April 13, 1965 A. P. CAWL ETAL 3,177,635

INDUSTRIAL VACUUM CLEANERS

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Fig. 1

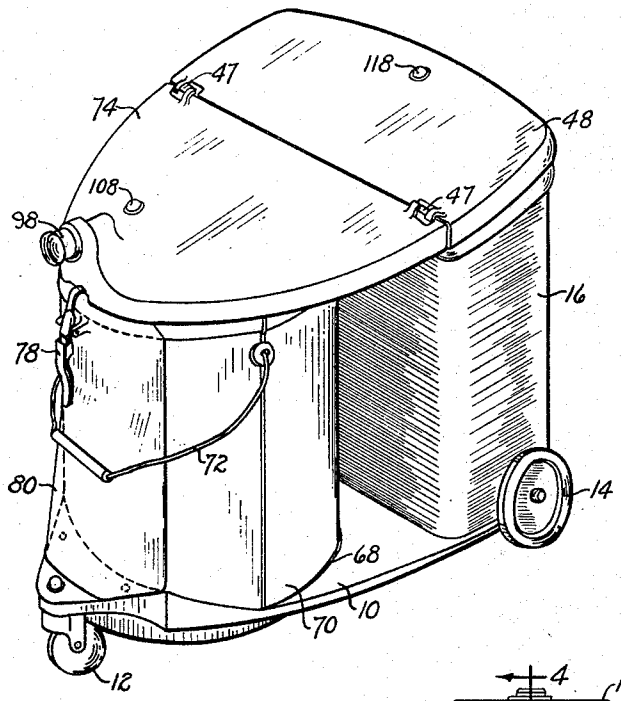


Fig. 2

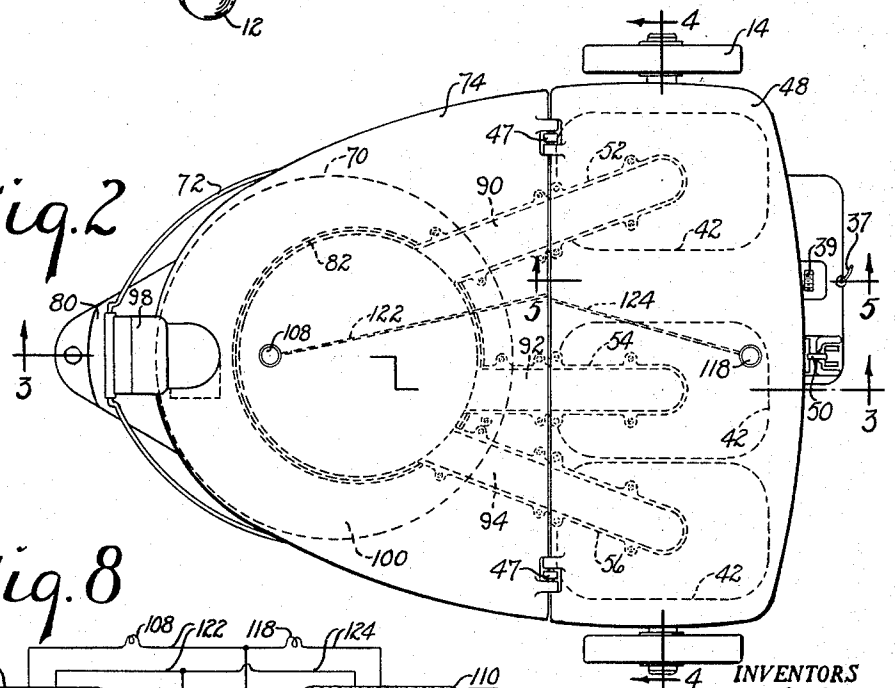
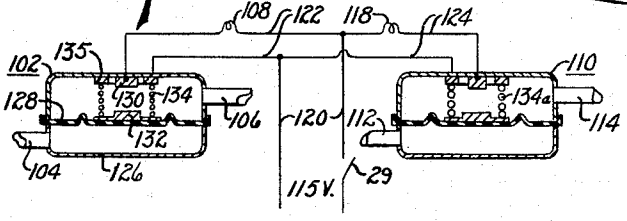


Fig. 8



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INDUSTRIAL VACUUM CLEANERS

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Fig. 3

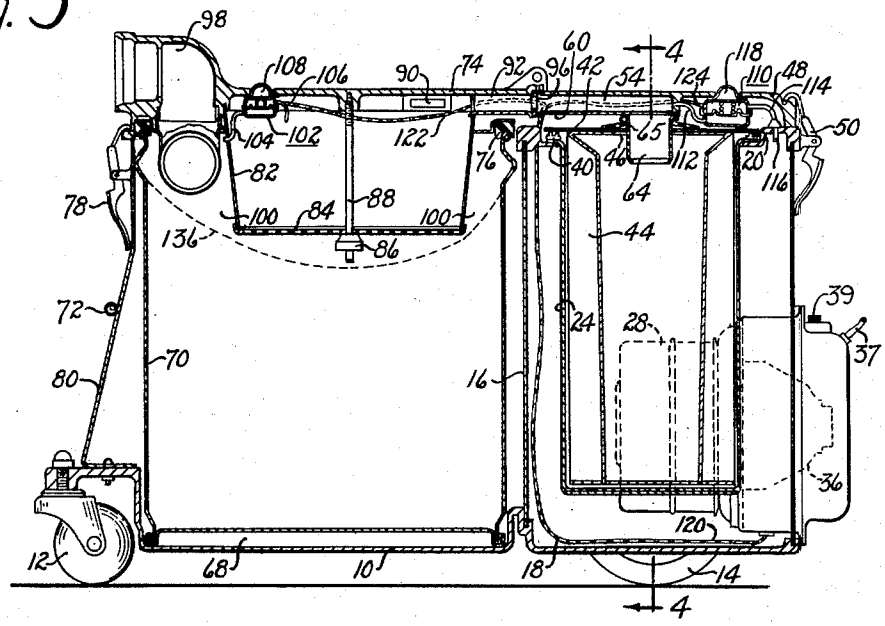


Fig. 4

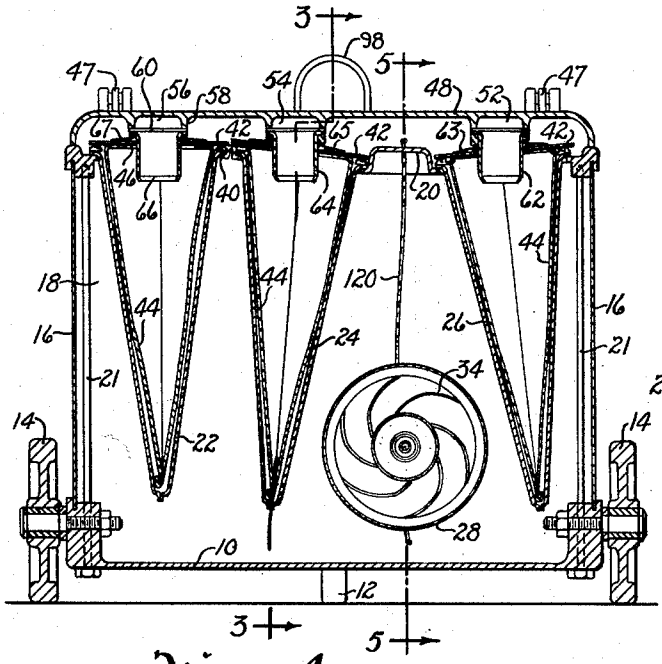
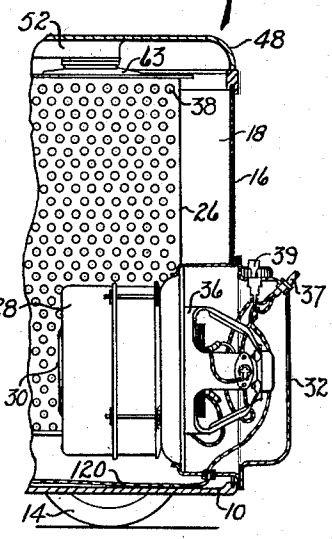


Fig. 5



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INDUSTRIAL VACUUM CLEANERS

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Fig. 6

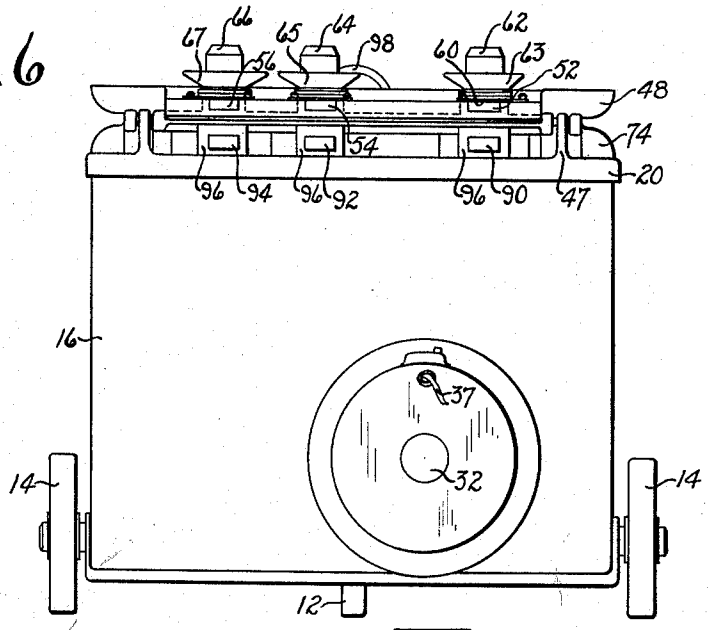
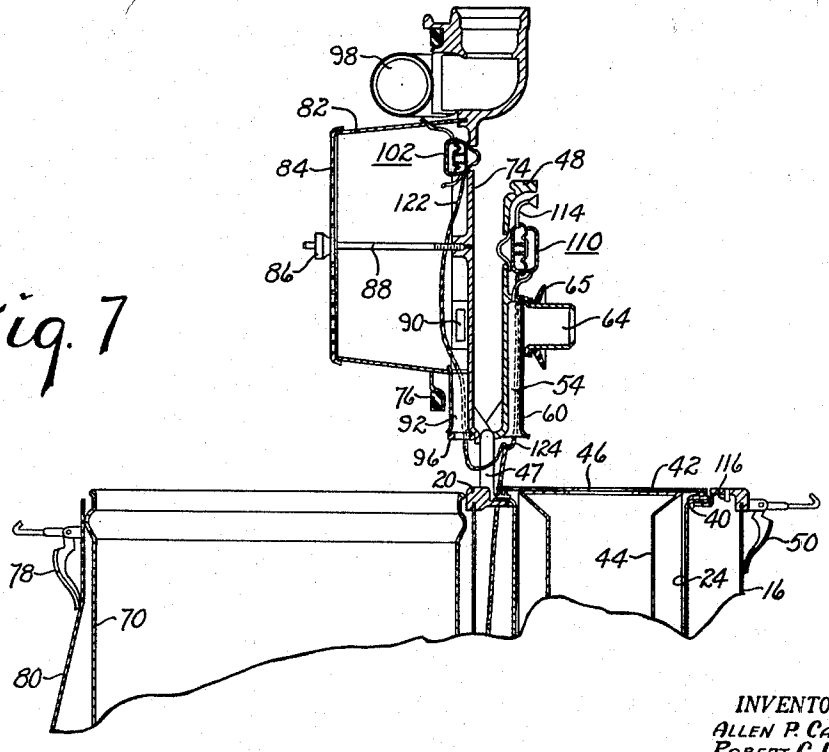


Fig. 7



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United States Patent Office 3,177,635 Patented Apr. 13, 1965

3,177,635

INDUSTRIAL VACUUM CLEANERS

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Filed June 22, 1960, Ser. No. 37,975
10 Claims. (Cl. 55—274)

Our invention relates to vacuum cleaners and more particularly to vacuum cleaners of the so-called commercial or industrial type.

Such vacuum cleaners, which are intended for use in commercial or industrial establishments, should have a much greater dirt storage capacity than a domestic vacuum cleaner because on the average they are used many more hours per day and it is desirable that it be necessary to empty them as infrequently as possible. Inasmuch as they are usually used by men, rather than women, size and weight are not so important as in a domestic cleaner, but it is desirable that when it is necessary to empty them, it may be done easily and conveniently.

In accordance with our invention we provide a vacuum cleaner having a removable container, preferably in the form of a pail, into which the dirt-ladened air is first introduced and in which the heavier dirt particles settle out from the air stream and remain. The finer dirt particles continue with the air stream which in accordance with our invention is divided into a plurality of parallel streams which are introduced into an equal plurality of filter bags which serve to retain this fine dirt while permitting the passage therethrough of air. If for instance, three bags are employed they would be expected to be able to retain three times the amount of dirt as a single bag. However, inasmuch as the heavy bulky dirt is separated in the pail, the bags are required to handle only the fine dirt and under these conditions the limiting factor is not the volume of dirt, but the pressure drop through the bags caused by the accumulation of this dirt on the inner surface of the bags. Due to the fact that the air is divided into three parallel paths, the velocity of the air through each bag is ⅓ of what it would be if all the air passed through a single bag. The pressure drop through a filter varies approximately directly with the velocity of flow and inversely with the porosity of the filter, the latter for a given filter being dependent on the amount and type of dirt collected. Hence, for a given amount and type of dirt the pressure drop through each of the three bags is ⅓ of what it would be if but a single bag were used and hence three times as much dirt may be accumulated in each bag as would be the case if it were a single bag and therefore the amount of dirt which may be collected in the three bags for a given pressure drop is 3^2 or nine times what it would be for a single bag. Thus, the amount of dirt for a given pressure drop increases approximately as the square of the number of bags.

This greatly increased ability of a plurality of bags to accumulate fine dirt is particularly important in a vacuum cleaner of this type in which the heavier dirt is separated before the air stream reaches the filter bags, because this heavier type of dirt often itself constitutes good filtering material which reduces the rate at which the finer dust clogs the filter bags. In accordance with this invention a greatly enlarged capacity for both coarse and fine dirt is obtained.

Another object of our invention is to provide separate indicator means for informing the operator when the pail and the dust bags, respectively, require emptying.

Further objects and advantages of our invention will be apparent from the following description when considered in connection with the accompanying drawings which form a part of this specification and of which:

FIG. 1 is a perspective view of a vacuum cleaner in accordance with our invention;

FIG. 2 is a top view of the vacuum cleaner shown in FIG. 1;

FIG. 3 is a cross-sectional view taken on the lines 3—3 of FIGS. 2 and 4;

FIG. 4 is a cross-sectional view taken on the line 4—4 of FIGS. 2 and 3;

FIG. 5 is a cross-sectional view of a portion of the vacuum cleaner taken on the lines 5—5 of FIGS. 2 and 4;

FIG. 6 is a rear elevational view of the vacuum cleaner shown in the previous figures with one of the cover members thereof in fully open position;

FIG. 7 is a cross-sectional view similar to that shown in FIG. 3 of the upper portion of the vacuum cleaner with two cover members each in partially open position; and

FIG. 8 is an enlarged view of the automatic signals shown in certain of the preceding figures, including a wiring diagram therefor.

Referring to the drawings, reference character 10 designates a rigid base member which is provided at its forward end with a caster wheel 12 and at its rear-end with a pair of wheels 14 in order that the cleaner may be easily moved about. Secured to the rear portion of the base 10 are vertical walls 16 forming a dust bag enclosure 18. A top wall 20 is secured to walls 16 by tie bolts 21 extending from base 10 and the wall 20 is formed with three rectangular openings therethrough. Wedge shaped dust bag retaining cages 22, 24 and 26 are secured in the respective openings and extended downwardly into the dust bag enclosure 18. Cages 24 and 26 are disposed in downward diverging relation to each other so as to provide space therebetween for a motor-fan unit 28 which is mounted in the rear wall of the enclosure. The motor-fan unit is formed with an inlet opening 30 communicating with the enclosure 18 and an outlet 32 communicating with the atmosphere. It includes a centrifugal fan 34 driven by an electric motor 36 supplied with current through a flexible cord 37 and a switch 39.

The cages 22, 24 and 26 are formed with a large number of perforations 38 so as to permit the unobstructed flow of air therethrough. Each of the openings through the top wall 20 is provided with a gasket 40 on which is adapted to seat a cardboard disc 42 to which is secured a dust bag 44 preferably made of porous paper. Each disc 42 is formed with an inlet opening 46. These bags are removably received within and supported by the cages and when filled are intended to be thrown away with their contents.

Pivotally mounted on lugs 47 extending upwardly from the top wall 20 of the dust bag enclosure is a rear cover member 48 which may be secured in closed position by means of a releasable latch 50. Cover 48 includes conduits 52, 54 and 56, each of which is formed by ribs 58 integral with the cover and by a plate member 60. The rear ends of these conduits terminate in inlet tubes 62, 64 and 66, respectively which, when the cover is closed as shown in FIG. 4, extend into the openings 46 formed in the cardboard disc 42 of the three filter bags. The other ends of the conduits 52, 54 and 56 terminate at the forward edge of the rear cover 48.

Tubes 62, 64 and 66 carry flexible slightly conical gaskets 63, 65 and 67 which, when the cover 48 is closed, bear against the cardboard discs 42 of the dust bags to provide an airtight seal between the tubes and the discs and to hold the latter tightly against the gaskets 40.

The forward portion of the base member 10 is formed with a preferably circular recess or depression 68 which is adapted to removably receive a preferably cylindrical

container 70 having a handle in the form of a bail 72. A front cover 74 is hinged to the lugs 47 on the same axis as is the rear cover 48. The front cover carries a gasket 76 which is adapted to seal against the top edge of container 70 when the cover is closed. A latch 78 carried by a member 80 extending upwardly from the base 10 is provided for retaining the cover 74 in closed position which holds the container 70 within the recess 68.

Depending from the underside of cover 74 is a substantially cylindrical member 82 of large cross-sectional area having an open lower end across which extends a coarse screen or perforated plate 84 which is removably held in position by means of a nut 86 on a rod 88 extending downwardly from the cover. Formed within cover 74 are three conduits 90, 92 and 94, the rear ends of which terminate at the rear edge of cover 74 in alignment with the front ends of conduits 52, 54 and 56, respectively, when both covers 48 and 74 are closed. Gaskets 96 carried by the rear ends of the conduits 90, 92 and 94 are provided for forming an airtight connection with the corresponding conduits in the rear cover 48. The forward ends of conduits 90, 92 and 94 communicate with the interior of cylindrical member 82.

Front cover 74 is formed with an inlet conduit 98 which terminates in a circumferential direction within an annular space 100 formed in the upper part of container 70 by the cylindrical member 82 when the cover is closed.

A first pressure responsive device designated generally by reference character 102 is carried by the front cover 74 and is provided with a conduit 104 leading through cylindrical member 82 to the annular space 100 and a conduit 106 leading to the interior of the member 82. Device 102 also includes a signal light 108 disposed so as to be visible on top of the front cover 74. A similar pressure responsive device 110 is carried by rear cover 48 and includes a conduit 112 which communicates with passage 54 and with a conduit 114 which, when the cover 48 is closed, connects with a conduit 116 extending through top wall 20 and communicating with dust bag enclosure 18. Device 110 includes a visual signal 118 visible from the top of rear cover 48. Electric current for operating signals 108 and 118 is supplied through a pair of conductors 120 connected to the leads for motor 36 on the load side of switch 39 and extending within the dust bag enclosure 18 and through the top 20 thereof to the neighborhood of the axis about which the two covers are hinged. At this point the conductors are divided into two pairs, one pair of which is designated by reference character 122 and leads to differential pressure responsive device 102, while the other is designated by reference character 124 and leads to pressure responsive device 110.

The pressure responsive devices and the electrical connections thereto are shown more in detail in FIG. 8. As thereshown, device 102 includes an airtight casing 126 divided by a flexible diaphragm 128. Conduit 104 leads to the space below the diaphragm while conduit 106 is connected to the space above the diaphragm. The upper part of the case, which is made of insulating material, carries a fixed electrical contact 130 while a movable contact 132 is carried by the diaphragm. A spring 134 is disposed between the contact 132 and a metal washer 135 surrounding but spaced from the fixed contact 130. One conductor of the pair 122 is connected to the washer 135, while the other is connected to the fixed contact 130, the visual signal 108 in the form of an electric light bulb being included in the circuit. Consequently, if the diaphragm 128 is moved upwardly against the force of spring 134 sufficiently to cause contacts 130 and 132 to close, the bulb 108 will be lighted. The pressure responsive device 110 is the same as device 102, with the exception that the spring 134*a* therein is heavier than the spring 134, thus requiring a greater pressure difference acting on the diaphragm to close the contacts. The reason for this will be explained hereinafter.

The above described device operates as follows:

Operation of the motor-fan unit 28 serves to exhaust air from the dust bag enclosure 18 and to discharge it through the outlet 32 to atmosphere. This induces the flow of air through the conduit 98, to which a flexible hose leading from a suction nozzle may be connected. Consequently, if the nozzle is moved over a dirty surface, dirt-ladened air is drawn into the annular space 100 in the upper part of container 70. Inasmuch as the conduit 98 terminates in a circumferential direction, this air is caused to whirl and, because of the greatly enlarged cross-sectional area of the container 70 as compared with the inlet 98, the velocity of the air is reduced with the result that the heavier and coarser particles settle to the bottom of the container where they remain. The screen or perforated plate 84 prevents the passage of any large and light articles, such as threads, but this screen does not get clogged up so as to increase the resistance of flow of air therethrough.

Due to the large diameter of member 82, which constitutes the outlet from container 70, the velocity of air flow therethrough is low and consequently a minimum of fine dust is carried out of the container. However, the lightest particles, which are not separated out in the container 70, pass with the air through the screen 84 to within the cylindrical member 82 where the airflow divides into substantially three equal streams passing through the conduits 90, 92 and 94 and the connecting conduits 52, 54 and 56 and the inlet tubes 62, 64 and 66, respectively, into the three dust bags 44 received within the cages 26, 24 and 22, respectively. The porous paper of which the bags 44 are made serves to filter the fine particles from the air stream and consequently these particles are retained within the bags while the air passes therethrough and through the perforations 38 of the cages to the inlet 30 of the fan.

As previously mentioned, the bulky portion of the dirt is retained in the container 70 and consequently the dust bags do not have to handle a large bulk of dirt, but it is important that they have a large filtered area in order not to be rapidly clogged by the fine dirt. Obviously, three bags will have three times as much area as one bag, but actually it is possible to collect about nine times as much fine dirt in the three bags as would be possible to collect in a single bag while still maintaining the same maximum pressure drop through the bag system. This is so because the velocity of flow through each of the three bags is ⅓ of what it would be through a single bag. Inasmuch as the pressure drop through the filter is approximately proportional to the velocity, a reduction of the latter by ⅓ means that about three times as much dirt may be collected in each bag before a given pressure drop is attained, and hence with three bags it is possible to accumulate in the neighborhood of nine times the amount of fine dirt for a given pressure drop than could be accumulated in a single bag.

Another advantage of the reduced air velocity resulting from the use of three bags is that it reduces the sandblast effect of air borne sharp particles entering the bags. While the heavier particles are separated from the air in the container 70, should there be present very fine but hard and sharp particles, some of these may be carried into, and impinge against the interior of, the bags and have the tendency to wear holes through the paper of which the bags are made. The lower the velocity, the lesser is this tendency and it is practically non-existent when three bags are employed.

As operation of the vacuum cleaner continues, the coarse dirt builds up within pail 70 and the accumulation of fine dirt within the bags 44 increases. Whether the capacity of the pail or that of the bags is first reached depends upon the nature of the dirt being picked up. However, separate signals 108 and 118 are provided, as previously described. Should the pail first become filled, the upper surface of the dirt will be disposed as

indicated by the dotted line 136 in FIG. 3, which is close to the lower edge of the cylindrical member 82. Due to the restriction thus imposed to flow from the annular space 100 to the interior of cylindrical member 82, a pressure drop will result and consequently the pressure acting on the lower side of diaphragm 128 of pressure responsive device 102 as communicated thereto through conduit 104 will be greater than the pressure acting on the upper surface of the diaphragm as communicated thereto through conduit 106. This will cause the diaphragm to move upwardly against the force of spring 134 and when this movement is sufficient to close the contacts 130 and 132 the electrical circuit will be completed therethrough to light the signal lamp 108.

On the other hand, if the capacity of the dust bags 44 is first reached, the pressure drop through the bag in the middle cage 24 will be communicated through the conduit 112 and the conduits 116 and 114 to the diaphragm in the differential pressure device 110. When the pressure drop through the bag has reached a predetermined value, the diaphragm will have been moved upwardly against the force of spring 134A sufficiently to close the contacts and light the signal lamp 118.

Inasmuch as the pressure drop between the annular space 100 and the interior of cylindrical member 82 caused by filling of the pail 70 is considerably less than the permissible pressure drop through the dust bags, spring 134 in differential pressure responsive device 102 is lighter than spring 134A in device 110.

While device 110 is responsive to the pressure drop through only one of the dust bags, it has been found by experience that the division of flow between the three bags is practically equal and that they all accumulate dirt at substantially the same rate. Consequently, when one bag has accumulated sufficient dirt, they all have.

When the operator notices that either lamp 108 or 118 is lighted, he should shut off the motor by throwing the switch 39. If the lamp 108 is lighted, indicating that the pail 70 is filled, the clamp 78 may be released and the cover 74 pivoted to its fully opened position, whereupon the pail 70 may be lifted from the base 10 and its contents emptied into any trash receptacle, such as an ash barrel, whereupon the pail is replaced and the cover closed. If the lamp 118 is lighted the latch 50 may be released and the cover 48 pivoted to its fully opened position, as shown in FIG. 6, whereupon each of the dust bags 44 may be removed and thrown away with their contents. Thereafter, three new bags are placed in the cages and the cover 48 closed. Frequently, the operator may find it convenient to empty both the pail and the bags at the same time when either of the lamps is lighted, but nevertheless it is preferable to have separate warning lights because it is impossible to predetermine whether the pail or the bags will first require emptying.

If, during cleaning, the operator comes upon a quantity of bulky waste, such as wood shavings for instance, which would be too large to pass through the hose connected to inlet 98, he may stop the motor, open the cover 74 and place such waste by hand in the open container 70, thus making unnecessary the use of a separate waste basket or other similar container.

While we have shown a vacuum cleaner having three bags, it is to be understood that our invention contemplates any plurality of bags and that the embodiment shown and described is by way of illustration only and is not to be considered as limiting scope of our invention, which is to be determined from the appended claims.

What we claim is:

1. In a vacuum cleaner, a base member, an open-top container forming a dirt receiving chamber removably supported by said base member, walls secured to said base member and defining a dust bag enclosure open at the top, hinged cover means for closing the tops of said container and said enclosure, conduit means forming an inlet for introducing dirt-ladened air into said container, a plurality of dust bags removably supported in said enclosure, an equal plurality of conduits supported by said cover means and each extending from said container to a separate one of said dust bags, and means for exhausting air from said enclosure to induce flow of air from said inlet into said container and from said container through said conduits in parallel to the respective dust bags.

2. In a vacuum cleaner, a base member, an open-top container forming a dirt-receiving chamber removably supported by said base member, walls secured to said base member and defining a dust bag enclosure open at the top, hinged cover means for closing the tops of said container and said enclosure, a generally cylindrical member open at the bottom and supported at the top by said cover means so as to depend into said container and form an annular space in the upper part thereof when the cover is closed, conduit means forming an inlet extending through said cover means for introducing dirt ladened air into said annular space, a plurality of dust bags removably supported in said enclosure, an equal plurality of conduits supported by said cover means and each extending from the upper part of said cylindrical member to a separate one of said dust bags, and means for exhausting air from said enclosure to induce flow of air from said inlet into and through the annular space in said chamber and from said chamber through said cylindrical member and in parallel through said conduits to the respective dust bags.

3. In a vacuum cleaner, a base member, an open-top container forming a dirt receiving chamber mounted on said base member, walls secured to said base member and defining a dust bag enclosure open at the top, a hinged cover member for said chamber, a hinged cover member for said enclosure, said cover members being hinged about a common axis, inlet means for introducing dirt-ladened air into said container, a plurality of dust bags removably supported in said enclosure, an equal plurality of conduits each connecting said container to a separate one of said dust bags, each conduit including a first part carried by one of said cover members and a second part carried by the other of said cover members, the parts of the respective conduits being so disposed that they are connected to each other when both of said cover members are closed, and means for producing flow of air from said inlet means into said chamber and from said chamber through said conduits in parallel to the respective dust bags.

4. In a vacuum cleaner, a base member, an open-top container removably mounted on said base member, walls secured to said base member and defining a dust bag enclosure open at the top, a first cover member for said container and a second cover member for said enclosure both hinged to one of said walls about a common axis, an inlet conduit extending through said first cover member for introducing dirt-ladened air into said container, a plurality of dust bags removably supported in said enclosure, an equal plurality of conduits each connecting said container to a separate one of said dust bags, each conduit including a first part carried by said first cover member and a second part carried by said second cover member, the parts of the respective conduits being so disposed that they are connected to each other in abutting relation when both of said cover members are closed, and means for producing flow of air from said inlet into said container and from said container through said conduits in parallel to the respective dust bags.

5. In a vacuum cleaner, a base member, an open-top container removably mounted on said base member, walls secured to said base member and defining a dust bag enclosure open at the top, a first cover member for said container and a second cover member for said enclosure both hinged to one of said walls about a common axis, a generally cylindrical member open at the bottom and having a diameter less than that of said container depend-

ing from said first cover member and forming an annular space within the upper part of said container when said first cover is closed, an inlet conduit extending through said first cover member and discharging circumferentially into said annular space, a plurality of dust bags removably supported in said enclosure, an equal plurality of conduits each connecting said container to a separate one of said dust bags, each conduit including a first part carried by said first cover member and communicating with the interior of said cylindrical member, and a second part carried by said second cover member, the parts of the respective conduits being so disposed that they are connected to each other in abutting relation when both of said cover members are closed, and means for producing flow of air from said inlet into and through said annular space in said container and from said container through said cylindrical member and in parallel through said conduits to the respective dust bags.

6. In a vacuum cleaner, means forming a cylindrical dirt receiving chamber disposed with its axis extending vertically, a generally cylindrical member open at the bottom and having a diameter less than that of said chamber disposed in the upper part of the latter and forming an annular space therewith, conduit means forming an inlet for introducing dirt-ladened air into said annular space, means defining a dust bag enclosure, a plurality of dust bags removably supported in said enclosure, an equal plurality of conduits each extending from the interior of said cylindrical member to a separate one of said dust bags, means for exhausting air from said enclosure through an outlet means to induce flow of air from said inlet into and through the annular space in said chamber and from said chamber through said cylindrical member and in parallel through said conduits to and through the respective dust bags, the open bottom of said cylindrical member being located a substantial distance above the bottom of said dirt receiving chamber whereby when sufficient dirt has ben collected in said chamber below said opening the upper surface of the dirt will be adjacent to said opening and will produce restriction of flow between the exterior and interior of said cylindrical member, first differential pressure means responsive to the difference in pressures existing in said annular space and in said cylindrical member resulting from said restriction of airflow, second differential pressure means responsive to the difference in pressures existing in one of said plurality of conduits and in said dust bag enclosure, and separate signal means operated by the respective differential pressure means.

7. In a vacuum cleaner, a base member, an open-top container forming a dirt receiving chamber removably supported by said base member, walls secured to said base member and defining a dust bag enclosure open at the top, hinged cover means for closing the tops of said container and said enclosure, a generally cylindrical member open at the bottom and depending from said cover means so as to extend into said container and form an annular space in the upper part thereof when said cover means is closed, conduit means forming an inlet extending through said cover means for introducing dirt-ladened air into said annular space, a plurality of dust bags removably supported in said enclosure, an equal plurality of conduits supported by said cover means and each extending from the interior of said cylindrical member to a separate one of said dust bags, means for exhausting air from said enclosure to induce flow of air from said inlet into and through the annular space in said chamber and from said chamber through said cylindrical member and in parallel through said conduits to and through the respective dust bags, first differential pressure means carried by said cover means and responsive to the difference in pressures existing in said annular space and in said cylindrical member resulting from the restriction of air flow from said dirt receiving chamber into the open bottom of said cylindrical member caused by the accumulation of dirt in said chamber, second differential pressure means carried by said cover means and responsive to the difference in pressures existing in one of said plurality of conduits and in said dust bag enclosure, and separate visual signal means each carried by said cover means and operated by the respective differential pressure means.

8. In a vacuum cleaner, a base member, an open-top container forming a dirt receiving chamber removably supported by said base member, walls secured to said base member and defining a dust bag enclosure open at the top, a first hinged cover member for said chamber, a second hinged cover member for said enclosure, said cover members being hinged about a common axis, a substantially cylindrical member open at the bottom and supported at the top by said first cover member so as to depend into said chamber and form an annular space in the upper part thereof when the first cover is closed, conduit means forming an inlet extending through said first cover member for introducing dirt-ladened air into said annular space, a plurality of dust bags removably supported in said enclosure, an equal plurality of conduits each connecting the interior of said cylindrical member to a separate one of said dust bags, each conduit including a first part carried by said first cover member and a second part carried by said second cover member, the parts of the respective conduits being so disposed that they are connected to each other when both of said cover members are closed, means for exhausting air from said enclosure to induce flow of air from said inlet into and through the annular space in said chamber and from said chamber through said cylindrical member and in parallel through said conduits to and through the respective dust bags, first differential pressure means carried by said first cover member and responsive to difference in pressures existing in said annular space and in said cylindrical member, second differential pressure means carried by said second cover member and responsive to difference in pressures existing in one of said plurality of conduits and in said dust bag enclosure, and separate visual signal means carried by the respective cover members and operated by the respective differential pressure means.

9. In a vacuum cleaner, means forming a vertically extending dirt receiving chamber, a hollow member open at the bottom disposed in the upper part of said chamber and spaced inwardly from the vertical walls of the latter, conduit means forming an inlet for introducing dirt-ladened air into the space between said hollow member and said walls, means for producing flow of air from said inlet into and through said space in said chamber and from said chamber through said hollow member to an outlet means, the open bottom of said hollow member being located a substantial distance above the bottom of said dirt receiving chamber whereby when sufficient dirt has been collected in said chamber below said opening the upper surface of the dirt will be adjacent to said opening and will produce restriction of flow between the exterior and interior of said hollow member, differential pressure responsive means responsive to the difference in air pressure existing in said space and in said hollow member resulting from said restriction of airflow, and signal means operated by said differential pressure means in response to a predetermined pressure difference.

10. In a vacuum cleaner, means forming a cylindrical dirt receiving chamber disposed with its axis extending vertically, a generally cylindrical member open at the bottom and having a diameter less than that of the chamber disposed in the upper part of the chamber and forming an annular space therewith, first conduit means forming an inlet for introducing dirt-ladened air into said annular space, second conduit means communicating with the cylindrical member and forming an outlet from the chamber, means for producing flow of air from said inlet into and through said annular space in said chamber and from said chamber through said cylindrical member and

said second conduit means, the open bottom of said cylindrical member being located a substantial distance above the bottom of said dirt receiving chamber whereby when sufficient dirt has been collected in said chamber below said opening the upper surface of the dirt will be adjacent to said opening and will produce restriction of flow between the exterior and interior of said cylindrical member, differential pressure responsive means responsive to the difference in air pressure existing in said space and in said cylindrical member resulting from said restriction of airflow, and signal means operated by said differential pressure means in response to a predetermined pressure difference.

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