Technology Review:

1-U Chassis Thermal Management, 2004-2012

Qpedia continues its review of technologies developed for electronics cooling applications. We are presenting selected patents that were awarded to developers around the world to address cooling challenges. After reading the series, you will be more aware of both the historic developments and the latest breakthroughs in both product design and applications. We are specifically focusing on patented technologies to show the breadth of development in thermal management product sectors. Please note that there are many patents within these areas. Limited by article space, we are presenting a small number to offer a representation of the entire field. You are encouraged to do your own patent investigation. Further, if you have been awarded a patent and would like to have it included in these reviews, please send us your patent number or patent application.

In this issue our spotlight is on 1-U chassis thermal management. There is much discussion about its deployment in the electronics industry, and these patents show some of the salient features that are the focus of different inventors.

FLOW-THROUGH COOLING IN THE ROUND SYSTEM

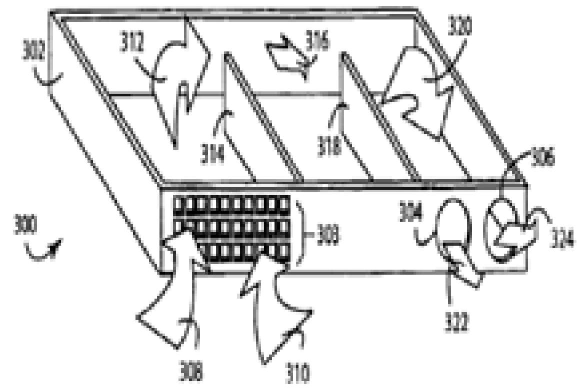
US 6,704,196 B1, Wilson, J.

Computer-based network equipment is typically mounted in so-called RETMA equipment racks. Such racks are 19″ wide and the vertical spaces are measured in units of 1.75″, e.g., "1U". Rack space is typically at a premium, especially in modem farm sites that are rented by the phone companies. So packaging equipment designs into the smallest vertical space can result in tremendous economic savings.

Unfortunately, packaging a computer-based piece of network equipment into a 1U-space works against being able to adequately cool the electronics inside. The large footprint, typically 17″ by 28″, can be a challenge to force air through when CPU-boards, memories, disk drives, and power supplies are all stuffed into a vertical space only 1.75″ high.
In recent years, high-performance Intel and AMD microprocessors have required rather large heatsinks and associated forced-air cooling fans.

PATENT NUMBER	TITLE	INVENTORS	DATE OF AWARD
US 6,704,196 B1	FLOW-THROUGH COOLING IN THE ROUND SYSTEM	Rodrigues, L., et al.	Mar 9, 2004
US 2004/0207981 A1	ELECTRONIC CHASSIS AND HOUSING HAVING AN INTEGRATED FORCED AIR COOLING SYSTEM	Gorenz, H., et al.	Oct 21, 2004
US 8,310,832 B2	SIDE-EXHAUST COOLING SYSTEM FOR RACK MOUNTED EQUIPMENT	Vanderveen, A., et al.	Nov 13, 2012

Fig. 3



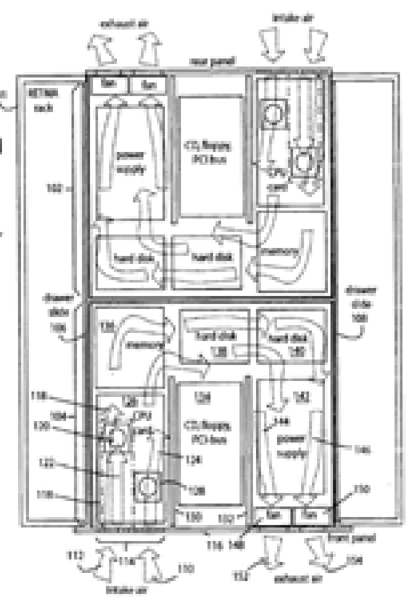
Many of these CPU-cooling devices need more vertical room than is available in a 1U-space. The ones that will fit in such a confined space need excellent cold-air intake and sufficient air volume movement to keep temperatures under control. The system 100 mounts, for example, inside a standard 19″ RETMA-rack 101. A pair of rear and front "1U" high chassis racks 102 and 104 are horizontally bound together by a pair of drawer slides 106 and 108. Each chassis rack 102 and 104 is separately fully enclosed and both have independent forced-air cooling systems. For example, the front chassis rack 104 draws-in intake cool air 110 and 112 through slots 114 in a front panel 116. The intake cool air 112 becomes airflow 118 that is channeled directly to a rear CPU fan and heatsink 120. The intake cool air 110 becomes airflows 122 and 124 that first pass over a processor board 126 that includes a front CPU fan and heatsink 128.

A pair of floor-to-ceiling partitions 130 and 132 direct an airflow back around a bay 134 over a memory 136, hard disks 138 and 140, and then past a power supply 142. The bay 134 provides space for a CD-ROM, floppy, PCI-bus, or other subassembly. The length to which the partitions 130 and 132 extend toward the back is adjusted experimentally to result in good, non-turbulent airflow around the rear components.

The power supply 142 is typically the hottest component inside chassis rack 104, so it very much heats airflows 144 and 146. These are immediately exhausted by fans 148 and 150 into exhaust-air flows 152 and 154.

The internal airflows and construction of chassis rack 102 is very similar to chassis rack 104, but faces the opposite direction. This allows the full horizontal footprint in the vertical 1U-space to be filled by equipment, e.g., network servers and routers. Such footprint is, in one instance, 17″ by 28″. Each chassis rack 102 and 104 is independent, and one can be opened and serviced while the other is still operating normally.

Fig. 1



A chassis top assembly 200 includes a flat lid 202 fitted with a ductwork 204. An intake port 206 ducts to an exhaust port 208 that sits immediately above a fan. For example, a fresh-air flow 210 is drawn in, airflow 118 by fan 120 through intake slots 114. It exits as airflow 212 directly onto the CPU fan and heatsink 120.

A matching chassis 300 has an enclosure 302 with a number of air intake ports 303. A pair of exhaust ports 304 and 306 allow heated heat to escape to

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Kryotherm
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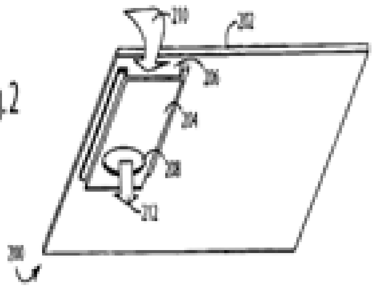


the environment. A fresh air inflow 308 is directed into ductwork 204. Another fresh air inflow, 310 flows internally as airflows 312, around a first floor-to-ceiling partition wall 314. A bypass flow 316 continues around back and turns forward past a second floor-to-ceiling partition wall 318. An airflow 320 is exhausted, as airflows 322 and 324.
The sequence of how cooling air visits the internal components is important. The power supply usually runs the hottest, and it should be the last item visited by the in-the-round circulating forced-air before being exhausted out the front panel. The CPU's on the processor boards are very critical, and one of the most expensive components in the whole system. So these are preferably placed close to the front-panel air intakes. The usual Intel and AMD microprocessor CPU-heatsink has fins that are preferably oriented orthogonal to the airflow entering from the front panel intake slots. A small fan is customarily mounted atop such heatsinks. At least one of these CPU fans and heatsinks receives a cool air intake ducted directly in from the front panel slots through a ductwork fabricated in the chassis lid.

A variable number of the air intake ports 303 are deliberately blocked to improve cooling. Adhesive film tape can be used. Too many, or the wrong ports 303 being opened can result in ineffective airflow and stagnation, which leads to spot overheating. The particular ones and numbers of air intake ports 303 to block-off are empirically arrived at by replacing lid 202 with a clear plastic material. Smoke is then introduced into airflows 308 and 310 and the internal circulation is observed. Various combinations of blockages with film tape are tried on air intake ports 303 until temperature probe measurements confirm optimal and uniform cooling of internal components within chassis 302. Such patterns of blockages can then be repeated in volume manufacturing.

ELECTRONIC CHASSIS AND HOUSING HAVING AN INTEGRATED FORCED AIR COOLING SYSTEM

2004/0207981 A1, Gorenz, H., et al.

The present invention relates generally to rack-mounted electronics chassis systems and, more particularly, to a chassis and housing having an integrated forced air cooling system that preserves the front panel and display appearance generally associated with a rack-mounted electronics chassis system.

There exists a trend toward a more compact chassis for a cable modem termination system (CMTS). The reduction in the overall size of the chassis causes two distinct problems. One, a reduction in the size of the chassis requires a corresponding reduction in the size of the front panel and display module. Most chassis manufacturers use variations of material finish (i.e. paint), printed logos, labels, etc. on the front panel to differentiate their products. In addition to reducing the front panel billboard space, the reduction reduced the available space for logos, labels, I/O connectors, user displays, user controls, and cooling vents. Accordingly, there exists a need for a reduced size front panel that is equally functional. Larger chassis systems are able to maintain the desired operating temperature by having more space for fans and vents located on the exterior walls. However, a reduction in the size creates an associated reduction in room for such airflow features.

Chassis cooling systems in the prior art that provide for front-to-back cooling typically feature 40 mm axial fans that do not have the strength or capacity to pull and/or push air through the high static pressure for a 1 rack-unit (herein after

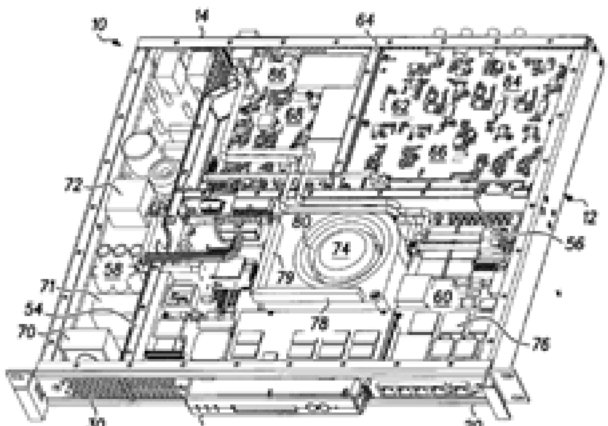


FIG. 5

“1U”) chassis. Existing chassis designs have placed the axial fans adjacent to the front or rear panels which is not feasible for a 1U chassis that requires substantial area for I/O connectors, user interface, and various other components.

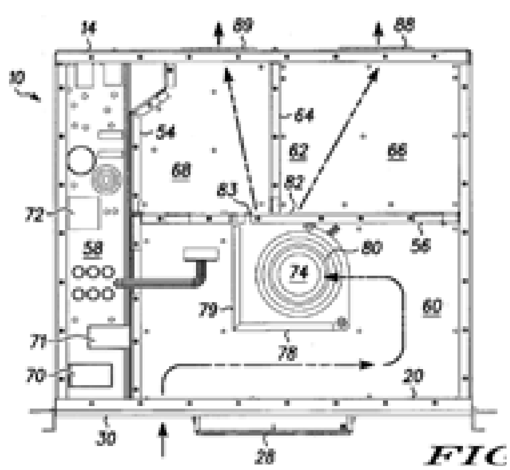
The prior art also discloses cooling systems for conventionally-sized chassis (e.g. 2U or larger) with centrally located blowers designed to create a low pressure on one side of an internal wall, and high pressure on the other side to achieve front-to-back cooling. However, the prior art centrally located blowers do not direct the path of air intake or divide the airflow exiting the blower.

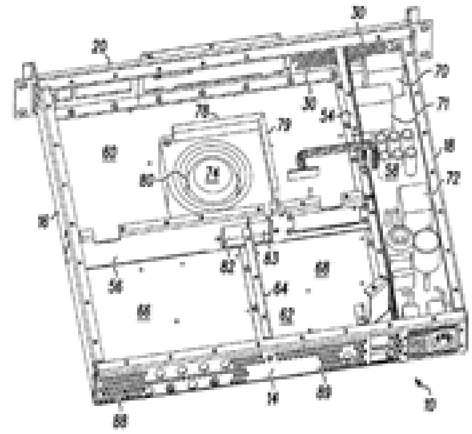
The invention provides a chassis for housing printed circuit boards comprising: a housing having a top, bottom, front, back, left and right side walls, and having a height, measured from the bottom wall to the top wall, that is equal to a 1 rack-unit. The front wall includes an inlet vent, a display module, and a jack and the back side wall includes an exhaust vent. A centrifugal blower is provided inside the chassis housing to establish the air flow pattern. A front wall face plate overlies the inlet vent, display module and jack, respectively so the inlet vent are arranged in parallel, overlapping but offset planes.

The ensuing detailed description provides preferred exemplary embodiments only, and is not intended to limit the scope, applicability, or configuration of this invention. Rather, the ensuing detailed description of the preferred exemplary embodiments will provide those skilled in the art with an enabling description for implementing the invention. It being understood that various changes may be made in the function and arrangement of elements without departing from the spirit and scope of the invention as set forth in the appended claims.

Chassis 10 for a single “rack-unit” which is commonly referred to as a 1RU cable modem termination system (CMTS). Under current industry standard a “rack-unit” equals approximately 1.75 inches, 2RU equals approximately 3.5 inches and etcetera. Chassis 10 includes a base 12 having a rear 14, left 16 and right 18 side walls, a front panel 20, and a top 22, combined to form the base enclosure or housing 24. The front panel 20 includes a display module slot 26, an air inlet vent 30 and jack slots 32, 33. In this embodiment, the front panel 20 includes left and right handles, 36 and 37 respectively, to aid the user with inserting and removing the chassis 10 from an industry standard communications infrastructure equipment rack. A display module 28 is detachably secured to the front panel 20 to house a module such as an LCD, and functional switches 27, such scroll, enter select, abort and mode selection, and displays 29, such as LEDs for indicating status or warning signals (thermal conditions or power) for various modules and functions within the chassis.

The preferred face bar 38 is detachable from the front panel 20 to ease access for service and cleaning. The face bar 38 may display a logo on the billboard surface 40. The face bar 38 includes a slot 39 for the display module 28 and cut out 41 around jack slots 32 and 33. The face bar 38 also serves to cover and conceal the air inlet vent 30. In this embodiment, the face bar 38 is removably secured to the front panel 20 by outwardly biased exterior tabs, 44 and 45, which engage behind a respective handle 36 or 37. The face bar 38 is additionally secured by mounting clips, 48 and 49 which mate to the display module with a respective tab, 50 or 51. An air intake slot 52 is formed by spacing the face bar 38 when it is secured to the front panel 20. The air intake slot 52 permits air from above and below the face bar 38 ingress into the air inlet vent 30. The design of the face bar 38 accommodates the preferred functional requirements for the front of the chassis 10 while maintaining an attractive appearance.





An internal view of the chassis 10 with the face bar 38 and top plate 22 removed. Chassis 10 is preferably divided into three (3) internal chambers, 58, 60, and 62, by an intake dividing wall 54 and a central dividing wall 56. In this embodiment, the chambers include a power supply circuitry chamber 58, a digital printed wiring assembly (PWA) chamber 60, and a radio frequency ("RF") PWA chamber 62. The RF PWA chamber 62 may be further divided by an exhaust dividing wall 64 into a receiving PWA chamber 66 and a transmitting PWA chamber 68. The RF PWA chamber 62 may be divided into additional chambers by the use of exhaust dividing walls.

The intake air flowing into the air inlet vent 30 initially enters the power supply circuitry chamber 58 and the digital PWA chamber 60. One or more axial fans 70, 71 secured to the base plate 12 and located within the power supply circuitry chamber 58, sweep air from the front of the chamber 58 to the rear of the chamber 58 to cool the internal circuitry of the chamber 58, including power supply circuitry 72. One example of an axial fan is the Panasonic model 4Bko4f.

The path of air entering the digital PWA chamber 60 is influenced by the centrifugal blower 74. The centrifugal blower 74 is centrally located within the digital PWA chamber 60 with its blower facing up. One acceptable blower is available from Comair Rotron as model BD12B7, also known as Biscuit (r)

DC. This unit occupies a footprint of no more than 4.75 inches squared and has a height or thickness of 1.25 inches. A digital PWA 76 is located within the digital PWA chamber 60. The digital PWA 76 is the most temperature sensitive component within the chassis 10, and accordingly requires a sufficient flow of air to maintain its operating temperature. One or more baffles 78, 79, may be secured to the top plate 22 to direct air flowing through the digital PWA chamber 60 over as much of the circuitry as possible. In this embodiment, the baffles are made of foam and are carried by the top plate 22. By placing the baffles 78, 79 in an L-shape, the centrifugal blower 74 pulls the intake air in a non-linear path through the circuitry within the digital PWA chamber 60. Of course, the baffles 78, 79 may be placed in the required configuration for the desired airflow to cool each particular circuit design.

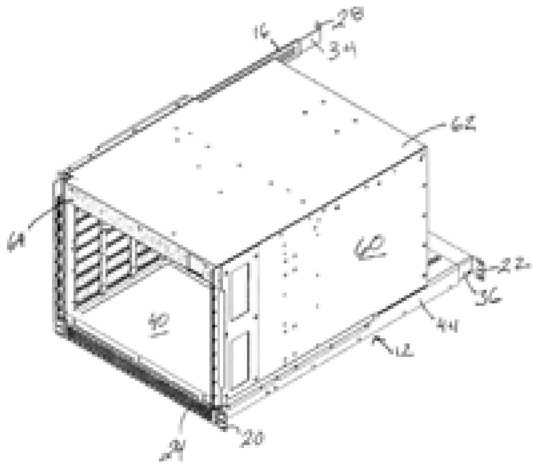
The centrifugal blower 74 pulls the intake air into its intake port 80. The blower intake port 80 faces upward to move the hotter air outwardly through the blower exhaust ports 82, 83 and into the RF PWA chamber 62. Air exiting the centrifugal blower 74 is forced into the RF PWA chamber 62 at a high velocity to cool receiving PWA 84 and transmitting PWA 86. Air exiting the centrifugal blower 74 may be separately directed by wall 64 into the receiving PWA chamber 66 and transmitting PWA chamber 68. The exhaust dividing wall 64 may also be located to direct a higher volume of air to either the receiving PWA chamber 66 or transmitting PWA chamber 68. The final air egress from the RF PWA chamber 62 is through one or more exhaust vents 88, 89 located on the rear wall 14. The use of a dividing wall 64 and multiple ports on the exhaust side of the blower 74 allows the cooling system of the present invention to effectively cool many different components of the internal circuitry.

Side-exhaust cooling system for rack mounted equipment US 8,310,832 B2, Vanderveen, A., et al.

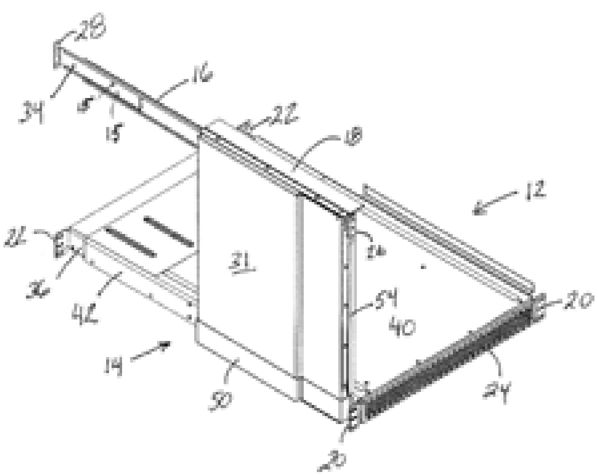
SIDE-EXHAUST COOLING SYSTEM FOR RACK MOUNTED EQUIPMENT

US 8,310,832 B2, Vanderveen, A., et al.

A generally box-shaped exhaust shelf configured for mounting in a rack mount enclosure, generally adjacent a parallelepiped chassis having a height, a width and a depth, the exhaust shelf comprising a top panel, an opposing bottom panel spaced apart from the top panel to define an interior space, a first side panel, an opposing second side panel having at least one opening, a front panel having at least one vent therein, and a rear panel having at least one vent therein, a top rail adapted for mounting in the rack mount enclosure at a rack position that is remote from, above and generally parallel to the second side of the exhaust shelf; and, a side duct having an outer panel, a bottom panel, a front panel and a rear panel which panels define an interior plenum open towards the side of the duct opposite the outer panel thereof, the duct connected between the top rail and the second side panel of the exhaust shelf and in fluid communication with the interior of the exhaust shelf such that air within the plenum may move from the side duct into the interior space of the exhaust shelf and out through the at least one vent in the front panel and the at least one vent in the rear panel of the exhaust shelf and wherein the side duct is sized such that the distance between the top of the top rail and the top panel of the exhaust shelf does not exceed the height of the chassis.



A side-exhaust cooling system 10 may comprise exhaust shelf 12, side duct 14 and top rail 16. Exhaust shelf 12 may be a box-like structure comprising six sides—top surface 40, an opposing bottom surface, a right side panel 42, an opposing left side panel 44, a front panel and an opposing rear panel comprised of grill 24 for exhausting warm air towards the back of a rack-mount enclosure in which cooling system 10 is mounted. Exhaust shelf 12 may comprise sliding extension 36 which telescopically extends from the front side of exhaust shelf 12 to accommodate mounting in rack mount enclosures of varying depth. For rack mounting, exhaust shelf 12 may comprise rear mounting tabs 20 and front mounting tabs 22. Top rail 16 is configured to mount between one front rail of a rack mount enclosure and the opposing rear rail of the enclosure. Top rail front mounting tab 28 may be secured to the front rail and rear mounting tab 26 may be secured to the rear rail. Top rail 16 may comprise sliding extension 34 which telescopically extends from the front side of top rail 16 in order to accommodate mounting in rack mount enclosures of varying depth. Screws 15 may be provided to lock extension 34 at a desired point. It will be appreciated by those skilled in the art that a sliding extension may additionally or alternatively be provided in the rear section of top rail 16.



Side duct 14 connects top rail 16 and exhaust shelf 12. Side duct 14 is a generally box-shaped structure open on at least a portion of its inner side. Side duct may comprise top air seal 18, front side air seal 52 and opposing rear side air seal 54 all of which are connected to outer panel 31 to form side duct plenum 30. Side duct 14 may be sized to clear the rack vertical rails and Power Distribution Units (PDUs) installed in the side portions of the rack mount enclosure to be used.

Lower portion 50 of side duct 14 is in fluid communication with the interior of exhaust shelf 12. This may be accomplished by providing one or more openings in right side panel 42 of exhaust shelf 12 such that air within side duct plenum 30 may flow into the interior cavity of exhaust shelf 12 and exit through vent grill 24 thereby maintaining the desired front-to-back cooling airflow pattern within an enclosure notwithstanding a side air exhaust from a chassis mounted on shelf 12.

The components of cooling system 10 may be constructed of any suitable material. Stamped sheet metal is one, particular preferred material. It is not necessary that all components comprising cooling system 10 be fabricated of the same material. By way of example, top rail 16 and exhaust shelf 12 may be formed of sheet metal while side duct 14 may be thermoformed plastic or composite material.

Chassis 60 comprises integral, top exhaust plenum 62 having exhaust vent 64. Chassis 60 may be equipped with mounting flanges for conventional 4-rail rack mounting. Alternatively, chassis 60 may be supported entirely on exhaust shelf 12.

Chassis 60 may comprise fans or blowers (not shown) configured to move air into duct 14 and exhaust through the upper portion of chassis 60 out through vent 64 in addition to shelf 12 and out through vent 24. As is well-known in the art, air within chassis 60, heated by contact with power-dissipating electrical equipment, tends to rise due to convention. This heated air enters duct 14 and then exhaust plenum 62 and is fan-forced out of the chassis through grill 64, in addition to entering shelf 12 and through grill 24.

Chassis 60 may contain equipment which has a fan-forced exhaust from an opening in that portion of side 70 of chassis 60 which is adjacent to side duct 14. This exhaust air collects in plenum 60 and is pushed by the positive pressure of the cooling fans within chassis 60 into exhaust shelf 12 and out grill 24. Alternatively and/or additionally, one or more openings in top rail 16 may align with corresponding openings in side 70 of chassis 60 such that air within top vent 62 can enter plenum 30 (due to positive pressure within vent 62) and be exhausted through exhaust shelf 12.

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