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(71) Applicant: **Sandvik Mining and Construction Oy**
33330 Tampere (FI)

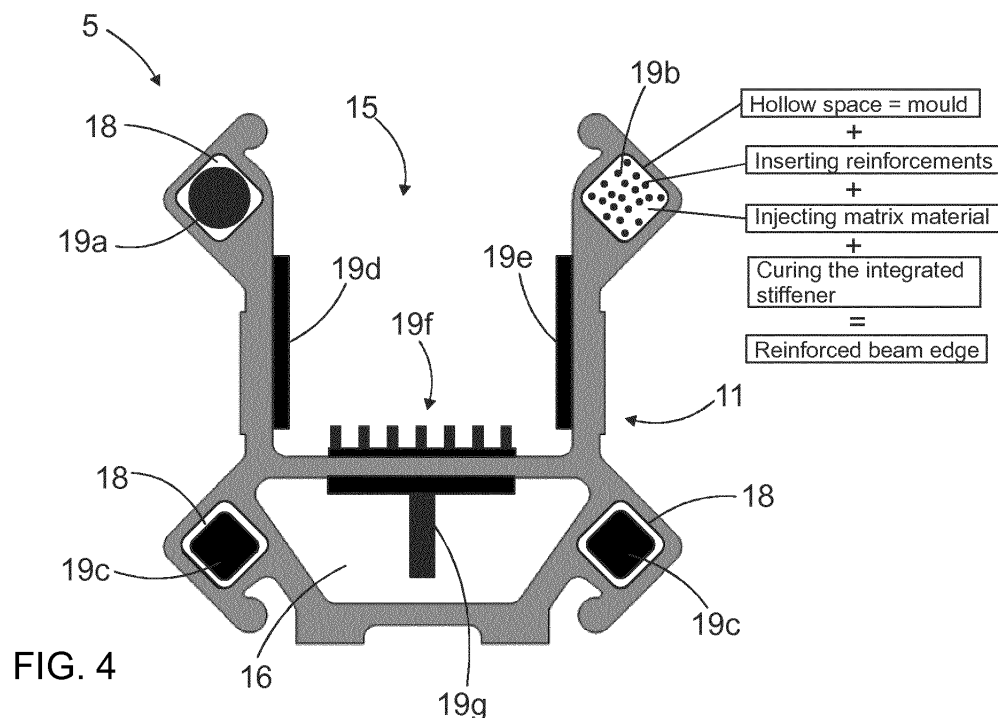
(72) Inventors:
• **Eronen, Kimmo**
33960 Pirkkala (FI)
• **Hyvärinen, Anssi**
33270 Tampere (FI)

- **Brown, Paul**
00150 Helsinki (FI)
- **Connelly, Stephen**
33230 Tampere (FI)
- **Kallinen, Risto**
37120 Nokia (FI)
- **Majander, Teemu**
33330 Tampere (FI)
- **Launis, Sirpa**
33330 Tampere (FI)
- **Piipponen, Juha**
33330 Tampere (FI)
- **RANTALA, Mr. Esa**
33330 Tampere (FI)

(74) Representative: **Sandvik**
Sandvik Intellectual Property AB
811 81 Sandviken (SE)

(54) **FEED BEAM AND METHOD OF STIFFENING THE SAME**

(57) The invention relates to a feed beam, rock drilling unit and to a method. The feed beam comprises a metallic base profile component and one or more composite stiffening elements.



Description

Background of the invention

[0001] The invention relates to a feed beam of a rock drilling unit. The feed beam is an elongated piece comprising support surfaces for supporting and guiding a rock drilling machine.

[0002] The invention further relates to a method of stiffening a feed beam.

[0003] The field of the invention is defined more specifically in the preambles of the independent claims.

[0004] In mines and at other work sites different type of rock drilling rigs are used. The rock drilling rigs are provided with one or more booms and rock drilling units at distal ends of the booms. The rock drilling unit comprises a feed beam along which a rock drilling device is configured to be moved during the drilling procedure. Modern feed beams consist of extruded aluminum profiles, which are relatively strong and light in weight. However, the present feed beams have still shown to contain some disadvantages.

Brief description of the invention

[0005] An object of the invention is to provide a novel and improved feed beam. The invention further relates to a method of stiffening a feed beam.

[0006] The feed beam according to the invention is characterized by the characterizing features of a first independent apparatus claim.

[0007] The rock drilling unit according to the invention is characterized by the characterizing features of a second independent apparatus claim.

[0008] The method according to the invention is characterized by the characterizing features and steps of an independent method claim.

[0009] An idea of the disclosed solution is that the feed beam of a drilling unit is an elongated piece comprising a basic profile element provided with support surfaces allowing a rock drilling machine to be supported movably on the feed beam. The mentioned basic profile element is reinforced by providing it with one or more stiffening elements made of composite material. The composite stiffening elements comprise reinforcing fibers and matrix material. The basic profile element and the stiffening elements are made of different materials whereby it is entitled to be named as a hybrid feed beam.

[0010] An advantage of the disclosed solution is that the feed beam can be construed extremely rigid and still light in weight. Thus, the included one or more composite elements improve properties of the basic feed beam, which may be made of metallic material. The stiffening elements do not substantially increase outer dimensions of the feed beam, which has positive effect on usability of the drilling unit. Further, when the feed beam is stiffer than before, positioning of the feed beam may be more accurate. The feed beam may also be provided with ver-

satile auxiliary devices and components since the stiffer structure allows greater payload to be supported to the feed beam. Mounting of the rod and tool handling devices and other auxiliary devices may also be executed more freely than in conventional feed beams. One additional benefit is that due to the composite stiffeners fatigue and service life of the feed beam may be extended. To sum up, the hybrid feed beam may enjoy the best material and structural properties of the basic profile elements and the composite stiffeners.

[0011] According to an embodiment, the basic profile elements and the basic structure of the feed beam may be made of metal material or other such material that withstands external forces without damages and cracks.

15 The basic structure is provided with support elements and points for fastening the auxiliary devices and slides of the drilling machine, for example. The composite stiffening elements may be located so that the metallic basic structure provides mechanical protection against external forces for the stiffeners.

20 [0012] According to an embodiment the disclosed solution may be implemented with only slight modifications to current aluminum extrusion profiles. Thereby the disclosed solution is also easy to produce and the new feed beam may be retrofitted to the existing drilling units without extensive modifications.

25 [0013] According to an embodiment, the feed beam comprises one or more elongated composite rods, which serve as the stiffening elements. The composite rods may be prefabricated, the mounting of which elements is straightforward.

30 [0014] According to an embodiment, the feed beam comprises one or more elongated pultrusion profiles, which serve as the stiffening elements. Pultrusion is an effective manufacturing method for forming rod-like components.

35 [0015] According to an embodiment, the feed beam comprises one or more stiffening elements comprising carbon fibers as reinforcements and thermoplastic and/or thermoset resin as matrix or binding material.

40 [0016] According to an embodiment, the feed beam is a multi-material structure wherein the basic profile element of the feed beam and the stiffening element are made of different materials. The basic structure of the feed beam may consist of one or more extruded high strength aluminum profile sections, and the stiffening element consists of reinforcement fibers and thermoplastic or thermoset plastic matrix material.

45 [0017] According to an embodiment, the stiffening element of the feed beam is fastened to the basic profile element of the feed beam by means of an adhesive bonding. Then the stiffening element is an inseparable integrated part of the feed beam. In other words, the stiffening element is mounted in place already at the manufacturing place and cannot be removed without breaking the structure.

55 [0018] According to an embodiment, the stiffening element of the feed beam may be a prefabricated item,

bonded to the basic profile element. This way, manufacture of the stiffening element may be executed effectively beforehand and still the mounting ensures that the stiffening element serves extremely well as a load bearing element.

[0019] According to an embodiment, the stiffening element of the feed beam is formed directly against surfaces of the basic profile element. In other words, the stiffening element is integrated to the structure of the feed beam.

[0020] According to an embodiment, the stiffening element is an inseparable integrated part of the feed beam and forming process of the stiffening element may comprise the following features or steps: inserting reinforcements, possibly a prefabricated reinforcing structure, inside a hollow space or cavity of the basic profile element; injecting the matrix or binding material inside the space for filling the space; and curing the formed integrated stiffening element. In this embodiment the cavity of the basic profile element serves as a mould for the manufacture of the stiffening element. Further, when the stiffening element made of composite material is inside the cavity, then it is automatically perfectly protected against external forces and harsh conditions.

[0021] According to an embodiment, the stiffening element of the feed beam is laminated against inner or outer surfaces of the basic profile element. An advantage of the laminating technique is that number of the laminated layers, their materials as well as directions of the reinforcing fibers may be easily chosen according to the need. In other words, the laminating technique offers multiple variations to be implemented for the structures and properties of the integrated stiffening elements and portions. The included reinforcing layers are relatively easy to laminate together with the matrix material directly on the surfaces of the basic structure of the feed beam. As an alternative to the machine or manually laminated layers, prepregs may be implemented. The prepregs comprise reinforcement fiber elements which are pre-impregnated with thermoplastic or thermoset resin matrix in a certain ratio.

[0022] According to an embodiment, the stiffening element of the feed beam is fastened by means of mechanical fastening elements to the basic structure of the feed beam. Then the stiffening element may be a changeable element and it may be substituted if being damaged or when greater payload than originally designed is supported to the feed beam, or when use of the feed beam is changed. Furthermore, it may even be possible to retrofit one or more stiffening elements to existing feed beams and to thereby update their structures and properties. The mentioned mechanical fastening elements may comprise different type of fastening screws, quick coupling elements, clamps, wedges and corresponding elements.

[0023] According to an embodiment, the stiffening element of the feed beam is an elongated rod-like piece ends of which are fastened to the basic profile element

by means of the mechanical fastening elements. Thus, in this embodiment only the ends of the stiffening element are fastened to the basic profile element and the portion between the ends is free of fastening with the basic profile element. The basic profile element may comprise an elongated space, such as a tubular space, inside which the rod-like stiffening element is inserted and only the ends are then fastened. This type of stiffening element is easy to mount and change.

[0024] According to an embodiment, the mechanical fastening of the stiffening element of the feed beam is dismountable and re-mountable. The separate stiffening element is a spare part which is easily mountable and dismountable to a basic structure of the feed beam. Alternatively or in addition to the spare part may comprise heat and/or pressure activated bonding agent for the fastening.

[0025] According to an embodiment, the stiffening element is fastened to the basic profile element by means of the mechanical fastening and adhesive bonding. The stiffening element may be a rod-like piece the ends of which are fastened by means of screws to the basic feed beam structure and the middle section between the ends may be glued to the feed beam structure, for example. This way the stiffening element is fastened extremely rigidly to the basic feed beam components and may thus receive well forces and increases thereby rigidity of the feed beam.

[0026] According to an embodiment, the stiffening element of the feed beam is tensioned longitudinally between two structural elements of the basic profile element of the feed beam. The tensioning increases significantly rigidity of the stiffening element.

[0027] According to an embodiment, the stiffening element of the feed beam is a pre-tensioned element as it is disclosed in the previous embodiment. Further, the stiffening element is a rod-like piece comprising ends and at least one end is connected to a pre-tensioning element for generating pre-tensioning force for the stiffening element. The opposing end may comprise anchoring or locking elements.

[0028] According to an embodiment, the feed beam comprises one or more stiffening elements which are pre-tensioned by means of at least one pre-tensioning element. The pre-tensioning element comprises screw elements. Advantages of the screw element is that great forces can be generated and yet the structure may be simple and durable. The screw elements or members are also inexpensive, easy to use and they offer accurate adjustment.

[0029] According to an embodiment, the stiffening element is tensioned by means of an external tensioning device during the mounting. The tensioning device is removed after the stiffening element is being tensioned and locked to the basic profile element in the tensioned state by means of locking screws of other fastening means.

[0030] According to an embodiment the stiffening element mounted to the feed beam may extend from end to

end of the feed beam, or alternatively, the stiffening elements may be located only at specific longitudinal portions of the feed beam for stiffening only limited portions of the feed beam.

[0031] According to an embodiment, cross-section of the basic profile element of the feed beam comprises at least one hollow space enveloped by material of the basic profile. Further, at least one stiffening element of the feed beam is located inside the mentioned space. The hollow space wherein the stiffening element is located may be a space dedicated for the stiffening element, or alternatively, it may be a structural space inside which may possibly locate other components and devices belonging to the drilling unit.

[0032] According to an embodiment, the stiffening element is invisible to the outer side of the feed beam. Then the vulnerable composite structure is protected against damage and dents by means of the structure of the basic profile element. A further advantage of this embodiment is that it has no influence to outer dimensions of the cross-section of the basic profile element.

[0033] According to an embodiment, the cross-section of the basic profile element comprises several corners and at least one of the corners comprises a hollow space provided with the stiffening element. Cross-section of the basic profile element may comprise at least one hollow space enveloped by material of the basic profile.

[0034] According to an embodiment, the cross-section of the basic profile element of the feed beam comprises four corners and each of the corners are provided with the stiffening elements inside the hollow spaces. The stiffening elements located at corners are at a distance from the center line of the feed beam which is beneficial according to strength theory.

[0035] According to an embodiment, the basic profile element of the feed beam is made of aluminum, titanium, magnesium or any other suitable alloy. Thereby the feed beam may be light-weight and may withstand well moisture and harsh conditions.

[0036] According to an embodiment, the basic profile element of the feed beam is an extruded profile.

[0037] According to an embodiment, the basic profile of the feed beam is made of light-weight metal material, such as aluminum, and rigidity of the feed beam structure is improved by means of several carbon composite rods integrated to corners of the profile. The carbon composite rods may be pre-tensioned.

[0038] According to an embodiment, a rock drilling unit comprises a feed beam and a rock drilling machine is supported on the feed beam. A feed device is configured to move the drilling machine longitudinally on the feed beam. The feed beam of the drilling unit is stiffened by means of one or more composite stiffening elements. Further, the rock drilling unit may be arranged to a drilling boom of a rock drilling rig. The rock drilling rig may be a surface drilling rig or an underground drilling rig. The rock drilling unit may be a production drilling unit or it may be arranged in connection with a rock bolting device, for

example. The rock drilling device of the rock drilling unit may comprise an impact device for executing percussion drilling, or alternatively, the drilling may be based on rotation of a drilling tool only.

[0039] According to an embodiment, cross section of the feed beam comprises one or more hollow spaces and the feed beam is stiffened by arranging one or more composite rods into one or more of the hollow spaces.

[0040] According to an embodiment, the stiffening element is without any fixed fastening to the basic profile element, but instead the separate stiffening element is inserted into a tight space of the basic profile element and is thereby capable to receive forces directed to the feed beam. When the basic structure of the feed beam is subjected to bending forces, then surfaces of the tight space transmit the bending forces to the inserted rigid stiffening element.

[0041] According to an embodiment, the feed beam comprises means, such as tensioning screws or apparatuses, for generating longitudinal tensioning force to the stiffening element during the mounting. Alternatively, the tensioning of the stiffening elements is executed by means of an external tensioning apparatus used during the mounting phase. An advantage of this embodiment is that improved rigidity of the structure may be achieved by means of pre-loading.

[0042] According to an embodiment, the feed beam comprises at least one tensioning device allowing changes and adjustment of the longitudinal tensioning force to the stiffening element during the use of the feed beam of the drilling unit. This way the tensioning of the stiffening elements may be adjusted remote controlled or automatically. The tensioning device comprises at least one actuator for generating the tensioning force. The actuator may be a hydraulic cylinder or motor, for example.

[0043] According to an embodiment, the feed beam comprises the tension adjusting device as disclosed in the previous embodiment. The feed beam further comprises one or more sensors or measuring devices for sensing loadings and forces directed to the feed beam. The adjusting device may be controlled on the basis of the sensing data for adjusting the tension caused by the pre-tensioning means. The adjusting device may be operated electrically or hydraulically, for example. The control of the adjusting device may be automatic or it may be controlled by an operator. The adjusting device may be remote controllable. In this embodiment the feed beam may comprise a dynamic stiffening system.

[0044] The above disclosed embodiments may be combined in order to form suitable solutions having those of the above features that are needed.

Brief description of the figures

[0045] Some embodiments are described in more detail in the accompanying drawings, in which

Figure 1 is a schematic side view of a rock drilling

rig for underground drilling and being provided with a drilling boom equipped with a drilling unit, Figure 2 is a schematic side view of a rock drilling rig for surface drilling and also being provided with a drilling unit,

Figure 3 is a schematic view of a feed beam seen in longitudinal direction and comprising four composite stiffening elements at its corners,

Figure 4 is a schematic longitudinal view of a feed beam comprising corner stiffeners and some additional stiffening elements mounted on its inner surfaces,

Figure 5 is a schematic longitudinal view of a feed beam basic structure of which comprises a longitudinal hollow space on its bottom part and the mentioned hollow space is filled with reinforcements and matrix material,

Figure 6 is a schematic longitudinal view of a feed beam wherein the bottom part hollow space comprises tubular reinforcements and the hollow space between them and the basic structure of the feed beam is filled with matrix material,

Figure 7 is a schematic side view of feed beam comprising pre-tensioned stiffening elements arranged inside hollow spaces of metallic basic components, Figure 8 is a schematic view of two rod-like stiffening elements, which are made of composite material and may be inserted inside hollow spaces of the feed beam or which may be pre-tensioned between two support flanges or corresponding surfaces,

Figures 9 and 10 are schematic views showing that the stiffening element may be formed by laminating desired number of reinforcing layers and matrix material on a surface of the basic structure of the feed beam,

Figure 11 is a schematic view showing that a prepreg element may be fastened on a surface of the feed beam,

Figure 12 is a schematic view showing that a side surface of the feed beam may be provided with a stiffening element comprising laminated layers and that thickness of the stiffening element may be different at different portions, and

Figure 13 is a schematic and cross-sectional view of a feed beam, wherein a basic metallic structure comprises a substantially rectangular hollow tube and wherein inner corners of the basic structure are provided with composite corner stiffeners.

[0046] For the sake of clarity, the figures show some embodiments of the disclosed solution in a simplified manner. In the figures, like reference numerals identify like elements.

Detailed description of some embodiments

[0047] Figure 1 shows a rock drilling rig 1 as an example of a mine vehicle comprising a feed beam. Also rock

bolting rigs, charging rigs and measuring vehicles may comprise booms provided with feed beams. The improved feed beam disclosed in this patent application may be applied in all type of feed beams implemented in mine operations.

[0048] The rock drilling rig 1 may comprise a movable carrier 2 and one or more booms 3 connected to the carrier 2. At a distal end portion of the boom 3 may be a drilling unit 4. The drilling unit 4 may comprise a feed beam 5 and a rock drilling machine 6 supported on it. The rock drilling machine 6 may comprise a shank at a front end of the rock drilling machine 6 for connecting a tool 7. Further, the drilling unit 4 may comprise one or more rod handling devices 8, such as a tool hold device, a tool changing apparatus or manipulator and a tool magazine or storage. In addition to this, one or more additional devices 9 may be supported to the feed beam 5. Thereby the feed beam is subjected to several different loads during the operations and still it should be light in weight and rigid enough to allow accurate positioning for a drill bit 7b mounted to a front end of the tool 7 comprising one or more drilling rods 7a. Figure 1 further disclose drilling axis DA.

[0049] In Figure 1 the rock drilling rig 1 is operating in an underground mine space 8, which may be a tunnel, storage hall or corridor, for example.

[0050] Figure 2 discloses a surface rock drilling rig 1 which also comprises a carrier 2, a boom 3 and drilling unit 4 provided with a feed beam 5. A rock drilling machine 6 is supported on the feed beam 5 and may be moved in the drilling direction and reverse direction by means of a feed device 10. The feed beam 5 may be equipped with needed auxiliary devices and components.

[0051] Figure 3 discloses a feed beam 5 comprising a basic structure or basic profile element 11, which may be made of metallic material. The basic profile element 11 may be made of aluminium material by means of extrusion technique. However other light-weight metallic materials and manufacturing techniques may of course be implemented. Cross sectional profile of the disclosed feed beam 5 comprise four corners 12a - 12d, two sides 13a, 13b, a bottom surface 14 and an open top space 15. Between the open top space 15 and the bottom surface 14 is a closed hollow bottom space 16 limited vertically by the bottom surface and an intermediate support 17. The bottom space 16 may be left hollow or it may be provided with one or more composite stiffening elements as will be disclosed below.

[0052] At the corners 12a - 12d may be longitudinal hollow spaces 18 inside which composite stiffening elements 19 are arranged. The stiffening elements 19 may be rod-like elements and they may be fastened by means of mechanical fastening means and/or by means of gluing or bonding to the basic profile element 11. Outer surfaces of the corners 12a - 12d may comprise support surfaces 20 for slide elements of a carriage, which is for supporting a rock drilling rig movably on the feed beam 5. The side surface 13a, 13b of the feed beam 5 may com-

prise second support surfaces 21 for supporting different kind of tool handling devices and elements to the feed beam as well as any auxiliary devices. The open top space 15 may receive a feed cylinder or corresponding feed device.

[0053] Figure 4 discloses a feed beam 5 having a similar basic profile element 11 as in Figure 3. The corners 12a - 12d are provided with stiffening elements 19a - 19c. In Figure 4 it is demonstrated that the hollow spaces 18 at the corners 12a - 12d may be provided with different type of stiffening elements. In addition to the corner stiffeners, one or more inner surfaces of the open top space 15 may also be provided with stiffening elements 19d - 19f which may be bonded directly on the surfaces. The stiffening elements 19d - 19f may be laminated directly against the surfaces, or they may be pre-fabricated elements which are fastened to the surfaces by means of bonding agents or mechanical fasteners. As can be noted the stiffening elements may have flat outer surfaces or they may comprise protrusions of other surface topography for additionally increasing rigidity. Furthermore, the bottom space 16 may also comprise one or more stiffening elements 19g. In Figure 4 the stiffening element 19g has a T-shaped profile, but it should be understood that other suitable profiles may also be utilized for stiffening the feed beam 5.

[0054] Figure 4 also discloses one possible process of making the stiffening element 19b into the hollow space 18. This method is already disclosed more accurately above in this patent application.

[0055] Figure 5 discloses a feed beam 5 the basic profile element 11 of which corresponds to that shown in Figures 3 and 4. In addition to the corner stiffening elements 19c the bottom space 16 may be filled with reinforcements and matrix material so that a bottom space stiffening element 19h is formed. The solution of Figure 6 differs from the solution shown in Figure 5 in that several hollow elements 22, such as fibre reinforced tubes, are arranged inside the bottom space 16. Then the inner spaces of the tubes are empty and only the space between the tubes are filled with inserted matrix material and possible fibre material. Thus, an alternative bottom space stiffening element 19i is formed.

[0056] Figure 7 discloses that a basic profile component 11 of basic metallic structure of the feed beam 5 may comprise hollow spaces inside which are arranged rod-type stiffening elements 19j and 19k. The stiffening elements 19j, 19k comprise tensioning elements 23 for generating pre-tensioning forces PT for them. The tensioning elements 23 may be screw members, wedges of tensioning devices. As can be noted the pre-tensioned stiffening elements may extend from end to end of the feed beam 5 of they may cover only a limited portion of the feed beam.

[0057] Figure 8 illustrates two alternative rod-like stiffening elements 19l and 19m. Cross-sectional shapes of the stiffening elements may be selected freely according to the shape of the hollow insertion space and according

to needs.

[0058] Figures 9 and 10 show two types of laminated stiffening elements 19n and 19o, which may be formed directly on a surface of the basic profile element 11. Figure 10 discloses that the stiffening element 19o may comprise different type of reinforcement layers 24a, 24b having different materials, thicknesses and/or fibre orientations.

[0059] Figure 11 discloses that a stiffening element 19p may comprise a pre-preg element 25. Figure 12 discloses that a stiffening element 19q may comprise differing portions 26a, 26b with differing thickness.

[0060] Figure 13 discloses a feed beam 5 which has a substantially rectangular cross sectional shape. Inside a hollow space may be located a feed cylinder 27 and a carriage 28 may be supported on the feed beam 5 by means of slide elements 29. Inner corners of the basic profile element 11 may be provided with corner stiffening elements 19r.

[0061] The drawings and the related description are only intended to illustrate the idea of the invention. In its details, the invention may vary within the scope of the claims.

Claims

1. A feed beam of a drilling unit, wherein the feed beam is an elongated piece comprising a basic profile element provided with support surfaces allowing a rock drilling machine to be supported movably on the feed beam;
characterized in that
the basic profile element is provided with at least one stiffening element made of composite material comprising reinforcing fibers and matrix material.
2. The feed beam as claimed in claim 1, **characterized in that**
the stiffening element is a composite rod.
3. The feed beam as claimed in claim 1 or 2, **characterized in that**
the stiffening element is fastened to the basic profile element of the feed beam by means of an adhesive bonding, whereby the stiffening element is an inseparable integrated part of the feed beam.
4. The feed beam as claimed in claim 1 or 2, **characterized in that**
the stiffening element is fastened by means of mechanical fastening elements to the basic structure of the feed beam.
5. The feed beam as claimed in any one of the preceding claims 1 - 4, **characterized in that**
the stiffening element is tensioned longitudinally between two structural elements of the basic profile

element.

6. The feed beam as claimed in claim 5, **characterized in that**
the stiffening element is a rod-like piece comprising ends; and
at least one end of the stiffening element is connected to a pre-tensioning element for generating pre-tensioning force for the stiffening element. 5
7. The feed beam as claimed in any one of the preceding claims 1 - 6, **characterized in that**
cross-section of the basic profile element comprises at least one hollow space enveloped by material of the basic profile; and
at least one stiffening element is located inside the mentioned space. 10
8. The feed beam as claimed in claim 7, **characterized in that**
the cross-section of the basic profile element comprises several corners and at least one of the corners comprises the hollow space provided with the stiffening element. 15
9. The feed beam as claimed in any one of the preceding claims 1 - 8, **characterized in that**
the basic profile element is made of aluminum, titanium, magnesium or any other suitable alloy. 20
10. A rock drilling unit, comprising:
a feed beam;
a rock drilling machine supported on the feed beam; and
a feed device for moving the drilling machine longitudinally on the feed beam; 25
characterized in that
the feed beam is in accordance with the previous claims 1 - 9, wherein the feed beam is stiffened by means of at least one composite stiffening element. 30
11. A method of stiffening a feed beam of a rock drilling unit, wherein the feed beam comprises an elongated basic profile element; 35
characterized by
providing the basic profile element with at least one stiffening element made of composite material. 40
12. The method according to claim 11, **characterized by**
using a composite rod as the stiffening element;
providing cross-section of the basic profile element with at least one hollow space; and
arranging the composite rod into the hollow space. 45
13. The method according to claim 11 or 12, **characterized by** 50

generating longitudinal tensioning force to the stiffening element during the mounting.

14. The method according to any one of the previous claims 11 to 13, **characterized by**
adjusting longitudinal tensioning force to the stiffening element during the use of the feed beam of the drilling unit. 55

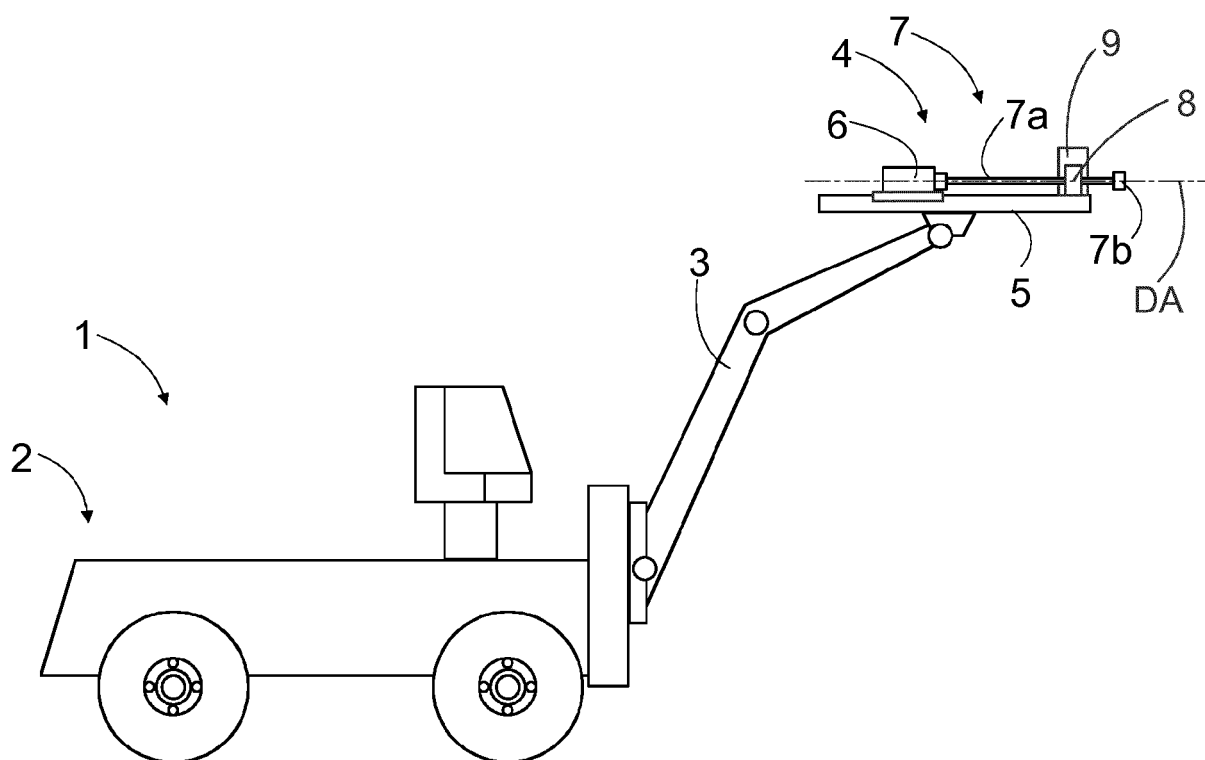


FIG. 1

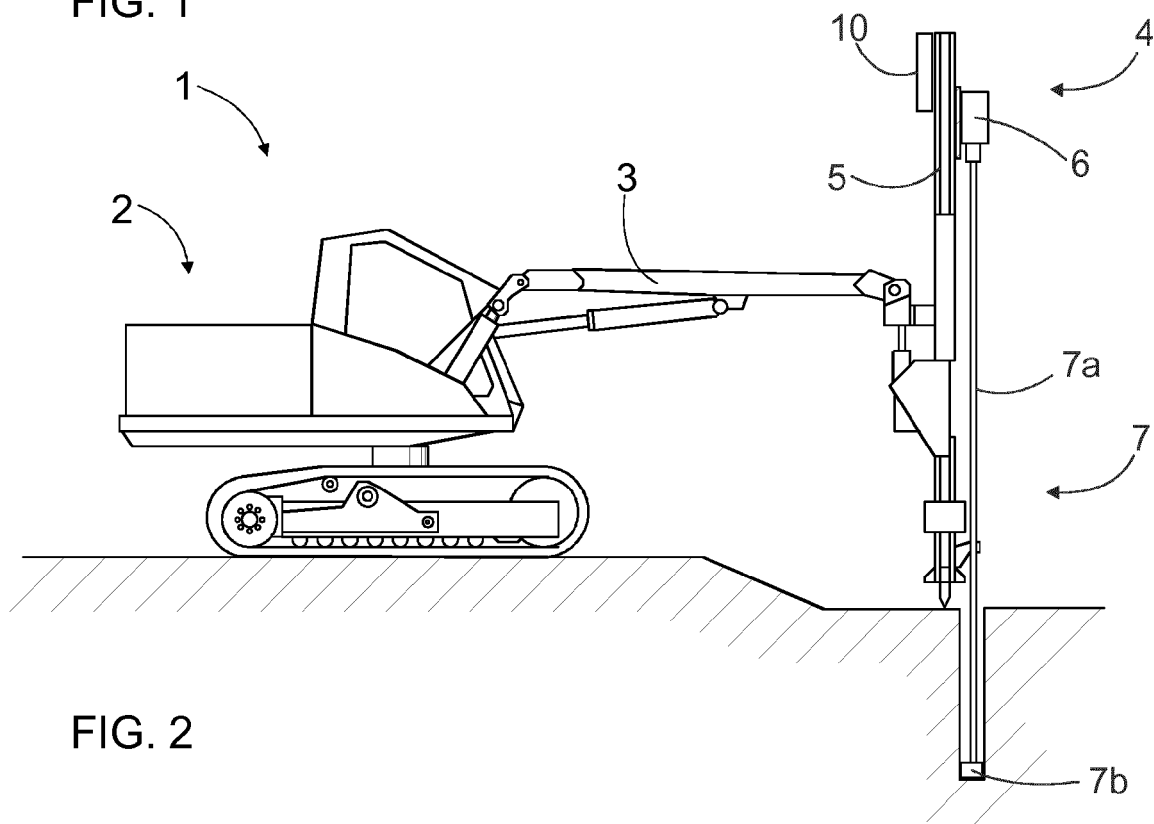


FIG. 2

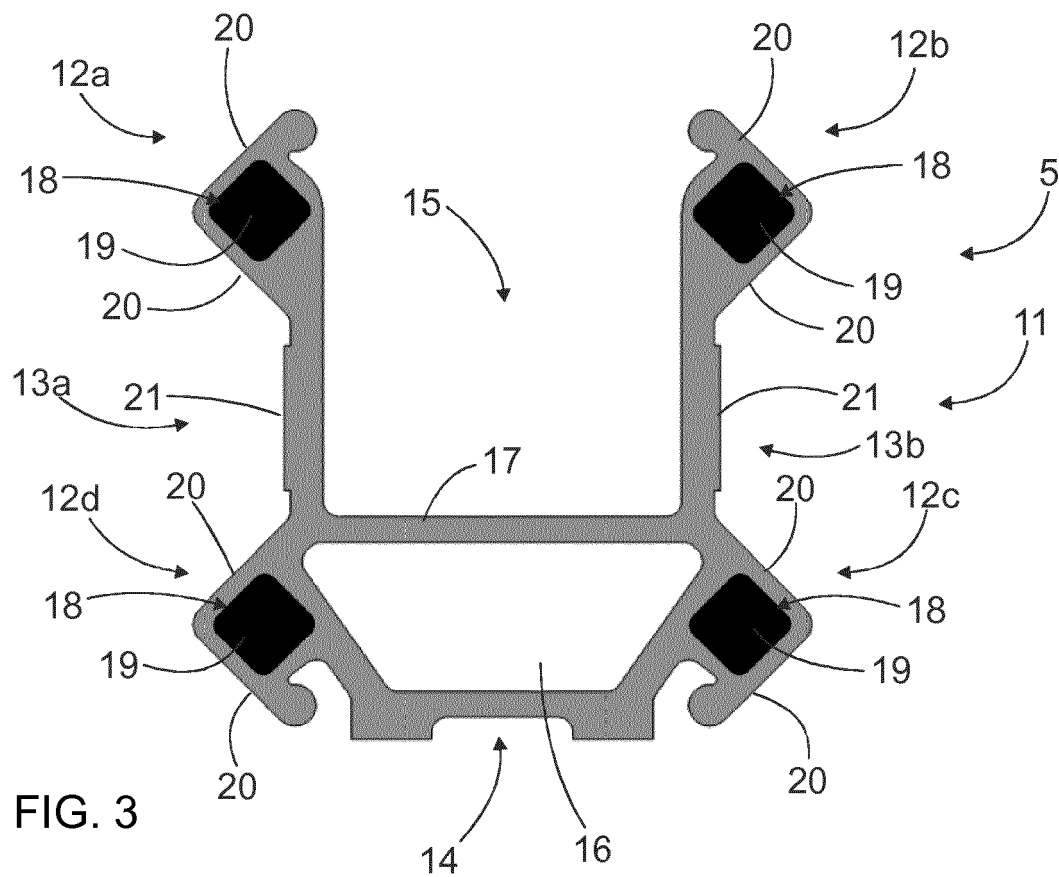


FIG. 3

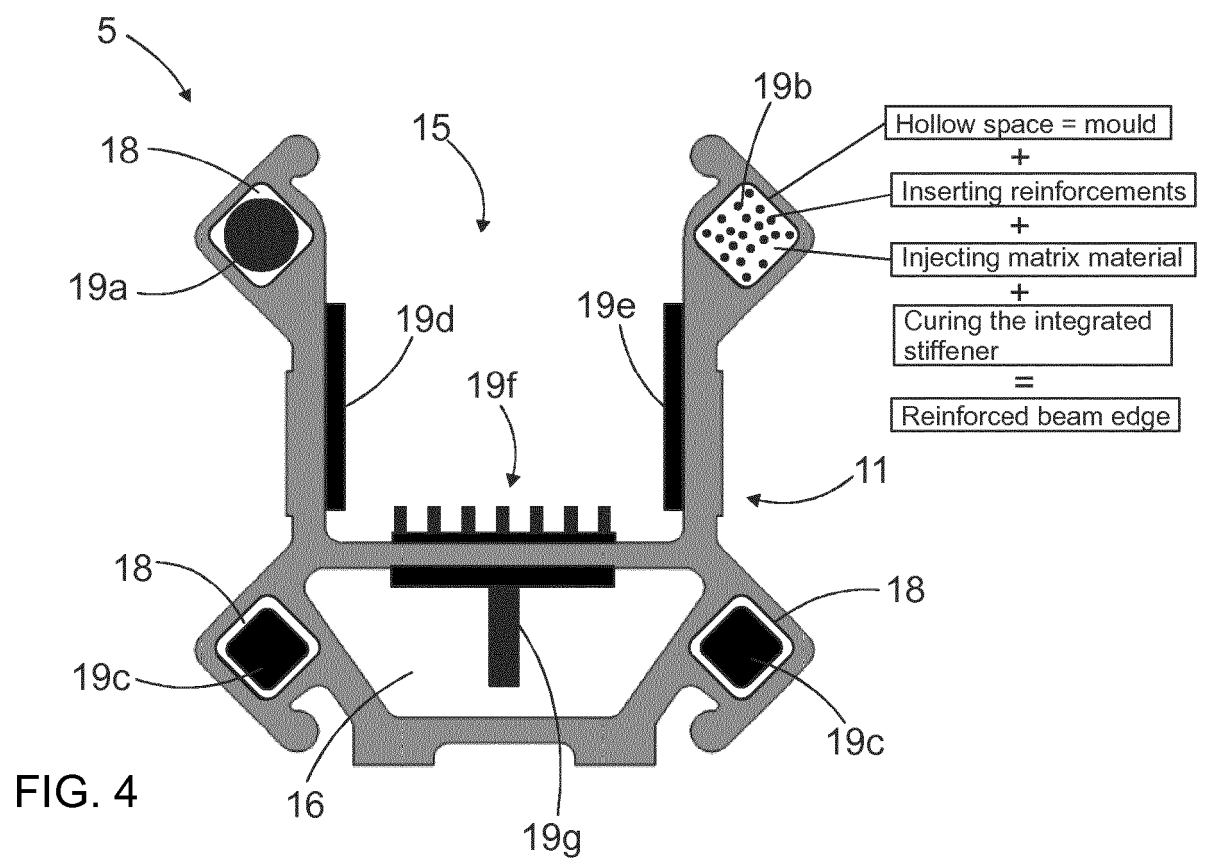
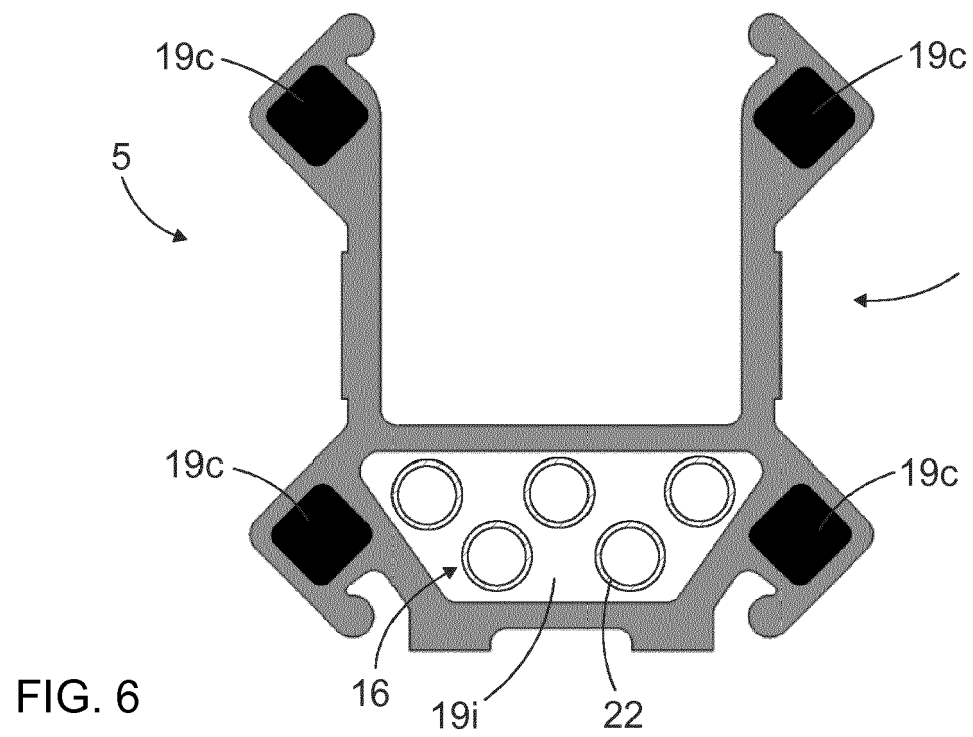
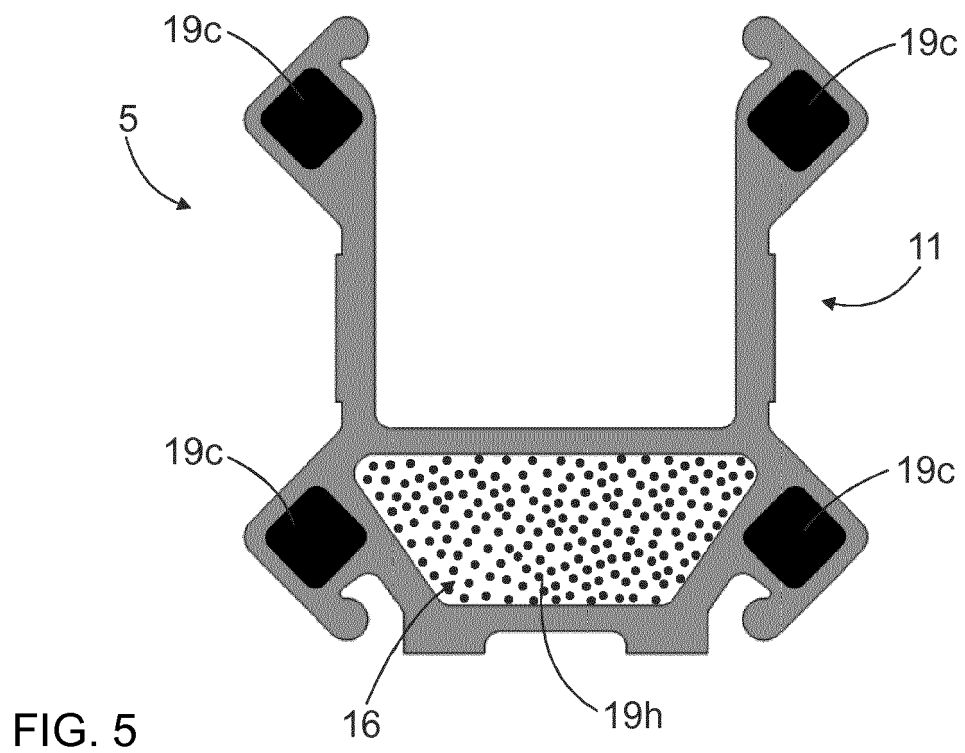


FIG. 4



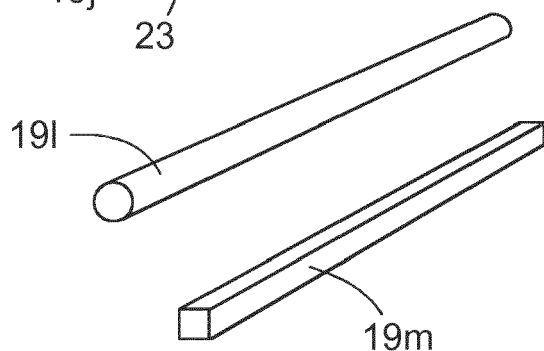
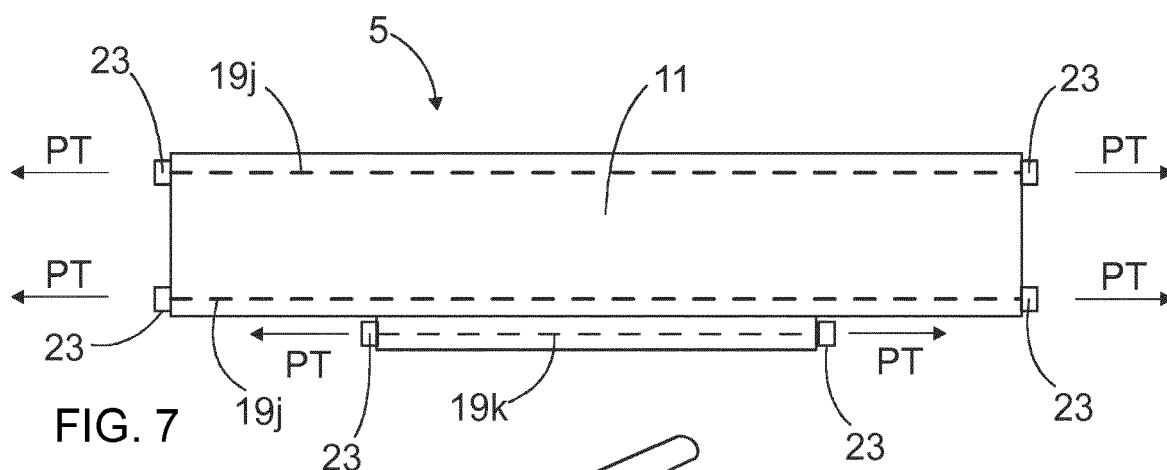


FIG. 8

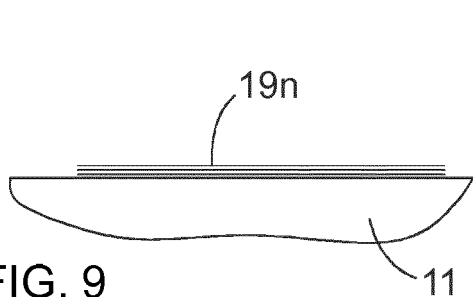


FIG. 9

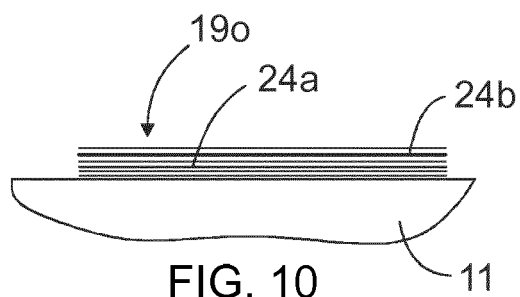


FIG. 10

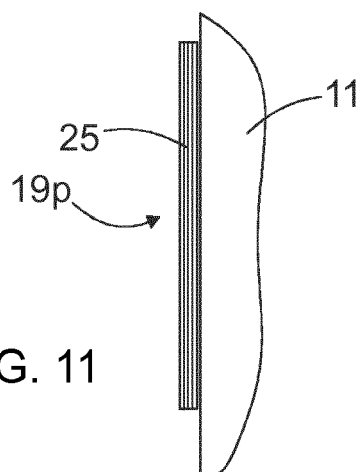


FIG. 11

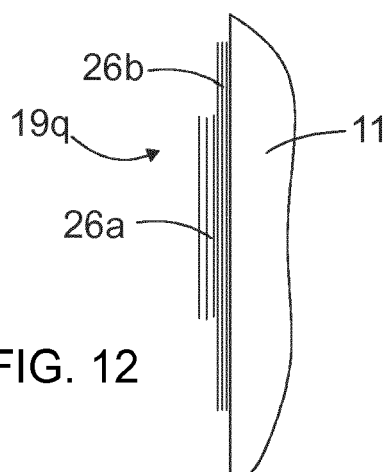


FIG. 12

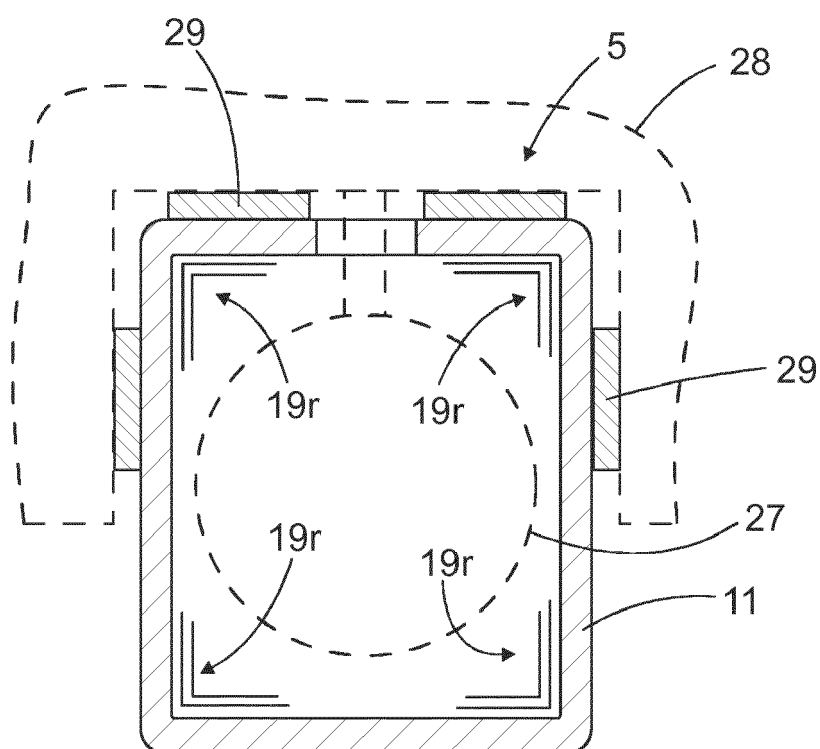


FIG. 13



EUROPEAN SEARCH REPORT

 Application Number
EP 17 20 8109

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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