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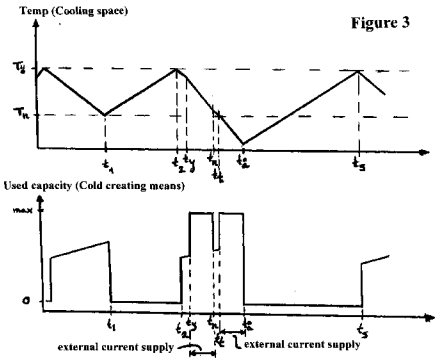
(54) **Title:** REFRIGERATION APPARATUS

Figure 3



(57) **Abstract:** Refrigeration apparatus comprising a electrically operated cold creating means (4) and a thereto connected cold emitting means (6), which cold emitting means (6) cools a cooling space (8), and further voltage detecting means (10) for observing the driving voltage (U) for the cold creating means (4) and temperature detecting means (12) for observing the temperature (T_k) in the cooling space (8), where the refrigeration apparatus (2) further comprises a control unit (14) which during battery operation of the cold creating means (4) controls switching on and switching off of the same based on the temperature (T_k) in the cooling space (8) according to a normal battery operation cycle, where the control unit (14) is arranged to, when the cold creating means (4) is in operation, to switch on maximum capacity of the cold creating means (4) for a predetermined period of time irrespective of the temperature (T_k) in the cooling space (8) when the driving voltage (U) for the cold creating means (4) reaches above a certain given level that indicates that external current supply is available, after which period of time the control unit (14) is arranged to return to the normal battery drive cycle.

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REFRIGERATION APPARATUS

Technical field of the invention

The present invention relates to an electrically operated refrigeration apparatus with a control unit.

Background

When using electrical devices in boats, buses and other vehicles, a problem exists by having a limited current supply when only having access to battery operation at the same time as one requires drawing large amounts of electrical energy for lighting, heater, refrigerator etc when the engine is not running and the generator thus does not charge the batteries.

People have tried to solve this problem by increasing the battery capacity and by reducing the current consumption in the electrical equipment. Concerning refrigeration apparatuses, people also have tried to increase the stored cooling capacity by installing an eutectic cooling plate which may accumulate cooling energy during engine operation.

SE 438 061 shows a refrigeration apparatus where a cooling means is charged up to large cooling capacity during periods of good supply of current.

Summary of the invention

The problem of having limited current supply to run refrigeration apparatuses when only having access to battery operation is solved according to the invention by arranging a refrigeration apparatus as claimed in claim 1.

By that the refrigeration apparatus comprises the characteristics that a control unit is arranged to, when the cold creating means is in operation, switch on maximum capacity of the cold creating means for a predetermined period of time irrespective of the temperature in the cooling space when the driving voltage for the cold creating means reaches above a certain given level and indicates that external current supply is available, after which period of time the control unit is arranged to return to the normal battery drive cycle, the advantage of being able to utilize the surplus of current which is obtained at external current supply is attained

whereby a surplus of cooling energy may be built up thus saving the in the batteries stored power.

Brief description of drawings

The invention will be described in more detail below with reference to the accompanying drawings, in which:

Figure 1 shows schematically a refrigeration apparatus according to a first embodiment of the invention,

Figure 2 shows schematically an embodiment of an operation cycle for a refrigeration apparatus according to the invention, and

Figure 3 shows schematically an embodiment of a modified operation cycle for a refrigeration apparatus according to the invention.

Description of preferred embodiments

Figure 1 shows schematically a refrigeration apparatus 2 according to a first embodiment of the invention comprising an electrically operated cold creating means 4 and a thereto connected cold emitting means 6, which cold emitting means 6 cools a cooling space 8, and further voltage detecting means 10 for observing the driving voltage U for the cold creating means 4 and temperature detecting means 12 for observing the temperature T_k in the cooling space 8, where the refrigeration apparatus 2 further comprises a control unit 14 which during battery operation of the cold creating means 4 controls switching on and switching off of the same based on the temperature T_k in the cooling space 8 according to a normal battery operation cycle.

The particularly novel of the invention is that the control unit 14 is arranged to, when the cold creating means 4 is in operation, switch on maximum capacity of the cold creating means 4 for a predetermined period of time irrespective of the temperature T_k in the cooling space 8 when the driving voltage U for the cold creating means 4 reaches above a certain given level that indicates that external current supply is available, after which period of time the control unit 14 is arranged to return to the normal battery drive cycle.

The voltage detecting means 10 and the temperature detecting means 12 are connected to the control unit 14 in such a way that the control unit 14 may receive voltage and temperature data from said means. Optionally, at least one of said means is integrated with the control unit 14.

The electrically operated cold creating means 4 may e.g. be a refrigeration compressor. The cold emitting means 6 may e.g. be a cooling coil or an eutectic cooling plate inside a cooling space. The cooling space 8 may be the inner space in e.g. a refrigerator 9 or a freezer. The temperature detecting means 12 is preferably arranged inside the cooling space 8. In the figure, also an accumulator battery 11 and a generator 15 are shown.

Figure 2 shows schematically an embodiment of an operation cycle for a refrigeration apparatus according to the invention. In that in the figure shown operating cycle, the refrigeration apparatus is operated only by battery operation by rechargeable accumulator batteries whereby the supply of electrical energy is limited. In order to reduce the energy consumption, the control unit is arranged to control switching on and switching off and the power, i.e. the capacity, of the cold creating means in such way that the efficiency of the cold creating means is maximized whereby the current consumption is minimized. As many starts and shut downs of the cold creating means decreases the efficiency, the control unit is preferably arranged to calculate the appropriate power based on the change in temperature in the cooling space for the cold creating means so that it is kept in operation during a appropriately long and possibly predetermined period of time such as e.g. 30 or 60 minutes. As can be seen in the figure, the cold creating means of the refrigerating apparatus is fed according to this operating cycle embodiment with voltage until a point of time t_1 when the temperature detecting means registers that the cooling space has reached a predetermined lower threshold temperature T_n at which the cold creating means is switched off. As can be seen in the figure, the temperature in the cooling space will rise slowly, where this increase in temperature inter alia depends on the number of times that the door of the cooling space is opened and thus varies with time, during the time when the cold creating means is kept switched off until the temperature detecting means at the point of time t_2 registers that the cooling space has reached a predetermined upper threshold temperature T_0 at which the cold creating means is again switched on in order to lower the temperature in the cooling space until at the point of time t_3 again reaching the lower threshold temperature T_n. This operation

cycle is repeated the whole time during which the refrigeration apparatus is operated only by battery operation.

If the cold creating means is a refrigeration compressor, it is possible to control the rotation speed of the compressor by using the control system in order to vary the supplied cooling power. During those intervals when the compressor is running, the compressor thus may be operated with a constant, a constant increasing, a constant decreasing, or a varying rotation speed. For the best efficiency and the lowest current consumption, the rotation speed is preferably kept as low as possible and constant in order to minimize the number of starts and shut downs.

Figure 3 shows schematically an embodiment of a modified operation cycle for a refrigeration apparatus according to the invention. As can be seen, the refrigeration apparatus follows the operation cycle according to figure 2 until the control system at the point of time t_y registers that the cold creating means has access to additional current supply in addition to battery operation, i.e. to external current supply e.g. in the form of current from ashore, solar cells, a running engine or similar. When external current supply is available, the normal temperature controlled battery operation cycle according to figure 2 is switched off and is saved in a memory, whereafter the control unit instead switches on the cold creating means for a predetermined time such as e.g. 15 or 30 minutes, preferably with full capacity, which in the case with a compressor as cold creating means implies that the compressor is switched into operation for a predetermined period of time, preferably with maximum rotational speed.

When the cold creating means has been in operation during the predetermined time, the control system returns to the normal battery operation cycle such as can be seen at the point of time t_n. If the temperature has fallen down below the lower threshold temperature T_n , the cold creating means thus remains switched off until the temperature again reaches up to the upper threshold temperature $T_ö$. However, if the temperature still is above the lower threshold temperature T_n , the cold creating means continues to be in operation but with the lower power which it is operated with according to the normal battery operation cycle, or as can be seen in the figure at the point of time t_t, if the control unit registers that the cold creating means has access to additional current supply in addition to battery operation, another time period is started during which the normal temperature controlled battery operation cycle according to figure 2 is switched off and saved in a memory, whereafter the control unit

instead again switches on the cold creating means for a predetermined time, preferably with full capacity, which in the case with a compressor as cold creating means implies that the compressor is switched into operation for a predetermined period of time, preferably with maximum rotational speed. If the control unit registers that the external current supply no longer is available, i.e. even if the predetermined period of time has not run out, the refrigeration apparatus returns to the original operating cycle which can be seen in the figure at the point of time $t_{å}$.

If the cold creating means is operated with high power for a longer time, the temperature in the cooling space will be lowered below the lower threshold temperature T_n without the cold creating means being switched off as long as external current supply is available. Hereby an addition of cooling energy is built up "gratis" in the cooling space as there at external current supply exists a surplus of electrical power whereby the batteries are not drained, if anything being charged up. Furthermore, it takes longer time than at a normal operation cycle before the cold creating means again is switched on according to the normal battery operation cycle as it takes longer time before the cooling space again reaches the upper threshold temperature $T_ö$ as can be seen in the figure at the point of time t_s. This additional time times the current consumption for the cold creating means is the saving in current consumption which is obtained for the batteries which is why they are not drained as fast as would be the case with battery operation only.

For a normal 12 V system, the control unit registers preferably that external current supply is available when the driving voltage U for the cold creating means is 13,2 V or more and that only battery operation is available when the driving voltage U for the cold creating means is 12,6 V or lower. For a 24 V system, the corresponding values are preferably 26,4 V and 25,2V, respectively, and for a 48 V system preferably 52,8 V and 50,4 V, respectively.

The above mentioned predetermined temperatures lower threshold temperature T_n and upper threshold temperature $T_ö$ may e.g. be preset on certain values or as an alternative these temperatures may be chosen by a user e.g. freely or as an alternative within certain ranges that have been found to be suitable for different kinds of refrigeration systems for different kinds of cooling spaces such as e.g. refrigerators or freezers as long as the lower threshold temperature T_n is lower than the upper threshold temperature $T_ö$.

CLAIMS

1. Refrigeration apparatus comprising a electrically operated cold creating means (4) and a thereto connected cold emitting means (6), which cold emitting means (6) is arranged to cool a cooling space (8), and further voltage detecting means (10) for observing the driving voltage (U) for the cold creating means (4) and temperature detecting means (12) for observing the temperature (T_k) in the cooling space (8), where the refrigeration apparatus (2) further comprises a control unit (14) which during battery operation of the cold creating means (4) is arranged to control switching on and switching off of the same based on the temperature (T_k) in the cooling space (8) according to a normal battery operation cycle, **characterized in**, that the control unit (14) is arranged to, when the cold creating means (4) is in operation, to switch on maximum capacity of the cold creating means (4) for a predetermined period of time irrespective of the temperature (T_k) in the cooling space (8) when the driving voltage (U) for the cold creating means (4) reaches above a certain given level that indicates that external current supply is available, after which period of time the control unit (14) is arranged to return to the normal battery drive cycle.

2. Refrigeration apparatus as claimed in claim 1, **characterized in**, that the cold creating means (4) is a compressor.

3. Refrigeration apparatus as claimed in claim 2, **characterized in**, that the control unit (14) is arranged to switch on maximum capacity of the compressor (4) by switching on maximum rotational speed for the compressor (4).

4. Refrigeration apparatus as claimed in one of the above claims, **characterized in**, that according to the normal battery operation cycle, the cold creating means (4) of the refrigerating apparatus (2) is arranged to be fed with voltage until a point of time (t_1, t_3) when the temperature detecting means (12) registers that the cooling space (8) has reached a predetermined lower threshold temperature (T_n) at which the cold creating means (4) is arranged to be switched off, and that the cold creating means (4) thereafter is arranged to be kept switched off until the temperature detecting means (12) at a point of time (t_2) registers that the cooling space (8) has reached a

predetermined upper threshold temperature (T_6) at which the cold creating means (4) is arranged to be switched on.

5. Refrigeration apparatus as claimed in claim 4, **characterized in**, that the control unit (14) further is arranged to control the capacity of the cold creating means (4) during the normal battery operation cycle.

6. Refrigeration apparatus as claimed in claim 5, **characterized in**, that the control unit (14) is arranged to calculate the appropriate capacity based on the change in temperature in the cooling space (8) during the normal battery operation cycle so that the number of starts and shut downs of the cold creating means (4) is minimized.

7. Refrigeration apparatus as claimed in one of the above claims, **characterized in**, that the cooling space (8) is the inner space in a refrigerator (9) or a freezer and that the cold emitting means (6) is a cooling coil or an eutectic cooling plate.

8. Refrigeration apparatus as claimed in one of the above claims, **characterized in**, that the refrigeration apparatus (2) is arranged to return to the normal battery operation cycle when the control unit (14) registers that the external current supply is no longer available.

9. Refrigeration apparatus as claimed in one of the above claims, **characterized in**, that the control unit (14) is arranged for a 12 V system to register that external current supply is available when the driving voltage (U) for the cold creating means (4) is 13,2 V or more and that only battery operation is available when the driving voltage (U) for the cold creating means (4) is 12,6 V or lower.

10. Method for controlling of a refrigeration apparatus (2) comprising a electrically operated cold creating means (4) and a thereto connected cold emitting means (6), which cold emitting means (6) is arranged to cool a cooling space (8), where the refrigeration apparatus (2) further comprises voltage detecting means (10) for observing the driving voltage (U) for the cold creating means (4) and temperature detecting means (12) for observing the temperature (T_k) in the cooling space (8), and where the refrigeration apparatus (2) further comprises a control unit (14) which during battery operation of the cold creating means (4) is arranged to control

switching on and switching off of the same based on the temperature (T_k) in the cooling space (8) according to a normal battery operation cycle, **characterized in,** that the method comprises the step of:

- the control unit (14) switching on, when the cold creating means (4) is in operation, maximum capacity of the cold creating means (4) for a predetermined period of time irrespective of the temperature (T_k) in the cooling space (8) when the driving voltage (U) for the cold creating means (4) reaches above a certain given level, after which period of time the control unit (14) is arranged to return to the normal battery drive cycle.

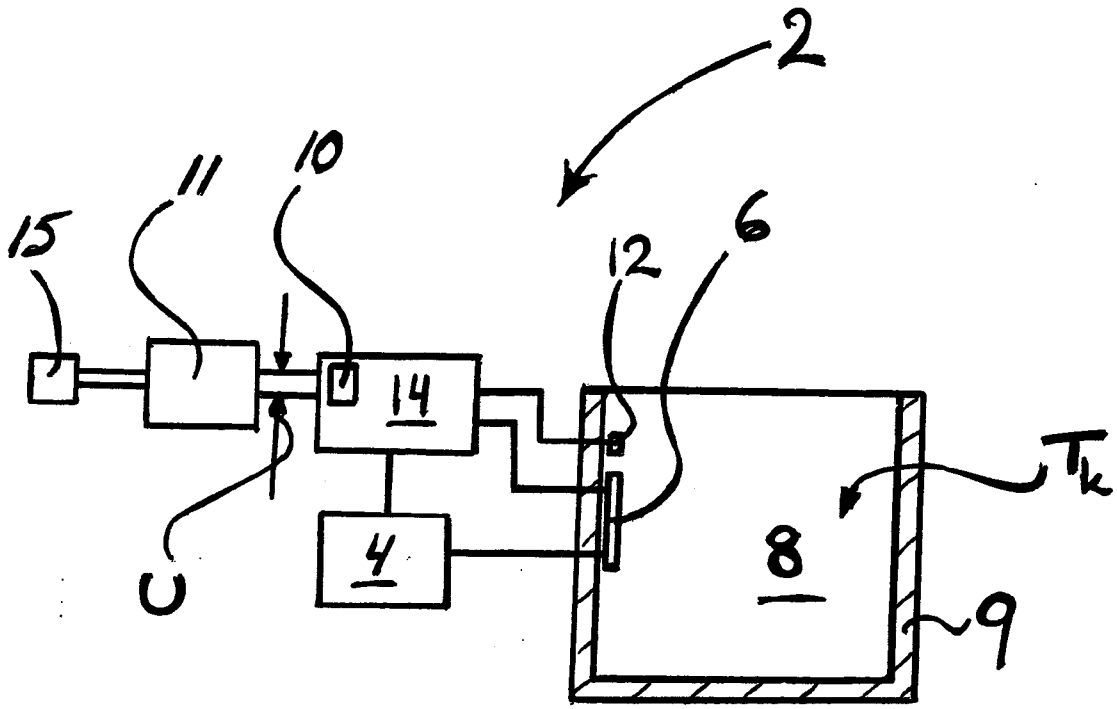


Figure 1

Figure 2

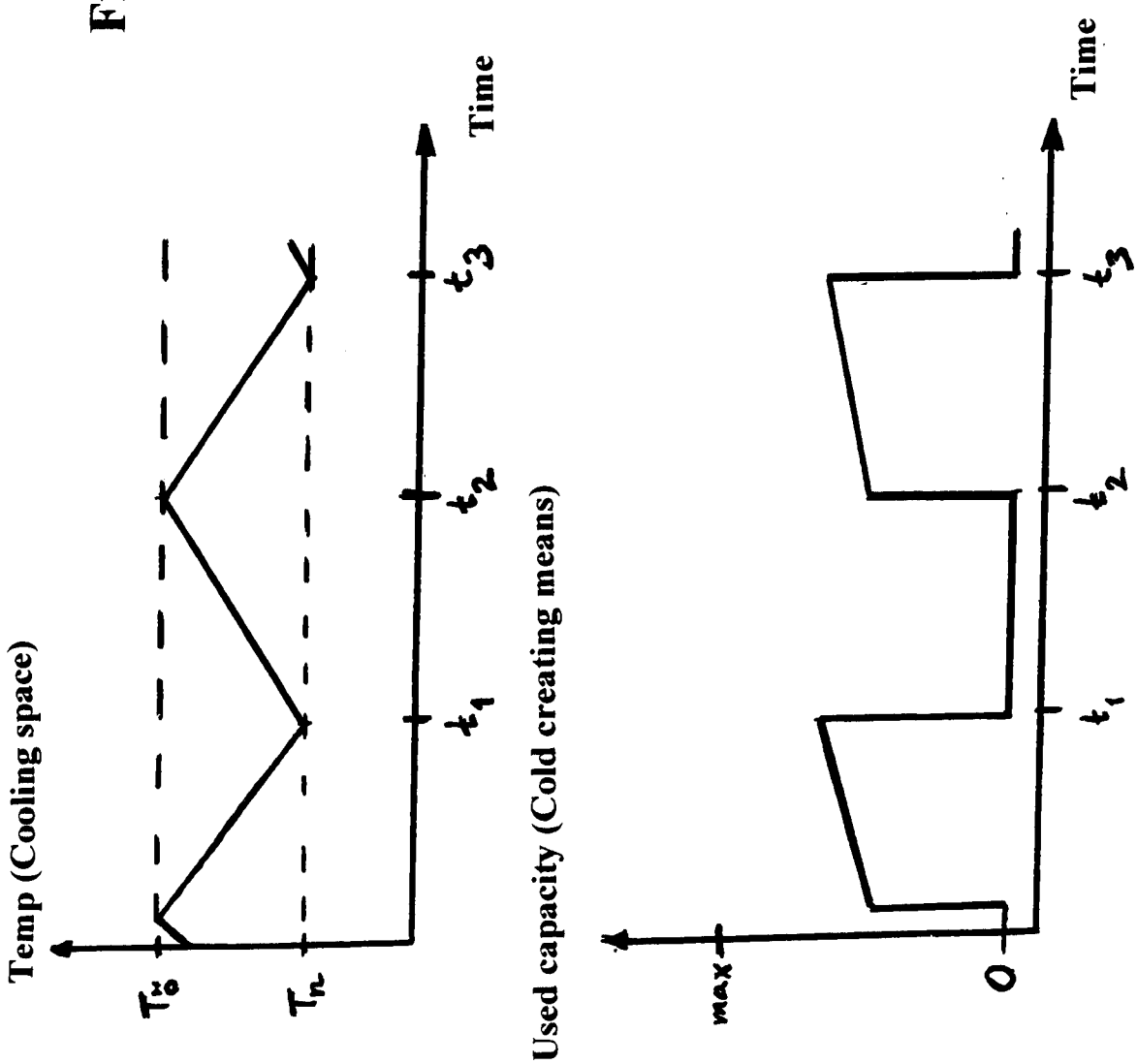
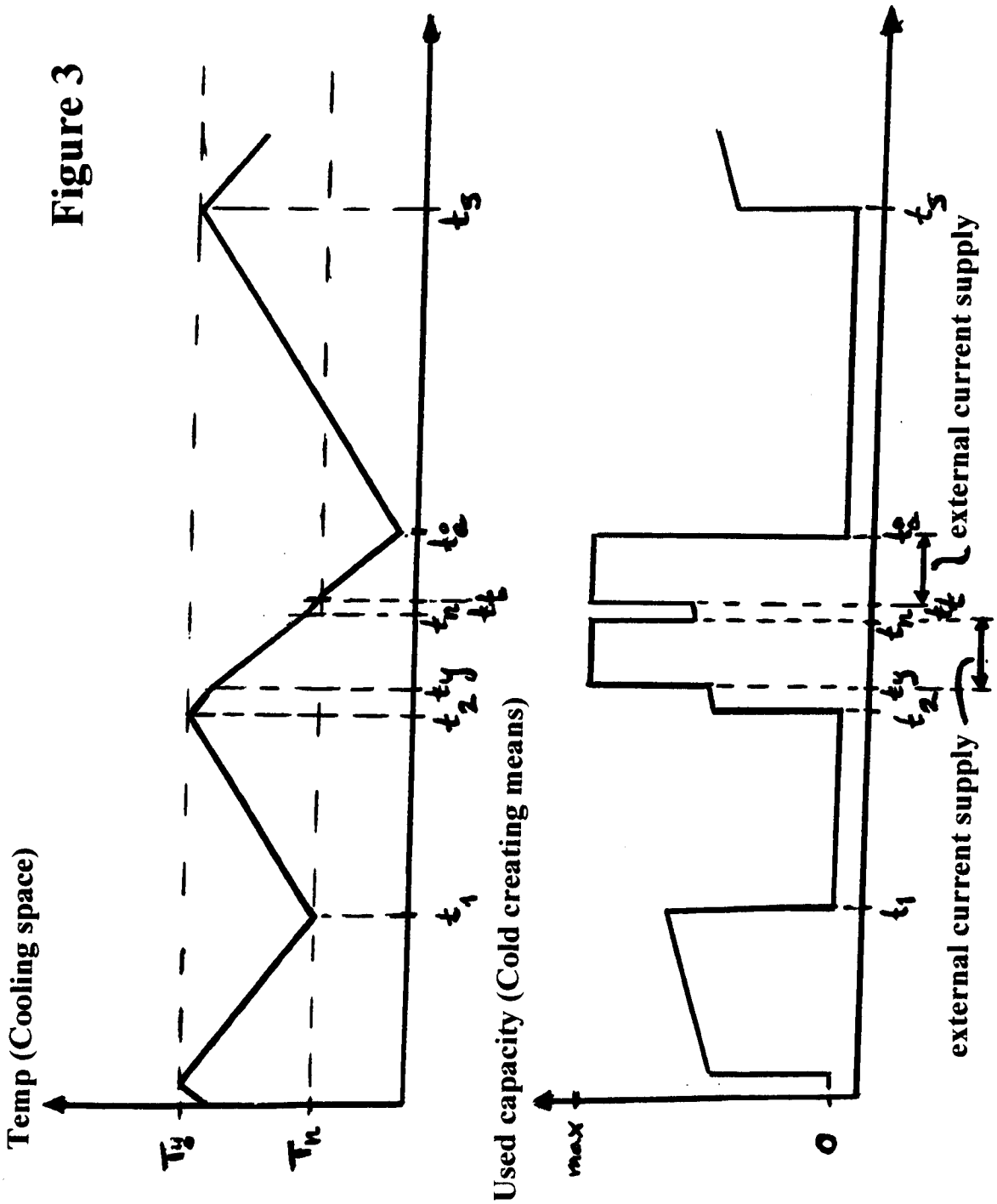

Temp (Cooling space)
Time
$T_{ö}$
T_n
t_1
t_2
t_3
Used capacity (Cold creating means)
Time
max
0
t_1
t_2
t_3

Figure 3


Temp (Cooling space)
Tu
Tn
t1
t2
tu
tn
te
ts
Used capacity (Cold creating means)
max
0
external current supply
external current supply

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2008/000415

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
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)

IPC: F25D

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)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6253563 B1 (EWERT ET AL), 3 July 2001 (03.07.2001), column 2, line 51 - column 5, line 6, figures 1,2, claims 7,8, abstract	1-5,10
Y		6-8
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Y	JP 5340659 A, SHARP KK, 1993-12-21: (abstract) Retreived from: PAJ database	6
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Y	SE 438061 B (THERMO PRODUKTER B S AB), 25 March 1985 (25.03.1985), page 4, column 1 - page 5, column 3, figure 1, claim 6, abstract	7-8
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
13 October 2008	14-10-2008
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Christer Bäcknert / JA A Telephone No. +46 8 782 25 00

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International application No.
PCT/SE2008/000415

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4367633 A (STRATHMAN), 11 January 1983 (11.01.1983), abstract ---	1-10
A	EP 1548381 A2 (DOMETIC SWEDEN AB), 29 June 2005 (29.06.2005), abstract --- --------	1-10

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PCT/SE2008/000415

International patent classification (IPC)

F25D 11/00 (2006.01)
F25D 29/00 (2006.01)

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Cited literature, if any, will be enclosed in paper form.

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