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(54) **PRECAST FLOOR SLAB AND METHOD FOR FORMING A FLOORING DECK AND BUILDING FORMED OF PRECAST FLOOR SLABS**

(57) The invention relates to a floor slab, which is intended to form a flooring deck. The floor slab (26) includes cast concrete and building service systems. The cast concrete includes a ribbed slab (10) and a cast cover (11) closing the ribbed slab (10) in order to form a load-bearing hollow-core structure. In addition, building service systems are arranged in the hollow cores (13) of the hollow-core structure. The invention also relates to a method for forming a flooring deck and a building formed of floor slabs (26).

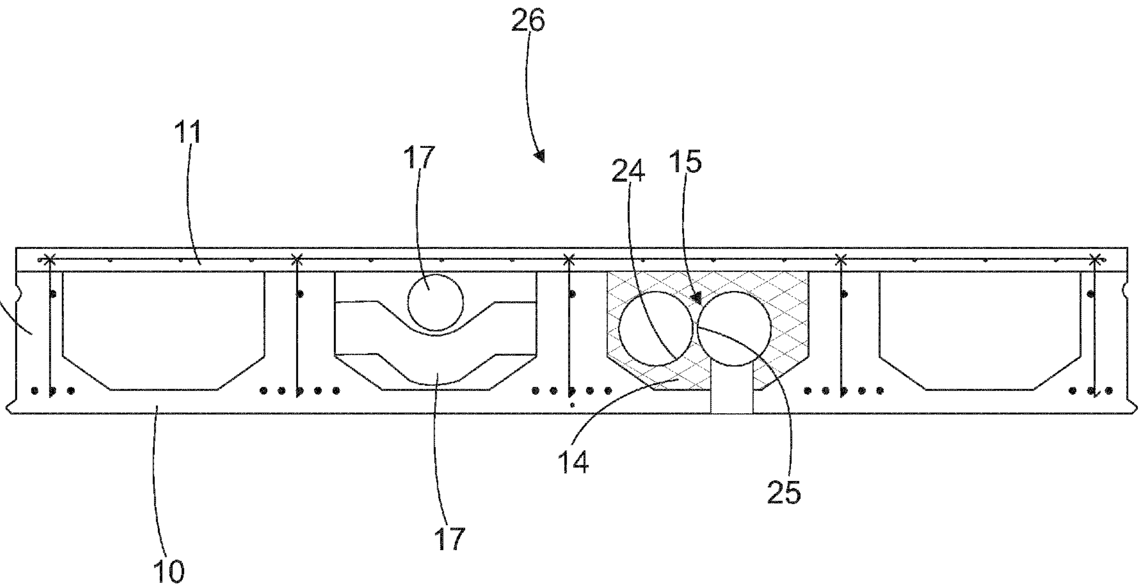

Fig. 5

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Description

[0001] The invention relates to a floor slab, which is intended for forming a flooring deck, and which floor slab includes cast concrete and building service systems. The invention also relates to a method for forming a flooring deck and a building formed of precast floor slabs.

[0002] A flooring deck is used in buildings of two or more floors, in which the flooring deck is the ceiling of the lower floor and the floor of the upper floor. It is known to start building the flooring deck using hollow-core slabs, the hollow cores of which can be used, for example, for installing electrical cabling. On top of the hollow-core slab comes a surface screed and the chosen floor covering. Electrical heating can also be installed in the surface screed. In the lower floor, a so-called suspended ceiling is used, which is attached to the hollow-core slabs. Ventilation and electrical installation, for example, are installed in the air space remaining between the ceiling and the hollow-core slab. As such, building using hollow-core slabs is rapid and reasonably economical. Heating, plumbing, ventilation and electrical installations are, however, difficult despite that hollow cores. Routes transverse to the hollow core are nearly impossible. In addition, a suspended ceiling is slow and expensive to make. Heating, plumbing, ventilation and electrical installations are challenging to make even in the air space between the structures. In addition, insulation of footstep sounds, for example, is poor in the aforementioned structure.

[0003] A cast-concrete floor slab, in which some of the concrete is replaced with inserts cast from lightweight expanded clay aggregate, is also known from EP application number EP3003664A1 . The inserts make the floor slab lighter than a mass concrete slab. At the locations of bathrooms, the inserts are omitted and drainpipes, electrical conduits, and heating pipes are placed inside the floor slab during manufacture. In other words, at least some of the building service systems are factory-installed. At the same time, a separate surface screed is avoided, so that the flooring deck takes up less of the room height than previously. Elsewhere in the building there are normal floor slabs. The sound insulation of a concrete floor slab is poor. In addition, a floor slab is laborious to manufacture and the finished floor slab is heavy despite the inserts. This limits the span, even if prestressed reinforcement is used. In addition, building service systems can only be installed in a floor slab to a limited extent.

[0004] The invention is intended to create a new type of floor slab, which is cheap to manufacture and in which building service systems can be fitted, and which is lower and lighter than previously, but which has a greater load-bearing capacity. In addition, the intention is to create a new type of method for forming a flooring deck, by which at the same time a significant number of the building service systems installations can be made. Further, the invention is intended to create a new type of building formed of floor slabs, in which the building service systems can be arranged more easily and freely than before. The characteristic features of the floor slab according to the present invention are stated in the accompanying Claim 1. Correspondingly, the characteristic features of the method according to the invention are stated in the accompanying Claim 9, and the features of the building in Claim 13. In the floor slab according to the invention, there is a new and surprising construction, by which the ratio of the load-bearing capacity of the floor slab to its total mass is greater than before. At the same time, the overall height of the floor slab is clearly reduced, but the width and span are greater. In addition, the insulating capacity of the floor slab improves. Using the method, the manufacture of a floor slab is rapid and the building service systems are effectively arranged in the finished building.

[0005] In the following, the invention is described in detail with reference to the accompanying drawings showing some embodiments of the invention, in which

Figure 1a	shows a blank for a floor slab according to the invention,
Figure 1b	shows the casting parts of a floor slab according to the invention,
Figure 1c	shows a cross-section of a floor slab according to the invention,
Figure 1d	shows a cross-section of a variation of a floor slab according to the invention,
Figure 1e	shows one manufacturing stage of a floor slab according to the invention,
Figures 2a-c	show the manufacture of a floor slab according to the invention,
Figure 3a	shows the manufacture of a flooring deck according to the invention,
Figure 3b	shows a schematic diagram of a partial enlargement of a floor slab according to the invention,
Figure 3c	shows a schematic diagram of a partial enlargement of Figure 3a,
Figure 4	shows the manufacture of a flooring deck according to the invention, at a joint between two floor slabs,
Figure 5	shows a finished floor slab and part of the building service systems and insulation in a cross-sectional direction,
Figure 6a	shows a top view of a floor slab according to the invention,
Figure 6b	shows a cross-section on a plane A-A of Figure 6a,
Figure 7	shows a cross-section on a plane B-B of Figure 6a,
Figure 8	shows a schematic top view of part of a building formed of floor slabs according to the invention,
Figure 9	shows a side view of part of Figure 8.

[0006] The floor slab in intended to form a flooring deck. The factory-made floor slab includes cast concrete and building service systems. According to the invention, the cast concrete includes a ribbed slab 10 and a cast cover 11 closing the ribbed slab 10 in order to form a load-bearing hollow-core structure. In addition, building service systems are arranged in the hollow cores 13 in the hollow structure formed. If necessary, feed-throughs can be made in the ribs for building service systems. Thus it is easy to install building service systems, a great deal of which will fit into the floor slab. At the same time, the floor slab becomes light compared to a solid structure.

[0007] Figure 1a shows a ribbed slab 10, which is preferably slipform cast. Slipform casting is quick and the length of the ribbed slab can be chosen freely. The ribbed slab 10 additionally includes longitudinal prestressed reinforcement 12. The length of the floor slab can then be increased further.

[0008] In Figure 1b, there is a cover 11, which is also preferably slipform cast, cast on top of the ribbed slab 10. The cover can be cast on top of all the ribs, or then the outermost ribs used as casting forms, according to Figures 1b and 1c. Independently of the application, the cover adheres to the ribs, thus forming a composite structure.

[0009] Initially in the figures shown the thickness of a rib corresponds essentially to the thickness of the web of the ribbed slab. As does the thickness of the cover. The castings then dry evenly. For example, with a thickness of 50 mm and a rib height of 230 mm a floor slab of six to seven metres will be achieved, the load-bearing capacity of which will be sufficient without intermediate supports. At the same time, space of 130 mm will remain between the web and the cover, so that drain and ventilation pipes with diameters of 110 mm and 100 mm will also fit inside the floor slab. The span can easily be increased by altering the height of the ribs. If necessary, the ribbed slab can be cast in two parts, so that first of all a basic ribbed slab is slipformed, on top of the ribs of which additional parts are slipformed (in Figure 1a on the section lines). For example, with 300-mm high ribs spans of eight to nine metres can be achieved. Corresponding dimensions are 10 - 12 metres with a height of 350 mm and 16 - 18 metres with a height of 500 mm. The total thickness of the floor slab can be as much as 650 - 800 mm. In the example the width of the floor slab is 2400 mm. With small changes to the casting machine a width of as much as 3000 mm can be achieved. Then using a single casting machine floor slabs of different dimensions can be made by simply altering the height of the ribs.

[0010] In Figures 1c and 1d, the cover 11 is already cast. In addition, the building service systems are arranged in the hollow covers 13 formed in the hollow structure. In practice, before casting the cover 11, the building service systems are fitted to the floor slab. The floor slab is then factory-made and ready for installation, containing also the building service systems. An preading insulation 14 is also arranged in the hollow cores 13 of the hollow-core structure formed. In practice, the ribbed slab 10 is filled with spreading insulation 14 before the casting of the cover 11. The thermal and sound insulation of the floor slab then improves. At the same time, the insulation supports the inner building service systems and reduces the total mass of the floor slab. The insulation is preferably crushed foamed glass or a similar spreading material. Due to its foamed cellular structure, crushed foamed glass is light in weight (about 190 kg/m^3) and extremely insulating (thermal conductivity when dry about 0.1 W/mK). In addition, crushed foamed glass settles well, which permits the cover to be cast directly on top of the crushed foamed glass. If necessary, at the hollow cores a protective fabric is used to prevent the cast concrete dropping down. In addition, the crushed foamed glass is non-combustible and completely recyclable (it does not contain organic matter). Crushed foamed glass is granular, so that the gaps between the building service systems installations are easily filled. A similar insulation can be, for example, siporex lightweight crushed concrete, or foamed crushed concrete granules, or EPS concrete. The self-weight of dry EPS concrete is about 350 kg/m^3 and its thermal conductivity about 0.08 W/mK.

[0011] Figure 2a shows an air-conditioning pipe 15 installed between the ribs 16, and even, if necessary, through the ribs 16. In other words, the connection 17 is an air-conditioning pipe 15. The feed-throughs required are machined in the cast ribbed slab. Drainpipes, electrical conduits, and other building-service-systems components can be similarly installed. In Figure 2b, the gaps between the ribs 16 are filled with a spreading insulation 14, preferably crushed foamed glass. In Figure 2c, the cover 11 has already been cast on top. One connection opens to the upper surface of the floor slab. The connection can quite as easily also open to the lower surface of the floor slab. The actual floor covering (not shown) comes on top of the cover. The air-conditioning pipe 15 is preferably formed of two small pipes 24 and 25 (Figure 5). Firstly, the small pipes can cross over each other inside the floor slab. Secondly, two small pipes are cheaper than a large pipe. In the adjacent hollow core two pipes crossing over are shown schematically.

[0012] Despite the wide floor slab, the building service systems must often be taken through several floor slabs, as in the invention the floor slab contains the greatest possible share of the building service systems, such as air-conditioning pipes. In other words, a factory-made floor slab must be joined to an adjacent floor slab. In Figure 3a, two floor slabs 26 are set in parallel. Generally building service systems include a connection 17, the end 18 of which is arranged to be exposed for part of the distance. The connections can then be connected on the building site. In the embodiment shown, the end 18 is arranged in the recess 19 formed in the cast concrete. At the connection point, the recesses in the parallel floor slabs are next to each other (Figure 3a). There can also be a recess in the end of the floor slab, when the abutting floor slabs can be joined or a joint made to a vertical duct.

[0013] Figure 3b shows a side view perpendicularly to the connections 17. The larger connections are, for example, drain or air-conditioning pipes and the smaller ones electrical conduits or waterpipe casings. Figure 3c is a top view. In the floor slab, there is a side welt and in addition the parallel floor slabs are installed with a small gap of, for example, 15 mm. The distance between the outermost ribs is then, for example, 60 mm. The end 18 of the connection 17 includes a joint part 20 arranged to move, which is arranged to extend to the end 22 of a corresponding connection 21 in another floor slab, to join the connections to each other. The connection can then be connected easily, rapidly, and securely. In the embodiment shown, the depth of the recess is 180 mm, which is in practice the maximum size of the joint part. This then avoids the joint part protruding outside the external dimensions of the floor slab. With the aforementioned dimensioning, the joint part set in place extends over the ends of both connections by 50 mm, which ensures a tight connection.

[0014] One alternative joint part 20 is a muff, which is external in Figure 4. The muff can also be internal. In the muff there is preferably sealing and, if necessary, also tensioning means. The muff's position in the finished flooring deck is shown by a broken-line rectangle. At the recess, the rib is cut and a separate casting wall 23 is made to limit the recess. The casting wall supports the connections and also prevents the insulation from leaking out. In practice, the building service systems are left partly exposed and after connecting the building service systems of adjacent floor slabs the exposed parts are covered with concrete. In other words, the recesses 19 of Figure 4 and the gap between the floor slabs are filled with a single casting.

[0015] Rigid connections, such as drain and air-conditioning pipes, must be aligned sufficiently precisely for the joint part to be able to be moved into place. Flexible electrical conduits and waterpipe casings permit a slightly greater tolerance. In the factory manufacture of floor slabs this alignment is taken into account and otherwise too it is sought to minimize the number of joints. In practice, the entire flooring deck and the floor slabs it demands are planned beforehand and the floor slabs are made at the factory read for installation. If necessary, separate joint parts are used, which are installed when forming the deck.

[0016] To prevent the insulation spreading the ends of the floor slab must be closed. Using slipforming, conventional formwork is avoided. Moulds are mainly only used at the recesses. At the planned end of the floor slab, a two-part mould is placed, by which the end walls of two consecutive slipformed floor slabs are cast. The end walls become part of the composite structure. In practice, the concrete casting is formed by slipforming, from which the floor slab is separated by sawing. In Figure 1e, the diagonally shaded areas depict the end walls, which are separated from each other by sawing. Sawing can even be done only after the casting of the cover.

[0017] The thickness of the example slab shown in Figure 5 is 350 mm. Equipped with prestressed reinforcing strands, the span can be chosen to be as much as 12 000 mm. Here the width of the floor slab 26 is increased at the same time to be 2400 mm. This is then a considerably larger slab than a normal hollow-core slab. The floor slab shown is, however, suitable for transportation using normal equipment and can even be handled on site, though the floor slab weighs nearly thirteen tonnes. The lower and upper strands and the cover casting mesh are joined together by dowels. The same reference numbers are used for parts that are functionally the same.

[0018] In addition, there are also building service systems in the floor slab. In accordance with slabs of the prior art, drainage and floor heating are preferably arranged in the floor slab. Domestic-water pipes and air-conditioning pipes, for example, can also be included in the invention. The necessary building service systems are installed in the floor slab at the factory when making the floor slab. Thus on the building site it is enough to join the various connections in the parallel and consecutive slabs. In the prior art individual so-called service systems slabs are used, but the floor slab according to the invention is widely used in building. Installing separate ducts and lines on site is then unnecessary, which considerably accelerates building work. At the same time, suspended ceilings are avoided, or at least their extent is reduced considerably. The vertical distance between floor slabs can then be reduced without reducing the room height. This reduces building costs. At the same time, the thicker floor slab than before and its internal structure improve sound insulation, which increases dwelling comfort.

[0019] The space left over from building service systems is filled with a suitable material, when the cover can be cast. Sound and thermal insulation also improves. The space in the hollow cores can be filled with an insulating material, such as mineral wool or polyurethane. However these are expensive and placing them takes time. Some insulating material may be combustible, which increase the fire load. Preferably a spreadable and non-combustible material is used. Various lightweight concretes are possible. These harden when drying and lock the building service systems in place. In lightweight concrete, the filler can be expended clay or styrox, i.e. the aforesaid EPS. When using expanded-clay concrete, protective fabric is not needed. Preferably crushed foamed glass is used, which is even lighter than lightweight concrete. In addition, crushed foamed glass spreads into even small holes, but does not harden. Thus in cases of possible damage the building service systems can be drilled out and locally repaired. Crushed foamed glass is then easy to remove. In addition, crushed foamed glass is non-combustible and easily recycled. After compaction, the cover can be cast on top of the crushed foamed glass.

[0020] The ribbed slab together with the reinforcing steel is cast first. After sufficient drying, the building service systems are installed and the remaining spaces are filled with a material, such as the aforesaid crushed foamed glass. Finally the cover is cast with reinforcing mesh. If necessary, protective fabric strips or similar are used under the cover casting to prevent the cover casting seeping into the insulation. After the casting has dried sufficiently, the tension in the reinforcement is released and the tightness and joints of the connections are checked and protected during storage and transporting.

[0021] In Figure 6a, the air-conditioning pipes 15 are in two different places. Figures 6a, 6b, and 7 also show the socket anchors 27, to which the lifting chains are attached. The socket anchor 27 is cast between the ribs 16 as part of the floor slab 26. In the casting of the cover 11, the head of the socket anchor 27 remains in the recess. Nevertheless, the connecting part can be threaded through the head of the socket anchor. The floor slab can then be safely lifted by four socket anchors.

[0022] On the building site, each floor slab is installed in a pre-planned location and position. The protection is removed and the connections connected and the floor slabs are cast in. In the invention, essentially all the feed-ins inside a floor are implemented using connections inside the floor slab. This avoids separate reservations and ducts for building service systems. The making of lines and ducts on the building site is also eliminated. Between floors, one or more vertical ducts are used, the connections in which being connected to the connections coming from the deck. More generally, in a building formed of floor slabs according to the invention, a feed point 29 (Figure 8) is arranged for the building service systems formed from the floor slabs 26 joined to the floor 28. In the feed point, for example, the hot-water line is connected to a pipe in the floor slab, which extends to the area of the deck. Similarly, the other connections are connected, so that the entire floor's deck is taken care of in a centralized manner. The drainpipes and exhaust-air ducts also come to the feed point. The feed point 29 is preferably formed by a shaft 30, which is arranged separately from other spaces. The building service systems can then be easily isolated and monitored. Adjustments and maintenance are also easy to do. In Figure 8, the outline of the shaft 30 is emphasized with a thick line. In addition, the shaft 30 extends to the various floors of the building. Then, for example, replacement air can be distributed from the air-conditioning room through the ducts run in the shaft to the air-conditioning ducts in the decks of the various floors.

[0023] Figure 8 shows schematically a part of a building that is formed of the floor slabs 26 according to the invention. Here there are four parallel spaces 31, for example office rooms, and after the broken line there is a foyer space 32 in front of them, and next two parallel lift shafts 33. Each floor slab 26 extends from a window 34 to the plane of the lift shafts 33. Next to the lift shafts 33 is a shaft 30 according to the invention. The deck is designed for each object, so that the connections are at the desired locations. Differing from the prior art, the replacement-air ducts are placed to open near the window's 34 surface. The air-conditioning pipes being inside the floor slab 26, the replacement-air device can be placed on the lower surface of the floor slab. By utilizing low and wide structures, the installation height remains low and the replacement air spreads evenly to a wide area. The replacement air is preferably directed towards the window surface, thus preventing misting of the windows. The replacement-air pipe 15 is lowest in Figure 8 and initially it has a size of 160 mm. The final part has a size of 100 mm and the replacement-air pipe opens close to the windows 34. Secondly, there is an exhaust-air pipe of corresponding dimensions. Thirdly, there are domestic-water pipes, which are located inside flexible casings. Thus their route can be selected more freely.

[0024] Figure 9 shows a side view of the same part of the building. On the third floor 28 a replacement-air pipe 15 is shown, which open near the surface of the window 34. On the second floor, an exhaust-air pipe is shown. On the first floor are domestic-water pipes, which descend from the ceiling to a suitable height. In the shaft 30, each connection is connected to the vertical ducts.

[0025] The floor slab can also be used installed at a slant arranged as a ceiling. The building service systems then contain mainly electrical cables and air-conditioning ducts, which would be difficult to implement if made in the known manner.

[0026] The structure of the floor slab according to the invention is a prestressed slab element, which is cast in two parts. The lower part, in which the prestressed reinforcement strands are located, is cast first. The prestressed strands are located in the area of the ribs, so that feed-throughs can be made in the hollow cores. After this the piping is installed and the cores are filled, for example with EPS concrete. Finally the cover is reinforced and cast. The deck formed of floor slabs is connected to the local district-heating network. The heating and cooling system is water-circulation radiation heating. The main heating pipes are steel pipes to be threaded or welded in the shaft and the main cooling pipes are copper or steel pipes. The distribution pipes coming from the headers in the floor slabs are of PEX piping in casings.

[0027] Water and drain lines are connected to the network of the local waterworks. Networks for cold and hot domestic water and warm circulating water are made in the building. The main pipes of the domestic-water network are of copper and the distribution lines in the elements after the headers are of encased PEX piping. In the vertical rises there are leak detectors. The material of the drainpipes is plastic, that of the exposed drains is cast iron or stainless steel. The drains of the water furnishings are run mainly inside the floor slab.

[0028] The building has a distributed replacement and exhaust-air ventilation system equipped with heat recovery. The main ducts of the ventilation system run a separate shaft built on site and the horizontal runs are inside the floor slab, in accordance with the invention. The material is galvanized steel.

[0029] The diameter of the duct running inside the floor slab can be as much as 160 mm. Nevertheless it has space to cross over the other pipes of the system. The replacement and exhaust ducts run in parallel in the floor slab. The terminal devices of the ventilation are installed, for example, in the cover plate of a radiator panel. The replacement-air duct extends to close to the window surface. Window misting problems are then avoided. This is important, especially in passive buildings, in which air and heat leaks are minimized. The exhaust-air duct is placed to open at a different location sufficiently far from the replacement-air duct.

Claims

1. Floor slab, which is intended for forming a flooring deck, and which floor slab (26) includes cast concrete and building service systems, **characterized in that** the cast concrete includes a ribbed slab (10) and a cast cover (11) closing the ribbed slab (10), for forming a load-bearing hollow-core structure, and the building service systems are arranged to be formed in the hollow cores (13) of the hollow-core structure.

2. Floor slab according to Claim 1, **characterized in that** the ribbed slab (10) includes longitudinal prestressed reinforcement (12) and the ribbed slab (10) and cover (11) are separately cast using slipforming.

3. Floor slab according to Claim 1 or 2, **characterized in that** insulation (14), which is crushed foamed glass or some other similar spreading material, is arranged in the hollow cores (13) of the hollow-core structure formed.

4. Floor slab according to any of Claims 1 - 3, **characterized in that** the building service systems include a connection (17), the end (18) of which is arranged to be exposed for part of the distance.

5. Floor slab according to Claim 4, **characterized in that** the end (18) is arranged in a recess (19) formed in the cast concrete.

6. Floor slab according to Claim 4 or 5, **characterized in that** the end (18) of the connection (17) includes a joint part (20) arranged to move, which is arranged to extend to the end (22) of a corresponding connection (21) belonging to another floor slab, in order to join the connections to each other.

7. Floor slab according to any of Claims 4 - 6, **characterized in that** the connection (17) is an air-conditioning pipe (15) .

8. Floor slab according to Claim 7, **characterized in that** the air-conditioning pipe (15) is formed of two small pipes (24, 25).

9. Method for forming a flooring deck, in which method the flooring deck is formed of several floor slabs (26), which include cast concrete and building service systems, **characterized in that** the cast concrete is formed by first casting a ribbed slab (10), which is closed by casting a cover (11) in order to form a load-bearing hollow-core structure, and the building service systems are arranged in the hollow cores (13) formed in the floor slab (26), before the cover (11) is cast.

10. Method according to Claim 9, **characterized in that** after arranging the building service systems before the cover (11) is cast the ribbed slab (10) is filled with spreading insulation (14).

11. Method according to Claim 9 or 10, **characterized in that** the cast concrete is formed by slipform casting, from which the floor slab is separated by sawing.

12. Method according to any of Claims 9 - 11, **characterized in that** the building service systems are left partly exposed, and after the connection of the building service systems of the parallel floor slabs (26) the exposed parts are covered with cast concrete.

13. Building formed of floor slabs according to any of Claims 1 - 8, **characterized in that** a feed point (29) is arranged for the building service systems formed in the floor (28) of joined floor slabs (26).

14. Building according to Claim 13, **characterized in that** the feed point (29) is located in a shaft (30), which is arranged separately from the rest of the spaces.

15. Building according to Claim 14, **characterized in that** the shaft (30) extends to the various floors (28) of the building.

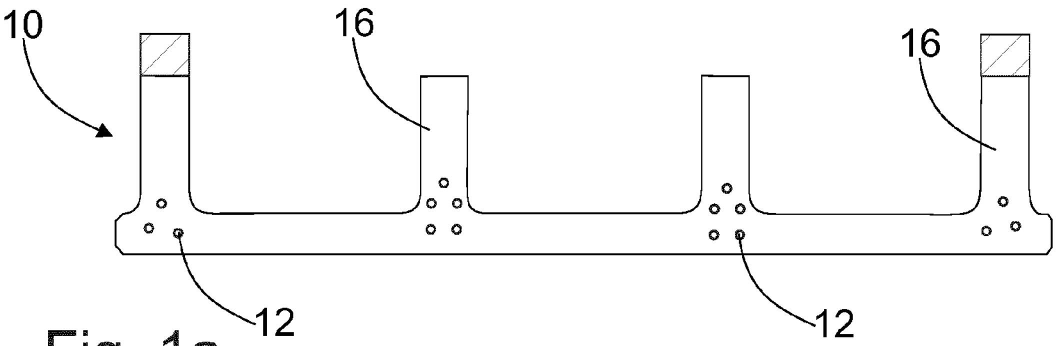

Fig. 1a

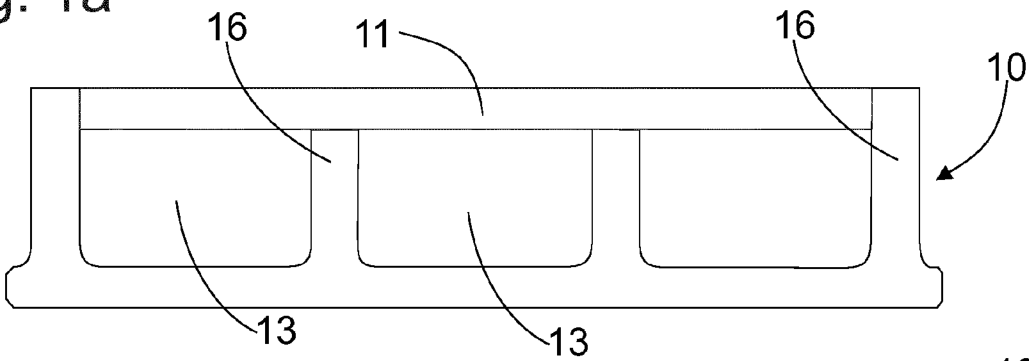

Fig. 1b

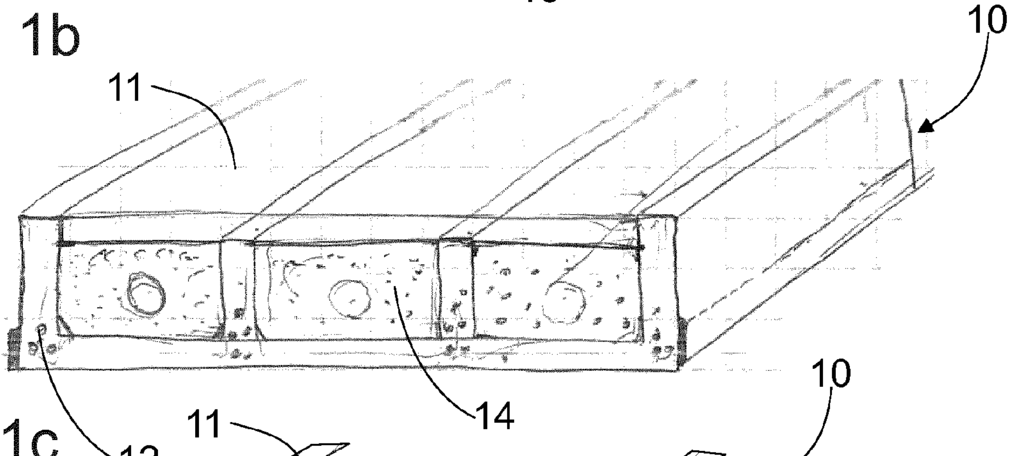

Fig. 1c

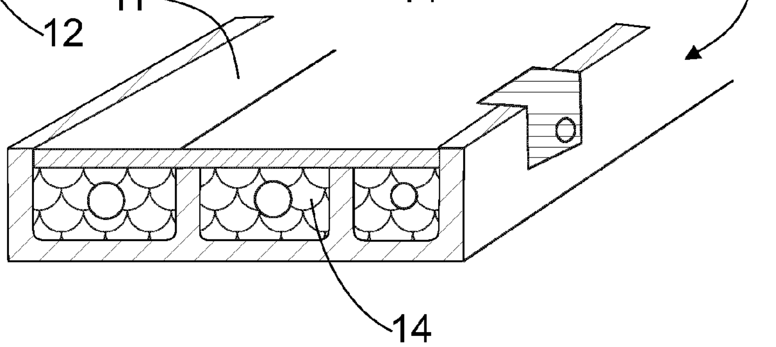

Fig. 1d

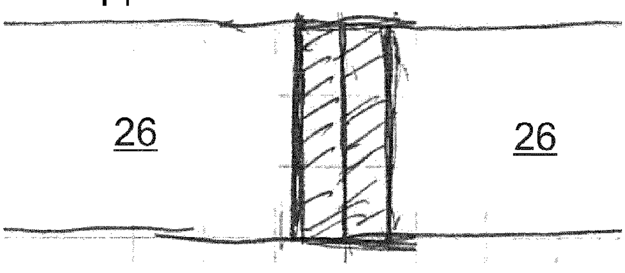

Fig. 1e

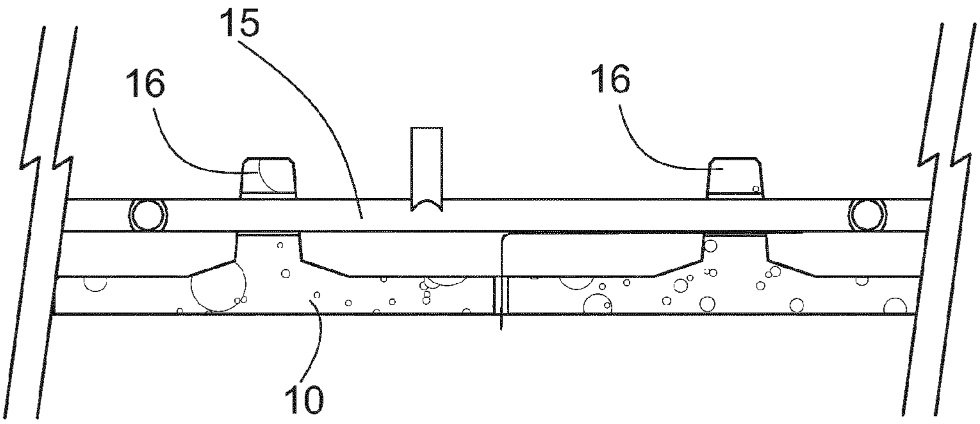

Fig. 2a

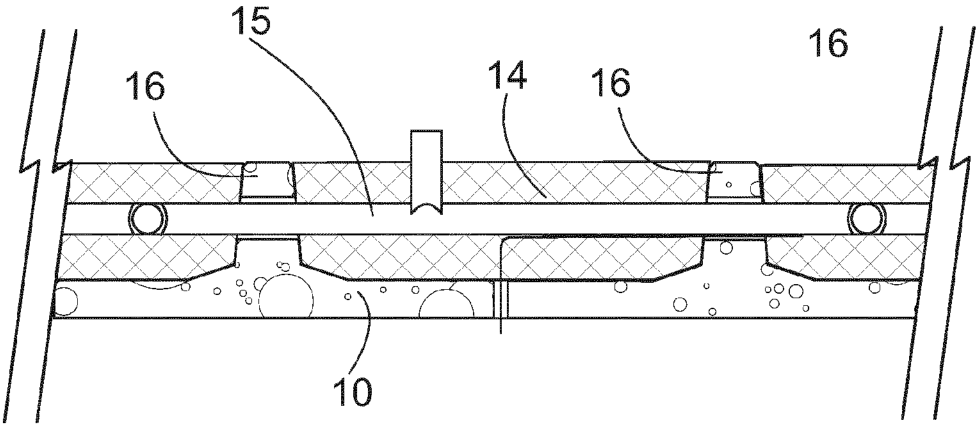

Fig. 2b

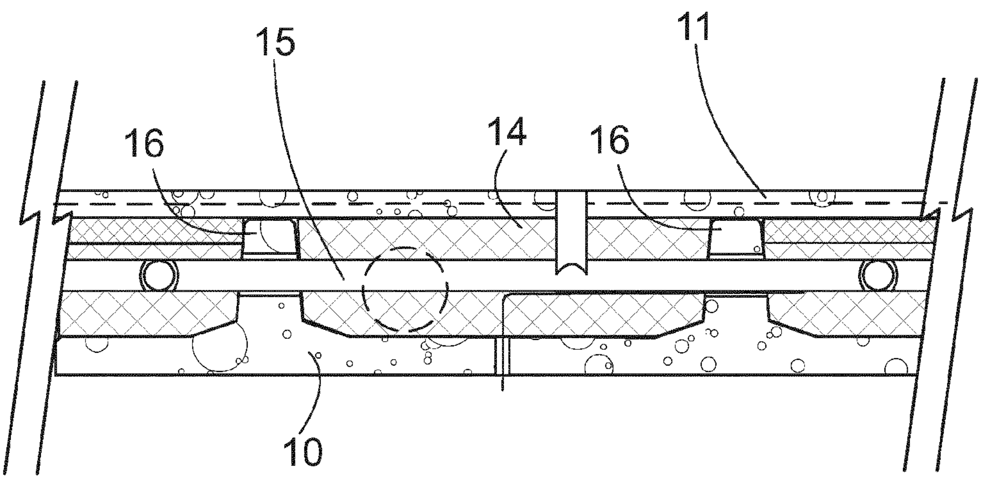

Fig. 2c

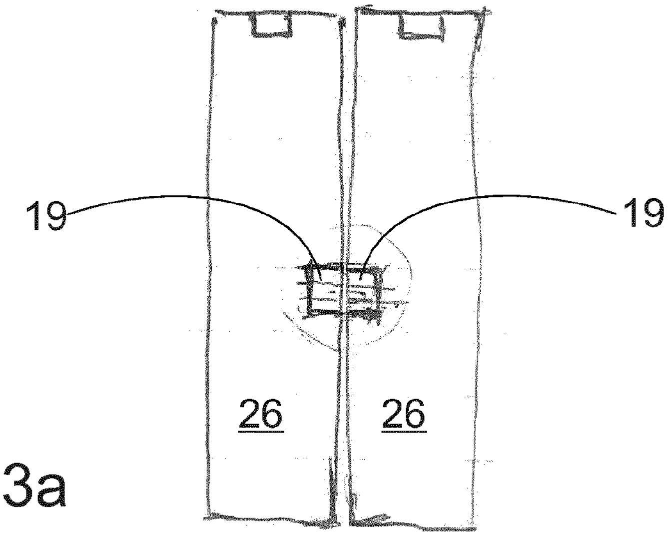

Fig. 3a

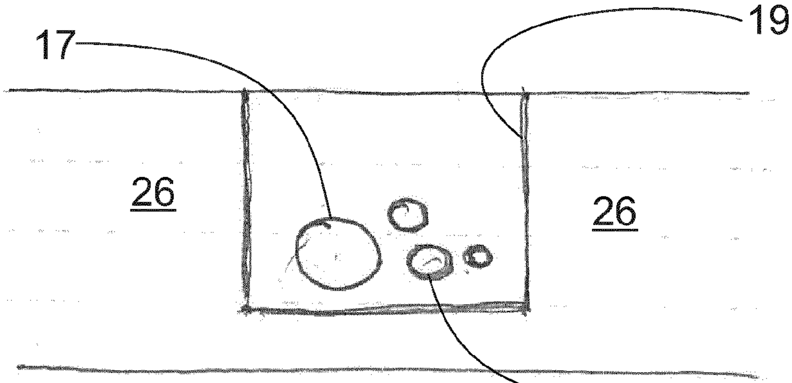

Fig. 3b

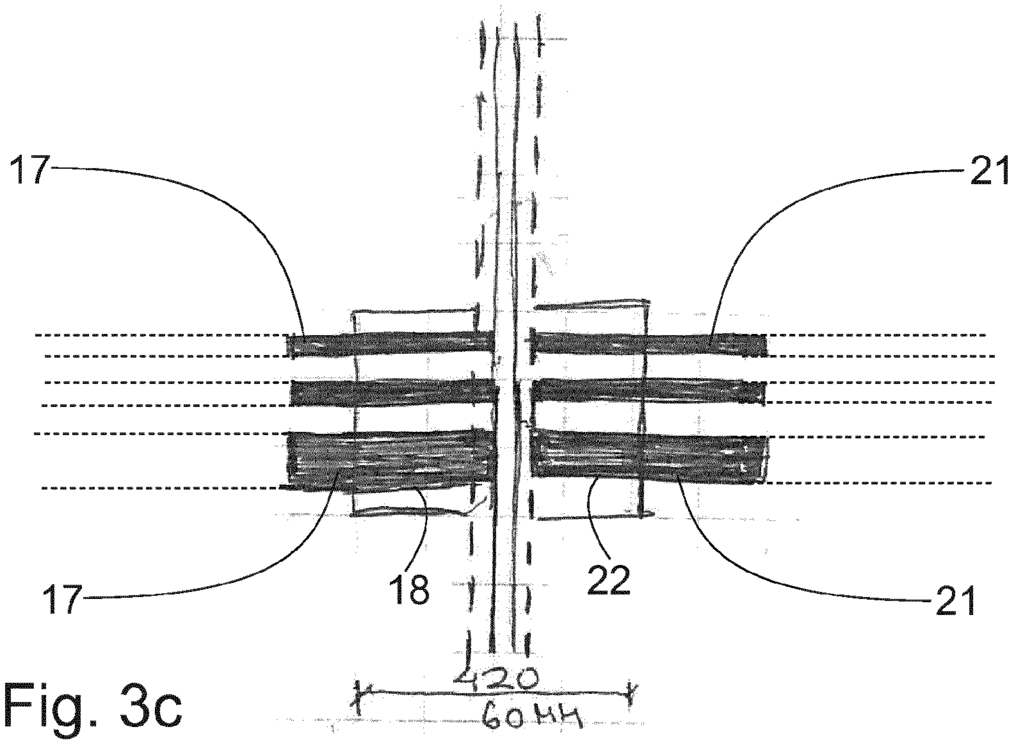

Fig. 3c

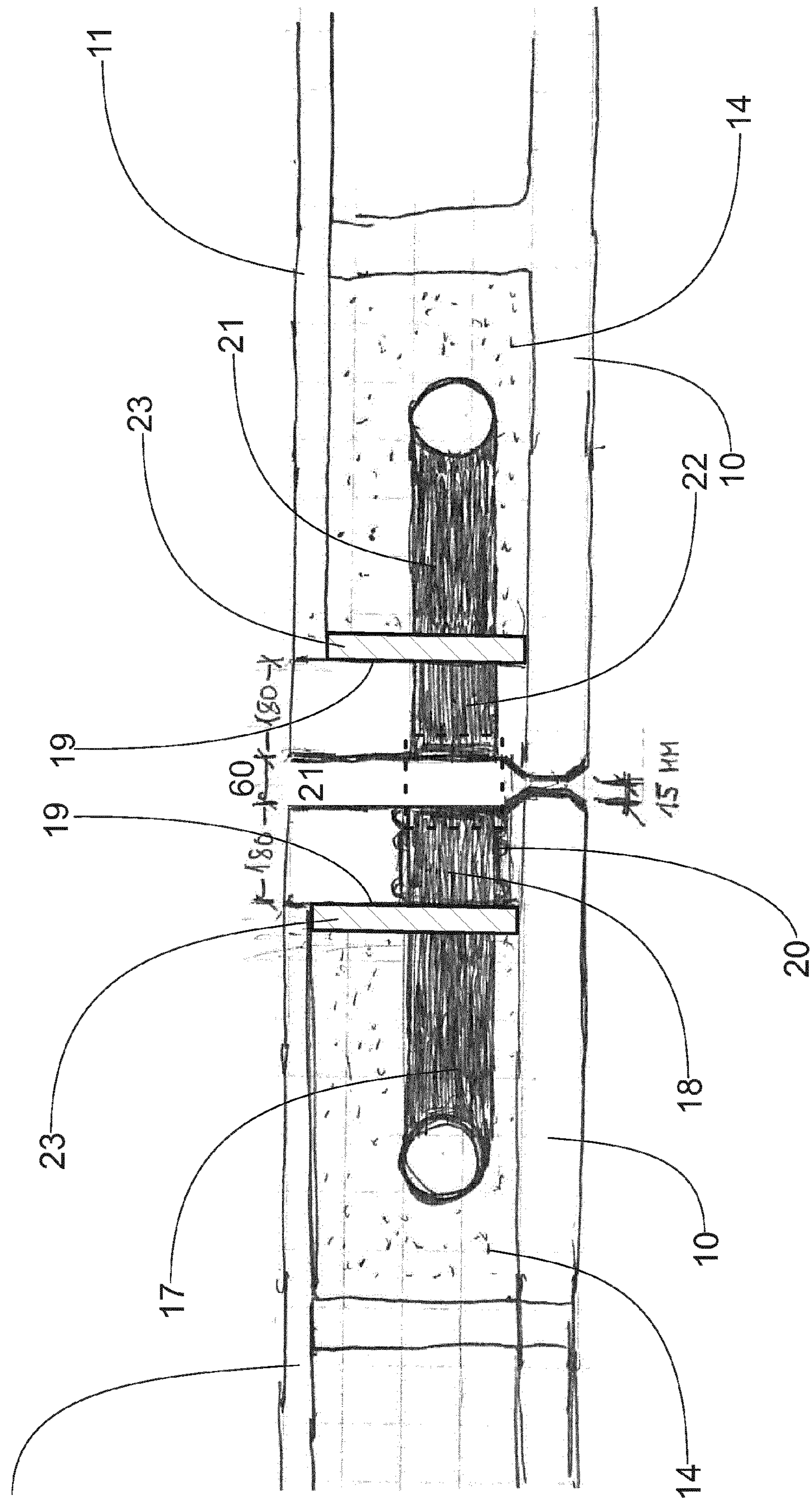

Fig. 4

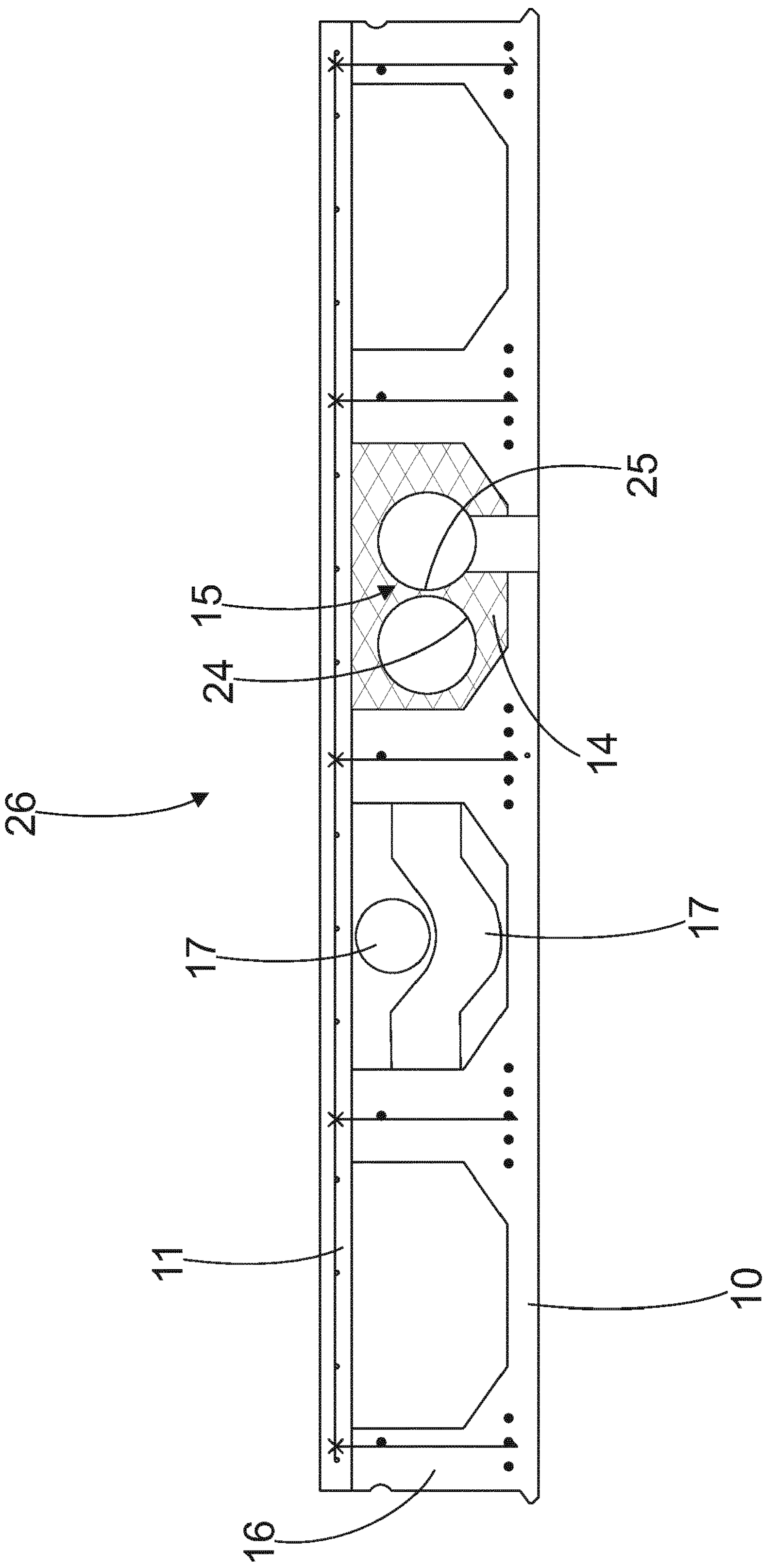

Fig. 5

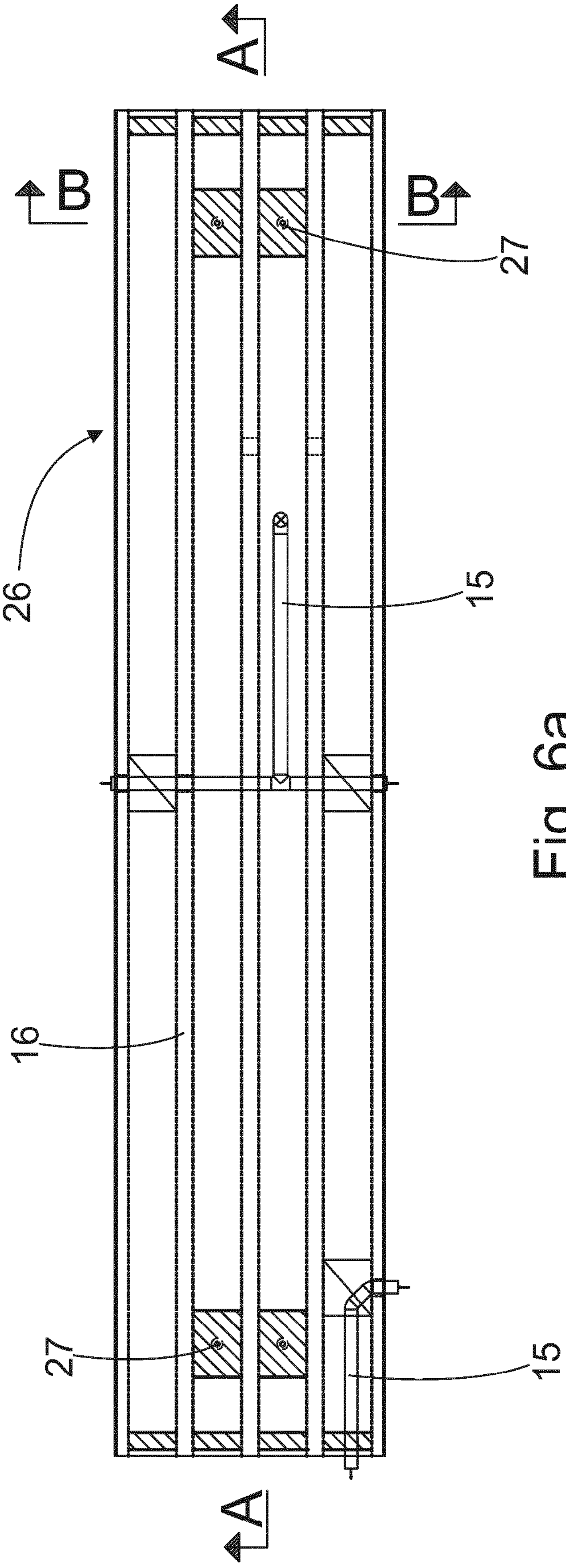

Fig. 6a

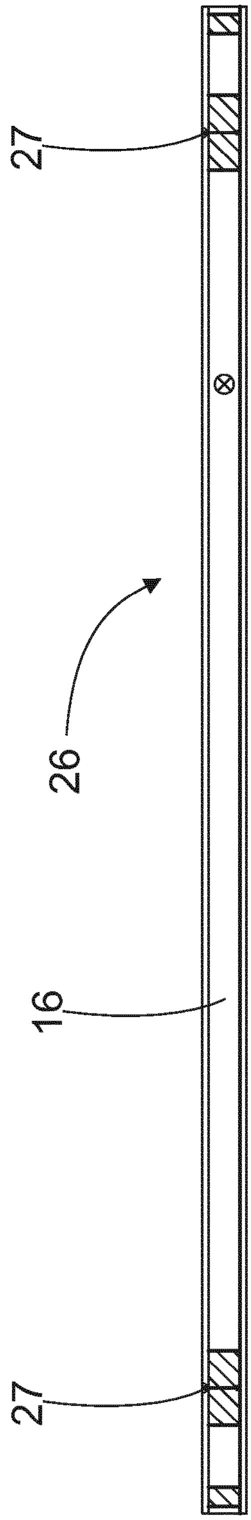

Fig. 6b

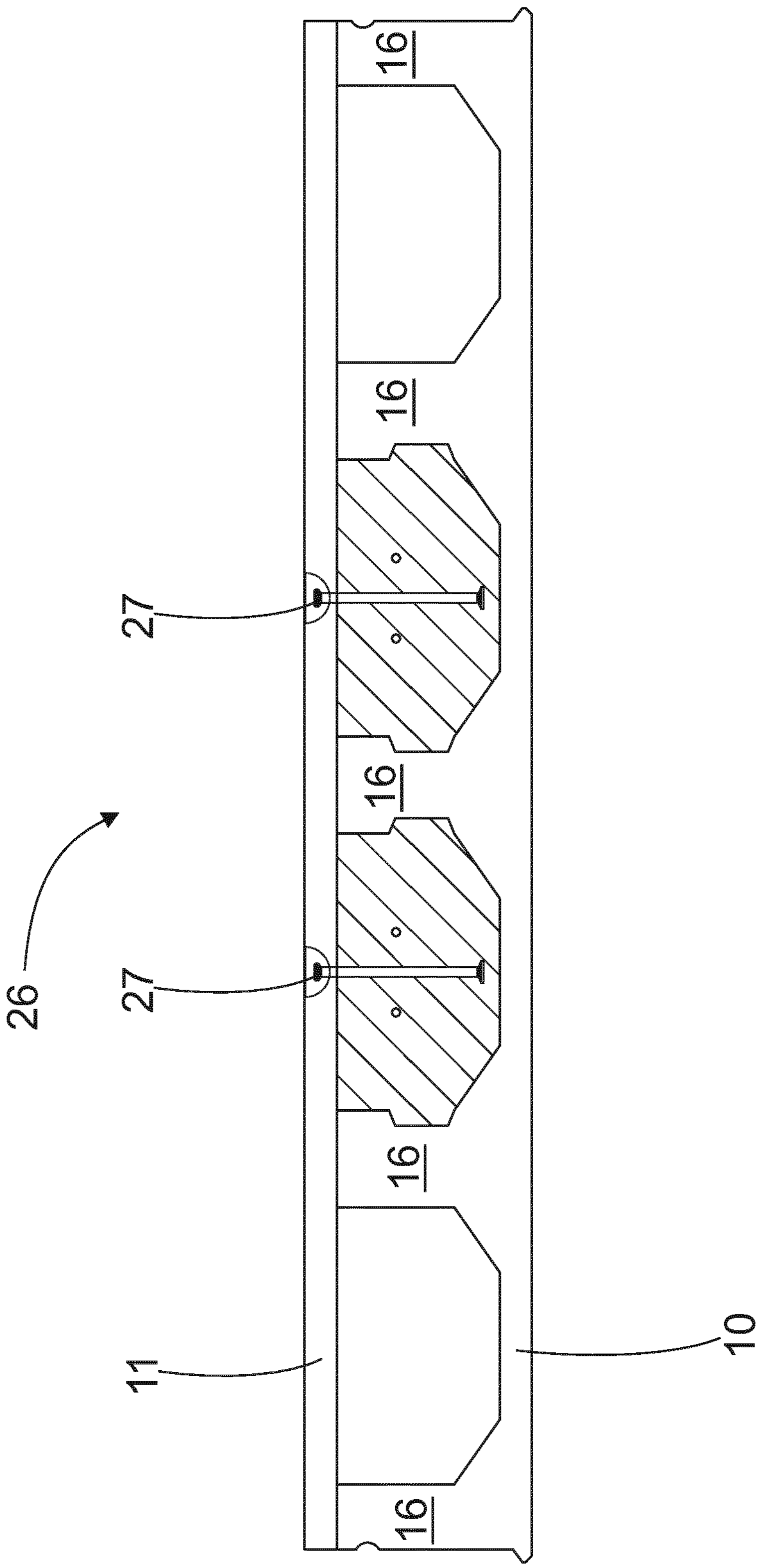

Fig. 7

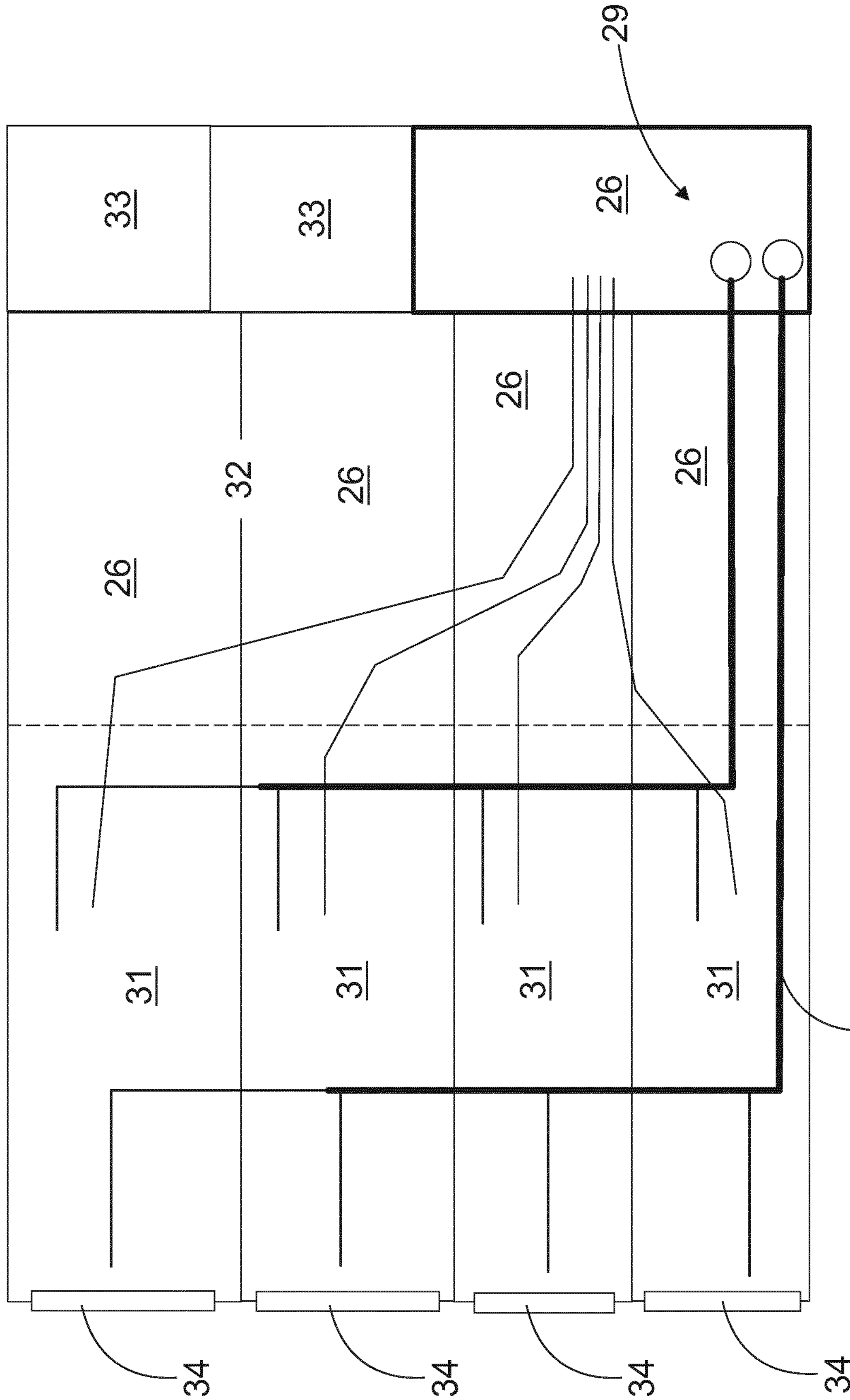

Fig. 8

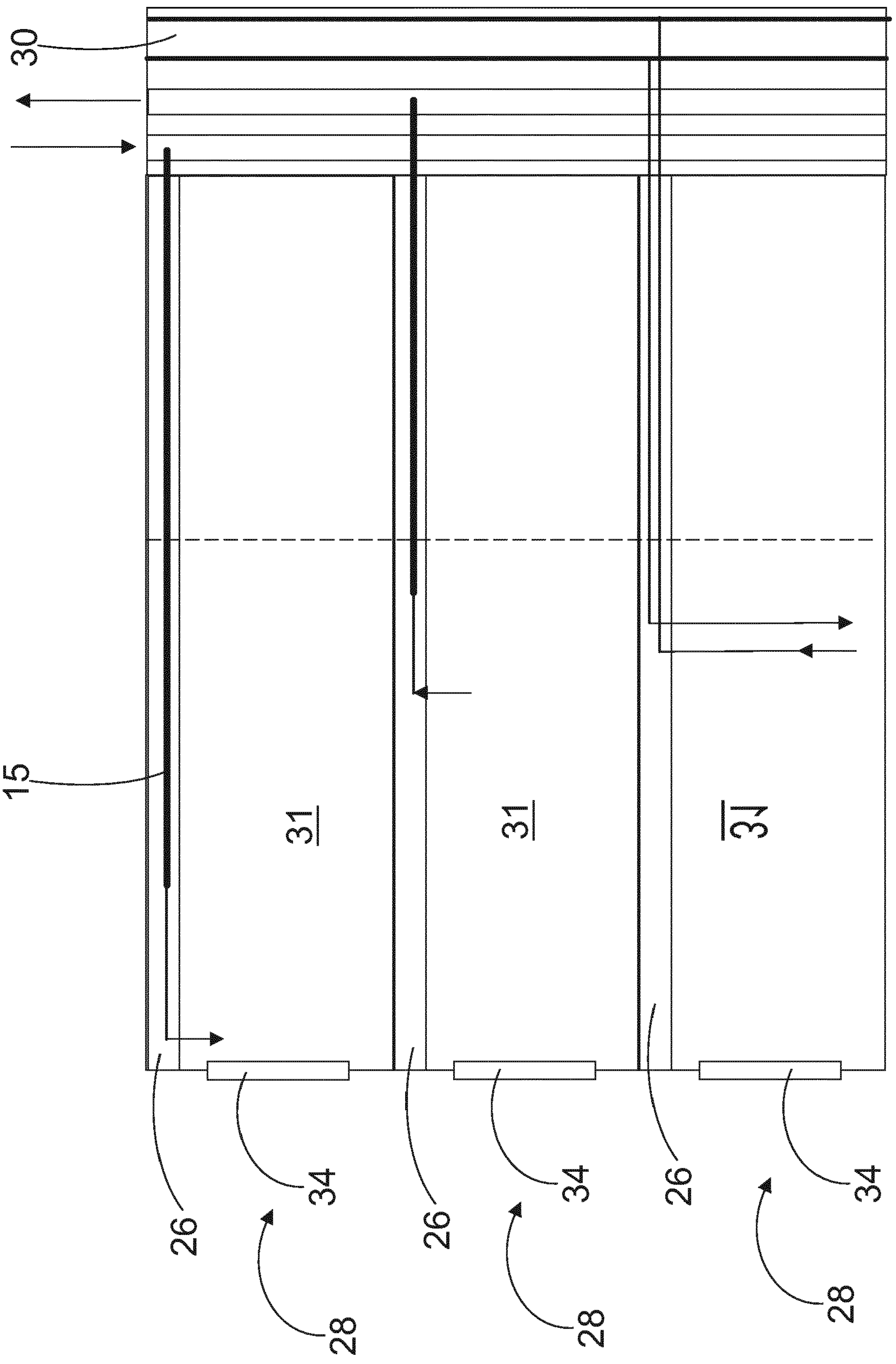

Fig. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 19 15 4203

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	DE 30 06 672 A1 (RUPPMANN OTTO) 10 September 1981 (1981-09-10) * figures 1-3 * * page 2, line 9 - line 11 * -----	1,4-9, 12-15 2,11	INV. E04B5/04 E04B5/26 E04B5/48
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TECHNICAL FIELDS SEARCHED (IPC)

E04B
B29C
B28B
E04C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	13 June 2019	Petrinja, Etiel

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