

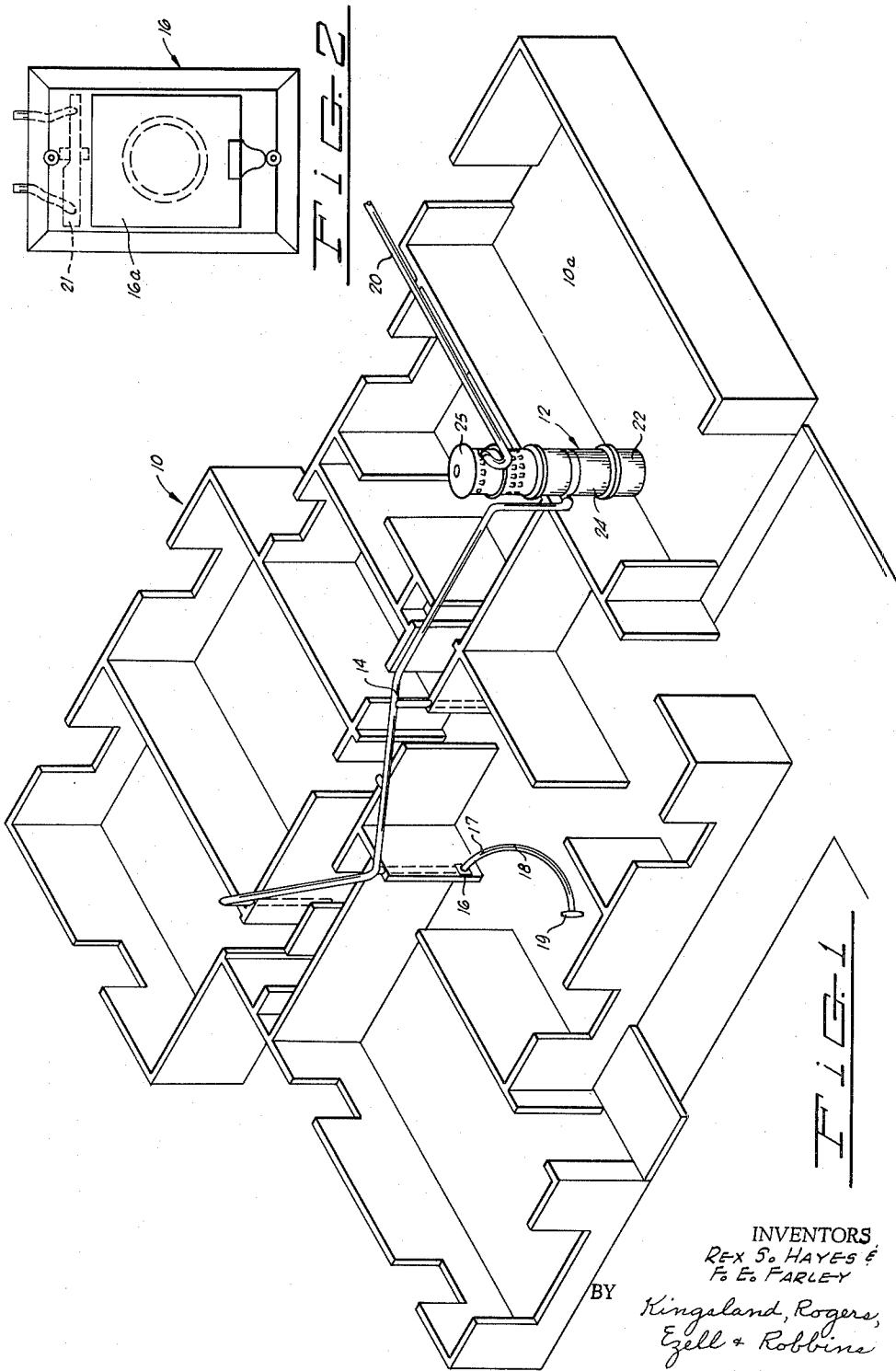
March 15, 1966

R. S. HAYES ET AL  
VACUUM CLEANING SYSTEM

3,240,000

Filed Nov. 2, 1962

3 Sheets-Sheet 1



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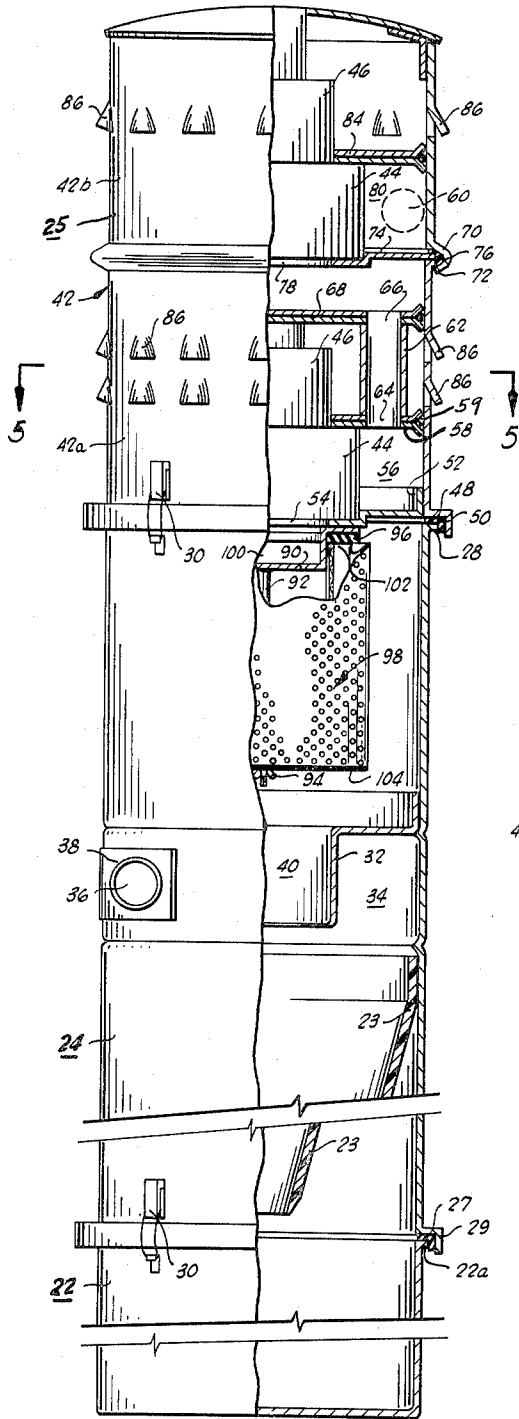


FIG. 3

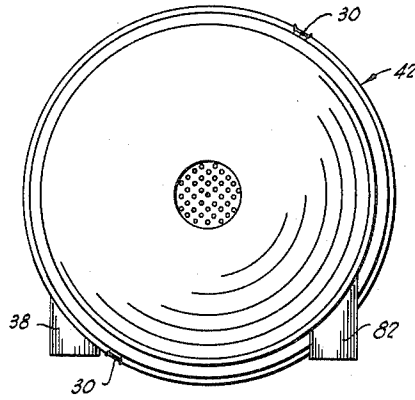


FIG. 4

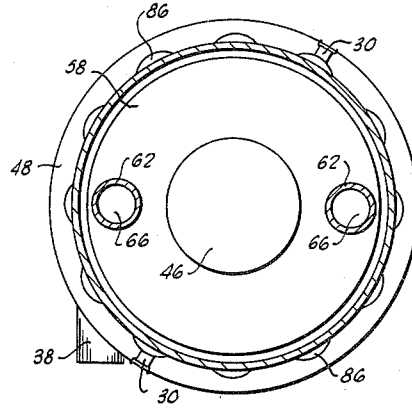


FIG. 5

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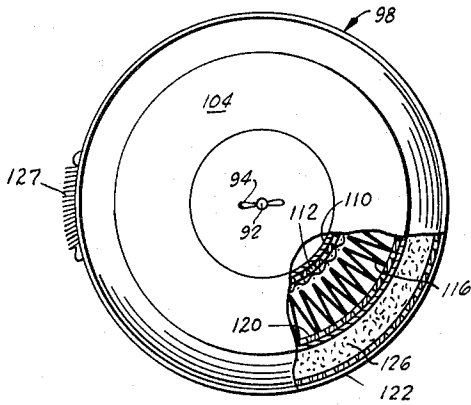


FIG. 8

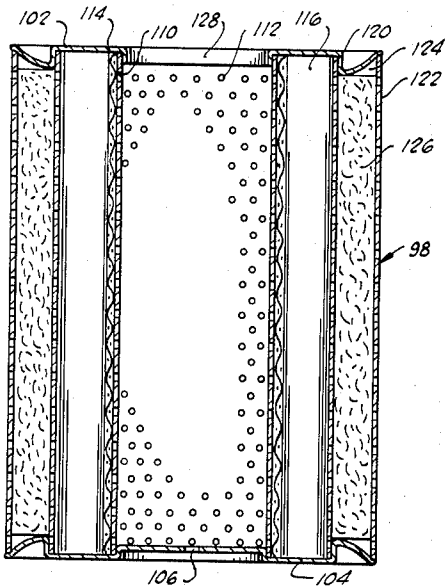


FIG. 7

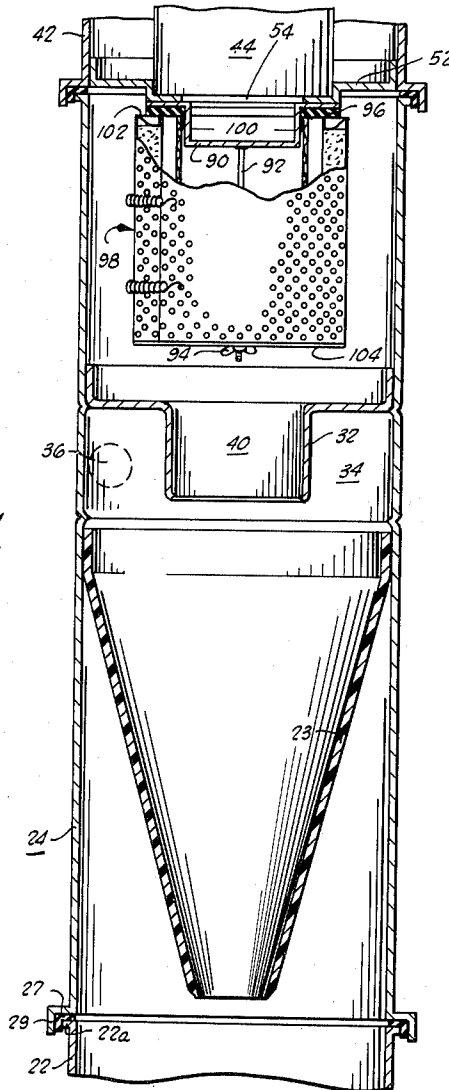


FIG. 6

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**VACUUM CLEANING SYSTEM**

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 Filed Nov. 2, 1962, Ser. No. 235,101  
 6 Claims. (Cl. 55-337)

This invention relates to cleaning systems by means of which a vacuum is applied to the surface to be cleaned. More particularly, but not by way of limitation, the present invention relates to a vacuum cleaning system which, in a preferred embodiment, is characterized by a centrally located source of vacuum which is connected by a conduit system to a plurality of remotely located receptacles, to any one of which a cleaning head may be attached. In essence, the present invention presents an improvement over the central vacuum cleaning system disclosed in application for United States Letters Patent, Ser. No. 120,873, filed June 15, 1961, and now abandoned.

Although various types of vacuum cleaning systems, and in particular, central cleaning systems, have heretofore been known, efforts have constantly gone forward to improve the filtration systems of these vacuum cleaners and the amount of suction developed thereby in order that "deeper" and more efficient cleaning may be effected thereby. In general, all of such vacuum cleaning systems perform their cleaning function by inducing a flow of air from the surface to be cleaned through a straining filter of some type, such as a cloth bag, or, in a few instances, an oil type filter such as that shown in the cited copending application. The air is exhausted from the vacuum cleaner following its passage through the filter, and any fine particles of dust which are not effectively removed from the air stream by the filter are returned to the air in the area which is being cleaned.

Simultaneously with the efforts to develop more efficient filtration systems to remove as completely as possible the fine dust particles which are entrained in the air flowing through the vacuum cleaner system, it has been an objective of the research directed toward the development of improved vacuum cleaners to reduce the noise level which results from the motors and vacuum pumps of the system when they are in operation, and also to increase the amount of vacuum which is pulled by the system in order that deeper and more efficient cleaning may be effected. It is frequently a problem in vacuum cleaning that the fine dust and dirt particles are deeply ingrained in rugs having a thick pile structure so that unless a very strong vacuum is applied through the cleaning nozzle or head of the vacuum cleaning system, this deep dirt cannot be effectively extracted and removed. This problem of removing relatively inaccessible dirt is especially pronounced in the case of automobiles. With the recent development of vacuum cleaning systems which may be usefully employed in automobile service stations for cleaning the interior of automobiles, such as that system described in the cited co-pending application, the importance of providing a high vacuum which may efficiently perform cleaning at greater depths has become amplified.

The present invention provides a vacuum cleaning system of the type in which the power or vacuum unit is disposed in a central location and is connected to one or more conduits which lead to the specific location where the cleaning operation is to be carried out. The vacuum cleaning system of the invention constitutes a marked improvement over the types of systems heretofore utilized in that an improved, dry type filter has been incorporated in the system which eliminates the oil type filter described in the co-pending application cited above, and which yet accomplishes a more efficient removal of

dust and fine particles of solid material from the air which is circulated through the system. The filtering function of the cleaning system of this invention is also substantially improved by virtue of the new type of cyclone separator which functions in combination with the dry filtering element which is incorporated in the system to preliminarily remove almost completely the larger particles of dust, grit and dirt which are entrained in the air stream passing through the system.

Another extremely important feature of the present invention is the attainment of a very high vacuum or suction through the utilization of a plurality of serially arranged motors and vacuum pumps or centrifugal fans which permit the power unit to be compactly built, and yet which permit the system to generate a vacuum exceeding that which has characterized previous central cleaning systems of this general type.

The novel serial or tandem arrangement of the several vacuum pumps and the motors by which they are driven in the present invention permits a much more powerful and efficient cleaning operation to be performed than has previously been possible with conventional vacuum cleaners. Moreover, by reason of the central location of the vacuum and separation units, the noise level at the remote location where the cleaning is being carried out is reduced to a minimum and is so slight that the operator has no difficulty in hearing a television set, a doorbell or a telephone while utilizing the invention. To use the device, the operator need only insert one end of a flexible tubular member in an appropriately located vacuum receptacle and then move a cleaning head which is attached to the other end of the tubular member over the surface which it is desired to clean. In moving from one cleaning location to another, the operator simply detaches the flexible tubular member from the vacuum receptacle and carries the tubular member and cleaning head from the location which has just been cleaned to the next location which is to be cleaned. These simple operations effect a considerable saving in overall cleaning time and a further saving in time is realized due to the fact that it is unnecessary to empty or replace the filter element or dust receptacle at frequent intervals as is the case with conventional vacuum cleaners.

As indicated above, the invention is especially well adapted for use in service stations for cleaning the upholstery and interiors of automobiles. The powerful vacuum unit of the invention permits dust to be removed from inaccessible corners and from fabrics covering the floorboards of automobiles where the dirt and dust have become deeply ingrained over an extended period of time.

From the foregoing description, it will be apparent that it is a major object of the present invention to provide a powerful and efficient vacuum cleaning system which is characterized by a centrally located composite filtration unit and source of vacuum.

A further object of the invention is to provide a vacuum cleaning system which more efficiently separates dust and lint particles from the air which is circulated through the system than any type of vacuum cleaning system heretofore in use.

Another object of the present invention is to provide a vacuum cleaning system which generates a higher vacuum, and thus is capable of more thorough cleaning than the types of vacuum cleaning systems heretofore utilized.

Another object of the present invention is to provide a filtration system in a vacuum cleaner which is improved from the standpoint of the efficiency of filtration achieved as well as in the capacity of the filter. The capacity of the filter is such that less frequent changing or cleaning of the filter is required than in these types of vacuum cleaning systems previously marketed.

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It is a further object of the present invention to provide a central vacuum cleaning system which permits substantially noiseless cleaning to be carried out in all of the rooms or spaces of a home or building.

A further object of the present invention is to reduce the time which is required to clean a plurality of rooms or individual spaces in a building.

A further object of the present invention is to provide a vacuum cleaning system which is well adapted for use in automobile service stations and similar facilities.

Another object of the present invention is to provide a central cleaning system in which the receptacle utilized to receive the coarser dirt removed during cleaning requires relatively infrequent emptying.

Another object of the present invention is to provide a central cleaning system which exhausts to the atmosphere and thus does not return any of the air which is circulated through the system to the space which has been cleaned.

An additional object of the present invention is to provide a central vacuum cleaning system which is effective to remove both solid and liquid wastes and impurities from a surface to be cleaned.

A further object of the present invention is to provide a cleaning system having a centrally located source of vacuum which is comprised of a plurality of vacuum units connected to each other in tandem or series so that the total vacuum produced by the system is extremely high, and the ability of the system to extract ingrained or "deep" dirt is vastly enhanced.

A further object of the present invention is to provide a central vacuum cleaning system which employs a dry filtering element which does not require the use of oil or other liquids to effect the efficient removal of extremely fine particles of dust and lint from the air which is circulated through the system.

Yet another object of the present invention is to provide a central cleaning system which is relatively inexpensive to manufacture, simple and inexpensive to maintain, and characterized by a long and trouble-free operating life.

Other objects and advantages of the invention will be evident from the following detailed description when read in conjunction with the accompanying drawings which illustrate our invention.

In the drawings:

FIGURE 1 is an isometric view of a home with a roof removed to show the manner in which the central cleaning system of the present invention is installed therein.

FIGURE 2 is a view in elevation of one of the remote receptacles of the invention with the switch element associated therewith shown in dashed lines.

FIGURE 3 is a view in elevation of the composite centrally located source of vacuum and filtration elements of the present invention. A portion of the housings of the composite source of vacuum and filtration elements have been broken away to show the arrangement of the vacuum pumps, motors and filters therein.

FIGURE 4 is a plan view of the centrally located composite source of vacuum and filtration system shown in FIGURE 3.

FIGURE 5 is a view in section taken along line 5—5 of FIGURE 3.

FIGURE 6 is a vertical sectional view through the central portion of the composite separator and filtration system showing the construction of the dry filter element utilized in the present invention.

FIGURE 7 is an enlarged vertical sectional view taken through the center of the dry filter element utilized in the present invention.

FIGURE 8 is a bottom view of the dry filter element of the present invention with a portion of the bottom plate of the filter housing broken away to more clearly illustrate the manner in which the filter element is constructed.

Referring now to the drawings in detail, and particularly to FIGURE 1, reference character 10 generally designates

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a home or other building having a plurality of rooms and a garage 10a and having the central vacuum cleaning system of the present invention installed therein. The centrally located composite separator and source of vacuum is designated generally by reference character 12, and, according to one plan of installation, is located in the garage 10a. Location of the composite separation unit and source of vacuum 12 in the garage 10a insures that a minimum of noise from the operation of the cleaning system will be experienced in the various rooms of the home as they are being cleaned. This arrangement also conserves valuable space in the home.

A conduit system 14 connects the centrally located composite source of vacuum and separator 12 to a plurality of remotely located vacuum receptacles 16 which are strategically located throughout the home 10 so as to afford readily accessible sources of vacuum in all locations. During a cleaning operation, one end 17 of a flexible tubular member 18 is plugged into or attached to, an appropriate receptacle 16, and the opposite end of the flexible tubular member 18 is fitted with a suitable cleaning attachment 19 of conventional design. An exhaust duct 20 leads from the composite unit 12 to the outside of the house so that air which has been circulated through the cleaning system may be discharged to the atmosphere.

FIGURE 2 illustrates the manner in which an electrical switch may be associated with the receptacle 16 to provide for automatic energization of the centrally located composite unit 12 when the flexible tubular member 18 is connected to one of the receptacles 16. Each of the receptacles 16 has a cover plate 16a to which is secured a suitable normally open switch 21 which is adapted to be closed when the cover plate is lifted to permit the end 17 of the flexible tubular member 18 to be inserted into the receptacle. Closure of the switch 21 permits electrical current to flow to the power unit of the centrally located, composite separator and source of vacuum 12.

In referring to FIGURE 1, it will be seen that in a preferred embodiment of the invention, the composite separator and source of vacuum 12 comprises three individual, serially connected units. The lowermost of these units is a dust or waste receptacle 22. The second unit of the composite separator and source of vacuum 12 comprises a cyclone separator which includes a generally frusto-conical member 23 (see FIGURE 3) disposed inside a cylindrical casing 24. The cylindrical casing 24 is extended past the large end of the frusto-conical member 23 for a considerable distance in order to receive the solid filter element hereinafter to be described. Resting on top of the casing 24 is a vacuum unit 25. It is believed that a clearer understanding of the invention will be obtained if the construction and relative arrangement of the components and elements making up each one of the three individual, serially connected units is described completely before proceeding to a description of the components and elements of another of the three units. The description will therefore commence with the dust receptacle 22 and will be completed with the description of the vacuum unit 25.

The dust receptacle 22 is generally cylindrical in configuration and is characterized by a circumferential, outwardly extending flange 22a at its upper end. A gasket 27 is bonded to the flange 22a and extends around the top of the dust receptacle 22.

The casing 24 of the frusto-conical member 23 is of substantially the same diameter as the diameter of the dust receptacle 22 and has an outwardly extending, circumferential flange 28 at its upper end and an outwardly and downwardly projecting rim 29 at its lower end which rests upon the gasket 27 of the dust receptacle when the casing 24 is in place.

A plurality of quick-disconnect clamps 30 are employed to tightly clamp the casing 24 to the dust receptacle 22 so that the rim 29 of the casing 24 makes a tight seal with the gasket 27 of the dust receptacle. Approximately

midway of the casing 24 or intermediate the length thereof, an annular flange 32 of generally L-shaped transverse cross-section is coaxially secured inside the casing 24 and defines with the side walls of the casing an annular channel 34 which extends concentrically around the casing. An intake opening 36 is provided in the casing 24 and communicates with the channel 34 defined by the annular flange 32 and the side walls of the casing 24. The intake opening 36 is formed by a tubular member 38 which extends generally tangentially with respect to the cylindrical casing 24. Mounted concentrically in the casing 24 immediately beneath the annular channel 34 is the frusto-conical member 23. This frusto-conical member, in a preferred embodiment of the invention, is molded as a single or integral unit from a plastic material such as a high density polyethylene sold under the trade name Marlex, or a polyamide of the type sold under the trade name Nylon. It will be noted that the frusto-conical member 23 is coaxially aligned with the central opening 40 which is defined by the annular and L-shaped flange 32. This arrangement is an important feature of the present invention and its function is explained hereinafter.

The frusto-conical member with its open upper and lower ends, the annular L-shaped flange 32 with its central opening 40, the wall of the casing 24 between the member 23 and the flange 32, and the tangential intake opening 36 constitute the cyclone separator. This cyclone separator, as a part of the combination, is an important part of the invention.

Resting atop the cylindrical casing 24 is another cylindrical casing of substantially the same diameter as the cylindrical casing 24 and designated generally by reference character 42. The casing 42 includes a pair of housings 42a and 42b, each of which contains a vacuum pump 44 and an electric motor 46 which is drivingly connected to the vacuum pump. The lower end of the casing 42 is provided with a downwardly and outwardly projecting rim 48 which is identical to the rim 29 provided at the bottom of the cylindrical casing 24 and which rests upon a gasket 50 which is interposed between the rim 48 and the circumferential flange 28 at the top of the cylindrical casing 24. Additional quick-disconnect clamps 30 such as those which are used to connect the dust receptacle 22 to the casing 24 are used for attaching the casing 42 to the casing 24.

At the bottom of the cylindrical casing 42, a centrally apertured supporting plate or partition 52 is secured transversely across the casing 42 and is welded, riveted, or otherwise suitably secured at its outer periphery to the internal walls of the casing 42. The central aperture 54 in the supporting plate 52 is, of course, coaxially aligned with the casings 24 and 42. A vacuum pump 44 which may comprise a centrifugal fan or other type of vacuum generating device rests upon the supporting plate 52 over the central aperture 54. Suitable air passageways (not seen) are provided through the housing of the vacuum pump to connect the vacuum unit with an annular space 56 which exists between the walls of the vacuum unit and the internal walls of the housing 42.

A second centrally apertured partition plate 58 sealingly surrounds the motor 46 which is drivingly connected to the vacuum pump 44, and the partition plate 58 is also sealingly secured at its outer periphery to the internal walls of the casing 42 by means of an O-ring seal 59. This partition plate 58 functions to prevent the air being circulated through the vacuum system from coming in contact with the motor 46. In order to permit this air to bypass the motor 46 enroute to a discharge opening 60 which is provided in the casing 42, a cylindrical member 62 is aligned with an aperture 64 formed in the partition plate 58 and provides a passageway for air being circulated through the system. The cylindrical member 62 is also aligned with a second aperture 66 which is formed in a third transverse partition plate 68 which extends across

the casing 42 in contact with the top of the motor 46.

The upper portion of the casing 42 comprises a second housing 42b which contains the second vacuum pump 44 and its motor 46. The housing 42b is semi-permanently secured to the housing 42a by a turned-over flange 70 which engages a small flange or projection 72 formed at the upper end of the housing 42a. A transverse, centrally apertured partition plate 74 is also engaged at its outer periphery by the turned-over flange 70 and rests atop the flange 72. A suitable elastic sealing member 76, is provided between the transverse partition plate 74, the flange 72 and the turned-over flange 70. Resting in a central position upon the transverse partition plate 74 so as to be aligned with the central aperture 78 therein is the vacuum pump 44 of the upper housing 42b of casing 42. As in the case of the vacuum pump 44 of the lower housing 42a, a plurality of air passageways (not seen) are provided in the lower end of the housing of vacuum pump 44 to permit air to be drawn by the vacuum pump from the lower housing 42a of the casing 42 into the annular space 80 which surrounds the vacuum pump 44.

From the space 80, air circulated by the vacuum system is discharged or vented through a discharge opening 60 in the casing 42. As shown in FIGURE 4, the discharge opening 60 is formed by a conduit or port 82 which extends substantially tangential with respect to the cylindrical casing 42. A centrally apertured partition plate 84 similar to the partition plate 68 used in the lower housing 42a of the casing 42 is provided to sealingly surround the motor 46 and prevent the air circulated by the system from contacting the motor 46. In order for the motors 46 to be cooled by ambient air surrounding the composite vacuum and separation unit 12, a plurality of louvered ports 86 are provided in the casing 42 so that air may flow in through the casing walls and cool the motors.

At the lower end of the casing 42 and secured to the plate 52 across the central aperture 54 therein is a U-shaped bracket 90. The bracket 90 is provided with an elongated, downwardly extending bolt 92 which is threaded on the lower end thereof to receive a wing nut 94. A thick, elastic annular sealing element 96 is secured to the plate 52 around the aperture 54 and passes over the legs of the bracket 90 which are secured to the plate 52 in the manner shown in FIGURES 3 and 6. A cylindrical dry filter element 98 which is provided at one of its ends with an opening 100 (see FIGURE 6) which is large enough to pass over the bracket 90 and surround the aperture 54 in plate 52, is slipped over the bracket 90 so that its upper end plate 102 contacts the annular sealing element 96. The bottom of the dry filter element 98 is closed by a bottom plate 104 which is provided with a central aperture 106 (see FIGURE 6) just large enough to pass the lower end of the bolt 92. In mounting the dry filter 98 within the casing 24, the lower end of the bolt 92 is passed through its aperture 106 in the plate 104 at the lower end of the cylindrical, dry filter element 98 and the wing nut 94 is then tightened to press the upper end plate 102 of the filter element tightly against the annular sealing element 96. It will be noted, in referring to FIGURES 3 and 6, that the dry filter element 98, when secured in the housing 24 in the manner described, is positioned with its lower end spaced above the L-shaped flange 32.

The relative arrangement of the frusto-conical member 23 the annular L-shaped flange 32 and the dry filter element 98 may be best understood by referring to FIGURE 6 of the drawings. This figure and FIGURES 7 and 8 are also the best illustrations of the detailed construction of the dry filter element 98. It should here be noted that the dry filter element which is utilized in this invention may, if desired, be a standard type of filter such as that now marketed by the Fram Corporation of Providence, Rhode Island. While no novelty is claimed by us to reside in the dry filter element 98 per se, we have

found that this type of filter, when used in combination with the member 23 and annular L-shaped flange 32 in the system of the present invention, provides vastly improved filtration and extended operating life in the central vacuum cleaning system. In order to clearly explain the co-operation between the member 23, annular flange 32 and the dry filter element 98, it is believed that it will be helpful to explain the constructional details of the dry filter element 98, and the manner in which this structure functions in the system.

As shown in FIGURES 7 and 8 of the drawings, the dry filter element 98 comprises a first rigid cylindrical member 110 which forms the internal wall of the filter element 98 and which is provided with a number of perforations 112. The rigid cylindrical member 110 is open at both of its ends and is preferably constructed of a rigid material such as sheet metal or the like. Surrounding the first or internal cylindrical member 110 is a cylindrical screen or wire mesh member 114, and this element is in turn surrounded by an annular band of radially pleated paper 116. The manner in which the paper is radially pleated is best illustrated in FIGURE 8 which is a bottom view of the dry filter element 98 with a portion of the bottom plate 104 broken away to more clearly illustrate the details of construction of the dry filter element 98. The radially pleated paper band 116 constitutes the final or fine filtering stage of the invention. The paper is provided with microscopic pores of a size not exceeding five microns so that extremely fine particles of lint and dust are removed by the paper as air is passed there-through in moving from the outer periphery of the dry filter element 98 to the space inside the first cylindrical member 110.

Surrounding the annular band of radially pleated paper 116 is a second rigid perforated cylindrical member 120. Except for its larger diameter, the second cylindrical member 120 is substantially identical to the first cylindrical member 110 and is also preferably constructed of sheet metal. At the outer periphery of the dry filter element 98, a third rigid cylindrical member 122 which is also substantially identical to the members 110 and 120 is provided and is spaced radially outward from the second rigid cylindrical member 120 to provide an annular space 124 between these two metallic elements of the filter. Within the space 124, a mass of fibrous bat material 126 is positioned and serves as an initial, coarse filtering element to remove coarser dust particles and dirt from the air stream passing radially through the dry filter element 98 from the external periphery thereof to the space inside the first, rigid cylindrical member 110. The outer member 120 is fastened around the bat material 126 by a plurality of spring fasteners 127.

The rigid cylindrical member 122 may not be used or may be replaced by a close mesh nylon sheet fastened around the mat by any convenient clamp or spring fastener such as the fasteners 127. The nylon mesh protects the filter mat 126 when it is being cleaned. To clean the mat it may be removed and placed upon a horizontal surface with the nylon sheet lying over it. Then the mat can be vacuumed with the machine of this invention, the nylon sheet preventing particles of the mat from being sucked into the vacuum cleaner.

The elements of the dry filter 98 thus far described are maintained in their relative positions with respect to each other by the top plate 102 and the lower plate 104. Appropriate indentations and channels are made in these plates to define the spacing of the three rigid perforated cylindrical members 110, 120 and 122 and, a fortiori, the positions of the coarse and fine filtering elements, 126 and 116, respectively, with respect to each other. It is to be noted that the top or upper end plate 102 is provided with an annular aperture 106 in the center thereof, which aperture is of a diameter which corresponds to the diameter of the first, rigid cylindrical member 110. The lower plate 104, on the other hand, closes the bottom

of the first rigid cylindrical member 110 except for a very small aperture 106 which is provided in the lower plate to receive the lower end of the elongated bolt 92 as illustrated in FIGURES 2 and 5.

Having described in detail the construction of the system of the present invention, the manner in which the system is operated to perform a cleaning operation will now be discussed.

#### OPERATION

In the preferred embodiment of the invention which is illustrated in FIGURE 1, the composite separator-central vacuum source 12 has been located in the garage 10a of the home 10. The source of vacuum, which comprises the vacuum pumps 44 and motors 46 contained in the housing 42a and 42b of casing 42, is connected through the intake opening 36 to the conduit system 14 which leads into the interior of the house 10, and to the exhaust duct 20 leading to the exterior of the house. The exhaust duct 20 is connected to the discharge port 32 disposed on the casing 42 of the composite separator-central source of vacuum 12. The conduit system 14 leads from the vacuum unit 25 to a plurality of vacuum receptacles 16 which are strategically located throughout the house so as to provide maximum accessibility for cleaning. In order to utilize the central cleaning system, a housewife or operator has merely to insert the end 17 of a flexible tubular member 18 into any of the vacuum receptacles 16 and lead the other end of the flexible tubular member which carries a suitable cleaning head or attachment 19 to the location where the cleaning operation is to be effected.

As shown in FIGURE 2, each of the vacuum receptacles 16 has a cover plate 16a which effectively seals the receptacle against undesirable leakage of air when the receptacle is not being utilized. The cover plate 16a carries a suitable electrical switch 21 which is closed when the cover plate is lifted to insert the end 17 of the flexible tubular member 18 preparatory to commencing a cleaning operation. The closure of the switch 21 energizes the electric motors 46 in the housings 42a and 42b, respectively, which motors in turn actuate their associated vacuum pumps 44.

The central cleaning system of the present invention is characterized by a substantial increase in power and efficiency over the portable vacuum cleaners of the prior art, as well as over the central vacuum cleaning systems with which applicant is familiar. In using the tandem or serial arrangement of motors and vacuum pumps prescribed in this invention, very small motors of a fractional horsepower may be utilized to generate a very high vacuum. For example, in a preferred embodiment of the invention, each of the motors 46 is a  $\frac{1}{16}$  horsepower motor which, by virtue of the arrangement illustrated in FIGURE 2, are capable, in combination with their respective vacuum pumps 44, of pulling a vacuum equal to 120 inches of water, and of circulating 175 cubic feet per minute of air. Those familiar with the comparable characteristics of other vacuum cleaning systems will appreciate the unexpected nature of the results which are achieved by the tandem plural motor-vacuum pump arrangement which is utilized in the central cleaning system of this invention.

As has been previously indicated, a second very important improvement realized in the present invention over the various types of central vacuum cleaning systems previously proposed, including that which is shown in the co-pending application to which reference was hereinbefore made, is the much higher filtration efficiency which is achieved by the system. This efficiency is realized as a result of several novel structures which are here proposed for the first time. One of these structural features is the construction of the frusto-conical members 23 and the annular, generally L-shaped flange 32, together with the novel relative arrangement of these elements with respect to each other. It is reiterated that

the member 23 in the preferred embodiment of the invention is molded as a single piece from a plastic or resinous material. By virtue of such integral or single piece construction, seams extending along the walls of the separator are eliminated, and the vortical airflow in the separator is thus not disturbed or interfered with in any manner. In previous types of frusto-conical members where a seam extending from the top to the bottom thereof was necessarily provided, the centrifugal or vortical motion of air entering the member and passing from the top to the bottom thereof was disturbed so that some of the air stream was deflected into the middle of the member prior to being cleansed by the centrifugal removal of dirt particles therefrom. No such interference is provided by the absolutely smooth walls of the molded plastic member 23 which is used in the present invention.

A great improvement in the cleaning efficiency of the cyclone separator is also made possible by the provision of the annular, L-shaped flange 32 which is provided above the member 23 in the casing 24, and which terminates with its lower end in approximately the same horizontal plane as the upper end of the member 23. In referring to FIGURES 3 and 6, it will be perceived that the intake opening 36 which is provided in the casing 24 communicates tangentially with the annular space 34 which is defined by the flange 32 and the walls of the casing 24. Thus, air which is drawn into the composite separator-vacuum source 12 of the invention from the conduit system 14 will initially pass through the opening 36 into the annular channel 34. The air, by virtue of the annular configuration of the channel 34, is caused to move with a circular motion, and thus is already going into its downwardly moving centrifugal motion at the time it enters the top of the frusto-conical member 23. The annular, L-shaped flange 32 functions to prevent any of the air mass moving in the channel 34 from moving inwardly into the center of the casing 24 and thus becoming dead air not subjected to the centrifugal cleaning action which is to be effected in the member 23. In other words, the combined effect of the use of the seamless, one piece member 23 in juxtaposition to the annular, L-shaped flange 32 is to assure that air moving into the composite vacuum-separation unit 12 will initially move only in a vortical movement from the top of the bottom of the member 23, and will then return upwardly through the opening 40 in the center of the flange 32 after the larger particles of dirt and dust have been centrifugally extracted therefrom by the member 23. The air circulation in the member 23 tends to become ideal in that no entry of air into the central space of the member 23 occurs until the air mass has swirled downwardly to the bottom of the member and yielded up most of the entrained dirt and lint particles carried thereby.

The dust, dirt and lint particles which are extracted from the air stream by the member 23 gravitate downwardly into the dust receptacle 22 positioned below the casing 24. The air stream, with the major portion of the coarser dirt and grit removed therefrom, then passes upwardly through the opening 40 in the center of the annular flange 32 and will be deflected by the bottom plate 104 of the dry filter element 98 into the annulus between the filter element 98 and the walls of the casing 24. Any coarse particles of dust or grit which might have escaped the separatory action of the cyclone separator tend to be removed by the sudden change in the direction of movement of the air stream caused by the contact of the stream with the bottom plate 104 of the dry filter element 98, and the resultant deflection of the air from movement in a vertical direction to movement in a lateral or horizontal direction.

The efficiency of the cyclone separator in separating the longer particles of dirt usually encountered in vacuum cleaning operations is evidenced by the results of a test which was conducted. In the tests 13 pounds of

ordinary vacuum sweepings were passed through the system of the invention. All but 54 grains of the sweepings were removed by the cyclone separator and collected in the dust receptacle 22.

The vacuum which is generated by the vacuum pumps 44 in the housings 42a and 42b acts downwardly through the opening 54 in the partition plate 52 and thus creates a very large pressure drop across the walls of the dry filter element 98. This suction which is developed from the outer to the inner periphery of the dry filter element 98 causes the air stream moving up from the cyclone separator to pass through the perforations in the third or outermost rigid cylindrical member 122 of the dry filter element 98, through the fibrous bat material 126, through the perforations in the second or intermediate rigid cylindrical member 120, through the radially pleated paper band 116, and finally through the screen 114 and innermost or first rigid cylindrical member 110. As the air stream passes through these elements of the dry filter element 98, any intermediate sized dust or dirt particles are removed from the air stream by the fibrous bat material 126. This fibrous material may be a natural or synthetic material such as Fiberglas or cellulose. Although the extent of filtration normally attained in central cleaning systems of this general type is attained in the present invention by the time the air stream has passed through the fibrous bat material 126 located between the rigid cylindrical elements 120 and 122, a further filtration of extremely fine dust particles of down to 5 micron size is effected by the radially pleated band of paper 116.

When the air stream has reached the space inside the first rigid cylindrical element 110, it is, in most instances, at least as pure and clean as the air which is normally present in the rooms or spaces which are being cleaned. In many instances, it is, in fact, purified to a greater extent than this air. After reaching the inside of the dry filter element 98, the air is sucked upwardly through the opening 54 in the partition plate 52, through the lower vacuum pump 44, and passes outwardly into the annular space 56 which surrounds the vacuum pump 44. From the space 56, the air flows upwardly through the tubular member 62, through the opening 78 in the partition plate 74, through the upper vacuum pump 44, and out through the opening 60 and the discharge conduit 82. As previously indicated, at no time during the passage of the air through the composite separator-central vacuum source 12 is the circulated air permitted to come in contact with the motors 46. This provides an extra safeguard against any contamination of the electrical elements of the motors by deleterious materials which might not be filtered from the air stream in the event of filter failure.

In concluding the discussion of the operation of the invention, it should be pointed out that the dry filter element 98 is not only effective to remove practically all of the lint, dirt and dust which is entrained in the air stream, but is also effective to remove entrained droplets of liquid such as water and oil which might be sucked up by the extremely high vacuum generated by the system. Furthermore, the relationship between the member 23 and the annular confining shell or channel 34 defined by the flange 32 has been found to separate all such liquids downwardly to the pan 22. Virtually no liquid is carried upwardly with the air to the filter element 98.

Another very significant advantage of the dry filter element 98 is its very considerable capacity. Since most of the entrained dirt and dust will have been removed from the air stream by the cyclone separator and the coarse filtering element consisting of the fibrous bat material 126, it will be necessary to clean or replace the radially pleated paper band 116 which constitutes the final, extremely fine filtering element of the invention only, infrequently. Moreover, the large capacity dust receptacle 22 requires a relatively long period of time



to become filled to the extent that it must be removed from the composite vacuum-separation unit 12 and emptied. When such emptying of the dust receptacle is necessary, the detachment of the receptacle from the casing 24 can be quickly and easily facilitated simply by opening the quick-disconnect clamps 30 and lifting the relatively light casings 24 and 42 from the top of the dust receptacle.

Changes may be made in the combination and arrangement of parts or elements as heretofore set forth in the specification and shown in the drawings, it being understood that changes may be made in the precise embodiment disclosed without departure from the spirit and scope of the invention as defined in the following claims.

I claim:

1. A vacuum cleaner comprising:

a first casing having an intake opening in one end thereof and discharge vent therein;

means in said casing for producing a vacuum;

a filter element secured over said intake opening for filtering air drawn into said first casing through said intake opening, the filter element comprising a hollow cylinder having a cylindrical inner surface and a cylindrical outer surface with filter material therebetween, a plate for blocking the flow of air to one of the filter element, the inlet to the filter element comprising its outer cylindrical surface, the outlet comprising the end of the cylindrical surface opposite the plate;

a casing of generally cylindrical configuration on a vertical axis connected to said one end of said first casing and enclosing said filter element, said cylindrical casing having an air intake opening in the side wall thereof;

an annular flange of generally L-shaped transverse cross-section coaxially secured in said cylindrical casing and spaced from said filter element, said flange defining with the cylindrical walls of said cylindrical casing an annular channel including a plate extending radially inwardly from the cylindrical casing, an opening in the center of the plate, the flange further including a cylindrical wall defining a passage spaced radially inwardly of the cylindrical casing and coaxial with the casing, the cylindrical wall extending from the periphery of the opening in the plate in a direction away from the filter element, the annular channel thereby opening away from said filter element and communicating with the air intake opening in the side wall of said cylindrical casing;

a frusto-conical member coaxially secured in said cylindrical casing with the large end of the member adjacent said annular flange and on the opposite side thereof from said filter element whereby said annular channel opens into the large end of

said member, the cylindrical wall extending toward the member; and

a dust receptacle attached to said cylindrical casing in juxtaposition to the small end of said member.

2. A vacuum cleaner as claimed in claim 1 wherein said member is of one piece seamless molded plastic construction.

3. A vacuum cleaner as claimed in claim 1 wherein said filter element comprises:

a first rigid cylindrical member having perforations in the side walls thereof positioned around said first mentioned intake opening and coaxially in said cylindrical casing;

a generally cylindrical, fine filtering means secured around said first rigid cylindrical member and covering the perforations in the side walls thereof;

a second rigid cylindrical member having perforations in the side walls thereof secured around said generally cylindrical fine filtering means; and

a generally cylindrical, coarse filtering means secured around said second rigid cylindrical member.

4. A vacuum cleaner as claimed in claim 3 wherein said fine filtering element comprises an annular, radially pleated porous paper band.

5. A vacuum cleaner as claimed in claim 3 wherein said generally cylindrical coarse filtering element is constructed of a fibrous bat material.

6. The vacuum cleaner of claim 1 wherein the means for producing a vacuum comprises two vacuum pumps each having an air inlet side and an air outlet side, the air inlet side of one vacuum pump communicating with the filter element outlet, the air outlet side of said one vacuum pump communicating with the inlet side of the other vacuum pump, the air outlet side of said other vacuum pump communicating with the discharge vent, and wall means in the casing confining the air to a serial path through the filter element, the said one vacuum pump and the said other vacuum pump.

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