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### (54) PAINTING PLANT AND METHOD

(57) A painting plant and method are described, wherein an anthropomorphous robot moves a supporting frame, on which the pieces to be painted are arranged, with respect to one or more spray-painting dispensing devices installed on a fixed structure. The plant comprises a drawing apparatus with drawing openings to draw the air flow, which are facing the spray dispensing devices.

The base of the anthropomorphous robot is arranged upstream of the spray dispensing devices with respect to the direction and way of the air flow drawn by the drawing apparatus, as well as with respect to the direction and way of paint dispensation by the spray dispensing devices.

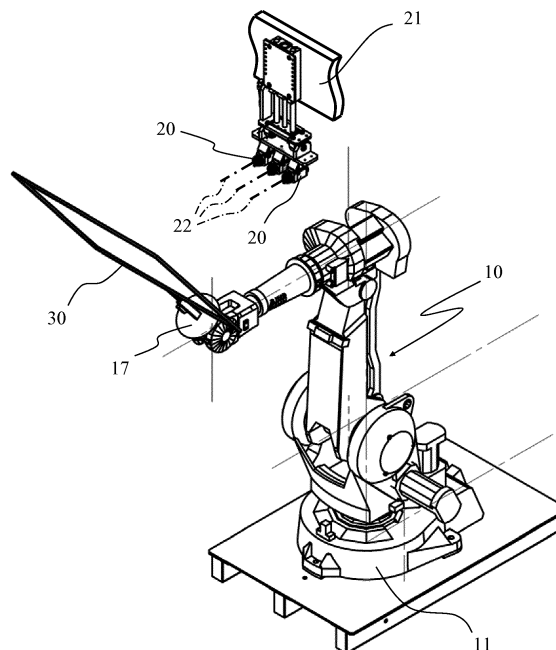


Fig. 1

## Description

### Field of the art

**[0001]** The present invention relates to a spray-painting plant and a method to apply one or more paint layers on the surfaces of pieces to be subjected to such a treatment.

**[0002]** With the general term "paint" herein and in the following various coating products are meant that can be spray-applied on pieces, for example primers, base paints, coloring paints and transparent paints.

### Prior art

**[0003]** Such plants are known for example from patent applications WO 2011/080484 and n. WO 2012/001307, in which a painting plant is described comprising one or more spray-painting dispensing devices installed on a fixed structure and an anthropomorphous robot to move the pieces to be painted with respect to the spray dispensing devices while pieces are painted.

**[0004]** Spray dispensers are suspended on the fixed structure and oriented to direct the paint dispensation downwards while the robot moves the pieces under the same dispensers.

**[0005]** On the robot resting flooring a drawing grid is arranged such that the drawn air flow and gravity aid the flow of spray-painting dispensed towards the pieces to be painted.

**[0006]** With this arrangement, most of robot articulations are affected by the excess paint flow (overspray) that is not intercepted by the pieces to be painted. Paint buildups on robot articulations can impair the proper operation of the robot itself and thus require frequent interventions of cleaning and maintenance.

**[0007]** It has further to be noted that both the above mentioned patent applications refer to painting of large size pieces, for example car bumpers or the like. In case pieces with more limited size have to be painted, both individually and in groups of several units, the excess paint flow not intercepted by the pieces is significantly larger.

**[0008]** US 2002/023585 A1 describes a painting plant and method wherein the piece to be painted is fixed to a rotary arm belonging to a carriage. The carriage is advanced along a series of stations comprising a spraying booth wherein the paint dispensers are arranged in fixed positions with respect to the piece to be painted that is rotated through a supporting arm. The rotation of the supporting arm is imparted through a transmission chain engaging a sprocket when the carriage is positioned at the spraying booth. In the spraying booth a pressurized air flow is further fed to prevent the air or dust intake through an opening wherein the rotary supporting arm is inserted. The base of the mechanism for rotating the supporting arm is however placed outside the spraying booth, whereby it is not subjected to the excess paint flow in

any way. It is a plant suitable for painting pieces having simple shapes, in particular pieces having axial symmetry and being therefore able to be painted by rotating them with respect to an axis thereof, but little suitable for painting pieces with complex shapes, for example pieces lacking in axial symmetry or pieces with undercuts, recesses or the like.

### Summary of the Invention

**[0009]** Object of the present invention is to provide a painting plant and a method wherein the anthropomorphous robot moving the pieces facing one or more spray dispensing devices is protected from the excess paint flow during the painting operations the pieces are subjected to.

**[0010]** Another object of the present invention is to provide a painting plant and a method of the above mentioned type that are mostly suitable to painting of pieces having limited size, both treated individually and grouped in several units, with respect to those treated in the known art.

**[0011]** Further object of the present invention is to provide a painting plant and a method of the above mentioned type that are able to paint pieces having complex shapes, for example shapes with undercuts or free from axial symmetries.

**[0012]** These objects are achieved thanks to a painting plant according to claim 1. Further characteristics of the present invention are reported in the respective dependent claims.

**[0013]** In a possible embodiment, a painting plant comprises at least one supporting frame for the pieces to be painted, one or more spray-painting dispensing devices installed on a fixed structure and an anthropomorphous robot having releasable-engagement means assembled on its end to move the supporting frame with respect to the spray dispensing devices while pieces are painted.

**[0014]** The plant according to the present invention comprises a drawing apparatus with drawing openings to draw the air flow, which are facing the spray dispensing devices.

**[0015]** The base of the anthropomorphous robot, in addition to be arranged upstream of the spray dispensing devices with respect to the direction and way of paint dispensation by the spray dispensing devices, is advantageously also arranged upstream of the spray dispensing devices with respect to the direction and way of the air flow drawn by the drawing apparatus. This allows avoiding that possible turbulences inside the plant can also cause unwanted paint deposit on the robot during painting.

**[0016]** In a plant according to the present invention, the base of the anthropomorphous robot is advantageously arranged upstream of the spray dispensing devices with respect to the direction and way of paint dispensation by the spray dispensing devices.

**[0017]** Thereby, the anthropomorphous robot is not affected by the paint flow dispensed towards the pieces by the spray dispensing devices and is thus protected by the excess paint that is not intercepted by the pieces subjected to painting.

**[0018]** The anthropomorphous robot is preferably an industrial six-axes manipulator on which a screen is mounted perpendicular to the rotation axis of the robot wrist for protecting the wrist articulation of the robot itself. The screen can be made up for example of a disc assembled on the end of the robot at the releasable-engagement means and allows further protection of the wrist articulation of the robot from possible paint splashes bouncing against the surfaces of the pieces subjected to painting or the supporting frame on which they are mounted.

**[0019]** In a possible embodiment, the releasable-engagement means include a pin adapted to be fitted in a hollow post of the supporting frame. During the painting, when the supporting frame is engaged with the anthropomorphous robot, the pin and hollow post of the frame have axes aligned and coplanar with the rotation axis of the wrist of the anthropomorphous robot. By this particular geometry of the engaging means the supporting frame can be picked-up and deposited from/to a deposit station without using gripping means, such as grippers or the like, that would be critical to be used with the particular plant arrangement.

**[0020]** The plant comprises in fact one or more deposit stations provided with hooking means for resting the supporting frame when the latter is released by the anthropomorphous robot and/or for picking-up the supporting frame by the anthropomorphous robot.

**[0021]** The supporting frame comprises in its turn at least one element integral with the post, for coupling with the hooking means of the deposit stations.

**[0022]** In a possible embodiment, at least one of the spray dispensing devices can be moved between at least two positions with respect to the fixed structure in order to vary the dispensation axis of such a spray dispensing device with a translation and/or rotation movement, by keeping the dispensing axis in a single plane. This allows in practice doubling the operating area of the anthropomorphous robot.

**[0023]** In other possible embodiments, at least one of the spray dispensing devices can be rotatable between at least two stable positions around an axis coincident with its own dispensing axis. This can be useful for example if the section of the dispensing cone of such a dispensing device has a prevalent dimension, such to adapt the paint application to the shape and arrangement of the pieces to be painted arranged on the frame moved by the anthropomorphous robot.

**[0024]** Various types of dispensing devices can be used in a plant according to the present invention. For example, at least one of the spray dispensing devices can be made up of a rotary atomizer, or also by an electrostatic atomizer.

**[0025]** The invention also relates to a painting method comprising the steps of:

- a) providing at least one supporting frame for the pieces to be painted, one or more spray-painting dispensing devices installed on a fixed structure and an anthropomorphous robot having releasable-engagement means assembled on the end thereof to move the supporting frame with respect to the spray dispensing devices;
- b) moving the supporting frame with an anthropomorphous robot with respect to the spray dispensing devices during the painting, wherein the anthropomorphous robot has releasable-engagement means assembled on the end thereof to bear the supporting frame.

**[0026]** According to the present invention, the method advantageously provides the drawing by openings drawing the air flow, which are facing the spray dispensing devices. The base of the anthropomorphous robot is arranged upstream of the spray dispensing devices also with respect to the direction and way of the suction-drawn air flow.

**[0027]** The method further advantageously provides that the base of the anthropomorphous robot is arranged upstream of the spray dispensing devices with respect to the direction and way of paint dispensation by the spray dispensing devices.

**[0028]** The anthropomorphous robot is a six axes robot that is provided with a screen perpendicularly to the rotation axis of the wrist of the anthropomorphous robot for further protecting the wrist articulation of the anthropomorphous robot.

**[0029]** The releasable-engagement means installed on the robot include for example a pin adapted to be fitted in a hollow post of the supporting frame. When the supporting frame is connected to the anthropomorphous robot, in particular during the painting, the pin and post are kept with the respective axes aligned and coplanar with the rotation axis of the wrist of the anthropomorphous robot.

**[0030]** The method further provides for resting the supporting frame on suitable hooking means of at least one deposit station, when it is released by the anthropomorphous robot, as well as picking-up the supporting frame from the deposit station by the anthropomorphous robot.

**[0031]** At least one of the spray dispensing devices can be moved between at least two positions with respect to the fixed structure on which it is installed in order to vary the dispensation axis of such a spray dispensing device with a translation and/or rotation movement, still keeping the dispensing axis in a single plane.

**[0032]** In other possible implementations of a method according to the invention, at least one of the spray dispensing devices can be rotated between at least two stable positions around an axis coincident with its own dispensing axis.

### Brief Description of the Drawings

**[0033]** Further characteristics and advantages of the present invention will be more evident from the following specification of some embodiments depicted for illustrative purposes and without limitation, with reference to the accompanying drawings, wherein:

- Figure 1 is a perspective view of some elements of a painting plant according to a possible embodiment of the present invention;
- Figure 2 is a side view of the elements depicted in Figure 1;
- Figure 3 is a schematic side view of some elements of a painting plant according to a possible embodiment of the present invention;
- Figure 4 schematically shows the direction of the paint dispensation and drawing flows in a painting plant according to a possible embodiment of the present invention;
- Figure 5 is an exploded view of a possible embodiment of the releasable-engagement means assembled on the end of the anthropomorphous robot to move a supporting frame of the pieces to be painted;
- Figure 6 is a schematic plan view of some elements of a painting plant according to a possible embodiment of the present invention;
- Figures 6A and 6B are perspective views illustrating a possible embodiment of the deposit stations;
- Figure 7 is a front view of some elements of the plant depicted in Figures 1 and 2;
- Figure 8 is a side view of the positions the spray-painting dispensing devices can take, according to a possible embodiment of a plant of the present invention;
- Figures 9A and 9B show some arrangement examples of a supporting frame for the pieces to be painted with respect to the positions the spray dispensing devices can take;
- Figures 10A and 10B are perspective views of another embodiment of the spray dispensing devices in a plant according to the present invention;
- Figures 11A and 11B are side views illustrating respectively the dispensing devices of Figures 10A and 10B installed on the fixed structure of a plant according to the present invention;
- Figure 12 shows another embodiment of the spray dispensing devices according to the present invention; and
- Figure 13 shows a further embodiment of the spray dispensing devices according to the present invention.

### Detailed description

**[0034]** In Figures 1 and 2 an anthropomorphous robot 10 and a group of spray-painting dispensing devices 20

installed on a fixed structure 21 are shown. In the embodiment herein depicted by way of example three dispensing devices 20 are installed with coplanar dispensing axes denoted by reference 22, but it is well understood that the number of devices 20, the type and their positioning can vary upon the various paint typologies that have to be applied to the pieces.

**[0035]** The base 11 of the robot 10 is arranged upstream of the spray dispensing devices 20 with respect to the direction and way of paint dispensation by the spray dispensing devices 20.

**[0036]** On the robot 10 a supporting frame 30 is engaged for the pieces to be painted (not shown for the sake of clarity). It is therefore apparent that the robot 10 is not affected by the paint flow dispensed by the spray dispensing devices 20.

**[0037]** In the schematic view of Figure 3 a possible embodiment is illustrated of a plant according to the invention, wherein the robot 10 and the spray dispensing devices 20 are housed in a chamber 40 isolated with respect to the outer environment. The plant comprises in particular a drawing apparatus 45 with drawing openings 46 to draw the air flow, which are facing the spray-painting devices 20. Thereby, as highlighted by the arrows F in Figure 4, the base 11 of the robot 10 is arranged upstream of the spray dispensing devices 20 also with respect to the direction and way of the airflow drawn by the drawing apparatus 45. The arrow V shown in Figure 4, coincident with the dispensing axes 22, indicates the direction and way of paint dispensation by the spray dispensing devices 20 with a maximum opening angle  $\alpha$ , such that the spray dispensed paint affects the supporting frame 30 on which the pieces to be painted are placed without however affecting the articulations of the robot 10.

**[0038]** In Figure 5 an example of implementation of the releasable-engagement means installed at the end of the robot 10 to bear the supporting frame 30 is shown. The engaging means include a pin 13 protruding from a base 14 fixed at the end of the robot 10 by screws 15. The pin 13 has shape and size suitable to allow it to be fitted in a hollow post 33 of the supporting frame 30. On the pin 13 a screen 17 is fixed and rests on arms 18 perpendicular to the pin 13. The screen 17 is depicted for example in a disc shape and allows protecting the wrist articulation of the robot 10 when the frame 30 adopts certain positions with respect to the spray dispensing devices 20, for example in particularly closely spaced positions in which the wrist of the robot 10 could be affected by bouncing paint splashes.

**[0039]** On a side of the hollow post 33 a hollow element 35 is arranged integral with the post 33, that serves to deposit the frame 30 on one or more deposit stations by coupling for example the hollow element 35 with a pin.

**[0040]** In fact, as depicted in the plan view of Figure 6, the plant comprises deposit stations 50 provided for example with vertical pins 55 on which the frames 30 can be deposited by fitting the hollow element 35 integral with

the post 33 on one of the pins 55. The deposit stations 50 are arranged in positions reachable by the robot 10 to allow the robot to rest the supporting frames 30 at the end of a painting step, as well as to pick them up the moment they have to be subjected to the application of further paint layers once again, for example in order to apply a second hand of the same paint or to apply a paint different from the last applied layer. The deposit stations 50 are preferably movable and can be manually moved, otherwise automatically along an endless chain for moving the deposit stations 50.

**[0041]** In Figure 6A a bar 56 of the deposit stations 50 on which three supporting frames 30 are arranged is shown by way of example. In the view of Figure 6B the pins 55 are highlighted and fixed to the bar 56, on which the frames 30 are deposited. One of the frames 30 is further depicted while it is deposited/picked-up, with the respective hollow element 35 that is fitted on/taken out of the respective pin 55.

**[0042]** In the embodiment depicted in Figure 7, all the spray dispensing devices 20 are movable between two positions with respect to the fixed structure 21. In the first position denoted by 20a in Figure 7, all the devices 20 have a substantially horizontal dispensing axis 22a, whereas in the second position denoted by 20b, all the devices 20 have a dispensing axis 20b tilted downwards.

**[0043]** Referring also to Figure 8, the moving of the spray dispensing devices 20 between the two positions is obtained for example with a rotation movement produced by a first actuator 26 acting on a pivoted bracket 25 on which all the spray dispensing devices 20 are mounted. A second actuator 27 is housed inside a box 29 constrained to the fixed structure 21, and causes a translation movement in the vertical direction. In Figure 8 the rod 28 of the actuator 27 and a pair of guides 23 for the bracket 25 can be seen. Both the actuators 26 and 27 are preferably actuators of double effect type and can have for example pneumatically operated cylinders.

**[0044]** By varying the dispensing axis of the spray dispensing devices 20, the utilization space of the robot 10 can be widened. In Figures 9A and 9B the relative position taken by the spray dispensing devices 20 with respect to the supporting frame 30 is schematically shown. In Figure 9A the devices 20 are arranged with substantially horizontal dispensing axis 22a and the frame 30 can be tilted forward by the robot to allow the paints reaching the lower surfaces of the pieces to be painted.

**[0045]** In Figure 9B the devices 20 have dispensing axis 22b tilted downwards while the frame 30 is brought by the robot closer to the spray dispensing devices 20, up to a position adequate to apply paint also on the upper surfaces of the pieces. Especially in this position, in which the spray dispensing devices 20 are particularly closely spaced, it can be appreciated the usefulness of the protecting screen, or disc, 17, that prevents, or at least limits, possible unwanted paint deposits or splashes directed towards the robot wrist.

**[0046]** Regardless of the various positions taken by

the supporting frame 30 during the painting, the pin 13 integral with the robot 10 and the post 33 of the frame 30 are kept with the respective axes aligned and coplanar with the rotation axis of the wrist of the robot 10.

**[0047]** In Figures 10A and 10B an embodiment is shown, wherein one of the spray dispensing devices 20 is mounted on a rotary actuator 24 to make it rotatable between at least two stable positions around an axis coincident with its own dispensing axis 22. In the position of Figure 10A, the largest section D of the dispensing cone is in a substantially vertical position, whereas in the position of Figure 10B the spray dispensing device 20 has been rotated by 90° such that the prevailing dimension D of the dispensing cone is substantially horizontal.

**[0048]** In the side views of Figures 11A and 11B the two positions taken by the dispensing device 20 are schematically depicted. In Figure 11A the position is the same as the one depicted in Figure 10A, in which the largest section D is substantially vertical, whereas in Figure 11B, the position of the dispensing device 20 corresponds to that of Figure 10B, with the largest section D of the dispensing cone arranged horizontally and the smallest section d arranged vertically.

**[0049]** In Figure 12 another embodiment is depicted, in which it is provided for example that at least one dispensing device 20' is made up of a rotary atomizer.

**[0050]** In the embodiment of Figure 13 at least one dispensing device 20" is provided and constituted by an electrostatic atomizer. The paint particles can be for example negatively charged, whereas the pieces P subjected to painting are positively charged. It is however apparent that the electrostatic charges can be reversed as compared to what herein depicted in Figure 13.

**[0051]** Various modifications can be made to the embodiments herein depicted for illustrative purposes, without departing from the scope of the present invention as defined by the attached claims. For example, the number and combination of the spray dispensing devices 20, 20', 20" can also be different from the herein depicted one, depending upon the types and number of different paints to be applied. In addition, the dispensing devices can for example be suspended from the ceiling of chamber 40 rather than assembled on a fixed structure 21.

## Claims

1. A painting plant, comprising at least one supporting frame for pieces to be painted, one or more spray-painting dispensing devices installed on a fixed structure and an anthropomorphous robot having releasable-engagement means assembled on the end thereof to move said at least one supporting frame with respect to said spray dispensing devices while pieces are painted, **characterized by** comprising a drawing apparatus with drawing openings to draw the air flow, which are facing said spray dispensing devices, wherein the base of said anthropomor-

phous robot is arranged upstream of said spray dispensing devices with respect to the direction and way of the air flow drawn by said drawing apparatus, and in that the base of said anthropomorphous robot is arranged upstream of said spray dispensing devices with respect to the direction and way of paint dispensing by said spray dispensing devices.

2. The plant according to claim 1, wherein said anthropomorphous robot is a six axis robot, and wherein a screen is mounted perpendicular to the rotation axis of the wrist of said anthropomorphous robot for protecting the wrist articulation of said anthropomorphous robot.
3. The plant according to claim 1, wherein said releasable-engagement means include a pin adapted to be fitted in a hollow post of said at least one supporting frame, said pin and said post having axes aligned and coplanar with the rotation axis of the wrist of said anthropomorphous robot when said at least one supporting frame is engaged with said anthropomorphous robot and the spray-painting dispensation is activated.
4. The plant according to claim 1, **characterized by** comprising one or more deposit stations provided with hooking means for resting said at least one supporting frame when the latter is released by said anthropomorphous robot and/or for picking-up said at least one supporting frame by said anthropomorphous robot.
5. The plant according to claim 4, wherein said supporting frame comprises at least one element integral with said post for coupling with said hooking means of said one or more deposit stations.
6. The plant according to claim 1, wherein at least one of said spray dispensing devices is movable between at least two positions with respect to said fixed structure in order to vary the dispensation axis of said spray dispensing device with a translation and/or rotation movement, by keeping said dispensing axis in a single plane.
7. The plant according to claim 1, wherein at least one of said spray dispensing devices is rotatable between at least two stable positions around an axis coincident with its own dispensing axis.
8. The plant according to claim 1, wherein at least one of said spray dispensing devices is a rotary atomizer.
9. The plant according to claim 1, wherein at least one of said spray dispensing devices is an electrostatic atomizer.

10. A painting method, comprising the steps of:

- a) providing at least one supporting frame for the pieces to be painted, one or more spray-painting dispensing devices installed on a fixed structure and an anthropomorphous robot having releasable-engagement means assembled on the end thereof to move said at least one supporting frame with respect to said spray dispensing devices;
- b) moving said at least one supporting frame by an anthropomorphous robot with respect to said spray dispensing devices during the painting, wherein said anthropomorphous robot has releasable-engagement means assembled on the end thereof to bear said at least one supporting frame,

**characterized by** providing drawing with drawing openings to draw the air flow facing said spray dispensing devices, wherein the base of said anthropomorphous robot is arranged upstream of said spray dispensing devices with respect to the direction and the way of the air flow drawn by suction, and in that the base of said anthropomorphous robot is arranged upstream of said spray dispensing devices with respect to the direction and the way of paint dispensation by said spray dispensing devices.

11. The method according to claim 10, wherein said anthropomorphous robot is a six axis robot, and wherein a screen is provided perpendicularly to the rotation axis of the wrist of said anthropomorphous robot for protecting the wrist articulation of said anthropomorphous robot.
12. The method according to claim 10, wherein said releasable-engagement means include a pin adapted to be fitted in a hollow post of said at least one supporting frame, **characterized by** keeping said pin and said post with the respective axes aligned and coplanar with the rotation axis of the wrist of said anthropomorphous robot when said at least one supporting frame is connected to said anthropomorphous robot and the spray-painting dispensation is activated.
13. The method according to claim 10, **characterized by** resting said at least one supporting frame on hooking means of at least one deposit station when it is released by said anthropomorphous robot and/or picking-up said at least one supporting frame from said deposit station by said anthropomorphous robot.
14. The method according to claim 10, wherein at least one of said spray dispensing devices is moved between at least two positions with respect to said fixed

structure in order to vary the dispensation axis of the spray dispensing device with a translation and/or rotation movement by keeping said axis in a single plane.

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15. The method according to claim 10, wherein at least one of said spray dispensing devices is rotated between at least two stable positions around an axis coincident with its own dispensing axis.

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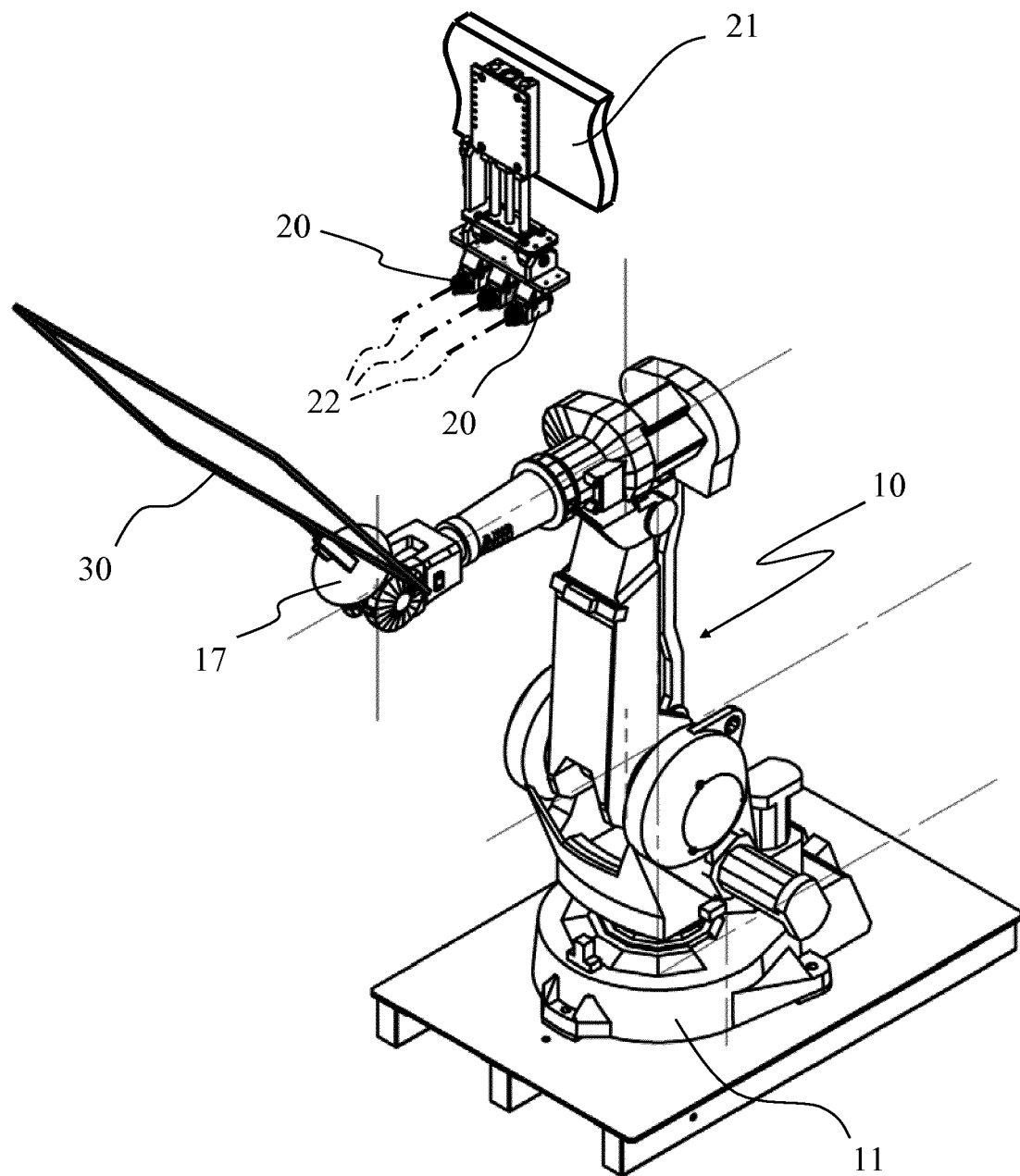


Fig. 1

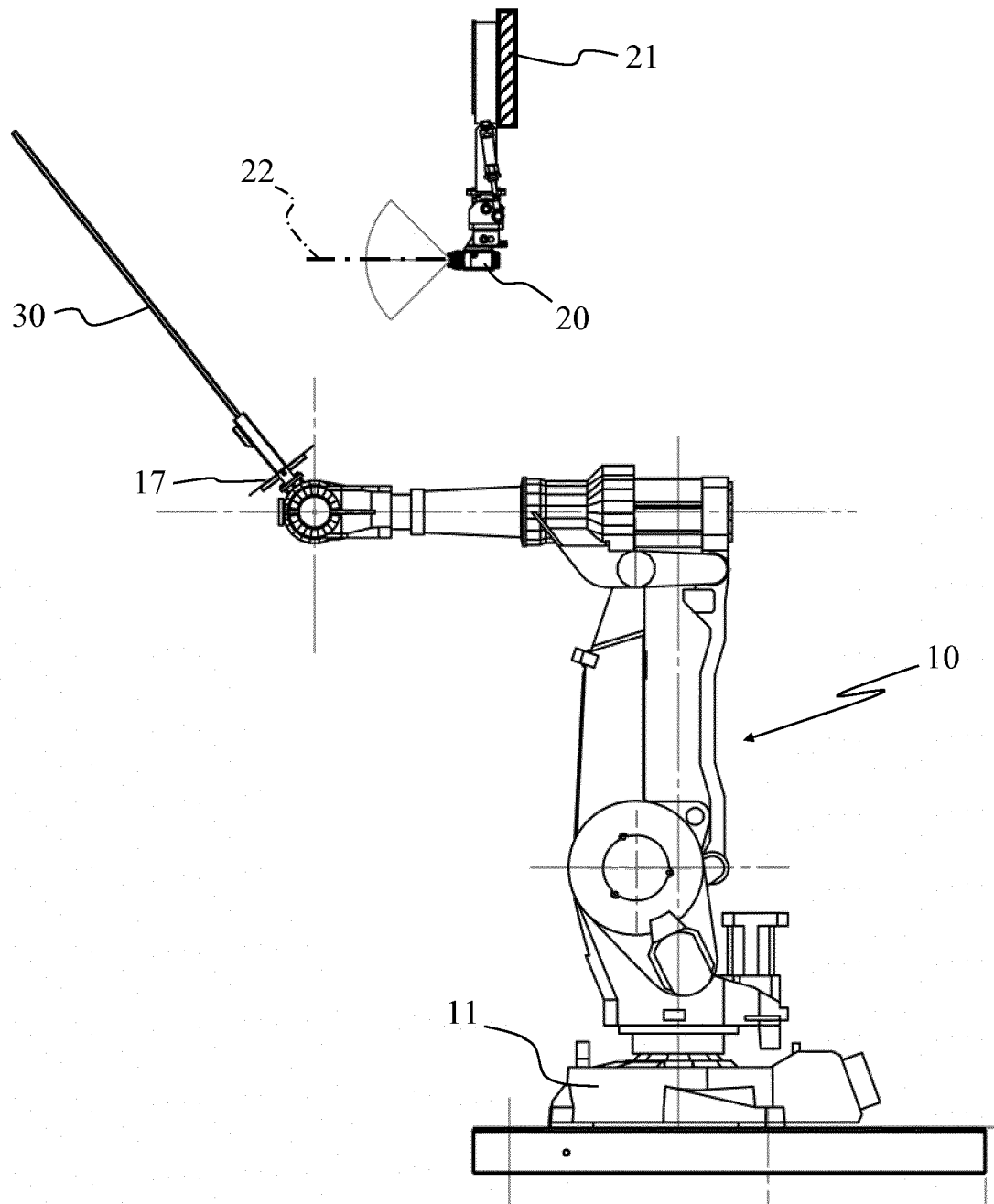


Fig. 2

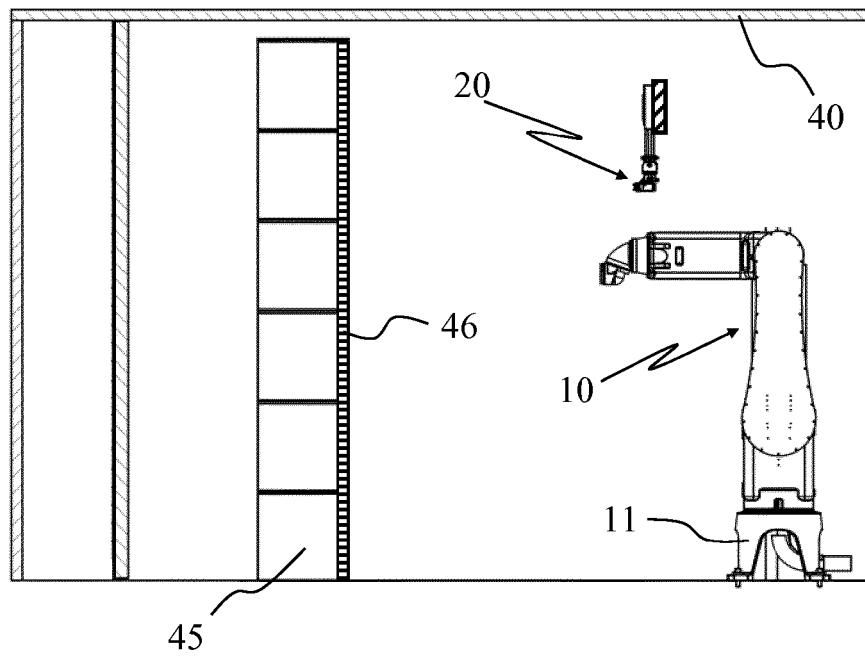


Fig. 3

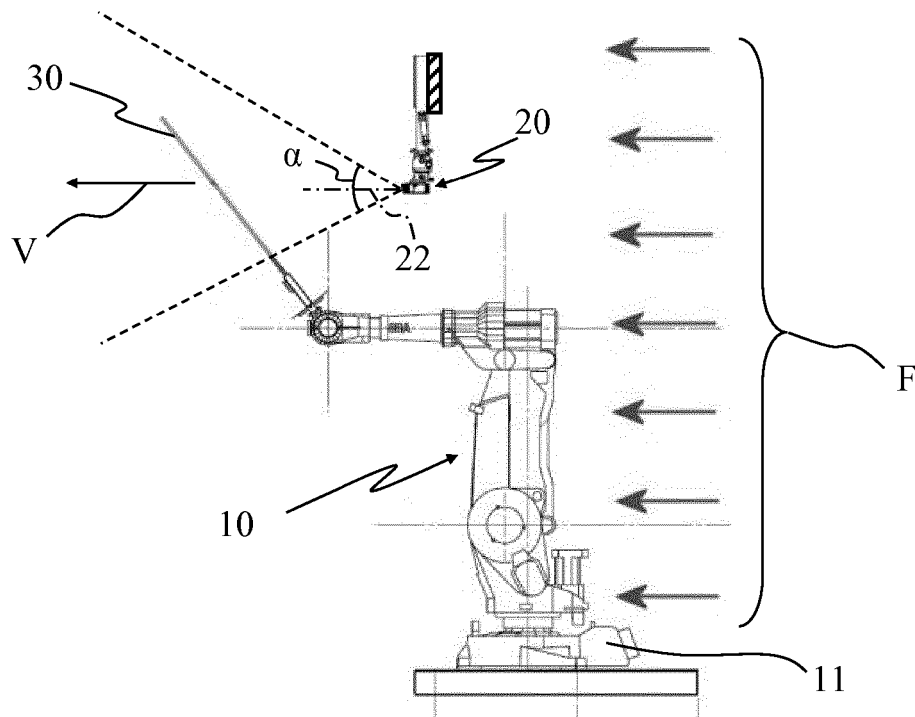


Fig. 4

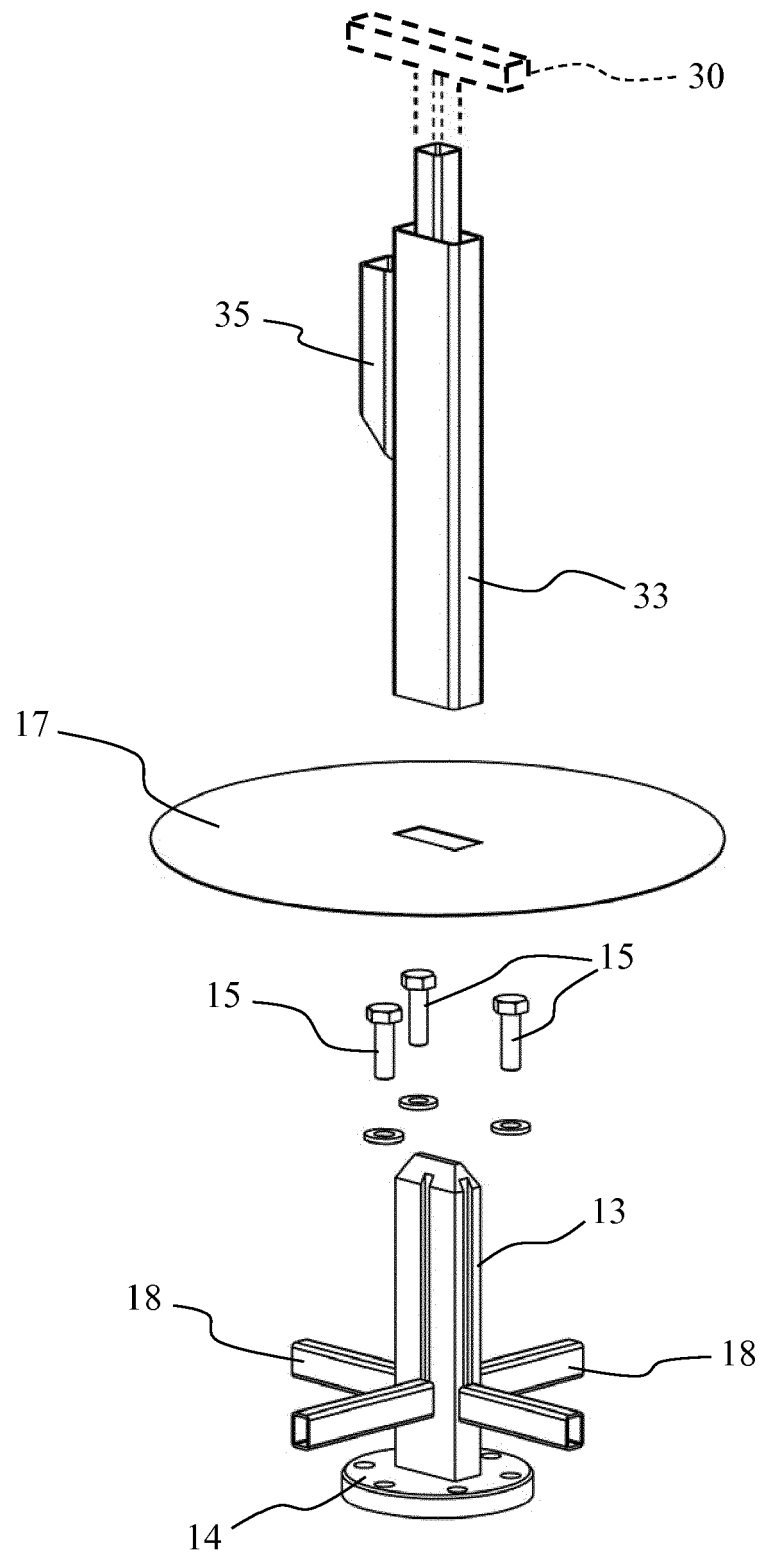


Fig. 5

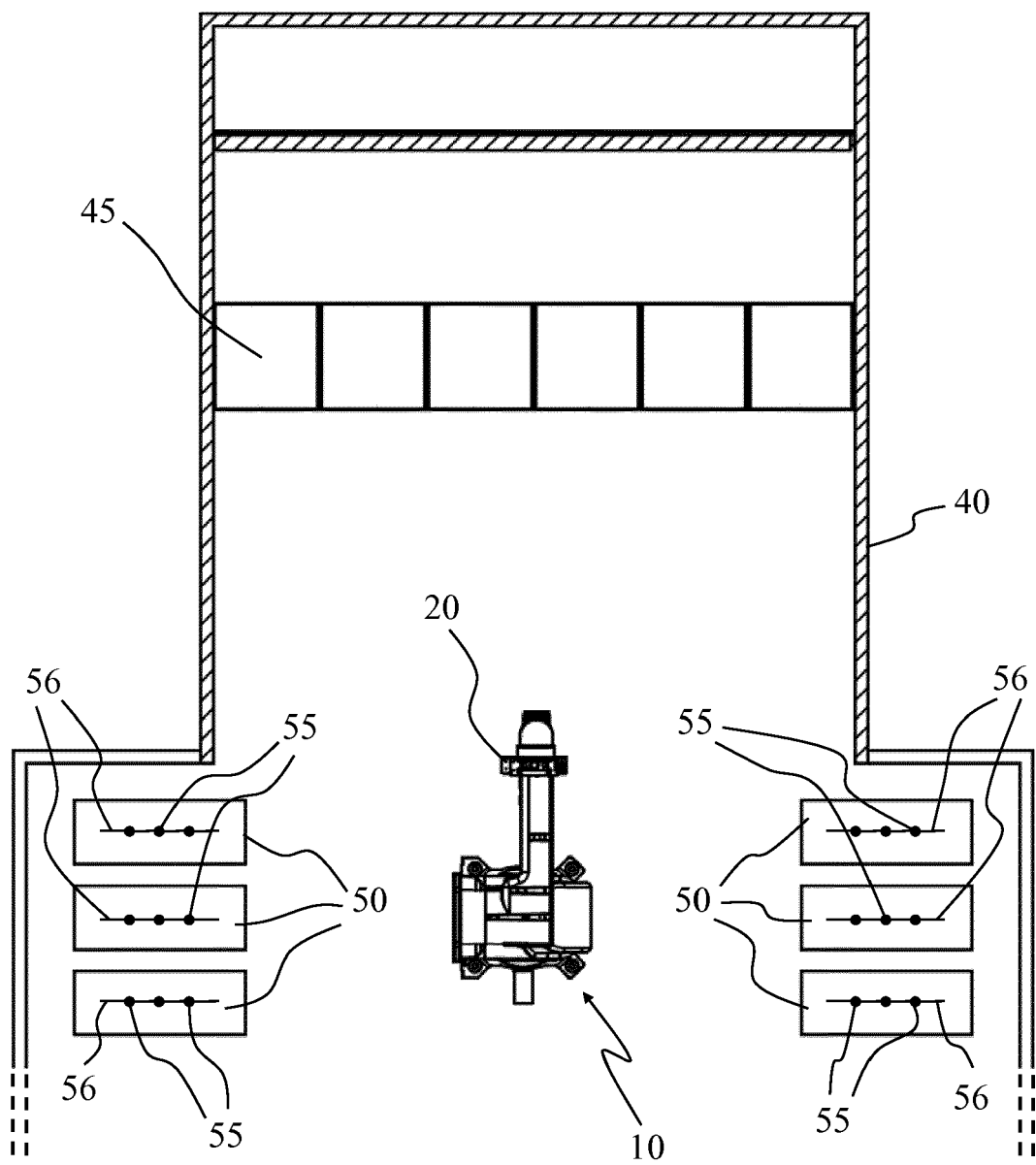


Fig. 6

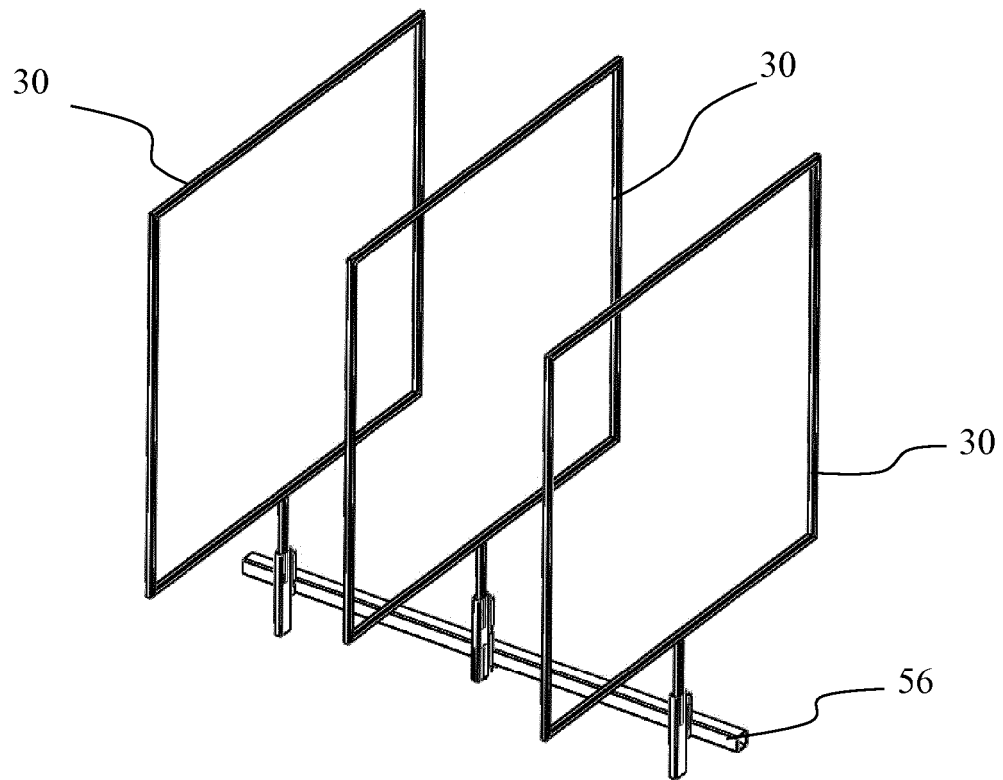


Fig. 6A

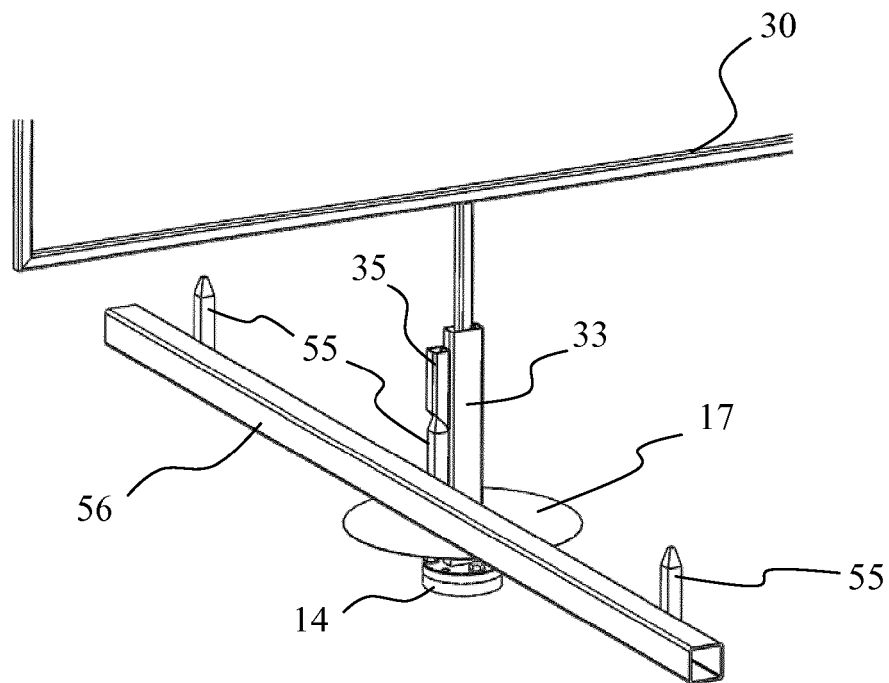


Fig. 6B

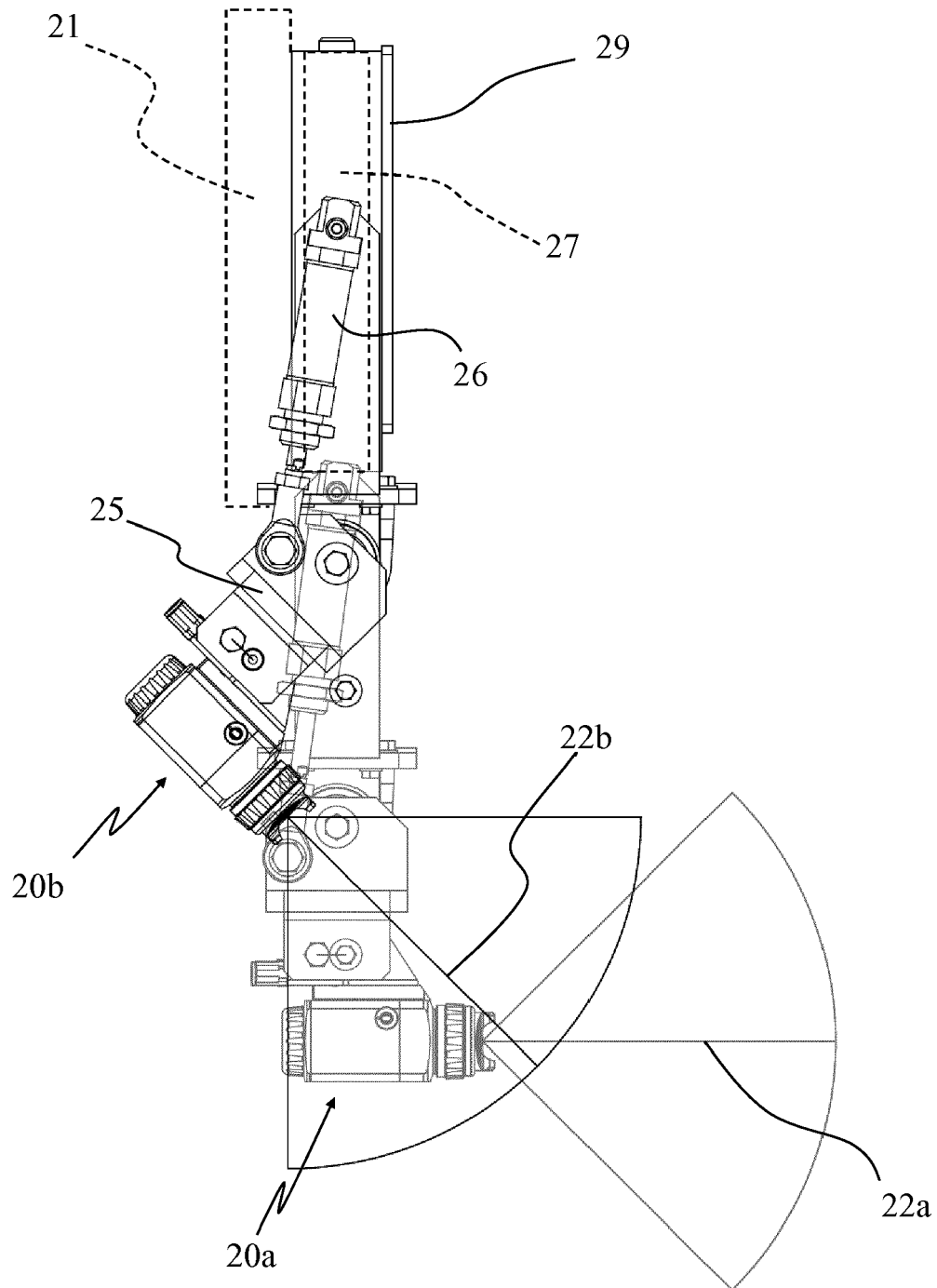


Fig. 7

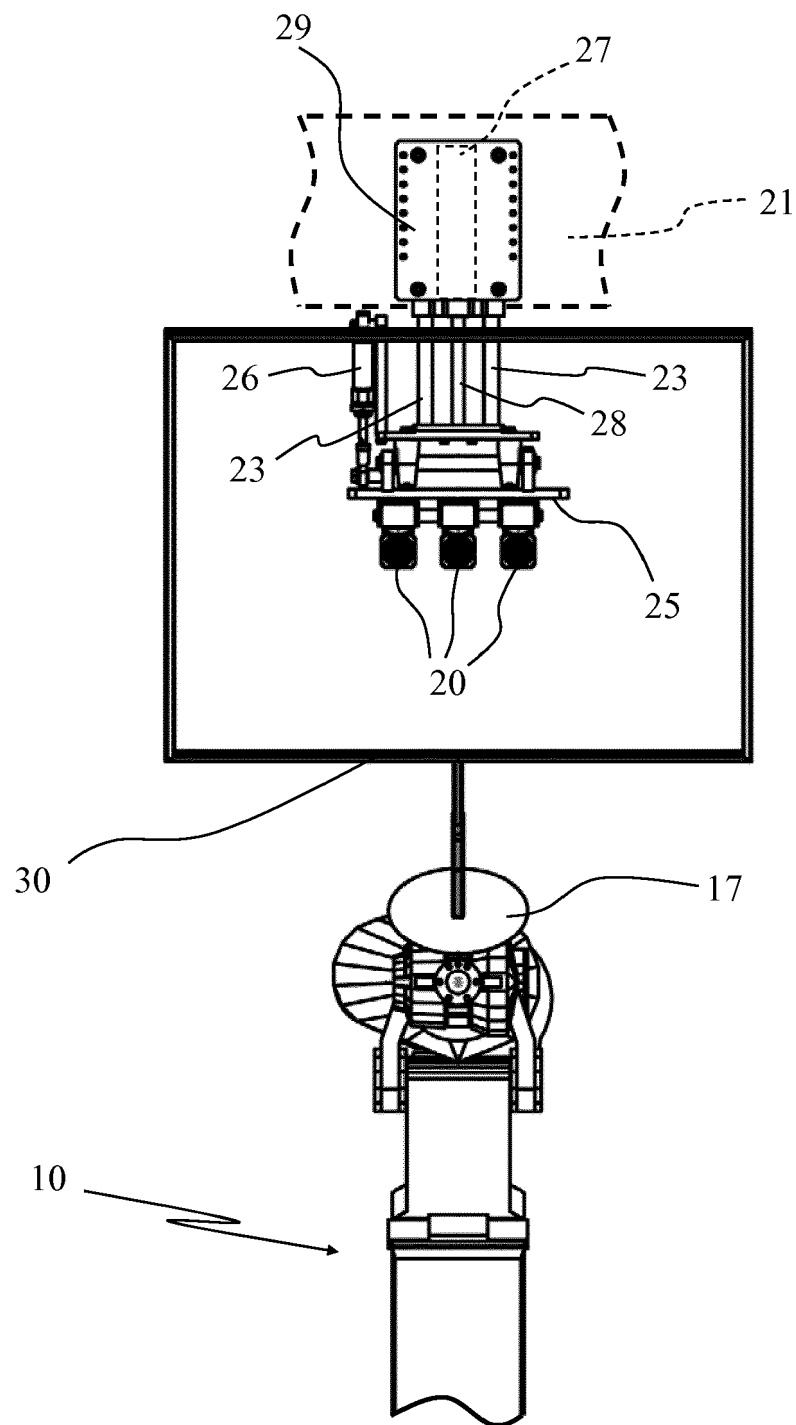


Fig. 8

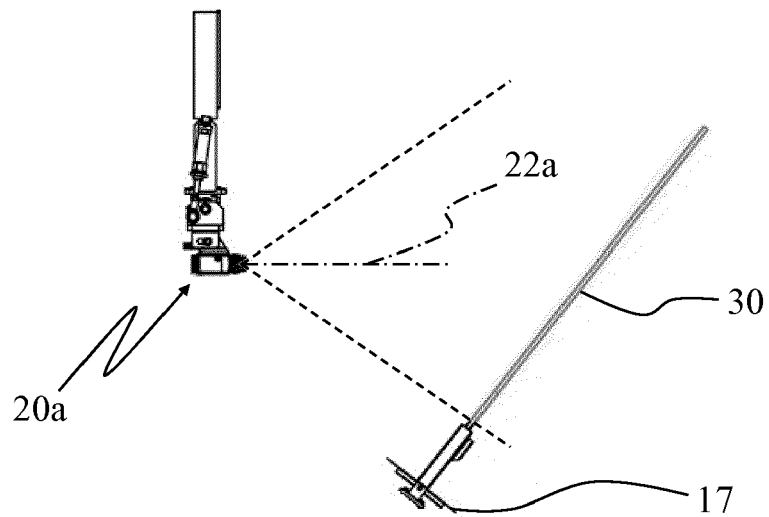


Fig. 9A

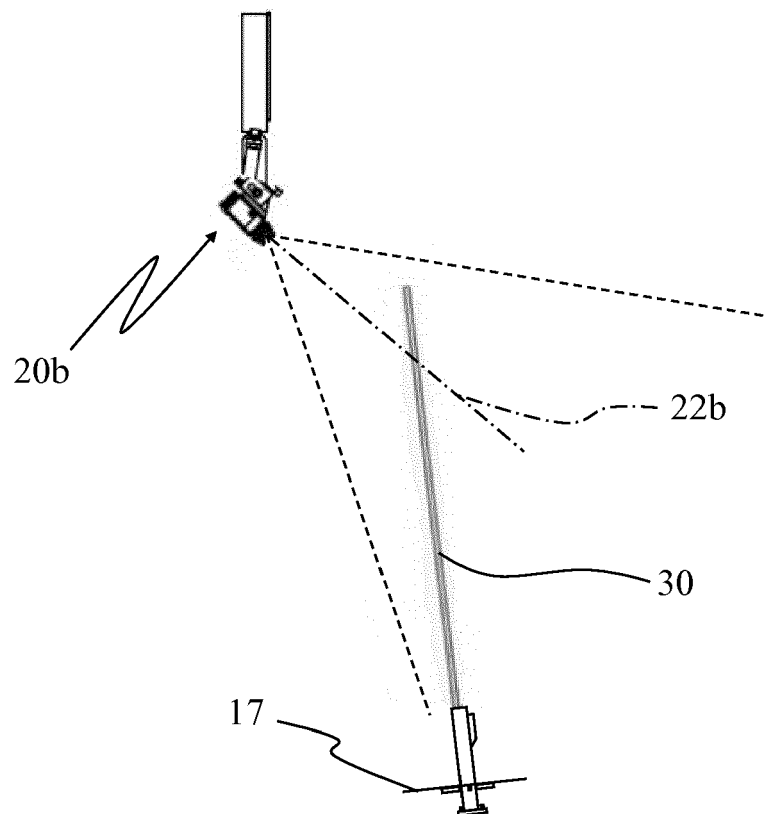


Fig. 9B

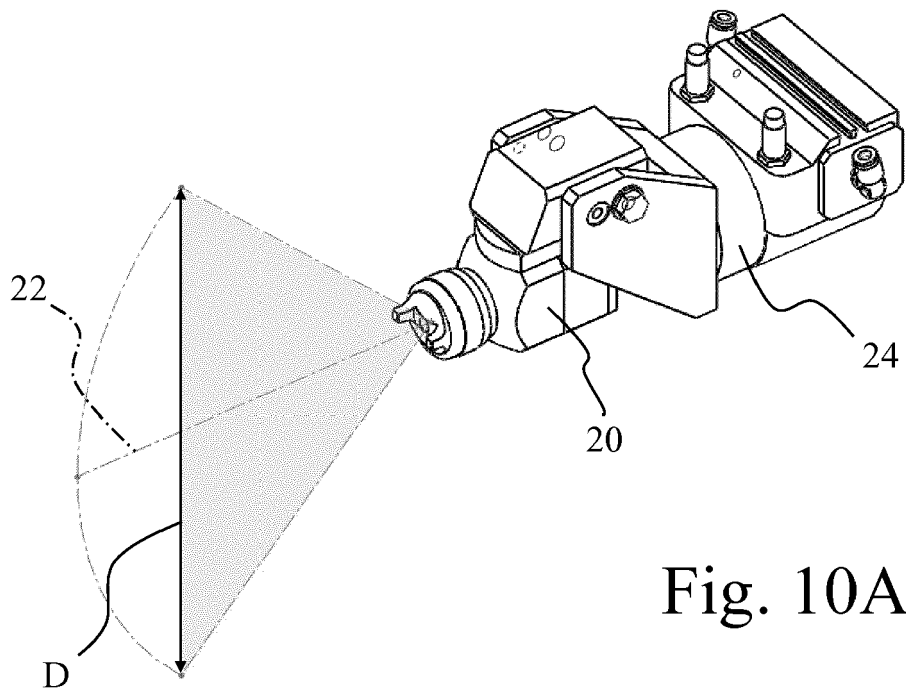


Fig. 10A

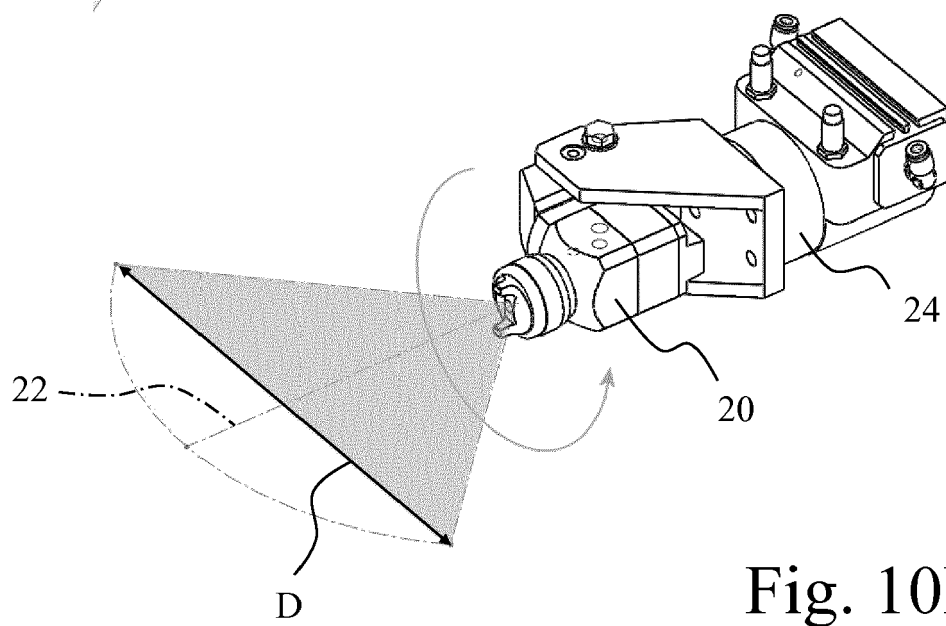


Fig. 10B

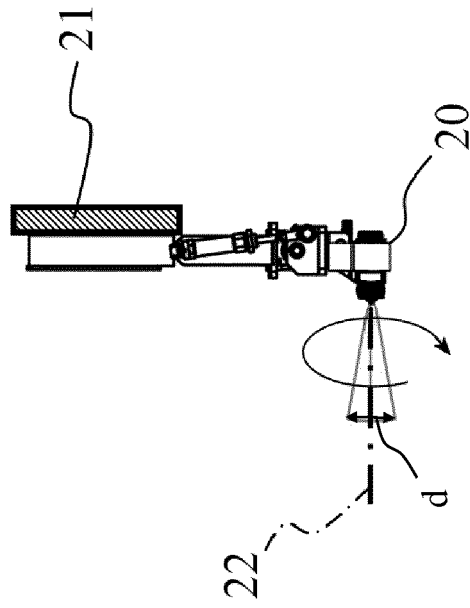


Fig. 11B

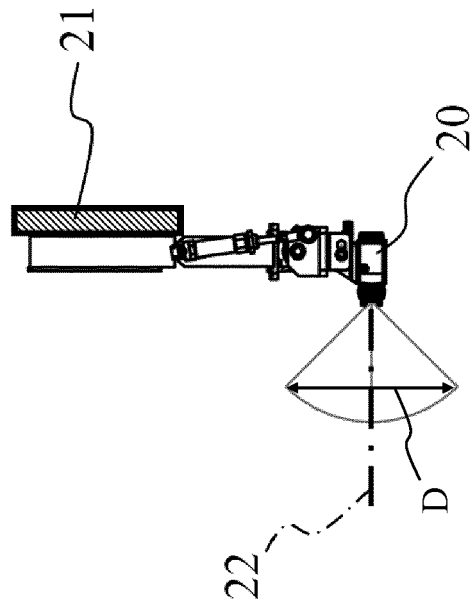


Fig. 11A

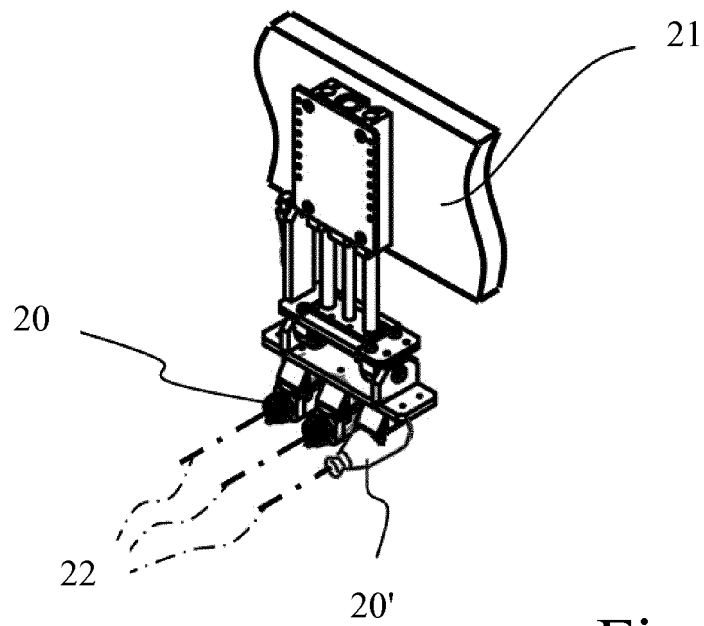


Fig. 12

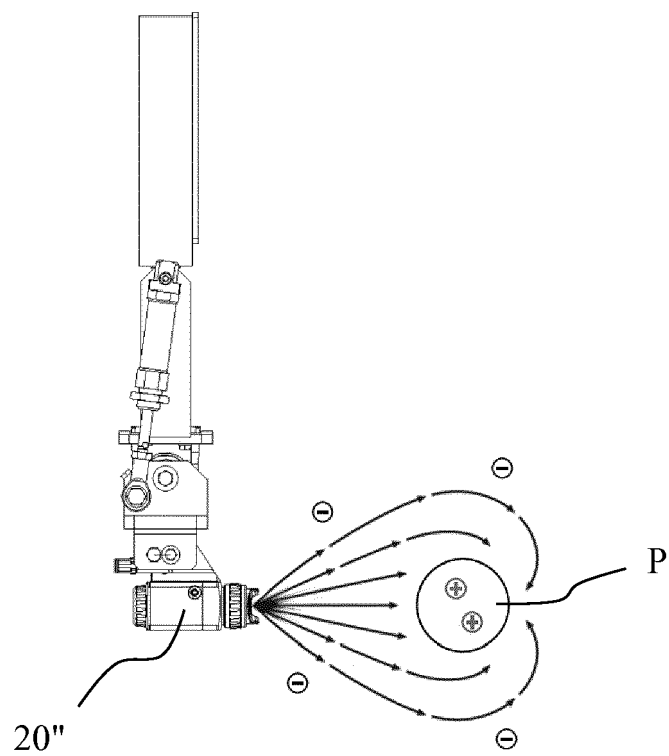


Fig. 13



## EUROPEAN SEARCH REPORT

 Application Number  
 EP 17 15 7046

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2002/023585 A1 (SASHIHARA KOUICHI [JP]) 28 February 2002 (2002-02-28) * abstract; figure 2 * * paragraph [0041] * * paragraph [0047] *	1-15	INV. B05B13/02
A	WO 2015/079685 A1 (AKEBONO BRAKE IND [JP]) 4 June 2015 (2015-06-04) * the whole document *	1-15	
A	EP 1 745 858 A2 (DUERR SYSTEMS GMBH [DE]) 24 January 2007 (2007-01-24) * the whole document *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			B05B
The present search report has been drawn up for all claims			
Place of search <b>Munich</b>		Date of completion of the search <b>16 May 2017</b>	Examiner <b>Moroncini, Alessio</b>
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