METHOD AND APPARATUS FOR RAISING A STEEL FRAME

Fig.2

A method of erecting the steel frame of a building, the frame comprising horizontal beams (17) and vertical pillars (4, 14), in which method the parts of the frame (1, 14, 17) are taken into place by means of at least one lifting apparatus, at least one of the pillars (14) of the frame is taken into place by means of a rigid boom system (2) by moving with a grabber (3) attached to the boom system (2) and rotated into correct installation position by rotating the gripping means (3) of the grabber about at least two axes of rotation. The lifting apparatus can preferably be based on a forest harvester and it can transport with it the supplies needed for manufacturing and assembling the frame.
Method and apparatus for raising a steel frame

The present invention relates to a method for erecting a steel frame of a building the frame comprising at least horizontal beams and vertical pillars.

The present invention also relates to an apparatus for performing the method.

The steel frame of buildings is a construction mainly consisting of vertical support pillars and horizontal load-bearing beams. Additionally, trellis structures having various kinds of diagonal braces, triangular structures and the like, are used. The trellis structures are often prefabricated into installation modules in the workshop. The dimensioning and structure of the frame are planned individually for each case. The frame can, for example, be a part of the load-bearing frame structure of the building and act as connector structure with, for example, concrete structures. The frame can also act as a stand-alone load-bearing structure. The advantages of a steel frame are, among others, quick assembly, precisely dimensioned parts due to which they can easily be attached to each other and a good load-bearing capacity in relation to the dimensions and weight of the frame. The flexibility of designing a steel frame is exemplified in thin and low structures and the easiness of connections. A steel frame makes it possible to achieve a good dimensional precision for e.g. parts related to the façade.

At a construction site, the steel frames are transported and handled with the same lifting and transport apparatuses as the other component parts, i.e. either fixed cranes or movable vehicle cranes. Both of these lift the load with a hook or other carrying means suspended by wires and the load hangs freely from the ends of the wires. During such lifting the load can freely swing sideways and the pillars or beams must be guided precisely onto their places by hand. Thus, installing the parts requires in addition to the crane driver at least one installer for guiding the beam or pillar and for performing the necessary fastening. The most common ways of fastening structures are welding and various bolt connections. The frame is assembled one floor at a time and the crane is used for moving the pillars and beams into their correct places. Screw fastenings can be
lightly installed in their places and the welded connections can also preinstalled for final fastening welding and the bolts are tightened and the final welding is made in their time after the parts are lifted in place. However, regardless of the phase in which the final fastening is performed, the installation work of the frame requires a lot of labour because the pillars and frames must be guided into their places by hand. The precision of a free-hanging wire-operated crane is not sufficient for placing the parts without manual labour.

The aim of the invention is to provide a novel type of method and apparatus for erecting a steel frame of a building, preferably for erecting a steel frame comprising vertical pillars and horizontal beams.

The invention can, for some parts thereof, also be applied for assembling prefabricated trellis structures.

The invention is based on handling the parts of the frame with a grabber arranged to be suspended by a rigid boom system, the grabber having at least two degrees of freedom in relation to the end of the boom.

According to one embodiment of the invention the grabber can turn at least about a vertical axis and rotate about a horizontal axis.

According to one preferred embodiment the grabber is a work head of a forest harvester provided with grabbing means.

According to one embodiment the boom system is the boom system of a digger or a forest harvester.

According to one important embodiment in the apparatus is arranged a positioning point by means of which the position of the grabber and the part attached thereto can be calculated by means of a positioning system.
Further, according to one embodiment of the invention at least one of the following actuators is attached to the grabber: a welding head, a positioning system, an ultrasound checking apparatus and a camera.

Further, according to one preferable embodiment the apparatus is provided with autopilot by means of which the parts can be automatically transported in place, e.g. sequenced by means of remote control.

The invention is defined in more detail in the claims.

Considerable advantages are achieved by means of embodiments of the invention.

By means of the invention assembly of the frame is faster and less labour-intensive than with previous installation methods. The location of each pillar, beam or prefabricated part can be entered into the control system of the apparatus from the construction drawings, whereby the parts are automatically correctly placed. The system can include a log file by means which of it is possible to monitor correct installation sequence and installation of parts in correct positions. If the grabber is provided with, for example, automatic welding, the erection of the frame can be accomplished very fast and efficiently. Further, automatic control of seams makes it possible to create a quality file for the product having exact information about the frame structure for construction monitoring and for the whole service life of the building. Thus it is easy to prove that the frame has been erected according to the construction plan and regulations. A slightly modified forest harvester can be used as transport apparatus, with cutting and branching means removed and provided with a suitable grabber for taking a hold of pillars and beams and with other accessories falling within the scope of the invention.

The invention can also be applied in connection of a conventional trellis-framed beam crane if a vertical beam is attached to the slide of the cross-beam and the vertical beam is provided either directly or via an articulated beam with a grabber having at least two degrees of freedom. Thus it is easy to achieve a relatively wide work area.
It is also possible to apply the invention so that it is only used for installing pillars or beams. Especially when the grabber is based on a forest harvester it can transport the necessary pillars and beams, because many forest harvesters readily have a load compartment.

In the following, the invention is examined by means of examples and by reference to the appended drawings.

Figure 1 illustrates one apparatus according to the invention.

Figure 2 illustrates another apparatus according to the invention.

The apparatus illustrated in figure 1 comprises a conventional known tractor 1 and a transfer beam system 2 attached thereto. The end of the beam system 2 is provided with a grabber 3 for gripping the pillars 4. In this example the boom system 2 comprises a first boom part 3 attached to the tractor 1, the first boom part connecting the boom system 2 to the tractor preferably by means of an pivot joint, around the axis of which the first boom part 5 and the whole boom system 2 attached thereto can be rotated around the vertical axis of the pivot joint. The drive of the pivot can be a pair of hydraulic cylinders, a hydraulic engine or other suitable actuator. The second part 7 of the boom system 2 is an extension boom with variable length. The angle of the second boom part in relation to horizontal level can be vertically changed by means of hydraulic cylinder 6. A third boom part 8 is located at the end of the second boom part, fastened to the end of the second boom part 7 by means of a articulated joint 10. The third boom part 8 can be rotated about the articulated joint 9 by means of a hydraulic cylinder 10. The end of the third boom part 8 is provided with a grabber 3 fastened by means of a articulated joint 11, the grabber being rotatable about the articulated joint 11 in the direction of the longitudinal axis of the third boom part 8 by means of a hydraulic cylinder 12. The grabber 3 also comprises actuators for rotating the gripping means of the grabber 3 about the horizontal axis.
The boom arrangements described above are well known in, for example, diggers and forest harvesters, and one skilled in the art can with these known apparatuses realize for certain conditions a boom system having sufficient reach and lifting capacity. The boom system 2 is to transfer the grabber 3 in a three-dimensional environment to a certain point and this function can be carried out by means of many kinds of boom systems. The grabber is to, naturally, first to try and grip the pillar 4 (in the figure) or a beam. On the other hand it is to position the end of the pillar at exactly the correct place by means of rotation movements about the horizontal and vertical plane of the grabber. The grabber also makes sure that the position of the pillar or the beam is correct. In the example of figure 1 the pillars 3 are positioned horizontally and the beams are positioned vertically. Construction regulations for steel structures include tolerances for, e.g. the largest permissible inclination of the pillars. In order to control this it is preferable to provide the grabber with sensors by means of which the inclination can be controlled and the pillars can be installed vertically.

The main difference of the apparatus of figure 2 to that of figure 1 is that therein pillars 3 are transported in a load compartment arranged in the erection apparatus, whereby they can easily be gripped. The machine can also transport other parts necessary for the installation and it can be built so that it can climb from one level of the building to another level. The climbing can be carried out by driving along ramps or by means of, for example, hydraulic lift feet.

With the above-described apparatuses a steel frame is erected as follows.

The grabber 3 of the erection apparatus picks the pillar 4 by gripping it near the lower end thereof, i.e. the end located lower when installed in the frame. The pillar is turned to a vertical position by movements of the boom system 2 and the grabber 3 and it is moved to its installation point, in this case to the upper end of the already erected pillar 14. The new pillar 4 is turned into a vertical position and moved to the top 15 of the erected pillar and lowered so as to be supported by the pillar. In this example the upper ends 15 of the pillars are provided with cones 15 so the lower end of a new pillar, guided by the cone, is easily located on top of the erected pillar. The lower end of the
cone is provided with a flange 16 on which the lower end of the new pillar 4 is lowered and on which the beam 17 also rests. The beam 17 is provided with a cut for the ends 4, 14 of the pillars. When the pillar positioned in its correct place, it can be fastened. Any suitable connection can be used for fastening, but if the grabber 3 is provided with an automatic welding apparatus is, welding is a very preferable connection method. Thereby the connection will be ready at one go. The frame can be erected by first installing the first line of pillars and then positioning cross-beams on it, subsequent to which another line of pillars and the next beams are installed. On the other hand, the beams can be installed with a site crane as well by manually guiding them, whereby it is possible to simultaneously install new pillars and immediately thereafter beams on the formed installation places.

The pillars and beams can be guided into places in a number of ways. The most simple way is to control the apparatus from the cockpit of the installation apparatus and the operator of the machine guides the pillar to its place. In this case a helper is most probably needed for monitoring the positioning of the part in the correct place. The helper can be replaced by a camera located in the grabber or a suitable place in the boom so that the operator can see the installation location. Another method is to arrange guidance on the basis of the levelling points of the site. In this case in the installation apparatus is needed a positioning system by means of which the position of the grabber and the pillar or beam fastened thereto can be determined. One way of carrying this out is to arrange a reference point in the apparatus, the point being positioned in relation to the levelling points of the site. The control system of the apparatus thus calculates the position of the grabber and the end of the pillar on the basis of this point and the pillar is guided into its destination point either automatically or by the operator using a display screen. The disadvantage of this arrangement is the inaccuracy between the calculated position and the real position caused any movements and the inaccuracies in the movement of the boom system. A better accuracy is achieved by positioning the reference point directly into the grabber and its position in relation to the levelling points is determined by means of, for example, laser measurement. This allows an accurate determination of the position of the grabber and the flexibility of the boom or other inaccuracies of the movement do not have an effect on the positioning. This
positioning method can possibly allow an automatic installation of the pillar in which the operator of the apparatus only commands the apparatus to transfer the next pillar into its place. When this is combined with automatic welding, automatic seam and quality control, a very efficient frame erection system is achieved and the quality of the workmanship of the whole frame can easily be monitored.

The essential feature of the invention is that the grabber is moved by means of a rigid boom system. This means that the grabber and the piece attached thereto are continuously supported during the movement and the installation. Thus, there must be no flexible support members or freely turning articulated joints in the transfer apparatus. In addition to the above-described boom system one could consider installing a rigid vertical boom to the slide of the cross-beam of a construction site crane, the end of which is provided with a boom system providing the sufficient area of movement described above. The end of the rigid vertical beam can also be provided with just a grabber that can be guided in vertical direction with guides arranged in the vertical beam. The articulated beam system can also be attached to a guide or guides. The advantage of this arrangement is the large movement area achieved by means of the construction site crane, but its disadvantage in large cranes is the need for a tall rigid vertical boom. The vertical boom must also probably be shortened as the frame of the building is erected so that it has room to turn above the erected frame.

If the frame of the building comprises trellis structures or the like, a gripping point must be determined for them for the grabber to take hold of. The location of the partial structure can then be calculated on the basis of this point or the structure component can be guided into place with visual guidance or guided by a helper.
We claim:

1. A method of erecting the steel frame of a building, the frame comprising at least horizontal beams (17) and vertical pillars (4, 14), in which method the parts of the frame (1, 14, 17) are taken into place by means of at least one lifting apparatus, characterized in that at least one of the pillars (14) of the frame is taken into place by means of a rigid boom system (2) by moving it with a grabber (3) attached to the boom system (2) and rotated into correct installation position by rotating the gripping means of the grabber (3) about at least two axis of rotation.

2. A method according to claim 1, characterized in that the grabber (3) is rotated about at least a vertical axis and a horizontal axis.

3. A method according to any of claims 1-2, characterized in that a work head of a forest harvester provided with gripping means is used as the grabber (3).

4. A method according to any of claims 1-3, characterized in that the boom system of a digger or a forest harvester is used as the boom system (2).

5. A method according to any of claims 1-4, characterized in that a positioning point is formed into the apparatus on the basis of which the position of the grabber (3) and the part of the steel frame attached thereto can be calculated by means of a positioning system.

6. A method according to any of claims 1-5, characterized in that at least one of the following operations is performed by means of an actuator attached to the grabber. welding, positioning, ultrasound control and recording with a camera.

7. A method according to any of claims 1-6, characterized in that the positioning of at least one pillar (4) is controlled by automatic control by means of which the parts (4, 14, 17) can be automatically moved into place, such as sequenced with remote control.
8. An apparatus for erecting a steel frame of a building, the frame comprising at least horizontal beams (17) and vertical pillars (4, 14), the arrangement comprising at least one lifting apparatus by means of which the parts (1, 14, 17) of the frame are taken to their places, characterized in that the lifting apparatus comprises a rigid boom system (2) and a grabber (3) attached to the boom system for gripping at least one pillar (4) and for rotating it to the correct installation position, the grabber (39) having at least two degrees of freedom for rotating the gripping means of the grabber (3) about at least two axes of rotation.

9. An apparatus according to claim 8, characterized in that the axes of rotation of the grabber (3) are vertical axis and horizontal axis.

10. An apparatus according to any of claims 8-9, characterized in that the grabber (3) is a work head of a forest harvester provided with gripping means.

11. An apparatus according to any of claims 8-10, characterized in that the boom system (2) is the boom system of a digger or a forest harvester.

12. An apparatus according to any of claims 8-11, characterized in that a positioning point is formed into the apparatus on the basis of which the position of the grabber (3) and the part (4) of the steel frame attached thereto can be calculated by means of a positioning system.

13. An apparatus according to any of claims 8-12, characterized in that at least one of the following operations is performed by means of an actuator attached to the grabber: a welding head, a positioning system, a ultrasound control apparatus and a camera.

14. An apparatus according to any of claims 8-13, characterized in that the apparatus is provided with an automatic control by means of which the parts (4, 14, 17) can be automatically moved into place, such as sequenced with remote control.
### A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)


Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C. See patent family annex.

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Date of the actual completion of the international search

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