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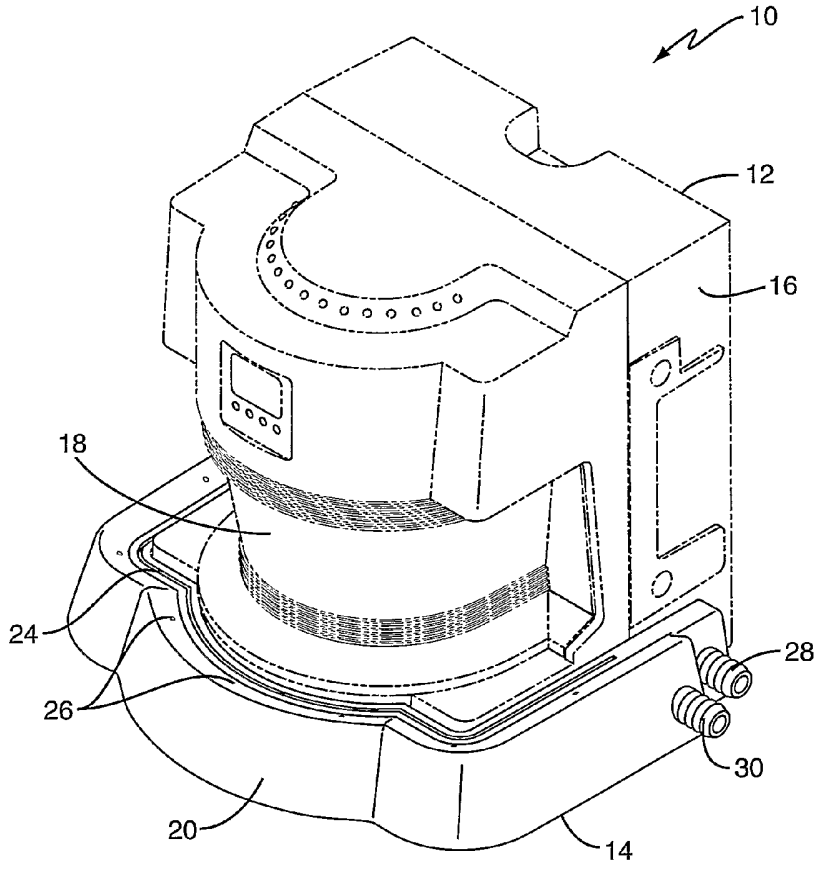

(57) Abstract: An air guard directs air toward a viewing window of an optoelectronic presence sensing device to reduce surface contamination thereon. The air guard may include a control valve, and possibly control circuits, to enable selective activation of the air guard. In one embodiment, the air guard includes one or more slits configured to vent pressurized air in a generally laminar (curtain like) flow in front of the window to prevent the deposition of airborne contaminants thereon. Alternatively, or additionally, the air guard may include one or more nozzles configured to vent pressurized air in directed air streams toward the window to remove surface contaminants thereon, and may include a control valve enabling selective operation in preventive, cleaning, or standby modes. Mode control may be effected by an external control system, by the presence sensing device, or by the air guard itself, which may include a timer or other control circuit.

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APPARATUS AND METHOD FOR LASER SCANNER CLEANING AND PROTECTION

BACKGROUND OF THE INVENTION

The present invention generally relates to optoelectronic presence sensing devices, and particularly relates to the use of forced air systems to facilitate the maintenance and operation of such devices.

Optoelectronic presence sensing devices find wide use in a variety of industrial applications. For example, one prevalent use arises in the context of "machine guarding," wherein the object detection functionality of such presence sensing systems provides a triggering mechanism for shutting down hazardous machines before personnel get too close. Because of the safety-critical nature of this type of application, the installation, testing, and ongoing maintenance of such presence sensing systems represent vital functions.

Other critical uses of such presence sensing systems include vehicle navigation and/or collision avoidance systems. For example, a shop floor forklift or other utility vehicle may be configured with one or more optical presence sensing systems that aid its operator in avoiding hazards or, in more sophisticated embodiments, provide for limited or full autonomous vehicle movement.

Regardless of their particular uses, optoelectronic presence sensing systems characteristically use some type of optical emitter, a corresponding optical receiver, and supporting power and control electronics. Optical energy emitted from a presence sensing device is directed into or through a field of view and objects within that field of view are detected based upon sensing return reflections from them. Object distance can be calculated by timing the round trip time of the outgoing and reflected light signals, and that distance can be compared to one or more pre-programmed thresholds to determine whether the encroachment merits a safety response.

Understandably, the operation of such devices can be compromised by the buildup of dust or other contamination on any device surfaces through which outgoing or reflected optical signals must pass. For example, a given device typically uses one or more optically transparent "viewing" windows through which its optical signals are passed and any contamination of these windows can reduce device sensitivity and/or trigger the detection of a device fault.

Device faults can be costly because one or more production machines typically are tied in with a given presence sensing system, and these machines typically are automatically taken offline for the duration of any presence sensing fault condition. As such, the buildup of contamination on the viewing windows of optoelectronic presence sensing devices raises a number of safety and efficiency issues in the typical manufacturing environment.

SUMMARY OF THE INVENTION

The present invention comprises a method and apparatus to reduce the surface contamination of a viewing window of an optoelectronic presence sensing device, such as the "scanning" window of a laser scanner as might be used in hazardous machine guarding applications or in object avoidance system applications. More particular, the present invention uses an air guard that is supplied with a source of pressurized air to vent air toward the viewing window to reduce the surface contamination thereof. The air guard may be configured such that it blows air across or in front of the window such that airborne contaminates generally are prevented from settling on the window. Additionally, or alternatively, the air guard may be configured such that it blows more focused and/or higher velocity air streams toward the viewing window toward the window surface to remove contaminants from the window's exterior surface. More generally, the air guard can be configured to direct air toward or across the window's surface in modulated (time varying) patterns and amplitudes as needed or desired.

Thus, according to an exemplary embodiment, an air guard for reducing surface contamination of a viewing window of an optoelectronic presence sensing device comprises a body section generally conforming to a contour of the viewing window, a first chamber formed within the body section and configured to receive pressurized air from an external source, and one or more first outlets in the body section configured to vent the pressurized air from the first chamber toward the viewing window to reduce surface contamination thereof. The body section may be integrated with the device housing of the presence sensing device, or may be affixed thereto, either permanently or removably. Indeed, air guards may be built as optional add-ons for particular models of presence sensing devices, or may be built into such devices.

In another exemplary embodiment, the present invention comprises an air guard for reducing surface contamination of a viewing window of an optoelectronic presence sensing device. The air guard comprises a body section generally conforming to a contour of the viewing window, first and second chambers formed within the body section, each configured to receive pressurized air from an external source, one or more slits formed in the body section and configured to vent pressurized air from the first chamber in a curtain like flow in front of the viewing window, and one or more nozzles formed in the body section and configured to vent pressurized air from the second chamber in one or more generally focused air streams directed toward the viewing window.

This exemplary air guard can be configured selectively to operate in a preventive mode wherein it vents air from the slits to create a curtain like air flow in front of the window, or in a cleaning mode wherein it vents air from the nozzles to create directed air flows that clean the window surface. The air guard may include or be associated with one or more control valves that provide operating mode control, and which may be configured to include the option of selectively blocking pressurized air from the air guard so that it can be operated in a standby mode. Mode control may be effected according to a timed schedule and/or may be controlled

by the presence sensing device, an external controller, or by a control circuit included in the air guard itself.

With these control aspects in mind, then, an exemplary embodiment of an air guard according to the present invention may comprise an air guard body section with one or more chambers and corresponding vents or outlets, and a control circuit configured to enable selective pressurization of the one or more vented chambers to effect a desired air flow pattern with respect to an optical window of the optoelectronic presence sensing device. The control circuit may be implemented in whole or in part within the air guard enclosure or implemented in whole or in part externally, such as in the optoelectronic presence sensing device or in a control system remote from the air guard. The particular implementation of the control circuit, which may include a microprocessor, Field Programmable Gate Array (FPGA), Application Specific Integrated Circuit (ASIC), Complex Programmable Logic Device (CPLD), or other such processing circuit, depends to some extent on the number and configuration of air chambers and control valves involved, and on the sophistication of any time-varying air flow control algorithms implemented.

Regardless, an exemplary optoelectronic presence sensing system comprises an optoelectronic presence sensing unit configured to detect objects by emitting optical signals through a viewing window and detecting return reflection signals therefrom, and an air guard unit configured to direct air generally toward the viewing window of the optoelectronic presence sensing unit to reduce exterior surface contamination thereof. The air guard may be configured according to the previously mentioned exemplary details, and may be integrated with a housing of the optoelectronic presence sensing unit, or affixed thereto.

Independent of any particular physical embodiments, the present invention further comprises a method of maintaining a viewing window of an optoelectronic presence sensing device with respect to window contamination. In an exemplary embodiment, that method comprises providing an air guard proximate to the viewing window of the presence sensing device, supplying the air guard with pressurized air, and selectively operating the air guard in a preventive mode wherein it vents the pressurized air in a generally laminar flow in front of the viewing window to prevent airborne contaminants from settling thereon, or in a cleaning mode wherein it vents the pressurized air in one or more directed air streams toward the viewing window to remove deposited surface contaminants thereon. Again, such operation may be controlled by the presence sensing device, by the air guard itself, or by an external controller.

Of course, the present invention is not limited to the above features and advantages. Those skilled in the art will recognize additional features and advantages of the present invention upon reading the following detailed description and upon viewing the accompanying figures, in which like elements are assigned like reference numbers.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram of an exemplary optoelectronic presence sensing system in accordance with one or more embodiments of the present invention.

Fig. 2 is a partial cut-away side view of the system of Fig. 1.

Fig. 3 is a perspective view of the air guard included in the system of Fig. 1.

Fig. 4 is a plan view of the air guard of Fig. 3.

Figs. 5-8 are selected cut-away views of the air guard of Fig. 3.

Fig. 9 is a perspective view of an exemplary alternative air guard.

Fig. 10 is a diagram of exemplary control and detection circuits optionally included in the presence sensing device of Fig. 1 for controlling air guard operating modes.

Fig. 11is a diagram of exemplary processing logic for operating an air guard according to a timed schedule.

Fig. 12 is a diagram of another exemplary air guard embodiment.

Fig. 13 is a diagram of exemplary processing logic for operating an air guard responsive to sensing contamination of a viewing window in a presence sensing device.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 is a diagram of an exemplary optoelectronic presence sensing system 10 that is configured according to one or more embodiments of the present invention. In the illustrated embodiment, system 10 comprises an optoelectronic presence sensing unit or device 12 and an associated air guard unit 14 that is integrated with or affixed to a housing 16 of the presence sensing device 12.

In operation, the air guard 14 prevents the deposition of airborne contaminants (dust, oil, etc.) on an exterior surface of a viewing window 18 of the presence sensing device 12 by creating a laminar air flow in front of window 18 and/or cleans the exterior of window 18 by directing one or more streams of air at the window 18. By preventing contamination of window 18 and/or by at least partially removing surface contaminants from window 18, air guard 14 improves the operation of presence sensing device 10. That is, use of air guard 18 can reduce the frequency at which maintenance personal must clean window 18 and makes viable the use of presence sensing device 12 even in areas with substantial amounts of dust and/or mist.

With respect to such use, one typical application of presence sensing device 12 is as a "guarding" mechanism in and around hazardous machinery. In that role, presence sensing device 12 may be configured to remove power from a hazardous machine, or otherwise stop its hazardous moving parts, in response to detecting the encroachment of an object, e.g., a person, into a designated zone of danger. To that end, the typical presence sensing device uses some type of optoelectronic transmitter/detector arrangement that transmits optical signals outward through the viewing window 18. Objects within a defined detection range of the

device 12 return reflected optical signals, which are received through the viewing window 18, and detected by the appropriate circuitry within device 12.

Such circuitry may include calculation units that translate detection signal transit times and angles into relative distances and directions, thus enabling the device 12 to determine whether any detected objects are within the zone of danger. Of course, device 12 may be used in other applications, such as in object detection and avoidance applications that, for example, include the use of presence sensing systems on factory floor vehicles to facilitate vehicle movement in potentially crowded industrial settings. Additional exemplary but non-limiting details for presence sensing device 12 may be found in U.S. Application Serial No. 09/934352, filed on 21 Aug. 2001 and entitled "Presence Sensing System and Method." That application is co-pending and commonly assigned with the instant application, and is incorporated herein by reference in its entirety.

However, it should be understood that exemplary details regarding the optoelectronics implemented in device 12 are not limiting with respect to the present invention. Thus, as used herein, the term "optoelectronic presence sensing device" encompasses diffuse sensing systems, such as those based Charge-Coupled Detectors (CCDs), and scanning systems, such as those using rotating mirror-based laser scanner assemblies.

In any case, turning to the exemplary details as illustrated in Fig. 1, one sees that the air guard 14 comprises a body section 18 that is integrated with, or is affixed to the housing 16 of sensing device 12, either permanently or removably. Body section 20 is configured generally to follow the contours of housing 16 and, preferably, particularly is configured to follow the contours of the viewing window 18. Thus, one sees that body section 20 includes one or more slits 24 on its top surface that generally following along at least a portion of the lower perimeter of window 18, and further includes one or more nozzles 26, which may be configured at spaced apart intervals along that same perimeter.

In operation, pressurized air is supplied to the air guard 14 from an external source (not illustrated), which may be provided to air guard 14 through air supply hoses coupled to one or more air inlet ports—two such inlet ports, ports 28 and 30, are illustrated. Note that ports 28 and 30 may include body ferrules for more secure coupling of the air supply lines.

As is seen in the partial cut-away view of Fig. 2, air guard 14 is at least partially hollow inside, and thus has an interior cavity forming one or more chambers—a first chamber 32 and a second chamber 34 are illustrated. Inlet port 28 is in fluid communication with interior chamber 32, and inlet port 30 is in fluid communication with interior chamber 34. The one or more slits 24 vent chamber 32 to the outside, while the one or more nozzles 26 vent chamber 32 to the outside.

When pressurized air is supplied to chamber 32 via inlet port 28, that pressurized air is vented through the one or more slits 24, which are configured to create a generally laminar flow in front of viewing window 18—illustrated as the roughly vertical air currents in the drawing.

That laminar vertical flow in front of window 18 acts like an "air curtain" that at least partially prevents airborne contaminants from settling onto the exterior surface of window 18. Thus, the air guard 14 may be understood as operating in a "prevent" mode when it is venting pressurized air from the one or more slits 24, in that the curtain-like air flow created in front of window 18 prevents at least some contaminants from settling onto the exterior surface of the window. Note that, preferably, the one or more slits 24 comprise one or more long slits generally running the length of the viewing window's bottom edge, or at least spanning the perimeter length of the viewing window 18 that corresponds to the field of view being monitored by device 12.

When pressurized air is supplied to chamber 34 via inlet port 30, that pressurized air is vented through the one or more nozzles 26, which may be configured as a plurality of spaced apart holes generally arrayed along the bottom perimeter of window 18. As seen in Fig. 2, venting pressurized air from the nozzles 26 creates relatively focused air streams directed toward the window's surface. By properly sizing the nozzles, relatively high velocity directed air streams—as compared to the laminar flow from slits 24—can be created via nozzles 26, and those streams of air can thus be used to blow at least some contaminants off of the window's exterior surface. Thus, air guard 14 may be understood as operating in a "cleaning" mode when it is venting air from the nozzles 26, in that the resulting directed air streams blow onto the face of window 18 and dislodge at least some of the contaminants deposited thereon. Additionally, or alternatively, the air guard may be configured such that it blows more focused, higher velocity air streams or air patterns, modulated or varying patterns, and/or modulated or varying velocities, toward the window surface to remove contaminants from the window's exterior surface.

Preferably, the nozzles are configured such that there is some overlap between the directed air streams emitted therefrom, to ensure that a contiguous cleaning pattern is formed by the combination of air streams. That is, the nozzles preferably are arranged to prevent gaps between the areas cleaned by each particular nozzle 26. As with the one or more slits 24, the number and positioning of nozzles 26 may be set up to span the bottom edge of window 18, or at least to span the length of window 18 corresponding to the desired field of view for device 12.

While the above configuration illustrates an exemplary air guard body system defining two chambers 32 and 34, with corresponding air inlets 28 and 30, it should be understood that air guard 14 may be implemented with one chamber, two chambers, or more than two chambers, and that each chamber can be vented through differently positioned and/or differently configured outlets, such that variable air flow patterns and velocities can be achieved by pressurizing different ones of the chambers individually or in desired combinations. Each chamber can be configured with its own inlet, in which case control valves can be omitted if desired, and wherein supplying air through the appropriate air hose pressurizes the corresponding chamber. However, whether each chamber has its own air inlet, or two or more chambers share an air inlet, the use of control valves within the air guard 14 still may be

desirable as it allows the hose or hoses to remain pressurized while air is shut off from the chambers.

In any case, Fig. 3 offers a perspective view of an exemplary configuration of air guard 14, wherein it is configured as separate element that may be attached to housing 16 of device 12 (see Fig. 2), either removably or permanently. For example, the body section 20 of air guard 14 and the corresponding mounting area of housing 16 of device 12 can be configured with complementary mating features, e.g., a snap-on mechanism, that permits easy attachment of the air guard 14 to the device 12. Of course, other fastening arrangements can be used, such as adhesives, screw fastenrs, etc. Also, as noted above, housing 16 of device 12 may be formed such that it includes air guard 14 as an integral part of its structure. Those skilled in the art should appreciate that all such configurations are contemplated herein, and fall within the scope of the present invention.

Fig. 4 offers a plan view of an exemplary air guard 14 with the identification of selected cross-sections of interest, including cross section 5-5 shown in Fig. 5, cross section 6-6 shown in Fig. 6, cross section 7-7 shown in Fig. 7, and cross section 8-8 shown in Fig. 8. Starting with Fig. 5, one sees a cross section of the air guard's body section 20, illustrating the positioning of a control valve 36, e.g., solenoid, within inlet port 28 that may be used to pass or block pressurized air into chamber 32 from an air supply line attached to the inlet port 28. Use of control valve 36 allows the air flow from slits 24 to be turned off and on as desired.

Thus, during times when the preventive air flow across window 18 is not needed, control valve 36 may be closed to block pressurized air from flowing into chamber 32. Similarly, cross section 6-6 shown in Fig. 6 illustrates the use of another control valve 38 that provides the same on/off flow functionality for chamber 34. Thus, the air flow from the nozzles 26 also can be turned on and off as needed or desired.

Continuing with a discussion of the cross section views, Figs. 7 and 8 depict cross sections 7-7 and 8-8, respectively. In particular, Fig. 7 depicts exemplary details for a slit portion of chamber 32, and illustrate that slit(s) 24 are configured to vent pressurized air from chamber 32 to the outside as described above. Similarly, Fig. 8 depicts exemplary details for one of the nozzles 26, and illustrates that each nozzle 26 vents pressurized air from chamber 34 to the outside as described above.

In considering the above details, it should be understood that the control valves 36 and 38 can be omitted if flow control is not needed or desired. Further, in at least one embodiment, the control valves 36 and 38 may be configured such that chambers 32 and 34 are operated in mutually exclusive fashion. Thus, if the air flow into chamber 32 is on, then the air flow into chamber 34 is off, and vice versa. With that configuration, the air guard 14 operates in either the prevent mode (i.e., the air curtain mode), or in the cleaning mode (i.e., the contaminant blow-off mode), responsive to one or more valve control signals.

Further, as shown in Fig. 9, air guard 14 may be configured to include a single inlet port 40, that is operatively associated with a control valve 42, e.g., a solenoid, that is configured to provide selective air flow into chambers 32 and 34 in response to actuation by a control circuit 44. In one embodiment, control circuit 44 may comprise no more than an electrical interface to solenoid 42, and thus provide coupling between control valve 42 and control signals applied to an input terminal 46.

In such an embodiment, a cable 48 may be connected to the input terminal 46 of air guard 14, such that an external controller (not shown) and/or device 12, may provide one or more valve control signals to air guard 14 to control air flow into one or both chambers 32 and 34 as needed or desired. In an exemplary embodiment, input terminal 46 may include power, ground, and control connections, but such details are implementation specific and can be varied as needed.

If an external controller is used to control air guard 14, it may be convenient to configure terminal 46 for easy field access. However, it should be understood that terminal 46 still may be recessed and/or covered for reliability reasons and for the option of operating in a wet or damp environment. Further, if device 12 is used to control operation of air guard 14, then any electrical interconnections between air guard 14 and device 12 may be made through one or more internal wiring connections, such that external wiring connections are not required. Such an arrangement may be particularly convenient where air guard 14 is formed integrally with housing 16 of device 12. Even if air guard 14 is not integrally formed with housing 16, the inside face of body section 20 of air guard 14, and a corresponding mating surface of housing 16, each may be configured with complementary electrical mating connectors, such that mounting or fastening air guard 14 to housing 16 provides for any desired signal interconnection between the two items.

In general, the number of signal interconnections implemented can be varied according to the configuration of the air guard. For example, in one or more of the above embodiments, air guard 14 included two air chambers 32 and 34, with one used for blowing an air curtain to reduce dust accumulation on the window, and one used for blowing more focused, cleaning air streams toward the window. Air guard 14 can provide separate signal control inputs to actuate these different modes and, extending that concept further, it should be understood that air guard 14 can include multiple chambers, possibly with each chamber having a different arrangement or configuration of air outlets. In such configurations, then, air guard 14 can be configured with additional signal lines, or possibly with an intelligent control interface (e.g., a command/data bus interface) that permits external actuation of the different chamber/nozzle combinations to effect a desired, possibly time-varying, air flow pattern for cleaning and/or guarding the window.

Regardless of such details, Fig. 10 illustrates exemplary control and detection circuits 50 and 52 that may be implemented in device 12 for exemplary control of air guard 14. Circuit(s) 52 are configured for detecting contamination of window 18. By way of non-limiting

example, circuits 52 may comprise one or more optical emitters and receivers configured to detect the contamination condition of window 18 as a function of its transmissivity. In any case, circuits 52 provide a valve control circuit 50 with a signal, analog or digital, from which valve control circuit 50 can determine the contamination condition of window 18 either as a continuous function or in terms of discrete levels of contamination.

In either case, control circuit 50 may be configured to assert one or more valve control signals for controlling air flow from air guard 14 as a function of window contamination. In an exemplary embodiment, control circuit 50 is configured to switch air guard 14 from a standby mode (no air flow), or from the prevention mode (air flow from slits 24), to a cleaning mode (air flow from nozzles 26), in response to detecting a given level of window contamination. Thus, the cleaning operation of nozzles 26 could be temporarily enabled responsive to sensing a buildup of contamination on window 18. In a similar variation of this embodiment, the control circuit 44 of air guard 14 can be configured to have at least limited control decision logic and thus can be configured to provide selective activation responsive to receiving dust detection information from device 12, or from an external controller that has access to data or signals from device 12.

It should be understood that the term "control circuit" as used in the above paragraphs in the context of device 12 and/or air guard 14 broadly connotes hardware, software, or some combination thereof. Thus, it should be understood that control circuit 44 of air guard 14 and/or control circuit 50 of device 12, each may be implemented using discrete logic circuits, integrated logic circuits, or other hardware circuits, or may be implemented functionally based on stored program instructions as executed by one or more microprocessors or other digital processing circuits. Such details are implementation dependent, based on cost considerations and the desired level of control functionality, and thus should not be considered as limiting the present invention.

Indeed, as shown in an exemplary embodiment of the present invention illustrated in Fig. 12, an air guard broadly comprises an air guard body section 20 comprising one or more vented chambers 60 (e.g., 60-1....60-N), and a control circuit 62 configured to enable selective pressurization of the one or more vented chambers 60 to effect a desired air flow pattern with respect to an optical window of the optoelectronic presence sensing device. Note that control circuit 60 may interface with air supply controls through one or more interface circuits 64, and further note that the supply controls, e.g., valves, may be included in body section 20 of air guard 14, or may be implemented external to air guard 14. Similarly, those skilled in the art should recognize that control circuit 60 can be implemented in whole or in part within the air guard body section 20, in whole or in part within the optoelectronic presence sensing device 12, or in whole or in part within a remote system, such as factory floor control system that is configured to manage or otherwise control air flow to the air guard 14.

As a further illustration of the range of control methods contemplated by the present invention, Fig. 13 illustrates operation of the air guard 14 according to one or more timed schedules. Such logic may be implemented in controller 44 of air guard 14, which may comprise a timer circuit, in controller 50 of device 12, which also may include a timer circuit, or may be implemented based on the timing operations of an external controller that provides one or more control signals to air guard 14. Of course, in keeping with the illustration of Fig. 12, timing control can be implemented in control circuit 60, which may be embodied in control circuit 44 of air guard 14, controller 50 of device 12, another external system, or in any combination thereof.

In any case, exemplary processing begins with default operation in the prevention mode (air flow from slit(s) 24 enabled) (Step 100). Of course, standby (no air flow) could be the default starting mode. In any case, a timer, denoted as TIMER1, is initialized to time the interval at which it is desired to temporarily switch air guard 14 from operating in the prevention mode, to operating in the cleaning mode (air flow from nozzles 26) (Step 102).

Control logic then checks for expiration of TIMER1 (Step 104). Upon such expiration, control logic actuates one or more control valves in air guard 14—alternatively, the control valves can be located in or associated with the air supply lines feeding air guard 14 for convenient external control—to switch air flow from slits 24 to nozzles 26 (Step 106). That is, upon expiration of TIMER1, air guard 14 temporarily is switched from prevention mode to cleaning mode and a second timer, denoted as TIMER2, is initialized/started (Step 108).

The cleaning mode of operation is maintained until expiration of TIMER2 (Step 110), at which point operation reverts back to the prevention mode (Step 112). That is, TIMER1 may be reinitialized/re-started and the above operations repeated. Of course, standby periods where no air flows from air guard 14 may be incorporated into the above logic as needed or as desired, and, as noted earlier herein, air guard 14 may be operated non-modally, such that air flows continuously from slits 24 and nozzles 26 so long as pressurized air is supplied.

Rather than the above timed operation, Fig. 12 illustrates the earlier described method of operating air guard 14 responsive to detecting window contamination. In this embodiment, the air guard 14 may be operated by default in standby mode, prevention mode, or some combination thereof. Then, in response to detecting a given level of window contamination (Step 114), generically referred to as "dust" in the illustration, air guard 14 temporarily is switched into its cleaning mode of operation (Step 116). That mode of operation may be continued based on contamination sensing feedback from detection circuits 52 and/or may be based on a timed interval.

In any case, once cleaning mode operation ends or times out (Step 118) operation reverts back prevention and/or standby mode operation (Step 120), and the process repeats responsive to detecting and subsequent build-up of window contamination. Note that the detection-based processing of Fig. 12 can be modified to adaptively set a timing based

approach to air guard operation. That is, the intervals air guard 14 is operated in standby mode, prevention mode, and cleaning mode, may be individually or collectively changed responsive to detecting how quickly or how frequently contamination buildup on window 18.

Thus, in relatively clean environments, system 10 could save pressurized air resources by remaining in standby mode for longer periods. Conversely, in relatively dirty environments, system 10 may run in prevent mode more or less continuously, with frequent cleaning mode switchovers. Of course, system 10 can be configured so that such timer settings are manually settable, so that installation personal can "tune" the operation of system 10 for the needs of a particular installation location.

Further, it should be understood that control circuit 44 of air guard 14 and/or control circuit 50 of device 12 can be configured to implement guarding/cleaning modes of essentially any desired degree of sophistication, particularly when air guard 14 is implemented with multiple chambers/nozzles that provide a number of different cleaning and/or guarding patterns, or with nozzle/outlet configurations that enable time-varying flow types and directions. Thus, it should be understood that control circuits 44 or 50 can be configured with various timing algorithms, time-varying air flow pattern algorithms, and time-varying air flow amplitudes, as needed or desired.

Along these lines, the present invention also contemplates the use of a controllable air source, such that flow rate and/or pressure can be varied to effect different modes of air guard operation. For example, a low flow rate can be used for general contamination protection, and a high flow rate can be periodically provided for brief cleaning intervals.

In general, then, air guard 14 can be configured with one or more chambers that vent through multiple outlets (nozzles) that provide multiple cleaning "channels" at multiple angles with respect to the device window. With the ability to direct different streams at different angles, air guard 14 may be operated according to sophisticated cleaning algorithms that vary the time, direction, and/or intensity of cleaning air directed toward the device window.

From the variations described immediately above, and from the various embodiments described throughout this document, those skilled in the art should appreciate that the present invention contemplates a variety of physical and functional embodiments for system 10. As noted, air guard 14 may be separate from device 12, and may be permanently or removably attachable thereto, or may be integrated into the housing 16 of device 12. It may, by way of non-limiting examples, be operated in a continuous air flow mode, or may be operated in one or more of standby, prevention, and cleaning modes. Such variations may be based on timed schedules and/or based on sensing contamination.

Additionally, it should be understood that air guard 14 can be configured for use with a variety of optoelectronic presence sensing devices. While the illustrated device 12 is, by way of non-limiting example, configured as a laser scanner, device 12 may comprise another type of device. For example, device 12 may comprise a "light curtain," which in an exemplary

embodiment comprises one or more linear transmitter segments ("sticks") and one or more corresponding receiver segments. The transmitter segments generally include an optical face through which an array of optical transmitters transmit individual beams, and the corresponding receiver segments generally include an optical face through which an array of optical receivers detect the beams from respective ones in the transmitter array.

Air guard 14 could be configured for attachment to light curtain segments such that guarding/cleaning air is directed across the optical faces of such segments. Also, if desired, the light curtain control electronics can be used to control or otherwise trigger operation of the air guard 14 in such configurations.

Finally, it should be understood that air guard 14 can be configured to include its own control/timing logic, e.g., control circuit 44, such that it operates wholly, or at least partly, autonomously with respect to alternating between preventive modes and cleaning modes, and with respect to varying the cleaning patterns and flow velocities as needed or desired. Alternatively, air guard 14 may be simplified in favor of implementing control logic for its operation in external logic. If the control logic is implemented apart from air guard 14, its signal interface can be configured to provide for externally controlled actuation of its various chambers and nozzles in desired combinations.

Such external logic may be implemented in the device to which air guard 14 is attached, which may be a particularly suitable arrangement where that device triggers air guard cleaning operations responsive to detecting contamination of its viewing window. However, it should be understood that such logic can be implemented remotely, such as in a remote controller of a factory floor control system. To that end, air guard 14 may be configured with a direct control interface (e.g., discrete signal lines, dry contacts, signaling current loops, or other suitably robust signal interface), or with an intelligent bus or network interface (e.g., CAN Bus, Safety Bus, IIC Bus, RS-422, etc.) through which air guard mode control signals or commands are sent. In such embodiments, the earlier illustrated air guard control circuit 44 can be configured with the appropriate bus interface/isolation circuits and bus control/command logic as needed.

Thus, it should be understood that the present invention is not limited by the foregoing description or by the accompanying drawings. Instead, the present invention is limited only by the following claims, and the reasonable equivalents thereof.

CLAIMS

What is claimed is:

1. An air guard for reducing surface contamination of a viewing window of an optoelectronic presence sensing device, the air guard comprising:

a body section generally conforming to a contour of the viewing window;

a first chamber formed within the body section and configured to receive pressurized air from an external source; and

one or more first outlets in the body section configured to vent the pressurized air from the first chamber toward the viewing window to reduce surface contamination thereof.

2. The air guard of claim 1, wherein the body section is integrated with a device housing of the optoelectronic presence sensing device.

3. The air guard of claim 1, wherein the body section is affixed to a device housing of the optoelectronic presence sensing device.

4. The air guard of claim 1, wherein the one or more first outlets comprise one or more slits in the body section configured to direct a relatively low velocity air curtain in front of at least a portion of the viewing window.

5. The air guard of claim 4, wherein the one or more slits in the body section generally follow the contour of the viewing window.

6. The air guard of claim 1, wherein the one or more first outlets comprise one or more spaced apart nozzles, each configured to direct a relatively high velocity air stream toward a region of the viewing window.

7. The air guard of claim 1, wherein the body section includes a first inlet port in fluid communication with the first chamber, said first inlet port configured for coupling with a pressurized air line from the external supply.

8. The air guard of claim 1, further comprising a control valve disposed within the body section and configured selectively to block the flow of pressurized air into the first chamber.

9. The air guard of claim 1, further comprising a second chamber formed within the body section and configured to receive pressurized air from an external source, and one or more second outlets in the body section configured to vent the pressurized air from the second chamber toward the viewing window to reduce surface contamination thereof.

10. The air guard of claim 9, wherein the one or more first outlets are configured as one of slits or nozzles, and wherein the one or more second outlets are configured as the other one of slits or nozzles.

11. The air guard of claim 9, further comprising a first inlet port configured to receive pressurized air for the first chamber, and a second inlet port configured to receive pressurized air for the second chamber.

12. The air guard of claim 11, further comprising one or more control valves configured selectively to block the flow of pressurized air into one or both the first and second chambers.

13. The air guard of claim 1, wherein the first chamber comprises one of multiple chambers, and wherein the multiple chambers are configured such that they enable the air guard to produce different directed combinations of air flow patterns with respect to the viewing window.

14. The air guard of claim 13, wherein the air guard includes one or more solenoids configured to selectively pressurize individual ones of the multiple chambers in desired combinations to achieve the different directed combinations of air flow patterns.

15. The air guard of claim 1, further comprising a control circuit configured to control operation of the air guard.

16. The air guard of claim 15, wherein the control circuit is configured to control operation of the air guard by controlling the flow of pressurized air into the first chamber based on turning a control valve on and off.

17. The air guard of claim 15, wherein the first chamber is one of two or more chambers, and wherein pressurization of different chambers effects different air flow characteristics, and wherein the control circuit is configured to select different chambers according to a timed schedule.

18. An air guard for reducing surface contamination of a viewing window of an optoelectronic presence sensing device, the air guard comprising:

a body section generally conforming to a contour of the viewing window;

first and second chambers formed within the body section, each configured to receive pressurized air from an external source;

one or more slits formed in the body section and configured to vent pressurized air from the first chamber in a curtain like flow in front of the viewing window; and

one or more nozzles formed in the body section and configured to vent pressurized air from the second chamber in one or more generally focused air streams directed toward the viewing window.

19. The air guard of claim 18, wherein the body section includes at least one inlet port for receiving pressurized air for the first and second chambers, and further includes one or more control valves to control admission of pressurized air into the first and second chambers via the at least one inlet port.

20. The air guard of claim 19, further comprising a control circuit to control actuation of the one or more control valves, such that pressurized air can be blocked from one or both the first and second chambers.

21. The air guard of claim 20, wherein the control circuit includes a timing circuit, and wherein the control circuit is configured to actuate the one or more control valves responsive to operation of the timing circuit.

22. The air guard of claim 19, further comprising one or more input terminals to receive valve control signals for controlling the one or more control valves.

23. The air guard of claim 18, wherein the body section includes a first inlet port for receiving pressurized air for the first chamber and a second inlet port for receiving pressurized air into the second chamber.

24. The air guard of claim 23, wherein the body section includes a control valve configured selectively to admit pressurized air from the first inlet port into the first chamber, and selectively to admit pressurized air from the second inlet port into the second chamber.

25. The air guard of claim 18, wherein the air guard unit includes one or more control valves configured to permit selective operation of the air guard unit in a standby mode wherein

no air flows from the air guard, in a preventive mode wherein the air guard directs a generally laminar flow in front of the viewing window by venting pressurized air from the slits to block airborne contaminates from settling on the viewing window, or in a cleaning mode wherein the air guard directs one or more air streams at the viewing window by venting air from the nozzles to remove surface contamination deposited thereon.

26. An optolectronic presence sensing system comprising:

an optoelectronic presence sensing unit configured to detect objects by emitting optical signals through a viewing window and detecting return reflection signals therefrom; and

an air guard unit configured to direct air generally toward the viewing window of the optoelectronic presence sensing unit to reduce exterior surface contamination thereof.

27. The system of claim 26, wherein said air guard unit includes a body section that is integrated with a housing of the optoelectronic presence sensing unit.

28. The system of claim 26, wherein said air guard unit includes a body section that is removably attached to a housing of the optoelectronic sensing unit.

29. The system of claim 26, wherein the optoelectronic presence sensing unit is configured to provide a control signal to the air guard unit, and wherein the air guard unit includes one or more control valves configured to control air flow from the air guard unit responsive to the control signal.

30. The system of claim 26, wherein the air guard unit includes one or more control valves configured to permit selective operation of the air guard unit in a standby mode wherein no air flows from the air guard, in a preventive mode wherein the air guard directs a generally laminar flow in front of the viewing window to block airborne contaminates from settling on the viewing window, or in a cleaning mode wherein the air guard directs one or more air streams at the viewing window to remove surface contamination deposited thereon.

31. The system of claim 30, wherein the optoelectronic presence sensing unit is configured to provide a control signal for controlling the one or more control valves, such that the optoelectronic presence sensing unit controls the operating mode of the air guard unit.

32. The system of claim 30, wherein the air guard unit includes a control signal input configured to receive one or more control signals from an external controller and to couple the

control signals to the one or more control valves, such that the operating mode of the air guard unit is controllable via the external controller.

33. A method of maintaining a viewing window of an optoelectronic presence sensing device with respect to window contamination, the method comprising:

providing an air guard proximate to the viewing window;

supplying the air guard with pressurized air; and

selectively operating the air guard in a preventive mode wherein it vents the pressurized air in a generally laminar flow in front of the viewing window to prevent airborne contaminants from settling thereon, and in a cleaning mode wherein it vents the pressurized air in one or more directed air streams toward the viewing window to remove deposited surface contaminants thereon.

34. The method of claim 33, further comprising sensing that the viewing window is contaminated and operating the air guard in the cleaning mode responsive thereto.

35. The method of claim 34, wherein sensing that the viewing window is contaminated and operating the air guard in the cleaning mode responsive thereto comprises, at the optoelectronic presence sensing device, monitoring one or more dust detection sensors and generating a valve control signal responsive thereto, and providing the valve control signal to a control valve in the air guard that is configured to switch the air guard between the preventive mode and the cleaning mode.

36. The method of claim 33, further comprising selectively operating the air guard in a standby mode wherein it does not vent the pressurized air.

37. The method of claim 33, further comprising operating the air guard in the preventive and cleaning modes according to a timed schedule.

38. The method of claim 37, further comprising including a timing circuit in the air guard or in the optoelectronic presence sensing device by which the timed schedule is maintained.

39. An air guard for an optoelectronic presence sensing device, said air guard system comprising:

an air guard body section comprising one or more vented chambers; and

a control circuit configured to enable selective pressurization of the one or more vented chambers to effect a desired air flow pattern with respect to an optical window of the optoelectronic presence sensing device.

40. The air guard of claim 39, wherein the control circuit comprises a valve control circuit configured to operate one or more control valves for selective pressurization of the one or more chambers responsive to one or more control signals.

41. The air guard of claim 39, wherein the control circuit comprises timer control logic and associated valve control circuits configured to operate one or more control valves for selective pressurization of the one or more chambers responsive to a timed schedule.

42. The air guard of claim 39, wherein the control circuit comprises a control bus interface and associated valve control circuits configured to operate one or more control valves for selective pressurization of the one or more chambers responsive to signals received through a control bus.

43. The air guard of claim 39, wherein the control circuit comprises a portion of control logic included in the optoelectronic presence sensing device.

44. The air guard of claim 39, wherein the control circuit resides within the air guard body section.

45. The air guard of claim 39, further comprising one or more control valves configured to admit or block pressurized air from the one or more chambers responsive to control signals generated by the control circuit.

46. The air guard of claim 39, wherein the control circuit is configured to enable air flow from one or more of the one or more chambers responsive to detecting contamination of the optical window.

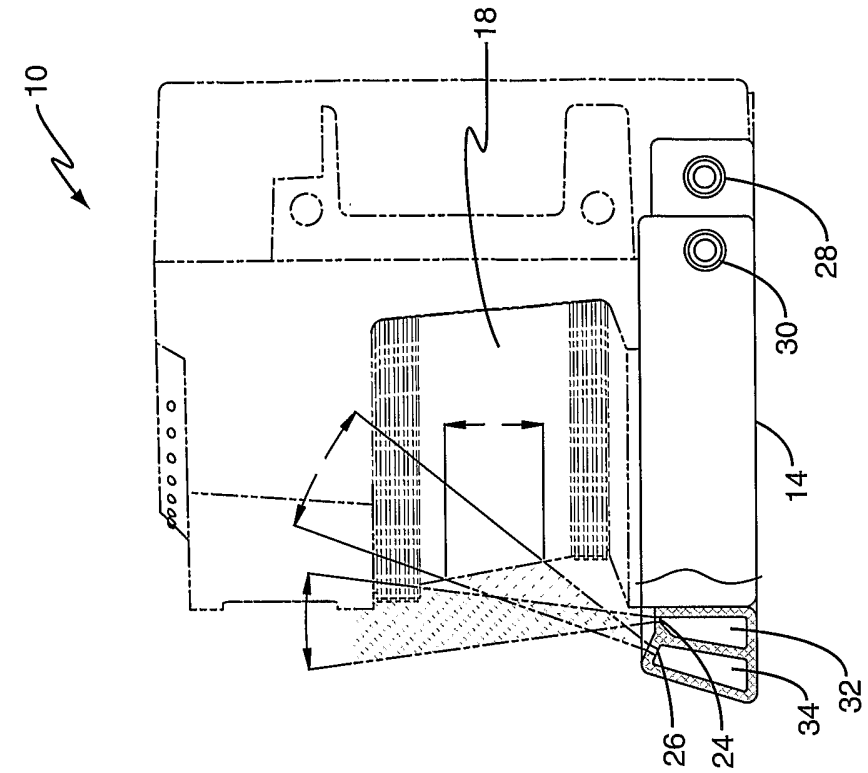

FIG. 2

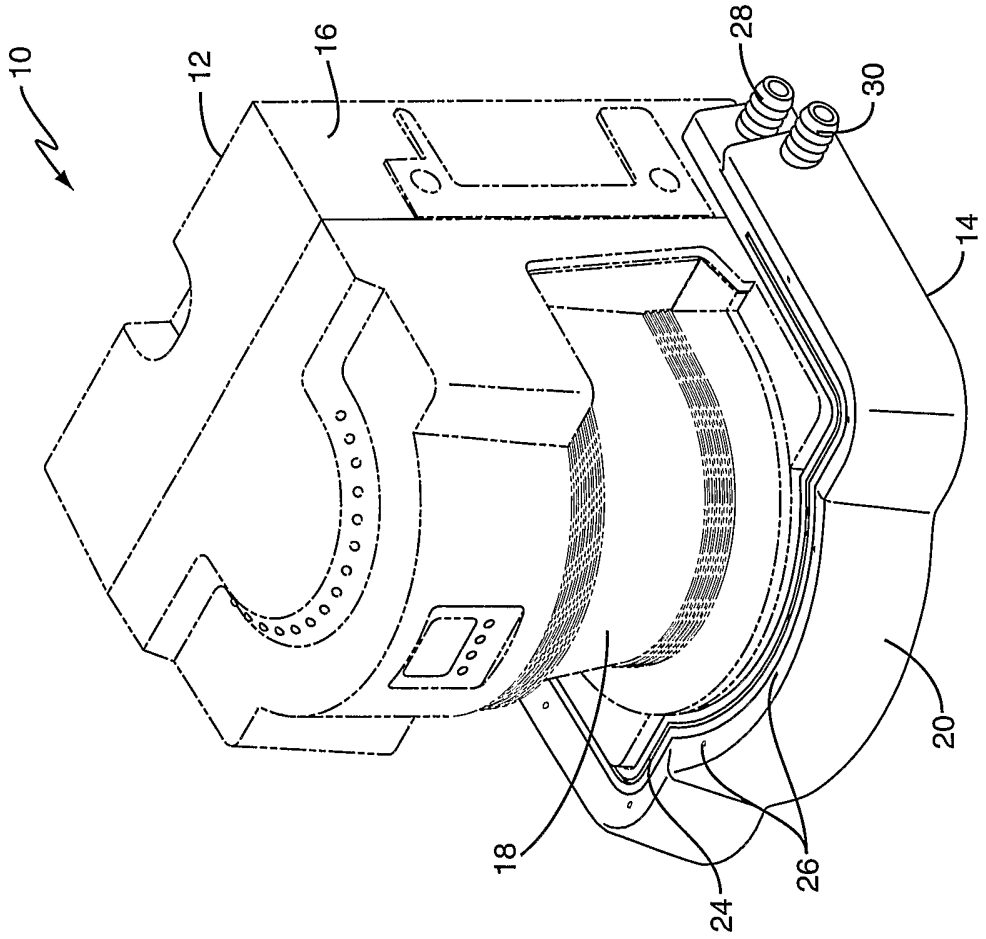

FIG. 1

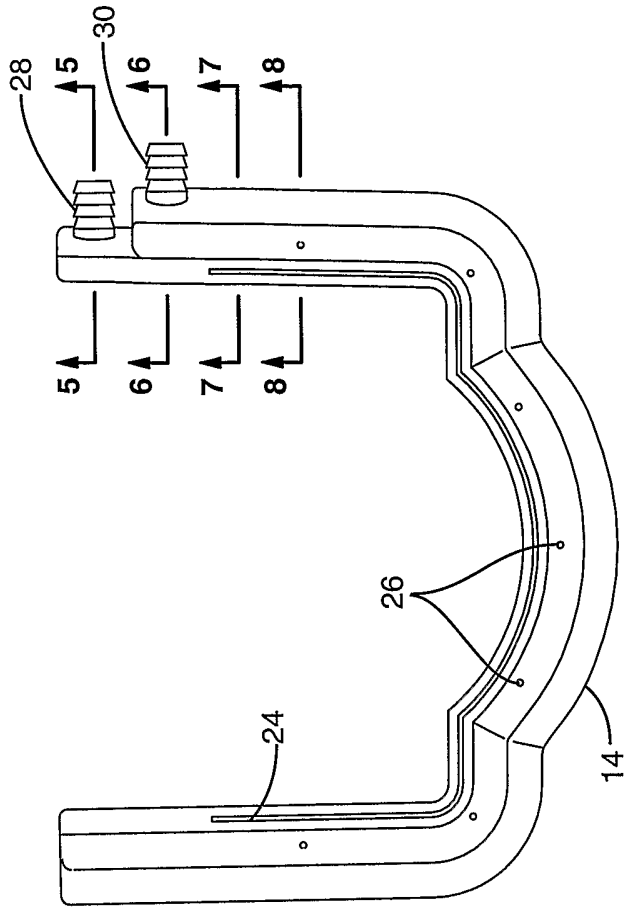

FIG. 4

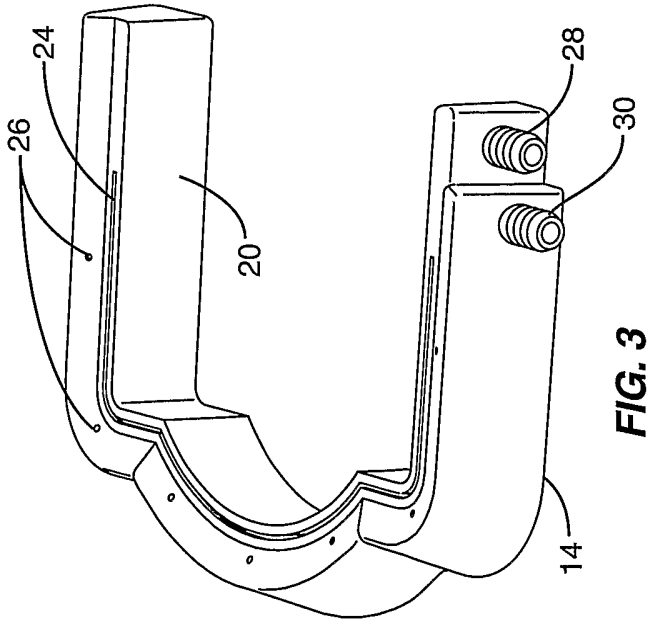

FIG. 3

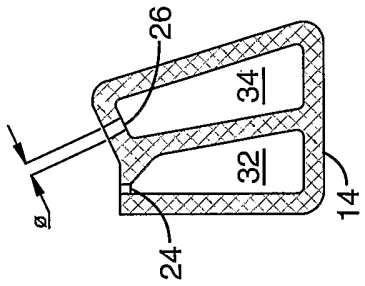

FIG. 8

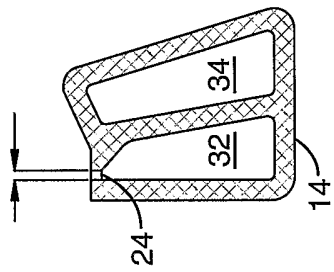

FIG. 7

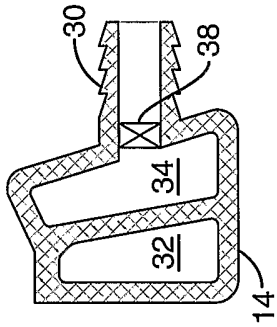

FIG. 6

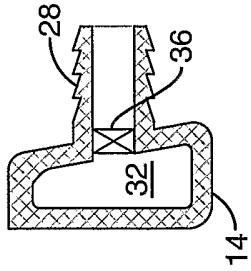

FIG. 5

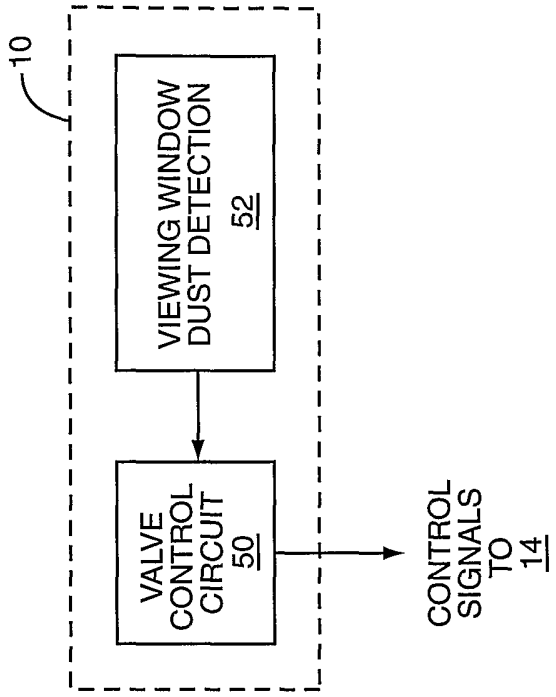
10
VIEWING WINDOW DUST DETECTION 52
VALVE CONTROL CIRCUIT 50
CONTROL SIGNALS TO 14

FIG. 10

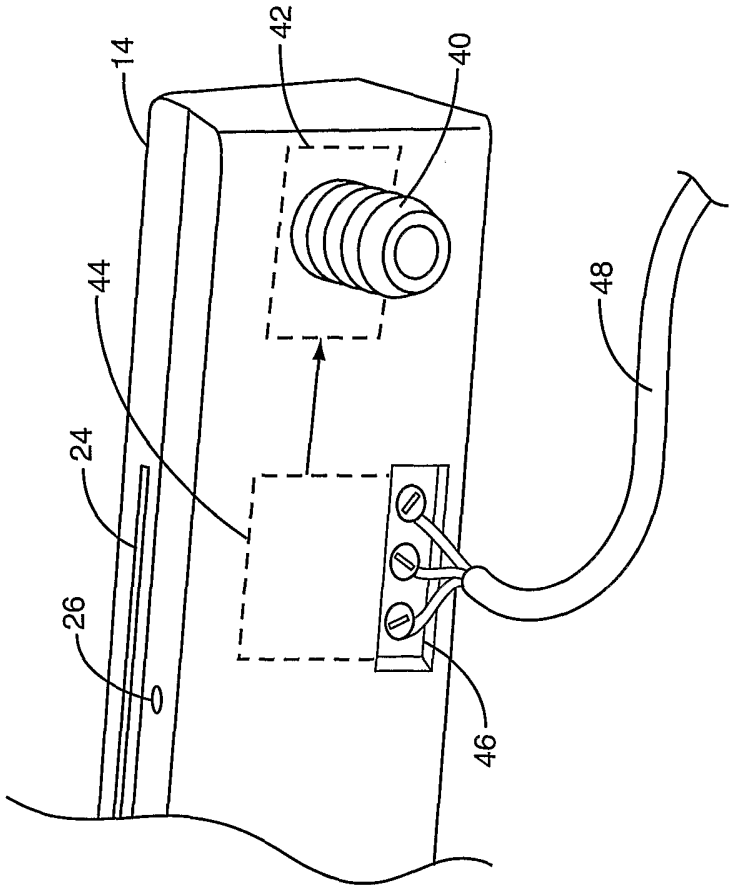
14
42
40
44
48
24
26
46

FIG. 9

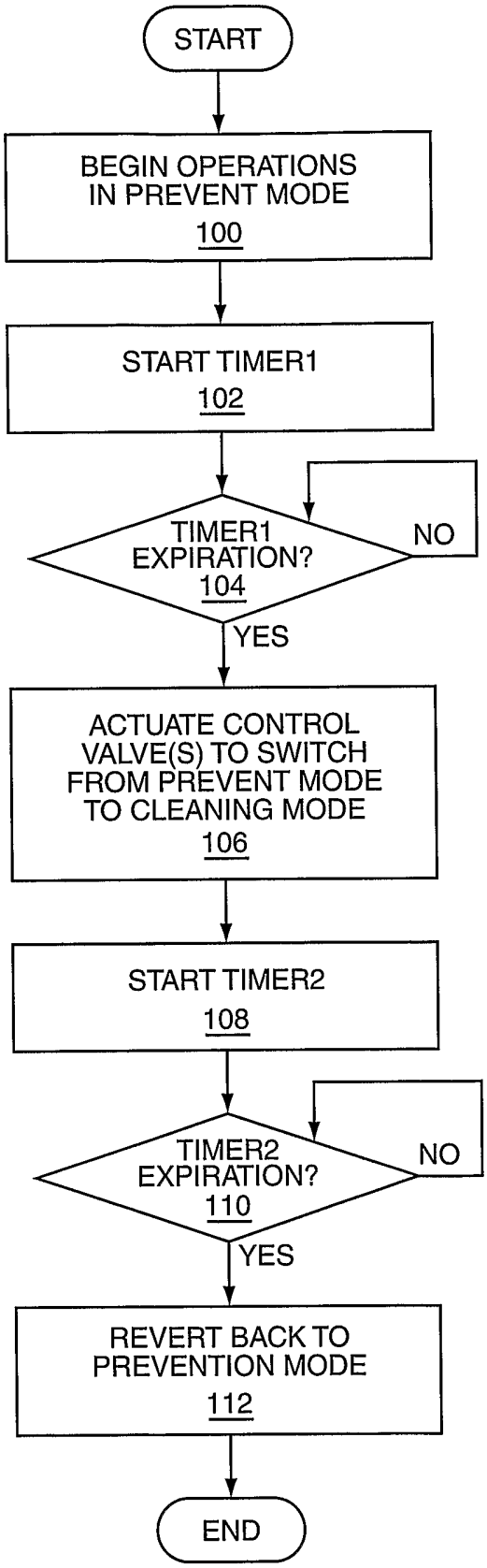
START
BEGIN OPERATIONS IN PREVENT MODE
100
START TIMER1
102
TIMER1 EXPIRATION?
104
NO
YES
ACTUATE CONTROL VALVE(S) TO SWITCH FROM PREVENT MODE TO CLEANING MODE
106
START TIMER2
108
TIMER2 EXPIRATION?
110
NO
YES
REVERT BACK TO PREVENTION MODE
112
END

FIG. 11

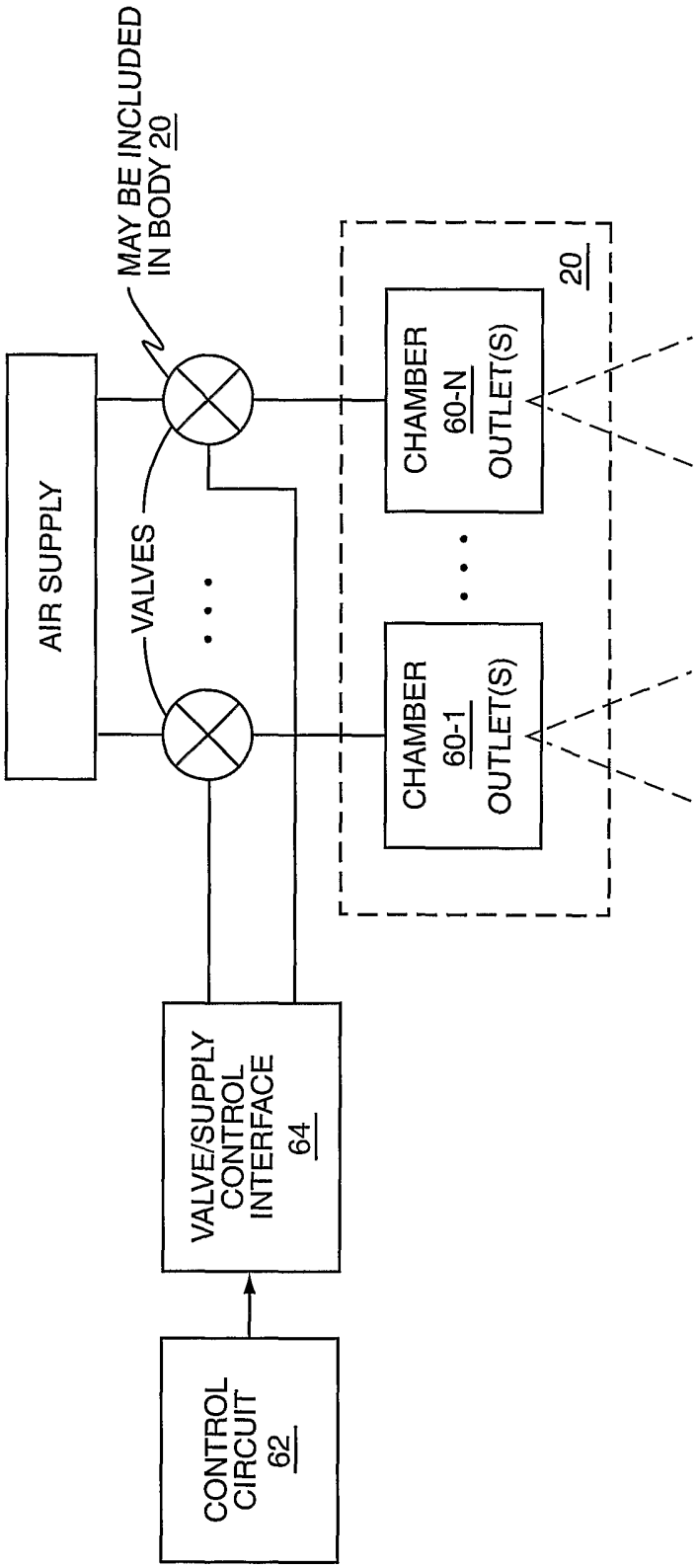
MAY BE INCLUDED IN BODY 20
AIR SUPPLY
VALVES
CHAMBER 60-N OUTLET(S)
CHAMBER 60-1 OUTLET(S)
20
VALVE/SUPPLY CONTROL INTERFACE 64
CONTROL CIRCUIT 62

FIG. 12

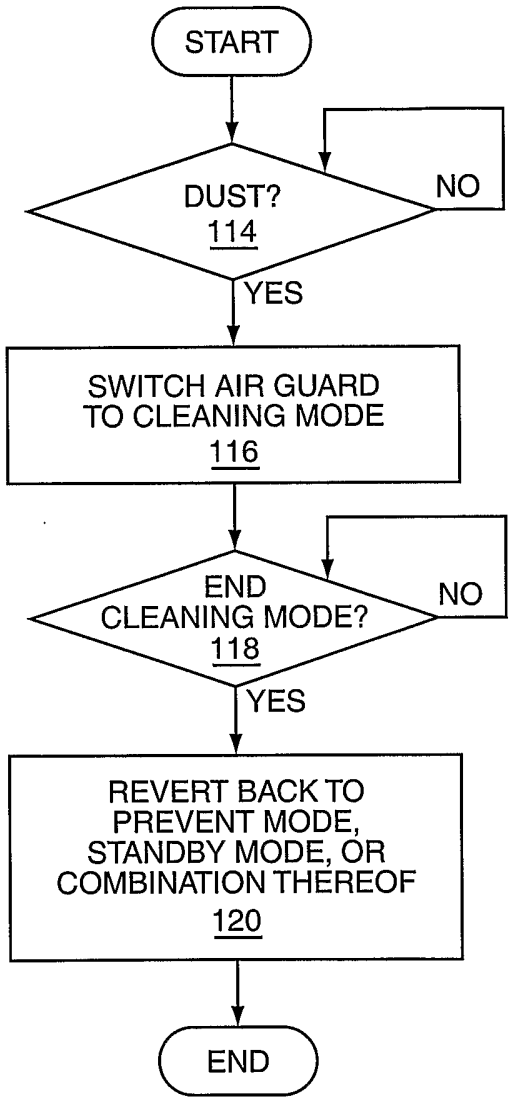
START
DUST?
114
NO
YES
SWITCH AIR GUARD
TO CLEANING MODE
116
END
CLEANING MODE?
118
NO
YES
REVERT BACK TO
PREVENT MODE,
STANDBY MODE, OR
COMBINATION THEREOF
120
END

FIG. 13

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2005/031776

A. CLASSIFICATION OF SUBJECT MATTER
G08B29/18 G08B13/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G08B G01V G01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 414 576 A (RANDMAE ET AL) 8 November 1983 (1983-11-08)	1-5
A	abstract page 5, lines 10-25; figures 2,11	18,33,39
X	PATENT ABSTRACTS OF JAPAN vol. 1999, no. 11, 30 September 1999 (1999-09-30) & JP 11 155764 A (KOITO IND LTD), 15 June 1999 (1999-06-15)	26,27
A	abstract	33

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 December 2005	15/12/2005

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Wright, J

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US2005/031776

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4414576 A	08-11-1983	NONE	
JP 11155764 A	15-06-1999	NONE	