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Method and device for cooling rooms

The invention relates to a method for cooling rooms, where hot air is cooled in the upper section of a flow duct serving as a fall shaft and then at least partly flows downwards through the flow duct as a result of its specific weight owing to its gravity.

Furthermore, the invention relates to a device for the gravity cooling of rooms by means of at least one heat exchanger which can be operated with a coolant, this being located in the vicinity of the inlet of a flow duct serving as a fall shaft for the cool room air.

In particular, a method of the type described above is known from EP 0 308 856 A1, for example. The air-conditioning method described there is also known as gravity room-cooling or silent cooling. Gravity room-cooling is performed via the location of a heat exchanger at room height, which is operated with cool water or another coolant. The heat exchanger is located at the end of a convection shaft of room height, into which the cool air generated by the heat exchanger falls. Owing to the difference in specific weight of the cool air, this is directed downwards through the convection shaft or fall shaft by its gravity and then flows and spreads into the room at the lower end of the fall shaft with little turbulence. Such silent ventilation has the advantage that no energy whatsoever is consumed by fans, as the room air is exclusively circulated by the difference in specific weight between cold and warm air. The warm air rises, while the cool air flows downwards. A further advantage is that air can be simultaneously fed in from outside. Silent ventilation is extraordinarily cheap, comfortable owing to its low turbulence and, above all, silent owing to the absence of fans.

The known devices for gravity room-cooling are operated using heat exchangers whose surface temperature does not drop below the dew-point temperature of the room to be cooled. On the one

hand, this is unnecessary at the relatively low atmospheric humidity and moderate temperatures prevalent in our latitudes and, on the other hand, this eliminates the need for expensive condensate collectors or condensate drain pipes. Furthermore, the selection of too great a temperature difference between cool air and hot room air is not desirable, as this is generally perceived as uncomfortable. In particular, an excessively great vertical temperature difference in the room has an adverse effect on the feeling of well-being of the persons in the room.

However, in warmer and more humid latitudes, for example in tropical and subtropical regions, much higher temperatures and a higher atmospheric humidity prevail, meaning that the known methods and devices for gravity cooling do not offer sufficient cooling capacity and, above all, do not generate the desired comfortable room climate. Above all, the high atmospheric humidity is perceived as particularly uncomfortable, as a high relative atmospheric humidity displays a low vapour pressure gradient in comparison with saturated air. The human body's possibility of giving off heat by means of perspiration - i.e. via water evaporation - is thus limited at high humidity levels owing to the low vapour pressure gradient. This is uncomfortable wherever the ambient temperature approaches that of the body, meaning that the human body can no longer dissipate the heat generated in it by metabolism by means of convection.

The task of the invention is thus to provide a method and a device for cooling rooms of the type mentioned at the start, with which a pleasant room climate can be generated even in warmer and more humid latitudes.

The task is solved, on the one hand, by a method of the type mentioned at the start, which is characterised in that the hot air is cooled to below the dew point and that the cool air is reheated before or upon entry into the room to be cooled.

Cooling the room air to below the room-air dew point increases the otherwise undesirable formation of condensate, meaning that

dehumidification of the room air is effected in an advantageous manner as a result. For example, at temperatures above 35 °C with a relative atmospheric humidity of 80% and more in countries such as Brazil, extensive dehumidification of the air by means of an air-conditioning system is perceived as particularly pleasant. In order to avoid an excessively great vertical difference in temperature between the cold-air outlet and the upper areas of the room, in which the head and trunk of the persons in the room are normally to be found, the cool air is advantageously reheated before or upon entering the room to be cooled. The invention thus caters to the comfort of dry air, as well as the comfort of small temperature differences in the room.

The cool air is preferably reheated by admixing hot air. The hot air can, for example, be taken from the cushion of air on the ceiling of the room to be cooled. If this is admixed to the cold air directly below the cold-air outlet from a heat exchanger, for example, this has the advantage that the temperature only falls below dew point locally, i.e. in the vicinity of the heat exchanger, meaning that no condensation water can form on indirectly cooled surfaces.

The hot air is expediently admixed by sucking in secondary air with the cold-air flow. In this context, the convection flow of the cold air is used in an advantageous manner to draw in this uncooled, hot secondary air. A mixed temperature in the comfortable range can then arise between the cold air and hot air.

One version of the method according to the invention envisages that the cold air is reheated by means of a heated heat exchanger. This type of air-conditioning has the advantage that the throughput capacity of the air circulation generated by convection is not impaired by bypass openings.

A particularly advantageous version of this method envisages that the waste heat of a refrigeration unit for generating the cold-air flow is used to heat the heat exchanger. For example, the waste heat of a centrally located refrigeration unit which

supplies several heat exchangers can be used in this context. This type of air-conditioning is also particularly favourable in terms of energy.

5 A further method for cooling rooms pursuant to the characterising section of Claim 1 is characterised in that the hot air is cooled to below the dew point and that an adjustable partial flow of the cool air is prematurely diverted from the flow duct and fed into the room air at an elevated point.

10 In this context, the ratio of diverted air to cool air which completely flows through the flow duct can be adjustable. Above all, this has the advantage that the vertical temperature difference in the room is reduced. By absorbing hot room air
15 outside the flow duct and sinking, the diverted cold air causes the temperature on the room side to decline, resulting in the reduction of large temperature differences in the zone occupied by persons without the cooling capacity being impaired as a result.

20 Furthermore, the task described at the start is solved by a device for the gravity cooling of rooms, particularly for implementing the method according to the invention, with at least one heat exchanger which can be operated with a coolant,
25 this being located in the vicinity of the inlet of a flow duct serving as a fall shaft for the cool room air, characterised in that means for reheating the air cooled in the heat exchanger are provided.

30 At least one bypass, preferably adjustable, for admixing hot secondary air into the cold-air flow can be provided as a means of reheating the air cooled in the heat exchanger.

To this end, an operable bypass flap is expediently provided in
35 the flow duct below the cold-air inlet. When the flap is open, hot room air is entrained below the cold-air inlet into the flow duct owing to the convection generated.

Alternatively, an adjustable flow divider can be provided in the vicinity of the cold-air inlet in the flow duct, with which at least part of the cold-air flow can be prematurely diverted out of the flow duct.

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For example, the flow divider can be designed as a dividing flap articulated downstream on the flow duct in swivelling fashion, with which the flow duct can be opened. In this context, the dividing flap can be fitted in such a manner that between 0 and 100% of the cold-air flow can be prematurely diverted out of the flow duct.

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According to a preferred version of the invention, it is envisaged that the heat exchanger extends vertically in the upper section of the flow duct, dividing this into an exchanger section and a bypass duct, and that a control flap is provided, by means of which the air inlet into the heat exchanger or through the bypass can be controlled. In this case, only part of the hot air from the ceiling cushion of the room passes through the heat exchanger, while the rest is diverted past the heat exchanger by the convection of the cold-air flow.

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Alternatively, at least a second heat exchanger for reheating the air cooled by the first heat exchanger can be provided, this preferably being located on the outlet side of the flow duct.

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It is particularly favourable in terms of energy if the second heat exchanger is operated with the waste heat of the refrigeration unit.

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In another device according to the invention, it is envisaged that the flow duct is formed by telescopic elements arranged in moveable fashion relative to one another and forming openings between them to draw in secondary air. Such a telescopic flow duct is used in freely suspended gravity cooling devices in television studios, for example, where the heat exchanger is suspended in the hot-air area and the flow duct is also freely suspended in the room, but may not appear in the television

picture and has to be retracted depending on the picture selected. In this context, the invention can advantageously benefit from the fact that is difficult enough to seal such elements against one another when they are arranged in telescopic fashion relative to one another. Alternatively, however, it is also conceivable to provide bypass openings in a flow duct designed as a folding hose.

Alternatively to the solutions described above, it can be envisaged that the pipes of the heat exchanger are set a great distance apart in order to increase the natural bypass effect in a device pursuant to the characterising section of Claim 8. The effect that only part of the hot air passing through the heat exchanger comes into contact with the exchanger surface is referred to as the natural bypass effect. This air which is cooling down entrains hot air and mixes with this. The larger the gap selected between the heat exchanger pipes, or the smaller the heat exchanger surface in relation to the cooler opening area, the larger the natural bypass factor, i.e. despite major condensate formation in the heat exchanger and the consequent dehumidification of the air, no very great temperature difference prevails in the room to be cooled.

The invention is described below on the basis of several practical examples illustrated in the drawings.

The drawings show the following:

Fig. 1 a simple configuration of the device according to the invention,

Fig. 2 a configuration of the cooling device according to the invention with an adjustable bypass flap,

Fig. 3 a configuration of the device with a flow divider which is designed as a dividing flap articulated on the flow duct,

Fig. 4 a representation of the device with a second heat exchanger,

Fig. 5 a further practical example of the device according to the invention with an open-top flow duct or fall shaft and

Fig. 6 a configuration of the device according to the invention with a heat exchanger located in the flow duct.

The drawings only give a rough schematic representation of the gravity cooling device according to the invention.

As shown in Figs. 1 and 2, in particular, the device according to the invention essentially consists of a cooling unit referred to as 1, which is located at the upper end of a room-high flow duct 2 designed as a fall shaft. In the practical example shown, flow duct 2 is represented in simplified fashion as a duct with a rectangular cross-section. However, it can also display different cross-sections and shapes. The overall gravity cooling system according to the invention can be designed as a cooling wall, or also as a cupboard unit, partition wall, free-standing cooling shaft or the like. Cooling unit 1 essentially consists of heat exchanger 3, a condensate collecting tray 4 and a condensate drain 5. Heat exchanger 3 is connected to permanently installed feed and return pipes 6 and 7 of a central refrigeration system, preferably a cold-water generator. When heat exchanger 3 is in operation, the cold air generated falls or surges into flow duct 2 adjoining cooling unit 1, where it sinks owing to the difference in specific weight compared to the hot air, then exiting lower end 8 of flow duct 2 and entering either the room or a cooling floor. The cold air surging into the floor area of the room displaces the hot air there, which rises in known fashion, meaning that a convection flow with self-regulating circulation is created.

In the practical example shown in Fig. 1, it is envisaged that flow duct 2 displays openings 9 on the room side, which form a

bypass for the room air. The cold air sinking in flow duct 2 entrains hot air from the room through openings 9, which mixes with the sinking cold-air flow in such a way that the temperature difference between the air exiting lower end 8 of flow duct 2 and the rest of the room air is not excessively high.

In the practical example shown in Fig. 2, an adjustable bypass flap 10 which can be opened to a varying extent is provided in cooling unit 1 immediately below heat exchanger 3. When bypass flap 10 is fully open, a maximum amount of "secondary air" from the room to be cooled is added to the previously cooled air.

In the practical example shown in Fig. 3, a dividing flap 11 designed as a flow divider is provided instead of bypass flap 10, this being articulated on room-side wall 12 of flow duct 2 in swivelling fashion. The further dividing flap 11 is opened, the greater the cold-air flow prematurely drawn off from flow duct 2 below cooling unit 1 which can thus be added to the room air again at room height. When dividing flap 11 is fully opened, flow duct 2 is completely shut off.

The schematic diagrams shown are intended to illustrate a sectional or side view of the gravity cooling device. The invention is to be understood in such a way that both the flow duct designed as a fall shaft and dividing flap 11 extend into the drawing plane and can have the entire width of a wall, for example.

Figure 4 shows a practical example of the invention, in which the cold-air flow is reheated by a second heat exchanger 13 located at lower end 8 of flow duct 2. The feed and return pipes of the second heat exchanger 13 are connected to a central refrigeration unit 14 which is only suggested in the drawing. In this context, the second heat exchanger is heated via the waste heat of refrigeration unit 14. This reheating without the addition of moisture also makes a considerable contribution to improving the room climate. However, two feed-pipe and two return-pipe connections, i.e. a total of four pipes, are necess-

ary in this context.

Figure 5 shows a practical example of the invention in which the top of flow duct 2 is completely closed, where a central ambient-air feed pipe 15 is provided to cater to the need of the persons in the room for fresh air. The hot ambient air is admixed to the cold-air flow exiting cooling unit 1.

One of many further different possible configurations of the invention is shown in Fig. 6. In this case, cooling unit 1 extends vertically into flow duct 2. This divides flow duct 2 into a vertical exchanger section 16 through which air flows and a bypass duct 17. Either bypass duct 17 or exchanger section 16 can be optionally closed using control flap 18, meaning that the quantity of bypass air which can be fed past heat exchanger 3 can be adjusted in an advantageous manner. In order to improve access to cooling unit 1, room-side wall 12 of flow duct 2 can be designed to be swung open.

Method and device for cooling rooms**Reference numbers**

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	1	Cooling unit
	2	Flow duct
	3	Heat exchanger
	4	Condensate collecting tray
10	5	Condensate drain
	6	Feed pipe
	7	Return pipe
	8	Lower end of flow duct
	9	Openings
15	10	Bypass flap
	11	Dividing flap
	12	Room-side wall of flow duct
	13	Second heat exchanger
	14	Central refrigeration unit
20	15	Central ambient-air feed pipe
	16	Exchanger area
	17	Bypass duct
	18	Control flap



Method and device for cooling rooms

Patent claims

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1. Method for cooling rooms, where hot air is cooled in the upper section of a flow duct serving as a fall shaft and then at least partly flows downwards through the flow duct as a result of the change in its specific weight owing to its gravity, characterised in that the hot air is cooled to below the dew point and that the cool air is reheated before or upon entry into the room to be cooled.
2. Method as per Claim 1, characterised in that the cool air is reheated by admixing hot air.
3. Method as per Claim 1 or 2, characterised in that the hot air to be admixed is taken from the cushion of air on the ceiling of the room to be cooled.
4. Method as per one of Claims 1 to 3, characterised in that the hot air is admixed by sucking in secondary air by the cold-air flow.
5. Method as per one of Claims 1 to 4, characterised in that the cold air is reheated by means of a heated heat exchanger.
6. Method as per one of Claims 1 to 5, characterised in that the waste heat of a refrigeration unit for generating the cold-air flow is used to heat the heat exchanger.
7. Method for cooling rooms, where hot air is cooled in the upper section of a flow duct serving as a fall shaft and then at least partly flows downwards through the flow duct as a result of the change in its specific weight owing to



its gravity, characterised in that the hot air is cooled to below the dew point and that an adjustable partial flow of cool air is prematurely diverted out of the flow duct and added to the room air in an elevated area.

8. Device for the gravity cooling of rooms, particularly for implementing the method as per one of Claims 1 to 7, by means of at least one heat exchanger (3) which can be operated with a coolant, this being located in the vicinity of the inlet of a flow duct (2) serving as a fall shaft for the cool room air, characterised in that means are provided for reheating the air cooled in the heat exchanger (3).

9. Device as per Claim 8, characterised in that at least one, preferably adjustable, bypass for admixing hot secondary air into the cold-air flow is provided as a means of reheating the air cooled in the heat exchanger (3).

10. Device as per Claim 8 or 9, characterised in that an operable bypass flap (10) is provided in the flow duct (2) below the cold-air inlet.

11. Device as per one of Claims 8 to 10, characterised in that an adjustable flow divider is provided in the flow duct (2) in the vicinity of the cold-air inlet, with which at least part of the cold-air flow can be prematurely diverted out of the flow duct (2).

12. Device as per Claim 11, characterised in that the flow divider is designed as a dividing flap (11) articulated downstream on the flow duct (2) in swivelling fashion, with which the flow duct (2) can be opened.



13. Device as per Claim 8, characterised in
t h a t the heat exchanger (3) extends vertically in the
upper section of the flow duct (2), dividing this into an
exchanger section (16) and a bypass duct (17), and that a
5 control flap (18) is provided, by means of which the air
inlet either into the heat exchanger (3) or through the
bypass duct can be controlled.
14. Device as per Claim 8, characterised by at
10 least a second heat exchanger (13) for reheating the air
cooled by the first heat exchanger (3), which is preferably
located on the outlet side of the flow duct (2).
15. Device as per Claim 14, characterised in
15 t h a t the second heat exchanger (13) is operated with
the waste heat of the refrigeration unit (14).
16. Device as per one of Claims 8 to 10, character-
i s e d i n t h a t the flow duct (2) is formed by
20 telescopic elements arranged in moveable fashion relative
to one another and forming openings between them to draw in
secondary air.
17. Device as per the characterising section of Claim 8,
25 characterised in t h a t the pipes of the
heat exchanger (3) are set a great distance apart in order
to increase the natural bypass effect.