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IN-DUCT CLEANING APPARATUS

This invention relates to an apparatus traveling inside a duct which caliber is very small, e.g., 150mm and cleaning the surface inside the duct.

Heretofore, for an apparatus for cleaning the surface inside a duct, a large robot for the use of cleaning has been used in the case of a large duct. And in the case of an ordinary middle or small sized duct, either ventilation through the duct has been performed, or, in most cases where such ventilation has been ineffective, manual work has been depended on.

In the case of said ordinary middle or small sized duct and as far as manual work has to be de depended on for cleaning the surface inside the duct, the cleaning has never gone well because of difficulty of the work itself or preparing workers, thus mold and bacteria have grown or dust has accumulated in the duct, and the accumulation of such foreign substances has been considered to be a cause of, e.g., infection in a hospital or food poisoning in a restaurant. Henceforth, with expectable increase of small sized ducts, above problem will accumulate still more.

It is an object of this invention to provide an in-duct cleaning apparatus which overcomes said existing faults and is effectively usable in place of a man particularly in a middle or small sized duct.

The in-duct cleaning apparatus of the present invention is firstly characterized by comprising a traveling means traveling forwardly and backwardly in an interior of the duct to be cleaned, a rotating duct-cleaning means secured to a forward end of forwardly extending rotatable shaft provided on said traveling means, said duct-cleaning means comprising in combination compressed air ejection throughholes that pass therethrough, brush bristles that extend radially therefrom and a whip that is detachable therefrom, a monitor video camera for monitoring the state of cleaning of the interior of said duct, said video camera being carried by said travelling means, an air compressor for supplying compressed air to said compressed-air ejection throughhole, a monitored image display means for displaying an image taken by said monitor video camera, and a control means for controlling the travelling of said travelling means and the rotating of said rotating duct-cleaning means in accordance with an image displayed on said monitored image display means.

In addition to said first characteristic, the in-duct

cleaning apparatus of the present invention is secondly characterized in that the compressed-air ejection thoughholes have their openings directed obliquely forward with respect to the forward traveling direction of said traveling means.

In addition to said first characteristic, the in-duct cleaning apparatus of the present invention is thirdly characterized in that the brush bristles are provided on a circumference of said rotating duct-cleaning means in the form of plurality of radially spaced bundle having fixed intervals.

In addition to said first characteristic, the in-duct cleaning apparatus of the present invention is fourthly characterized in that the whip consists of a flexible tube that connects with front portion of said rotating duct-cleaning means and is waved by compressed air threrethough.

In addition to said first characteristic, the in-duct cleaning apparatus of the present invention is fifthly characterized in that the apparatus is equipped with a straight- ejective nozzle that ejects compressed air concentratedly toward the narrow area of duct inside surface in front of the travelling mean.

In addition to said first characteristic, the in-duct cleaning apparatus of the present invention is sixthly characterized in that the travelling means is equipped with guide rollers for making said travelling means to travel precisely along the interior of said duct.

Said six characteristic of the present invention yield operational effects as follows:

By virtue of said first characteristic, the monitored image display means keeps displaying the image coming from the video camera, the control means makes the travelling means travel inside the duct and makes the rotating duct-cleaning means rotate and makes the air compressor supply the compressed-air to the rotating duct-cleaning means; Accordingly, the compressed air is ejected from each of the plural number of compressed air ejection throughholes of the rotating duct-cleaning means toward the duct inside surface of the traveling means, the brush bristles extended radially from the rotating duct-cleaning means arrives rotatingly upon the duct inside surface, and also the whip attached to the rotating duct-cleaning means is waved and hit on the duct inside surface. As a result, the foreign substances, like trash and dust, accumulated on or attached to the duct inside surface are successively cleaned out.

By virtue of said second characteristic, in addition

to the operational effect brought about by said first characteristic, the compressed air ejection throughholes have their openings directed obliquely forward with respect to the forward traveling direction of said traveling means; Accordingly, the compressed air is ejected from each of the air ejection throughholes toward the duct inside surface of the traveling means in oblique front of the advancing traveling means, that is, the compressed air is successively blown against the circumference obliquely of the duct inside surface; As a result, trash and dust are evenly cleaned throughout the whole circumference of the duct inside surface.

By virtue of said third characteristic, in addition to the operational effect brought about by said first characteristic, the brush bristles are provided on a circumference of said rotating duct-cleaning means in the form of plurality of radially spaced bundle having fixed intervals; Accordingly, the brush bristles arrives rotatingly upon a certain surface part inside the duct successively and clean that part efficiently.

By virtue of said fourth characteristic, in addition to the operational effect brought about by said first characteristic, the whip consists of a flexible tube that connects with front portion of the rotating duct-cleaning means and waved by compressed air therethrough; Accordingly,

the whip is waving to hit on the a certain surface part inside the duct randomly while the compressed air is supplied through the flexible tube.

By virtue of said fifth characteristic, in addition to the operational effect brought about by said first characteristic, when foreign substance are found to be firmly attached to a specific narrow area of the duct inside surface, the compressed air is ejected from the straight-ejective nozzle toward said narrow area of the duct inside surface in front of the travelling truck; and as a result, the foreign substances and the like accumulated on said narrow area of the duct inside surface are predominantly and powerfully cleaned out by said compressed air.

By virtue of said sixth characteristic, in addition to the operational effect brought about by said first or fifth characteristic, when the travelling truck, while travelling, approaches the left or right wall surface inside the duct, the guide rollers guide the progressive direction of the truck by keeping contact with the above wall surface; and resultingly, the travelling truck can travel without being brought into direct contact with the above wall surface, and is never stagnated even at the curvatures inside the duct.

Fig.1 is an illustrative drawing showing the whole aspect of a preferred embodiment of the present invention;

Fig.2 is a schematic block diagram showing the outline of the travelling portion controller on board the travelling portion and the monitor/remote-control portion remotely connected to said travelling portion controller in said preferred embodiment;

Fig.3 is a detailed side view showing the travelling portion in said preferred embodiment;

Fig.4 is a detailed plan view showing the travelling portion in said preferred embodiment;

Fig.5 is a detailed side view showing the rotating duct-cleaning means in said preferred embodiment; and

Fig 6 is a detailed front view showing the rotating duct-cleaning means in said preferred embodiment;

The preferred embodiment of the in-duct cleaning apparatus of the present invention will be described in accordance with Fig.1 to Fig.6.

In Fig.1, 1 is a duct. 2 is an entry of equipment and materials to the duct 1.

3 is a travelling portion carried in through the entry 2.

4 is a monitor/remote-control portion whose first function is to execute monitoring the front of the travelling portion 3 by using a TV 5 and a VTR 6 in accordance with the signal given by a video camera 25 on

board the travelling portion 3 and whose second function is, while executing the above monitoring, to execute remote-controlling of the travelling portion 3 by using a remote-control switch 7.

8 is a transceiver. 9 is a video amplifier. 10 is a power supply unit supplied with AC-100V, having a battery built-in to enable it to work about 5 hours even when said AC-100V supply is interrupted.

11 is a compressor for generating compressed air.

12 is an antenna line for transmitting the signal sent out from the monitor/remote-control portion 4 to the travelling portion 3 and for transmitting the signal of the camera sent back from the travelling portion 3 to the monitor/remote-control portion 4.

14 is an air pipe for transmitting the compressed air generated by the compressor 11 to the travelling portion 3.

21 is a travelling truck, of the travelling portion 3, equipped with crawlers 20 as shown in Fig.3.

50 is a rotating duct-cleaning means.

64 is a direction in which the travelling portion 3 progresses inside the duct 1.

Further explanation will be given referring to Figs.2, 3, 4, 5, and 6

The rotating duct-cleaning means 50 has a body 51

which is secured to the forward end of a forwardly extending rotatable shaft 82, equipped with compressed air ejection throughholes 52, brush bristles 53, and whip 54.

Each of the compressed air ejection throughholes 52 (4 holes 52 are indicated in Fig. 6) is connected to the main hole 51a which is penetrated the longitudinal center of rotating duct-cleaning body 51.

Openings of the throughholes 52 are on the circumference of the body 51 having a fixed interval, and are directed obliquely forward with respect to the forward traveling direction of the travelling truck 21.

The mainhole 51a is connected to the throughhole of rotatable shaft 82 connected with a air pipe 14 via an air joint 22. The compressed air transmitted through said air pipe 14 and the rotatable shaft 82 into the main hole 51a of body 51

Brush bristles 53 are provided on the circumference, behind the compressed air ejection throughholes 52, of the rotatable duct-cleaning body 51, directed obliquely forward with respect to the forward traveling direction of the travelling truck 21, and are in the form of plurality of radially spaced bundle having fixed intervals.

The whip 54 consists of the flexible tube which connects with the main hole 51a at front portion of the body 51, and wave to hit randomly the duct inside surface in

front of the travelling truck 21 while the compressed air from main hole 51a pass through the flexible tube. The whip 54 can be detached from the body 51 when there no need to use it.

The foreign substances accumulated on the duct inside surface is firstly being hit by whip 54 and secondly being blown by the compressed air and thirdly being swept by the brush bristles while the traveling truck 21 is traveling forwardly and the body is rotating and the compressed air is being providing.

24 is a straight-ejective nozzle. 25 is a video camera . 26 is a double illuminating lamp for helping the video camera 25 take pictures. 13 is the central part of a travelling portion controller 27.

Regarding the travelling portion controller 27 (as shown in Fig.2) and the monitor/remote-control portion 4 connected remotely to said travelling portion controller 27 in the preferred embodiment, 4, 5, 6, 7, 8, 9, 10, 12 and 14 have already been described. Among them the transceiver 8 plays a pivotal role at the side of the monitor/remote-control portion 4 in exchanging signals between the travelling portion controller 27 via said antenna line 12.

Said transceiver 8 firstly, receives the signal 75 generated by the video camera 25 of the travelling portion

controller 27 via a control substrate 30 and a control substrate 30 and a signal converter 32 in the central part 13 of the same travelling portion controller 27, secondly, transmits the signal 75 to the TV 5 and the VTR 6 in the monitor/remote-control portion 4, via a radio wave line 29 in the same monitor/remote-control portion 4, thirdly, makes " the scene inside the duct 1 and in front of the travelling portion 3 caught by the video camera 25" changed immediately into the images of the TV 5 and the VTR 6, fourthly, receives later-described operating signals 76 which an operator sends out by using the remote-control switch 7 in accordance with said images of the TV 5 and the VTR 6, via a radio wave line 28, fifthly transmits said operating signals 76 to the control substrate 30, via the antenna line 12 and also via the signal converter 32 in the central part of the travelling portion controller 27, and thereby, makes said control substrate 30 execute the control of each of the later-described several system.

31 in the central part 13 of the travelling portion controller 27 is a voltage regulator for regulating " the voltage to the electric machinery or electric machineries of each of the later-described several systems", i.e., " the voltage to each load of the control substrate 30 " .

33 is a travelling system comprising electric motors 41 and 42 of DC 12V drive for propelling the travelling

truck 21 of the travelling portion 3.

34 is a rotating duct-cleaning body rotating system comprising an electric motor 43 of DC 12V drive for rotating the rotating rotating duct-cleaning body 51.

35 is a camera tilt system comprising an electric motor 44 of DC 12V drive for giving the video camera 25 an appropriate tilt angle (refer to fig. 3) .

36 is a video camera system comprising the video camera 25.

37 is an illuminating lamp system comprising a double DC 6V illuminating lamp 26.

38 is a straight-ejective nozzle system, comprising the straight-ejective nozzle 24, which execute ejection by receiving the compressed air transmitted through the air pipe 14 via an electromagnetic valve 39 of DC 12V drive.

40 is a duct-cleaning system, comprising the rotating duct-cleaning means 50, the shaft 83, the air pipe 14, and an electromagnetic valve 39a.

Further it should be added that when the aforementioned remote-control switch 7 is used, several operating signals 76 to effect the following can be sent out ; putting on or off the control substrate 30; making the traveling truck 21 relating to said system 33 turn left or right, or go ahead or backward, or stop; making the rotating duct-cleaning body 51 relating to said system 34 start or

stop rotation; making the video camera 25 relating to said system 35 tilt upward or downward; turning on or off the illuminating lamp 26 relating to said system 37; and making the straight-ejective nozzle 24 and the rotating duct-cleaning means 50 start ejection of the compressed air through the operation of the electromagnetic valves 39 and 39a of said system 38 and 40.

The aforementioned rotating duct-cleaning body 51 is installed in the front part of the travelling portion 3 (the travelling truck 21), and is ratted with the electric motor 43 via a belted speed changer 61 (whose speed change ratio is determined by the ratio of the diameter of a belt pulley 80 to that of a belt pulley 81) while being supplied with the compressed air from the compressor 11 through the air pipe 14.

The compressed air is ejected from the compressed air ejection throughhole 52 toward a cylindrical part of the inside surface of the duct 1 with an appropriate ejection angle, wherein said cylindrical part is to be shifted successively in the progressive direction 64 of the travelling truck 3. The aforementioned rotating duct-cleaning body 51 can be rotated continuously covering an angle of 360 degrees, so it enables the compressed air to be blown successively and evenly against the whole circumference of the inside surface of the duct 1.

The detailed plan view of said rotating duct-cleaning means 50 is as shown in Fig.5 and Fig.6.

Besides, the rotating duct-cleaning body 51 may be made to rotate reciprocatively within the range of an angle of 180 degrees covering the lower half part inside the duct.

For that purpose, the motor 43 itself may be made to rotate reciprocatively, or a part of the rotating duct-cleaning body rotating system 34 may be equipped with a mechanism which can interchange 360 degrees' rotating motion with 180 degrees' reciprocative rotating motion. As a result of such as the above, the lower half part inside the duct where trash and dust are liable to accumulate, except the ceiling part where no dust and the like are liable to accumulate, can be efficiently and swiftly cleaned out.

The aforementioned straight-ejective nozzle 24 is installed separately from the aforementioned rotating duct-cleaning means 50, can be made, at need, to eject the compressed air concentratedly toward a specific area inside the duct 1, and constructed such that the direction of a straight-ejective nozzle tip part 62 can be changed manually or automatically by the operation at the monitor/remote-control portion 4 (the drawing in these embodiments illustrate the case of manual operation).

Besides, the compressed air ejection angle of the tip

part 62 is made to be so small that the compressed air is enabled to be blown concentratedly against a narrow area 65 inside the duct 1.

The aforementioned travelling truck 21 is equipped with guide rollers 66, 67, 68 and 69. Said guide rollers 66, 67, 68 and 69 are provided with roller outer rings as shown by

70 made of, e.g., rubber and supported on vertical axes as shown by 71 at the four corners of the travelling truck 21 so as to be rotatable freely, with said roller outer rings being made to project out of the outer frame of the travelling truck 21. Accordingly, as shown in Fig.4, in case that the travelling truck 21 approaches, e.g., a vertical wall surface 74 inside the duct 1, i.e., the right-hand wall surface facing the progressive direction 64 (of the travelling truck 21), the outer ring of said guide rollers 66 and 68 become brought into contact with said vertical wall surface 74 at the points 72 and 73, roll and move on said wall surface 74, guide the progressive direction 64 of the travelling truck 21 running inside the duct 1, and thus enable the travelling truck 21 to advance inside the duct smoothly. In case that the duct 1 is curved as shown in Fig. 4, the function of the guide rollers as stated above becomes particularly effective.

The in-duct cleaning apparatus of the present

invention consists of the aforementioned structure, bring about the aforementioned operational effects, and consequently yields overall effects as follows.

Firstly, said in-duct cleaning apparatus is equipped with the traveling means, the rotating duct-cleaning means, the monitor video camera, the air compressor, the monitored image display means, and the control means, can hit the duct inside surface by the whip, and can eject compressed air toward the duct inside surface by the compressed air ejection throughholes, and further can sweep the duct inside surface by brush bristles, as a result, said apparatus can successively remove foreign substances and the like attached to said duct inside surface the while traveling means travels.

Secondly, said in-duct cleaning apparatus, in addition to the above first effect, by making the opening of compressed air ejection throughholes direct obliquely forward with respect to the forward traveling direction of the traveling means, can blow the compressed air against the circumference of duct inside surface, as a result, said apparatus can clean out trash and dust evenly throughout the whole circumference of duct inside surface.

Thirdly, said in-duct cleaning apparatus, in addition to the above first effect, by making the brush bristles be provided on the circumference of rotatable duct-cleaning

means in the form of plurality of radially spaced bundle having fixed intervals, can successively sweep the circumference of duct inside surface, as a result, said apparatus can clean out trash and dust evenly throughout the whole circumference of duct inside surface.

Fourthly, said in-duct cleaning apparatus, in addition to the above first effect, by making the whip consist of the flexible tube that connects with front portion of the rotating duct-cleaning means and is waved by compressed air therethrough, can hit the surface part inside the duct at short and random interval while the compressed air is supplied through the flexible tube, as a result, said apparatus can remove foreign substances and the like attached to said duct inside surface smoothly.

Fifthly, said in-duct cleaning apparatus, in addition to the above first effect, by being equipped with the straight-ejective nozzle which can eject the compressed air cocentratedly toward the narrow area of duct inside surface in front of the travelling meaning, can clean predominantly and powerfully said narrow area of the duct inside surface at need, and thus can remove particular foreign substances and like clinging to said narrow area.

Sixthly, said in-duct cleaning apparatus, in addition to the above first effect, by being equipped with the guide rollers for making the travelling means to travel precisely

along the interior of duct, can not only make the travelling means advance smoothly inside the duct without incurring any stagnation even at the duct curvatures but also make the truck driving motor entirely free from being excessively overloaded with direct contact between the truck side surface and the duct inside wall surface, and can thereby bring about the effect that the failure of said apparatus will be made to be minimized.

It can be summarized that the in-duct cleaning apparatus of the present invention can perform cleaning inside a duct too narrow for a man to enter; can perform, taking the place of a man and more skillfully than a man, a dirty, dangerous and severe work inside a duct even if the duct allow a man to enter; can serve to improve and to perform labour saving of said dirty, dangerous and severe job site; and can, through in-duct cleaning, contribute to the improvement of environmental sanitation.

CLAIMS

1. An in-duct cleaning apparatus for cleaning duct inside surfaces, said apparatus comprising;

a traveling means traveling forwardly and backwardly in an interior of the duct to be cleaned;

a rotating duct-cleaning means secured to a forward end of forwardly extending rotatable shaft provided on said traveling means, said duct-cleaning means comprising in combination compressed air ejection throughholes that pass therethrough, brush bristles that extend radially therefrom and a whip that is detachable therefrom ;

a monitor video camera for monitoring the state of cleaning of the interior of said duct, said video camera being carried by said travelling means;

an air compressor for supplying compressed air to said compressed-air ejection throughhole ;

a monitored image display means for displaying an image taken by said monitor video camera, and

a control means for controlling the travelling of said travelling means and the rotating of said rotating duct-cleaning means in accordance with an image displayed on said monitored image display means.

2. An in-duct cleaning apparatus as defined in claim 1



, wherein said compressed-air ejection thoughholes have their openings directed obliquely forward with respect to the forward traveling direction of said traveling means.

3. An in-duct cleaning apparatus as defined in Claim 1, wherein said brush bristles are provided on a circumference of said rotating duct-cleaning means in the form of plurality of radially spaced bundle having fixed intervals.

4. An in-duct cleaning apparatus as defined in Claim 1, wherein said whip consists of a flexible tube that connects with front portion of said rotating duct-cleaning means and is waved by compressed air threrethough.

5. An in-duct cleaning apparatus as defined in Claim 1, wherein said apparatus is equipped with a straight-ejective nozzle that ejects compressed air concentratedly toward the narrow area of duct inside surface in front of the travelling mean.

6. An in-duct cleaning apparatus as defined in Claim 1, wherein said travelling means is equipped with guide rollers for making said travelling means to travel precisely along the interior of said duct

