(19) DANMARK

(10) **DK/EP 2433676 T3**

(12) Oversættelse af europæisk patentskrift

Patent- og Varemærkestyrelsen

(51) Int.Cl.: ***A 62 C 2/06 (2006.01)*** ***A 62 C 3/07 (2006.01)*** ***A 62 C 3/16 (2006.01)***
***H 02 B 1/28 (2006.01)***

(45) Oversættelsen bekendtgjort den: **2017-06-06**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2017-03-22**

(86) Europæisk ansøgning nr.: **11182275.5**

(86) Europæisk indleveringsdag: **2011-09-22**

(87) Den europæiske ansøgnings publiceringsdag: **2012-03-28**

(30) Prioritet: **2010-09-28 AT 16192010**

(84) Designerede stater: **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 MK MT NL NO PL PT RO RS SE SI SK SM TR**

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(54) Benævnelse: **Brandbestandigt hus til en omformer**

(56) Fremdragne publikationer:
**EP-A1- 1 882 496**
**EP-A1- 1 948 881**
**EP-A2- 1 215 420**
**DE-A1- 3 718 911**
**DE-U1- 20 217 661**
**DE-U1-202004 019 510**

Description

## Technical area

The present invention relates to a fire-resistant housing for a frequency converter, in particular for a frequency converter of a rail vehicle, wherein the housing is manufactured from a metallic material, with a heat insulation part made of a non-flammable material which is arranged on a housing part of the housing on an outer wall surface, in order, in the event of a fire in the interior space, to attenuate the heat flow into an adjacent exterior space.

## Prior art

It is known that power electronic components of a frequency converter are usually housed in a metal housing which in addition to mechanical protection also forms a shield for electromagnetic radiation. The metallic structure is a good heat conductor for the power loss accruing in the interior space.

This good thermal conductivity is a disadvantage when it comes to keeping an adjacent external escape route passable for as long as possible in the event of a fire in the interior space of the frequency converter housing. For safety reasons, it increasingly a requirement for rail vehicles that in the event of a frequency converter fire the metallic structure facing the exterior space only undergoes a limited temperature increase. These requirements differ depending on the risk class of the rail vehicle. The requirements for vehicles which use a tunnel are more stringent than for trams. In Germany, the German national standard DIN 5510 determines which limit values apply. A rail vehicle, for example, may be required to

have a housing for high performance components in the interior space which is embodied such that no gap or openings or persistent flames can arise on the outside of the housing for 30 minutes. This measure protects the escape corridor but also prevents the spread of fire in the evacuation phase.

As is well known, there are tight space constraints in a rail vehicle, e.g. in the traction unit of an electric locomotive. Heat development in the interior space of a rail frequency converter may be considerable, however, resulting in the fire resistance requirements for the frequency converter housing being increasingly stringent for safety reasons. This applies not only to frequency converters which are arranged in the interior space of a rail vehicle, but also to those assembled under the floor, in the case of which the heating of an escape route above should be delayed for as long as possible and the spread of fire prevented.

Fire protection is known from EP 1 882 496 A1 in which a protective wall is coated with an intumescent, in other words thermally expansible flexible sheet material. In the event of a fire, the flexible sheet material swells. Expansion may be several 100% and forms a barrier to the heat flow. In the case of a frequency converter, however, the temperatures occurring in the interior space in the event of a fire may be so high that an intumescent coating alone is insufficient to keep an adjacent escape route passable.

In the course of constantly growing safety awareness, fire regulations are becoming stricter. As a result, not only is the permissible surface temperature of the frequency converter housing reduced but the standard also prescribes the durability of the protective measure for a rail vehicle which must remain functional for more than 20 years (German industry

standard DIN 50 155). In addition, there is the desire on the part of the operator of a rail vehicle to avoid protective measures requiring any expensive maintenance for the maximum possible operating time.

## Description of the invention

The object of the present invention is to provide a fire-resistant housing for a frequency converter which, in the event of a fire inside the housing, better isolates the heat flow through a housing part in an adjacent safety-critical exterior space and for which this isolation effect remains as maintenance-free as possible for the maximum operating time possible.

This object is achieved by a fire-resistant frequency converter with the features of claim 1. Advantageous embodiments of the invention are defined in the dependent claims.

According to the invention, the object is achieved in that a heat insulation part is provided which is connected both by means of a substance-to-substance bond as well as by means of a form-fit connection to the housing part which adjoins a safety-critical exterior space. In other words, according to the invention the heat insulation part is therefore fastened to its support in two ways: on the one hand, it is bonded to it; on the other hand, it is held on the support by means of fire-resistant means of retention. The housing part can be a door part or lid part or a side part, but can also comprise various housing component parts. Friction adhesive bonding results in the heat insulation part adhering extensively to its support during normal operation, in other words without exposure to fire. As a result, impact loads which operate

throughout the entire operating period of the rail vehicle can be absorbed by a large surface. The mechanical means of retention have less effect during normal operation as a result and can therefore be less developed. In the event of shocks, areas of the heat insulation part in the region of the mechanical retainers are subject to less stress. This is favourable for the service life of the connection. In the event of fire, on the other hand, where the adhesive bond may come loose as a result of the effect of heat, the fire-resistant means of retention ensure that the heat insulation part also lies flat on the housing part when the support begins to deform on account of the effect of heat. This increases the stability of heat insulation. As a result, the function of the measure to delay the passage of heat remains effective over a longer period. The burning interior space is better thermally isolated from an adjacent exterior space. Due to the better isolated temperature, an escape route which passes a frequency converter in a machine room of a rail vehicle can be passed unharmed by the fleeing vehicle driver for longer in an emergency. The escape route is not blocked by protruding parts of the heat insulation. The heat insulation attached to the outer wall surface also has the advantage that for maintenance purposes checking from outside by means of visual inspection is easily possible without having to open a lid part. The attachment of the heat insulation part to the external wall of the housing by means of mechanical fastening elements is robust and almost maintenance-free in its effect over a long operating period. Assembly on the outside of the housing has the further advantage that the interior space of the frequency converter housing, which as a rule is a clean room, is not contaminated by parts of the insulation material being detached. In principle, all insulation materials which, in case of fire, are suitable for forming a sufficiently large barrier for the heat flow coming from the interior space are

eligible for the heat insulation part.

It is particularly advantageous if the outer wall surface of the housing part is completely covered with a layer of adhesive. As a result, the vibrations occurring during operation of the rail vehicle are essentially absorbed by the adhesive layer and excessive mechanical stress on the heat insulation part is avoided. This increases the durability of the heat insulation.

A preferred embodiment provides that the form-fit connection is formed by a plurality of connectors, wherein each connector is connected by one end to the housing part and by another end is inserted through a through-hole in the heat insulation part, wherein the inserted end engages behind the heat insulation part by means of a retaining part. In the event of a fire, the escape corridor is freely passable and not blocked by protruding heat insulation parts.

Cost-effectively, the connectors can be designed as screw bolts, or also as retaining straps which are folded or caulked at their inserted end. The connectors may also consist of an insulator. The retaining part may, for example, be formed by a washer, or a perforated plate, a grid, a steel mesh, an expanded metal mesh which is pulled apart, or another plate with recesses.

The heat insulation part is preferably made of a web of a mineral material, e.g. a mineral or rock wool which is, for example, laminated with an aluminium layer. The low weight of these mineral webs is particularly advantageous for a rail vehicle.

Alternatively, a further embodiment may also be such that the

heat insulation part is formed by a commercially available fire protection plate on a cement base, e.g. of calcium silicate or plasterboard and/or mineral fibreboard.

Particularly good heat insulation is achieved when the heat insulation part extends beyond the frame of the frequency converter housing, in other words, when viewed in the direction of the interior space of the cabinet body, the heat insulation part is greater and so overlaps it at the edges. The result of this is that the heat emitted by the metal frame is also kept away from the adjacent escape route and the spread of fire is delayed.

A particularly preferred embodiment may be characterised in that the housing part is coated on an inner wall surface facing the interior space with an intumescent coating known per se. This intumescent coating foams in the event of a fire, as a result of which an additional heat barrier is formed. In the event of a fire, the metallic structure heats up later. Even if this effect is only of a comparatively short duration, the useful life of the escape route is extended. Such an intumescent coating may, for example, be a formulation containing exfoliated graphite.

In order to prevent the escape of hot gases from the interior space of the frequency converter housing in the event of a fire, a preferred embodiment can provide that an intumescent coating or an intumescent sealing tape is attached in the gap formed by the inner wall surface of the housing part and the opposite end face of the frame, on either one and/or the other of these surfaces. For example, this can be done in such a way that the intumescent coating applied to the inner wall surface of the housing part is extended into the gap.

It is favourable if this intumescent coating is reinforced, for example, with metal fibres, glass fibre or strands of carbon fibres or the like.

It may in turn be advantageous if this reinforcement is extended into the gap between the lid part and the frame part as this improves the sealing effect in the event of a fire.

A further improvement of the physical barrier can also be achieved by likewise coating the end face of the frame facing the housing part with an intumescent coating. Having a coating on both gap surfaces is particularly effective in preventing the escape of hot flue gases in the event of a fire.

In a particularly preferred embodiment of the invention, the interior space of the cabinet body is divided into individual partial spaces by means of abrasion-free insulation plates. As these partial spaces present a lower hazard potential, the fire protection requirements are reduced.

As a result, a lid part which covers these partial spaces as far as the escape corridor can be formed with thinner insulation.

Preferably the thickness of the insulation part is approximately 0.5 cm to 3 cm.

It can also be advantageous if the fire-resistant connection part is made of an insulator. As a result, in the event of a fire, the heat flow by way of the means of retention is also prevented. A ceramic, glass or porcelain part is suitable, for example.

## Brief description of the drawing

To further explain the invention in the following part of the description reference is made to the drawings from which further advantageous embodiments, details and developments of the invention can be taken with reference to the unrestrictive exemplary embodiment shown. In the drawings:

Figure 1 shows a railway vehicle in a top view, in which two frequency converters between which there is an escape corridor are arranged in a space adjacent to the driver's cab;

Figure 2 shows a frequency converter in a rail vehicle of which a housing part likewise borders on an adjacent escape route, wherein according to a particular embodiment of the invention, the interior space of the frequency converter housing is divided into partial spaces by means of insulation plates;

Figure 3 shows a detailed description of the housing part of the frequency converter housing which shows the fastening according to the invention of the heat insulation part;

Figure 4 shows a detailed description of the housing lid part in the area of the frame of the frequency converter housing, wherein the seal in the gap between the lid part and the frame is shown.

## Execution of the invention

Figure 1 shows a top view of the arrangement of two frequency converters at the front of a rail vehicle 14. A route passes between the two housings 1, providing access to the driver's

cab 15. In an emergency, for example, in the event of a fire, this route is simultaneously the escape route for people in the driver's cab. In the event of a fire inside a frequency converter housing 1, the heat exposure of people using the escape route 13 must be kept so low, at least for a time, that they can use the corridor to reach the passenger area 16 unharmed.

Both frequency converters 1 are in a space demarcated both in terms of the driver's cab 15, and also in terms of the passenger area 16, in each case by a wall 17, 18 with doors which meet the physical barrier and/or heat insulation criterion "EI15".

As aforementioned, in the event of a fire the escape corridor 13 must be passable for as long as possible. This is accomplished by providing at least the housing parts 12 adjacent to the exterior space 13 - in this case a lid part on the frequency converter housing - with heat insulation according to the invention.

Figure 2 shows in a spatial representation a static, self-supporting cuboid frequency converter housing 1 which is arranged in a carriage of a rail vehicle 14. Here too, a housing part 12 - a lid part of the housing frame - borders on a safety-critical escape route 13. In the event of a fire in the interior space 11 of the frequency converter housing 1, this escape route 13 should remain passable for passengers from the passenger area 16 for as long as possible, without these people coming to any harm on account of the heat emitted by the housing part 12. In the illustration of Figure 2 dotted lines indicate that the interior space 11 of the frequency converter is divided into individual partial spaces 11' by means of insulation plates 27. This ensures that the fire

protection requirements are reduced because of the lower volume, enabling the insulation of the housing lid 12 to be correspondingly thinner.

Figure 3 shows a sectional detail view of the fastening of the heat insulation part 4 on the housing part 12. An adhesive layer 2 forms an adhesive bond 20 with the metal wall 12 on the one hand, and with the insulation part 4 on the other hand. In addition to this substance-to-substance bond 20, the heat insulation part 4 is fastened by means of a number of fastening elements 6 distributed on the outer wall surface 22 in each case by means of form-fit connection 21. This form-fit connection 21 is fire-resistant, in other words it is designed such that, even in the event of a fire, if the adhesive bond 20 separates from the interior space 11 of the frequency converter housing 1 because of heat exposure, it retains the heat insulation part 4 in connection with the outer wall surface 22 of the housing part 12. In the present example this consists in each case of a metallic bolt, one end 9 of which is welded to the housing part 12 and the other end 8 of which is inserted in a through-hole 7 in the heat insulation part 4. This inserted end 8 has a thread. By means of a washer 5 made of metal and a threaded nut 6, in the event of a fire the heat insulation part 4 is also kept attached to the housing part 12 so that even in the event of exposure to great heat, the insulating effect is not impaired by the separation of the heat insulation part 4 from the housing wall 12.

In the exemplary embodiment shown, the heat insulation part 4 is a fire protection plate on a cement base which, even in the event of a fire, is kept in connection with the outer wall surface 22 by means of the connectors 3. However, the heat insulation part 4 can also be made of another insulation material such as, for example, a mineral web, a mineral wool

or a rock wool which, for example, is laminated with an aluminium layer. In such an embodiment, it is appropriate for the retaining part 5 to be flat, for example embodied as a metal sheet with recesses, or as a wire mesh, grid, expanded metal, perforated plate, or the like.

Naturally, the detachable nut and bolt connection shown in the present exemplary embodiment can also be a permanent connection, for example by means of a retaining part snapped onto the connectors 3 using a snap-on connection.

Figure 4 shows a sectional detail view of a particularly preferred exemplary embodiment of the invention. A section of the closure at the edge of the body is shown. The heat insulation part 4 is - as aforementioned - fastened to the housing part 12 by means of an adhesive bond 20 and a nut and bolt connection 3,6. At the edge, the housing part 12 is folded in the shape of a "U". The housing part 12 extends over the end face 27 of the frame 19. An intumescent coating 24 is applied to the surface 23 facing the interior space 11. This coating 24 also extends into the gap 25 which is formed between the surfaces 23 and 27. It has a reinforcement 10. In the event of a fire, the volume of the coating 24 is increased because of the heat exposure from the interior space 11. As a result, the gap 25 is closed by the intumescent material 24, at least when the fire starts. Hot flue gases are prevented from reaching the exterior space 13 as a result.

If there is no fire, the rubber seal 26 closes the interior space 11 hermetically, which also protects the intumescent coating 24 from the effect of moisture from outside.

In the drawing of Figure 4, in addition on the end face 27 an intumescent coating 28 surrounding the inside of the gap 25

can also be seen, as a result of which, in the event of a fire, the sealing action described is further improved.

In practice, it has been shown that for a frequency converter housing of the kind typically used for rail vehicles, a thickness 29 of the heat insulation part 4 in the region of 0.5 cm to 3 cm is favourable.

List of reference characters

| | |
|---|---|
| 1 | Housing |
| 2 | Adhesive |
| 3 | Connector |
| 4 | Heat insulation part |
| 5 | Retaining washer |
| 6 | Fastening element |
| 7 | Through-hole |
| 8 | The inserted end of the connector 3 |
| 9 | The end of the connector fastened to the housing part |
| 10 | Reinforcement |
| 11 | Interior space |
| 11' | Partial space |
| 12 | Housing part, lid part |
| 13 | Exterior space, escape corridor |
| 14 | Rail vehicle |
| 15 | Driver's cab |
| 16 | Passenger area |
| 17 | Wall |
| 18 | Wall |
| 19 | Frame part |
| 20 | Substance-to-substance bond |
| 21 | Form-fit connection |
| 22 | Outer wall surface of the housing part 12 |
| 23 | Inner wall surface of the housing part 12 |
| 24 | Intumescent coating |
| 25 | Gap |
| 26 | Seal |
| 27 | Insulation plate |
| 28 | Coating |
| 29 | Thickness of the heat insulation part 4 |

## Patentkrav

1. Brandbestandigt hus til en omformer, især til en omformer af et skinnekøretøj, hvor huset (1) er fremstillet af et metallisk materiale, omfattende:
- en varmeisoleringsdel (4) af et ikke antændeligt materiale, som er anbragt på en husdel (12) af huset (1) på en udvendig vægflade (22) for at afsvække en varmestrøm ind i et tilgrænsende udvendigt rum (13) i tilfælde af en brand i det indvendige rum (11), hvor
- varmeisoleringsdelen (4) er forbundet med husdelen (12) ved hjælp af en materialesluttende forbindelse (20) og en ildfast, formsluttende forbindelse (21),
**kendetegnet ved, at**
den materialesluttende forbindelse (20) er dannet af et klæbemiddellag (2), som er udformet over hele fladen mellem den udvendige vægflade (22) og fladen af varmeisoleringsdelen (4), hvilken flade ligger mod husdelen (12).

2. Hus ifølge krav 1,
**kendetegnet ved, at** den formsluttende forbindelse (21) er dannet af en flerhed af forbindere (3), hvor hver forbinder (3) med en ende (9) er forbundet med husdelen (12) og med anden ende (8) er sat ind gennem et gennemgangshul (7) i varmeisoleringsdelen (4), hvor den indsatte ende (8) ved hjælp af en holdedel (5) griber ind bag varmeisoleringsdelen (4).

3. Hus ifølge et af kravene 1 eller 2,
**kendetegnet ved, at** varmeisoleringsdelen (4) er dannet af et mineralsk materiale, fortrinsvis af en mineral- eller stenuld, som er kacheret med et metallisk lag.

4. Hus ifølge et af kravene 1 eller 2,
**kendetegnet ved, at** varmeisoleringsdelen (4) er en brandbeskyttelsesplade, især fortrinsvis af kaliciumsilikat.

5. Hus ifølge krav 3 eller 4,
**kendetegnet ved, at** varmeisoleringsdelen (4) i det mindste fuldstændigt dækker legemets ramme (19) i synsretningen mod husdelen (12) set fra det

udvendige rum (13) i retning mod huslegemets indvendige rum (11).

6. Hus ifølge et af kravene 1 til 5,
**kendetegnet ved, at** husdelen (12) på en indvendig vægflade (23), som ligger mod det indvendige rum (11), er coatet med en intumescens-egnet belægning (24).

7. Hus ifølge krav 6,
**kendetegnet ved, at** den intumescens-egnede belægning (24) rager ind i en spalte (25), som er dannet af den indvendige vægflade (23) og den nabostillede endeflade (27) af husets (1) ramme (19).

8. Hus ifølge krav 7,
**kendetegnet ved, at** den intumescens-egnede belægning (24) er forsynet med en armering (10), som er formet helt ind i spalten (25).

9. Hus ifølge krav 7,
**kendetegnet ved, at** endefladen (27) er forsynet med en belægning (28) af et intumescens-egnet værktøj, hvilken belægning er omløbende i spalten (25).

10. Hus ifølge et af de foregående krav,
**kendetegnet ved, at** det indvendige rum (11) er opdelt i delrum (11') ved hjælp af isoleringsplader (27).

11. Hus ifølge krav 10,
**kendetegnet ved, at** husdelen (12) er en afdækningsdel, som dækker delrummene (11') af huset (1) mod det udvendige rum (13).

12. Hus ifølge et af de foregående krav,
**kendetegnet ved, at** varmeisoleringsdelen (4) har en tykkelse (29) på 0,5 cm til 4 cm.

FIG 1

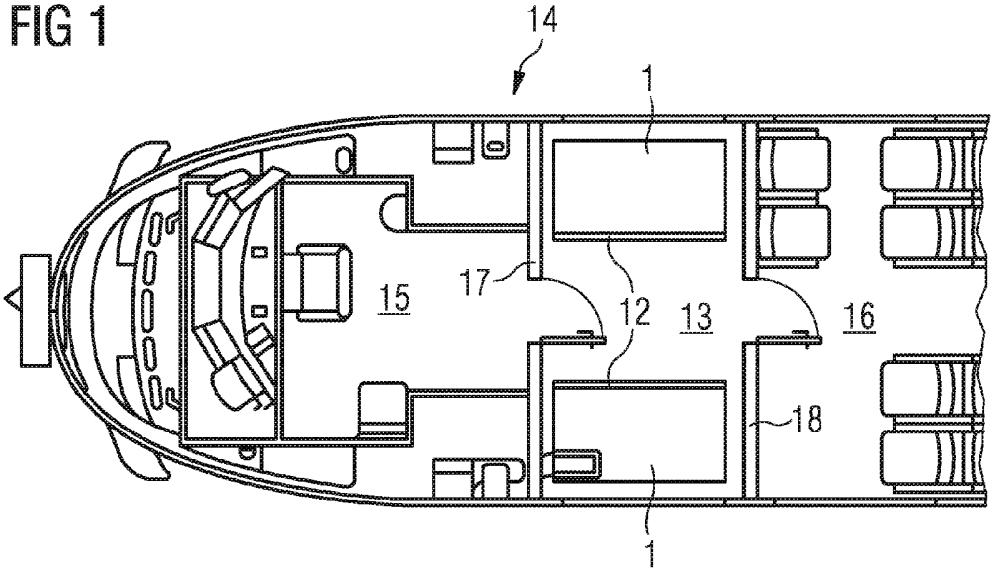


FIG 2

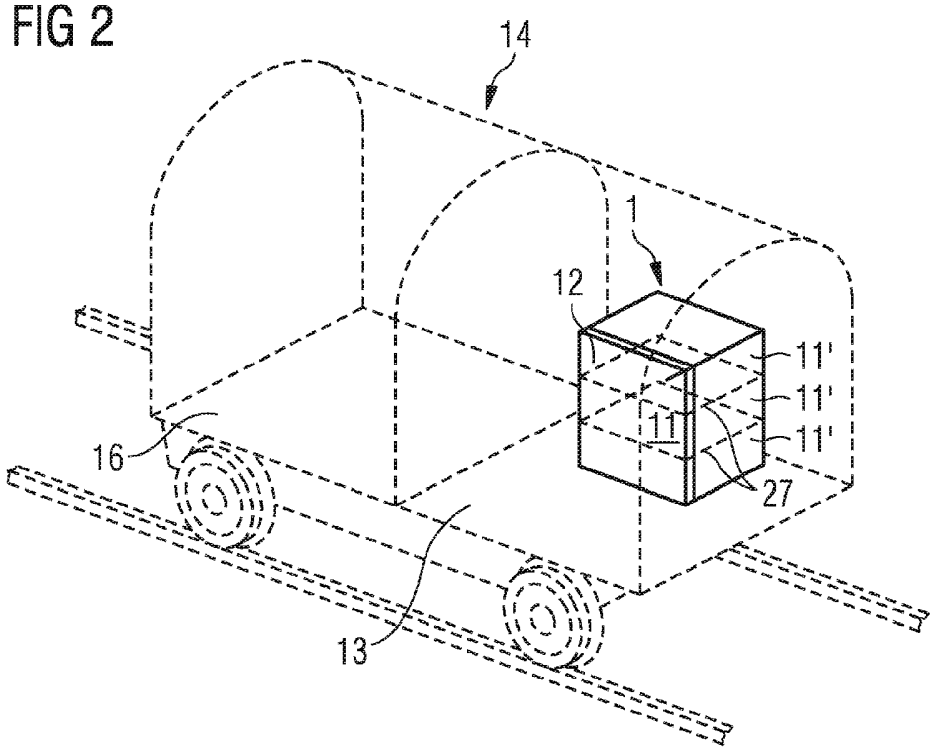

FIG 3

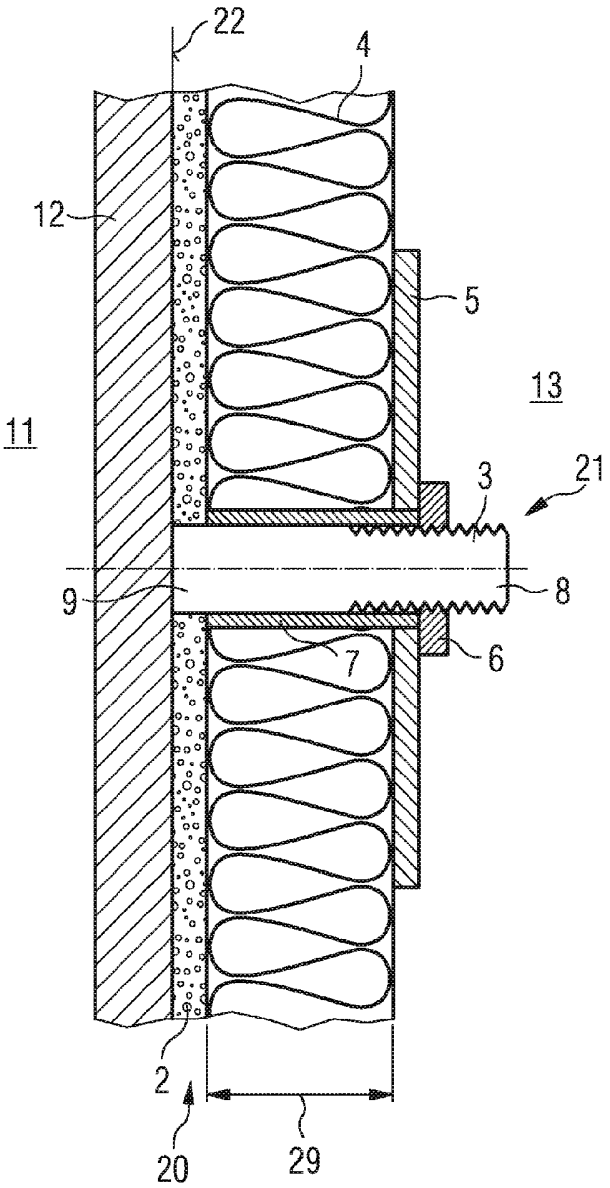

FIG 4