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(54) SAFETY SYSTEM FOR BYPASS TUNNELS AND THE LIKE

(57) A safety system for bypass tunnels and the like, which comprises:
- measurement means (2) for measuring the degree of opening of fire doors (3) arranged between a pressurized chamber (4) and a tunnel (5);
- fan means (7) arranged in the pressurized chamber (4) and adapted to create a pressurized atmosphere with an overpressure with respect to the atmospheric pressure present in the tunnel (5), the fan means (7) being configured so as to operate as a function of the calculated differential pressure between the pressure in the pressurized chamber (4) and in the tunnel (5) and the measurement performed by the measurement means (2);
- electronic control and management means functionally connected to the measurement means (2) and to the fan means (7) in order to adjust the operating speed of the fan means (7);
- door-closing means (8) applied on the fire doors (3);
- means (9) for the assisted opening and closing of the fire doors (3), configured so as to aid their opening following actuation of a panic bar (10) of the fire doors (3).

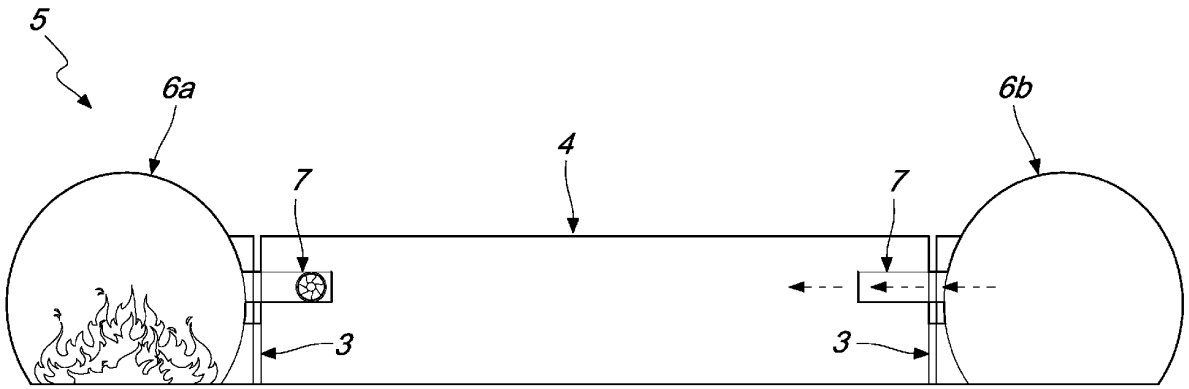

Fig. 2

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Description

[0001] The present invention relates to a safety system for bypass tunnels and the like.

[0002] In the sector of civil engineering, in particular in the branch of urban planning, regulations and directives are in force for infrastructure safety, which require there to be, inside tunnels, at predefined distances, an escape and/or evacuation route in order to ensure that users can be brought to safety.

[0003] In twin-bore tunnels and escape routes in general there are "bypass" tunnels, located at distances defined by regulations, which connect the two bores as escape routes in the event of emergencies. Bypass tunnels comprise a pressurized chamber; the reason it is pressurized is to prevent the passage of smoke from a zone on fire to the safe zone and, for this and other reasons, it is currently called the "filter zone".

[0004] The filter zone is provided with fire doors for the protection of persons and for the compartmentalization and containment of the propagation of a fire in one of the two bores.

[0005] The objectives of the filter zone can be summed up as follows:

- ensure the safety of the users;
- ensure the safe evacuation of the users from the structure;
- ensure the intervention of the emergency services and firefighting services.

[0006] As mentioned previously, the escape routes often consist of bypass tunnels that connect the bore where the incident is located and the adjacent bore, which is considered a safe zone.

[0007] In the most common configuration, these bypass tunnels are made up of one or more sealed pressurized chambers, with fire doors at least at one of the ends to delimit the chamber and protect the users from fire and smoke, via the combined action of the seal of the doors when closed, and the overpressure inside the chamber, which prevents smoke from entering.

[0008] In more detail, the configuration of the bypass tunnel includes unidirectional fans which, in the event of a fire in one of the two bores, will take air from the other bore in order to pressurize the filter zone, with an air flow rate that is such as to maintain the filter zone in overpressure even when all the doors are open.

[0009] The function of the doors of the bypass tunnel is therefore to allow, under conditions of safety, the transit of persons from the bore where the incident is located to the other bore.

[0010] The system is completed by the smoke control system for preventing the ingress and spread of fumes along the evacuation route.

[0011] The pedestrian bypass tunnel is designed and built, according to the specifications in the related documents, in full compliance with the laws and regulations in force on the subject, and in particular to:

- ensure a mechanical resistance to fire for a specified length of time, usually 120 minutes;
- prevent the passage of hot fumes for a specified length of time, usually 120 minutes;
- ensure a thermal insulation for a specified length of time, usually 120 minutes;
- resist, without loss of or reduction in the functionality, an overpressure of between 1 and 10 kilopascals, induced by the motion of the vehicles in the tunnel;
- ensure an easy and safe opening, with a maximum effort of 220 Newtons;
- ensure automatic but gradual closure;
- withstand ambient temperatures comprised between 0°C and 50°C;
- withstand relative humidity of 50% at 40°C;
- withstand high concentrations of dust and of metallic particles.

[0012] The local remote control system is usually constituted by an electrical switchboard, dimensioned to accommodate both the electrical switching gear (switches, motor protections, inverters), and the remote control gear.

[0013] The systems available can be described as follows:

- fans - cable, ducting;
- power switchboard + PLC, SW development, installation, testing.

[0014] In twin-bore tunnels and escape routes there are bypasses at distances defined by regulations, with one or more pressurized chambers for preventing the passage of smoke from the zone where the fire is located to the safe zone. This chamber is currently known as a "filter zone", and it is provided with fire doors for the protection of persons and for compartmentalizing the fire.

[0015] The regulations specify a series of conditions that must compulsorily be met during the opening and closing of the doors to ensure the safety of persons, including:

- during the evacuation, the maximum effort to be applied on the handle to ensure an easy opening of the doors must not exceed 220 Newtons;
- with the door open, the speed of the air exiting from the filter zone, measured at a point at the center of the free opening of the door, must be at least 2 meters per second;
- a minimum length of time for closing the door, at a constant speed, the value of which also depends on the width, with the goal of not crushing the escaping persons;
- a maximum length of time for automatically closing the door in accordance with regulations, in order to prevent fumes from penetrating the filter zone.

[0016] To date these conditions, insofar as they can be considered reasonable and necessary, have been found overall to be very restrictive, not always feasible in their entirety owing to as-yet inadequate technological and mechanical development, and effectively they remain just good intentions, even at the time of testing the system.

[0017] Effectively the suppliers of subsystems, i.e. doors, ventilation, and ventilation control, take care of ensuring the required performance levels solely and exclusively for their part of the supply, and not for the overall system.

[0018] The aim of the present invention consists in providing a safety system in which the components are mutually integrated in order to ensure a safe evacuation by overcoming the above limitations.

[0019] Within this aim, an object of the present invention consists in providing a safety system in which the subsystems contribute to ensure the performance of the whole, so as to ensure a correct protection and exit of the persons through the escape route, i.e. the bypass tunnel.

[0020] Another object of the present invention consists in providing a safety system that is capable of ensuring that the fire doors, even in presence of an internal pressure in the bypass tunnel, can be opened with an effort applied on the handle that does not exceed 220 Newtons.

[0021] A further object of the present invention is to provide a safety system that is capable of ensuring that the ventilation system modulates the flow rate as a function of the pressure differential and on the basis of the state of the doors, and thus ensuring, in the event of one or more open doors, an air speed of 2.2 meters per second measured at the center of the doors.

[0022] Another object of the present invention consists in providing a safety system that is capable of ensuring that the automatic closing of the fire doors is gradual and at a practically constant speed, within a maximum time of 30 seconds, in accordance with the specifications of the current regulations, without slamming and avoiding injury to the persons passing through the bypass tunnel or escape route.

[0023] Last but not least, an aim of the present invention is to provide a safety system that avails of technologies that are known per se and which therefore are economically competitive.

[0024] This aim and these and other objects which will become more apparent hereinafter are achieved by a safety system for bypass tunnels and the like, characterized in that it comprises:

- measurement means for measuring the degree of opening of fire doors arranged between a pressurized chamber and a tunnel;
- fan means arranged in said pressurized chamber and adapted to create a pressurized atmosphere with an overpressure with respect to the atmospheric pressure present in said tunnel, said fan means being configured so as to operate as a function of the calculated differential pressure between the pressure in said pressurized chamber and in said tunnel and the measurement performed by said measurement means;
- electronic control and management means functionally connected to said measurement means and to said fan means in order to adjust the operating speed of said fan means;
- door-closing means applied on said fire doors;
- means for the assisted opening and closing of said fire doors, configured so as to aid the opening and the closing of said fire doors following actuation of a panic bar of said fire doors.

[0025] Further characteristics and advantages of the invention will become more apparent from the detailed description of a preferred, but not exclusive, embodiment of a safety system for bypass tunnels and the like, illustrated by way of non-limiting example with the aid of the accompanying drawings wherein:

- Figure 1 is a schematic perspective view of a safe zone between the two bores of a twin-bore tunnel;
- Figure 2 is a front elevation view of the safe zone shown in Figure 1;
- Figure 3 is a front elevation view of one of many types of fire doors of the safe zone shown in the previous figures.

[0026] With reference to the figures, the safety system for bypass tunnels and the like comprises measurement means 2 for measuring the degree of opening of the fire doors 3, which are arranged between a pressurized chamber 4 and a tunnel 5.

[0027] In the embodiment proposed, a twin-bore tunnel 5 with two bores 6a and 6b is shown, in which the first bore 6a is affected by a fire.

[0028] Since the inventive concept described herein can be applied to both single-bore and twin-bore tunnels, the term tunnel 5 will be used to mean a tunnel that comprises at least one bore that is affected by a fire.

[0029] The measurement means 2 can comprise a first limit switch of the mechanical type, adapted to detect the closed and locked state of the fire doors 3, a second limit switch of the mechanical type, adapted to detect a degree of opening of the fire doors 3 substantially equal to 10°, and a third limit switch of the mechanical type, adapted to detect a degree of opening of the fire doors 3 equal to or substantially greater than 30°.

[0030] Furthermore, or as an alternative to the limit switches of the mechanical type, the measurement means 2 can comprise an incremental encoder adapted to detect the exact degree of opening of the fire doors 3.

[0031] Also according to the invention, the safety system comprises fan means 7 located in the pressurized chamber 4 or even outside it and adapted to create a pressurized atmosphere with an overpressure with re-

spect to the atmospheric pressure present in the tunnel 5.

[0032] Such fan means 7, which can comprise two or more fans, are configured so as to operate as a function of the calculated differential pressure between the pressure in the pressurized chamber and in the tunnel and the measurement performed by the measurement means.

[0033] Conveniently, for a twin-bore tunnel 5, the fan means 7 draw air from the bore that lies opposite the bore affected by the flames, i.e. the bore 6b.

[0034] Differently, for a single-bore tunnel, the fan means 7 will draw air from an aeration duct outside the bore that is affected by the flames.

[0035] Furthermore, there are also electronic control and management means which are functionally connected to the measurement means 2 and to the fan means 7, for adjusting the speed of operation of the latter; door-closing means 8, of the adjustable type, applied to the fire doors 3, and means 9 for assisted opening and closing of the fire doors 3 which are configured in such a way as to assist the opening of the fire doors 3 following actuation of the panic bar 10 thereof.

[0036] In more detail, the electronic control and management means can be based on a PLC system, have one CPU per switchboard, and share the I/O between both PLCs, so that the failure of one device can still be overcome by being taken over by the PLC mounted in the switchboard that controls a second fan.

[0037] Advantageously, the means 9 for assisted opening can comprise a pressure venting device functionally connected to the fan means 7 in order to reduce the incidence of the pressure on the surface on the filter zone side of the door, during opening and closing, from the moment of actuation of the panic bar 10.

[0038] In more detail, the venting device can for example comprise at least one ventilation grille 11, which is integrated in the fire doors 3 and can be switched between a closed state, in which its slits are closed hermetically, to an open state, in which the slits are open for the passage of air.

[0039] Alternatively, in a variation (not shown) of the embodiment proposed, the means 9 for assisted opening and closing can comprise a servo-mechanical device configured in such a way as to apply an additional thrust to the fire doors following actuation of the panic bar.

[0040] The operation of the safety system is described below.

[0041] The function of the safety system is to maintain the bypass tunnel at a set overpressure (with the fire doors closed) with respect to the tunnel 5, so that when even only one first fire door 3 is opened, the fumes originating from the combustion of a possible fire located in a bore 6a cannot enter.

[0042] Normally, if fire breaks out in a tunnel the fan means 7 in the affected areas are started up and kept at a speed of 20% and they vary their flow rate as a function of the pressure differential set and measured by the instrumentation and based on the position of the measurement means 2, which are described above.

[0043] Via the implementation of dedicated algorithms, if a first fire door 3 is opened, the system will increase the speed in order to maintain the required pressure differential; thus ensuring the prescribed air speed with the fire door 3 open, for example equal to two meters per second.

[0044] If the measurement means 2 detect an opening of the fire door 3, for example up to approximately 10°, the control and management means will increase the speed of the fan means 7, but not bring it to the maximum speed.

[0045] Once an opening of 30° is passed, however, the control and management means will make the fan means 7 reach the speed to ensure the set pressure and outflow of air (usually at least 2 meters per second), by proportionally adjusting the speed of the fan on the basis of the data of the measurement means 2 and of the detected pressure data.

[0046] If the second fire door 3 is also opened, the fan means 7 will continue to strive towards the set pressure, but ensuring an overpressure that is such as to not allow the entry of fumes.

[0047] In this case the control and management means will bring the fan means 7 to the maximum speed.

[0048] During the step of closing the fire doors 3, the control and management means will behave in the same way but in reverse, and proportionally so as to prevent the internal pressure generated by the fan means 7 from closing the fire doors 3 too quickly, while assisting the functionality of the door-closing means 8.

[0049] The safety system located at the entry points of the tunnel 5 can be managed by the centralized control system, through macro-commands to be executed in the event of an emergency.

[0050] The correct dimensioning of the fan means is arrived at by means of a CFD (Computational Fluid Dynamic) simulation.

[0051] The objective of the simulation is to obtain a minimum speed of the air passing through the fire door 3, on the side where the fire is, of two meters per second, and to define the ambient levels "with turbulence" and/or "dead zones" (without significant air speed).

[0052] In practice it has been found that the safety system for bypass tunnels and the like achieves the intended aim and objects in that it makes it possible to ensure a safe evacuation in any open condition and condition of overpressure inside the filter zone.

[0053] In particular, the safety system ensures:

- opening of the doors with an effort of not more than 220 Newtons;
- blocking of the fumes coming from the bore where the incident is to the filter zone, when the doors are open;
- closing of the doors within the maximum limits set down by the regulations;
- gradual closing of the doors, thus preserving the

safety of persons (anti-crush);
- correct ventilation and overpressure in various scenarios of the doors opening;
- modular construction and standardization of bypass tunnels;
- reduction of installation times and bringing into service times;
- high degree of safety achieved through the remote monitoring of every single bypass tunnel;
- direct interconnection and management of bypass tunnels from a central location.

[0054] The safety system for bypass tunnels and the like, thus conceived, is susceptible of numerous modifications and variations all of which are within the scope of the appended claims.

[0055] Moreover, all the details may be substituted by other, technically equivalent elements.

[0056] In practice, the materials employed, provided they are compatible with the specific use, and the contingent dimensions and shapes, may be any according to requirements and to the state of the art.

[0057] The disclosures in Italian Patent Application No. 102021000025091 from which this application claims priority are incorporated herein by reference.

[0058] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the interpretation of each element identified by way of example by such reference signs.

Claims

1. A safety system for bypass tunnels and the like, **characterized in that** it comprises:

   - measurement means (2) for measuring the degree of opening of fire doors (3) arranged between a pressurized chamber (4) and a tunnel (5);
   - fan means (7) arranged in said pressurized chamber (4) and adapted to create a pressurized atmosphere with an overpressure with respect to the atmospheric pressure present in said tunnel (5), said fan means (7) being configured so as to operate as a function of the calculated differential pressure between the pressure in said pressurized chamber (4) and in said tunnel (5) and the measurement performed by said measurement means (2);
   - electronic control and management means functionally connected to said measurement means (2) and to said fan means (7) in order to adjust the operating speed of said fan means (7);
   - door-closing means (8) applied to said fire doors (3);
   - means (9) for the assisted opening and closing of said fire doors (3), configured so as to aid the opening and the closing of said fire doors (3) following actuation of a panic bar (10) of said fire doors (3).

2. The apparatus according to claim 1, **characterized in that** said measurement means (2) comprise a first limit switch of the mechanical type, adapted to detect the closed and locked state of said fire doors (3), a second limit switch of the mechanical type, adapted to detect a degree of opening of said fire doors (3) substantially equal to 10°, and a third limit switch of the mechanical type, adapted to detect a degree of opening of said fire doors (3) equal to or substantially greater than 30°.

3. The apparatus according to claim 1 or 2, **characterized in that** said measurement means (2) comprise an incremental encoder adapted to detect the exact degree of opening of said fire doors (3).

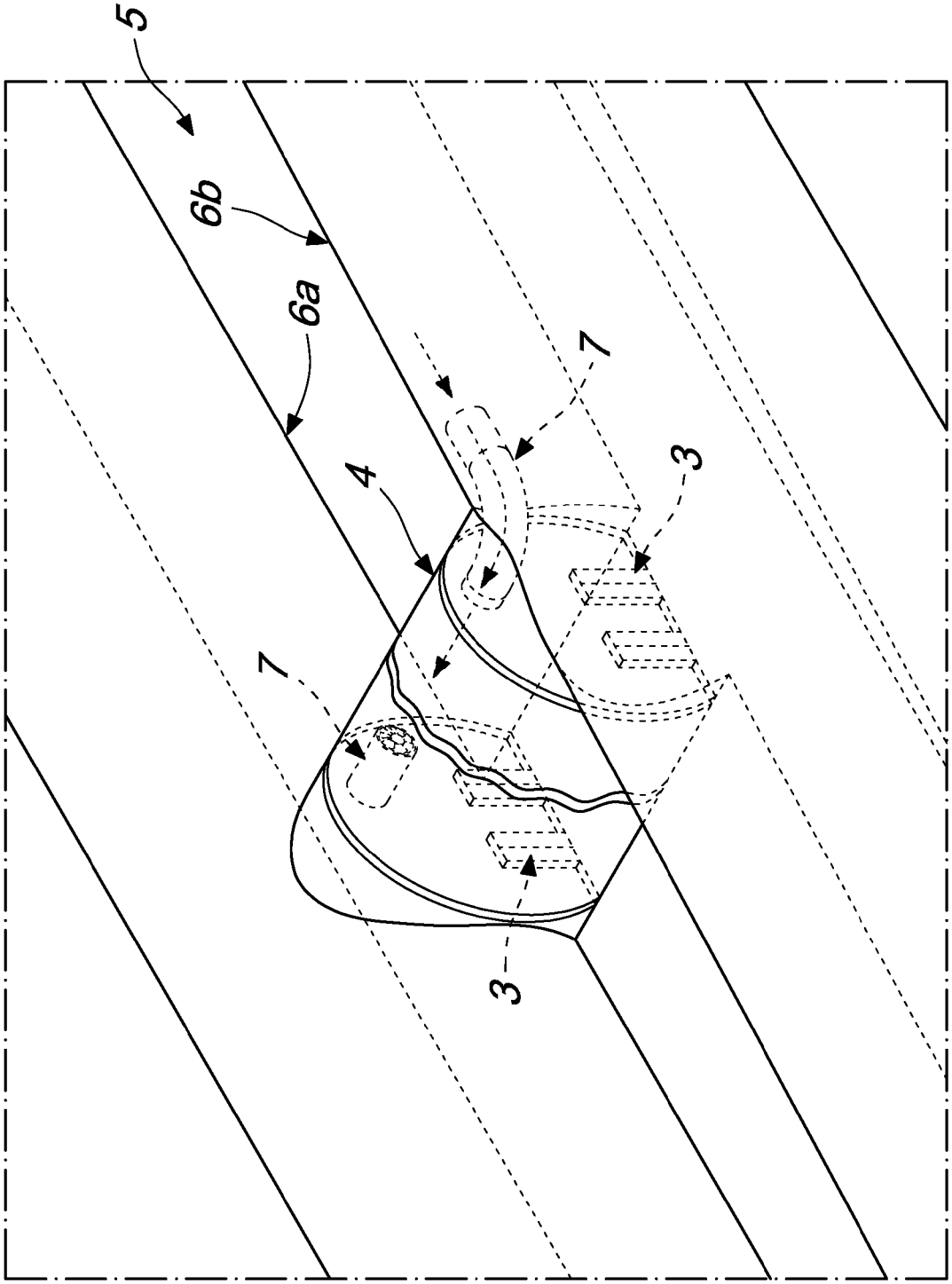
4. The apparatus according to one or more of the preceding claims, **characterized in that** said door-closing means (8) are of the adjustable type.

5. The apparatus according to one or more of the preceding claims, **characterized in that** said means (9) for assisted opening comprise a pressure venting device functionally connected to said fan means (7) in order to reduce the incidence of the pressure on the surface on the filter zone side of the door, during opening and closing, from the moment of actuation of the panic bar (10).

6. The apparatus according to claim 5, **characterized in that** said venting device comprises at least one ventilation grille (11), which is integrated in said fire doors (3) and can be switched between a closed state, in which the slits of said ventilation grille (11) are closed hermetically, to an open state, in which said slits are open for the passage of air.

7. The apparatus according to one or more of claims 1 to 6, **characterized in that** said means for assisted opening and closing comprise a servo-mechanical device configured in such a way as to apply an additional thrust to said fire doors (3) following actuation of said panic bar (10).

Fig. 1



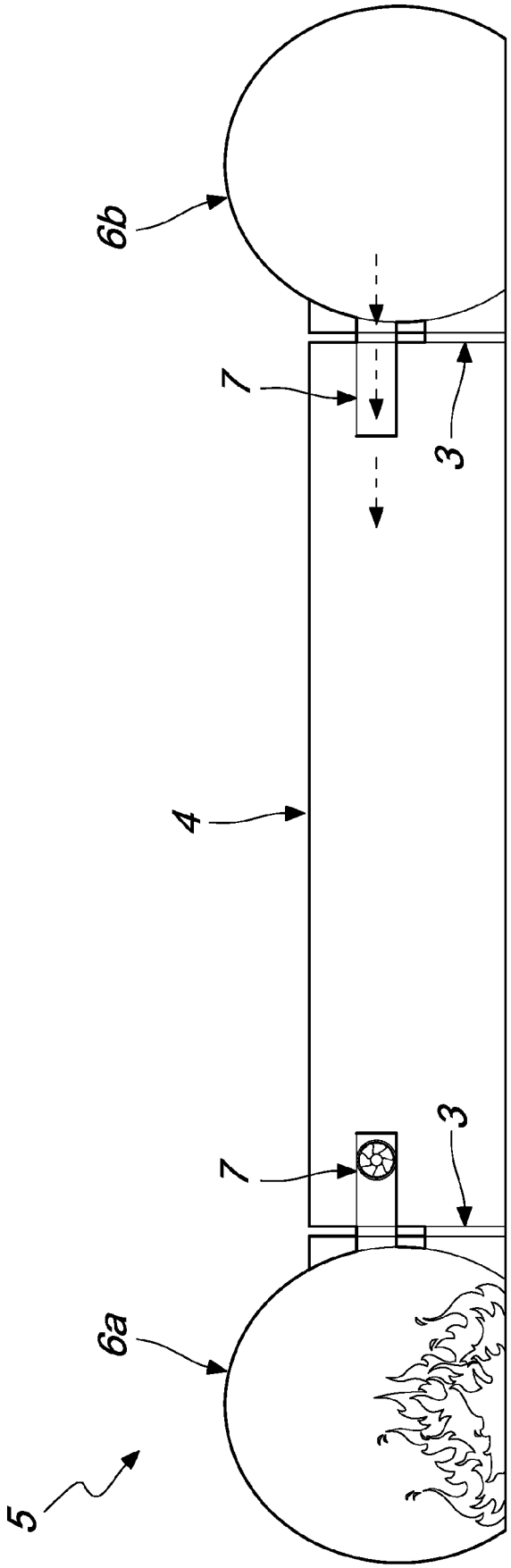


Fig. 2

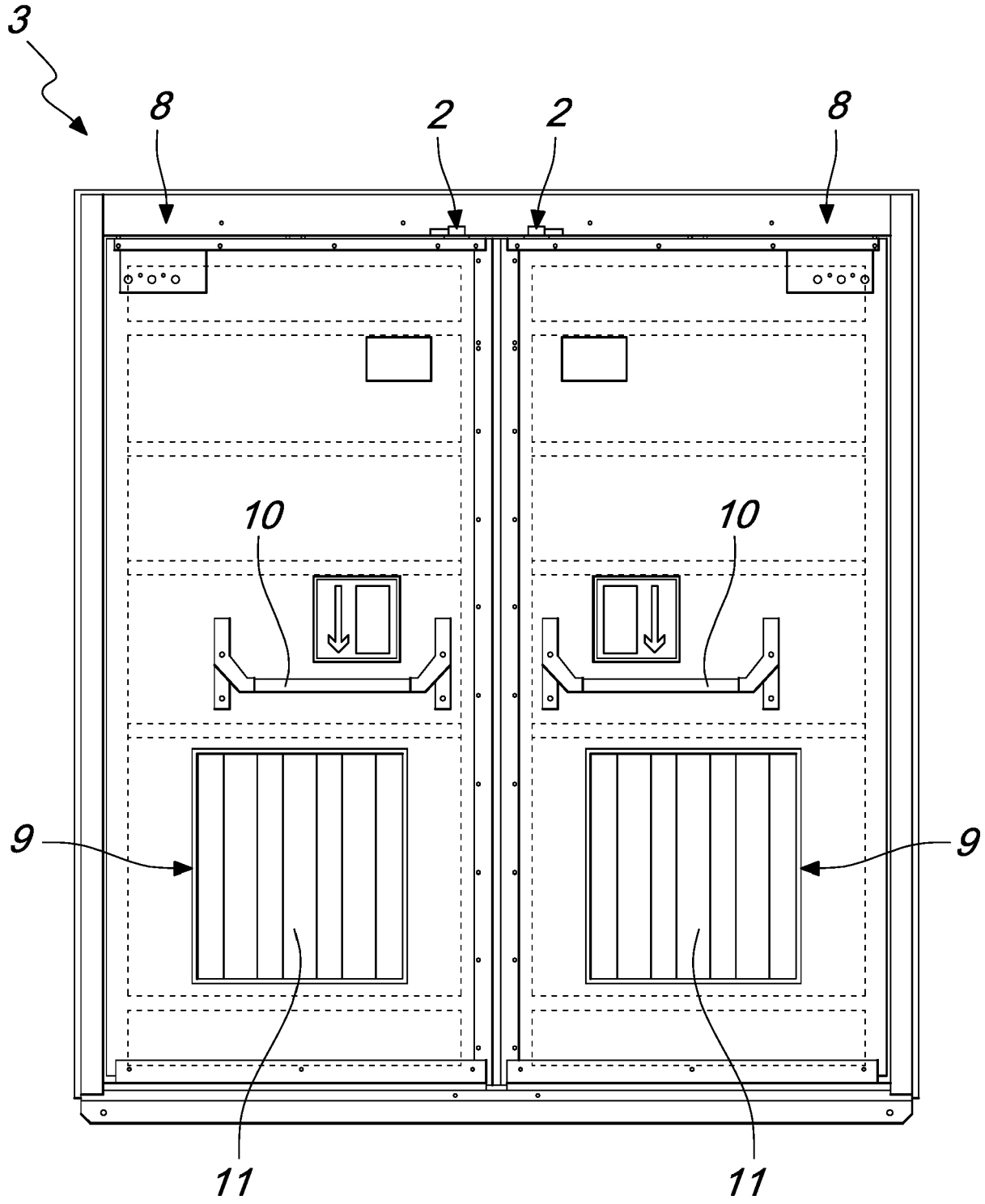


Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 22 19 7486

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	NO 20 200 449 A1 (FOSSHEIM SOLUTION [NO]) 30 August 2021 (2021-08-30) * the whole document *	1	INV. E21F1/00 E21F11/00
A	KR 101 986 751 B1 (TNC CO LTD [KR]) 7 June 2019 (2019-06-07) * paragraphs [0072], [0073]; figures 1,2 *	1	

TECHNICAL FIELDS SEARCHED (IPC)

E21F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	20 January 2023	Maukonen, Kalle

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
NO 20200449 A1	30-08-2021	NONE	
KR 101986751 B1	07-06-2019	NONE	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- IT 102021000025091 **[0057]**