(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
12 April 2007 (12.04.2007)

PCT

(10) International Publication Number
WO 2007/041160 A2

(51) International Patent Classification:
E04H 1/00 (2006.01)

(21) International Application Number: PCT/US2006/037676

(22) International Filing Date: 27 September 2006 (27.09.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
11/240,116 30 September 2005 (30.09.2005) US

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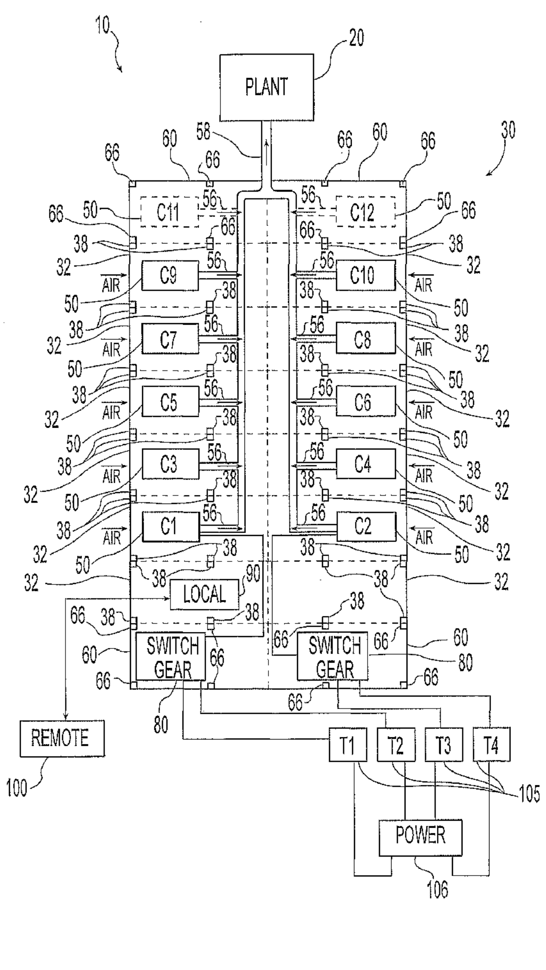
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,

[Continued on next page]

(54) Title: MODULAR INDUSTRIAL EQUIPMENT FACILITY



(57) Abstract: A modular industrial equipment facility is provided. This facility includes a plurality of pre-assembled, portable modules that may further include a plurality of internal modules, and a plurality of terminal modules for connecting to the plurality of internal modules, wherein each module may be configured to operate either in combination with or independent of the other modules. These modules are typically intended for use with heavy, industrial grade equipment. The internal modules and terminal modules may be arranged to form a single, integrated structure that has the appearance of a permanent, non-modular building. This invention may also include a computerized monitoring and control system that may further include a local component that monitors and controls the operation of equipment that may be housed in the various modules; and a remote monitoring and control component that is capable of monitoring and controlling the operation of the equipment in the various modules. Pre-installed ductwork and computerized air handling allow the facility to be expanded or contracted without significant structural modifications.

WO 2007/041160 A2

FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

TITLE OF THE INVENTION

MODULAR INDUSTRIAL EQUIPMENT FACILITY

BACKGROUND OF THE INVENTION

[0001] This invention relates in general to a facility for use with industrial equipment, and in particular to a modular equipment facility for use with heavy industrial equipment such as, for example, air compressor/dryer units.

[0002] In certain circumstances, the use of prefabricated, modular buildings for purposes such as constructing electrical facilities and residential housing may be an acceptable alternative to more traditional on-site construction methods. The use of individual building modules or units may save time and may reduce the overall complexity associated with some construction projects. However, many modular buildings or structures, although often highly functional, are unacceptable for certain applications because they include multiple modules or units that are connected to one another in a manner that creates a structure or structures that appear to be incomplete, i.e., unfinished, or non-permanent. For example, many modular facilities used for industrial applications include a series of trailers that are connected together or that are simply placed near one another at an equipment site. Facilities of this nature are often undesirable because they are deemed unacceptable by labor unions or because they negatively impact the appearance of the physical environment in which they are located. Thus, there is a need for a modular structure that can be used as an industrial equipment facility and that when complete, has the appearance of a finished, unified, non-modular structure.

[0003] Certain industrial factories and plants utilize large-scale equipment facilities that operate on a substantially continuous basis so that manufacturing or production can proceed without interruption. However, many industrial equipment facilities, including those that are modular in nature, do not include adequate backup systems or system redundancies that provide for substantially continuous operation in the event that one or more individual components within the system fails. In the absence of adequate safeguards or redundancies, manufacturing operations may be interrupted or may cease if a partial system failure occurs. Furthermore, if manufacturing or production output must be increased or decreased, a rapid expansion or contraction of the equipment facility servicing the factory or plant may become necessary. Existing modular facilities are not typically expandable or reconfigurable without reconstruction of the entire facility. Reconstructing an entire facility to accommodate additional heavy equipment significantly reduces or basically eliminates most of the advantages realized by using a modular structure or system in the first place. Thus, there is a need for a modular industrial equipment facility that provides certain redundancies that assure substantially continuous operation in the event of a partial system failure and that can be reconfigured, i.e., expanded or re-arranged, without significant reconstruction of the entire facility.

SUMMARY OF THE INVENTION

[0004] Deficiencies in and of the prior art are overcome by the present invention, the exemplary embodiment of which provides a modular facility suitable for housing a variety of industrial equipment or devices such as, for example, high-output air compressor/dryers. In accordance with one aspect of the present invention, an industrial system is provided. This system includes a plant for performing one or more industrial processes and a modular industrial equipment facility connected to the plant. The modular equipment facility further includes a plurality of individual modules which may be situated on the end portions of the facility or which may be situated on the inside portion of the facility. Each of the inside or "internal" modules further comprises at least one non-weight bearing external wall and each of the end or "terminal" modules further comprises at least two non-weight bearing external walls. The internal modules and terminal modules may be arranged in a variety of geometric configurations to form a single, integrated structure that has the appearance of a unified, non-modular building.

[0005] In accordance with another aspect of the present invention, a modular industrial equipment facility is provided. An exemplary embodiment of this facility includes a plurality of pre-assembled, portable modules suitable for use with heavy industrial equipment such as air compressor/dryers or other equipment. The modules may be situated, i.e., placed, on the end portions of the facility or they may be situated on the inside portion of the facility. Each of the inside or "internal" modules further comprises at least one non-weight bearing external wall and each of the end or "terminal" modules further comprises at least two non-weight bearing external walls. The internal modules and terminal modules may be arranged in a variety of geometric configurations to form a single, integrated structure that has the appearance of a unified, non-modular building. Each of the modules (referred to herein as "equipment modules") modules is typically configured to operate independent of the other equipment modules in the event of a partial system failure. In this embodiment, the terminal modules are typically used to house switchgear, computers, or other electrical equipment while the internal modules are typically used to house air compressor/dryer units. The construction and configuration of both the individual equipment modules and the facility itself creates an industrial facility in which each air compressor/dryer unit operates independent of the other air compressor/dryers in terms of environmental control, i.e., compressor cooling, but that is still fully integrated into the larger facility in terms of compressor air output. The internal environment of the facility itself does not significantly affect or limit the number of air compressor/dryer units that may be added to or removed from the system. Therefore, the output of the industrial equipment facility of this invention may be increased or reduced without the need to significantly reconstruct the entire facility to change internal airflow characteristics. This invention also includes a computerized control system that further includes a local component and a remote component. The local component is typically placed within the equipment facility and provides means by which to both monitor and control the operation of the equipment located within the facility. The remote component is typically placed at a location separate from the main equipment facility and also provides means by which to both monitor and control the operation of the equipment located within the facility.

[0006] In yet another aspect of this invention, a method for manufacturing, installing and operating a modular industrial equipment facility is provided. This method includes the general steps of: (i) fabricating a plurality of equipment modules for use with heavy industrial equipment such as air compressor/dryer units, wherein the equipment modules further include end or "terminal" modules each having at least two external non-weight bearing walls and inside or "internal" modules each having at least one external non-weight bearing wall; (ii) installing equipment in the equipment modules; (iii) transporting the equipment modules to a predetermined construction site; (iv) arranging the equipment modules to form a single, integrated structure, wherein the single, integrated structure has the appearance of a unified, non-modular building; and (v) connecting the equipment modules to a computerized control system, wherein the control system further comprises a local component and a remote component for monitoring and controlling the operation of the equipment installed in the modules.

[0007] Additional features and aspects of the present invention will become apparent to those of ordinary skill in the art upon reading and understanding the following detailed description of the exemplary embodiments. As will be appreciated, further embodiments of the invention are possible without departing from the scope and spirit of the invention. For example, the invention may be used to house and operate industrial equipment other than air compressor/dryer units. Accordingly, the drawings and associated descriptions are to be regarded as illustrative and not restrictive in nature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The accompanying drawings, which are incorporated into and form a part of the specification, schematically illustrate one or more embodiments of the invention and, together with the general description given above and detailed description of the exemplary embodiments given below, serve to explain the principles of the invention.

[0009] FIG. 1 is a generalized schematic representation of the industrial system of the present invention showing the factory or plant, the modular industrial equipment facility, the remote monitoring and control component, and the transformers and power source utilized by the equipment facility.

[0010] FIG. 2 is a side view of one of the equipment modules of the exemplary embodiment showing the ductwork and air compressor/dryer unit contained within the module.

[0011] FIG. 3 is a side view of one of the equipment modules of the exemplary embodiment showing various electrical components contained within the module.

[0012] FIG. 4 is a perspective view of an exemplary embodiment of the industrial equipment facility of the present invention under construction showing one of the equipment modules being lowered into position by a crane.

[0013] FIG. 5 is a perspective view of an exemplary embodiment of the assembled industrial equipment facility of the present invention showing the final placement of the internal modules and the terminal modules relative to one another.

[0014] FIG. 6 is a cross-sectional side view of an exemplary embodiment of the industrial equipment facility of the present invention showing the placement of air compressor/dryers and associated ductwork within the interior of two equipment modules that are facing one another.

[0015] FIG. 7 is a side view of the exterior of an exemplary embodiment of the industrial equipment facility of the present invention showing the placement of the internal modules and terminal modules relative to one another.

[0016] FIG. 8 is a schematic representation of the computerized local and remote components of an exemplary embodiment of the industrial equipment facility of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0017] This invention relates to a reconfigurable modular industrial equipment facility for use with a factory, manufacturing plant or other industrial system or operation. An exemplary embodiment of this facility includes a plurality of pre-fabricated, portable equipment modules that are typically transported to and arranged at a predetermined location. These equipment modules further include: a plurality of internal equipment modules (i.e., for placement on the interior or middle portion of the structure), wherein each internal module is configured to operate independently of or in combination with the other internal modules in the event of a partial system failure; and a plurality of terminal modules (i.e., for placement on the end portions of the structure) for use in combination with the plurality of internal modules. When final construction/assembly of the facility of the present invention is complete, the internal modules and terminal modules form a single, integrated structure that has the appearance of a unified, non-modular building. This invention also includes a computerized control system that further comprises a local electronic/digital component that monitors and controls the operation of the various equipment modules and a remote electronic/digital component that is also capable or monitoring and controlling the operation of the equipment modules. This control system facilitates the substantially continuous operation of the industrial equipment facility of this invention. This invention is useful for use with large, heavy duty air compressor/dryers or other equipment, and includes a variety of computer-controlled dampers that allow each air compressor/dryer to operate in a substantially self-contained environment that is largely independent of the internal environment and airflow of the building housing the air compressor/dryers and/or other equipment.

Industrial System and Modular Equipment Facility

[0018] With reference now to the Figures, FIG. 1 provides a schematic representation of an exemplary industrial system 10. Industrial system 10 typically includes an industrial plant 20, such as an automotive plant, which receives pressurized air from a modular industrial equipment facility 30 for operating equipment utilized in the plant. Modular industrial equipment facility 30 may be arranged in any of a variety of geometric configurations, i.e., floor plans, and includes a plurality of equipment modules that further include internal modules 32 and terminal modules 60. In the exemplary embodiment shown in FIG. 1, there are twelve internal modules 32 (six per side and facing one another), ten of which house an air compressor/dryer unit 50 (designated as C1-C10 in FIG. 1) and, optionally, other equipment. Other embodiments of this invention include a greater or lesser number of equipment modules and in some embodiments, at least one of the equipment modules is free of equipment and is used as a "service" module for accessing the equipment in the other modules. The air compressor/dryers 50 direct compressed air into a plurality of air outlets 56, which are connected to compressed air header 58, which supplies compressed air to plant 20. In FIG. 1, one of the two internal modules 32 that does not house an air compressor/dryer 50 houses the computer hardware and software included in local component 90, which monitors and controls the equipment located in facility 30. Local component 90 is in electrical/digital communication with remote component 100, which is also capable of monitoring and controlling the equipment located in facility 30. Control components 90 and 100 are typically in direct or indirect electrical/digital communication with each of the equipment modules. This communication may be wireless. In the exemplary embodiment of FIG. 1, there are also four terminal modules 60. Two of these modules 60 are empty, although as shown in the Figure, compressor/dryer units C11 and C12 may be added to equipment facility 30 as needed. The other two terminal modules 60 shown in FIG. 1

house electric switchgear 80, which is connected to transformers T1-T4, which are connected to external power source 105 for providing electric power to industrial equipment facility 30.

[0019] Numerous other arrangements of the equipment modules of facility 30 are possible, and it should be noted that FIG. 1 illustrates only one such configuration. In the configuration shown in FIG. 1, the construction and arrangement of the individual equipment modules creates space on the interior of the building that may be used by maintenance workers to access the individual air compressor/dryers 50 and other equipment. Supports 66 provide structural support to each end module and supports 38 provide structural support to each internal module 32 making internal weight bearing walls unnecessary. The dashed lines in FIG. 1 represent the physical boundaries of each individual module -- there are no internal walls present in this embodiment, thereby permitting relatively unrestricted movement within industrial equipment facility 30.

Construction of Equipment Modules

[0020] In the exemplary embodiment shown in the Figures, equipment modules 32 and 60 have been constructed for use with large, industrial capacity air compressor/air dryer units. Each equipment module is designed to be structurally stable independent of surrounding structures or modules and to accommodate very heavy equipment, if desired. In the exemplary embodiment shown in the Figures, each equipment module housing an air compressor/dryer unit weighs about 45,000 pounds. FIG. 2 provides a side view of an internal module 32, and illustrates the placement of an air compressor/air dryer unit 50 within the module. FIG. 2 also shows the various dampers, ductwork, and other equipment that is typically pre-installed within the module prior to transporting the module to a construction site. As shown in FIG. 2, the enclosure portion of internal module 32 includes at least one exterior wall 34, floor 36, supports 38, roof 40, and aperture 42. Equipment modules 32 and 60 are typically steel framed and supported over an I-beam framed, reinforced concrete base. Although not shown in the Figures, each equipment module 32 and 60 may be equipped with a monorail four-inch I-beam crane, trolley, and a half-ton hoist for facilitating lifting, placement, or replacement of equipment within the module.

[0021] The construction specifications of each equipment module may vary based on the site at which facility 30 is being constructed and/or on the equipment being housed and operated in each module. However, in an exemplary embodiment, the exterior walls of each equipment module are sided with 26-gauge "Span-Line 36" (Metal Sales Manufacturing Corp.). The exterior walls are metal studded with galvanized metal interior wall panels. The roofing consists of an EPDM membrane roof (60 mil, Firestone) on 3-inch rigid insulation over metal decking, and the insulation is 3.5-inch fiberglass insulation with a R13 rating. The metal deck is 3"x18" gauge type 3N galvanized steel. The roof slopes 0.25" per 12" from a height of 11 ft, 6 inches. The equipment modules 32 and 60 may also include one or more doors 70. Industrial equipment facility 30 is typically built to meet Zone 1 requirements as defined in the Uniform Building Code of the International Conference of Building Officials. Despite the specific application or equipment used, equipment facility 30 is typically built to be compliant with all relevant local building codes and standards for, but not limited to, building design and construction, steelwork and structural work, pressurized piping and vessels, and electrical wiring. Seismological factors are also typically considered in the construction of both the equipment modules and the facility itself. As will be appreciated by the skilled artisan, other materials may be used for the construction the equipment modules of the present invention.

[0022] Again with reference to FIG. 2, each internal equipment module 32 (or terminal module 60 if used to house an air compressor/dryer 50) is equipped with an air handling system that includes ductwork, dampers and computerized controls such that a high volume (e.g., 22,000 CFM) of compressor cooling air may be utilized by each air compressor/dryer 50 regardless of the volume of available air contained within the structure of equipment facility 30. Although the specifications of each equipment module may vary, in an exemplary embodiment, the air handling system includes: (a) a Total Filtration (28VB10WX06H V) bank inlet filter housing and filter bank 44; (b) two Ruskin CDTI-50 low temperature intake air control dampers 48a with 110 volt 90 degree actuators; (c) two 15 HP Atlas Copco cooling fans 43; (d) a Modicon PLC 53; (e) an Atlas Copco compressor/dryer cooling system 51, which includes an intercooler, an after- cooler, an oil cooler, and a dryer regeneration cooler; (f) discharge air ducts 52a and 52b; (g) two Ruskin CDTI-50 low temperature recirculation control dampers 48b with 110 volt 90 degree actuators; (h) a recirculation air duct 46; (i) a Ruskin CDTI-50 low temperature discharge control damper 48c with 110 volt 90 degree actuator; (j) a Ruskin CDTI-50 low temperature discharge control damper 48d with 24 volt modulating actuator; (k) an outside (ambient) air temperature sensor 41; and (l) an internal compressor cooling temperature sensor 45 (see FIG. 2).

[0023] With reference to FIGS. 1 and 3, an exemplary embodiment of this invention includes a variety of industrial grade electrical components that provide power to equipment facility 30 and to the equipment operating therein. In general, the electrical system includes a main power source, a series of transformers, switchgear, power distribution panels, and a series of electrical feeds and lines. More specifically (see FIG. 1), an exemplary embodiment of this invention includes a 13,800 V main switch house 106, which is connected to four transformers 105, which are connected to double-ended 480-volt GE AKD switchgear 80. In this example, switchgear 80 includes two 4000-amp main breakers; four 800-amp individual compressor and/or building power breakers 86, and one 4000-amp tie breaker. Each set of switchgear 80 includes one 800-amp breaker pre-wired to a GE distribution panel 81 for powering certain auxiliary equipment, such as space heaters, which may be installed in facility 30, and the single phase 480V/220-110 V single-phase transformer 83. Transformer 83 is pre-wired to a single-phase panel board 82. A 600-amp safety disconnect switch 87 may also be included for each air compressor/dryer 50. Each equipment module 32 and 60 may include pre-installed light switches, duplex receptacles, interior lighting, fluorescent lamps, and electrical wiring. To minimize on-site wiring requirements, "pig tails" or other devices for interconnecting lighting and outlet circuits between modular sections may be provided.

[0024] FIG. 4 shows modular industrial equipment facility 30 during the assembly process. In this Figure, one of the internal modules 32 is being lowered into place by crane 120. FIGS. 5-7 depict the assembled version of modular industrial equipment facility 30. As is evident from FIG. 5, the fully constructed and assembled facility has the appearance of a single, unified, permanent, non-modular structure. As previously discussed, the internal modules 32 typically include a metal frame, a concrete floor 36, a plurality of supports 38, and a roof 40. A single, non-weight bearing exterior wall or panel 34 is attached to the side of internal module 32 that faces the outside environment when industrial equipment facility 30 is assembled. Each terminal module 60 also includes a metal frame, a floor 64, a plurality of supports 66, and a roof 68. Two non-weight bearing exterior panels or walls 62 are attached to the sides of terminal module 60 that face the outside environment when industrial equipment facility 30 is assembled. Terminal modules 60 may be used for housing air compressor/dryers 50 by removing one of the wall panels 62, cutting an aperture 42 into the panel 62, and re-attaching the cut panel to the module. Additionally, the roof portion of each equipment module (terminal and internal) typically includes protruding "curbs" that may be used to accommodate discharge air ducts 52a and 52b.

[0025] With reference to FIG. 5, an air intake 72 is included at each end of equipment facility 30 for providing ventilation and cooling air to the interior of the assembled facility. In an exemplary embodiment, each air intake 72 includes a thermostatically controlled motorized damper and a 4' x 4' Total Filtration "v-bank" filter system. In the exemplary embodiment, an individually thermostatically controlled one-quarter HP exhaust fan is installed in discharge duct 52a above each air compressor/dryer 50 to discharge any excess compressor/motor/piping radiant heat. Relatively cool outside air is then drawn into equipment facility 30 by operation of the air intakes 72.

[0026] FIG. 6 provides a cross-sectional side view of two of the internal modules 32 as arranged in an exemplary embodiment of the final, assembled version of industrial equipment facility 30. As previously indicated, each individual module is typically constructed at a first location and then transported to a second location, in some cases fully loaded with equipment. As discussed, each individual equipment module is constructed to include some, or for certain applications, all of the necessary electrical connections and other connectors that allow that module to be easily connected to the other modules that are included in the completed and functional equipment facility. In an exemplary embodiment, each internal module houses an Atlas Copco ZT275FF air compressor/dryer that is equipped with an air dryer having preinstalled interconnecting piping that includes 3-way bypass piping. In the exemplary embodiment, each equipment module that houses an air compressor/dryer unit includes a 4-inch Victaulic air-piping riser 56 connected to a 10-inch, Schedule 40 air header 58 with flanges on each end for quick and easy interconnection with the other equipment modules. Additionally, prior to shipping, the condensate drain discharges of each air compressor/dryer 50 are connected by way of tubing to a 3-inch PVC manifold pipe 59, 10-feet in length (see FIG. 6), which is installed over each air compressor/dryer 50 and permits easy interconnection with the condensate drain discharges of the other equipment modules.

[0027] The overall size of the final structure may be changed, or the geometric configuration altered, by removing individual modules or groups of modules, by adding modules, or by rearranging the modules already in use. Advantageously, the significant weight of each module allows the final facility to be assembled in most cases without actually connecting, to any significant degree in terms of structure, the individual modules to one another. Thus, essentially, the final facility is a group of freestanding equipment modules that have been placed close to one another. Once the facility is assembled, a roofing material may be used to seal seams between the roof portions 40 and 68 to prevent the elements, especially water, from entering the industrial equipment facility 30. Metal siding filler pieces may also be used to cover seams between the exterior wall panels 34.

Equipment Facility Control System (Hardware and Software)

[0028] With reference to FIGS. 1 and 8, the industrial equipment located in facility 30 is monitored and controlled by a computerized system that includes an on-site local component 90 and a separate remote component 100. This computerized system allows the equipment in facility 30 to operate in a substantially autonomous or automated manner and typically very little human intervention is involved once the facility is brought on-line. The hardware and software included in this computerized system allows the equipment in each of the individual modules to function both in combination with and independent of the equipment in the other modules, and helps assure that the failure of equipment in one or more modules does not negatively impact the operation and output of the entire system. As shown in FIG. 8, an exemplary embodiment of local component 90 includes custom computer software for monitoring and controlling the equipment in the modules, a wireless router/switch 91, a system control computer 92, a power monitor damper control computer 93, a security camera computer 94, an ION® meter bank 95 for measuring power usage, and a bank of security cameras 96. Local component 90 is in electronic/digital communication with remote component 100. Remote component 100 typically includes custom computer software for monitoring and controlling the equipment in the modules, a remote access software component 101, a data connection 102, a remote access device or service (e.g., cell phone, Internet, or other means) 103, and a remote server 104. The Manag*AIR*® system (available from Ohio Transmission Corporation; Columbus, Ohio) is an example of a software-based system that may be used for local component 90, and the Monit*AIR*® system (also available from Ohio Transmission Corporation; Columbus, Ohio) is an example of a software-based system that may be used for remote component 100. These systems may be used to generate and send alarms and various reports by way of e-mail or other electronic/digital communications means. Both of these systems are useful for monitoring and controlling the operation of a compressed air facility. However, as will be appreciated by those skilled in the art, other custom or customizable software-based systems may be used with the present invention.

[0029] In an exemplary embodiment, each air compressor/dryer 50 contains a wireless communication device that provides at least two communications ports. A first port is used to connect to the compressor/dryer's Elektronikon (Atlas Copco) control system and power metering equipment located in the compressor/dryer disconnect. A second data port is used for connection to a Modicon programmable logic controller (PLC) that is added to each air compressor/dryer 50. In general terms, programmable logic controllers are known computerized devices typically used for automating industrial processes. These devices are microprocessor- based and include either modular or integral input/ouput circuitry that monitors the status of field connected sensor inputs and controls attached devices (motor starters, solenoids, actuators, pilot lights/displays, speed drives, valves, etc.) according to a user-created program stored in battery-backed memory. The functionality of a PLC may include typical relay control, sophisticated motion control, process control, distributed control, and complex networking. The PLCs used with the present invention automate the process of regulating each air compressor/dryer's cooling air temperature in response to changes in ambient conditions and/or compressor heat loads. In this embodiment, the Manag*AIR*® system requests data from all the air compressor/dryers at predetermined intervals. These data include information such as current operational status; operating parameters such as pressures, temperatures and vibration levels; power information, warning and alarm status for each parameter, as well as service information. The Manag*AIR*® system analyzes this information and performs various operations based on these results. By communicating with the PLC used with each air compressor/dryer 50, the Manag*AIR*® system may be used to: (i) log data for trending and diagnostics; (ii) start or stop machines based on demand; (iii) load and unload machines based on demand; (iv) adjust compressor sequence; (v) analyze data for predictive intervention; (vi) calculate energy efficiency; (vii) provide alarms by way of alphanumeric page; and (viii) provide e-mail and/or facsimile communications.

[0030] In addition to power monitoring equipment, which is typically provided for each air compressor/dryer 50, in an exemplary embodiment, four ION power-metering devices are located in switchgear 80. These devices are connected by an Ethernet cable to router 91. A second complete computer system running ION Windows based software monitors all information from the ION power metering equipment. Also installed on this computer is software designed to monitor and control the Modicon PLCs located in each air compressor/dryer 50. Communications between this computer and the PLCs are typically carried out over an encrypted wireless Ethernet connection. This computer also serves as a backup to the computer running the Manag*AIR*® software or other software.

[0031] In the exemplary embodiment, a third computer is also located at the facility site for the purpose of video surveillance. This surveillance system is a digital video recorder (DVR) system that includes a Windows-based computer that incorporates specialized video hardware and software. Attached to the computer is a plurality of cameras 96 located inside and outside of the building. Outdoor fixed cameras and indoor pan and tilt cameras are connected to the computer with standard video/power wiring. A portable wireless camera is also located inside industrial equipment facility 30. The DVR system is equipped to record all motion detected by the cameras for the purpose of security. The system also allows visual inspections of the site to be performed remotely by way of the Internet or other remote means.

Equipment Facility Operation (module micro-environment)

[0032] Due to the unique modular construction of industrial equipment facility 30, the operation of the equipment housed in each module, i.e., each air compressor/dryer 50, is not significantly limited by the volume of air that can be drawn into the integrated structure itself. Because each air compressor/dryer 50 draws compressor cooling air and compressor intake air from the environment *outside* the facility and not from inside the facility, the operation of each individual air compressor/dryer 50 does not restrict or negatively impact the operation of the other air compressor/dryers 50, nor does it limit number of air compressor/dryers that may be included in facility 30. The air handling on the interior of facility 30 is used to dissipate radiant heat and is not used as a source of compressor cooling air or compressor intake air. Consequently, additional equipment modules and air compressor/dryers may be added to or removed from industrial equipment facility 30 without necessitating reconstruction of the entire building.

[0033] With reference to the exemplary embodiment of the present invention shown in FIGS. 2 and 6, each internal module 32 (or terminal module 60 if an air compressor/dryer 50 has been installed therein) includes an aperture 42 in exterior wall 34. Inlet filter housing and filter bank 44 are connected to aperture 42, and air from the outside environment is drawn into each air compressor/dryer 50 through aperture 42. Air that is used by the components of air compressor/dryer cooling system 51, i.e., the intercooler, after cooler, oil cooler, and dryer regeneration cooler, is drawn into air compressor/dryer 50 though filter housing and filter bank 44 by compressor cooling fans 43. Compressor intake air is also drawn into the air compressor portion of compressor/dyer unit 50 through aperture 42, but bypasses the filter bank and enters compressor air intake hose 110, which is attached to roof 36 by support brackets 112. Compressor intake hose 110 is attached to the air compressor portion of compressor/dyer unit 50 at housing 111.

[0034] Each equipment module that contains an air compressor/dryer 50 includes a computerized system that operates dampers 48a-48d to control the intake, exhaust and recirculation of the cooling air utilized by the air compressor/dryer. This computerized system allows cooling air to be re-circulated to the extent necessary (based on temperature) to maintain the proper operating environment for the various coolers, and consequently, for each air compressor/dryer 50. Cooling air is not drawn into the air compressor/dryers from the inside of the building that houses the air compressor/dryers; thus, the internal environment and internal air handling capacity of industrial equipment facility 30 does not limit the number of air compressor/dryers that may be included in or added to any particular facility. The exemplary embodiment of the present invention does typically include at least one filtered vent 72 on each end of the industrial equipment facility 30 for supplying cooling air to disperse the radiant heat generated by the air compressor/dryers; however, the primary source of cooling air is the environment external to industrial equipment facility 30.

[0035] Regarding cooling air intake, exhaust and recirculation, Modicon PLC 53 monitors external temperature sensor 41, mixed temperature sensor 45, and the operating status of each air compressor/dryer 50 through an auxiliary motor starter contactor and controls the relative positions of the system's dampers and fans. When the temperature outside industrial equipment facility 30 is at or above 50^0F, and an air compressor/dryer 50 is operating: Modicon PLC 53 opens the inlet control dampers 48a, closes the recirculation dampers 48b, and opens the discharge control dampers 48c and 48d. When the air compressor/dryer 50 begins running, 22,000 CFM of cooling air is drawn into the air compressor/dryer through the inlet filter housing and filter bank 44. This air is then directed through the inlet air control dampers 48a into the air compressor/dryer's enclosure, up through the air compressor/dryer coolers 51 (which heats the cooling air), out of the air compressor/dryer enclosure into the discharge duct 52a, out through the two Modicon PLC-controlled discharge dampers 48c and 48d, and finally through discharge gooseneck duct 52b to the outside environment. The recirculation control dampers 48b remain closed during this operational mode. This procedure allows for a "once through" cooling air circuit which is preferable when air temperatures are relatively warm (i.e., above 50^0F).

[0036] If external air temperature sensor 41, which is connected to or in communication with Modicon PLC 53, measures an outside temperature below 50^0F, 22,000 CFM of cooling air is drawn into the air compressor/dryer through the inlet filter housing and filter bank 44. This air is then directed through the inlet air control dampers 48a (opened by Modicon PLC 53) into the air compressor/dryer enclosure, up through the air compressor/dryer coolers 51 (which heats up the cooling air), out of the air compressor/dryer enclosure, and into discharge duct 52a. At this point Modicon PLC 53, which is measuring the mixed cooling air temperature with temperature sensor 45, opens the recirculation damper 48b to allow warm air to recirculate and mix with the cold outside air in the inlet filter housing and filter bank 44. The Modicon PLC 53 will also turn off one of the two cooling fans 43 and close one of the two intake control dampers 48a to reduce the cooling airflow and save energy. If the mixed cooling air temperature drops below 45^0F, the Modicon PLC 53 closes the discharge control damper 48c and begins to modulate the discharge control damper 48d to maintain a mixed cooling air temperature between 45^0F and 55^0F; thereby preventing freeze-ups and/or air compressor/dryer malfunction. If compressor/dryer 50 is sensed as not operating (i.e., is not on), the Modicon PLC 53 closes the inlet control dampers 48a and the discharge control dampers 48c and 48d. A heater inside of air compressor/dryer enclosure is then turned on to prevent air compressor/dryer coolers 51 from being "cold soaked" by cold outside air and ready for startup. In the exemplary embodiment, the Modicon PLC 53 used with each air compressor/dryer 50 is connected by way of an encrypted wireless connection to software running on the backup PC. This software allows for remote adjustment of temperature set points in each Modicon PLC 53 as well as full manual control and override capabilities.

[0037] Advantages of the present invention include, but are not limited to, the following: (i) the operation or malfunction of one compressor/dryer unit does not affect any of the other compressor dryer units, thereby substantially improving overall system reliability; (ii) pre-installing the ventilation and recirculation subsystem greatly accelerates the overall on-site system installation and also allows for prototyping and testing the system's operation prior to on-site installation and startup, thereby ensuring proper performance; (iii) starting or stopping any individual unit in the system does not adversely affect operation of the entire the system; (iv) adding or removing equipment modules requires little or no building redesign or modification, thereby reducing costs and complications associated with changing the size and/or capacity of a system (i.e., adding or removing compressor/dryer units) after the initial installation; (v) the number of air-cooled compressor units or other industrial equipment installed in a single building/facility can be substantially greater than current facilities, thereby allowing for much larger system capacities with less complicated and more flexible ventilation systems; (vi) significant energy savings is realized due to the recovery of the hot discharge air in winter and due to the shutting off of one of the 15 HP fans under certain operating conditions; and (vii) remote adjustments of the ventilation system are possible, as is full manual control when needed. Additionally, the facility has the appearance of an actual, integrated structure or building and not a trailer or series of trailers and can be expanded or contracted by adding or removing individual modules to or from the existing structure without reconstructing the entire facility.

[0038] While the present invention has been illustrated by the description of exemplary embodiments thereof, and while the embodiments have been described in certain detail, it is not the intention of the Applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Therefore, the invention in its broader aspects is not limited to any of the specific details, representative devices and methods, and/or illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of the applicant's general inventive concept.

CLAIMS

What is claimed:

(1) An industrial system, comprising:

(a) a plant or factory for performing an industrial process; and

(b) a modular industrial equipment facility connected to the plant or factory, wherein the modular equipment facility further comprises:

(i) a plurality of internal modules, wherein each of the internal modules further comprises at least one substantially non-weight bearing external wall;

(ii) a plurality of terminal modules for use with the plurality of internal modules, wherein each of the terminal modules further comprises at least two external substantially non-weight bearing walls; and

(iii) wherein the internal modules and terminal modules are arranged to form an integrated structure.

(2) The industrial system of claim 1, further comprising a computerized monitoring and control system in communication with the modular equipment facility, wherein the monitoring and control system further comprises: a local component within the facility and a remote component separate from the facility and in communication with the local component.

(3) The industrial system of claim 2, wherein the local component is located in one of the internal modules or in one of the terminal modules, and further comprises computer hardware and software for operating the equipment facility.

(4) The industrial system of claim 1, wherein the plant or factory is an automotive manufacturing facility.

(5) The industrial system of claim 1, wherein the modular equipment facility is an air compressor facility, and wherein the air compressor facility is substantially automated and provides a substantially continuous supply of compressed air to the plant or factory.

(6) The industrial system of claim 1, wherein each of the internal modules further comprises an air compressor/dryer, and wherein each internal module is configured to operate the air compressor/dryer either in combination with or independent of the other air compressors.

(7) The industrial system of claim 1, wherein each of the modules further comprises pre-wired electrical lines and connections.

(8) The industrial system of claim 1, wherein each of the internal modules further comprises air-handling components, and wherein the air-handling components further comprise: filters; fans; dampers; and air ducts.

(9) The industrial system of claim 1, wherein at least two of the plurality of terminal modules each further comprise at least one vent for providing ventilation to the interior of the modular industrial equipment facility.

(10) The industrial system of claim 1, wherein each of the internal modules and each of the terminal modules is adapted to be crane lifted.

(11) The industrial system of claim 1, wherein the modular industrial equipment facility may be modified by adding modules or removing modules.

(12) An industrial equipment facility, comprising:

(a) a plurality of preassembled, portable equipment modules, wherein the plurality of preassembled, portable equipment modules further comprises:

(i) a plurality of internal equipment modules, wherein each of the internal equipment modules further comprises at least one substantially non-weight bearing external wall; and

(ii) a plurality of terminal modules for use with the plurality of internal equipment modules, wherein each of the terminal equipment modules further comprises at least two external substantially non-weight bearing walls; and

(b) wherein the plurality of preassembled, portable equipment modules are arranged to form a single, integrated structure.

(13) The industrial equipment facility of claim 12, further comprising a computerized monitoring and control system in communication with the equipment facility, wherein the monitoring and control system further comprises: a component located within the facility and a component located remotely from the facility, wherein the remotely located component is in communication with the control component located within the facility.

(14) The industrial equipment facility of claim 13, wherein the local control component is located in one of the internal modules or in one of the terminal modules, and further comprises computer hardware and software for operating the equipment facility.

(15) The industrial equipment facility of claim 12, wherein each of the internal equipment modules further comprises an air compressor/dryer unit, and wherein each air compressor/dryer unit operates either in combination with or independent of the other air compressor/dryer units.

(16) The industrial equipment facility of claim 12, wherein each of the modules further comprises pre-wired electrical lines and connections for connecting to the other modules.

(17) The industrial equipment facility of claim 12, wherein each of the internal modules further comprises air-handling components, and wherein the air-handling components further comprise: filters; fans; dampers; and air ducts.

(18) The industrial equipment facility of claim 12, wherein at least two of the plurality of terminal equipment modules each further comprises at least one vent for providing ventilation to the interior of the industrial equipment facility.

(19) The industrial equipment facility of claim 12, wherein each of the internal equipment modules and each of the terminal equipment modules are adapted to be crane lifted.

(20) The industrial equipment facility of claim 12, wherein the industrial equipment facility may be modified by adding equipment modules or removing equipment modules.

(21) An industrial equipment facility, comprising:

(a) a plurality of individual equipment modules; wherein the equipment modules are arranged to form an integrated structure;

(b) an industrial air compressor/dryer installed in at least two of the individual equipment modules, wherein each air compressor/dryer draws cooling air and compressor intake air from the environment outside of the industrial equipment facility;

(c) a plurality of air-handling components connected to or in communication with each of the at least two industrial air compressor/dryers; wherein the plurality of air-handling components further comprises: coolers, dampers, fans, air ducts, and temperature sensors;

(d) a computerized monitoring and control system in communication with the air-handling components in each equipment module and each air compressor/dryer for monitoring and controlling the operation of each air compressor/dryer; and

(e) wherein the computerized monitoring and control system operates each air compressor/dryer unit in combination with or independent of the other air compressor/dryers.

(22) The industrial equipment facility of claim 21, further comprising electric switchgear connected to the at least two industrial air compressor/dryers; and a source of electric power connected to the electric switchgear.

(23) The industrial equipment facility of claim 21, wherein the computerized monitoring and control system further comprises a component located within the facility and a component located remotely from the facility, wherein the remotely located component is in communication with the component located within the facility.

(24) The industrial equipment facility of claim 22, wherein the communication between the component located within the facility and the component located remotely from the facility is wireless.

(25) A method for constructing, installing and operating an industrial equipment facility, comprising:

(a) fabricating a plurality of internal equipment modules, wherein each of the internal modules further comprises at least one substantially non weight-bearing external wall;

(b) fabricating a plurality of terminal equipment modules, wherein each of the terminal modules further comprises at least two substantially non weight-bearing external walls;

(c) placing industrial equipment within some or all of the internal modules and the terminal modules;

(d) transporting the internal modules and the terminal modules to a predetermined site;

(e) arranging the internal modules and terminal modules at the predetermined site to form an integrated structure; and

(f) connecting the industrial equipment within the equipment modules to a computerized monitoring and control system, wherein the computerized system further comprises: a component located within the facility and a component located remotely from the facility, wherein the remotely located component is in communication with the component located within the facility.

(26) The method of claim 25, further comprising the step of installing 110 V or single phase electric lines and connections into each equipment module prior to transporting the module.

(27) The method of claim 25, further comprising the step of installing air-handling components in the internal modules, wherein the air-handling components further comprise: filters; fans; dampers; and air ducts.

(28) The method of claim 25, wherein the industrial equipment further comprises air compressor/dryers and electrical switchgear.

(29) The method of claim 25, wherein the remote component further comprises a remote access device.

(30) The method of claim 25, wherein the control system further comprises at least one camera installed within the industrial equipment facility for visually monitoring the industrial equipment.

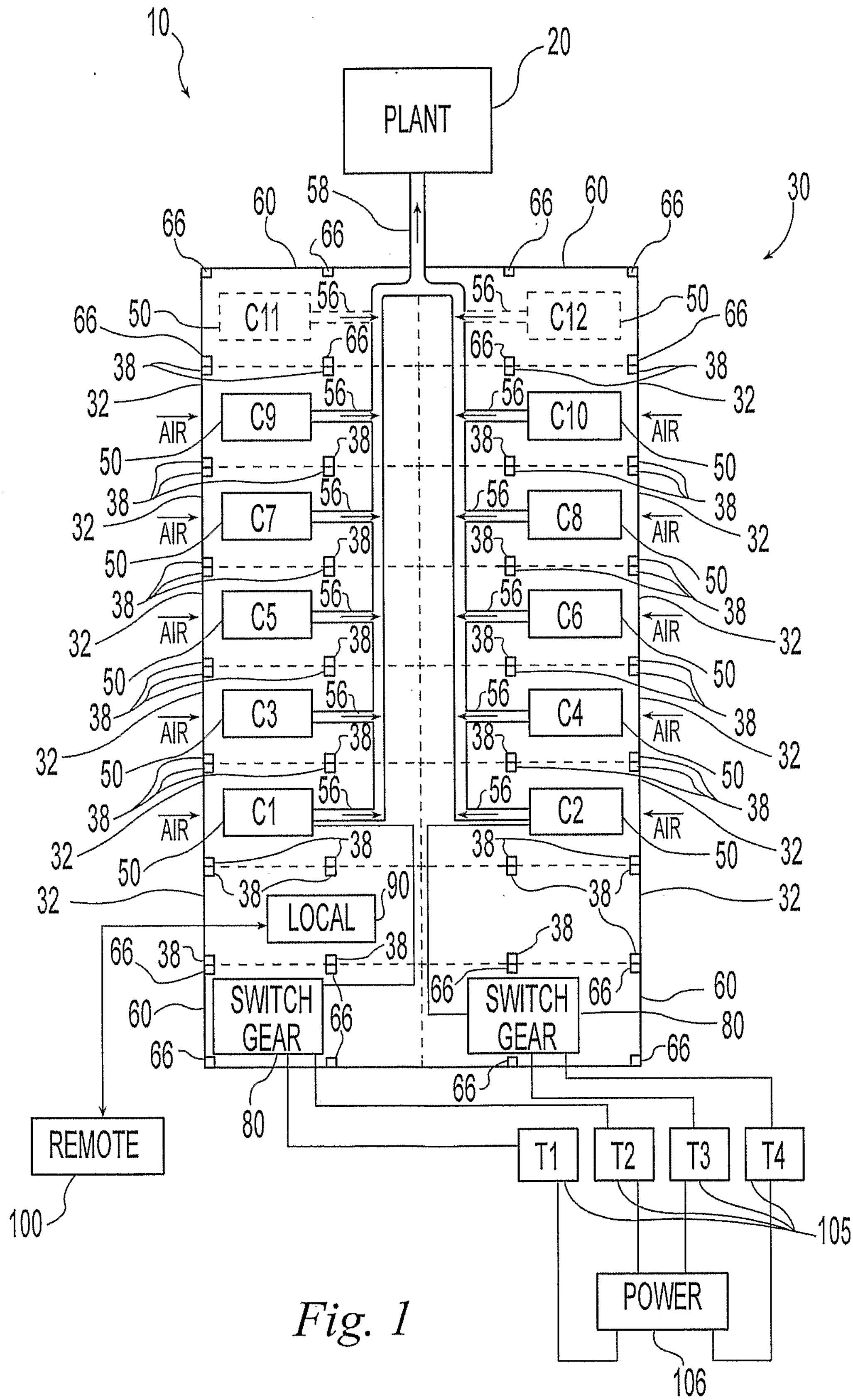

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Fig. 1

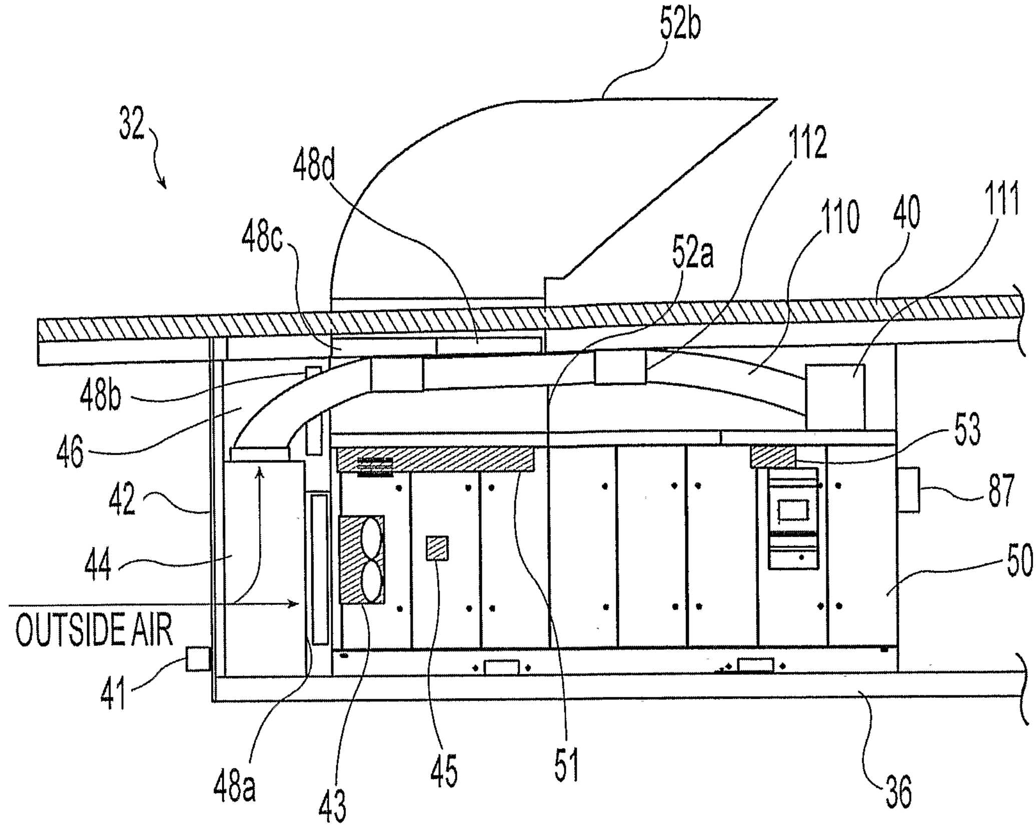
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Fig. 2

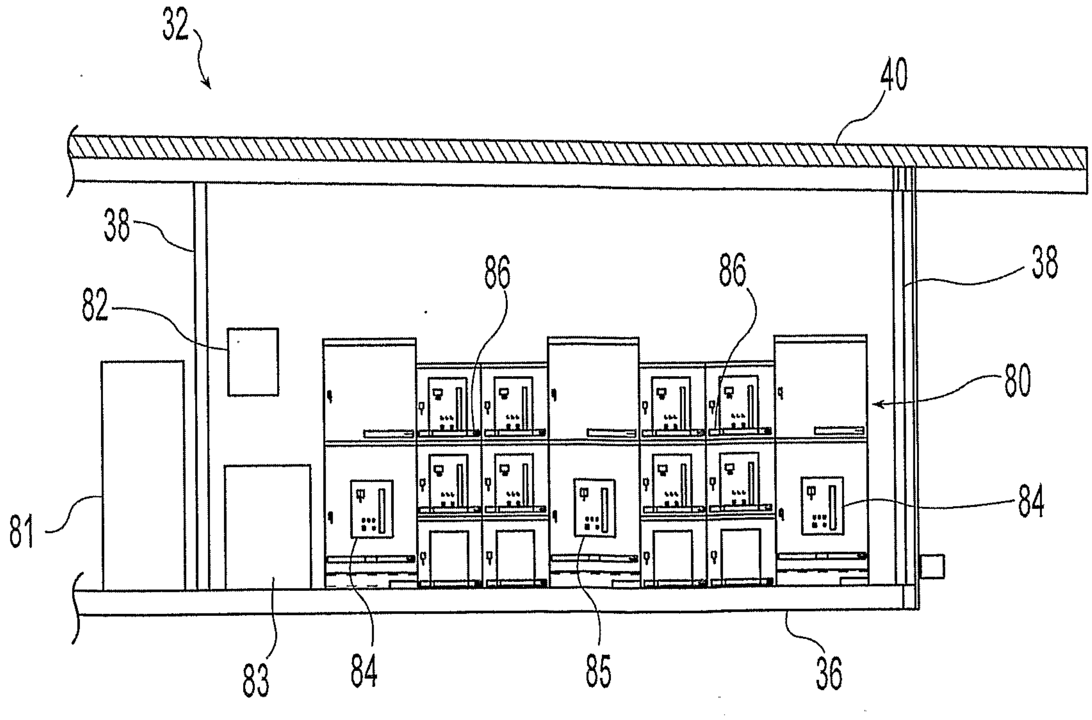
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Fig. 3

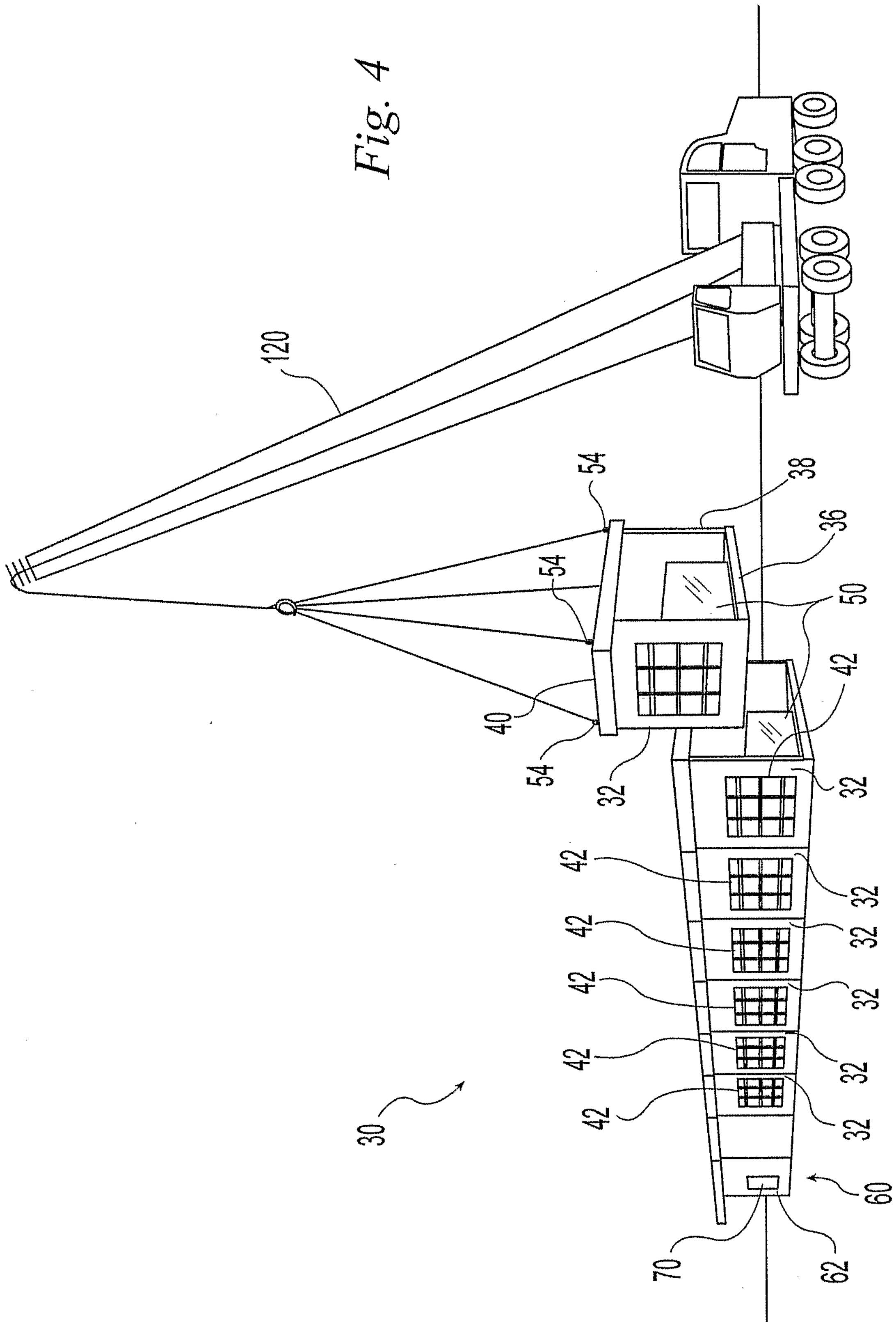
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Fig. 4

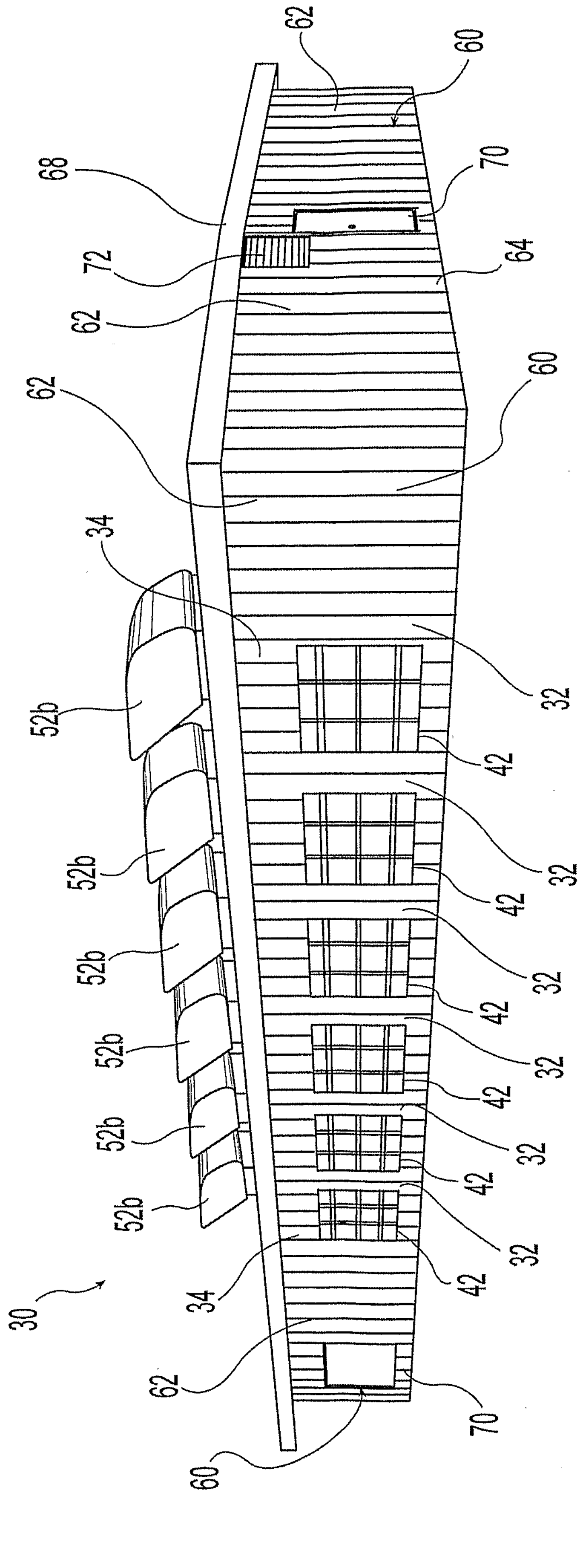

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Fig. 5

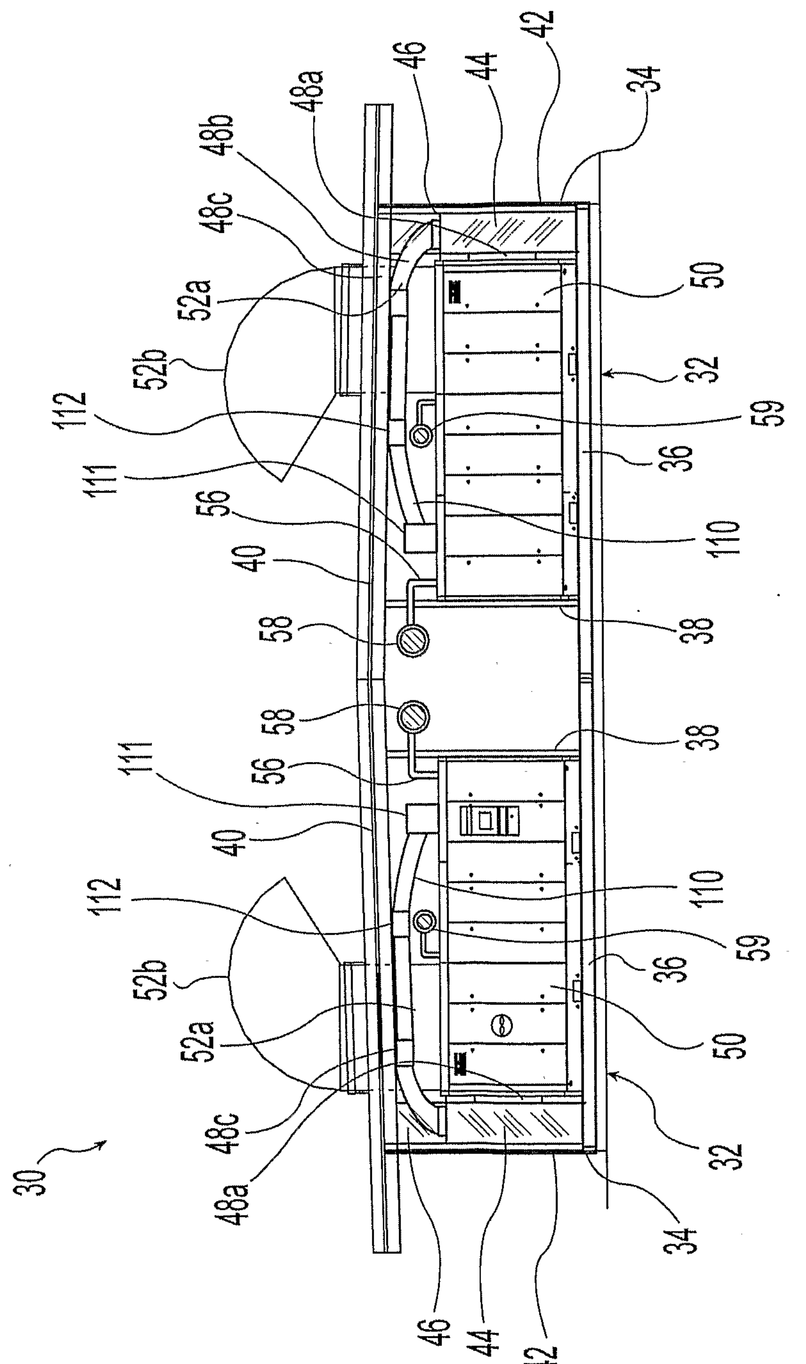
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Fig. 6

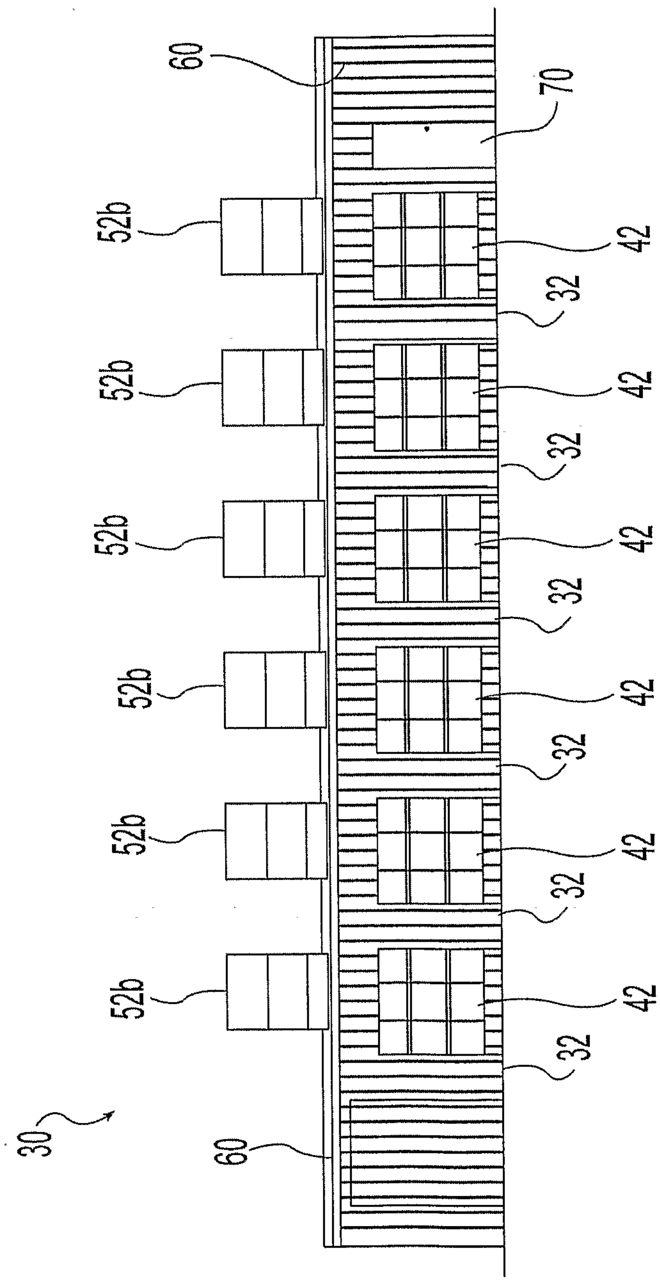
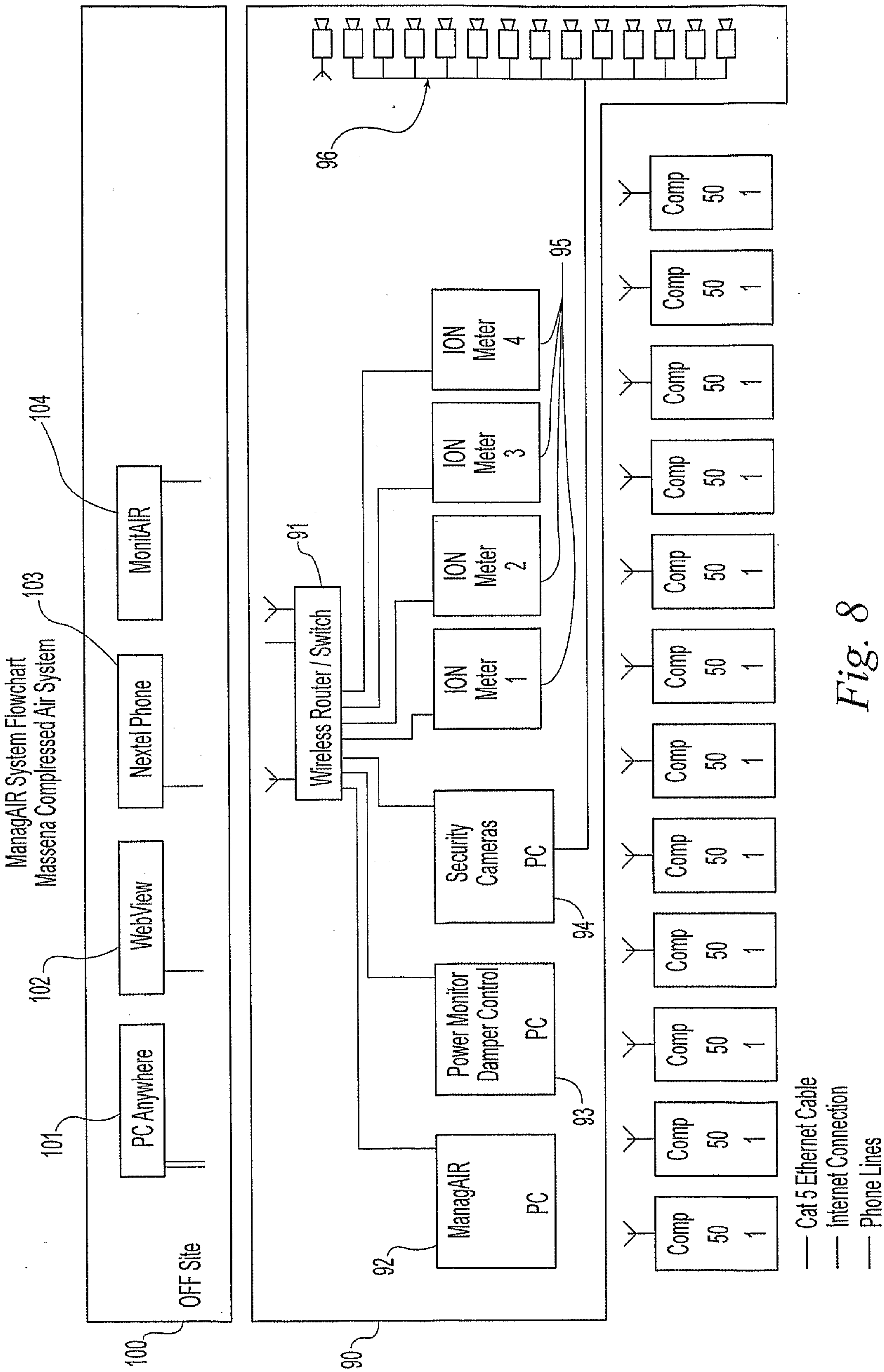


Fig. 7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Nextel Phone
MonitAIR
OFF Site
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101
102
103
104
ManagAIR PC
Power Monitor Damper Control PC
Security Cameras PC
Wireless Router / Switch
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ION Meter 2
ION Meter 3
ION Meter 4
Comp 50 1
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Cat 5 Ethernet Cable
Internet Connection
Phone Lines

Fig. 8