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(11) **EP 4 491 956 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
15.01.2025 Bulletin 2025/03

(21) Application number: **23461627.4**

(22) Date of filing: **12.07.2023**

(51) International Patent Classification (IPC):
F24F 5/00 *(2006.01)* ***F24F 11/56*** *(2018.01)*
F24F 13/08 *(2006.01)* *F24F 13/14* *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F24F 11/56; F24F 5/0046; F24F 11/74; F24F 13/08; F24F 13/1426; F24F 2005/0064; F24F 2005/0067; F24F 2110/10

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

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(54) **AN AIR FLOW REGULATOR**

(57) An air flow regulator (1, 1', 1"), comprising: a body (10, 10') forming a duct for conducting air flow, an air flow regulating mechanism located inside the body (10, 10'), and an operating module (22) coupled to an actuator (21) mounted outside the body (10, 10') for adjusting the air flow regulating mechanism. The air flow regulator (1, 1', 1") further comprises a perovskite cells module (41) connected to the operating module (22) to charge a battery (32) that powers the actuator (21), and the operating module (22) comprises a control signal receiver (34) configured to receive a control signal from a remote controller (51).

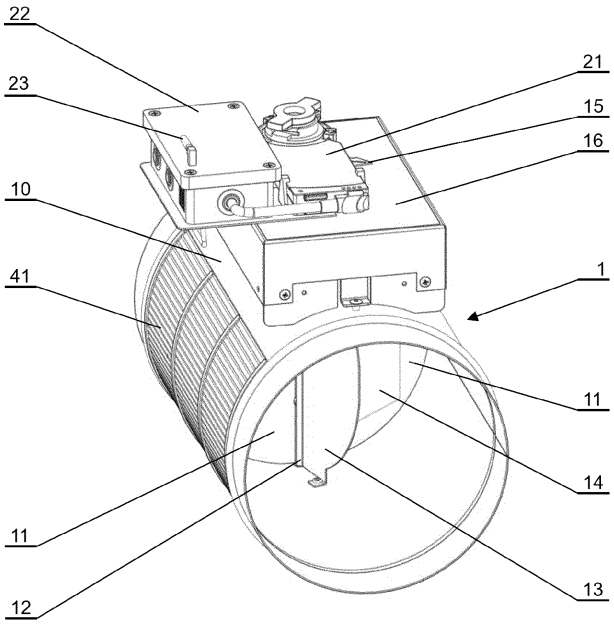

Fig. 1A

EP 4 491 956 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to the field of heating, ventilation, air conditioning (HVAC). In particular, it refers to an air flow regulator for use as a part of ventilation systems.

BACKGROUND

[0002] There are two main types of air flow regulators: constant air volume (CAV) regulators and variable air volume (VAV) regulators.

[0003] CAV regulators are used to provide constant air flow in ventilation installations, regardless of the pressure change in the air supply or extract duct. The air flow rate is controlled by adjusting the angular position of a blade within a duct. Thereby, desired air parameters can be controlled in the room supplied with air via a ventilation duct with the regulator, such as temperature, air quality or CO_2 level. The blade position may be adjusted manually or automatically.

[0004] VAV regulators are used to vary the air flow in a given part of the ventilation system, in order to maintain a specific parameter in the room at a certain level, such as a constant CO_2 level, room or duct pressure or temperature.

[0005] US7168627B2 discloses an electronically-controlled register vent (ECRV) for providing zoned heating and cooling, comprising: a controller; a mechanical actuator provided to said controller; a wireless communication system provided to said controller; a temperature sensor provided to said controller, said temperature sensor configured to measure a temperature of air inside a duct; and a power source provided to said controller, said controller configured to control said actuator in response to a wireless communication received from a zone thermostat, said controller further configured to open said register vent when power available from said power source drops below a threshold value.

[0006] EP2370748 discloses a system for controlling an HVAC system of a type having a plurality of HVAC vents, each HVAC vent disposed in a corresponding location in a building, the system comprising a corresponding plurality of intelligent controlled registers, each intelligent controlled register associated with a distinct one of the HVAC vents, each one of the intelligent controlled registers being in communication with at least one other of the plurality of intelligent controlled registers and executing an autonomous local control program, such program processing data provided by each of the other intelligent controlled registers, so as to collectively control the plurality of HVAC vents on a peer-to-peer basis.

SUMMARY OF THE INVENTION

[0007] There is a need to provide an alternative solution for air flow regulators which will not require wiring infrastructure to mount the air flow regulators, in particular with places of limited amount of daylight.

[0008] The invention relates to an air flow regulator, comprising: a body forming a duct for conducting air flow, an air flow regulating mechanism located inside the body, and an operating module coupled to an actuator mounted outside the body for adjusting the air flow regulating mechanism. The air flow regulator further comprises a perovskite cells module connected to the operating module to charge a battery that powers the actuator, and the operating module comprises a control signal receiver configured to receive a control signal from a remote controller.

[0009] The use of a perovskite cells module for charging the battery of the operating module eliminates the need to supply the air flow regulator with power from the mains power supply. This facilitates installation of the air flow regulator in hard-to-reach locations and reduces its operating costs. The operation of the air flow regulator is controlled wirelessly by a control signal received from a remote controller 51, thereby the air flow regulator may be installed in a convenient location without the need to guide any wires to it. Use of the perovskite cells allows achieving high efficiency, because the perovskite cells are capable of generating power in both sunlight and artificial light conditions, therefore they may be installed even in closed rooms with limited sunlight or even no sunlight at all. Furthermore, the perovskite cells may effectively receive light from a wide range of angles of incidence of light on the cell, in contrast to silicon cells which effectively receive mainly light incident perpendicularly to the surface of the silicon cell.

[0010] The perovskite cells module can be flexible. By using flexible perovskite cells, it is possible to adapt the shape of the perovskite cells module to the shape of the body of the air flow regulator. In particular, the perovskite cells may be applied as a coating, for example by printing, which allows application of the perovskite cells on various body shapes.

[0011] The perovskite cells module can be arranged adjacent to the outer surface of the body. Thus, the regulator together with the perovskite cells module occupy as little space as possible.

[0012] The body may have the form of a cylinder. This form is particularly preferable for integration into installations having channels of a circular cross-section.

[0013] The body may have the form of a cuboid. This form is particularly preferable for integration into installations having channels of a rectangular cross-section.

[0014] The regulator may further comprise an insulating layer between the outer surface of the body and the perovskite cells module. The insulating layer may provide acoustic insulation, in order to dampen the noise caused by the air flowing through the regulator. The use of insulation increases the outer surface area of the body, which allows the use of larger perovskite panels adjacent to the body of the air flow regulator.

[0015] The perovskite cells module can be mounted away from the regulator. This allows mounting the perovskite cells module in a location where more light is present and where it is possible to use a larger element as compared with a perovskite cells module integrated with the body.

[0016] The regulator may further comprise an additional perovskite cells module mounted away from the regulator. This allows providing additional energy to power the regulator.

[0017] The operating module can be configured to receive a control signal from a remote controller with a transmitter coupled to at least one sensor. The sensor measurements may be performed at the most optimal location for performing the particular type of measurement, rather than at the location where the controller is installed.

[0018] The at least one sensor can be an air pressure sensor, an air temperature sensor, an air composition sensor, a CO_2 level sensor, a light intensity sensor, a motion sensor or a human presence sensor.

[0019] The regulator may have a form of a CAV-type controller, comprising a blade with a shelf and bellows pivotably mounted inside the body on a blade axis, a setting mechanism coupled to the blade axis for adjusting the blade axis, wherein the operating module is configured to control the setting mechanism by the actuator.

[0020] The invention also relates to a system for regulating air flow, comprising a controller with a transmitter and the air flow regulator as described herein.

[0021] The controller with the transmitter can be coupled to at least two air flow regulators as described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The object of the invention is shown by means of example embodiments in a drawing, wherein:

Fig. 1A shows a first embodiment of the air flow regulator as viewed from a side opposite the air flow direction;

Fig. 1B shows the first embodiment as viewed from a side of the air flow direction, with the blade in the closed position;

Fig. 1C shows components of an operating module of the first embodiment;

Fig. 2 shows a second embodiment of the air flow regulator;

Fig. 3 shows a third embodiment of the air flow regulator, mounted in a room above a suspended ceiling;

Fig. 4 shows a controller with a transmitter.

DETAILED DESCRIPTION

[0023] The following detailed description is of the best currently contemplated modes of carrying out the invention. The description is not to be taken in a limiting sense but is made merely for the purpose of illustrating the general principles of the invention.

[0024] An air flow regulator 1 according to a first embodiment of the invention, shown in Figs. 1A - 1C, has a body 10 forming a channel conducting air flow. This embodiment refers to a CAV-type regulator.

[0025] The body 10 houses an air flow regulating mechanism, of a known type. Outside the body 10 there is an operating module 22 coupled to an actuator 21 for adjusting the air flow regulating mechanism. The operating module 22 and the actuator 21 are powered by energy generated by a perovskite cells module 41, also located outside the body 10. The operating module 22 works according to a control signal received wirelessly from a remote controller 51.

[0026] In this embodiment, the air flow regulating mechanism comprises a blade 11 mounted on an axle 12, a rigidly fixed shelf 13 and a bellows 14 with a valve 15. The bellows 14 is positioned on the blade 11 at the side of the shelf 13. The valve 15 passes through the blade 11 and is open in the direction opposite to the direction of air flow. The axle 12 is pivotable by a setting mechanism 16. During operation of the regulator, the bellows 14 is filled with air via the valve 15. The inflated bellows 14 pushes the blade 11 away from the shelf 13, thereby affecting the air flow by displacement of the blade 11. The setting mechanism 16 is located on the outside of the body 10 and is actuated by an actuator 21, also located on the outside. The actuator 21 is powered by the operating module 22.

[0027] The setting mechanism 16 has at least one spring (not shown) that is coupled by linkages (not shown) to the blade axis 12. The setting mechanism 16 causes the spring to stretch and act on the blade axis 12, thereby locking a desired position of the blade 11. The spring prevents deflection of the blade 11 from the shelf 13 under the influence of air filling the bellows 14, in the case the air flow increased within the duct. By locking the position of blade 11, the regulator maintains a fixed air flow within the duct. An air flow indicator 24 can be provided on the body 10, in particular on the setting mechanism 16.

[0028] The operating module 22 comprises a microcontroller 31 for controlling the operation of its individual components, a battery 32, a battery charging circuit 33 and a control signal receiver 34.

[0029] The microcontroller 31 is preferably configured to operate in a mode that ensures minimal use of electrical energy, so that during periods when the air flow regulator does not need to be adjusted, the operating module 22 is set to an idle state to consume as little energy as possible. In the idle state, the receiver 34 of the control signal may be set to a listening mode, awaiting arrival of the control signal. Upon receipt of the control signal, the microcontroller 31 may provide the power signal from the battery 32 to the actuator 21. Thereby, the actuator 21 is not powered in the idle state and

therefore does not consume energy. Thus, the power consumption is kept at a low level and the battery 32 may be charged faster. In addition, the microcontroller 31 may comprise a real-time clock used to activate the listening mode at selected time intervals (e.g. at particular times of a day), for further energy savings.

[0030] The electric power from the battery 32 to the actuator 21 may be provided as an ON/OFF power supply signal or as an analogue signal having a specific amplitude from a specific range, for example from 0 to 10 V.

[0031] Preferably, the individual components 31, 33, 34 are mounted on a common printed circuit board. This results in a compact size of the operating module and allows mounting it conveniently on the body 10. Also, the battery 32 may be integrated into this printed circuit board or located thereon, and the whole set may be housed in a compact housing, made for example from plastic.

[0032] In this embodiment, the operating module 22 is attached to the body 10, preferably in a manner that allows its easy disconnection and replacement, such as by mounting screws. In alternative embodiments, the operating module 22 may be mounted at a close distance away from the air flow regulator, for example on a wall, ceiling or pillar.

[0033] In this embodiment, the cylindrical body 10 of the regulator 1 has its outer surface coated with a flexible perovskite cells module 41.

[0034] The perovskite cells module 41 may be coated with a protective layer, e.g. in a form of a film to protect the cells from damage, in particular from mechanical, thermal or chemical damage. The protective layer may have mounting openings to facilitate attachment of the perovskite cells module 41 to the body 10.

[0035] The receiver 34 of the operating module 22 is connected to a receiving antenna 23, which receives a control signal from the controller 51 having a transmitting antenna 52 (as shown in Fig. 4). The controller 51 shall be positioned away from the air flow regulator, in a place that allows optimal conditions for measurement of relevant air parameters. The controller 51 is coupled with one or more sensors (not shown) that measure parameters of interest, such as CO_2 level in the ventilated room. Upon receiving a control signal from the controller 51, the operating module 22 communicates the need to power on the actuator 21 in order to actuate the setting mechanism 16 to set a corresponding blade position.

[0036] The operating module 22 may support a pair/-unpair function (activated, for example, by a dedicated button) for establishing a connection with a new controller 51 or disconnecting a previously connected controller 51. The operation of the pair/unpair function may be signaled by a dedicated signaling diode, such as an RGB LED.

[0037] The controller 51 may be powered from the mains or from a battery. For example, the controller may be supplied with 24V AC/DC or 230V AC power supply. Radio signal transmitted from one controller 51 may be set to a strong level, such as to cover an entire floor of a building, so that multiple air flow regulators may be controlled from a single controller, such that the single controller communicates with a plurality of air flow regulators 1.

[0038] In order to store the number of activations at the operating module 22, the controller 51 may have a recording functionality to record the number of activations or to reset the activations counter. The controller 51 may handle an optimizing function to minimize the number of activations in order to save energy resources of the air flow regulator 1.

[0039] The controller 51 may also comprise a pairing/unpairing function, for initiating/deactivating a connection with a particular operating module 22. The controller may also handle a channel selection function for assigning a particular radio communication channel to the respective operating module 22. Preferably, the controller 51 may comprise an RGB LED for indicating the status of operation of the pairing/unpairing function.

[0040] The controller may be coupled to a CO_2 or air quality sensor located in the same room as the operating module.

[0041] Fig. 2 shows a second embodiment of the air flow regulator 1', which is equivalent to the first embodiment, except that the body 10' is cuboid in shape (which also implies a corresponding rectangular shape of the blade) and the perovskite cells module 41 is applied on its outer side wall.

[0042] Fig. 3 shows a third embodiment of the air flow regulator 1", which is equivalent to the first embodiment except that it has the perovskite cells module 41" positioned away from the body 10. In this third embodiment, the perovskite cells module 41" is fixed to the underside of the suspended ceiling panel. This solution is particularly suitable for installation in rooms with a suspended ceiling 61, wherein the ventilation system 64 with the controller 1" is located in a dark space 62 between the suspended ceiling 61 and the main ceiling 63. Further alternative embodiments are possible, wherein the perovskite cells module 41" is attached to other elements of the room structure.

[0043] Further embodiments equivalent to the first or second embodiment are also possible, comprising a first perovskite cells module 41 integrated with the body 10 of the air flow regulator and a second (additional) perovskite cells module 41" mounted away from the body 10 of the air flow regulator.

[0044] The same technical features as described above with respect to the CAV-type regulator embodiments, can be implemented equivalently in VAV-type regulators.

[0045] While the invention has been described with respect to a limited number of embodiments, it will be appreciated that many variations, modifications and other applications of the invention may be made. Therefore, the claimed invention as recited in the claims that follow is not limited to the embodiments described herein.

Claims

1. An air flow regulator (1, 1', 1"), comprising:

   - a body (10, 10') forming a duct for conducting air flow,
   - an air flow regulating mechanism located inside the body (10, 10'), and
   - an operating module (22) coupled to an actuator (21) mounted outside the body (10, 10') for adjusting the air flow regulating mechanism,

   characterized in that:

   - the air flow regulator (1, 1', 1") further comprises a perovskite cells module (41) connected to the operating module (22) to charge a battery (32) that powers the actuator (21), and
   - the operating module (22) comprises a control signal receiver (34) configured to receive a control signal from a remote controller (51).

2. The air flow regulator according to claim 1, wherein the perovskite cells module (41) is flexible.

3. The air flow regulator according to any of previous claims, wherein the perovskite cells module (41) is arranged adjacent to the outer surface of the body (10, 10').

4. The air flow regulator according to any of previous claims, wherein the body (10) has the form of a cylinder.

5. The air flow regulator according to any of claims from 1 to 3, wherein the body (10') has the form of a cuboid.

6. The air flow regulator according to any of previous claims, further comprising an insulating layer between the outer surface of the body (10, 10') and the perovskite cells module (41).

7. The air flow regulator according to any of previous claims, wherein the perovskite cells module (41") is mounted away from the regulator (1").

8. The air flow regulator according to any of previous claims, further comprising an additional perovskite cells module (41 ") mounted away from the regulator (1).

9. The air flow regulator according to any of previous claims, wherein the operating module (22) is configured to receive a control signal from a remote controller (51) with a transmitter (52) coupled to at least one sensor.

10. The air flow regulator according to claim 9, wherein the at least one sensor is an air pressure sensor, an air temperature sensor, an air composition sensor, a CO_2 level sensor, a light intensity sensor, a motion sensor or a human presence sensor.

11. The air flow regulator according to any of previous claims, having a form of a CAV-type controller, comprising a blade (11) with a shelf (13) and bellows (14) pivotably mounted inside the body (10, 10') on a blade axis (12), a setting mechanism (16) coupled to the blade axis (12) for adjusting the blade axis (12), wherein the operating module (22) is configured to control the setting mechanism (16) by the actuator (21).

12. A system for regulating air flow, comprising a controller (51) with a transmitter (52) and the air flow regulator (1, 1', 1") according to any of previous claims.

13. The system according to claim 12, wherein the controller (51) with the transmitter (52) is coupled to at least two air flow regulators (1, 1', 1") according to any of claims 1-11.

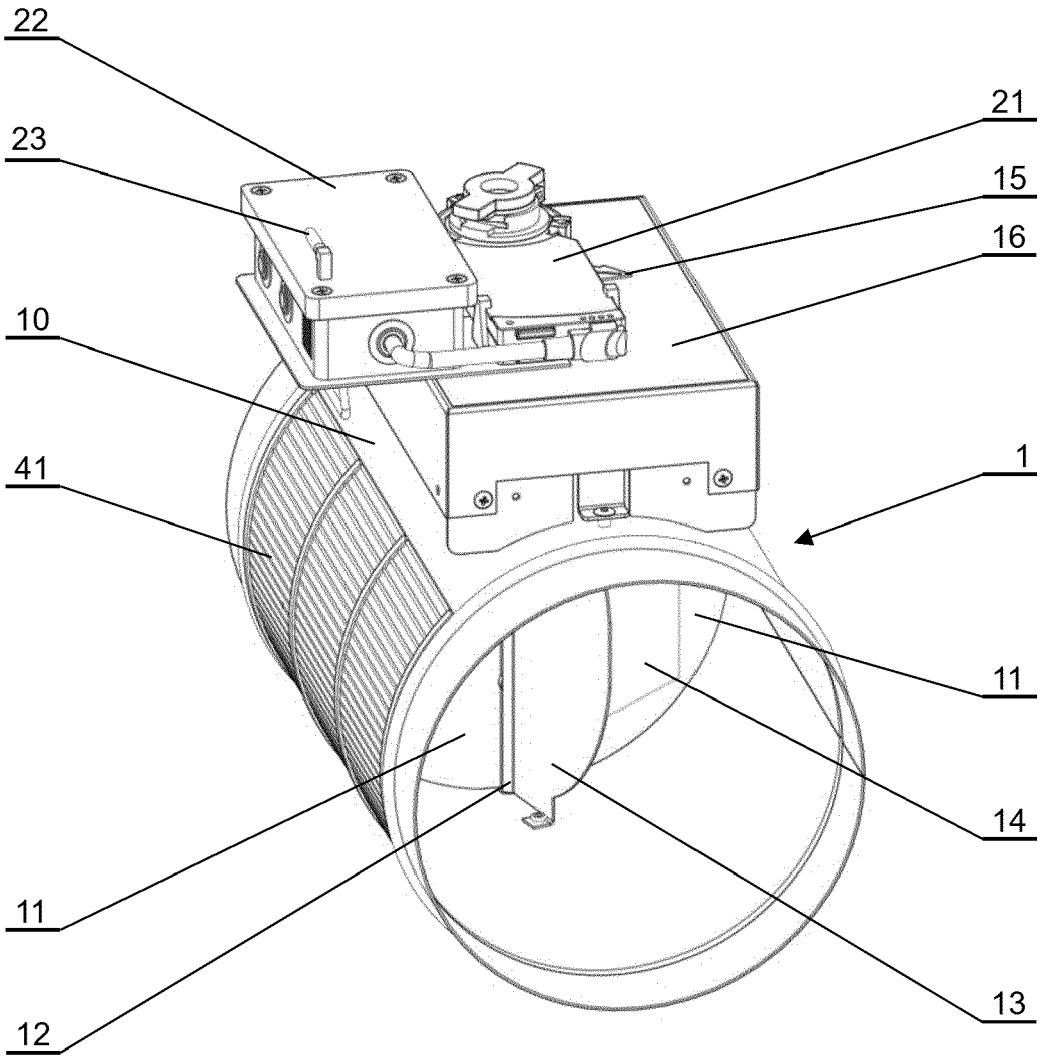

Fig. 1A

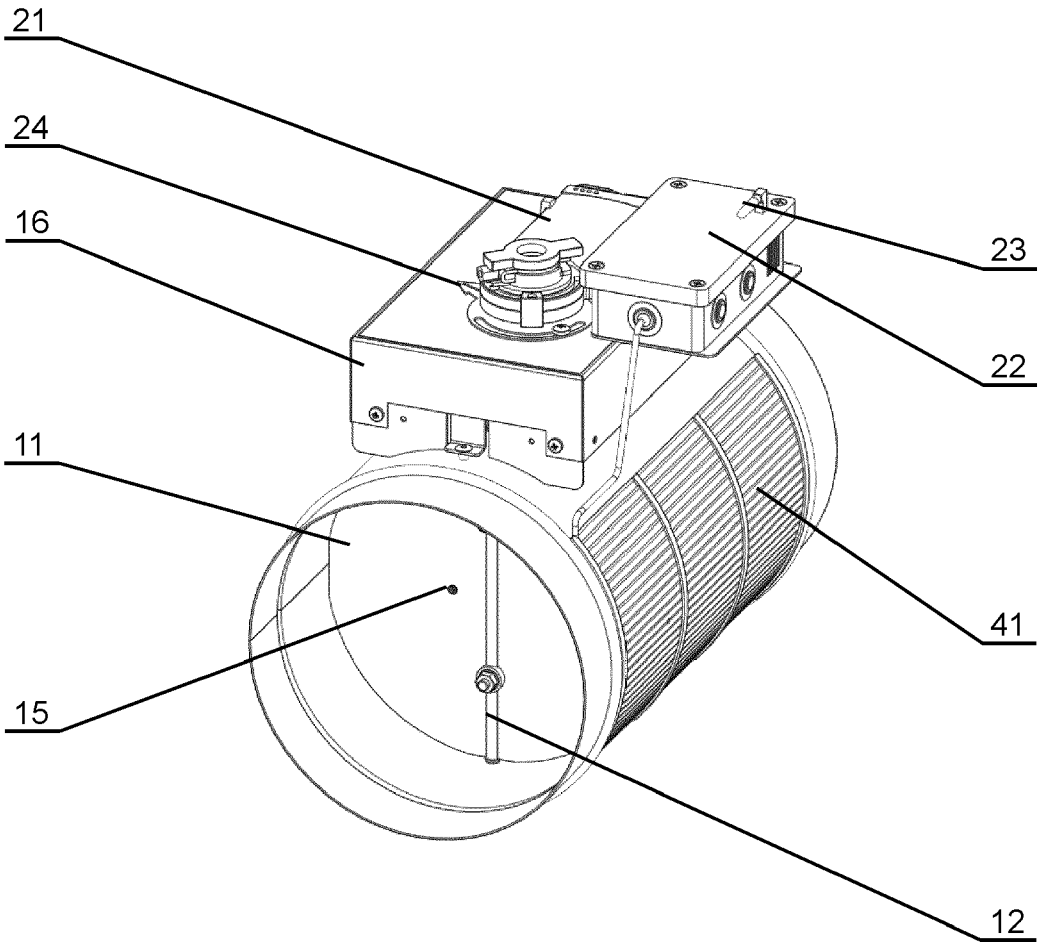

Fig. 1B

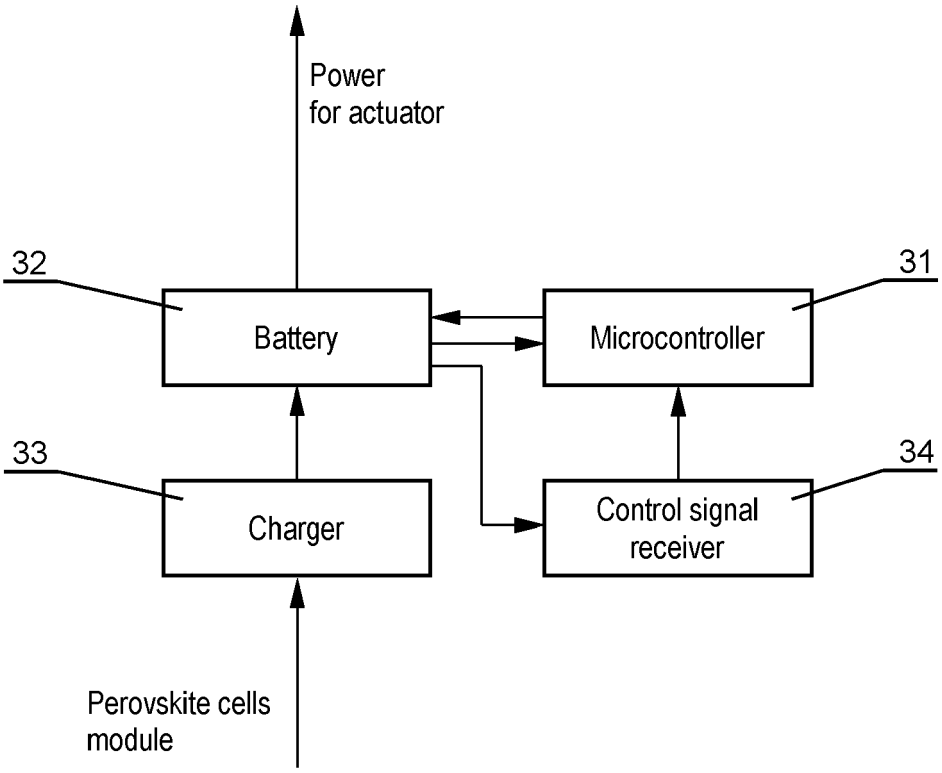
Power
for actuator
32
31
Battery
Microcontroller
33
34
Charger
Control signal
receiver
Perovskite cells
module

Fig. 1C

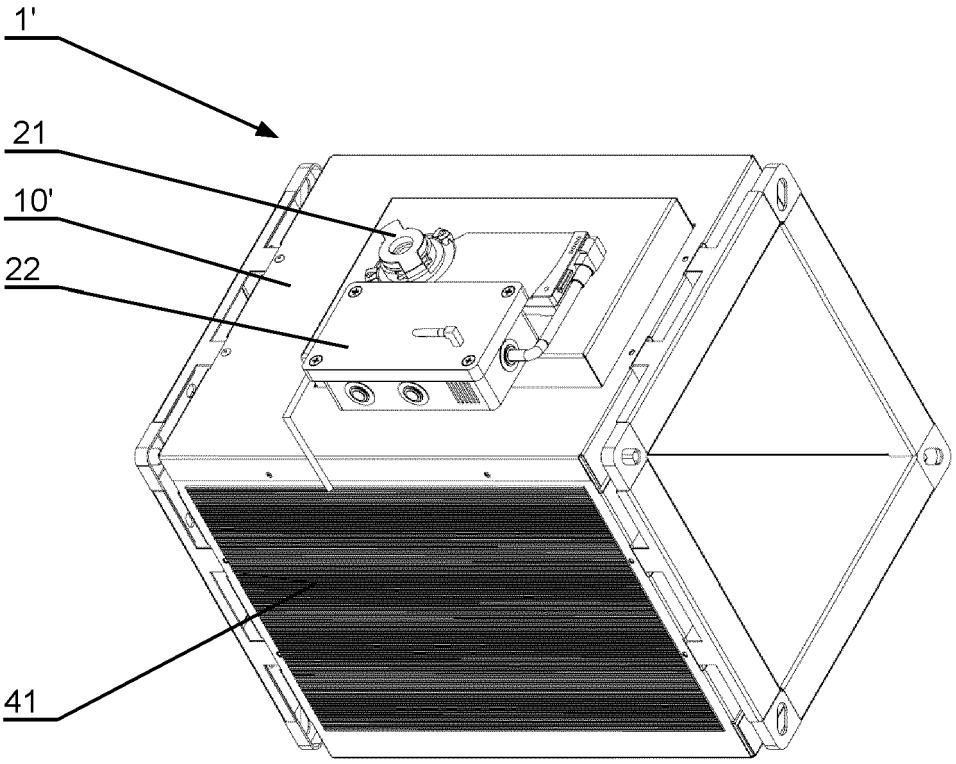

Fig. 2

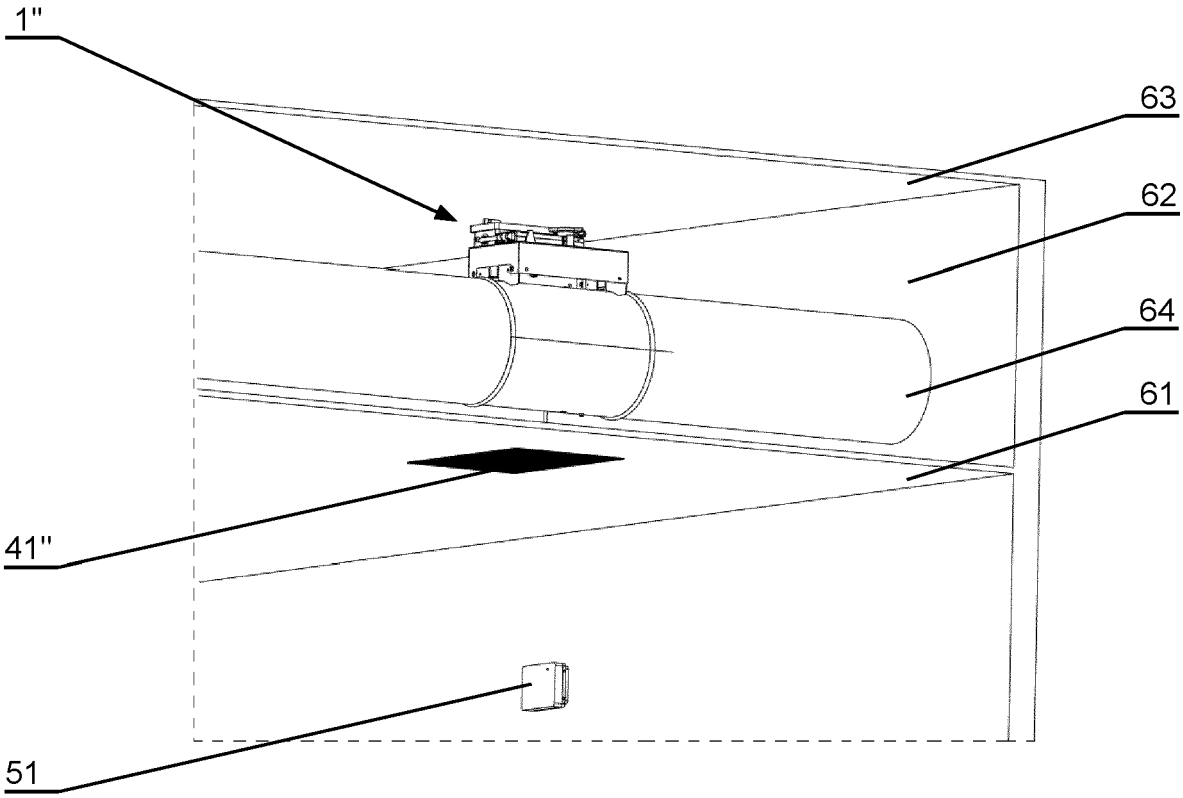

Fig. 3

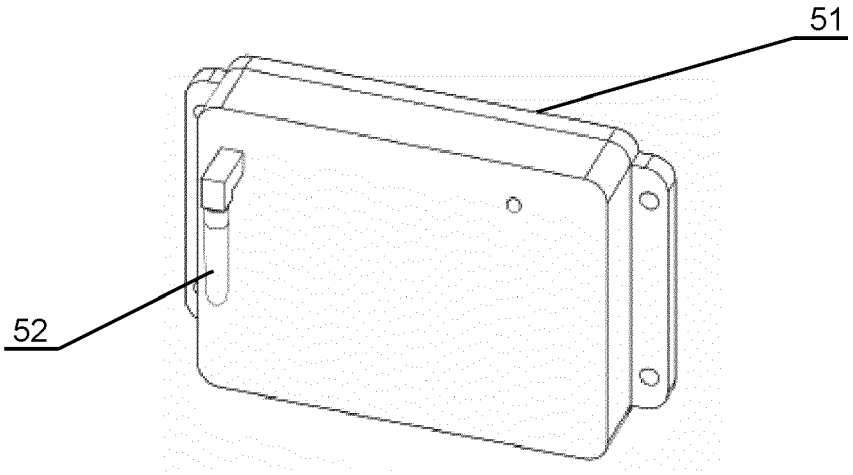

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 23 46 1627

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

F24F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	21 December 2023	Silex, Anna

CATEGORY OF CITED DOCUMENTS

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