DUCT CLEANING APPARATUS

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ABSTRACT

A remote-controlled, self-propelled, vehicular apparatus adapted to travel tractionally within a rectangular duct, and by a combined brushing and vacuum-cleaning operation, to remove dust and other foreign matter therefrom.

4 Claims, 6 Drawing Figures
DUCT CLEANING APPARATUS

SPECIFICATION

The improved duct cleaning apparatus comprising the present invention is designed for use primarily in connection with the removal of dust and other loose or adhered foreign matter from rectangular sheet metal or other ventilating air ducts, conduits, or the like. The invention is, however, susceptible to modification and apparatus embodying the principles of the present invention may, if desired and with or without modification as required, be employed for cleaning the interior of various forms of pipes, conduits, shafts, tunnels, and the like. Irrespective of the particular use to which the invention may be put, the essential features thereof are at all times preserved.

Heretofore, considerable difficulty has been encountered in connection with the commercial cleaning of air ducts as, for example, hot air furnace ducts, air conditioning ducts, ventilating ducts and the like such as are commonly employed in large office buildings, factories, foundries, laundries, and other commercial establishments too numerous to mention. Various methods are currently in use in connection with cleaning and conditioning such ducts, depending on the size, cross-sectional shape and the linear paths along which such ducts extend. More often than not, such ducts are formed of sheet metal and are rectangular in cross section so that with any given duct there are two side wall surfaces, an overhead surface, and a floor surface to be cleaned.

When the size of a particular duct is fairly large, interior duct cleaning is accomplished manually with the operator or operators working within the duct while the latter is internally illuminated. This is a laborious procedure inasmuch as it is necessary for an operator to carry his cleaning equipment such as brushes, dust receptacles, and the like with him. Furthermore, this procedure necessitates frequent exit and reentry of the operator from and into the duct for waste disposal operations. Where an overhead duct is concerned, the use of ladders with ladder placement along the duct at the regions of the access openings presents a time-consuming operation with attendant hazards, to say nothing of floor space obstructions and the consequence hindrance to normal factory or plant operation. With moderate size ducts, it is necessary that the operator crawl within the duct, and with small ducts, it is sometimes necessary that an operator work with his head and shoulders within a given access opening, utilizing a long-handled scraper device to perform the dust-loosening operation, followed by a similar posture when using a brush to remove the loosened dust and other foreign material.

In many instances, due to the lack of closely-spaced access openings, it is necessary that special access openings be cut through one side of a duct, and after cleaning operations have been completed, it is necessary that the removed panel section be replaced by a soldering or welding operation or that the oversize panel be bolted in position in order to cover the opening. Invariably, this involves ladder work and, therefore, is undesirable.

Apart from strictly manual duct-cleaning operations, certain semi-automatic cleaning procedures have been resorted to, these usually involving the manual feeding of a long flexible suction tube through the duct from different access openings, this procedure sometimes being preceded by a dust-loosening operation, utilizing a long-handled brush arrangement which must be selectively manipulated in order to insure loosening of dust from the side, overhead, and floor surfaces of the duct. Obviously, in such an instance, the duct must be interiorly illuminated. Furthermore, vacuum hose and electrical lead-in cable snagging is a factor that must be contended with. An additional and hazardous factor which is associated with this type of semi-automatic duct-cleaning procedure resides in the danger of dust explosion in case of inadvertent electrical arcing.

Where cylindrical conduits, pipes, and the like are concerned, many of the various limitations heretofore set forth remain prevalent although to a lesser degree inasmuch as it has been possible to devise rotary brushes which sweep circumferentially about the inner cylindrical wall of such a conduit, together with suction heads for withdrawing the loosened dust and other foreign matter. Whether such devices are self-propelled through the conduit or pipe, or whether they are manually guided therethrough, it is obvious that a rotary brush is incapable of reaching the corner edges of a rectangular conduit.

The present invention is designed to overcome the above-noted limitations that are attendant upon present-day methods and apparatus for cleaning rectangular air ducts, conduits and the like, and toward this end, the invention contemplates the provision of a fully automatic duct-cleaning apparatus embodying a self-propelled carriage which is adapted to travel in either direction, i.e., forwardly or rearwardly, through a rectangular duct and on which there are mounted scraper brushes, one for each planar wall of the duct to be cleaned, the brushes being effectively mounted on a suction head by means of which the loosened dust is withdrawn and deposited in a fabric filter bag which also is mounted on the carriage for movement bodily therewith. Dust-loosening operations are accomplished by passage of the brushes back and forth over the four walls of the duct so that there will be no possibility of the generation of sparks. Furthermore, the brushes are carried directly on the suction head so that immediate dust removal takes place in the vicinity of the brushes and there is no chance for spark-generating impact between the loosened dust particles and the metal walls of the duct.

According to the present invention, conventional remote-control means exteriorly of the duct are provided for regulating the movements of the carriage within the duct. This control means may assume the form of a control panel embodying a Sonar system whereby signals emitted therefrom are received by suitable apparatus on the movable carriage within the duct to the end that the drive motor for the carriage may be reversed or regulated for speed. Alternatively, the control panel may be directly connected by electrical lead-out wires to such motor for the same purpose. Irrespective of the particular control mechanism employed the essential features of the invention are not altered.

The provision of a duct cleaning apparatus such as has briefly been outlined above, and possessing the stated objects, constitutes the principal object of the present invention.

The provision of an apparatus which is relatively simple in its construction and, therefore, may be manufactured at a low cost; one which is comprised of a mini-
mum number of parts, particularly moving parts and, therefore, is unlikely to get out of order; one which is capable of ease of assembly and dismantlement for purposes of inspection, replacement, or repair of parts; one which is smooth and silent in its operation, and one which is otherwise well adapted to perform the services required of it are further desirable features which have been borne in mind in the production and development of the present invention.

Other objects and advantages of the invention, not at this time enumerated, will become readily apparent as the nature of the invention is better understood from a consideration of the following detailed description.

The invention consists in the several novel features which are hereinafter set forth and are more particularly defined by the claims at the conclusion hereof.

In the accompanying two sheets of drawings forming a part of this specification, one illustrative embodiment of the invention is shown.

In these drawings:

FIG. 1 is a perspective view of a duct cleaning apparatus constructed according to the present invention and showing the same operatively disposed in a rectangular duct, portions of the duct being broken away in the interests of clarity;

FIG. 2 is a sectional view taken on the vertical plane indicated by the line 2—2 of FIG. 1 and in the direction of the arrows;

FIG. 3 is a front elevational view of the duct cleaning apparatus with the brush-supporting suction head removed;

FIG. 4 is a transverse sectional view taken on the line 4—4 of FIG. 2;

FIG. 5 is an enlarged fragmentary perspective view of a corner region of the suction head, the view being taken in the vicinity of the line 5—5 of FIG. 4; and

FIG. 6 is a horizontal sectional view taken on the line 6—6 of FIG. 4.

Referring now to the drawings in detail and in particular to FIGS. 1 to 3, inclusive, a duct cleaning apparatus embodying the present invention is designated in its entirety by the reference numeral 10 and is shown as being operatively installed or positioned within a duct 12, the latter being rectangular in transverse cross section and comprising vertical side walls 14 and 16, a top wall 18 and a bottom wall 20. Briefly, the apparatus 10 is of rectangular suction head 30 and consists of longitudinal side members 32, front and rear end members 34 and 36, and a plurality of intermediate transverse members 38. The various frame members are preferably, but not necessarily, of channel design.

The aforementioned caterpillar-type drive mechanism 28 serves trationally to support the frame 30 and, accordingly, it embodies a rear drive shaft 40 which carries a pair of driving drums 42, and a front driven shaft 44 which carries a pair of driven drums 46. Endless crawler treads 48 encompass the driving and driven drums in the usual manner of caterpillar drive construction and the lower reaches of such treads are given reaction support by means of a series of idler rollers 50. The two shafts 40 and 42, as well as the idler rollers 50, are rotatably carried by the side members 32 of the rectangular frame 30. The caterpillar-type drive mechanism 28 is powered by the aforementioned electric motor M2, the latter being suitably mounted on the frame 30 and having associated therewith a gear reduction mechanism 52. The latter embodies an output shaft 54 which carries a drive sprocket 56. As shown in the drawings, said drive sprocket 56 is operatively connected by an endless chain 58 to a sprocket 60 which is secured to the drive shaft 40. The motor M2 is of the reversible type to the end that the apparatus may be caused to move in either a forward or a reverse direction.

The centrifugal blower 26 is operatively mounted on the frame 30. It is of conventional construction and includes a housing 62 from which there projects forwards and centrally a cylindrical air inlet flange 64. As will be described in greater detail presently, this air inlet flange constitutes the sole supporting means for the aforementioned brush-supporting suction head 22. The blower 26 is further provided with an eccentrically disposed air outlet neck 66 to which there is adapted to be removably secured the aforementioned filter bag 24. The connection between the bag 24 and outlet neck 66 is preferably in the form of a bayonet ring and slot combination 68 as is conventional procedure where industrial vacuum bags are concerned.

Referring now to FIGS. 3 to 6, inclusive, and considering the nature of the aforementioned brush-supporting suction head 22, this head, as previously indicated, is adapted to be supported solely from the inlet flange 64 of the blower housing 62 as best shown in FIG. 2 and, furthermore, it is capable of easy removal from such flange for the purpose of suction head substitution to accommodate the cleaning of rectangular ducts of varying cross section. This suction head 22 involves in its general organization a rectangular front plate 70 (see FIGS. 2, 5 and 6) and a rectangular rear plate 72. These two plates are maintained in slightly spaced parallelism by means of an appropriate number of spacer sleeves 74 which are spaced around the peripheral regions of the plates and are held in position by means of fastening bolts (not shown). The two plates 70 and 72 are of similar design and construction, each plate in the illustrated embodiment of the invention being substantially square in outline and being provided with a dished medial region 78 of generally pyramidal configuration, the two pyramids being of small slant height and large slant angle. Said two plates 70 and 72 thus define a relatively flat, generally rectangular suction head casing. Both pyramids are truncated, the pyramidal region 78 of the front plate 70 being cut
away or truncated on a circular bias as clearly shown in FIGS. 1, 2 and 4. The pyramidal region of the rear plate 72 is also relieved on a circular bias by reason of its intersection with an integrally formed tubular cylindrical mounting sleeve 80 (see FIG. 6). This mounting sleeve is designed for telescopic reception over the air inlet flange 64 of the blower housing at the time the suction head 22 is initially installed upon the blower. The mounting sleeve 80 is slitted as indicated at 82 in FIG. 6 to the end that it may be shrunk in centripetal fashion on the flange 64 by means of a split clamping band 84.

As best shown in FIGS. 4, 5 and 6 of the drawings, the front plate 70 serves to support a series of four floating brush-supporting manifold bars including an upper horizontal bar 90, a lower horizontal bar 92, and a pair of vertical bars 94 and 96. The four bars are disposed in quadrilateral relationship with the vertical bars lying in a transverse plane which is spaced forwardly from the plane of the horizontal bars. These four bars are individually movably as will be described presently and thus, collectively, they define an articulated rectangular brush frame. The various bars assume marginal positions with respect to the front plate 70 on the forward side of the latter, which is to say that each bar extends along a marginal edge of the plate. In order that each bar may span the full width or height of the plate, as the case may be, the ends of the vertical and horizontal bars overlap each other as clearly shown in FIGS. 5 and 6.

The various bars 90, 92, 94 and 96 are formed of rectangular tube stock and each bar is formed with a series of longitudinally spaced small holes 98 which are provided for the purpose of securing therein the bunched ends of a multiplicity of stiff wire bristle tufts 100. The bristle tufts of each manifold bar, when considered collectively, constitute, in effect, an elongated brush assembly. Although the various manifold bars are spaced inwardly from the edges of the plate 70, the bristle tufts project outwardly beyond the periphery of the plate to the end that they may cooperate with the walls of the duct 12 in a manner that will be described in detail presently. By thus causing the ends of the adjacent manifold bars to overlap each other, projection of bristle tufts into the corner edges of the duct is assured.

Each of the two vertical brush-supporting manifold bars 94 and 96 is floatingly supported along one of the vertical side edges of the front plate 70 by means of a cradle support in the form of a pair of spaced apart angle brackets 102 each of which has one flange 104 which lies flat against the marginal region of the plate 70 and is riveted or otherwise secured thereto. The other flange 106 of each angle bracket 102 extends at a right angle to the front plate 70. Pilot screws 108 have their ends threadedly received in the bars 94 and 96 and project through holes 110 in the flanges 106. Compression springs 112 surround these screws 108 and are interposed between the vertical bars and the flanges 106 of the bracket 102 so as yieldingly to urge the bars toward the periphery of the front plate 70, thus projecting the bristle tufts carried thereby laterally and outwardly beyond the periphery of the front plate.

Each of the two horizontal manifold bars 90 and 92 is similarly floatingly supported along one of the horizontal edges of the front plate 70 by a similar arrangement of angle brackets, pilot screws and compression springs, and in order to avoid needless repetition of description, similar reference numerals bearing a prime suffix have been applied to the corresponding parts as between the floating support for the manifold bars 90 and 92 and the manifold bars 94 and 96. It is to be noted, however, that because the end regions of the vertical manifold bars 94 and 96 are offset from the end regions of the horizontal bars 90 and 92 in crossing relationship as previously described, the flanges 106 of the angle brackets 102 are appreciably longer than are the flanges 106' of the angle brackets 102' in order that said flanges 106 may bridge the longer distance which is required of them due to the crossing relationship of the vertical and horizontal bars.

The rear plate 72 of the suction head 22 has floatingly mounted thereon a set of vertical and horizontal brush-supporting manifold bars, these bars and the mounting means therefore being identical to the manifold bars 90, 92, 94 and 96 which are associated with the front plate 70. It is deemed adequate for descriptive purposes to apply identical reference numerals to the corresponding parts as between the two brush mountings referred to.

From the above description and with reference to FIGS. 2 and 5, it will be observed that the two slightly spaced or juxtaposed plates 70 and 72 define therebetween a continuous rectangular or quadrilateral air inlet opening 120 which communicates with the air inlet flange 64 of the blower housing 62. On each side of this quadrilateral air inlet opening 120, there is disposed a series of quadrilaterally arranged brushes including a front series which is established by the floating brush mountings on the front plate 70, and a rear series which is established by the floating brush mountings on the rear plate 72. Thus, and as will be described in greater detail presently, as the apparatus 10 travels in either a forward or a rearward direction within the duct 12 undergoing cleaning, the two spaced apart series of brushes, in combination with the four walls of the duct, in effect "funnel" any dust or other foreign matter which may be loosened by the brushes directly into the quadrilateral air inlet opening 120 under the influence of the suction which is maintained by the blower 26.

As best shown in FIGS. 1 and 2, a sheet metal cover structure 130 encloses the blower 26 and the latter's motor M1, as well as the caterpillar drive motor M2. This sheet metal cover structure may be removably fastened in position on the chassis by means of sheet metal screws 132.

According to the invention, it is contemplated that an inventory of varying size brush-supporting suction heads 22 be maintained to accommodate the cleaning of varying sizes and shapes of ducts. Except for the rectangular dimensions of the front and rear dished plates 70 and 72, such suction heads will structurally be similar and possess substantially the same component parts such as the angle brackets 102, 102', the spiral compression springs 112, 112', etc.

In the operation of the herein described duct cleaning apparatus 18, a suction head which is commensurate with the transverse dimensions of the duct to be cleaned will be selected and applied to the blower 26 by means of the split clamping band 84 in the manner previously described. The apparatus 18 may then be introduced into the duct 12 to be cleaned via any one of the usual access openings (not shown) and then posi-
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tioned so that the crawler treads 48 rest on the bottom wall 20 of the duct. Such introduction of the apparatus 10 into the duct will, of course, be accomplished in the most expedient manner available, considering the nature of the duct. For example, where a given duct is of the overhead type and is provided with access openings in its bottom wall, the apparatus 10 will be lifted, hoisted, or otherwise introduced upwardly and into the duct. As previously stated, wireless remote control means embodying a floor-supported control box or panel (not shown) may be provided for selectively actuating the two motors M1 and M2. Suitable motor control solenoids may be carried by a junction box or the like (likewise not shown) which is mounted on the chassis 30, these solenoids being responsive to appropriate control switches in associated relation with the floor-supported control panel. In the illustrated forms of the apparatus, electric wires extending from the motors M1 and M2 pass through a flexible cable 140 and are adapted to extend to the control panel. Alternatively, the motor control solenoids may, if desired, be responsive to wireless impulses emanating from suitable sending equipment which is associated with the control panel. Such sensing equipment may be predicated upon the transmission of either sound or high frequency electrical impulses.

After the apparatus 10 has been thus introduced into the duct 12, the motors M2 and M1 will be energized so as to drive the apparatus in a forward direction while simultaneously operating the blower 26. During travel of the apparatus through the duct, the leading brush tufts 100, 100' traverse the four walls of the duct 12 and such dust and dirt as may be loosened by a scraping and sweeping action from these walls is immediately drawn inwardly through the air inlet opening 120 and thus conducted through the blower to the filter bag 24 where it is deposited therein. With the blower in operation, a strong suction is imparted to the space which exists between the front and rear series of brushes, and thus, any dust or dirt which may be loosened by the trailing set of brushes is drawn forwardly and also conducted through the air inlet opening 120 between the marginal or edge portions of the suction head 22. It will be appreciated that since the eight brush-supporting manifold bars are all yieldingly biased in an outward direction as previously described, the brush tufts 100, 100' are forced against the walls of the duct with considerable pressure for dust and dirt- loosening purposes. Furthermore, since the manifold bars are yieldable, any irregularities in the duct walls will be accommodated.

If the bottom wall 20 of the duct 12 is provided with a series of access openings, the duct may be cleaned by successive operations wherein the apparatus is caused to travel in one direction from its region of introduction to an adjacent access opening and then, by reversing the motor drive, caused to return to its point of introduction. Thereafter, the apparatus may be caused to travel in the other direction to the other adjacent access opening and similarly caused to return. It will be understood, of course, that whether the apparatus is traveling in a forward or a reverse direction, duct cleaning operations will take place. By such a procedure, it is necessary only that the apparatus be introduced into the duct through alternate ducts in a series thereof. This manner of duct cleaning ordinarily will be resorted to in situations where adjacent access openings are fairly remote from each other. In situations where adjacent duct access openings are relatively close to each other, if the electric cable 140 is sufficiently long, the closure plates associated with certain of the access openings may be left intact and the apparatus caused to traverse these plates.

Finally, it will be understood that the pulling power exerted by the apparatus as it travels forwardly is adequate to pull the cable behind it. During return movement of the apparatus in a reverse direction, the cable may be drawn rearwardly by the operator or by a suitable automatic winding and reeling mechanism (not shown).

The invention is not to be limited to the exact arrangement of parts shown in the accompanying drawings or described in this specification as various changes in the details of construction may be resorted to without departing from the spirit or scope of the invention. Therefore, only insofar as the invention is particularly pointed out in the accompanying claims is the same to be limited.

Having thus described the invention what I claim as new and desire to secure by letters patent is: said chassis operatively the being provided quadrilateral carried by and a manifold suction from the wall,

1. In a self-propelled vehicular apparatus for cleaning the interior wall surfaces of a rectangular duct having horizontal top and bottom walls and vertical side walls, in combination, a chassis, transport means engageable with said bottom wall and tractionsly supporting the chassis thereabove for movement therealong, a reversible drive motor mounted on said chassis and operatively connected to said transport means in driving relationship, a suction pump mounted on said chassis adjacent to the forward end thereof and having an air inlet and an air outlet, an actuating motor on said chassis and operatively connected to the suction pump, a filter receptacle removably secured to said suction pump and in communication with said air outlet, and a brush-carrying suction head removably secured to said suction pump and in communication with said air inlet, said suction head including a generally rectangular casing, said casing being provided with a substantially continuous peripheral quadrilateral, air inlet opening therearound, and a rectangular brush frame carried by said casing, said brush frame including a pair of horizontally brush-carrying manifold bars and a pair of vertical brush-carrying manifold bars, each of said bars being shiftable on said suction head casing toward and away from the adjacent duct wall, brush elements projecting outwardly from said manifold bars and designed for sweeping engagement with said duct walls incident to movement of the chassis along the duct in either direction, said brush frame being disposed in close proximity to said continuous air inlet opening, whereby dust or foreign matter which is loosened by such sweeping engagement with the duct walls by said brush elements is immediately drawn into the opening, and spring means for yieldingly urging said manifold bars in an outward direction with respect to the brush frame in order to insure sweeping engagement of the brush elements with said duct walls.

2. A self-propelled vehicular apparatus as set forth in claim 1 wherein said suction head further includes a second and similar rectangular brush frame on said casing and similarly having brush elements projecting outwardly therefrom, the second brush frame likewise
being disposed in close proximity to said continuous air inlet opening, the two brush frames assuming positions on opposite sides of the opening whereby the brush elements associated with said frames, in combination with the walls of the duct, establish a continuous suction area which surrounds the suction head and is in communication with the air inlet of the suction pump.

3. A self-propelled vehicular apparatus as set forth in claim 2 and wherein the suction pump is in the form of a centrifugal blower presenting a forwardly projecting cylindrical flange which defines said air inlet, and the suction head casing is comprised of a pair of generally flat front and rear rectangular plates which are maintained in slightly spaced apart relationship by spacer members, the peripheral edges of said plates defining said quadrilateral air inlet opening, the rear plate being provided with a cylindrical mounting sleeve in the central region thereof, the forward end of said sleeve being in open communication with the space existing between said front and rear plates, and the rear end of said sleeve being telescopically and removably received over said cylindrical flange of the blower.

4. A self-propelled vehicular apparatus as set forth in claim 2 and wherein each pair of horizontal brush-carrying manifold bars is offset from its respective pair of vertical brush-carrying manifold bars, the outer end regions of such pairs of bars overlap each other in crossing relationship, and said brush elements extend coextensively along each manifold bar.

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