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(54) **ROOF WINDOW SYSTEM WITH A VENTILATION ASSEMBLY WITH IMPROVED FLOW PATH AND METHOD OF OPERATING THE VENTILATION ASSEMBLY**

(57) A roof window system has a roof window (1) having at least one frame (2, 3) defining a frame plane and including a pane (4), the roof window (1) further comprising a ventilation device (40) adapted for providing ventilation of a building in which the roof window is mounted, and a ventilation assembly (100) comprising a housing (150) accommodating at least one ventilation unit (110, 120) including at least one ventilator (131, 132; 133, 134) and at least one regenerator (171, 172), and a set of flow channel sections (1502, 1504, 1508; 1503, 1507). The ventilation assembly is connected to an ap-

erture for air intake and exhaust, and to the ventilation device (40) of the roof window (1). In this way, a predefined flow path via the set of flow channel sections. Near the transition to the ventilation device of the roof window, the flow path in the housing (150) is divided by a splitter (1521; 1522) to form a pair of transition flow channel sections (1507, 1509; 1508, 1510) with a respective width dimension (d1, d2) and in connection with one respective adjacent flow channel section (1503; 1504) with a predefined width dimension (d0).

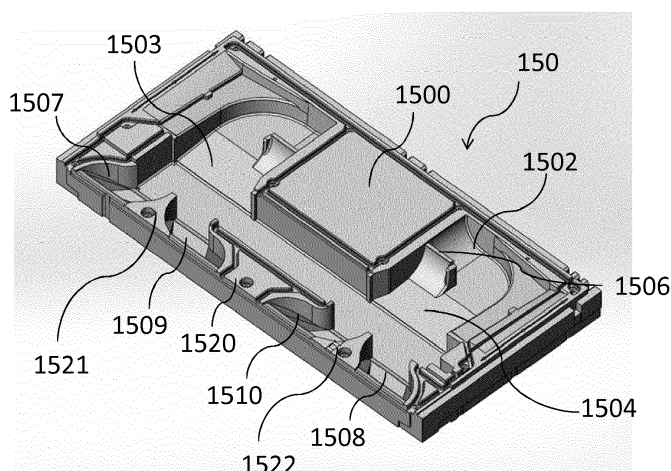


Fig. 6

Description

Technical Field

[0001] The present invention relates to a roof window system comprising a roof window and a ventilation assembly. The invention furthermore relates to a method of operating the ventilation assembly

[0002] One of the primary functions in a window, besides admitting light, is to allow stale, warm, or otherwise used or spent air inside the building (so-called "room air") to exit and allowing fresh air from the exterior ("outdoor air") to enter the building in which the window is installed. This presupposes that the window is openable. Over time, the provision of ventilation in windows, also in situations in which the window is not open, either because it is a fixed window, or simply is not open, has become more or less standard equipment. This is the result of, among other things, increased focus on improving indoor climatic conditions and the microclimate in buildings. One example of a roof window providing a ventilating aperture is the well-known VELUX® with a ventilation flap, which in pivot-hung windows also fulfils the double function of operating the window.

Background Art

[0003] Natural ventilation provided by such a ventilation device has a number of advantages. Among others, it is free of charge and noise-less. However, in certain fields of applications, for instance mechanical ventilation may be desirable. Examples of prior art roof window systems, including roof windows and ventilation assemblies, are shown in for instance Applicant's European patents EP0458725B1 and EP0372597B1, and in published Danish patent application DK200001472A. Other examples are shown in documents DE102004037563A1, 20204020630U1, DE19811469A1 and DE2906729U1. Another example of a prior art device is found in US 2002/164944 A1.

[0004] Although many of the above-mentioned prior art roof window systems, roof windows and ventilation assemblies provide well-functioning solutions, they also require that the roof window is built to receive such a ventilation assembly, typically by designing special parts and/or requiring further investment in the installation of auxiliary parts and installation equipment. Thus, severe limitations as to retro-fitting existing windows exist.

[0005] One recent development of such roof window systems is described in Applicant's European patent application published under EP 2 784 240 A2. Here, the ventilation assembly takes in outdoor air via ventilation units having flow channels connected to the ventilation device of the roof window and, conversely, allows room air to be led to the exterior in the form of exhaust air through the ventilation assembly. In one embodiment, the ventilation units comprise a ventilator and a heat exchange device in the form of a regenerator. The coun-

terpart commercial product has proven to work well, and the roof window system alleviates the disadvantages of the earlier prior art to a great extent. One document devising further improvements of the above EP application is found in DE utility model 20 2016 100 906 U1.

[0006] Although both of the last-mentioned documents devise well-functioning roof window systems, there is an ongoing aspiration to improve the product itself. The performance of the ventilation assembly is typically scaled-up in larger windows; however, this might require more powerful ventilator which in turn may give rise to more increased costs, power demand and noise.

Summary of Invention

[0007] With this background, it is therefore an object of the present innovation to provide a roof window system, which provides for improved functionality and in particular the field of applicability of the roof window system.

[0008] In a first aspect, this and further objects are achieved with a roof window system of the kind mentioned in the introduction, in which a transition portion of the flow path at the transition to the ventilation device of the roof window in at least one ventilation unit is divided by a splitter to form a pair of transition flow channel sections with a respective width dimension and in connection with one respective adjacent flow channel section with a predefined width dimension.

[0009] Thereby a roof window system is provided, by which the flow conditions are improved with simple means, and which has a broader range of applicability, as the ventilation assembly is able to provide an increased performance with otherwise unchanged components. In turn, this means that it is possible to provide sufficient ventilation also in roof windows having a larger width, which otherwise would require more powerful ventilation components.

[0010] By separating the flow path from the ventilator to the window into two flow channels at the transition to the ventilation device of the roof window, the flow performance of the ventilation assembly has surprisingly shown to improve significantly compared to the prior art design with a single but wider flow path.

[0011] In a presently preferred embodiment, the splitter has a curved triangular shape which diverges from one end at the adjacent flow channel section to the other end, at the transition to the ventilation device of the roof window. In this manner, an improved flow pattern is achieved in comparison to that of a straight flow path. The air guided from the respective regenerator through the ventilator, via the flow channel section, is split at the apex of the triangular shape and into the ventilation device of the roof window, and by the provision of the curved flow path, an improved flow rate is achieved.

[0012] A drawback of a roof window ventilation assembly comprising a heat exchange device in the form of a regenerator occurs when the outdoor temperature extends in daily intervals both above and below an average,

desired indoor temperature e.g. during summer seasons. In such cases, a heat regenerator can shift the time of the indoor maximum and minimum temperatures to inconvenient hours of the day. Typically, this will result in an elevated indoor temperature at inconvenient times, for instance in a bedroom which is preferred cool during evenings and nights.

[0013] In the alternative aspect it is another object of the present invention to provide a roof window system which provides for improved climate and temperature conditions. This and further objects are achieved with a roof window system of the kind mentioned in the introduction in which the ventilation assembly of the roof window system furthermore comprises a control unit to provide a by-pass function of the at least one regenerator.

[0014] The by-pass function can be automatically controlled by the roof window system based on a set comfortable indoor temperature and initiates when indoor temperature conditions will benefit from it such as when the outdoor temperature extends in daily intervals both above and below the indoor temperature. During such condition, when the outside temperature decreases below the inside temperature, the by-pass function will by-pass the regenerator and provide the indoor area with non-heat exchanged naturally tempered air resulting in a naturally conditioned area. As the outside temperature increases above the indoor temperature the by-pass function deactivates. Thereby a roof window system is provided, by which the indoor temperature during warm outdoor conditions is improved with simple means. The window system with included by-pass function allows a desired room to naturally cool during cold hours of the day and the regenerator maintains a comfortable condition during the warm hours of the day, thereby resulting in a naturally conditioned room. The benefits are achieved in a cost-friendly and power-saving means by the by-pass function by utilizing the outdoor temperature without opening the window.

[0015] In another aspect of the invention, a method of operating the ventilation assembly of the inventive roof window system is provided.

[0016] Further presently preferred embodiments and further advantages will be apparent from the following detailed description and the appended dependent claims.

Brief Description of Drawings

[0017] The invention will be described in more detail below by means of a non-limiting example of an embodiment and with reference to the schematic drawing, in which

Fig. 1 shows a perspective view of a prior art roof window system;

Fig. 2 is an exploded, partial perspective view of details of the roof window of the roof window system shown in Fig. 1;

Fig. 3 is a plan view of the ventilation housing of the ventilation assembly in a prior art roof window system;

Fig. 4 shows a partially exploded perspective view of details of the ventilation assembly in a prior art roof window system;

Fig. 5 is a perspective partial view of a roof window system in an embodiment of the invention;

Fig. 6 shows a perspective view of the ventilation housing of the ventilation assembly in an embodiment of the roof window system according to the invention;

Fig. 7 is a plan view corresponding substantially to Fig. 3, of the ventilation housing shown in Fig. 6;

Fig. 8 shows a perspective view, on a larger scale, of a detail of the roof window system in an embodiment of the invention; and

Fig. 9 is a schematic overview of the main components of an alternative embodiment of a roof window system according to the invention.

Description of Embodiments

[0018] Referring first to Figs 1 and 4 showing the overall appearance and principles underlying a prior art roof window system, the roof window system comprises a roof window 1' and a ventilation assembly generally designated 100' with a cover 151' having an aperture 152' for air intake and exhaust at each end and a housing to be described in further detail below. The roof window system shown in Fig. 1 is as described in the above-mentioned DE utility model 20 2016 100 906 U1. Explicit reference is made to this document, in particular to Figs 5 and 6, and the description associated thereto. Elements of the embodiments of the invention having the same or analogous function are denoted by the same reference numerals as in the description of the prior art roof window system, without the 'mark.

[0019] Thus, the roof window 1' comprises at least one frame, here two frames, of which one frame 2' is a stationary frame and the other is an openable sash 3' enclosing a pane 4'. The frame 2' and sash 3' each is substantially rectangular and has a top member, and further a bottom member and two side members, not shown in detail. The frame 2' is adapted to be built into a roof structure of virtually any kind, typically comprising a number of rafters and battens, and further non-shown details such as vapour barrier collars etc., below a roofing material. The window is centre-hung in that the sash 3' is connected to the frame 2' by a pivot hinge (not shown) provided between side members of the frame 2' and sash 3', respectively, to be openable by tilting the sash 3' of the window 1' about a pivot hinge axis defined by the pivot hinge. As used in this description, a closed position of the roof window 1' means a position in which the frame plane and the sash plane coincide, that is form an angle of 0 degrees with each other. Similarly, an open position of the roof window 1' as used herein generally means a

position in which the sash 3' is tilted about the pivot hinge axis such that the frame plane and the sash plane no longer coincide. Notwithstanding the centre-hung roof window described, the window according to the innovation may in other embodiments be top-hung, with or without an intermediate frame structure, have the hinge axis somewhere between the top and the centre, be side-hung or for that matter even be bottom-hung, or fixed, i.e. not openable. As will be described in further detail below, the roof window system also provides for optional ventilation in the closed position of the window. The sash 3' and frame 2' of the window according to the innovation may be made of wooden members or members made of cast or extruded polyurethane (PUR). In the installed position, the frame 2' and sash 3' are protected, in a manner known per se, by cover elements including a cladding and a flashing arrangement. Towards the interior, a suitable finishing may be provided, for instance comprising a lining panel.

[0020] The roof window 1' has a ventilation device as shown in Fig. 2, comprising a ventilation flap 40', which is connected to the top member of the sash 3' via a hinge connection 41' and which furthermore comprises a handle 42'. The ventilation flap 40' is an elongate element, which is connected to a lock 43' by means of a link connection 44' adapted to enable the ventilation flap 40' to be placed in at least two, and preferably at least three, different positions including a closed and at least one open position. In the top member of the sash 3, a top sash module 50' is provided, for instance of the kind described in Applicant's international application with publication No. WO 2013/050039 A1, allowing the passage of air when the ventilation flap is in the open position. Operating the handle 42' rotates the ventilation flap 40' from an open position to a closed position and vice versa. One or more intermediate positions, in which the ventilation flap 40' may be temporarily locked, may be defined between the open and closed position. In the embodiment shown and described, the sash 3' is pivotally connected to the frame 2', and the ventilation flap 40' is adapted to assume three position, viz. a first or closed position, in which the roof window 1' is closed and no ventilation is provided, a second and ventilating position, in which the roof window 1' is still closed but a ventilation aperture is provided to allow air passage, and a third and entirely open position, in which the sash 3' is able to pivot relative to the frame 2' to open the window. In other windows, for instance a top-hung roof window, the ventilation flap 40' may be able to assume only two position, viz. a closed position and an open, ventilating position, whereas operation of the sash takes place in other ways, for instance by a handle or other operating means located at the bottom member of the sash.

[0021] Referring now in particular to Figs 3 and 4, the general configuration details of a prior art housing 150' of the roof window system ventilation assembly is shown. A left-hand and a right-hand ventilation unit (not indicated) are provided in the housing, each comprising two

ventilators of which the two right-hand ventilators 132', 134' are shown. Each ventilation unit comprises a heat-exchange device in the form of a regenerator of which the left-hand regenerator 171' is shown. In the housing 150', a set of flow channels is provided, of which flow channels 1502' and 1504' of the right-hand ventilation unit are indicated in Fig. 4, and flow channel 1503' of the left-hand ventilation unit. At the interface with the roof window 1', two transition elements are provided, here only right-hand transition element 162' being shown. The flow of air is guided from the air intake 152' through the ventilation system via the flow channels 1502', 1504' and 1503', respectively, through a single flow path in the form of a respective flow channel section 1508' and 1507', to the ventilation flap 40'. Furthermore, the housing 150' is provided with a longitudinal partition wall 1500', a transverse partition wall 1506' and a central part 1520' housing an operating panel to be accessible from inside the room into which the roof window 1' of the roof window system is installed. The ventilation assembly 100' furthermore comprises a divider element 182' including means for providing flow connection to a respective flow channel 1502', 1504', and is mounted to the housing 150' via a plate 192'.

[0022] Turning now to Figs 5 to 7, a first embodiment of the roof window system of the present invention will be described. Reference is also made to Fig. 8 showing a transition element 162 in an embodiment of the invention, and to Fig. 9 indicating an overview of the main components of the roof window assembly including the roof window 1 with its ventilation device 40, and a ventilation assembly 100 including a housing 150 accommodating at least one ventilation unit, here two ventilation units 110; 120, each including at least one ventilator 131; 132 and at least one regenerator 171; 172. Transition elements 162, 164 are present in the right-hand side and transition elements 161, 163 in the left-hand side at the transition to the ventilation device 40 of the roof window 1. For the general operating principles underlying the ventilation assembly including components not shown in detail, explicit reference is made to the above-mentioned DE utility model 20 2016 100 906 U1.

[0023] In the housing 150, a set of flow channel sections 1502 and 1504 is present as in the prior art housing 150', connected to the aperture 152 in the cover 151 of the ventilation assembly 100. Different from the prior art arrangement however is that the respective flow channel section 1508' and 1507' of the prior art at a transition to the ventilation device 40 of the roof window 1 is replaced by a transition portion of the flow path which is divided by a splitter 1521; 1522 to form a pair of transition flow channel sections 1507, 1509; 1508, 1510, respectively. It is possible to have an asymmetric configuration as well, with only one side being split.

[0024] In the embodiment shown, the transition portion of the flow path in each ventilation unit 110; 120 is divided by a splitter 1521; 1522 such that the ventilation assembly 100 thereby comprises two pairs of transition flow chan-

nel sections 1507, 1509; 1508, 1510. In the following, reference may be made to only one of the left-hand and right-hand sides, and the person skilled in the art is able to discern where equal measures are taken on the other sides, and where differences may be applied.

[0025] The dimensions of the components such as longitudinal partition wall 1500, the central part 1520, splitters 1521; 1522, and the pairs of transition flow channel sections 1507, 1509; 1508, 1510 are typically chosen according the specific application of the ventilation assembly 100 to conform to different sizes roof windows 1 in the roof window systems. Here, transition flow channel sections 1507, 1509 of the left-hand ventilation unit 110 have respective width dimensions d_1 , d_2 . The transition flow channel sections 1508, 1510 of the right-hand ventilation unit 120 are typically configured in a corresponding manner. Each pair of transition flow channel sections are in connection with one respective adjacent flow channel section 1503; 1504, respectively. The adjacent flow channel sections 1503; 1504 each has a predefined width dimension d_0 .

[0026] Hence, the flow channel sections 1502 and 1504 guide the air from the regenerator 172 through the ventilator 132 (and possibly further ventilators) of the right-hand ventilation unit 120 towards the transition elements 162, 164 on either side of the splitter 1522 in the transition flow channel sections 1508 and 1510, and further into the ventilation device 40 of the roof window 1. By dividing the flow path into a plurality of flow paths, an improved flow pattern is achieved.

[0027] The maximum width dimension d_s of the splitter 1521 at the transition t is here smaller than the width dimension d_1 , d_2 of each of the pair of transition flow channel sections 1507, 1509.

[0028] In the present embodiment, the combined width dimensions d_1 , d_2 of the pair of transition flow channel sections 1507, 1509 substantially corresponds to the width dimension d_0 of the adjacent flow channel section 1503.

[0029] In the embodiment shown, each splitter 1521; 1522 is designed as a curved triangular shape which diverges from one end at the adjacent flow channel section 1503; 1504 to the other end, at the transition t to the ventilation device 40 of the roof window 1. The air guided from the respective regenerator through the ventilator, via the flow channel section, is thus split at the apex of the triangular shape. However, the splitter can have any design which divides the flow path and improves the flow pattern, such as, but not limited to; tubular or semi-circular shapes or a thin edged dividing wall. Correspondingly, the shape of each transition flow channel section 1507, 1509; 1508, 1510 is shown as curved, but variations may occur as well.

[0030] The invention is particularly advantageous in the case of wide roof windows, i.e. roof window systems in which the ventilation assembly 100 is provided with a large width w matching that of the roof window 1. The ratio between the total width w of the housing 150 of the

ventilation assembly 100 and the width dimension of the total width of the transition flow channel sections 1507, 1509; 1508, 1510 is in the range 1.5 to 2.5, more preferably 1.8 to 2.2. Even with this seemingly large ratio, it has proven possible to provide sufficient ventilation.

[0031] The dimensions of the transition elements 161, 163; 162, 164 provided at the transition t between the ventilation assembly 100 and the ventilation device 40 of the roof window 1 are chosen in accordance with the specifications to the roof window system, but typically the transition element 162 has, as shown in Fig. 8, a width dimension d_t substantially corresponding to the respective width dimension d_1 , d_2 of the transition flow channel sections 1507, 1509; 1508, 1510. Further details of the transition element 162 are shown in Fig. 8, including opening 1621 for the passage of air into and out of the room in which the roof window 1 of the roof window system is installed. Arc-shaped section 1622 provides for appropriate guiding of the air, and furthermore, fastening means 1623 for safe retention of the transition element 162 are shown.

[0032] In an alternative embodiment described with particular reference to Fig. 9, a control unit 200 is provided to allow the ventilation assembly 100 of the roof window system to by-pass the regenerator or regenerators 171; 172.

[0033] During normal operation, indicated by solid arrowed lines in Fig. 9, fresh air flows from the intake 152, through the regenerator 171, further to the ventilator 131 and via transition elements 161, 163 to the ventilation device 40 of the roof window 1 and into the building in which the roof window 1 is installed. Stale air flows in the opposite direction. The flow direction of the ventilators 131; 132 is switched at intervals, either in response to a pre-set pattern or to predefined values measured for instance by sensors.

[0034] By the provision of the control unit 200 it is possible to halt the regeneration of heat in the regenerators 171; 172 by a by-pass function. In practice, the by-pass may be provided by an additional flow path circumventing the regenerators 171; 172 and directing the air directly to the ventilators 131, 132 as indicated by dashed lines in Fig. 9, by not switching the flow direction of the ventilators as described in the above, or simply by stopping the operation of the regenerators and possibly also of the ventilators 131; 132.

[0035] The method of operating the ventilation assembly of the roof window system may be described as comprising the steps of:

providing a number of sensors in the building in which the roof window is mounted and coupling the sensors to the control unit 200,
selecting a target maximum temperature in the control unit 200,
optionally selecting a time period,
measuring the temperature in the building and comparing to the target maximum temperature in the con-

trol unit 200,
determining if the measured temperature exceeds
the target maximum temperature, and
by-passing the at least one regenerator 171; 172 if
the measured temperature exceeds the target max-
imum temperature.

[0036] The by-pass function may be automatically initiated and stopped based on a user-adjustable target maximum temperature and optionally time period, for instance by inputs to the operating panel.

[0037] It should be noted that the above description of preferred embodiments serves only as an example, and that a person skilled in the art will know that numerous variations are possible without deviating from the scope of the claims.

List of reference numerals

[0038]

1'	roof window
2'	stationary frame
3'	sash
4'	pane
40'	ventilation flap
41'	hinge connection
42'	handle
43'	lock
44'	link connection
50'	top sash module
100'	ventilation assembly
132'	right-hand ventilator
134'	right-hand ventilator
150'	housing
	1500' longitudinal partition wall
	1502' flow channel
	1503' flow channel
	1504' flow channel
	1506' transverse partition wall
	1507' flow channel
	1508' flow channel
	1520' central part
151'	cover
152'	aperture
171'	left-hand ventilator
182'	divider
192'	plate
1	roof window
4	pane
40	ventilation device
100	ventilation assembly
110	ventilation unit
120	right-hand ventilation unit
131	left-hand ventilator
132	right-hand ventilator
150	housing

	1500 longitudinal partition wall
	1502 flow channel
	1503 flow channel
	1504 flow channel
5	1506 transverse partition wall
	1507 transition flow channel
	1508 transition flow channel
	1509 transition flow channel
	1510 transition flow channel
10	1520 central part
	1521 splitter
	1522 splitter
151	cover
152	aperture
15	161 left-hand side transition element
162	right-hand side transition element
	1621 opening
	1622 arc-shaped section
	1623 fastening means
20	163 left-hand side transition element
	164 right-hand side transition element
	171 left-hand regenerator
	172 right-hand regenerator
200	control unit

Claims

1. A roof window system comprising:

30	a roof window (1) having at least one frame (2, 3) defining a frame plane and including a pane (4), the roof window (1) further comprising a ventilation device (40) adapted for providing ventilation of a building in which the roof window is mounted, and
35	a ventilation assembly (100) comprising a housing (150) accommodating at least one ventilation unit (110; 120), each including at least one ventilator (131; 132) and at least one regenerator (171; 172), and a set of flow channel sections (1502, 1504, 1508; 1503, 1507), each ventilation unit (110; 120) being connected to an aperture (152) for air intake and exhaust, and to a transition (t) to the ventilation device (40) of the roof window (1), to provide a predefined flow path from via the set of flow channel sections (1502, 1504, 1508; 1503, 1507) in each ventilation unit (110; 120),
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characterised in that

55	a transition portion of the flow path at the transition (t) to the ventilation device (40) of the roof window (1) in at least one ventilation unit (110; 120) is divided by a splitter (1521; 1522) to form a pair of transition flow channel sections (1507, 1509; 1508, 1510) with a respective width di-
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- mension (d1, d2) and in connection with one respective adjacent flow channel section (1503; 1504) with a predefined width dimension (d0).
2. A roof window system according to claim 1, wherein the transition portion of the flow path in each ventilation unit (110; 120) is divided by a splitter (1521; 1522) such that the ventilation assembly (100) thereby comprises two pairs of transition flow channel sections (1507, 1509; 1508, 1510).
 3. A roof window system according to any one of the preceding claims, wherein the width dimension (d1) of one transition flow channel section (1507) of said pair substantially corresponds to the width dimension (d2) of the other transition flow channel section (1509) of said pair.
 4. A roof window system according to claim 3, wherein the maximum width dimension (ds) of the splitter (1521) at the transition (t) is smaller than the width dimension (d1, d2) of each of the pair of transition flow channel sections (1507, 1509).
 5. A roof window system according to any of claims 3 and 4, wherein the combined width dimensions (d1, d2) of the pair of transition flow channel sections (1507, 1509) substantially corresponds to the width dimension (d0) of the adjacent flow channel section (1503).
 6. A roof window system according to any one of the preceding claims, wherein the splitter (1521; 1522) has a curved triangular shape which diverges from one end at the adjacent flow channel section (1503; 1504) to the other end, at the transition (t) to the ventilation device (40) of the roof window (1).
 7. A roof window system according to claim 6 when dependent on claims 3 to 5, wherein the shape of each transition flow channel section (1507, 1509; 1508, 1510) is curved.
 8. A roof window system according to any one of claims 2 to 7, wherein the ratio between the total width (w) of the housing (150) of the ventilation assembly (100) and the width dimension of each transition flow channel section (1507, 1509; 1508, 1510) is in the range 1.5 to 2.5, more preferably 1.8 to 2.2.
 9. A roof window system according to any one of the preceding claims, wherein a transition element (162) is provided at the transition (t) between the ventilation assembly (100) and the ventilation device (40) of the roof window (1), and wherein the transition element (162) has a width dimension (dt) substantially corresponding to the respective width dimension (d1, d2) of the transition flow channel sections (1507, 1509; 1508, 1510).
 10. A roof window system according to any one of the preceding claims, wherein the ventilation assembly (100) comprises a control unit (200) to provide a by-pass function of the at least one regenerator (171; 172).
 11. A method of operating the ventilation assembly of the roof window system according to claim 10, comprising the steps of:
 - providing a number of sensors in the building in which the roof window is mounted and coupling the sensors to the control unit (200),
 - selecting a target maximum temperature in the control unit (200), optionally selecting a time period,
 - measuring the temperature in the building and comparing to the target maximum temperature in the control unit (200),
 - determining if the measured temperature exceeds the target maximum temperature, and
 - by-passing the at least one regenerator (171; 172) if the measured temperature exceeds the target maximum temperature.
 12. The method of claim 10, wherein the by-pass function is automatically initiated and stopped based on a user-adjustable target maximum temperature and optionally time period.

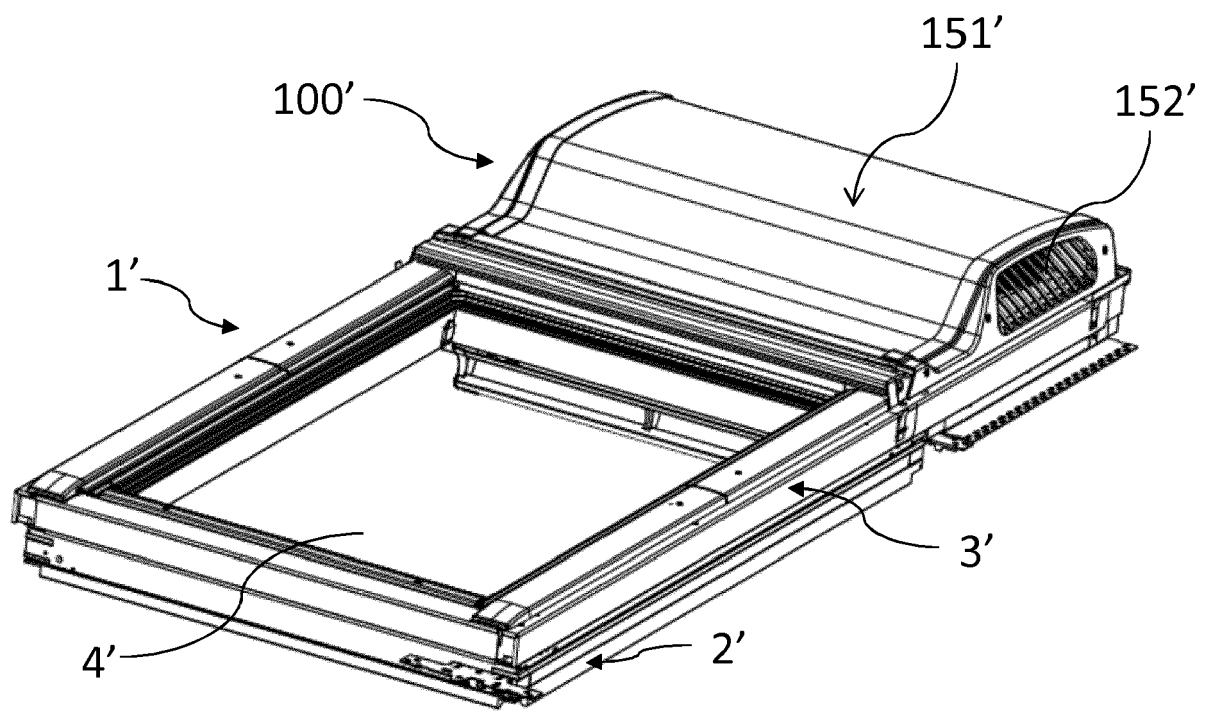


Fig. 1 (prior art)

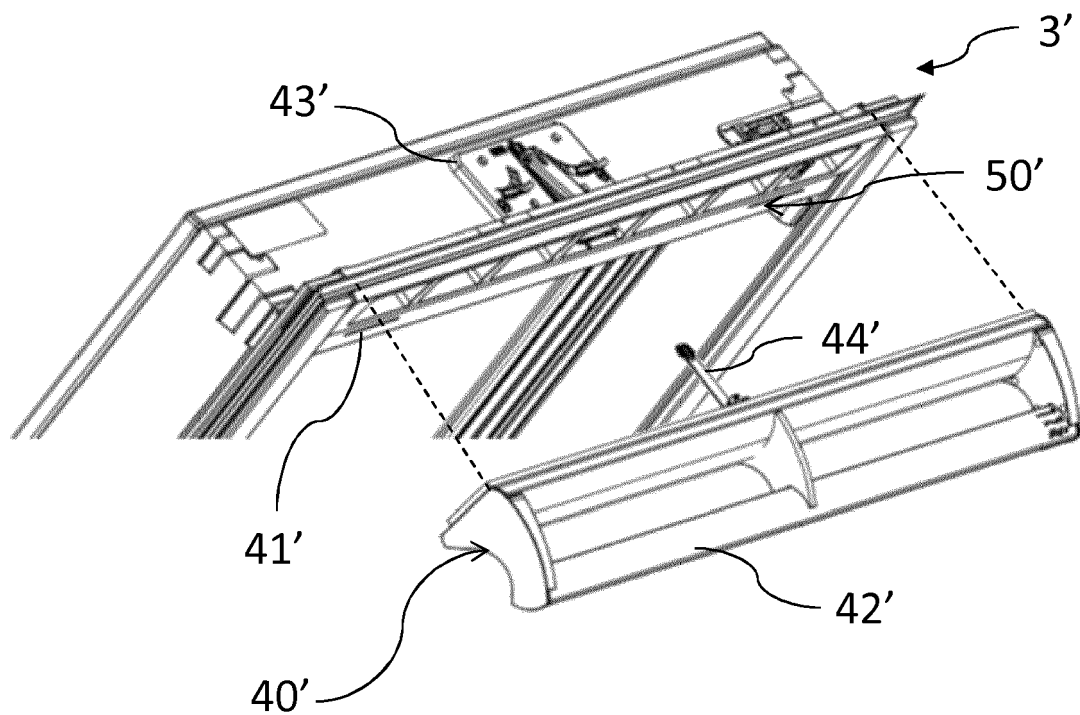


Fig. 2 (prior art)

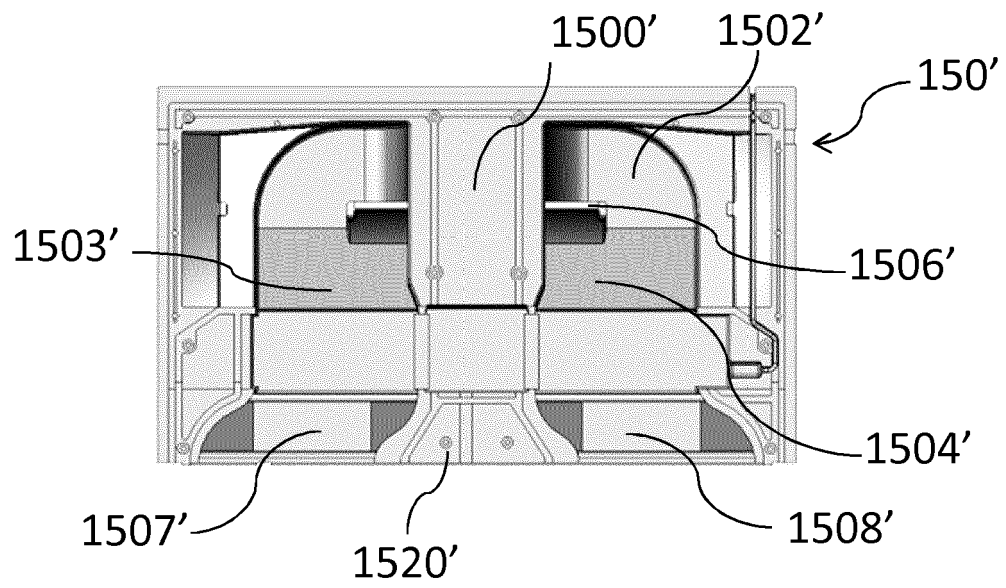


Fig. 3 (prior art)

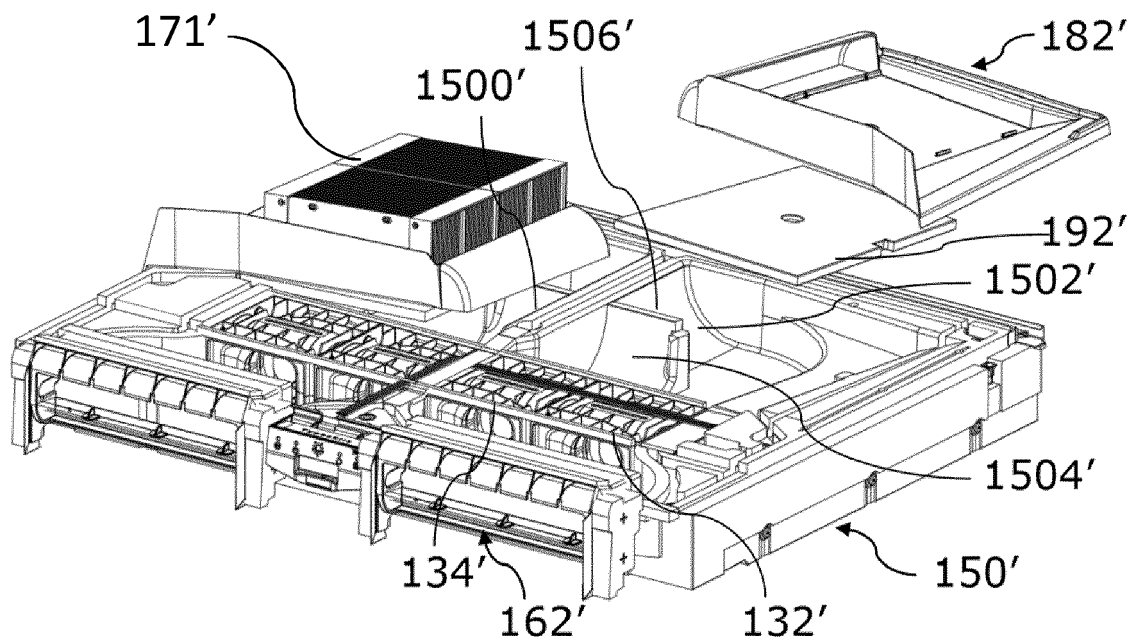


Fig. 4 (prior art)

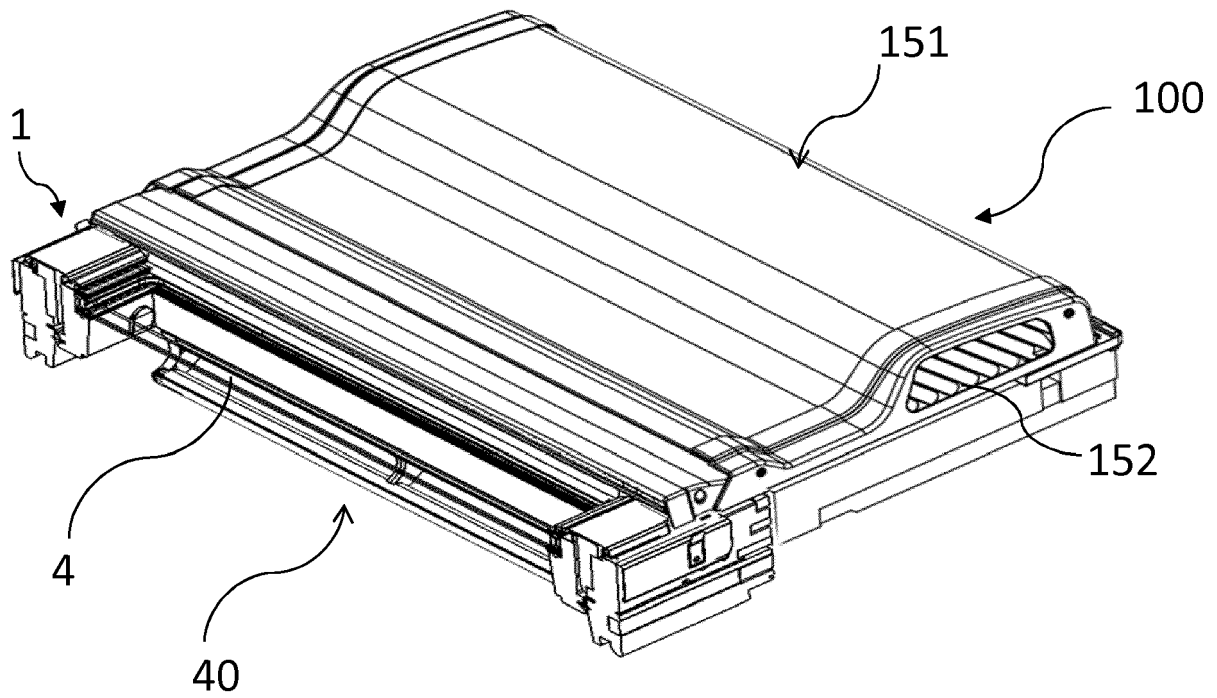


Fig. 5

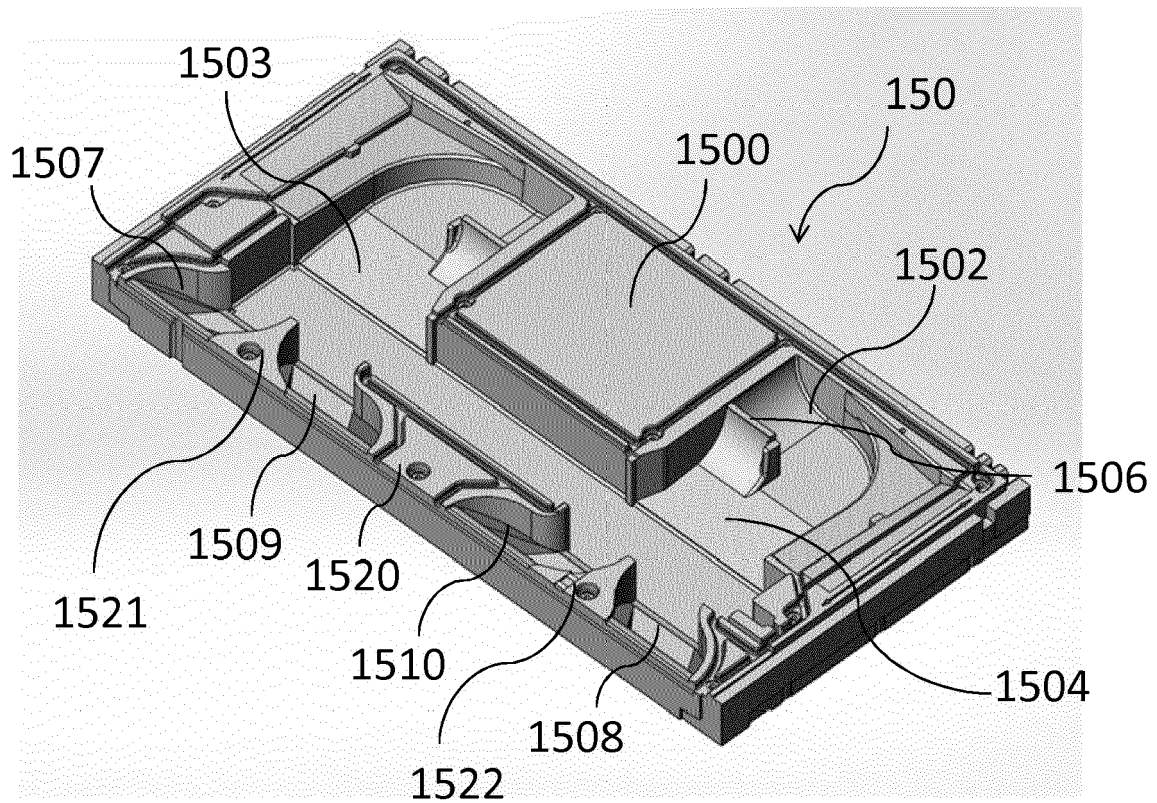


Fig. 6

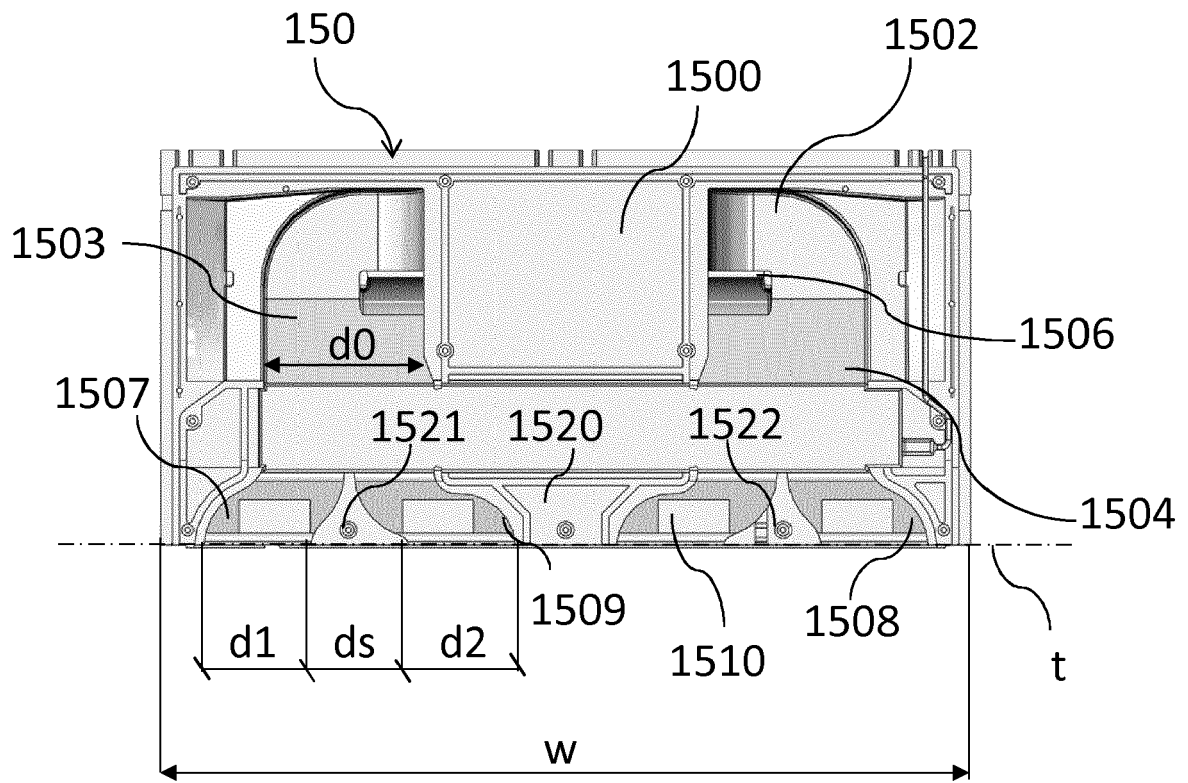


Fig. 7

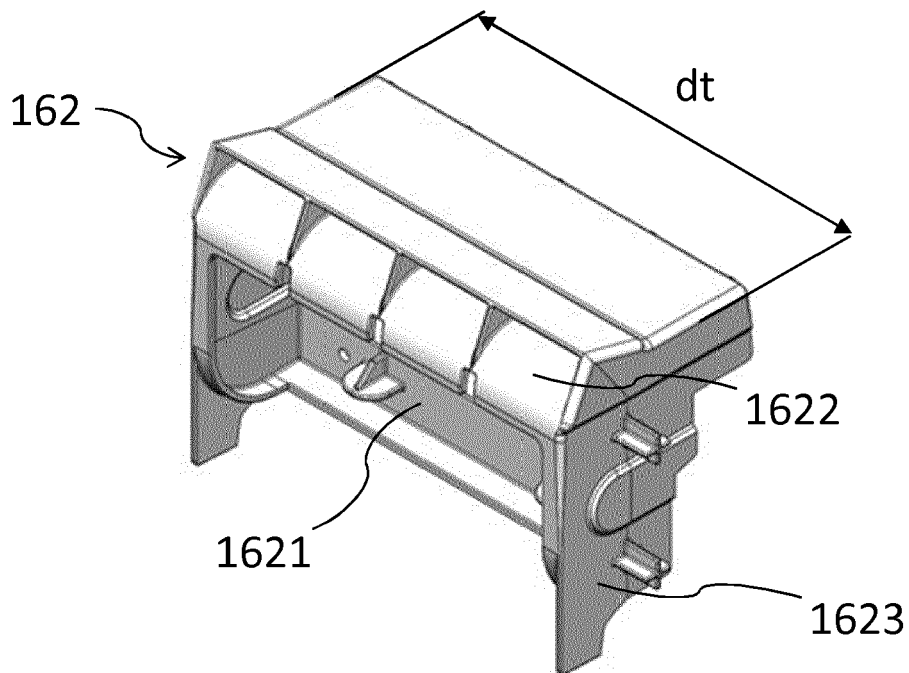


Fig. 8

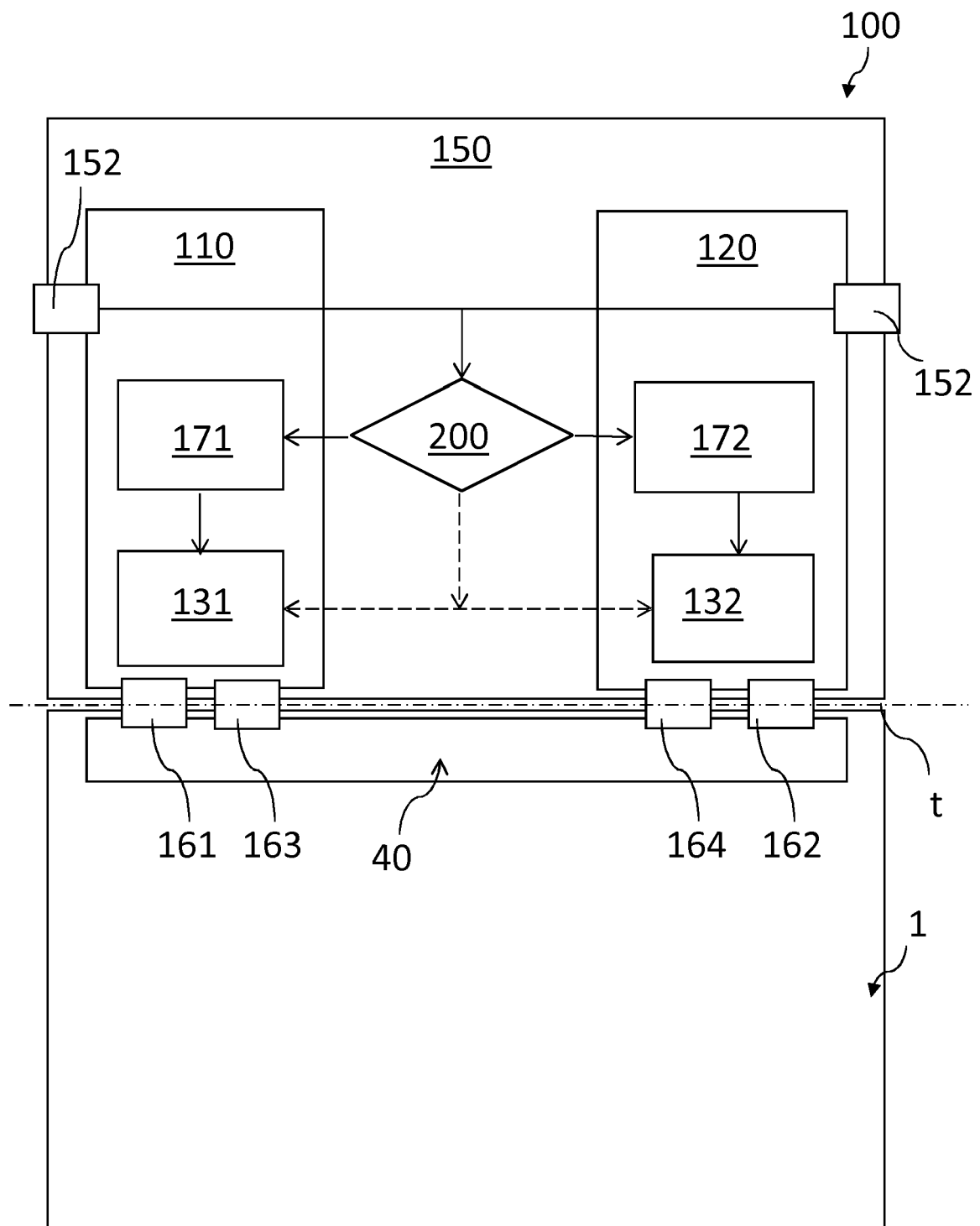


Fig. 9



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Place of search The Hague		Date of completion of the search 28 May 2018	Examiner Leroux, Corentine
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