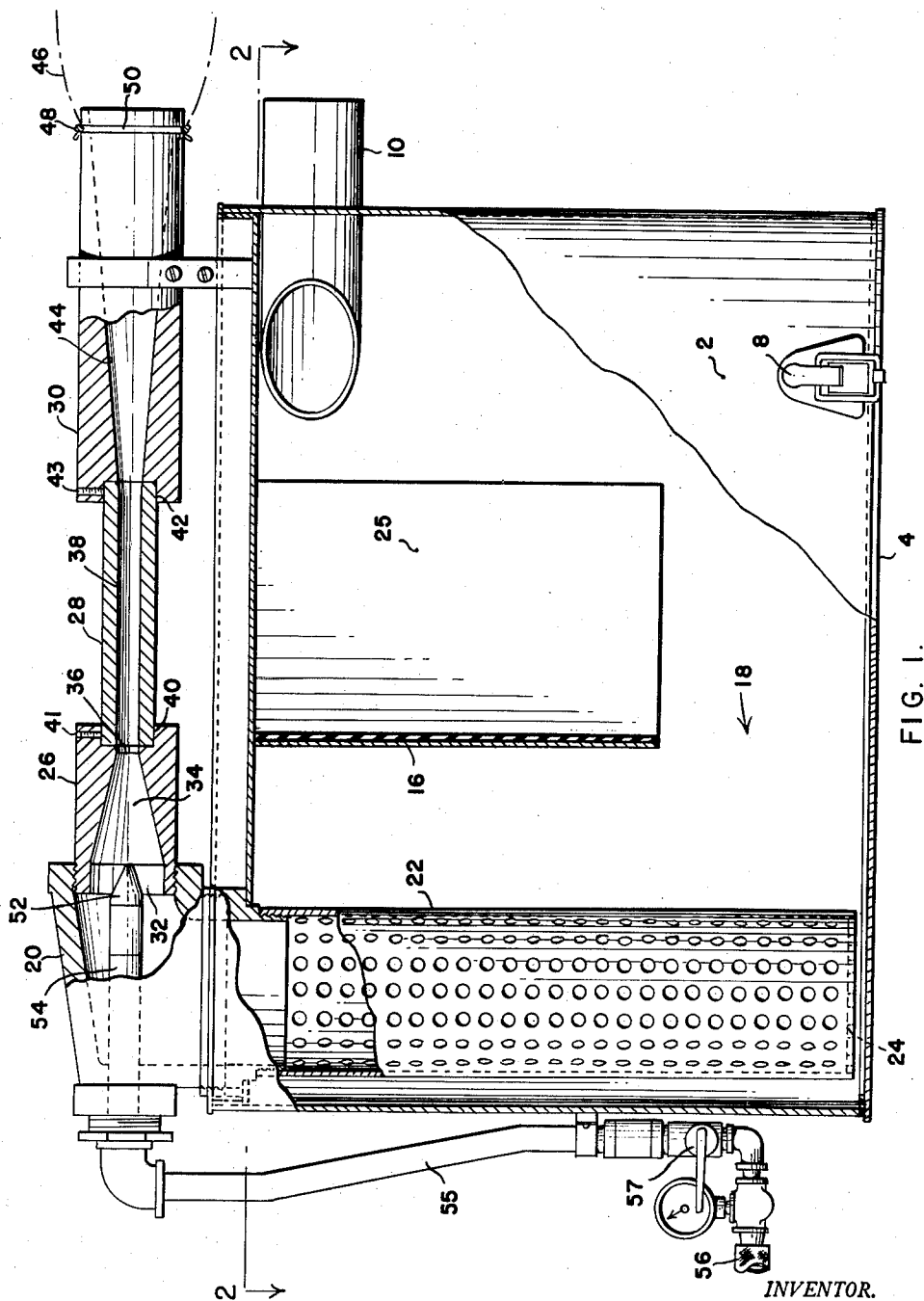
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VACUUM CLEANER

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Original Filed Feb. 4, 1953

2 Sheets-Sheet 1



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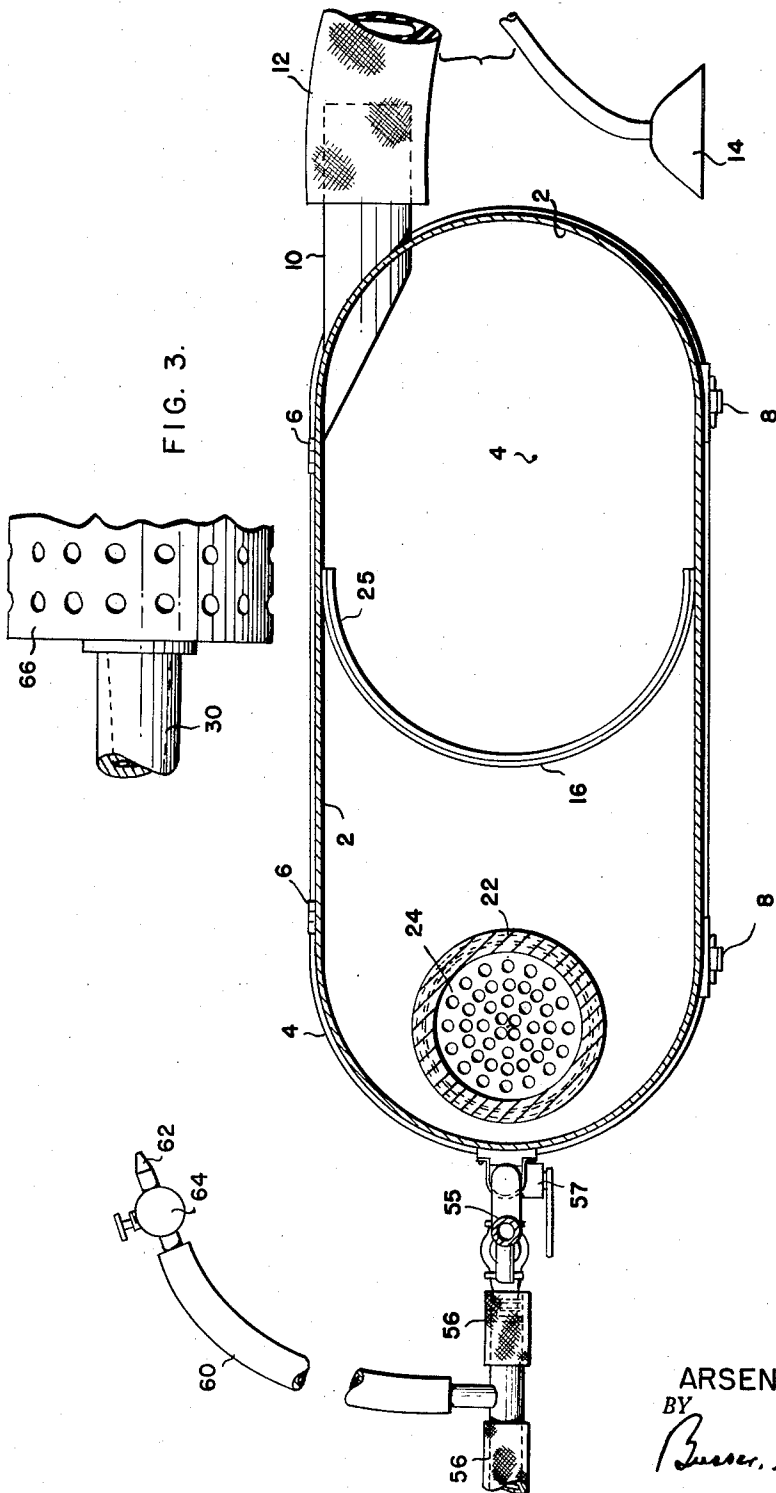
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VACUUM CLEANER

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Continuation of application Serial No. 335,105, February 4, 1953. This application June 1, 1956, Serial No. 588,918

5 Claims. (Cl. 183—37)

This invention relates to vacuum cleaners and has particular reference to a vacuum cleaner utilizing an air ejector pump supplied with high pressure air.

It is the general object of the present invention to provide a vacuum cleaner utilizing a supply of high pressure air for its energization, which vacuum cleaner contains no moving parts and is highly effective in its cleaning action.

Commercial vacuum cleaners are generally powered by electric motors driving vacuum-producing air pumps of centrifugal or other fan types. Such operation of a vacuum cleaner is, of course, necessary where the sole available source of power is a conventional electric supply. In many industrial plants, however, there is available high pressure air, for example, in textile mills, or the like, and high pressure air is also frequently available, or could be economically made available, in many other instances. Through the use of an air ejector, such high pressure air can be made to produce a vacuum as well as a large volumetric flow of air under subatmospheric pressure. Vacuum cleaners have been heretofore proposed utilizing air ejectors as the vacuum producing means, but such vacuum cleaners have, in general, not been particularly successful because of high cost of operation due to their large high pressure air requirements or because they have not been suited to vacuum cleaning under conditions of possible inclusion in the cleaning stream of large objects or of dirt which would serve to clog the ejector pump. Furthermore, in most instances, the effectiveness of cleaning is very much reduced by the accumulation of pick-up dirt serving to reduce the flow of cleaning air to such an extent that the pickup characteristics are detrimentally affected.

In accordance with the present invention, a vacuum cleaner is provided which is highly effective even under conditions of accumulation of dirt to its maximum receiver capacity. In brief, in accordance with the present invention, there is produced a partial vacuum and flow of cleaning air by means of an air ejector powered by high pressure air. Under normal conditions of operation, there may be produced a flow of cleaning air through the vacuum cleaner nozzle amounting to several times the high pressure air utilized in the ejector pump. The receiver of the vacuum cleaner is located on the suction side of the ejector pump and is provided with a baffle arrangement for removing from the inflowing air large particles of dirt and such objects as may be picked up by the cleaner nozzle and with an air filter to remove substantially completely from the inflowing air stream lint and fine dirt, before the inflowing air passes out through the Venturi chamber of the ejector pump. The arrangement, in particular, is such that the initial lint and

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other dirt picked up in the beginning of an operation serves to enhance the filtering action. At the same time, the lint and other dirt which accumulates is not packed so tightly so to substantially impede the inflow of air.

As a result of the foregoing, substantially clean air only flows through the ejector pump so that the reduced passages thereof are not liable to clogging or even accumulation of finer dirt due to the maintenance of relatively high flow velocities therethrough.

The air ejector pump is particularly advantageous for cleaning purposes since it has characteristics which are in better conformity with requirements than is the case when a motor-driven pump is used. A motor-driven pump suitable for vacuum cleaning cannot practically be of positive displacement type but, rather, is of centrifugal or fan type. Such a pump draws a vacuum only to a limited extent and, in fact, its vacuum-producing characteristics fall off as the flow therethrough is impeded. In contrast, an ejector type of pump produces its highest vacuum when the secondary air inlet is cut off. It is thus well suited to the characteristics required of an effective vacuum cleaner. The effectiveness of a vacuum cleaner is not so much dependent upon the vacuum which it can produce as upon its capabilities of providing a large flow of air at reasonably high velocity over or through the surface to be cleaned. As is well known to any housewife, the picking up of hair, threads or the like from the surface of a rug is not best achieved by pressing the vacuum cleaner nozzle tightly against the rug so as to enforce inflow of air through the rug, with consequent production of a greater vacuum in the nozzle, as it is by raising the nozzle slightly from the rug to produce a high velocity flow across its surface with a very considerable reduction of the vacuum existing in the nozzle. In fact, it has been customary to design nozzles generally for alternative operation so that the latter result may be achieved, there being provided in such instances slots at the nozzle boundary to produce flow across the surface being cleaned.

On the other hand, this is not the sole requirement of a vacuum cleaner which must under some circumstances pull fine dirt from the pores of the surface being cleaned. To secure this result there should be produced a relatively high vacuum in the nozzle so that the air is forced by the pressure differential to flow through the pores of the material. If the vacuum produced in the nozzle is sufficient, the velocity of flow through the restricted passages thus presented is sufficient to dislodge and carry dirt. If, however, as in the case of the usual motor-driven vacuum cleaner, the capabilities of producing high vacuum are very limited, only ineffective cleaning under the last mentioned circumstances occurs, even though the vacuum cleaner under conditions of little restriction to air flow may produce a large volumetric flow under low pressure gradient sufficient to remove surface dirt.

The ejector type of air pump is well suited to both these requirements. When the intake is unimpeded, a large volume of air flow at high velocity may be produced. However, when the flow is impeded there is produced a high vacuum capable of maintaining high velocities, now through restricted passages, for effective cleaning of deep-seated dirt.

The foregoing general objects of the invention as well as subsidiary objects having to do with detailed characteristics of construction and operation, and the provision of an efficient vacuum cleaner of light weight, will be

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come apparent from the following description read in conjunction with the accompanying drawing in which:

Fig. 1 is a vertical section through one embodiment of the invention;

Fig. 2 is a plan view of the same, additionally showing the vacuum cleaner nozzle and hose connection; and

Fig. 3 is a fragmentary view showing the provision of a muffler at the outlet of the cleaner.

The drawing, in particular, illustrates a readily portable type of vacuum cleaner which has been found particularly successful in the cleaning of the seats of railroad cars, textile machinery, etc. This vacuum cleaner is of light weight and readily portable despite a quite large dirt-accumulating capacity.

The receptacle of the vacuum cleaner may take the form of a metallic bucket indicated at 2 which may conveniently be of generally oval form in horizontal cross-section and provided with a bottom lid 4 hinged at 6 and arranged to be clamped in closed position by spring or other clamps such as indicated at 8, there being interposed between the lid and the lip of the bucket a suitable gasket to prevent inflow of air at the closure. Projecting through the wall of the bucket is a tube 10 to the exterior end of which there may be secured the hose 12 communicating with a conventional pickup nozzle 14.

As will be evident from the drawing, the tube 10 enters the bucket tangentially and in tangential relationship with a curved baffle which projects across the bucket as indicated at 16 but clears the lid 4 to provide a free passage 18, the tube 10 entering the bucket near its upper end. On the opposite side of the baffle 16 from the tube 10 there is provided at the top of the bucket an outlet L 20 surrounding the entrance opening of which there is a dirt filter in the form of a perforated cylinder 22 having, desirably, a perforated disc bottom 24 spaced from the lid 4. By the filter surrounding the outlet opening of the L 20, is meant that the filter extends directly across the opening rather than being in the form of a dust bag which encloses a large area of the receptacle and acts as an impedance to air flow as has been done heretofore.

Porosity of the filter is provided either by forming it of suitably fine screen both in its cylindrical portion and in its bottom 24, or by forming it of sheet metal containing punched perforations and, if necessary for certain applications, slipping over the cylinder a filter member of a suitable paper or fabric for filtering finer dust particles and the like. For many uses, as will hereafter appear, the openings need not be particularly fine since it is accumulation of lint and dirt which provides the major effective cleaning action rather than the filter itself. The baffle and filter arrangement may take many forms. The baffle, for example, may be disposed in various ways with respect to the inflowing stream of dirt laden air and may, if desired, be faced as indicated at 25 with rubber or other material of soft resilient nature which will be highly resistant to abrasion and, at the same time, reduce the speed of abrasive materials flowing inwardly from the tube 10.

The particular object of the baffle is first to create a swirling action thus slowing down the velocity of inflowing air and dirt, and secondly to slow down the flow of large materials to cause them to drop out of the air stream upon the lid 4 and prevent them from reaching the filter 22. As illustrated in the drawing, it will be noted that the clearance space 18 below the baffle has a large cross-sectional area as compared with the tube 10 with the result that the air flowing past the baffle is doing so at relatively low velocity so that any large particles will have a substantial tendency to settle out before passing the position of the baffle and thus be kept out of the vicinity of the filter 22. This results in the additional advantage that no direct high velocity stream of dirt-laden air can impinge upon and cause wear on the filter 22. The filter 22 may also take numerous forms other than the cylindrical one which is illustrated. It may, for example, be constituted by a flat perforated plate or screen closing

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off the entire area in a horizontal plane between the baffle and the walls of the bucket.

In general, the design should be such, as is satisfied by the construction illustrated, to minimize pressure drop between the inlet tube 10 and the outlet 20, and to provide the presentation to the flow of a large cross-sectional area to reduce velocities so as to cause large particles, in particular, to keep away from the filter. The cylindrical arrangement of the filter is such as to promote a reasonably uniform accumulation of dirt about its entire surface. This dirt, generally containing much lint, will then provide a pad about the screen or other perforated walls of the filter which pad will serve very effectively to enhance the filtering action, building up in thickness, while at the same time presenting a minimum impedance to the flow of the air.

It has, in particular, been found desirable to have the discharge outlet from the bucket at 20 of substantially greater cross-sectional area than the inlet tube 10. For example, a two inch diameter outlet has been found to be particularly effective when a one and three-eighths inch diameter inlet was provided.

Th L 20 communicates with passages in a series of tubular members 26, 28 and 30, the passages in which provide a Venturi chamber. The member 26 is threaded into the L and is bored to provide first a cylindrical passage 32 followed by a converging passage 34 and a cylindrical extension 36 thereof. It has been found desirable to have the converging portion of the passage of such type that the conical angle is about 30°, though this angle is by no means critical. Beyond the cylindrical extension 36, there is an enlarged cylindrical bore 40 of a size to receive one end of the member 28 which is provided with a cylindrical bore 38 throughout its length corresponding to the cylindrical extension 36 with which it forms a continuation. A screw 41 secures the member 28 in the bore 40. The opposite end of the member 28 is received in a bore 42 in the member 30 wherein it is secured by a screw 43. The member 30 is provided with a diverging opening 44 the smaller diameter of which is of the same diameter as the bore 38 to form a continuation thereof. The bore 44 has a relatively small rate of divergence and it has been found particularly satisfactory to provide a conical angle in the region of six to seven degrees. The bore 44 may discharge into the atmosphere though, if desired, there may be secured thereto a small dust bag 46, held in position by a resilient spring ring 48 received with the edge of the bag in a groove 50 extending about the member 30. Whether or not the bag 46 is provided depends upon whether it is permissible to discharge into the atmosphere some small amount of fine dust during the initial operation of the vacuum cleaner.

As heretofore stated, the filter 22 may have relatively large openings formed therein by the use, for example, of a relatively coarse mesh screen, with the result that as operation starts some dirt will find its way through the Venturi and out the exit of member 30. However, if the openings in member 22 are suitable for the particular cleaning involved, there will quickly build up on the surface of filter 22 a mat of fiber and other dirt which will have relatively small pores and will thereafter act effectively as a filter to remove substantially all dirt from the air passing from the bucket 2. A bag provided at 46 is thus called upon to collect only a relatively minor amount of dirt and, as stated, may in many cases be eliminated. In fact, as will more fully appear hereafter, it is undesirable to collect dirt at the outlet from the ejector pump inasmuch as under some conditions high pressure could exist at this outlet which would serve to pack the dirt into a dense mat and impede flow of air.

An orifice or nozzle 52 is carried by the inner end of a tube 54 mounted in the L 20, which tube 54 is adapted to be connected to a high pressure hose line indicated at 56 through a pipe connection 55 including a valve 57. The nozzle 52 may be of abrupt converging or of con-

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verging-diverging (De Laval) type. It has been found that the nozzle is most effective when its discharge end is located substantially in the plane of junction of the cylindrical bore 32 with the converging bore 34. Utilizing a high pressure air input to the nozzle of 30 to 80 pounds per square inch, it has been found that the nozzle orifices may range from 1/8 inch diameter upwards. This is consistent with a diameter of cylindrical bore 32 of 1 1/2 inch and of three-quarter inch diameter bore at 38. The cylindrical bore 38 may be on the order of 6 inches.

The characteristics of operation of the vacuum cleaner have been generally outlined heretofore. All air entering the ejector pump is well filtered, particularly shortly after operation is first started, and there is no tendency for accumulation of foreign matter tending to impede flow through the Venturi and alter the characteristics of operation. High velocity of flow through the Venturi is maintained to prevent any accumulation of dirt on its walls. It has been found that in typical operation the inflowing air entering the vacuum cleaner nozzle 14 is of the order of three times the volume of air utilized in the high pressure nozzle 52, both measured at atmospheric pressure. The pressure gradient existing across the filter 22 and the mat of dirt accumulating thereon is limited automatically to atmospheric pressure irrespective of the vacuum produced in the ejector pump which may at maximum range from about 50 inches of water for ordinary cleaning to more than 100 inches of water for certain types of industrial cleaning. Insurance is thus obtained against the packing of a compact and relatively non-porous mat of dirt on the filter. The result is that the porosity of the filter is maintained in such condition as not to impede undesirably the flow of air. This situation also explains why it is undesirable to have a filter at the outlet from the Venturi. If the inlet was for some reason impeded, up to the full pressure of the high pressure supply could be directed against the material at the output if collected there. This would produce objectionable clogging of the system.

If the intake line 12 should become clogged it is readily cleared merely by holding a hand over the outlet passage 44, whereupon high pressure air will build up pressure in the tank providing a back flow through the line 12.

As noted heretofore, the arrangement described will produce large volumetric flow at relatively low vacuum when the cleaning nozzle inlet is not impeded, as when lint is being removed from a surface, whereas a lower volumetric flow at relatively high vacuum is secured when the cleaning nozzle inlet is pressed tightly against a porous surface, such as upholstery, to remove dirt from its pores, the relatively high vacuum thus produced serving to produce high linear velocity of flow of air through the pores to dislodge the dirt.

The Venturi tube 28 provides a convenient handle for carrying the unit.

In certain cases, as in cleaning complicated machinery, it is desirable to blow dirt or lint out of portions of the machinery from which it cannot be drawn by the vacuum cleaner. For this purpose there may be provided a high pressure hose connection 60 to a nozzle 62 controlled by a valve 64. Dirt or lint displaced by the air jet from nozzle 62 may be later picked up by the pickup nozzle 14, or the nozzle 14 may be replaced by a large funnel into which the dirt may be directed by the jet from the nozzle 62.

Fig. 3 illustrates the application of a muffler 66 to the outlet of the Venturi. A muffler is sometimes desirable in this position for the purpose of diminishing the exit velocity of the outgoing air and elimination of noise. The former objective is particularly desirable where dust or other fine particles may have settled on floors, walls, etc. and where, if the dust is disturbed, there may exist the hazard of spontaneous explosions as in flour mills, power plants, or the like. Without a muffler the jet of

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air issuing from the Venturi may accidentally be so directed as to produce suspension of dust. If a muffler is provided there may be prevented the issuance of a high velocity jet of air, the air emerging at sufficiently low velocity to avoid dust disturbance. The muffler need not be described in detail since it may take any conventional form suitable for the purpose.

From the foregoing description, it will be seen that the present invention provides a vacuum cleaner of the ejector pump operated type wherein the suction inlet of the pump is connected to the outlet of the receiver or so called dust bag, and is located completely externally thereof. This arrangement improves the operating efficiency of the pump and maintains the same in clean condition because dust or other entrained matter is not drawn therethrough.

As various changes may be made in the form, construction and arrangement of the parts herein, without departing from the spirit and scope of the invention and without sacrificing any of its advantages, it is to be understood that all matter herein is to be interpreted as illustrative and not in any limiting sense.

This application is a continuation application of application Serial No. 335,105, filed February 4, 1953, now abandoned.

I claim:

1. Apparatus for creating suction to move fluid materials comprising a receptacle including an upper member and a lower member providing a closed chamber, said upper member having an inlet in direct communication with said chamber and an outlet opposite said inlet, the effective area of said outlet being more than double that of said inlet; a filter within said chamber surrounding said outlet and extending directly across said outlet and being supported by said upper receptacle member and being adapted for removing entrained matter from a flow of air through said chamber; an ejector pump being mounted externally on said upper receptacle member and including a nozzle, a suction inlet in direct fluid flow communication with said chamber outlet and a mixing venturi, and means for supplying high pressure operating air to said nozzle; said venturi having a converging passage communicating with said suction inlet and said nozzle being arranged to discharge into said suction inlet and having means providing a diverging passage for receiving air from said converging passage and discharging air exteriorly of said chamber, said apparatus being constructed and arranged so that it has a minimum of impedance to air flow.

2. Apparatus according to claim 1, including a baffle depending from said upper receptacle member and being disposed between said inlet and said outlet of said chamber and being spaced from the bottom of said chamber.

3. Apparatus according to claim 1, wherein said ejector pump extends across said upper receptacle member.

4. Apparatus according to claim 1, including means for releasably securing said receptacle members to each other.

5. Apparatus for creating suction to move fluid materials comprising a receptacle including a container member and a cover member cooperating to provide a closed chamber, said container member having an inlet in direct communication with said chamber and an outlet opposite said inlet, the effective area of said outlet being more than double that of said inlet; a filter within said chamber surrounding said outlet and extending directly across said outlet and being supported by said container member and being adapted for removing entrained matter from a flow of air through said chamber; an ejector pump being mounted externally on said container member and including a nozzle, a suction inlet in direct fluid flow communication with said chamber outlet and a mixing venturi, and means for supplying high pressure operating air to said nozzle; said venturi having a converging passage communicating with said suction inlet and said nozzle

being arranged to discharge into said suction inlet and having means providing a diverging passage for receiving air from said converging passage and discharging air exteriorly of said chamber, said apparatus being constructed and arranged so that it has a minimum of impedance to air flow.

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