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**(54) Title:** A METHOD FOR A HEAVY LOAD HANDLING AND A DEVICE FOR A HEAVY LOAD HANDLING

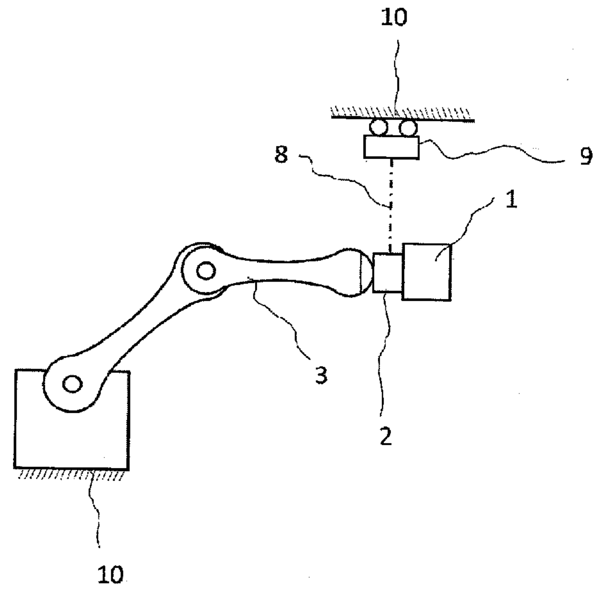


Fig. 4

**(57) Abstract:** The invention concerns a method for handling heavy objects by a force lower than a load weight in order to move a load into a required position during manufacturing or assembling operations lies in that outside a working area a load is attached by an industrial robot to a bearing tool fitted with grips for a human or a HRC robot, whereas after attaching the load to the bearing tool, the bearing tool with the load is gripped by a human or a HRC robot and moved into a required position for a manufacturing or assembling operation in the working area. A device for handling heavy objects by a force lower than a load weight for moving a load into a required position during manufacturing or assembling operations lies in that it incorporates bearing tool (2) movably connected to frame (10), whereas bearing tool (2) is attached to load (1) and fitted with grips for gripping by a human or stationary HRC robot (3) or mobile HRC robot (4). Bearing tool (2) is suspended on cable (8) of crane track (9) or is equipped with travel (6) or is equipped with passive manipulator (7) seated on frame (10) or suspended on it.

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# A method and a device for a heavy load handling

## Technical Field of the Invention

The invention concerns a method for a heavy load handling using a force lower than a load weight in order to move a load into a required position during manufacturing or assembling operations and a device for performing the method.

## State-of-the-art

Heavy load handling, e.g. in manufacturing or assembly lines, is carried out by humans or manipulators or robots for collaboration with humans called HRC (human-robot collaboration) robots putting out only such a force within their working area that does not endanger a safe movement of people in this area. However, HRC robots have a low carrying capacity and are not capable to handle heavy loads.

Therefore humans or HRC robots are replaced by industrial robots with an adequate force to handle heavy loads. However, a considerable disadvantage of the use of these industrial robots when failed is a relatively high risk for people moving around within their handling area, where serious human injuries may occur.

The aim of this invention is a method for handling heavy objects by a human or a HRC robot, the operating force of which is not sufficient itself for a heavy load handling, whereas a risk of endangering a human in the working area can be lowered owing to this manipulation.

## Subject Matter of the Invention

A subject matter of the method for handling heavy objects by a force lower than a load weight in order to move a load into a required position during manufacturing or assembling operations lies in that outside a working area a load is attached by an industrial robot to a bearing tool fitted with grips for a human or a HRC robot, whereas after attaching the load to the bearing tool, the bearing tool with the load is gripped by a human or a HRC robot and moved into a required position for a manufacturing or assembling operation in the working area.

A device for handling heavy objects by a force lower than a load weight for moving a load into a required position during manufacturing or assembling operations lies in that it incorporates a bearing tool movably connected to a frame, whereas the bearing tool is attached to a load and fitted with grips for gripping by a human or a stationary HRC robot or a mobile HRC robot. The bearing tool is suspended on a suspension cable of a crane track or is fitted with a travel that is in a contact with a frame by means of wheels or is fitted with a passive manipulator seated on a frame or suspended on a frame.

A suspension of a crane track is a part of a travelling crab moving along the crane track by means of crane wheels or a part of a bottom suspension hung on crane wheels moving along the crane track or a part of a travel of a suspension guide travelling along the frame itself.

A passive manipulator with a serial or parallel kinematic structure comprises arms and rotational joints or linear guides, whereas the arms are attached through attachments to a frame, to a stationary or mobile HRC robot and to a heavy load.

A passive serial manipulator with a serial or parallel kinematic structure consists of arms fitted with rotational joints or linear guides and attachments for connecting to a frame, to a stationary or mobile HRC robot and to a heavy load, whereas in rotational joints or linear guides there are actuators arranged or between an arm and an attachment on the frame or between both the arms or between the attachments on the frame and the stationary or mobile HRC robot there is at least one spring arranged or at least one of the arms is connected to a counterbalance by a cable passing over a pulley arranged on the frame or at least one of the arms is connected to a spring attached to the frame by a cable passing over a pulley arranged on the frame. Rotational joints or linear guides of the passive manipulator with a serial or parallel kinematic structure are fitted with springs.

## Overview of Figures in Drawings

Variants of a heavy load handling using a bearing tool as described in the invention are shown as schematic depictions in Figures below, where

Fig. 1 to Fig. 17 show particular alternative embodiments of a device for a heavy load handling described in examples of embodiments.

## Examples of the Embodiments of the Invention

Figure 1 shows a solution for handling heavy objects by people. A human 30 standing on frame 10 handles heavy load 1 in such a way that he/she uses bearing tool 2 to facilitate handling heavy load 1. Bearing tool 2 is gripped by a human on one side and attached to heavy load 1 on the other side, where it is also connected to frame 10 in order to transfer a part of the weight of load 1 to frame 10. This considerably decreases active forces needed for handling heavy load 1, and thus heavy load 1 handling by a human is made possible.

Connection of bearing tool 2 with frame 10 in order to transfer a part of the weight of load 1 to frame 10 is depicted in some of the following figures.

Figure 2 shows a method for handling using a stationary HRC robot 3 attached to frame 10 and connected to bearing tool 2 to which load 1 is attached. First, heavy load 1 is attached to bearing tool 2, e.g. by means of an industrial robot outside the handling area. Then stationary HRC robot 3 is attached to bearing tool 2 and controls, by its own forces and/or signals, a movement of bearing tool 2 with heavy load 1 to a target position, possibly to a demanded assembly position or another position within a manufacturing operation. Because bearing tool 2 reduces active forces needed for handling heavy load 1, so stationary HRC robot 3 is capable to develop a force and perform the demanded manipulation with heavy load 1. Thanks to the fact that the stationary HRC robot is capable to develop only a low force and there is no danger of human injury within its working area, people can work within its working area without a risk of being injured by HRC robot 3.

Figure 3 shows a similar method of a heavy load handling but instead of stationary HRC robot 3 there is mobile HRC robot 4 used, which moves along frame 10.

Figure 4, based on Fig. 2, shows an example of a method of handling by stationary HRC robot 3 attached to frame 10. First, heavy load 1 is attached to bearing tool 2 outside the working area of stationary HRC robot 3 to facilitate heavy loads handling. In this case, to facilitate heavy loads handling, bearing tool 2 is attached by cable 8 to suspension 9, for example to a crane track. Then bearing tool 2 is moved together with heavy load 1 to a rim of a working area of stationary HRC robot 3. Stationary HRC robot 3 grasps bearing tool 2 by its arm and is capable to move heavy load 1 within its working area into a demanded position using a low force. This is possible owing to a fact that the weight of heavy load 1 is carried by hanging bearing tool 2 on crane track suspension 9 using cable 8. The stationary HRC robot can also control remotely the force acting onto cable 8 or onto crane track suspension 9. After moving heavy load 1 into a demanded position, stationary HRC robot 3 carries out a demanded manipulation with heavy load 1, for example linking together or attaching two parts at assembly, still using bearing tool 2.

Figure 5 shows another example of a method for a heavy load handling, in this case using mobile HRC robot 4 movably attached to frame 10. First, heavy load 1 is attached to bearing tool 2 outside a working area of mobile HRC robot 4 to facilitate a heavy load handling. In order to facilitate a heavy load handling, in this embodiment bearing tool 2 is movably placed on frame 10 by means of travel 6 on wheels 16. Then bearing tool 2 is moved together with heavy load 1 to a rim of a working area of mobile HRC robot 4. Mobile HRC robot 4 grasps bearing tool 2 by its arm and is capable to move heavy load 1 within its working area into a demanded position using a low force. This is possible owing to a fact that the weight of heavy load 1 is carried by travel 6 of bearing tool 2. Mobile HRC robot 4 can also control remotely the force acting in travel 6. After moving heavy load 1 into a demanded position, mobile HRC robot 4 carries out a demanded manipulation with a heavy load, for example linking together or attaching two parts at assembly, still using bearing tool 2.

Figure 6 shows another example of a method for a heavy load handling using mobile HRC robot 4 movably attached to frame 10. First, heavy load 1 is attached to bearing tool 2 outside the working area of mobile HRC robot 4 to facilitate a heavy load handling. In order to facilitate a heavy load handling, in this embodiment bearing tool 2 is fitted with passive manipulator 7 seated on frame 10. A passive manipulator means no actuators in its joints and it is typically equipped with mechanisms for balancing a weight of the carried load and its own weight. Then bearing tool 2 is moved together with heavy load 1 to a rim of a working area of mobile HRC robot 4. Mobile HRC robot 4 grasps bearing tool 2 by its arm and is capable to move heavy load 1 within its working area into a demanded position using a low force. This is possible owing to a fact that the weight of heavy load 1 is carried by passive manipulator 7 of bearing tool 2. Mobile HRC robot 4 can also remotely control low forces acting in joints of passive manipulator 7. After moving heavy load 1 into a demanded position, mobile HRC robot 4 carries out a demanded manipulation with heavy load 1, for example linking together or attaching two parts at assembly, still using bearing tool 2.

Figure 7 shows a similar example of a handling method using mobile HRC robot 4 movably attached to frame 10 as depicted in Figure 6. In order to facilitate a heavy load handling, in this embodiment bearing tool 2 is fitted with passive manipulator 7 suspended on frame 10.

Figure 8 shows an example of suspending bearing tool 2 depicted in Fig. 4 using suspension 9 connected to cable 8, which is connected to bearing tool 2. Suspension 9 is a part of crane crab 12 moving by means of crane wheels 13 along crane track 11. A travel of crane crab 12 can be passive or energized by an actuator that is weak and fused not to endanger people in a working area of stationary HRC robot 3. The actuator can be in crane wheels 13 or can act directly onto crane crab 12. Crane track 11 can be even branched, so that suspension 9 can move along different tracks within a working area.

Figure 9 shows another example of suspending bearing tool 2 depicted in Fig. 4 using suspension 9 connected to cable 8, which is connected to bearing tool 2. Suspension 9 is a part of bottom suspension 14 hanging on crane wheels 13 moving along crane track 11. A travel of bottom suspension 14 can be passive or energized by an actuator that is weak and fused not to endanger people in a working area of stationary HRC robot 3. The actuator can be in crane wheels 13 or can act directly onto bottom suspension 14. Crane track 11 can be even branched, so that suspension 9 can move along different tracks within a working area.

Figure 10 shows another example of suspending bearing tool 2 depicted in Fig. 4 using suspension 9 connected to cable 8, which is connected to bearing tool 2. Suspension 9 is a part of a travel of suspension guide 15 travelling directly along frame 10 itself. Suspension guide 15 is attached to the frame either by a linear guide - roller, ball, sliding type, or by vacuum or the magnetic force. Suspension guide 15 can be passive or energized by an actuator that is weak and fused not to endanger people in a working area of stationary HRC robot 3. The actuator can be in suspension guide 15. Again, the linear guide can be even branched, so that suspension 9 can move along different tracks within a working area.

Figure 11 shows an example of a motion of bearing tool 2 as depicted in Fig. 5 by means of travel 6 on wheels 16. Several variants of an undercarriage of travel 6 are shown. The undercarriage can be equipped with one, two, three, four, six or more wheels 16. Wheels 16 can be fixed, swiveling independently, swiveling simultaneously according to the Ackermann principle, passive or controlled. Wheels 16 can be multidirectional, movable in more directions. Wheels 16 can be passive or energized by an actuator that is weak and fused not to endanger people in a working area of mobile HRC robot 3.

Figure 12 shows an example of a concrete solution of bearing tool 2 as depicted in Fig. 7 arranged as passive manipulator 7 suspended on frame 10. This is passive serial manipulator 7 consisting of arms 17 and rotational joints 18 (these can also be linear guides 5 in Fig. 17), attached by attachments 19 to frame 10, to HRC robot 3 or 4 and to heavy load 1. In rotational joints 18 there are torsion springs (or in linear guides 5 in Fig. 17 there are springs between moving arms) as mechanisms for balancing a weight of carried load 1 and own weight. In rotational joints 18 (or in linear guides 5) there can also be actuators, which would be weak and fused not to endanger people in a working area of HRC robot 3 or 4. Serial manipulator 7 is also called a manipulator with a serial kinematic structure.

Figure 13 shows an example of a concrete solution of bearing tool 2 as depicted in Fig. 6 arranged as passive manipulator 7 seated on frame 10. This is passive manipulator 7 with a parallel kinematic structure consisting of arms 17 and rotational joints 18 (these can also be linear guides 5), attached by attachments 19 to frame 10, to HRC robot 3 or 4 and to heavy load 1. A parallel kinematic structure means that one part of passive manipulator 7 called a platform and here consisting of arm $17_p$ is carried by two parallel linkages comprising arms 17 connected by rotational joints 18 from attachment 19 on frame 10 and from attachment 19 on HRC robot 3 or 4. In rotational joints 18 there are torsion springs (or in linear guides 5 in Fig. 17 there are springs between moving arms) as mechanisms for balancing a weight of the carried load and own weight. In rotational joints 18 (or in linear guides 5) there can also be actuators, which would be weak and fused not to endanger people in a working area of HRC robot 3 or 4.

Figure 14 shows an alternative solution for the embodiment depicted in Fig. 12, where instead of springs in joints there is spring 20 for balancing a weight of carried load 1 and own weight between arm 17 and attachment 19 on frame 10. Spring 20 can also act between both arms 17 or between attachments 19 on frame 10 and HRC robot 3 or 4.

Figure 15 shows another alternative solution for the embodiment depicted in Fig. 12, where instead of springs in joints there is a balancing mechanism used consisting of cable 8 passing over pulley 21 to counterbalance 22, the weight of which balances the weight of the carried load 1 and own weight of the manipulator through pulley 21.

Figure 16 shows an alternative solution for the embodiment depicted in Fig. 15, where instead of counterbalance 22 there is horizontal spring 20 used. Besides spring 20 an entire mechanism can be also used ensuring a constant compensating force as with a weight of counterbalance 22.

Figure 17 shows that, aside from rotational joints 18, passive manipulator 7 can also incorporate (in all the solutions described above) linear guides 5, in this embodiment between two arms 17.

An advantage of the described invention is that HRC robot 3 or 4 can handle heavy load 1 using a low force, thus enabling the presence of people within its working area without endangering them because the weight of the heavy load or even other forces are carried by tool 2.

All variants described above can be combined one with another. HRC robot 3 or 4 or other parts related to a load handling are computer controlled.

All the depictions are schematic in a projection into a plane, the devices are spatial.

# PATENT CLAIMS

1. A method for handling heavy objects by a force lower than a load weight in order to move a load into a required position during manufacturing or assembling operations, characterized in that outside a working area a load is attached by an industrial robot to a bearing tool fitted with grips for a human or a HRC robot, whereas after attaching the load to the bearing tool, the bearing tool with the load is gripped by a human or a HRC robot and moved into a required position for a manufacturing or assembling operation in a working area.

2. A device for handling heavy objects by a force lower than a load weight for moving a load into a required position during manufacturing or assembling operations, characterized in that it incorporates bearing tool (2) movably connected to frame (10), whereas bearing tool (2) is attached to load (1) and fitted with grips for gripping by a human or stationary HRC robot (3) or mobile HRC robot (4).

3. A device for a heavy load handling as described in Claim 1, characterized in that bearing tool (2) is suspended using cable (8) on suspension (9) of a crane track.

4. A device for a heavy load handling as described in Claim 1, characterized in that bearing tool (2) is equipped with travel (6), which is in a contact with frame (10) through wheels (16).

5. A device for a heavy load handling as described in Claim 1, characterized in that bearing tool (2) is equipped with passive manipulator (7) seated on frame (10).

6. A device for a heavy load handling as described in Claim 1, characterized in that bearing tool (2) is equipped with passive manipulator (7) suspended on frame (10).

7. A device for a heavy load handling as described in Claim 3, characterized in that suspension (9) is a part of crane crab (12) moving along crane track (11) by means of crane wheels (13).

8. A device for a heavy load handling as described in Claim 3, characterized in that suspension (9) is a part of bottom suspension (14) hanging on crane wheels (13) moving along crane track (11).

9. A device for a heavy load handling as described in Claim 3, characterized in that suspension (9) is a part of a travel of suspension guide (15) travelling directly on frame (10) itself.

10. A device for a heavy load handling as described in Claim 4, characterized in that wheels (16) can be fixed, swiveling or movable in one or more directions.

11. A device for a heavy load handling as described in Claims 5 or 6, characterized in that passive manipulator (7) with a serial or parallel kinematic structure consists of arms (17) and rotational joints (18) or linear guides (5), whereas arms (17) are attached through attachments 19 to frame (10), to HRC robot (3) or (4) and to heavy load (1).

12. A device for a heavy load handling as described in Claims 5 or 6, characterized in that passive manipulator (7) with a serial or parallel kinematic structure consists of arms (17) equipped with rotational joints (18) or linear guides (5) and attached through attachments (19) to frame (10), to HRC robot (3) or (4) and to heavy load (1), whereas there are actuators arranged in rotational joints (18) or linear guides (5).

13. A device for a heavy load handling as described in Claims 5 or 6, characterized in that passive manipulator (7) with a serial or parallel kinematic structure consists of arms (17) equipped with rotational joints (18) or linear guides (5) and attached through attachments (19) to frame (10), to HRC robot (3) or (4) and to heavy load (1), whereas there is at least one spring (20) arranged between arm (17) and attachment (19) on frame (10) or between both arms (17) or between attachments (19) on frame (10) and HRC robot (3) or (4).

14. A device for a heavy load handling as described in Claims 5 or 6, characterized in that passive manipulator (7) with a serial or parallel kinematic structure consists of arms (17) equipped with rotational joints (18) or linear guides (5) and attached through attachments (19) to frame (10), to HRC robot (3) or (4) and to heavy load (1), whereas at least one of arms (17) is connected to counterbalance (22) through cable (8) passing over pulley (21) arranged on frame (10).

15. A device for a heavy load handling as described in Claims 5 or 6, characterized in that passive manipulator (7) with a serial or parallel kinematic structure consists of arms (17) equipped with rotational joints (18) or linear guides (5) and attached through attachments (19) to frame (10), to HRC robot (3) or (4) and to heavy load (1), whereas at least one of arms (17) is connected to spring (20) attached to frame (10); the connection is made through cable (8) passing over pulley (21) arranged on frame (10).

16. A device for a heavy load handling as described in Claims 11 to 15, characterized in that rotational joints (18) or linear guides (5) of passive manipulator (7) with a serial or parallel kinematic structure are equipped with springs.

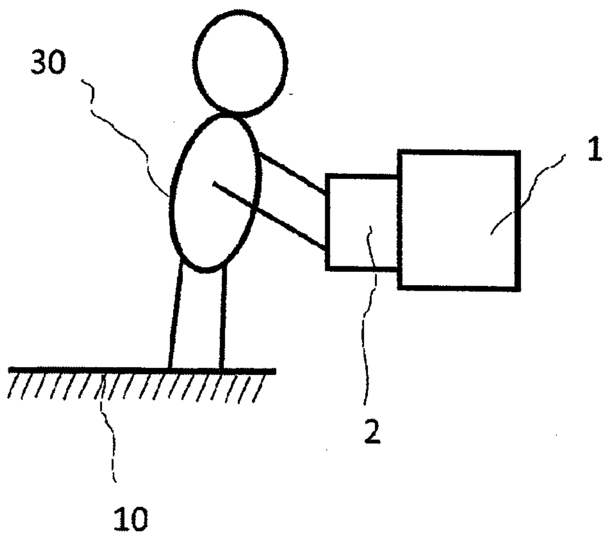


Fig. 1

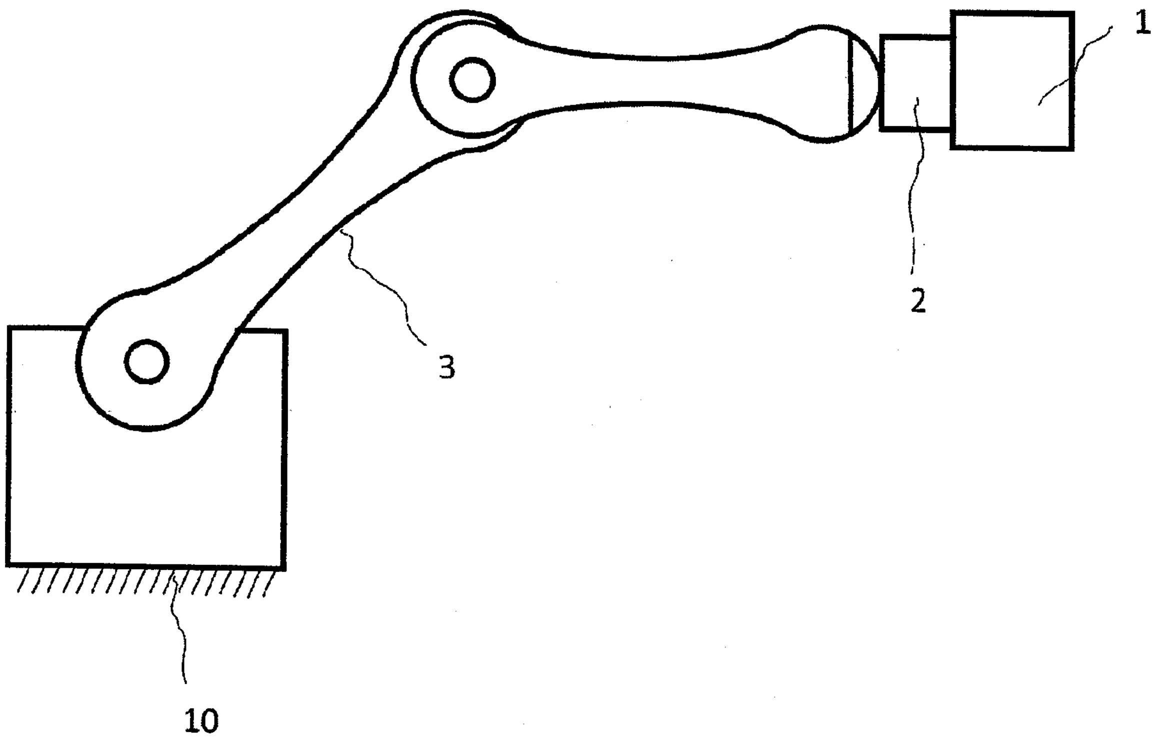


Fig. 2

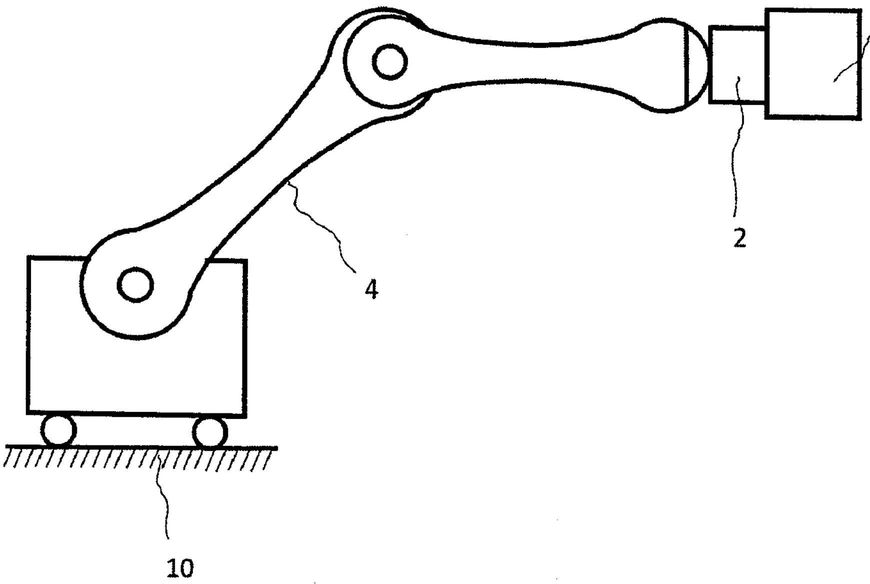


Fig. 3

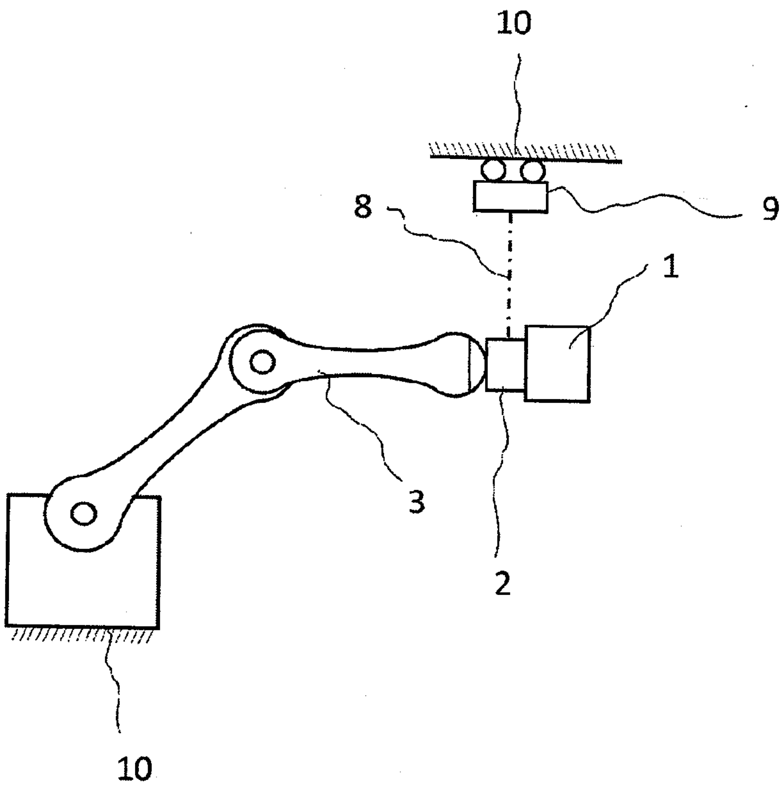


Fig. 4

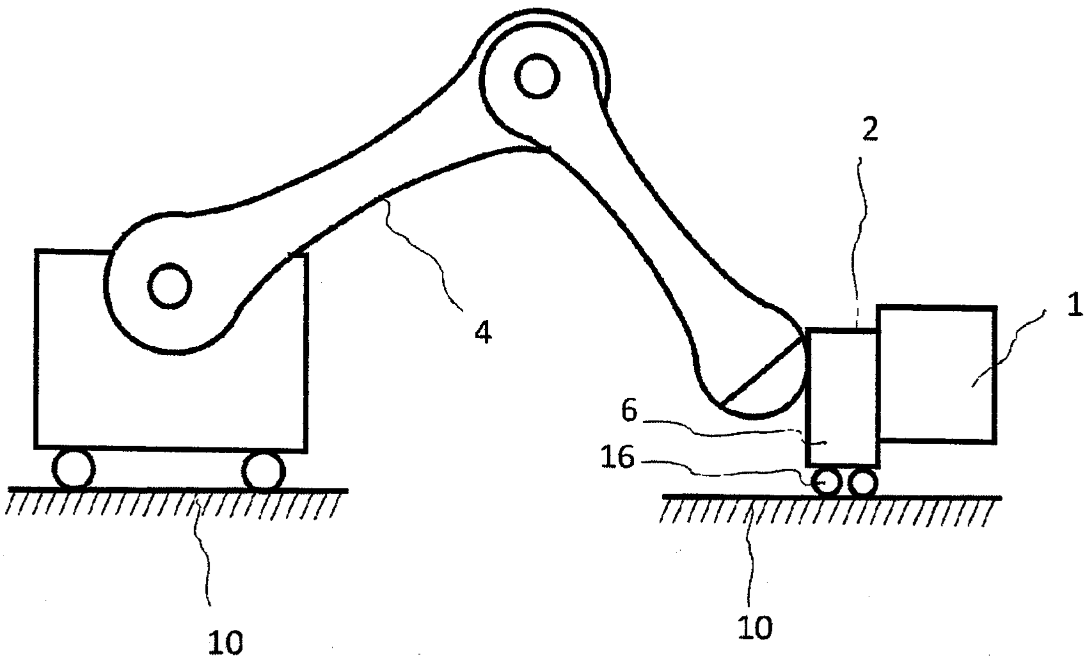


Fig. 5

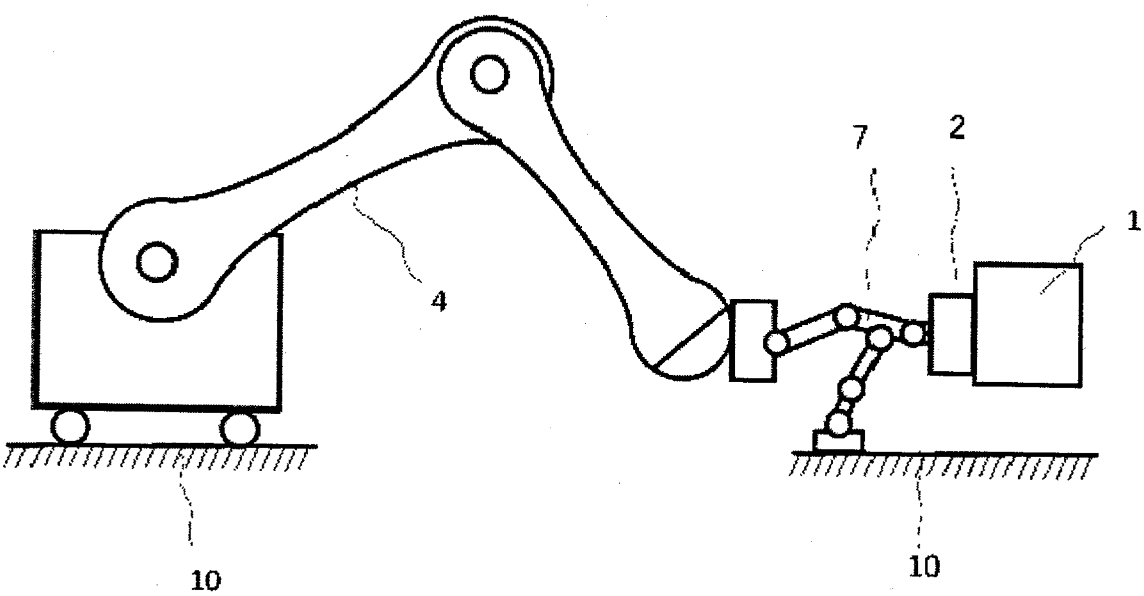


Fig. 6

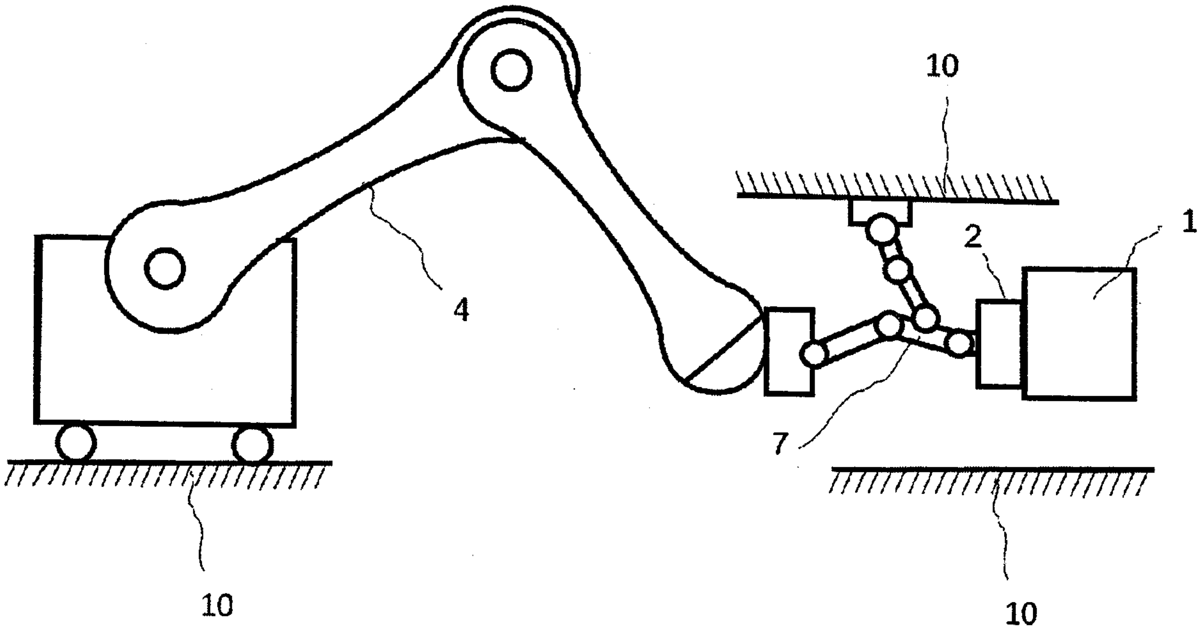


Fig. 7

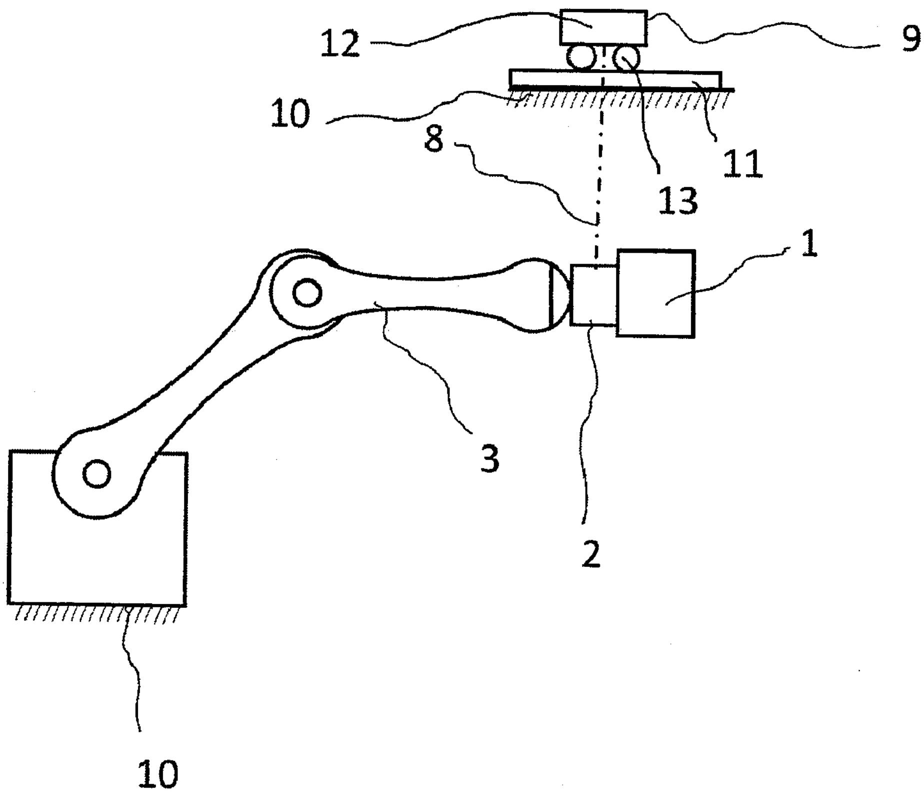


Fig. 8

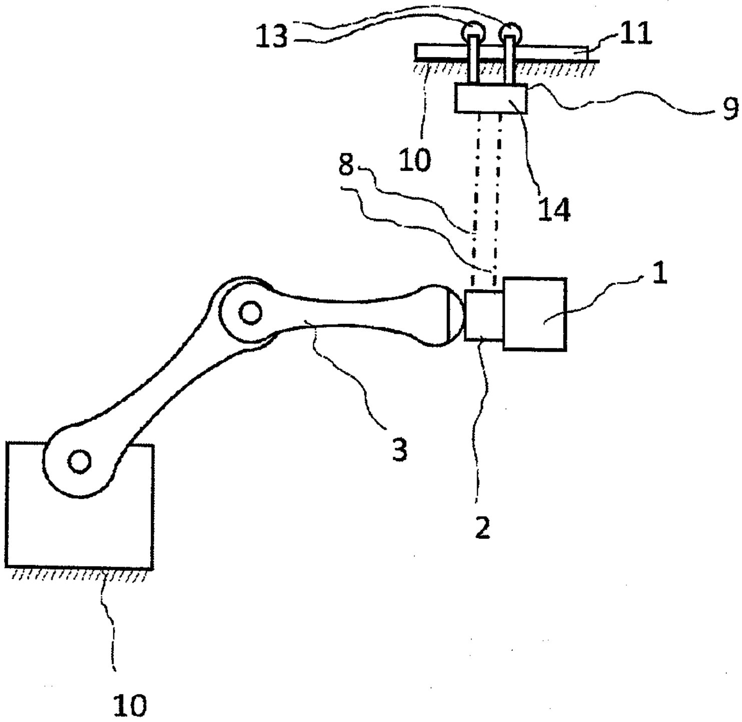


Fig. 9

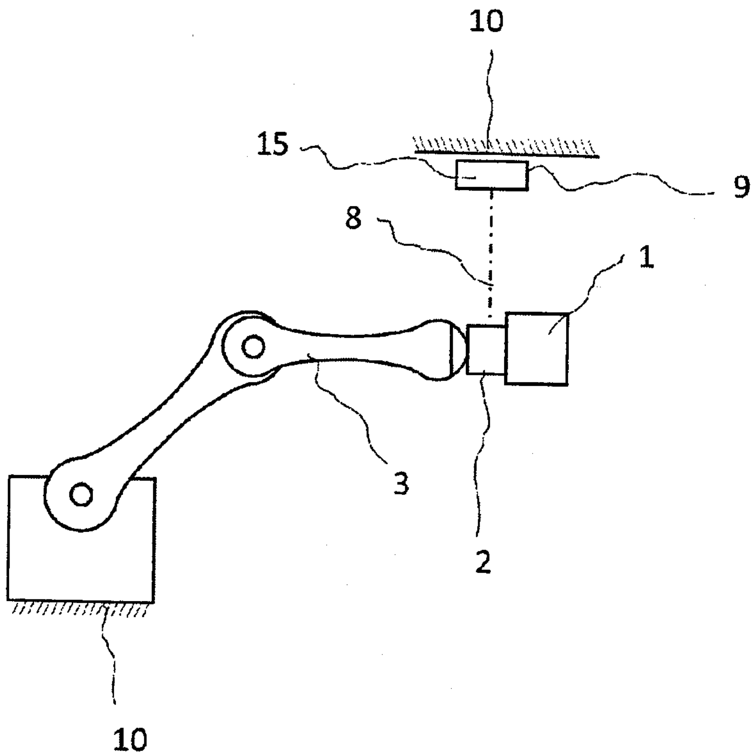


Fig. 10

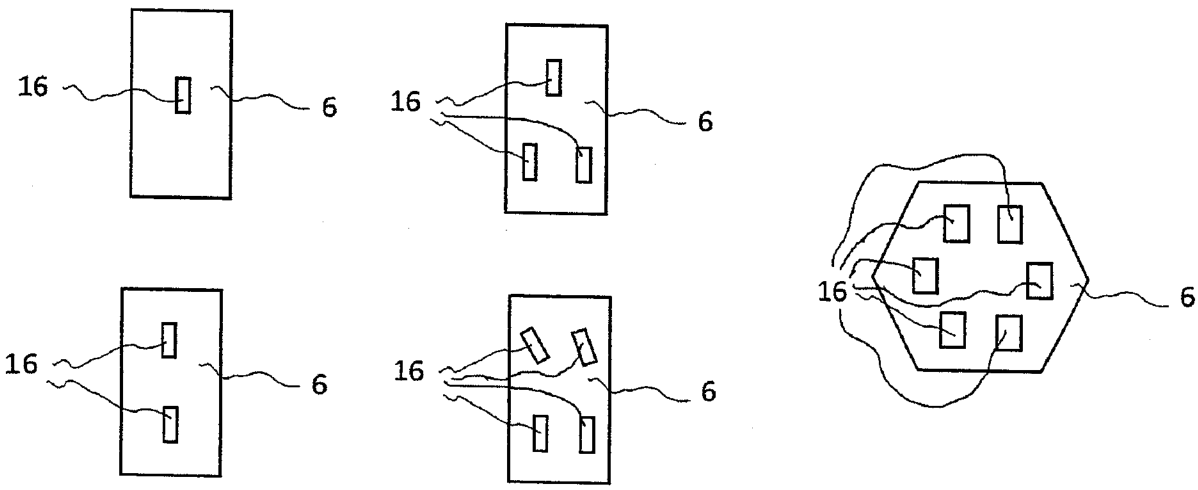


Fig. 11

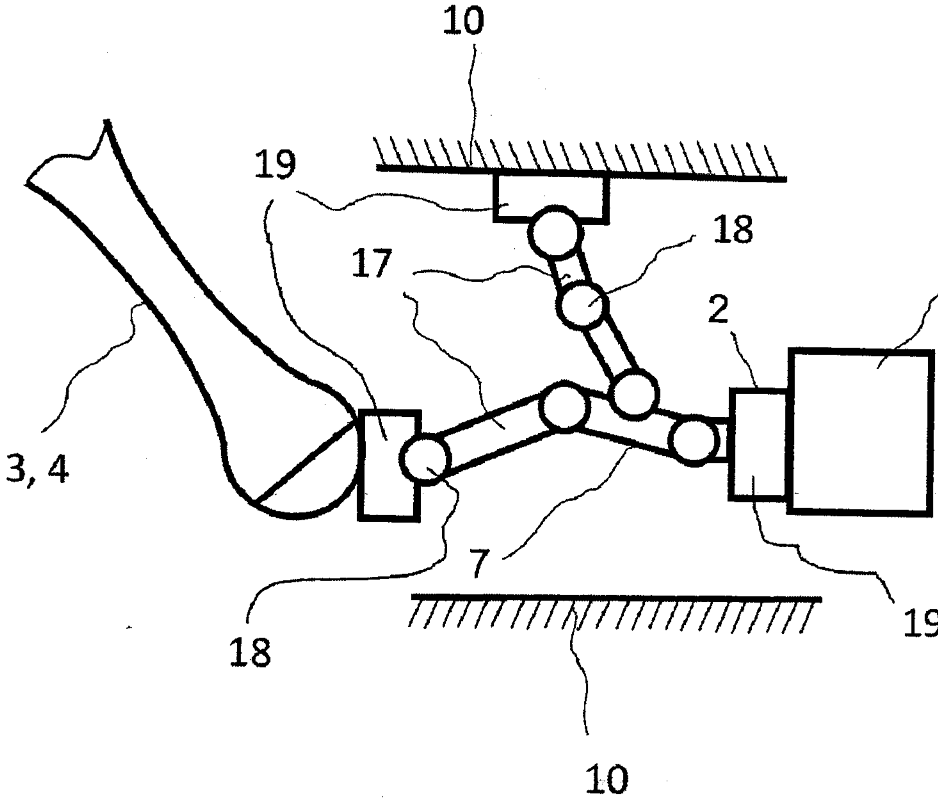


Fig. 12

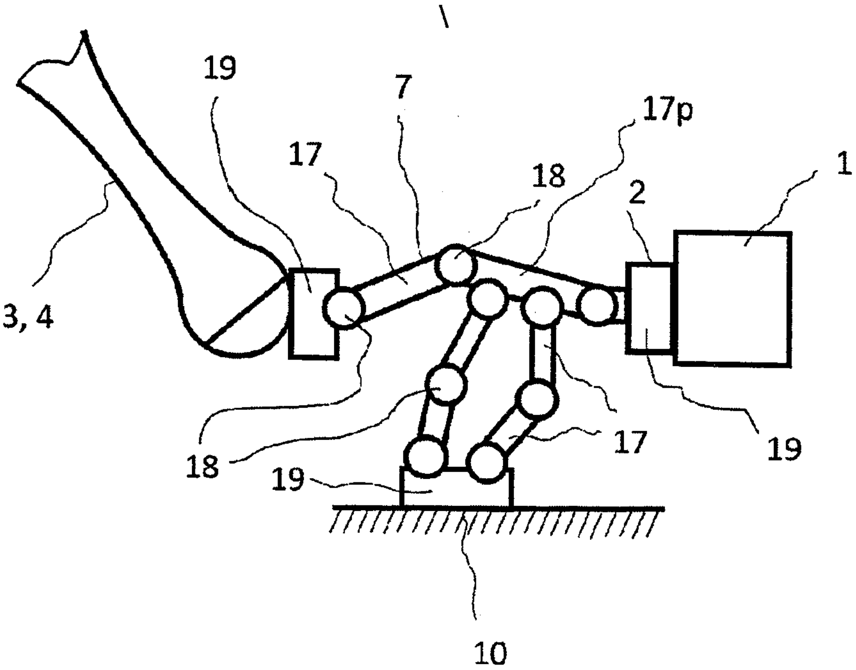


Fig. 13

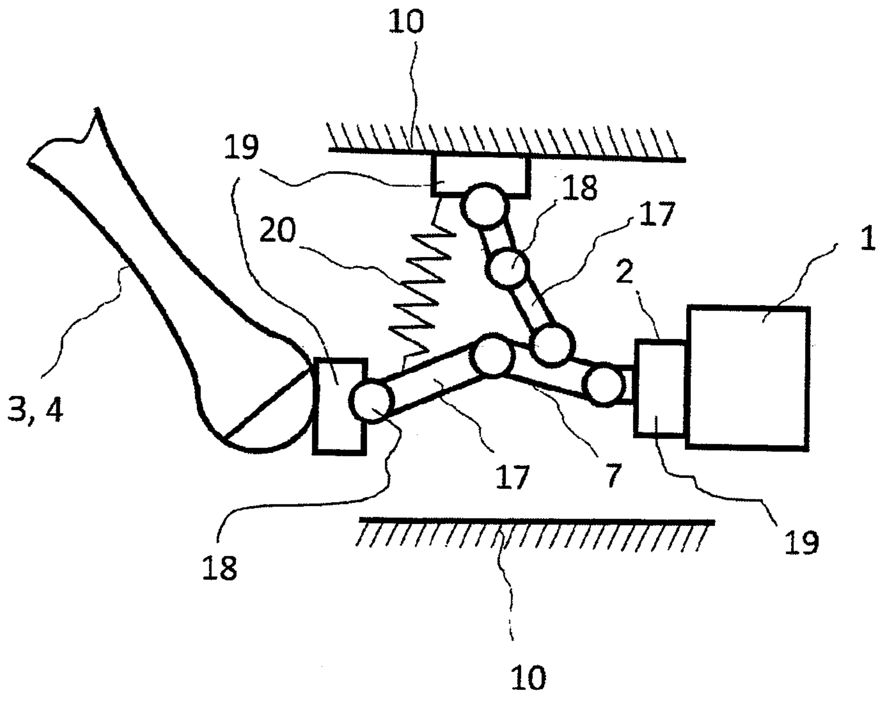


Fig. 14

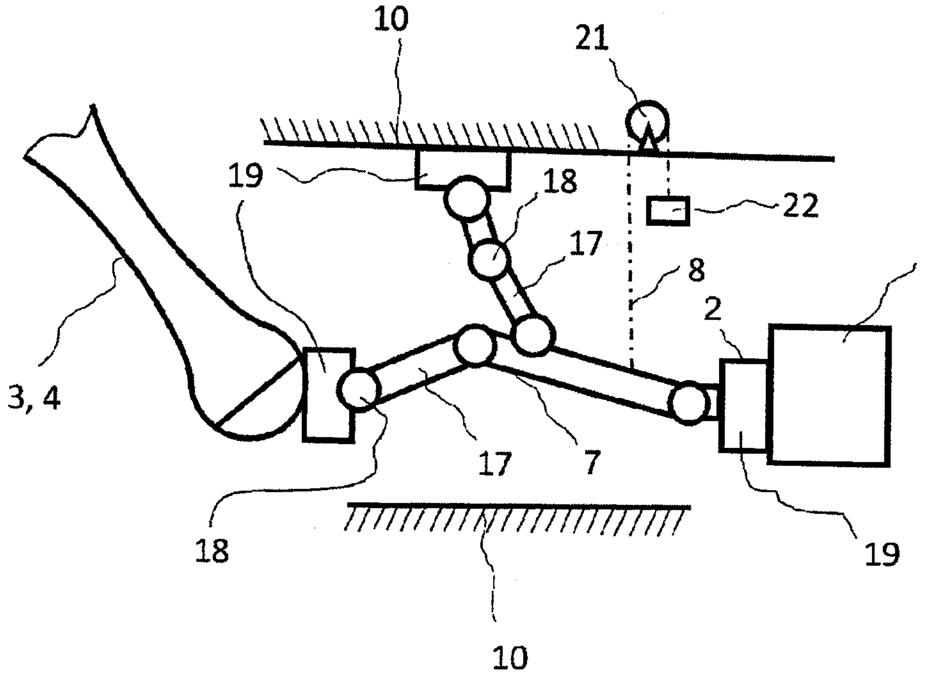
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Fig. 15

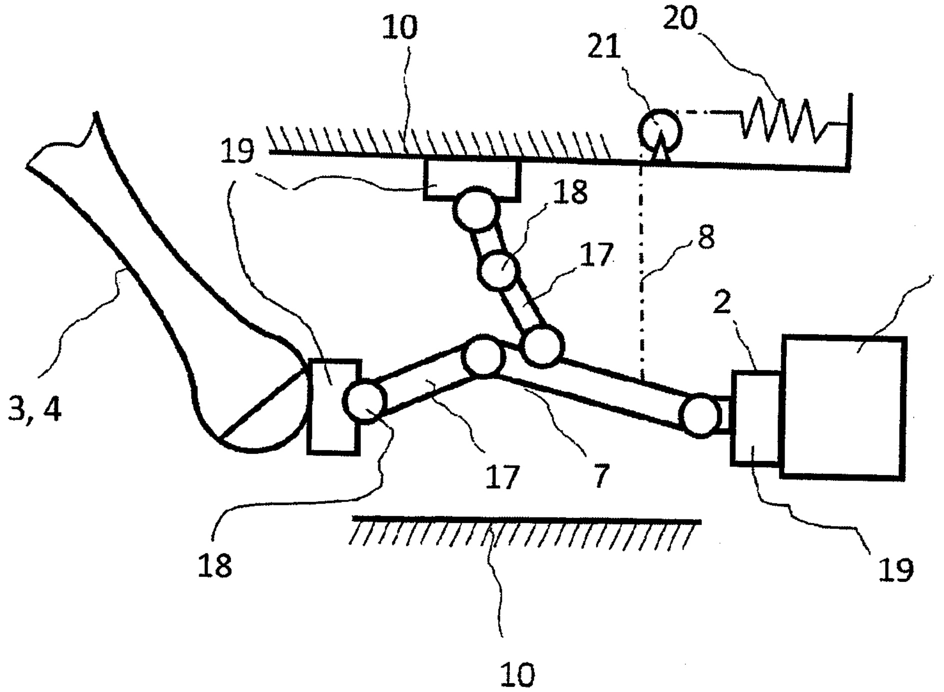
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Fig. 16

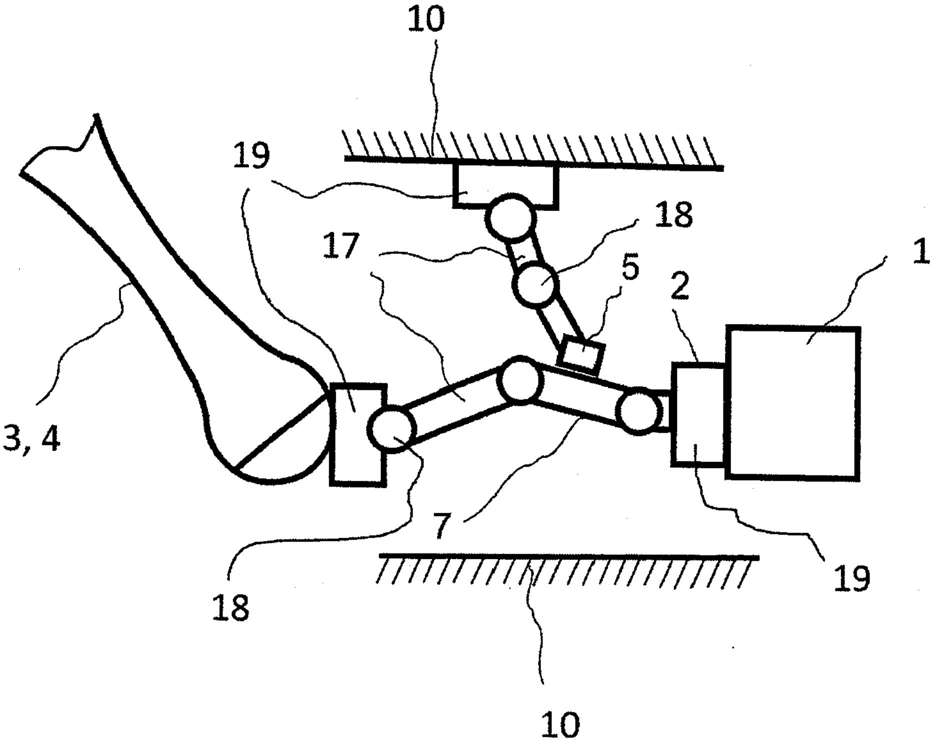


Fig. 17

# INTERNATIONAL SEARCH REPORT

International application No
PCT/CZ2018/000031

**A. CLASSIFICATION OF SUBJECT MATTER**
INV. B25J19/00 B25J5/00 B25J13/02 B25J9/00
ADD.

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)
B25J

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

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

EPO-Internal, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
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