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NOTICE OF ENTITLEMENT
(To be filed before acceptance)

We, TELEFONAKTIEBOLAGET LM ERICSSON


of, S-126 25 Stockholm, SWEDEN

being the applicant in respect of Application No. 13297/95 state the following:-

The Persons nominated for the grant of the patent have entitlement from the actual inventors by assignment.

The persons nominated for the grant of the patent have entitlement from the applicants of the application listed in the declaration under Article 8 of the PCT by assignment.

By our Patent Attorneys,
WATERMARK PATENT & TRADEMARK ATTORNEYS


.....
L. J. Dyson
Registered Patent Attorney


.....
(Date)



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- (54) Title
A METHOD AND DEVICE FOR COOLING IN CLOSED SPACES
- International Patent Classification(s)
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- (56) Prior Art Documents
US 4535386
- (57) Claim

1. A method for cooling devices such as the heat-generating components of telecommunications equipment located in a closed space, characterized by placing in the closed space a cooling unit, which functions to generate a displacing flow of cool air at low speed along the floor of the closed space and functions to draw by suction heated air at low speed along the ceiling of the closed space, wherein for cooling the devices the displacing flow of cool air from the cooling unit is drawn by suction from beneath, ~~achieving~~ ^{achieving} contact with the devices to be cooled and the heated air generated by the devices exits from above.

2. A cooling system for cooling devices such as heat-generating components of telecommunications equipment located in a closed space, characterized in that a cooling unit (1) is installed in said closed space (3), in that the cooling unit (1) is intended to deliver a displacing cold air flow at a low speed along the floor of the closed space (3), in that the cooling unit (1) is

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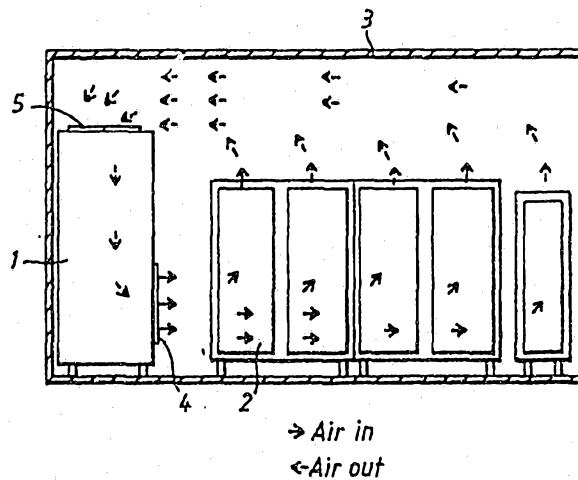
intended to draw by suction a heated air flow at a low speed along the ceiling of the closed space(3), in that for cooling the devices (2) are intended to draw by suction cold air from the displacing cold air flow from beneath and in that the devices (2) are intended to deliver heated air from above to the heated air flow.



<p>(51) International Patent Classification ⁶ : H05K 7/20, G12B 15/04</p>	<p>A1</p>	<p>(11) International Publication Number: WO 95/17805 (43) International Publication Date: 29 June 1995 (29.06.95)</p>
<p>(21) International Application Number: PCT/SE94/01223 (22) International Filing Date: 19 December 1994 (19.12.94) (30) Priority Data: 9304264-6 22 December 1993 (22.12.93) SE (71) Applicant (for all designated States except US): TELEFONAK- TIEBOLAGET L M ERICSSON [SE/SE]; S-126 25 Stock- holm (SE). (72) Inventors; and (75) Inventors/Applicants (for US only): STÅHL, Lennart [SE/SE]; Östa-viksvägen 17, S-640 61 Stallarholmen (SE). KARSTRÖM, Anders [SE/SE]; Bäverdammsgränd 132-III, S-124 63 Bandhagen (SE). (74) Agent: CEDERHOLM, Per, H.; L A Groth & Co. KP, P.O. Box 6107, S-102 32 Stockholm (SE).</p>		<p>(81) Designated States: AU, BR, CA, CN, FI, HU, JP, NO, RU, UA, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published With international search report. In English translation (filed in Swedish).</p>

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(54) Title: A METHOD AND DEVICE FOR COOLING IN CLOSED SPACES



(57) Abstract

To be able to cool telecommunications equipment in rack cabinets located in closed spaces in an energy-saving way with high operational reliability and little need of maintenance and with few movable parts there has been developed a method and a device, in which displacing air distribution and gravity flow are combined and applied for cooling of said equipment. Cold intake air is distributed at low speed, i.e. it displacingly flows out into a room towards the racks (2). The cold air is then fed to the racks in order to cool heat-producing components placed therein. The heated air is then discharged from the upper side of the racks and is recirculated at low speed so as to avoid turbulence at the intake of the refrigerating machine.

A METHOD AND DEVICE FOR COOLING IN CLOSED SPACES**TECHNICAL FIELD**

5 The present invention relates to a method and a unit for cooling devices that are installed in a closed space, for instance telecommunications equipment.

DESCRIPTION OF THE BACKGROUND ART

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It is known that the principle of natural convection can be applied to cool vertical surfaces by heating a cold medium to a lower density, ^{whereby} ~~wherein~~ underlying cold medium of higher density will force away the heated medium, causing it to rise. It is also known to distribute air by applying so-called air displacement flow principles. This type of flow functions in accordance with principles that are similar to the principle of natural convection, namely that cold air is heavier than warm air and will therefore take the lowest possible level. When the cold air is released immediately above a floor surface, the cold air will fall down onto the floor and force away air of higher temperature. It is usual to say that the cold air "runs out over the floor". One condition in this respect is that the air speed is low enough not to generate turbulence. Turbulence would cause the cold air to mix with ambient air and the resultant air flow would no longer be a displacing air flow.

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SUMMARY OF THE INVENTION

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With the intention of cooling telecommunications equipment in rack cabinets installed in closed spaces in an energy-saving manner with high operational reliability and little need of maintenance and with few movable parts, there has been developed a method and a unit for cooling telecommunications equipment installed in rack cabinets placed in closed spaces. The two principles earlier mentioned have been

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combined and have been applied in apparatus rooms in which cooling of equipment installed therein is necessary. When cooling and heating air, the amount of thermal energy that can be transported via the air per unit of time is determined primarily by two parameters, viz

- 5 - the amount of air cooled (or heated) per unit of time; and
- the drop (rise) in air temperature.

When a constant amount of thermal energy per unit time is to be transferred, these two parameters are inversely related: a large volume of air cooled (or heated) per unit time results in a small difference in air temperature, while a
 10 smaller volume of air cooled (or heated) per unit time will result in a larger temperature difference. The combination of displacement air distribution (distribution of cold air) and natural convection generated when the air is heated and thereby cooling heat-emitting objects is referred to here as displacement cooling.

15 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates a space in which cooling units and cooling equipment according to the invention are installed.

Fig. 2a illustrates the movement pattern of supply air in front of a rack cabinet.

Fig. 2b illustrates the passage of supply air through the rack, as seen from one
 20 side thereof.

Fig. 3 shows the layering of warm and cold air in front of and above the cabinet.

BEST MODE OF CARRYING OUT THE INVENTION

Fig. 1 shows schematically a cooling unit 1 and equipment 2 to be cooled placed in a space or room 3. The room is assumed to be airtight. The cooling
 25 unit 1 is constructed to take in



warm air at ceiling level, to cool the air and then to discharge the cooled air at a low speed at floor level. The front surface of the air outlet 4 is large, so as to obtain a low air speed. Return air heated in the room is drawn by suction into a unit intake 5 which is located as close as possible to the ceiling, and is cooled in the unit and returned to the room through the outlet 4, which is located as close to the floor as possible. The cold supply air is distributed at a low speed, i.e. the air disperses into the room to the vicinity of the cabinet in which the heat-generating components to be cooled are located. Cold supply air is now present in front of the cabinet and extends up from the floor to a level immediately beneath the uppermost point of the cabinet.

The air will pass along different routes as it is heated, these routes depending on the construction of the cabinet and the equipment housed therein. A common feature, however, is that cold supply air is drawn by suction into the interior of the cabinet and ^{thereby} ~~therein~~ cools the heat-generating components housed therein, while the warm air exits at the top of the cabinet. The exiting warm exhaust air is much warmer than the supply air in front of the rack and is also lighter in weight and will therefore endeavour to lie between the ceiling and the supply air, see Fig. 3. The warm exhaust air also moves at a speed which is sufficiently low to avoid turbulence. The warm air is drawn slowly back into the cooling unit by suction.

Fig. 2a illustrates air flowing in front of and into a cabinet. Normally, the front panels of the cabinet are perforated so as to enable supply air to enter the cabinet. Some of the air passes beyond the first cabinet to an adjacent cabinet, and so on. Fig. 2b illustrates supply air passing along the perforated front 6 of the cabinet and in against the heat-generating components 7 located in the cabinet, and then passing upwards through the cabinet. Fig.



2b also shows the routes followed by the air through the cabinet when the heat-generating components are seated on shelves 8. Although not necessary, these shelves may be constructed to guide the heated air towards a chimney means on the rear side of the cabinet. The principle is effective provided that the exhaust air is allowed to rise and to exit on the upper side of the cabinet. Neither is a perforated front absolutely necessary. However, it must be possible for supply air to enter the lower part of the cabinet structure in order to come into contact with the heat-generating components. Fans may also be mounted in the cabinet for the purpose of drawing in the cold supply air. In summary, three requirements are placed on the cabinet construction:

- 15 - Supply air shall be able to enter through the front or through the bottom of the cabinet.
- The air shall pass in contact with the heat-generating components housed in the cabinet and be heated thereby.
- 20 - The air shall be allowed to exit from the top of the cabinet.

When following the routes taken by the supply air from the front of the cooling unit up to the location of one of the shelves that support the heat-generating components inside the cabinet, as indicated by the arrows in Figs. 2a and 2b, it is found that the temperature remains unchanged along the whole of the route up to this location. The exhaust air exits from the top of the cabinet. The cold supply air 9 and the warm exhaust air 10 are kept separated from one another. The supply air disperses across the floor, from floor level to a point slightly up in front of the cabinet, whereas exhaust air collects beneath the ceiling. Fig. 3 illustrates the state of the two regions in relation to a cabinet seen from one side, and shows layering of warm and cold air in front of and above the cabinet.

The ~~displaced~~ distribution of supply air from the unit and



the exit of air from the cabinet with very low turbulence results in two air layers of mutually different temperatures and of low flow rates in mutually different directions, the cold air passing along the floor away from the cooling unit and into the vicinity of all cabinets in the room or space, and warm air flowing along the ceiling away from the cabinet and back to the cooling unit. In turn, this results in the supply air being distributed to all cabinets in the room and being drawn by suction away from all cabinets. In addition, the supply air will have the same temperature in front of all cabinets, provided that the temperature of the supply air exiting from the cooling unit is constant in time. This provides uniform and positive cooling of all cabinets located in the room.

The aforescribed construction also provides a highly efficient system, due to the fact that a large temperature difference between supply air and exhaust air in the unit combined with a relatively high supply air temperature and therewith vapourization temperature increases the efficiency of the compressor circuit, while the low rate of air flow enables relatively small and energy-lean fans to be used.

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CLAIMS

02-04-1996

1. A method for cooling devices such as the heat-generating components of telecommunications equipment located in a closed space, characterized by placing in the closed space a cooling unit, which functions to generate a displacing flow of cool air at low speed along the floor of the closed space and functions to draw by suction a heated air at low speed along the ceiling of the closed space, wherein for cooling the devices the displacing flow of cool air from the cooling unit is drawn by suction from beneath, ^{achieving} ~~achieving~~ contact with the devices to be cooled and the heated air generated by the devices exits from above.

2. A cooling system for cooling devices such as heat-generating components of telecommunications equipment located in a closed space, characterized in that a cooling unit (1) is installed in said closed space (3), in that the cooling unit (1) is intended to deliver a displacing cold air flow at a low speed along the floor of the closed space (3), in that the cooling unit (1) is intended to draw by suction a heated air flow at a low speed along the ceiling of the closed space (3), in that for cooling the devices (2) are intended to draw by suction cold air from the displacing cold air flow from beneath and in that the devices (2) are intended to deliver heated air from above to the heated air flow.

3. A cooling system according to Claim 2, characterized by a cold air outlet (4) at the bottom of the cooling unit (1), and by a heated air intake (5) at the top of said unit.

4. A cooling system according to Claim 2, characterized in that the heat-generating devices (2) to be cooled are provided with shelves (8) with function to guide the heated air flow.



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Fig. 1

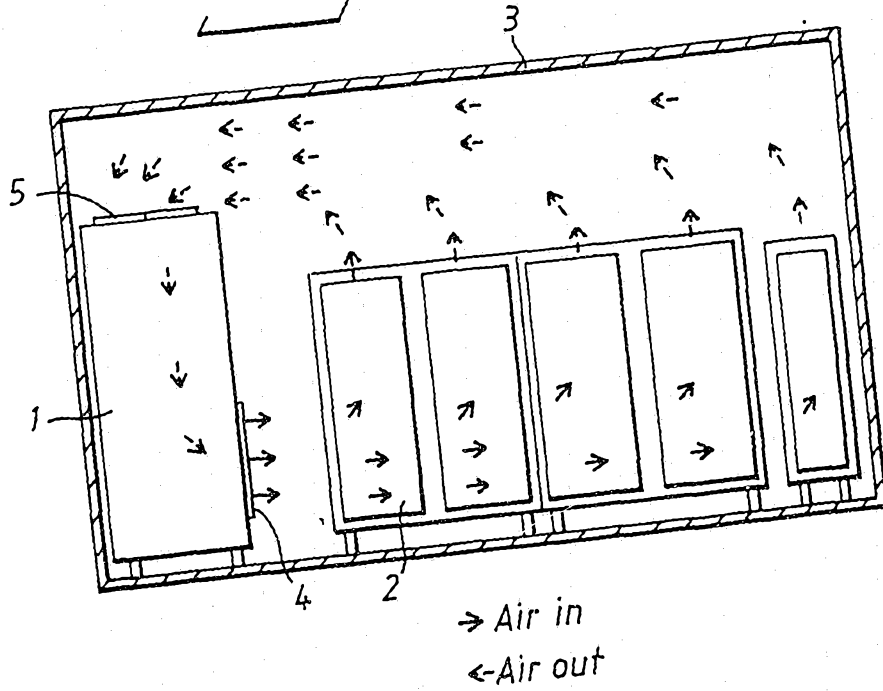


Fig. 2a

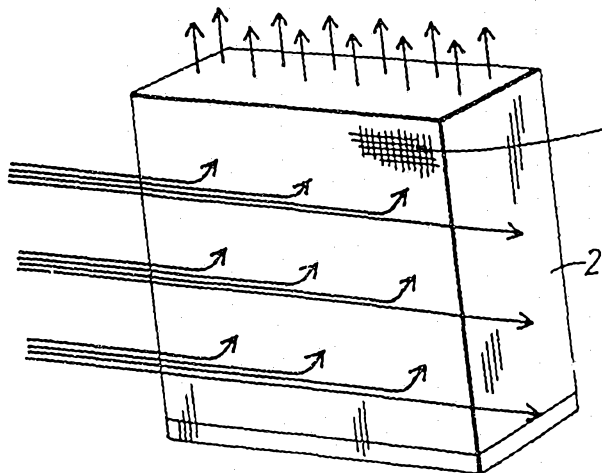


Fig. 2b

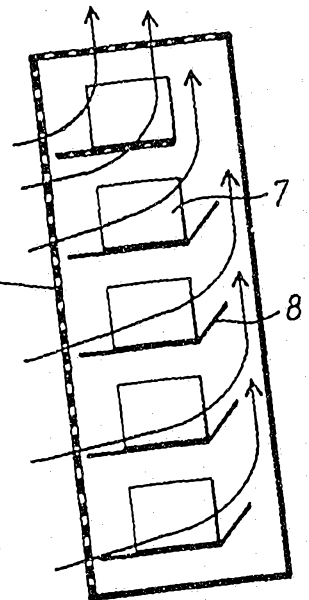
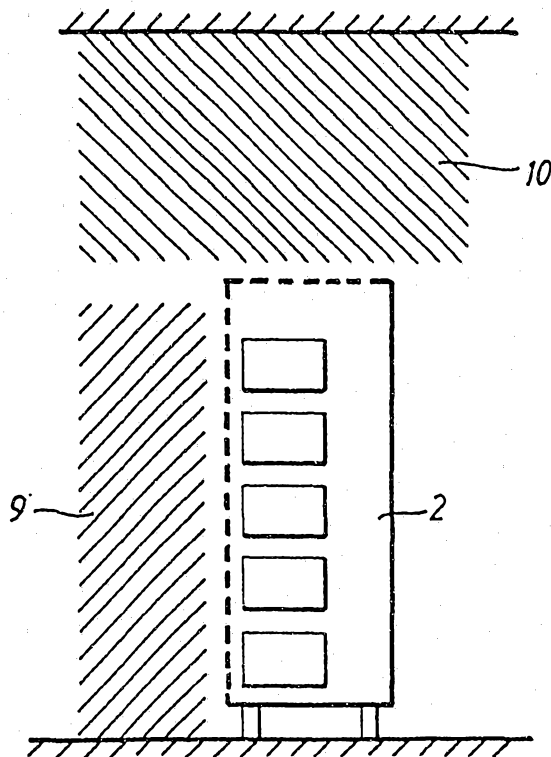


Fig. 3



INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 94/01223

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H05K 7/20, G12B 15/04

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)

IPC6: H05K, G12B

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

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

DIALOG: WPI, CLAIMS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 4535386 (SYDNEY W. FREY, JR. ET AL), 13 August 1985 (13.08.85), column 2, line 38 - line 50; column 7, line 2 - line 5 -----	1-3

 Further documents are listed in the continuation of Box C. See patent family 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
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- "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

28 March 1995

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INTERNATIONAL SEARCH REPORT
Information on patent family members

25/02/95

International application No.

PCT/SE 94/01223

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4535386	13/08/85	NONE	