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(54) Method and device for building terraced houses

(57) The present invention relates to a method for building a structure of terrace houses, comprising the steps of providing a foundation for the structure; placing at least one elongated guide member on a longitudinal axis of the foundation at least substantially along at least substantially the entire length of the foundation and fixing said elongated guide member with a robot crane device which is movable along said guide member to the foundation, which robot crane device is arranged for picking up and transporting building elements to a desired position on the structure; positioning the robot crane device at or near a first end of said at least one elongated guide member; erecting a first part of the structure to at least substantially its entire height by means of the robot crane device; moving and positioning the robot crane device in the direction of the second end of said at least one elongated guide member located opposite the first end of said at least one elongated guide member; subsequently erecting a part of the structure adjoining the already erected part of the structure by means of the robot crane device; repeating steps e) and f) until the construction of the structure is at least substantially complete. The invention further relates to a device for use in such a method.

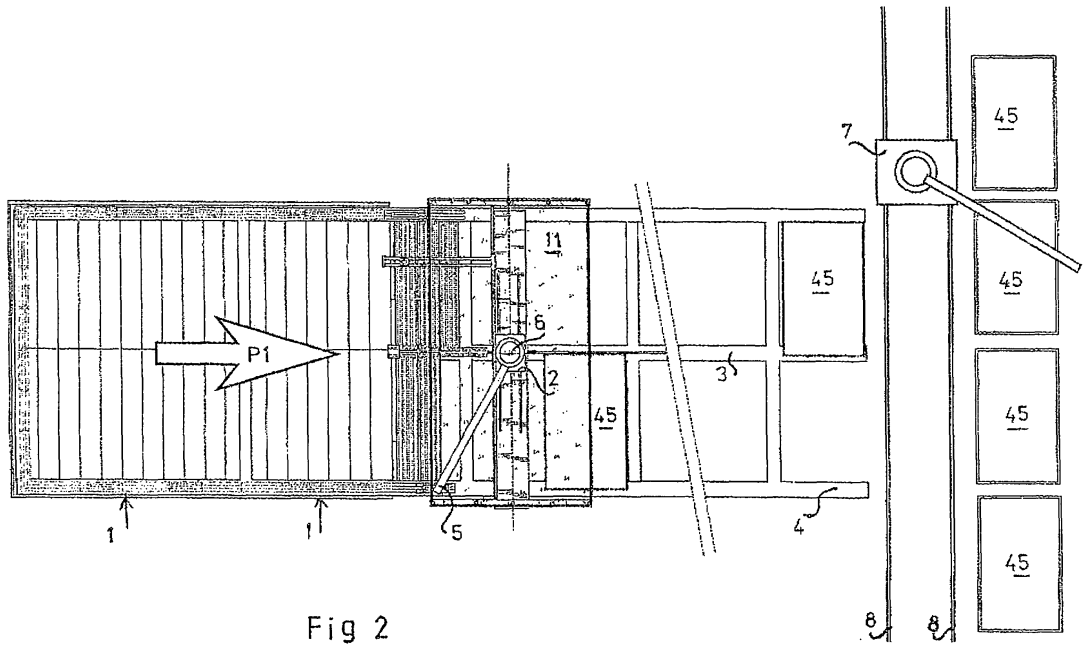

Fig 2

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Description

[0001] The present invention, according to a first aspect thereof, relates to a method for building terrace houses or comparable structures. The term "building" as used herein is understood to comprise at least the building of a hull, but it may also extend to a desired degree of finishing of the structure.

[0002] Terrace houses are traditionally built by successively constructing horizontal layers one on top of the other. That is, first a foundation for a row of houses is poured. Then the floor for the ground level of the row of houses is constructed. Following that, the first-floor level of the houses is constructed, and subsequently the second floor level and possibly the attic. Construction of a next floor level may already be started before construction of the floor level below is complete, but this does not alter the principle of building in layers. The fact that in this way some form of series production can be realised is considered to be an advantage of this method according to the known principle. First, all the floor elements are placed, and subsequently the wall elements, etc. Thus, an efficient use is made of the tools, the equipment and the materials for a series of repetitive operations. A tower crane that can travel along the structure is used for transporting building elements. Due to the major deformations of the telescopic jib and vibrations that occur in such a crane construction during construction it is not possible to realise a high degree of precision in positioning building elements, not even if a rail track for the crane is provided.

[0003] In a known method for putting up walls, for example for houses, an automatic bricklaying or building block stacking machine is used. Such machines are disclosed in, for example, DE 3,722,244, DE 4,412,681 and WO97/02397. A drawback of such machines, however, is the fact that they are heavy and voluminous. Because of this, they cannot be placed on upper level floors. Nor can they be moved through a doorway, and they are very difficult to manoeuvre, especially inside a building. They can for example be lifted and placed in a desired space by means of a crane. Due to the major deformations of the telescopic jib and vibrations in the crane construction, working with a high degree of precision in positioning building elements is not possible with such a crane, either. The relatively high weight of the block stacking machine will cause the upper level floors to sag, making it impossible to position the prefab elements with some degree of precision.

[0004] From WO 2007/076581 and DE 2,108,482 there are known telescopic crane-like structures which are disposed outside the building site and which are capable of putting elements or materials in place in vertical direction from above, but they require major investments. Moreover, dimensionally precise construction is hardly possible with said crane-like structures, if at all, whilst it is furthermore considered to be a drawback that the use of the crane-like structures, which makes it necessary to use very large building elements in order to work efficiently, has a limitative effect on architects' freedom of design.

[0005] Accordingly it is an object of the present invention to provide a method for building terrace houses in an efficient and dimensionally precise manner. This object is accomplished by the present invention by providing a method for building a structure of terrace houses, comprising the steps of:

a) providing a foundation for the structure;
b) placing at least one elongated guide member on a longitudinal axis of the foundation at least substantially along at least substantially the entire length of the foundation and fixing said elongated guide member with a robot crane device which is movable along said guide member to the foundation, which robot crane device is arranged for picking up and transporting building elements to a desired position on the structure;
c) positioning the robot crane device at or near a first end of said at least one elongated guide member;
d) erecting a first part of the structure to at least substantially its entire height by means of the robot crane device;
e) moving and positioning the robot crane device in the direction of the second end of said at least one elongated guide member located opposite the first end of said at least one elongated guide member;
f) subsequently erecting a part of the structure adjoining the already erected part of the structure by means of the robot crane device;
g) repeating steps e) and f) until the construction of the structure is at least substantially complete.

[0006] In the method according to the invention, the longitudinal axis of the foundation may form a physical part of the foundation for the structure to be built. The foundation may also comprise a longitudinal axis which is specifically provided as a foundation for the guide rail needed for building the structure by using the method according to the invention. Since the elongated guide member is fixed to the foundation, it is possible to realise a precise manipulation from the robot crane device to parts of the structure to be built, thus providing a correct reference point for the robot crane device with respect to the structure. It is important in that connection that the elongated guide element be fixed to the foundation in such a manner that it is suitable for absorbing pulling forces exerted thereon when heavy building elements are lifted by means of the robot crane.

[0007] When the surface on which the structure is being built allows so, a concrete beam serving as a support for a guide rail may function as a foundation. Steps a) and b) may in fact coincide.

[0008] The term "robot crane" is understood to mean a crane device provided with control means that can be programmed for controlling the crane device for picking up a building element from a defined location and placing

said building element at a desired position on the structure to be built, and that without human interference.

[0009] An elongated guide member can be fixed to a foundation on a surface in a relatively simple manner and at relatively low cost, for example by integrating said guide member in the foundation when pouring the foundation or by anchoring the guide member to the foundation by means of bolts. The guide member per se does not necessarily require a large investment, either. By programming the robot crane device such that it is capable of transporting the building elements for building part of the structure to a desired location more or less independently, the robot crane device can carry out the operations once again (repetitively) at different positions on said at least one elongated guide member and thus gradually complete the structure. In this way a structure of terrace houses can be built in an efficient manner, thus accomplishing the object of the present invention.

[0010] In the prior art, cranes are known which can move along a structure on rails disposed outside the structure (to be built). This is necessary when using the known construction methods, because a rail disposed within the structure would be covered upon placement of the floor slabs and no longer be available for erecting the next layers (walls, ceilings, second floor level, etc).

[0011] From NL 6514210 A there is known a method in which a construction bridge on wheels can be moved over rails. The rails are to that end arranged crosswise over transversely extending foundation elements. The rails are not fixed to the foundation, however. Static, at least non-movable lifting cranes are disposed on the movable construction bridge. In the method according to NL 6514210 A, only the trusses of a building are placed and possibly propped by means of the construction bridge, but the construction bridge is not used for building successive parts of a structure, in the sense of building defined in the introduction paragraph.

[0012] To be able to conceal said at least one elongated guide member under the floor slabs, it is preferable if space is reserved in the foundation for accommodating said at least one elongated guide member in a low position. This can for example be realised by leaving out cross beams and vertical walls extending transversely to the longitudinal axis of said at least one elongated guide member in the crawl space of the foundation. Said cross beams and vertical walls are in that case only placed on the respective part of the foundation upon erection of the structure by the robot crane device, or they may be left out altogether, in which case the load-bearing capacity of the foundation can be provided by a part of the foundation that extends parallel to the front and rear walls, for example. The robot crane device can thus be supported in a very stable manner, which has an advantageous effect on the precision with which the robot crane can operate.

[0013] Although it is preferable to provide said at least one elongated guide member as a whole in one operation, it is also possible to carry out the provision of said at least one elongated guide member in phases, in which case said guide member is extended in the direction away from the first end as construction progresses. The elongated guide member is preferably a rail over which the robot crane device can be moved, but it may also be configured differently.

[0014] Preferably, said at least one elongated guide member is placed so that it extends at least substantially over the central longitudinal axis of the foundation. The distance from said at least one elongated guide member to the (foundation for the) exterior walls of the structure to be built located on either side of said at least one elongated guide member is preferably the same on both sides, and the distance from said at least one elongated guide member to the furthest point to be reached is minimal. This is important because the moment exerted by the grab load on the robot crane device in the outermost position of the jib thus needs not be unnecessarily large.

[0015] To be able to build the structure up to and including the very last part of the structure to be built, for example the end terrace, it is preferable if said at least one elongated guide member is placed so that it extends beyond the foundation at the second end. The robot crane device can thus be disposed "outside" the structure for manipulating building elements for the last part to be built.

[0016] To provide a stable guidance for the robot crane device, it is preferable if a chassis for said at least one elongated guide member is supported on the fixed world via stabilisation elements extending transversely to said at least one elongated guide member. Alternatively, a chassis for the elongated guide member may be provided with such stabilisation elements. The stabilisation elements may be supported on a surface within the foundation of the structure to be built. Alternatively, the stabilisation elements may be directly or indirectly supported on the foundation of the structure, for example the foundation for the exterior walls thereof. In the latter case, a correct reference point with respect to the structure to be built is again provided for the robot crane device.

[0017] To achieve a correct positioning in the longitudinal direction of said at least one elongated guide member for the robot crane device, it is preferable if in steps c and e said at least one elongated guide member is positioned on the basis of reference points provided on said at least one elongated guide member. The robot crane device can be maintained in transverse direction and in vertical direction by said at least one elongated guide member. The reference points on said at least one elongated guide member thus provide a two-dimensional reference point for the robot crane device. Anchor points may be provided on said at least one elongated guide member. An anchor point may for example comprise a through hole through said at least one elongated guide member, so that the robot crane device can be fixed in position at the reference point by means of a locking pin.

[0018] In a preferred embodiment of the present invention, the robot crane device comprises a slewing jib crane,

by means of which building elements are transported to the desired location during erection of a part of the structure. A slewing jib crane is very suitable for picking up and moving (heavy) building elements to various positions on the structure to be built.

[0019] It is preferable in that case if a jib of the robot crane device is moved in vertical direction so as to reach a desired height. Thus, any desired point on the structure to be built can be reached with a relatively short arm of the manipulator.

[0020] It is preferable to use a manipulation robot for carrying out operations on positioned building elements. This makes it possible to arrange the robot crane device for carrying and moving building elements, whilst the manipulation robot can be of relatively light construction, for example for carrying tools and carrying out operations on building elements that are already in place. The manipulation robot may for example be movable over a guide member fixed to the chassis, which guide member extends transversely to said at least one elongated guide member. If the manipulation robot is of relatively light construction, the chassis for said at least one elongated guide member will not be subjected to overly large forces. Thus, a concrete drill can be moved to a positioned building element, for example, by means of the relatively light manipulation robot for drilling holes therein. The manipulation robot may be programmed dependently or independently of the robot crane device. If the manipulation robot is less high than the robot crane device, it can be passed under the robot crane device upon movement over the guide member.

[0021] A very flexible and versatile device is provided if the manipulation robot is equipped for carrying out operations with exchangeable tools. Said operations preferably comprise the placing of marks on positioned building elements and the drilling of holes therein.

[0022] To realise an efficient supply of building elements to the robot crane device, it is preferable if a further guide member is provided, over which building elements can be transported from an intermediate storage location to a location near the programmable manipulator. The building elements can thus also be presented at a fixed reference point with respect to the robot crane device and possible also the manipulation robot, so that not only the positioning but also the grabbing of the building elements by means of a robot crane device and/or the manipulation robot is simplified. Said further guide member may be used in combination with said at least one elongated guide member for supplying building elements, for example building elements which are moved on pallets over said further guide member (and possibly the first elongated guide member). If further guide members are provided on either side of said at least one elongated guide member, pallets with building elements may be presented alternately from one side and from the other side of the robot crane device. As a result, new stock can be supplied via one further guide member, whilst the robot crane device can continue to operate by manipulating building elements previously supplied via the other further guide member. Alternatively, said at least one elongated guide member for the robot crane device may be used independently for supplying and/or discharging building elements.

[0023] In a preferred method of the present invention, one bay or bay part of the structure is built before the robot crane device is moved to a new position for building a next bay, or a next bay part. It is not relevant in that connection whether the successive bays have the same width or are arranged in a pattern of alternating wide bays (for example for a living room) and narrow bays (for example for a hallway), of two wide bays and two narrow bays, respectively, or another regular or irregular pattern of bays.

[0024] If the robot crane device is equipped with a receiver and a reading device for reading information present on building elements to be manipulated by the robot crane device for the purpose of correctly manipulating the building elements in question on the basis of said information, a possibility is provided to have the robot crane device operate essentially automatically by programming the positions at which the various building elements are to be positioned on the basis of the information provided thereon.

[0025] Preferably, tunnel elements are placed over of said at least one elongated guide member after the erection of least part of the structure. If a comparatively inexpensive elongated guide member is used in the present invention, the cost of dismantling it would probably exceed the cost of the guide member itself. The tunnel elements hide the guide rail from view in an inexpensive and simple manner and can subsequently serve to support a floor element to be placed. Another advantage is that the part of said at least one elongated guide member that is disposed under the tunnel elements remains available, for example for a front jib arm (yet to be described).

[0026] The present invention, according to a second aspect thereof, relates to a device for building terrace houses or comparable structures, and accordingly provides a device for use in the method according to the first aspect of the invention, comprising at least one elongated guide member extending over a longitudinal axis of a foundation for a structure, which elongated guide member is fixed to said foundation and on which a robot crane device comprising a slewing jib crane with a grab and means for moving the slewing jib crane or at least one slewing jib thereof in vertical direction is movably provided. The advantages of such a device correspond to the advantages described above in relation to the method according to the first aspect of the present invention. The same applies to the term "robot crane".

[0027] It is preferable in that connection if one or more stabilisation elements extending transversely to a chassis for said at least one elongated guide member are provided, which can be supported on a surface in a stabilising manner. The stabilisation elements provide a stable and dimensionally precise positioning of said at least

one elongated guide member. The robot crane device can thus be positioned with a high degree of precision with respect to a foundation for building a structure by means of the robot crane device.

[0028] It is furthermore preferable if a second guide extends transversely to said first elongated guide element, along which guide a manipulation robot can be moved. The robot crane device and the manipulation robot can be optimised for their respective tasks in that case. Thus it is possible, for example, to adapt the robot crane device for grabbing and moving relatively heavy building elements, whilst the manipulation robot may for example be arranged for handling relatively light tools, by means of which operations can be carried out on building elements that are already in place.

[0029] To be able to quickly present building elements to the robot crane device at a predetermined position, it is preferable if at least one further guide member is provided, over which, in use, carriers for building elements can be supplied in the direction of the robot crane device. It is even more advantageous if such a further guide member is provided on both sides of said at least one elongated guide member. Alternatively, said at least one elongated guide member may be arranged for supporting and guiding a carrier for building elements. The advantage of this is that the carrier, for example a pallet, will at all times be correctly aligned relative to the robot crane device.

[0030] In a preferred embodiment of the present invention, a slewing jib crane for the robot crane device is movable transversely to the longitudinal axis of said at least one elongated guide member. This can for example be realised by means of a guide on the chassis of the robot crane device.

[0031] A very efficient and relatively labour extensive construction method can be provided if a reading device is provided, by means of which information present on the building elements to be manipulated by the robot crane device is read in use for correctly manipulating the building element in question on the basis of said information.

[0032] The present invention will be explained below by means of a description of a preferred embodiment of the present invention, in which reference is made to the appended figures, in which:

Figures 1a-1f are schematic side views of a structure of terrace houses under construction according to the method of the present invention;
Figure 2 is a top plan view showing the erection of a part of the structure by means of a method according to the present invention;
Figure 3 is a more detailed top plan view of part of the device of figure 2;
Figure 4 is a side view of the device of figures 2 and 3;
Figure 5 is a rear view of the device of figures 3 and 4;
Figure 6 shows the step of positioning a building element in a method according to the present invention;
Figure 7 shows a detail view of a way of concealing a guide rail;
Figures 8a-8e are schematic representations of the supply of building elements; and
Figures 9a and 9b show an alternative embodiment of a device according to the present invention.

[0033] Figures 1a-1f show a schematic side view of the erection in stages of a second house in a structure of terrace houses to be built (houses yet to be built are indicated in dotted lines). The houses 1 (to be) built comprise a wide bay 1a and a narrow bay 1b. The houses are erected by means of a slewing jib crane 2, which is movable over a guide rail.

[0034] Figure 2 shows a top plan view of terrace houses 1 which have been or will be built by means of a slewing jib crane 2 according to the present invention. The slewing jib crane 2 is centrally positioned on a guide rail 3 and is supported at its side on a foundation 4, viz. a foundation for the front and rear walls of the houses to be built. The slewing jib crane 2 comprises a jib 5, which is vertically adjustable and rotatable about a column 6 of the slewing jib crane 2. Arrow P1 indicates the direction in which building takes place. This part of the top plan view is shown in more detail in figure 3. Located at the end of the foundation, where the last houses will be built, is a second crane 7, which is movable on rails 8 extending perpendicularly to the guide rail 3.

[0035] Figure 3 shows in more detail the slewing jib crane 2 which is supported on the foundation 4 for the houses to be built via a frame comprising a chassis 9 and support beams 10. The slewing jib crane 2 is movable over the guide rail 3. A jib 5 is adjustable and rotatable about the column 6. Provided at the end of the jib 5 is a grabbing device 12, which is movable along the longitudinal axis of the jib. Disposed at the construction side of the slewing jib crane 2 are tunnel elements 12, on which ends of floor slabs 14 are supported.

[0036] Figure 4 shows a side view of the slewing jib crane 2, which is supported on the central longitudinal beam with the guide rail 3 via wheels 15 (only one of which is shown in figure 4). In the centre, the slewing jib crane 2 is supported on the guide rail 3 via a guide slide 17. A jib 5 is mounted in a U-shaped guide 20 of the column 6 via twin rollers 18 and a mounting plate 19. The column 6 can pivot in the direction indicated by the arrow R1. Suspended from the jib 5 is a grab (not shown in figure 4). A second column 21 of a manipulation robot embodied as a tool and dimensioning crane 44 is movable in horizontal direction along a guide plate 22. Mounted to the second column 21, via twin rollers 24 and a mounting plate 25, is a second jib 23. A tool holder 26 is suspended from the second jib 23. The tool holder 26 is movable in horizontal and vertical direction as indicated by the arrows P2 and P3, respectively, and can be pivoted about a vertical axis as indicated by the arrow R2. Standards 27 are fixed to the longitudinal beam 10, which

standards are interconnected by means of a girder 28 and over which a tarpaulin 29 is stretched.

[0037] Figure 5 shows in rear view an arrangement according to the present invention with the jib 2 and the tool and dimensioning crane 44. The elongated chassis 9 is supported on the foundation 4 via the guide rail 3 and the guides 30. The jib 5 on the column 6 has been pivoted to the left and the grab 12 is located near the end of the jib 5. Wall elements 31 have been placed in position by means of the grab 12. The tool and dimensioning crane 44 is located to the right of the slewing jib crane 2. A tarpaulin 29 covering the cranes 2 and 44 is stretched over the standards 27 and the girder 28, respectively.

[0038] Figure 6 shows a detail view of the step of positioning a building element 32b on a previously positioned building element 32a by means of the grab 12. The grab 12 is suspended from the jib 5 via a guide plate 33. The jib is vertically movable along the column 6 (not shown in figure 6). The grab 12 is movable in the longitudinal direction of the jib 5 via the guide plate 33a and guides 34 on the jib 5. The grab is movable in the direction transversely to the longitudinal axis of the jib 5 by means of the guide plate 33b and guides 35. The building element 32a is provided with bores 36, into which dowels 37 having a rubbery end 38, which project from the building element 32b, can be positioned. Disposed within the tube 39 is a camera, which is capable of detecting a mark 41 via the through bore 40 in the building element 32b so as to be able to position the building element 32b.

[0039] Figure 7 shows a detail of the finishing of the building. A guide rail 3 is disposed on the foundation 4, over which a front jib arm 42 of the slewing jib crane 2 is movable. By placing tunnel elements 13 on the foundation 4, the guide rail 3 for the front jib arm 42 remains accessible and the front jib arm 42 of the slewing jib crane can continue to move over the guide rail 3 under the tunnel elements. Floor slabs 14 and a concrete prefab element 43 are disposed on the tunnel elements 13.

[0040] Figures 8a-8e schematically show the manner in which building elements 51 loaded on a pallet can be transported from a truck 53 to the slewing jib crane 55 over the guide rail 54, and subsequently be handled by the slewing jib crane 55. Once a pallet 52a is empty, a new pallet 52b is supplied, whilst the first pallet 52a can be returned to the truck 53 over the guide rail 54.

[0041] Figures 9a and 9b schematically show an alternative embodiment of the method and device according to the present invention. As figure 9a shows, a slewing jib crane 61 may also be supported on two guide rails 62. In figure 9a the guide rails 62 are disposed on an upper level floor, and the slewing jib crane 61 can move sideways over a transverse beam 63, as is illustrated in dotted lines in figure 9b (slewing jib crane 61'). The tool and dimensioning crane 64 is likewise movable along the transverse beam 63.

[0042] With reference to figures 1a-1f again, the figures show in schematic side view the steps of realising the erection of terrace houses 1 according to the present invention. In figure 1a, a first house 1 comprising a wide bay 1a and a narrow bay 1b has been built by means of the slewing jib crane 2. The slewing jib crane 2 is then moved away from the completed house 1 in the direction indicated by the arrow P to a position as shown in figure 1b. Then the ground level (figure 1b), the first-floor level (figure 1c) and the second-floor level with the roof (figure 1d) are erected by means of the slewing jib crane 2. Following that, the slewing jib crane 2 is again moved away from the completed part of the structure to a position as shown in figure 1e. The movement that is made in this step is smaller than the movement made in the preceding step, because a narrower bay will now be built. Since the movement of the jib 5 could be impeded by already positioned building elements upon being manoeuvred, it is alternatively possible to move the slewing jib crane 2 the same distance in all cases. When a narrow bay is being built, the slewing jib crane 2 will in that case be removed further from said narrow bay than it would be from a wide bay during erection of said wide bay.

[0043] Figures 1e and 1f show the subsequent steps of erecting the first-floor and the second-floor level, respectively, of a narrow bay. The steps shown and described above are successively repeated until the structure is complete.

[0044] Figure 2 shows a top plan view of a structure under construction as shown in figures 1a-1f, in which use is made of a slewing jib crane 2 according to the present invention. The slewing jib crane 2 is centrally positioned on the guide rail 3 and is supported at its sides on the foundation for the front and rear walls, respectively, of the houses to be built. At its base, the pillar of the slewing jib crane 2 is mounted on a turntable bearing and steel sliding plate 46, which can move in longitudinal direction over the chassis 9. The slewing jib crane 2 comprises a jib 5, which is rotatable about the column 6 of the slewing jib crane 2 and which is vertically adjustable along said column 6. The arrow P1 indicates the direction in which building takes place and in which the slewing jib crane 2 is moved as construction progresses for erecting successive bays. At the end of the foundation 4, where the last houses will be built, the foundation 4 and the guide rail 3 extend beyond the last house to be built, as the figure shows. The fact is that when the last vertical part of the structure is being built, the slewing jib crane 2 will have to be located outside the contours of the structure so as not to be built in. Furthermore, the figure shows rails 8, along which a second crane 7 can move. The second crane 7 can be used for placing pallets 45 loaded with building elements from a truck (not shown), for example, onto the guide rail 3 for supplying said pallets to the slewing jib crane 2. The pallets 45 can be kept in balance by telescopic support beams, for example, whose distal ends are supported on the foundation 4 for the front and rear walls.

[0045] Figure 3 shows in more detail the slewing jib crane 2 with a frame of the elongated chassis 9 and support beams 10 and a tool and marking robot 21. Via the

chassis, the slewing jib crane 2 is supported with its ends on the foundation 4 for the houses to be built. At the base of the pillar, the slewing jib crane 2 is supported on a sliding plate 46 via a turntable bearing, which sliding plate can slide over guides 47 in a direction transversely to the longitudinal direction of the guide rail 3. The jib 5 is rotatable about the column of the slewing jib crane 2 and is vertically adjustable along said column 6. Located at the free end of the jib 5 is a grab 12 provided with a so-called data vision system, which grab is movable along the longitudinal axis of the jib 5 and which is provided with fine control means, so that the grab 12 can be placed exactly over a marking point. At the construction side of the slewing jib crane 2, tunnel elements 13 are placed over the guide rail 3, which tunnel elements obviate the necessity to move the slewing jib crane 2 and which function to support the floor slabs 14. The slewing jib crane 2 further comprises a front jib arm 42 functioning as an anti-tipping beam. Said front jib arm 42 obviates the necessity to move the slewing jib crane 2 during erection of a bay, so that its construction side can remain as close as possible to the part to be built. It is assumed in this connection that the guide member is not arranged for absorbing large pulling forces and can be loaded in particular by pressure forces.

[0046] Figure 4 is a side view of the slewing jib crane 2, which is supported by means of wheels 15 on the central longitudinal beam of the foundation 4 on which the guide rail 3 is disposed. The jib 5 of the slewing jib crane 2 is mounted in a U-shaped guide 20 of the column 6 via twin rollers 18 and a mounting plate 19. The support arm 5 may also be rotatably mounted on top of the column 6, in which case the column 6 is telescopic so as to be able to move the jib 5 in vertical direction. In the illustrated embodiment, the column can pivot in the direction indicated by the arrow R1 and back again. A grab (not shown in figure 4) is suspended from the jib 5. A second column 21 of a tool and marking robot 44 is horizontally movable along a guide plate 22. A jib 23 is mounted to the column 21 of the tool and marking robot 44 via twin rollers 18 and a mounting plate 25. Said jib 23 is provided with a grab 26, which is arranged for being fitted with various tools and which can place marking points on the underlying substructure or concrete elements by means of a so-called laser pointer. The tool holder 26 is movable in horizontal and vertical direction as indicated by the arrows P2 and P3, respectively, and can be pivoted about a vertical axis of rotation as indicated by the arrow R2. Standards 27 are fixed to the support beam 10 at the ends of the frame, which standards are interconnected by means of the girder 28 and over which a tarpaulin 29 is stretched. Thus it is possible with the device shown in figure 4 to transport a heavy load, such as a wall element, for example, to the correct position and position said load on a part of the already existing structure, using fine control means. Subsequently, operations can be carried out on the building element in question by means of the tool and marking robot 44. One of said operations is the placing of a mark, which can be used for the fine control by means of the data vision system upon positioning a next building element. The tarpaulin 29 protects an important part of the slewing jib crane 2 and the tool and marking crane 44 against undesirable weather influences and dust that is blown up.

[0047] Figure 5 shows a rear view of the device discussed herein. To avoid repetition, only those elements which are relevant for a better understanding of the present invention will be discussed. Thus, figure 5 for example shows that the tarpaulin 29 extends over the entire width of the foundation 4. Furthermore it can be inferred from figure 5 that the jib 5 of the slewing jib crane 2 is capable of positioning wall elements 31 over a foundation 4. The slewing jib crane 2 on the one hand and the tool and marking robot 44 on the other hand can move independently of each other in the transverse direction of the device. The figure shows the guide plate 22 for the column 6 of the slewing jib crane, which guide plate is positioned on guide rails 47.

[0048] Figure 6 shows a detail view of the step of positioning a building element 32 on a previously moved building element 31 (see figure 5) by means of the grab 12. Dotted lines indicate an area in the building element 31 in which a plastic insert is located, in which bores 36 and a mark 41 have been made by means of the tool and marking robot 44. Guide rails 47 having tapered rubber ends 38 can be placed in the bores 36. The rubbery ends 38 will act to make any vibrations in the element to be positioned fade away upon making contact with the previously positioned element 31. This construction is also suitable for other embodiments, such as the provisions of rubber damping elements directly on the building element to be positioned. To realise a correct positioning, a through bore 40 (indicated in dotted lines) is provided, through which the mark 41 can be detected from the grab 12. The building element 32 can thus be precisely positioned on the building element 31 by using the fine control means, which are provided on the jib 5 of the slewing jib crane 2 via guides 34, 35.

[0049] Figure 7 shows in detail how the device according to the present invention can cooperate with a foundation 4, so that the slewing jib crane (not shown in figure 7) can move with respect to already positioned floor slabs 14. Disposed on the foundation, viz. on the central longitudinal beam 4, is a guide rail 3, over which a guide 8 can be moved. The guide 48 is located under the front jib arm 42 of the slewing jib crane, which is provided to function as an anti-tipping beam. Said front jib arm 42 prevents the slewing jib crane 2 from tipping forward when a heavy building element is suspended from the jib 5 of the slewing jib crane. To ensure that the slewing jib crane 2 can still be moved sufficiently far in the direction of the structure to be built, tunnel elements 13 are placed over the guide rail 3, which elements provide sufficient space to allow the front jib arm 42 to move under the tunnel. The tunnel elements 13 in turn function as support points for the floor jabs 14 and any other concrete

prefab elements, such as the elements 43.

[0050] Figures 8a-8e schematically show the manner in which building elements 51 a loaded on a pallet 52a can be transported to the building site by means of a truck 53 and be further handled at said site. The truck 53 drives to a position near the guide rail 54, and the building elements 51a are placed from the truck 53 onto the guide rail 54. It has already been described with reference to figure 2 that this may be realised by means of a second crane 7, which can be moved over the rails 8. Once the pallet 52a with the building elements 51a has been transported to a position near the slewing jib crane 55, the building elements 51 a can be positioned on the structure to be built, as is schematically shown in figure 8c. When all the building elements 51 a have been picked up from the pallet 52a, a next pallet 52b is transported to the slewing jib crane 55 in a comparable manner over the guide rail 54. The slewing jib crane 55 lifts the pallet 52a, so that the pallet 52b with new building elements 51b can be moved to a position near the slewing jib crane 55. The slewing jib crane 55 subsequently places the empty pallet 52a back on the guide rail 54 (see figure 8e) for discharge, and the picking up of building elements 51b can be started in a manner as already described in the foregoing.

[0051] Figures 9a and 9b schematically show an alternative embodiment of the device according to the present invention. To avoid repetition, only the most characteristic elements will be discussed. It is clearly shown in figures 9a and 9b that two guide rails 62 are provided instead of one guide rail in the preceding embodiments. A dual-track guide rail system moreover has the advantage that this part can be produced as a prefab element with a high degree of dimensional precision at the works. Said prefab element, for example having the size of one or two houses, has concrete longitudinal beams with guide rails and three or more connecting beams. Said prefab elements can be directly positioned in succession in the structure. When construction is started, the foundation may thus only consist of interconnected dual-track prefab elements. The robot crane device may be programmed so that the rest of the foundation, i.e. the longitudinal beams of the outside walls, can be produced or positioned from there by means of the robot crane device. In case the longitudinal beams are produced, the load-bearing elements etc. are for example positioned in the structure and the dimensions are plotted by means of the tool and marking robot. Moreover, the guide rails 62 are not placed directly on a foundation, but they are situated on an upper level floor 65 of a building that was previously erected, for example by means of a crane device that was moved over a rail on the foundation. Furthermore a method according to the present invention is used again. By placing the guide rails 62 on an upper level floor, it is possible to build relatively high without an unnecessarily heavy slewing jib crane being needed. Inaccuracies will become exponentially greater as the crane height increases. Figure 9b, which is a top plan view of the device of figure 9a, shows that the column of the slewing jib crane 61 can move over the transverse beam 63 to outermost positions, one of which is indicated in dotted lines at 61'. The second crane 64, also referred to as the tool and marking robot 64, is located at the opposite end of the transverse beam 63. The operating range of the tool and marking robot 64 is schematically indicated.

[0052] Although the present description relates to the construction of so-called terrace houses, it is also possible to use the present invention in building structures of a different type, where construction is to take place along a relatively long axis, as is for example the case in relatively low apartment blocks.

[0053] In the present document a method has been described in which a structure, for example of terrace houses, is built from one end to the opposite end. It is also possible, of course, to work in two directions from the centre towards the two end terraces. Furthermore it is not relevant to the scope of protection whether or not the structure forms a continuous whole. It is also possible, for example, to build partially detached or even entirely detached houses by means of the method according to the present invention. It is desirable in that case if the buildings in question are substantially in line with each other, and the effect of the present invention becomes more distinct as the character of the construction work becomes more repetitive.

[0054] In the figures and the description, only exemplary embodiments of a device and a method according to the present invention have been shown and described. However, these examples by no means have a limitative effect on the scope of protection of the present invention, which is defined in the appended claims. Thus, an elongated guide member may also be provided laterally of the longitudinal axis of the foundation.

Claims

1. A method for building a structure of terrace houses, comprising the steps of:

   a) providing a foundation for the structure;
   b) placing at least one elongated guide member on a longitudinal axis of the foundation at least substantially along at least substantially the entire length of the foundation and fixing said elongated guide member with a robot crane device which is movable along said guide member to the foundation, which robot crane device is arranged for picking up and transporting building elements to a desired position on the structure;
   c) positioning the robot crane device at or near a first end of said at least one elongated guide member;
   d) erecting a first part of the structure to at least substantially its entire height by means of the robot crane device;
   e) moving and positioning the robot crane device

in the direction of the second end of said at least one elongated guide member located opposite the first end of said at least one elongated guide member;
f) subsequently erecting a part of the structure adjoining the already erected part of the structure by means of the robot crane device;
g) repeating steps e) and f) until the construction of the structure is at least substantially complete.

2. A method according to claim 1, **characterised in that** said at least one elongated guide member is placed so that it extends at least substantially over the central longitudinal axis of the foundation.

3. A method according to claim 1 or 2, **characterised in that** said at least one elongated guide member is placed so that it extends beyond the foundation at the second end.

4. A method according to one or more of the preceding claims, **characterised in that** a chassis for said at least one elongated guide member is supported on the fixed world via stabilisation elements extending transversely to said at least one elongated guide member.

5. A method according to one or more of the preceding claims, **characterised in that** in steps c and e said at least one elongated guide member is positioned on the basis of reference points provided on said at least one elongated guide member.

6. A method according to one or more of the preceding claims, **characterised in that** the robot crane device comprises a slewing jib crane, by means of which building elements are transported to the desired location during erection of a part of the structure.

7. A method according to one or more of the preceding claims, **characterised in that** a manipulation robot is used for carrying out operations on positioned building elements.

8. A method according to one or more of the preceding claims, **characterised in that** a further guide member is provided, over which building elements can be transported from an intermediate storage location to a location near the programmable manipulator.

9. A method according to one or more of the preceding claims, **characterised in that** one bay or bay part of the structure is built before the robot crane device is moved to a new position for building a next bay, or a next bay part.

10. A method according to one or more of the preceding claims, **characterised in that** the robot crane device is equipped with a reading device by means of which information present on the building elements to be manipulated by the robot crane device is read for the purpose of correctly manipulating the building elements in question on the basis of said information.

11. A device for use in the method according to one or more of the preceding claims, comprising at least one elongated guide member extending over a longitudinal axis of a foundation for a structure, which elongated guide member is fixed to said foundation and on which a robot crane device comprising a slewing jib crane with a grab and means for moving the slewing jib crane or at least one slewing jib thereof in vertical direction is movably provided.

12. A device according to claim 11, **characterised in that** one or more stabilisation elements extending transversely to a chassis for said at least one elongated guide member are provided, which can be supported on a surface in a stabilising manner.

13. A device according to claim 11 or 12, **characterised in that** a second guide extends transversely to said first elongated guide element, along which guide a manipulation robot can be moved.

14. A device according to one or more of claims 11-13, **characterised in that** at least one further guide member is provided, over which, in use, carriers for building elements can be supplied in the direction of the robot crane device.

15. A device according to one or more of claims 11-14, **characterised in that** a slewing jib crane for the robot crane device is movable transversely to the longitudinal axis of said at least one elongated guide member.

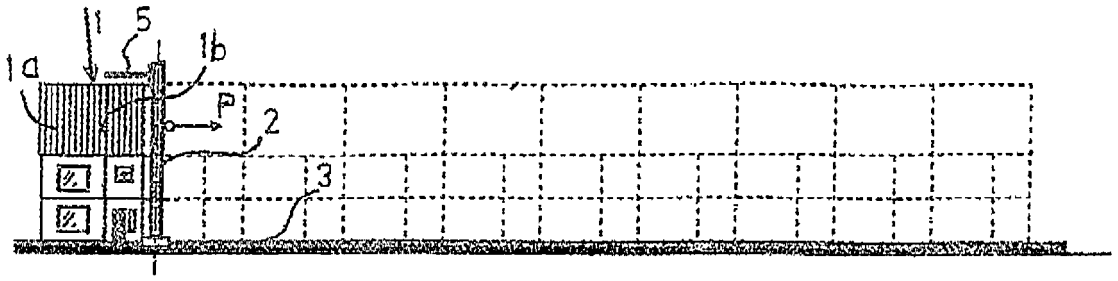


Fig 1a

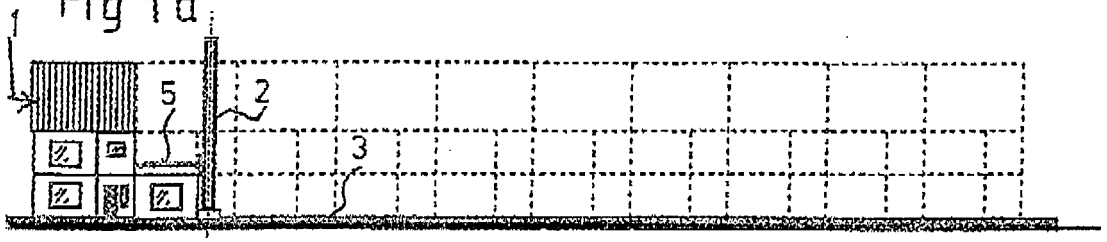


Fig 1b

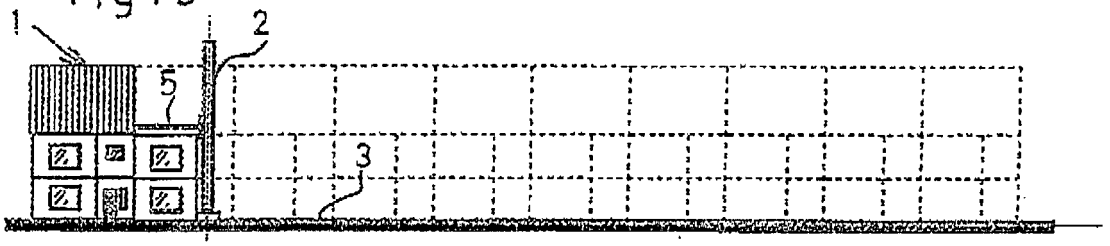


Fig 1c

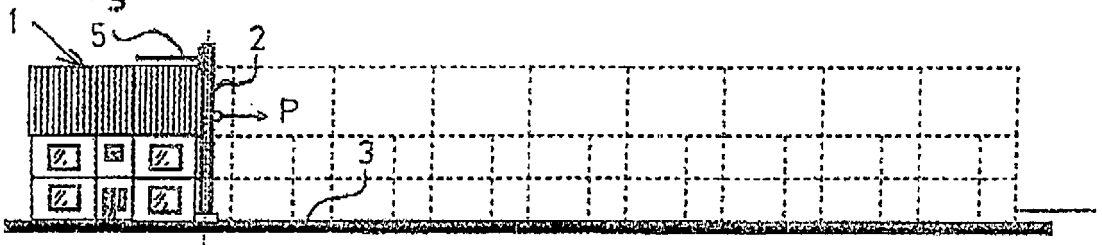


Fig 1d

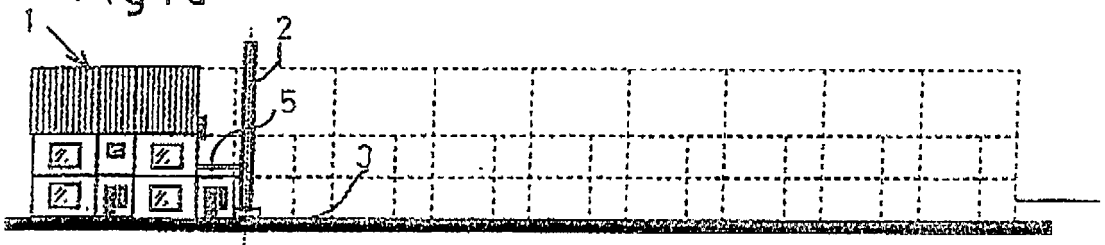


Fig 1e

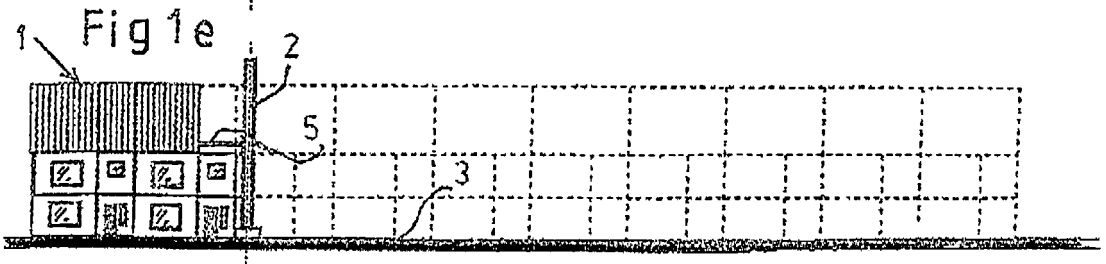


Fig 1f

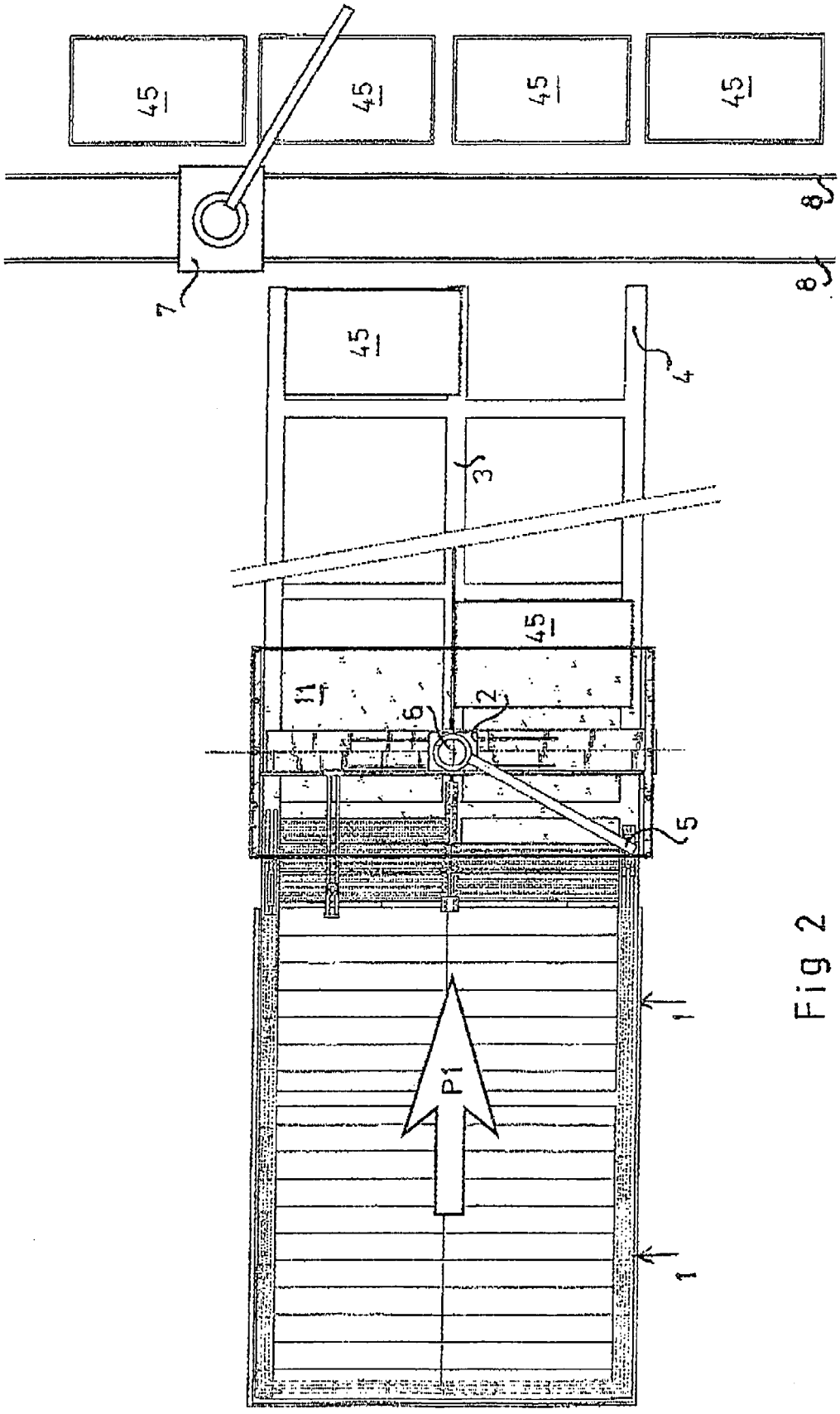


Fig 2

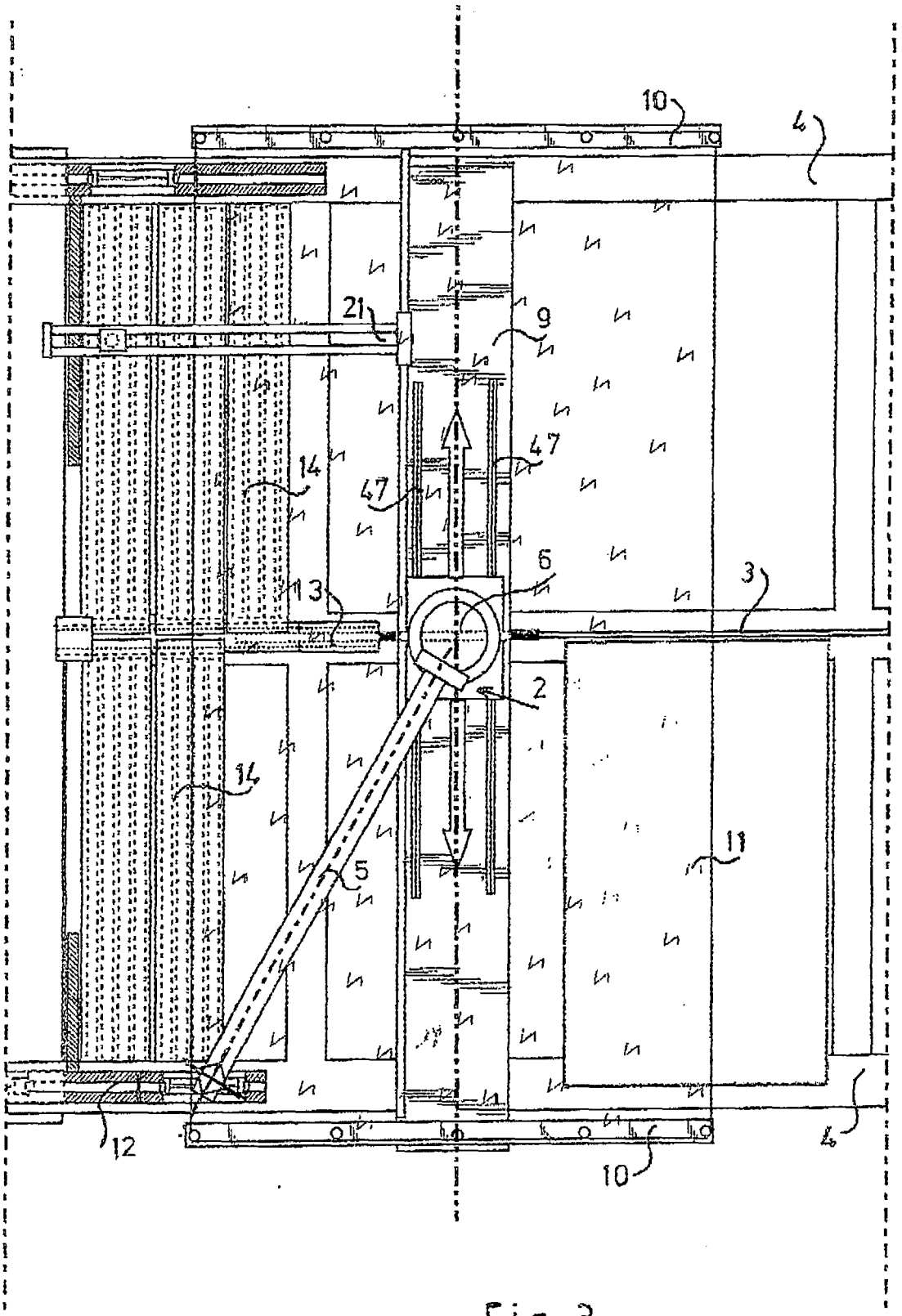
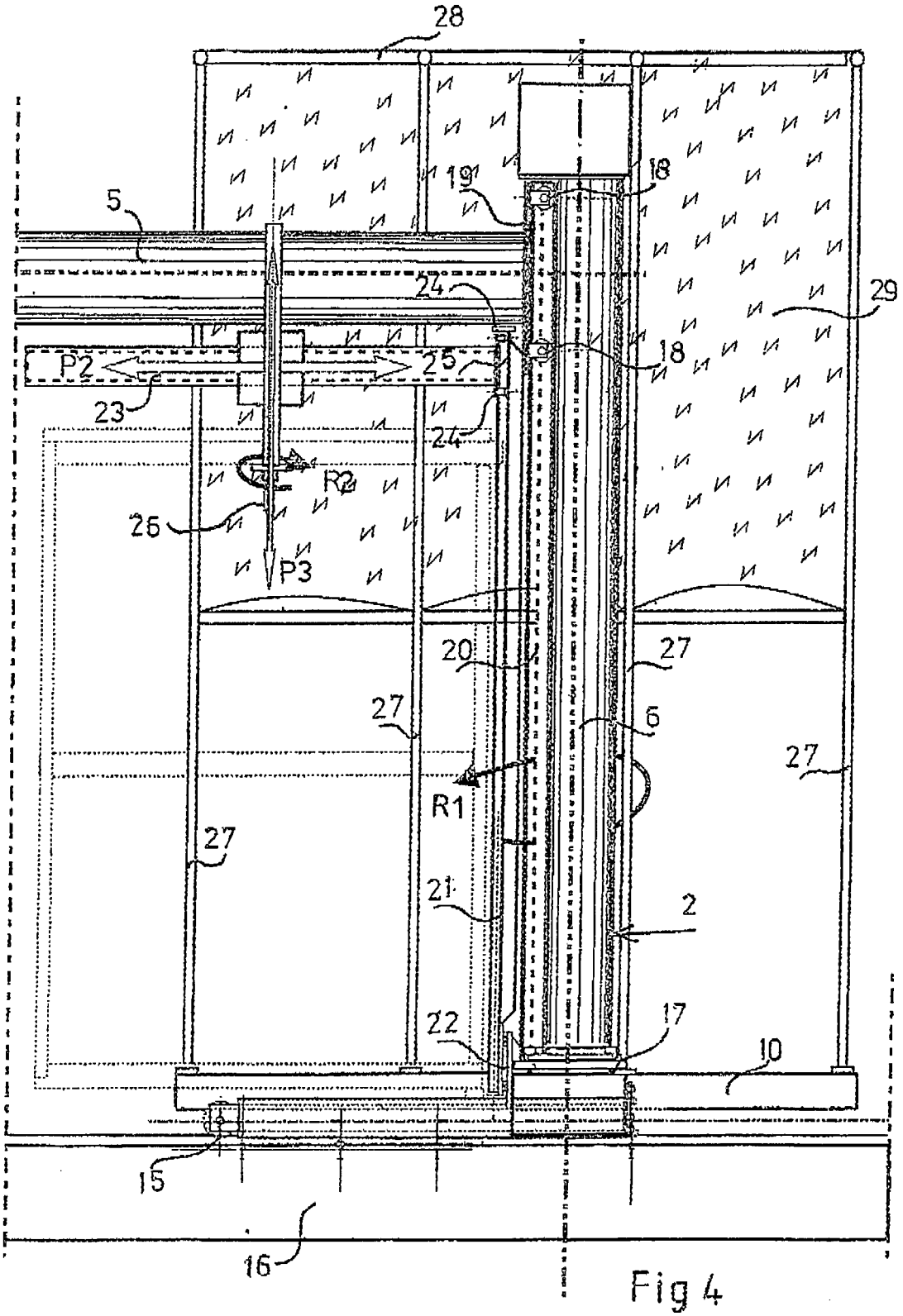


Fig 3


28
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P2
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23
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R2
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P3
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R1
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Fig 4

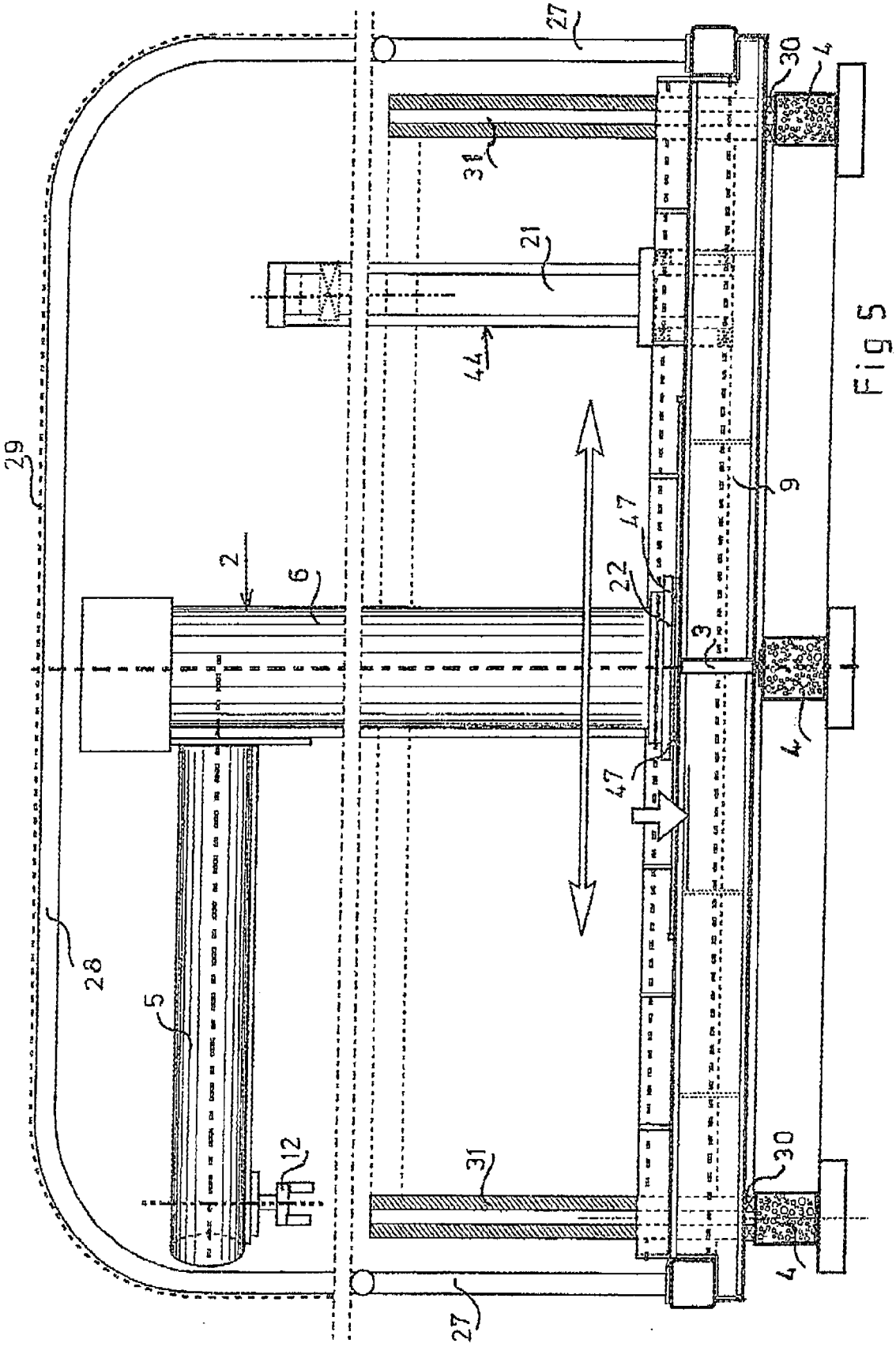

Fig 5

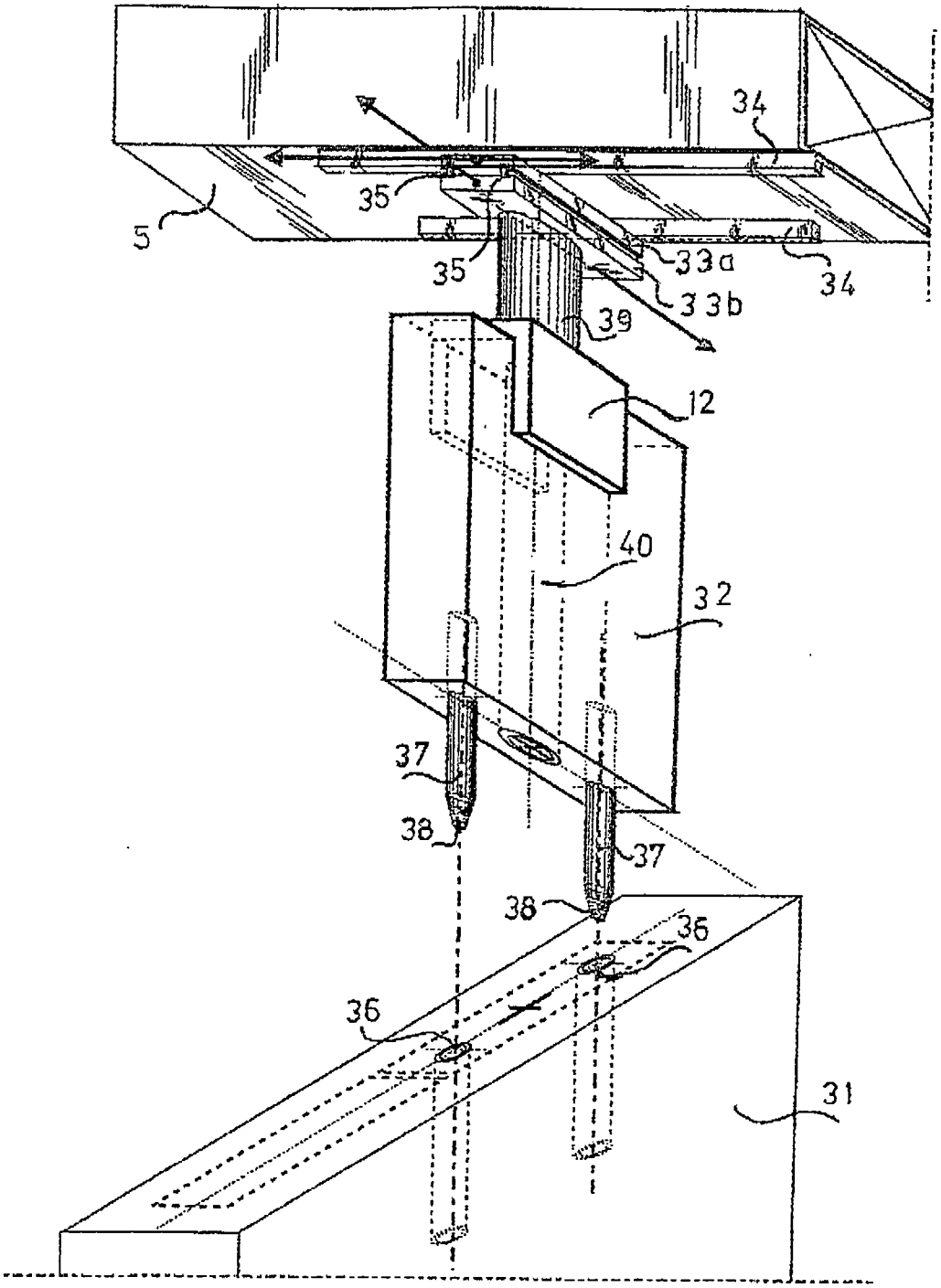

Fig 6

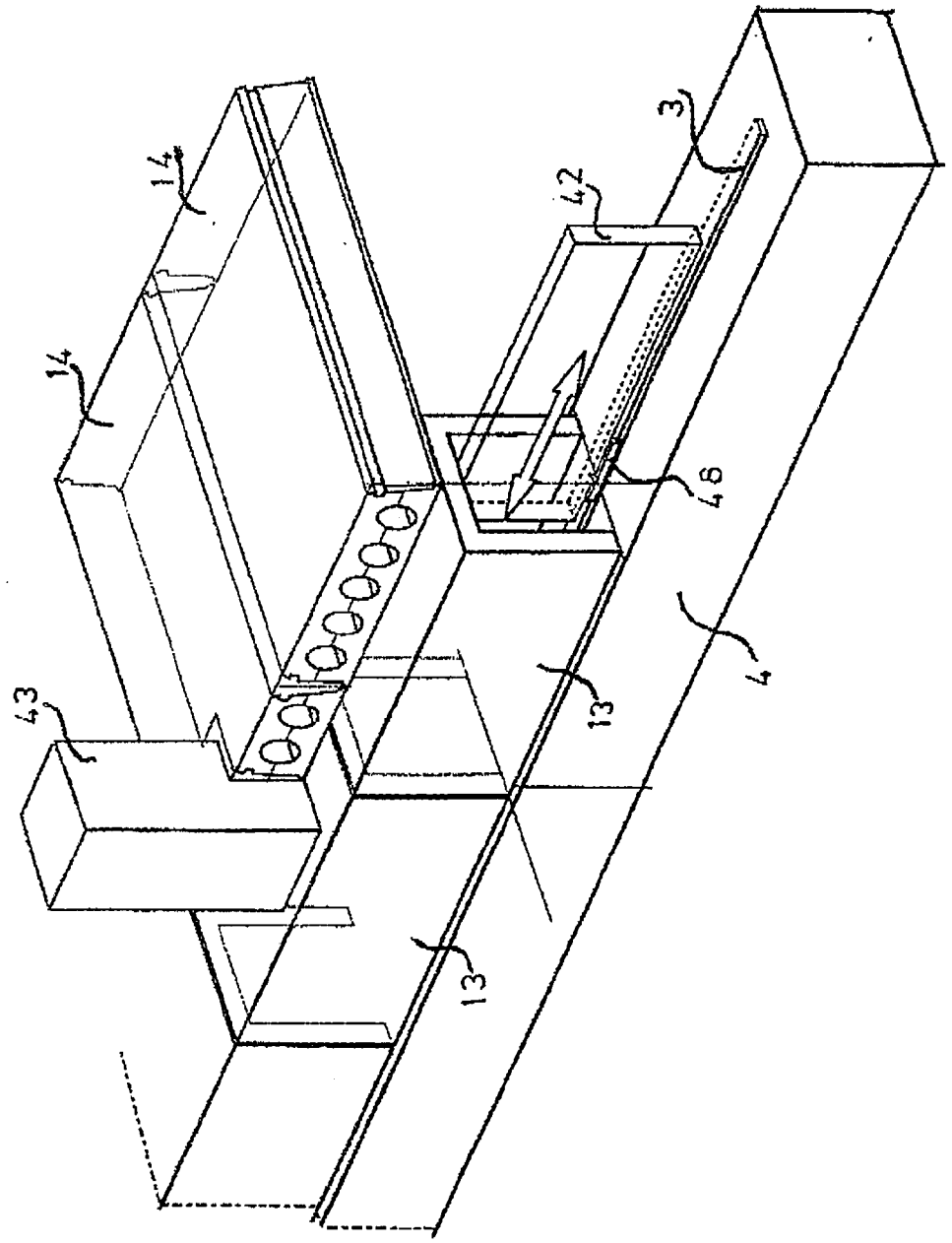

Fig 7

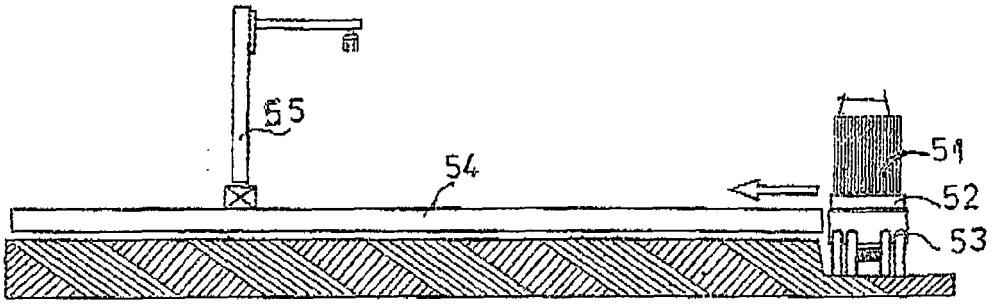

Fig 8a

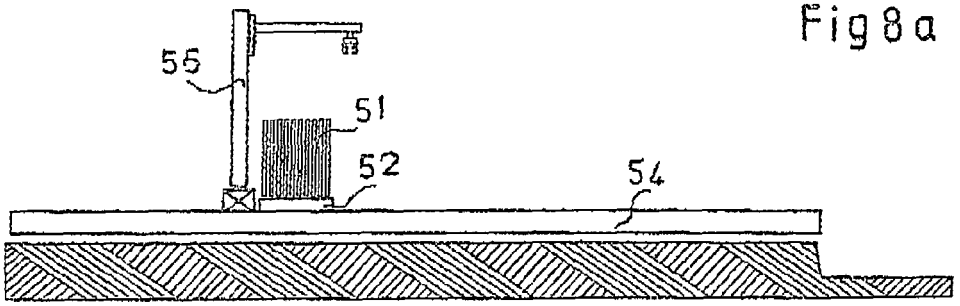

Fig 8b

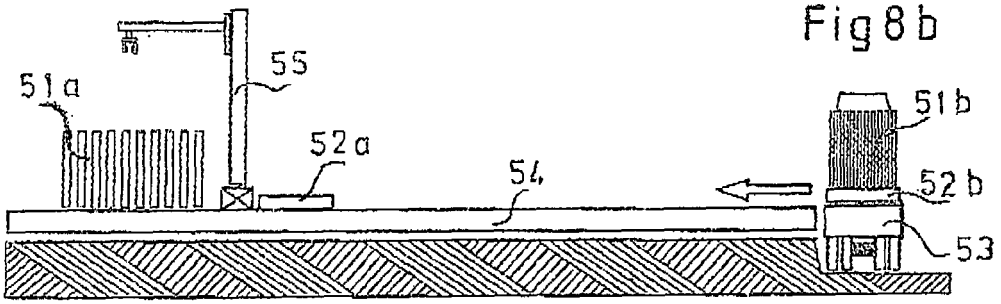

Fig 8c

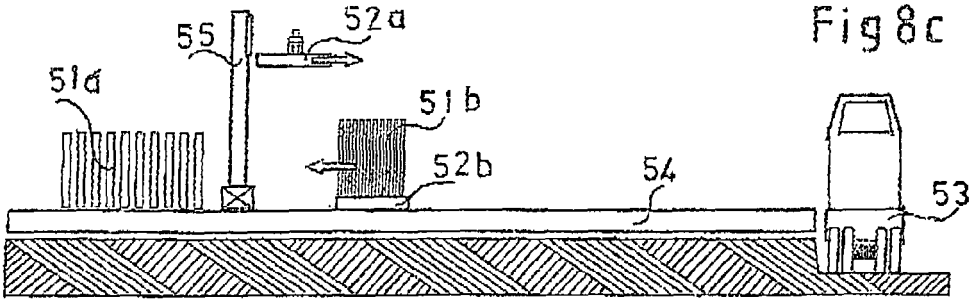

Fig 8d

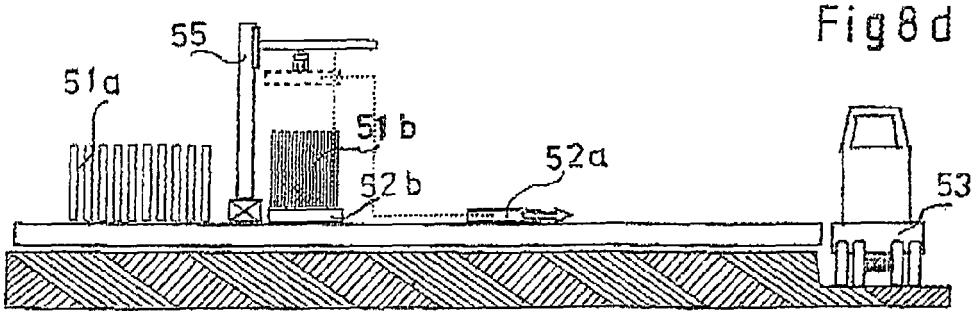

Fig 8e

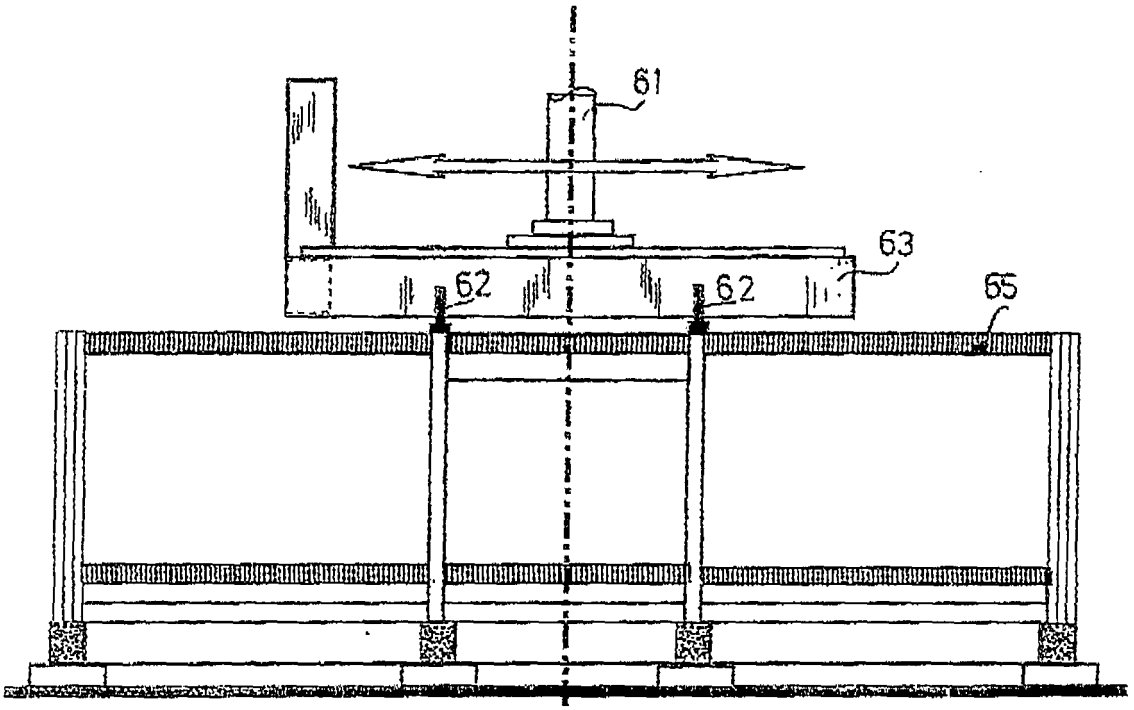

Fig 9a

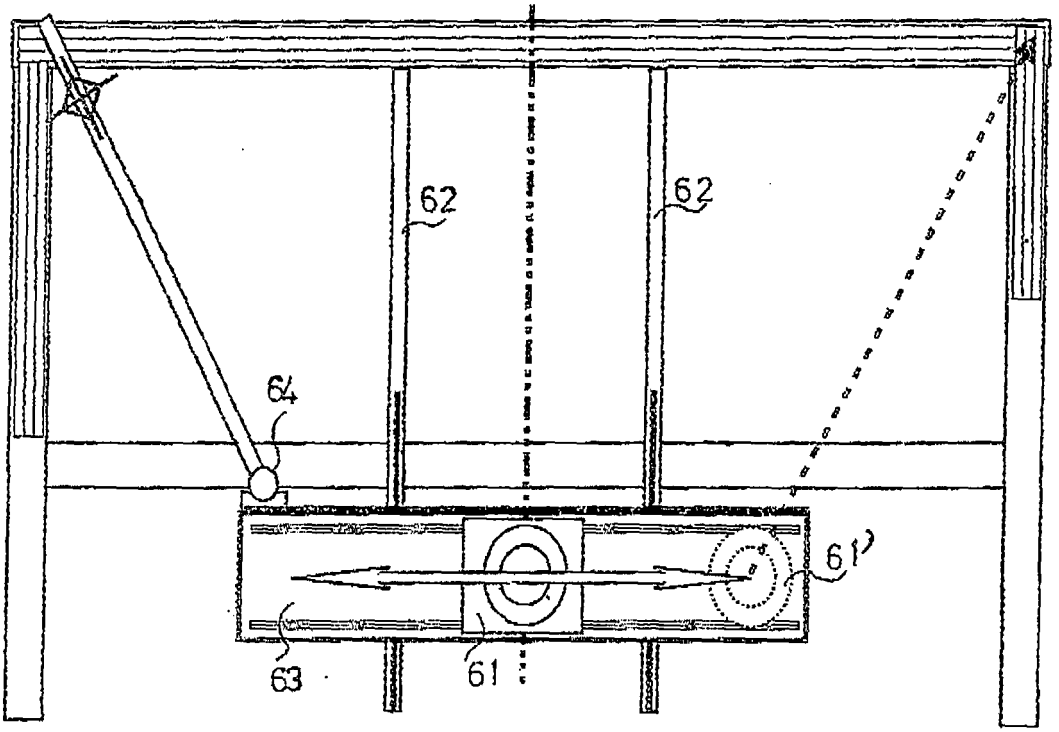

Fig 9b

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EUROPEAN SEARCH REPORT

Application Number
EP 09 00 5681

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	NL 6 514 210 A (PIETER GRIFFIOEN) 5 May 1967 (1967-05-05) * page 2, line 30 - page 3, line 15 * * page 4, line 31 - line 28 * * page 9, line 5 - line 16; figures 1-3,16 * -----	1-15	INV. E04B1/35 E04G21/16
A	DE 84 20 152 U1 (BEENKEN, HANS HEINRICH, DIPL.-ING., 2942 JEVER, DE) 16 May 1991 (1991-05-16) * page 4, paragraph 2 * * page 5, paragraph 3 * * page 6, paragraphs 2,5 * * page 7, paragraph 2; figures 1,2,4 * -----	1-15	
A	WO 2007/102773 A (SKANSKA SVERIGE AB [SE]; SIMFORS ANDREAS [SE]; LAGERQVIST OVE [SE]; JO) 13 September 2007 (2007-09-13) * the whole document * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

E04B
E04G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	4 August 2009	Zuurveld, Gerben

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 00 5681

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04-08-2009

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

REFERENCES CITED IN THE DESCRIPTION

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