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Device for the inspection of wind power plants

The invention relates to a device for inspection, cleaning or other types of examination of objects, e.g. rotor blades of wind power plants.

Such a device in the form of a robot for the inspection of rotor blades of wind power plants is known from WO 2014/059964 A1. The robot is equipped with a number of propellers for a flight movement of the robot, which can be used to control the height position of the robot, e.g. the frame structure of the latter, in relation to the ground or the nacelle of the wind power plant (WPP).

EP 1 583 905 A2 discloses a device for cleaning a rotor blade of a wind power plant.

The invention creates an effective, reliable device according to claim 1.

Further developments of the invention are stated in the dependent claims.

The invention allows easy and reliable positioning, e.g. vertical positioning of the device, e.g. a frame structure or a robot or a different examination device or cleaning device.

The invention thus provides an alternative suspension and position control of a device, for example a robot according to WO 2014/059964 A1, via a cable suspension, e.g. a cable pull-in.

The apparatus or a device has a frame structure for the examination of an installation such as a rotor blade for the inspection, cleaning, or maintenance of the same, with a cable pull-in on which the frame structure is suspended such that it can be adjusted in the vertical direction by movement of the cable pull-in, and with one or more propellers or rotor(s) for a movement of the frame structure in the horizontal direction. The frame structure comprises respectively one, preferably two, or more rotors for horizontal adjustment of the frame structure.

The device may have a cable winch, which carries the weight of the frame structure or a system via cables and a deflection roller, and is connected to cables for height adjustment and positioning of the frame structure or the system in a y axis on the blade of a wind power plant.

Cables may be connected from the deflection roller to junctions, and, if applicable, two cables may be respectively guided from the junctions as a V to respective corners of the frame structure or the system.

Cables from one respective junction may be connected to the frame structure or the system, and with deflection rollers provided at the four corners of the frame structure or the system to the cable pull-in.

The device may have at least one cable pull-in for moving a cable on or in the frame structure or system, wherein the cable pull-in contains a respective linear drive or is formed by a drum winch or cable winch.

The device may have apparatuses for inspection and examination of the installation or of a rotor blade of a wind power plant.

The device may comprise a robot for inspecting rotor blades of wind power plants.

The device according to one of the preceding aspects, in particular a robot for inspection of rotor blades of wind power plants, wherein the frame structure has an inner opening surrounding a rotor blade in use, one or more propellers arranged on the frame structure, and a status detection system attached to the frame structure for preferably contact-free examination of the rotor blades.

The device according to one of the preceding aspects may have a docking and/or guiding device for docking and/or guiding a robot on the rotor blade,

in which the docking and/or guiding device preferably has one or more adjustable arms, and/or

in which the arms of the docking and/or guiding device are spring-preloaded and/or adjustable by a motor, and/or

the arms of the docking and/or guiding device are provided with a coating such as buffers or rubber buffers, and/or

the docking and/or guiding device is attached to the narrow sides of the frame structure, and/or

the docking and/or guiding device or arms thereof is motor drivable to move up or down along the rotor blade to be examined, and/or

the docking and/or guiding device or arms have at least one roller drivable thereby, which drives a rotating belt connected to the rotor blade or is in direct contact with the rotor blade to be examined in order to move the robot, optionally in cooperation with the propellers, along the rotor blade to be examined, and/or

a controller with an inverter or converter attached to the frame structure and serving to convert supply voltage supplied via the cable is provided, and/or

with two or more, preferably four groups of one or more, preferably four propellers each, mounted on the two long sides and/or transverse edges of the frame structure, and/or

the state detection system comprises at least one camera and/or an ultrasonic inspection device.

Device according to one of the preceding aspects, preferably having one or more bearing blocks and one or more cables by means of which the frame structure can be fixed to the ground or other components such as a building or vehicle or any other configuration, in such a way that its height can be variably adjusted and thus the height of the system or robot can be variably adjusted.

Device or system according to one of the preceding aspects, preferably having one or more additional winches over which one or more cables for height adjustment can be guided below the frame structure or the system.

System with a device, in particular a robot, according to one of the preceding aspects, preferably comprising a station installed in a fixed or mobile

manner, e.g. a control and evaluation station, and/or a cable for connecting a robot to the station, and/or a cable haulage and/or one or more propellers.

Device or system according to one of the preceding aspects, preferably having a cable, e.g. a power and/or data cable for connecting the robot to the station, in particular a control and evaluation station, located e.g. on the ground or on a vehicle.

Device or system according to one of the preceding aspects, having at least one damper, spacer, or stabilizer, which stabilizes the frame structure against a tower of the wind power plant or secures it against unwanted contacts. The damper can be extended telescopically, electrically, or hydraulically, wherein a spacer is arranged centrally on a frame or a pair of dampers or spacers is provided at both corners on the frame.

Further features and details of the present invention are described in more detail by reference to the attached drawings. These show:

Fig. 1 shows a side view of an embodiment with cable-control suspension of an examination device, for example a system or robot 2;

Fig. 2 shows a plan view or a schematic representation of the system 2, which may be a frame structure;

Fig. 3 shows a representation of a corner area of the device and the cable-control suspension;

Fig. 4 shows a side view of the embodiment according to Figures 1 to 3;

Fig. 5 shows a side view of a further embodiment with cable-control suspension and attachment to the ground or a stationary or movable embedment;

Fig. 6 illustrates a plan view in the form of a schematic diagram of the system 2 with frame structure and ground-side embedment;

Fig. 7 shows a further embodiment with attachment or support at a stationary or movable bearing piece below the system 2, which is, e.g., designed for smaller wind power plants with a nacelle height of, e.g., below 100 m, or preferably below 60 m or 30 m, relative to the distance to the ground or mast base of the WPP tower;

Fig. 8 shows configurations of an embodiment that is also designed for lower nacelle heights with a ground distance to the ground of, e.g., less than 150 m, 100 m, less than 60 m, or less than 30 m, relative to the distance between the nacelle center and the ground; and

Figs. 9 to 12 show embodiments where at least one additional damper, spacer, or stabilizer is provided to avoid unwanted, dangerous, or damaging contact between the tower 18 and the frame structure or the robot or examination device 2, so that a spacer is provided to ensure a distance to the tower 18 of the wind power plant.

As can be seen from the front view or side view according to Fig. 1, a winch 1 is provided on the ground or in a transporter or another type of transport vehicle so that the system 2 can be moved to the respective place of use. Via the winch 1, the vertical height position of the system 2, for example of a robot according to WO 2014/059964 A1, can be controlled. A deflection roller 3 is provided below a nacelle 4 of a wind power plant, WPP.

A blade body, for example a rotor blade 5 of the wind power plant having the nacelle 4, can be examined using the system 2.

A cable pull-in 6 can be provided for height adjustment in or on the system 2, for example the robot.

According to one or more embodiments, the cable pull-in 6 can consist of a linear drive. As an alternative or in addition to a linear drive, the cable pull-in 6 can also be formed by a drum winch or a cable winch. It is also possible to use these configurations together.

A deflection roller 7 can be provided on or in the system 2, i.e. for example the robot 2, e.g. as shown in Fig. 3.

One or more propellers 9 for positioning in the direction of the direction x, i.e. in the x axis direction, as shown in Fig. 2, allows the lateral or horizontal position of the robot to be adjusted. One or more further propellers 10 allow positioning of the horizontal position of the robot or a different examination device 2 in the direction of the axis y according to Fig. 2.

Corners 11 of the system or the robot 2 are shown in more detail in Fig. 3.

A cable 12 of the cable pull-in 6 runs from winch 1 to the deflection roller 3 and via it to the robot 2 or the frame structure or other configurations of the device 2. According to the side view in Fig. 1, one or more junctions 14, see Fig. 1, may be provided to connect cables 13 to the cables 15, wherein, starting from the junction 14, the cables 15 are each connected to the system 2, via the deflection rollers 7 at the four corners 11 of the system 2 to the cable pull-in 6.

In the embodiment according to Fig. 1, the cable winch 1 is provided for vertical or horizontal positioning of the device, for example the robot 2. The positioning can be done in the direction of the axis y while maintaining the vertical height of the system 2. The cable winch 1 is located on the floor, in a transporter, or in a carrying frame which can be stationary or movable in the horizontal direction.

The cable winch 1 takes over the weight of the system 2 via the cables 12, see e.g. Fig. 4. The cables 12 can be connected to the cable 13 via the deflection roller 3 and further on to the junction(s) 14. Via the cables 12, 13, 15 and the cable winch 1, precise height control and positioning of the system 2 in the

direction of the y axis on the system 2 or blade 5 of the wind power plant (WPP) can be controlled.

From the winch (cable winch) 1 to the system or robot 2 for the inspection, examination, or other checking of one respective rotor blade 5 of the wind power plant at a time, tensioning a cable 12 from the winch 1 over the deflection rollers 3 and connecting this cable 12 with the cables 13 is provided as a cable guide. The cables 13 each consist, for example, of two cables which are tensioned in the form of a V from the deflection roller 3 to the junctions 14 or which are or can be connected to these. From the junctions 14, two cables 15 can be or are connected in the form of a V to the respective corners 11 of the system 2.

In the embodiment, a horizontal position control can be achieved on the system 2 using cable pull-ins. The horizontal position control can be achieved by one or more cable pull-ins 6, whereby a linear axis is realized. Here, the cables 15 of the cable pull-ins 6 are connected at all four corners 11 of the system 2, whereby the horizontal position control is ensured. At all four corners 11 of the system 2, the cables 15 are pulled in or out via a deflection roller using a linear axis in or on the frame of the system 2, in order to ensure a horizontal position of the system 2. The horizontal position control is detected and controlled by an electronic angle measurement. For this purpose, an electronically operating angle measuring device is provided, the measurement results of which are compared with a target angle or the corresponding horizontal target position specified electronically or by the system 2 and are used for horizontal position control.

In the described and shown embodiment, a feed control and direction control can be achieved in the x axis and the z axis by propellers 9, 10. Thrust and pulling propellers 9 are provided at the outside edges of the system or frame structure 2 in the embodiment according to Fig. 4. Lateral positioning in the z axis is ensured by propellers 10 which are provided at the outer edge regions of the frame structure 2 as shown in Figs. 4 and 1. Hereby the lateral positioning in the z axis can be ensured by the propellers 10. The exact distance to the tower of the wind power plant (WPP tower) is measured by a laser in the embodiment and

correlated via a GPS system. This also allows the exact angle to the tower and to the blade of the wind power plant to be maintained and checked, so that correct threading of the system 2 within the frame of the frame structure can be maintained and checked.

The propellers can be arranged in different groups. For example, two propellers 10 or two propellers 9 can be provided on each side edge, as can be seen for example in Fig. 1, Fig. 2, and Fig. 4. Preferably, two propellers are provided per side border, but it is also possible to provide four propellers or only one propeller per side border or more than two propellers 9, 10.

The details described above and shown in these and the further drawings may be combined in any free form and number in further embodiments of the invention, and may also be combined in any way with all configurations and embodiments according to the above-mentioned WO2014/059964A1, thus creating independent embodiments. The scope of protection, however, is defined by the claims.

The frame structure 2 and the corresponding system contain the measuring and evaluation units required for the measurement, retrieval and exploration of the blade 2 and/or can be connected to them via corresponding signal paths or measuring paths and evaluation paths.

In the embodiment as shown in Fig. 2, the axis z which is not shown runs at right angles to the axes x, y shown in Fig. 2. In the representation according to Fig. 1, this corresponds to a course which points upwards and downwards with respect to frame structure 2, i.e. at right angles to the two parallel lines of the frame structure 2 shown.

The embodiment according to Fig. 5 has the components according to the embodiment according to Fig. 1 already described above. In addition to the components of the embodiment shown in Fig. 1 (and Figs. 2 to 4), the embodiment shown in Figs. 5 to 8 has an additional, ground-side embedment via bearing blocks 17, to which cables 16 are attached, which are guided to the

system 2 via rollers or pulleys 19, allowing height adjustment of the frame structure 2 or the robot.

In the embodiment according to Fig. 5, a respective cable 16 is led to each deflection roller 19 and the frame structure 2. The desired height of the system 2 can thus be adjusted as desired by means of the block 17 which serves as a bearing block. Cables 19a can be connected to the frame structure 2.

In the embodiment according to Fig. 6, the components of the embodiment according to Fig. 5 are not shown in detail, whereby the bearing blocks 17 are schematically indicated, which are mounted below the frame structure on the floor side or in a variable manner on a height-adjustable or vertically or horizontally slidable element.

In the embodiment according to Figs. 7 and 8, in addition to the embodiment according to Figs. 3 and 4, an additional bearing according to the bearing block or block 17 is provided, which ensures embedment and securing of the system 2 even in gusts of wind or the like.

As can be seen from Figs. 7 and 8, similar to the embodiment according to Figs. 5 and 6, an additional embedment to the ground via components 16, 17, etc. is provided, whereby this design is also suitable for higher wind power plant heights, but is preferably used for lower wind power plant heights of the wind turbines of, for example, below 60 m or below a value between 10 m and 150 m.

The other designs according to the embodiments in Figs. 5 to 8 correspond in part to the embodiments in Figs. 1 to 4, unless otherwise or differently described above.

The embodiments described above and shown in the drawings can be modified in any way to adapt to the application height or test safety. The system 2 can be designed with regard to its configuration in a manner corresponding to the variation of embodiments 1 to 4 described above, whereby the frame

structure 2 and the system can also be designed in the manner described above or known from WO 2014/059964 A1.

In the embodiment according to Figs. 9 and 10, an additional damper or stabilizer 18 is provided, for example, acting horizontally or with a horizontal component. The damper, spacer, or stabilizer 18 can be designed as a telescopically extending configuration, but can also have a fixed, extended length. In Figs. 9 to 12, the tower of the wind power plant WPP is marked with the reference sign 19. The spacer 18 can, for example, be designed as a telescopically extendable shock absorber, can be additionally or alternatively designed as a damper or stabilizer that can be extended hydraulically or electrically in horizontal direction. The stabilizer 18 can be arranged as a damper on the left and/or right side of the robot 2 or the frame structure. Alternatively, the damper or spacer 18 can also be arranged centrally on the frame 2. Alternatively or additionally, one damper or spacer 18 can be provided as a pair at one or both or all corners of the frame 2, so that the frame 2 can be suspended halfway. As can be seen in Fig. 10, the spacer 18 can be located between the frame structure 2 and the tower 19 essentially in the middle.

Figs. 11, 12 show the support and securing of the frame structure 2 and thus of the robot and examination device in relation to the tower 19. By this also a protection or stabilization opposite the tower 19 is achievable. Due to the design of the damper 18, which can be moved in the horizontal direction like a telescope, vibrations of the frame structure or the robot 2 can be reliably avoided. Due to the horizontal shock absorption, the vertical suspension or securing of the robot 2 can be simplified even further, since now, for example, only a single cable or a pair of cables 16 is required to achieve a floor-side embedment.

All configurations of the embodiments described above and/or shown in the drawings can be combined in any way with each other and, for example, with the configurations according to WO 2014/059964 A1, thus creating independent embodiments. The scope of protection, however, is defined by the claims.

Patentkrav

1. Apparat med en rammekonstruktion (2) til undersøgelse af en indretning såsom en rotorvinge af et vindenergianlæg med henblik på inspektion, rengøring eller vedligeholdelse af samme, med et kabelindtræk (6), på hvilket rammekonstruktionen (2) er ophængt på en sådan måde, at den kan indstilles i vertikal retning ved bevægelse af sejlindtrækket, og med en eller flere propeller eller rotor/er til en bevægelse af rammekonstruktionen (2) i horisontal retning.

2. Apparat ifølge krav 1, hvor rammekonstruktionen er en robot til undersøgelse af indretningen såsom en rotorvinge.

3. Apparat ifølge et af de foregående krav, med et kabelspil, som bærer vægten af rammekonstruktionen (2) via kabler (12) og en styretrisse (3) og er forbundet med kabler (15) til en højderegulering og positionering af rammekonstruktionen (2) i en y-akse på vingen (5) af et vindenergianlæg.

4. Apparat ifølge et af de foregående krav, hvor kabler er forbundet fra styretrissen (3) til knuder (14), og der eventuelt fra knuderne (14) er ført respektivt to kabler (15) som V til respektive hjørner (11) af rammekonstruktionen (2).

5. Apparat ifølge et af de foregående krav, hvor kabler (15) fra respektivt en knude (14) er forbundet med rammekonstruktionen (2), og med styretrisser (7), som er til stede på de fire hjørner (11) af rammekonstruktionen (2) til kabelindtrækket (6).

6. Apparat ifølge et af de foregående krav, med mindst et kabelindtræk (6) til bevægelse af et kabel på eller i rammekonstruktionen (2), hvor kabelindtrækket (6) indeholder respektivt et lineardrev eller er dannet af et tromlespil eller et kabelgennemløbsspil.

7. Apparat ifølge et af de foregående krav, med anordninger til inspektion og undersøgelse af indretningen eller en rotorvinge af et vindenergianlæg.

8. Apparat ifølge et af de foregående krav, med en robot til inspektion af vindenergianlægs rotorvinger.

9. Apparat ifølge et af de foregående krav, hvor rammekonstruktionen (2) har en indvendig åbning, som omgiver en rotorvinge i anvendelse, en eller flere propeller, der er anbragt på rammekonstruktionen (2), og et tilstandsregistreringssystem, som er anbragt på rammekonstruktionen, til fortrinsvis berøringsfri undersøgelse af rotorvingerne.

10. Apparat ifølge et af de foregående krav, med en koblings- og/eller føringsindretning til kobling og/eller føring af en robot på rotorvingen,
hvor koblings- og/eller føringsindretningen har fortrinsvis en eller flere indstillelige arme, og/eller
hvor armene af koblings- og/eller føringsindretningen er fjederspændte og/eller er motorisk indstillelige, og/eller
armene af koblings- og/eller føringsindretningen er forsynet med en coating såsom buffere eller gummibuffere, og/eller
koblings- og/eller føringsindretningen er anbragt på smalle sider af rammekonstruktionen, og/eller
koblings- og/eller føringsindretningen eller armene af samme kan drives motorisk for at bevæge sig opad eller nedad langs rotorvingen, der skal undersøges, og/eller
koblings- og/eller føringsindretningen eller armene har mindst en rulle, som kan drives af disse, og som driver en omløbende rem, der er forbundet med rotorvingen, eller som direkte er i berøring med rotorvingen, der skal undersøges, for at bevæge robotten, eventuelt i samvirke med propellerne, langs rotorvingen, der skal undersøges, og/eller
en styring med en vekselretter eller omformer, som er anbragt på rammekonstruktionen og er tilvejebragt til omdannelse af forsyningsspænding, der tilføres via kablet, og/eller
med to eller flere, fortrinsvis fire grupper af respektivt en eller flere, fortrinsvis fire propeller, som er anbragt på de to langsgående sider og/eller tværgående kanter af rammekonstruktionen, og/eller
tilstandsregistreringssystemet har mindst et kamera og/eller en ultralydsundersøgelsesindretning.

11. Apparat ifølge et af de foregående krav, med en eller flere lejebukke (17) og et eller flere kabler (16), via hvilke rammekonstruktionen (2) kan fastgøres på jorden eller andre komponenter såsom en bygning eller et køretøj eller en anden udførelsesform på en sådan måde, at det kan indstilles variabelt i sin højdeposition, og systemets (2) eller robottens højde således kan indstilles variabelt.

12. Apparat ifølge et af de foregående krav, med et eller flere yderligere spil (16, 17), via hvilke et eller flere kabler til højdeindstilling kan føres under rammekonstruktionen (2).

13. Apparat ifølge et af de foregående krav, med en fast eller mobilt installeret station, f.eks. en styre- og analysestation, og/eller et kabel til forbindelse af en robot med stationen og/eller et kabeltræk og/eller en eller flere propeller.

14. Apparat ifølge et af de foregående krav, med et kabel, f.eks. et strøm- og/eller datakabel til forbindelse af robotten med en station, der eksempelvis befinder sig på jorden eller på et køretøj, især en styre- og analysestation.

15. Apparat ifølge et af de foregående krav, med mindst en dæmper (18), afstandsholder eller stabilisator, som stabiliserer rammekonstruktionen (2) i forhold til et tårn (19) af et vindenergianlæg eller sikrer mod uønskede kontakter.

16. Apparat ifølge krav 16, hvor dæmperen (18) kan køres ud på en teleskopisk, elektrisk eller hydraulisk måde, hvor der på en ramme i midten er anbragt en afstandsholder, eller der på begge hjørner på rammen er tilvejebragt et par af dæmpere (18) eller afstandsholdere.

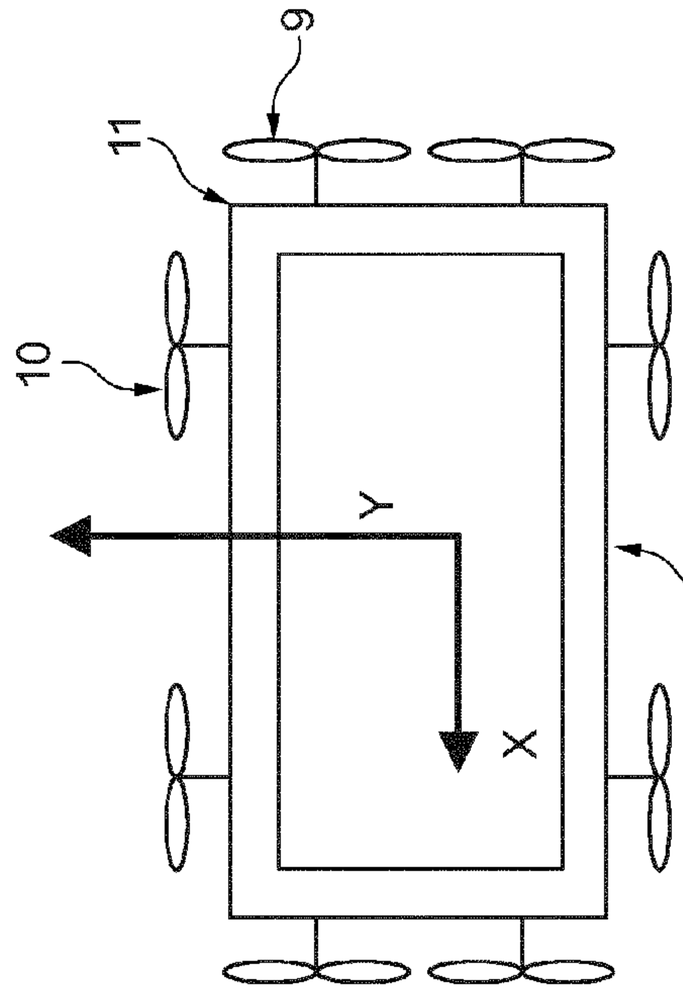

Fig. 2

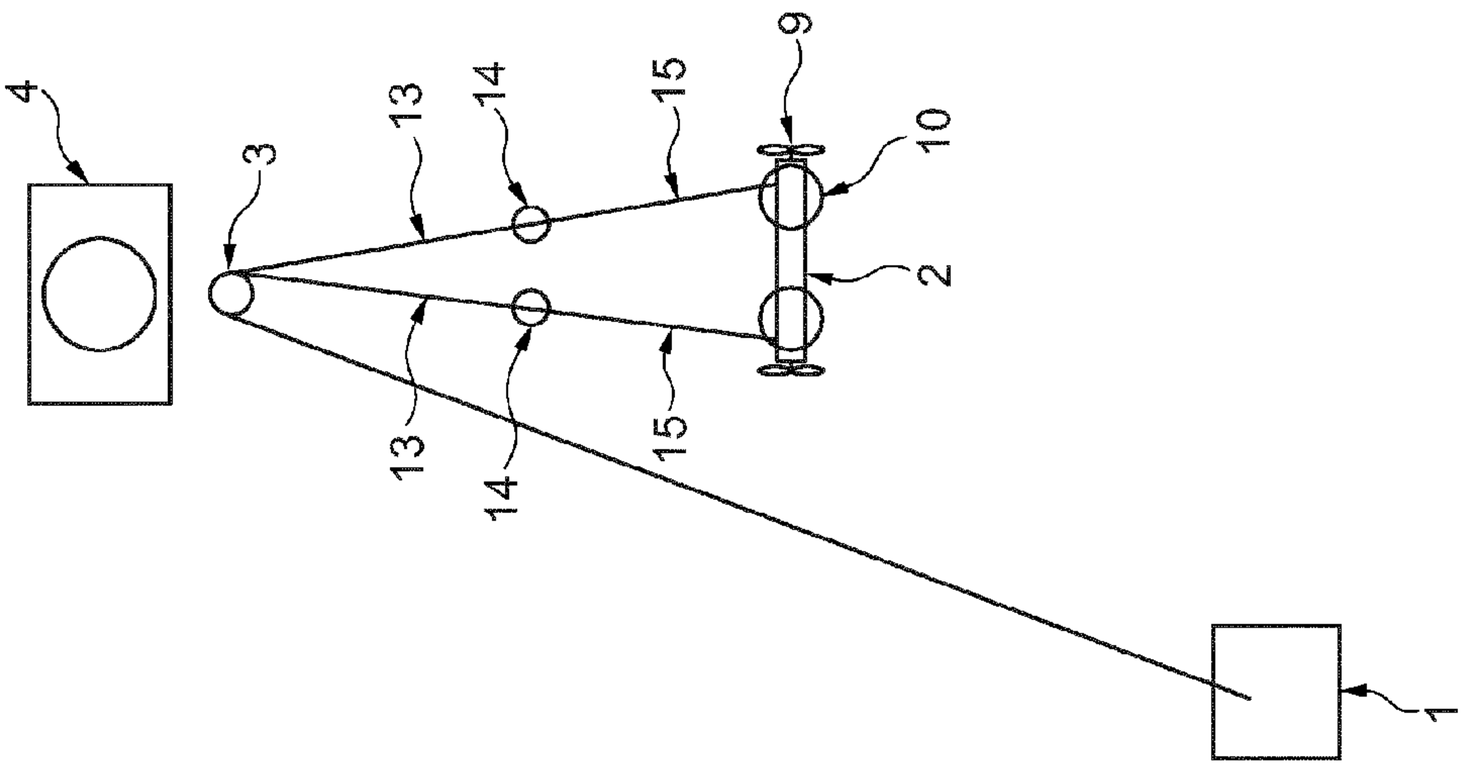

Fig. 1

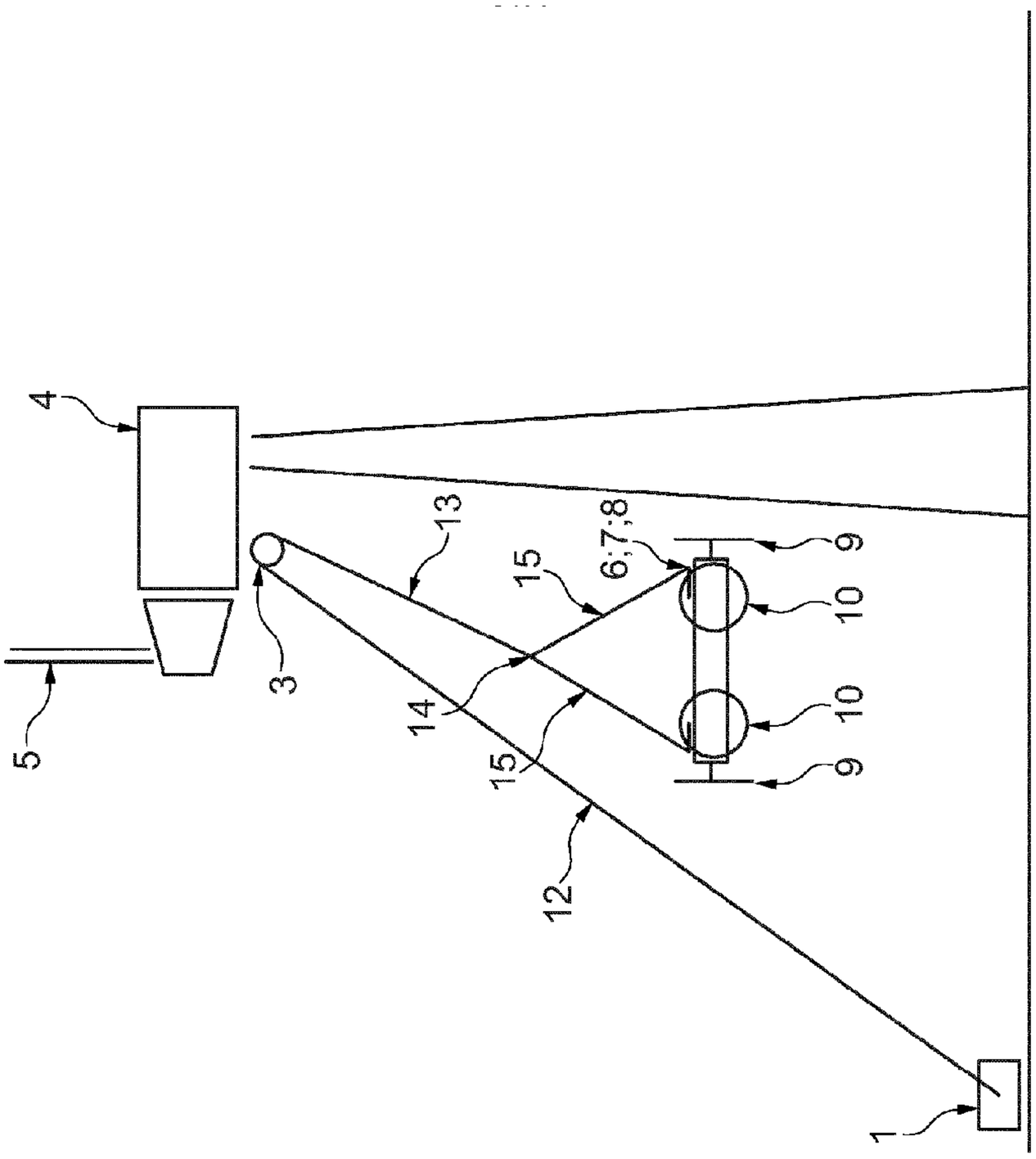

Fig. 4

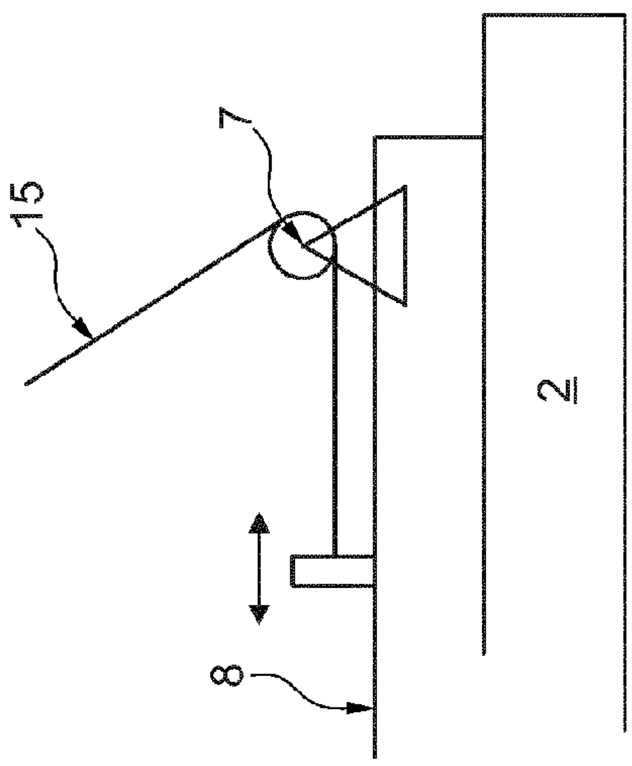

Fig. 3

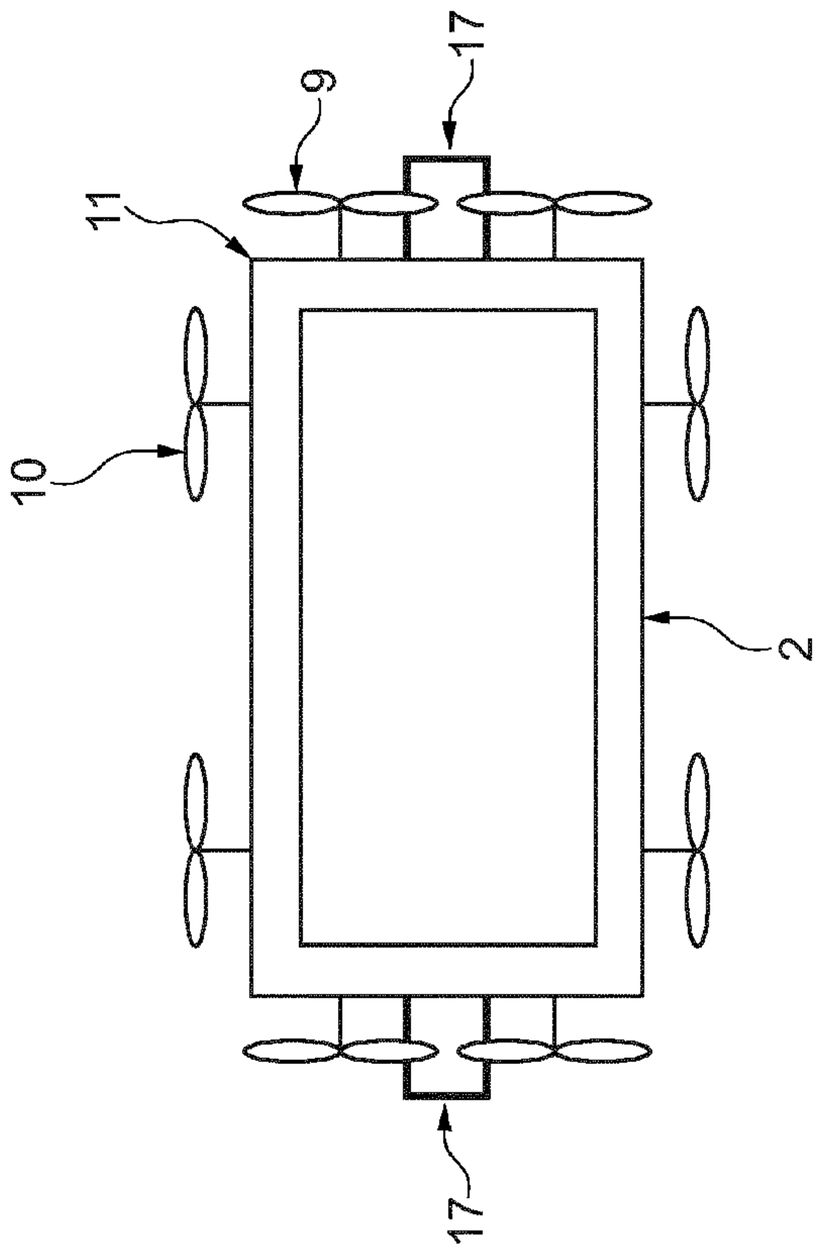

Fig. 6

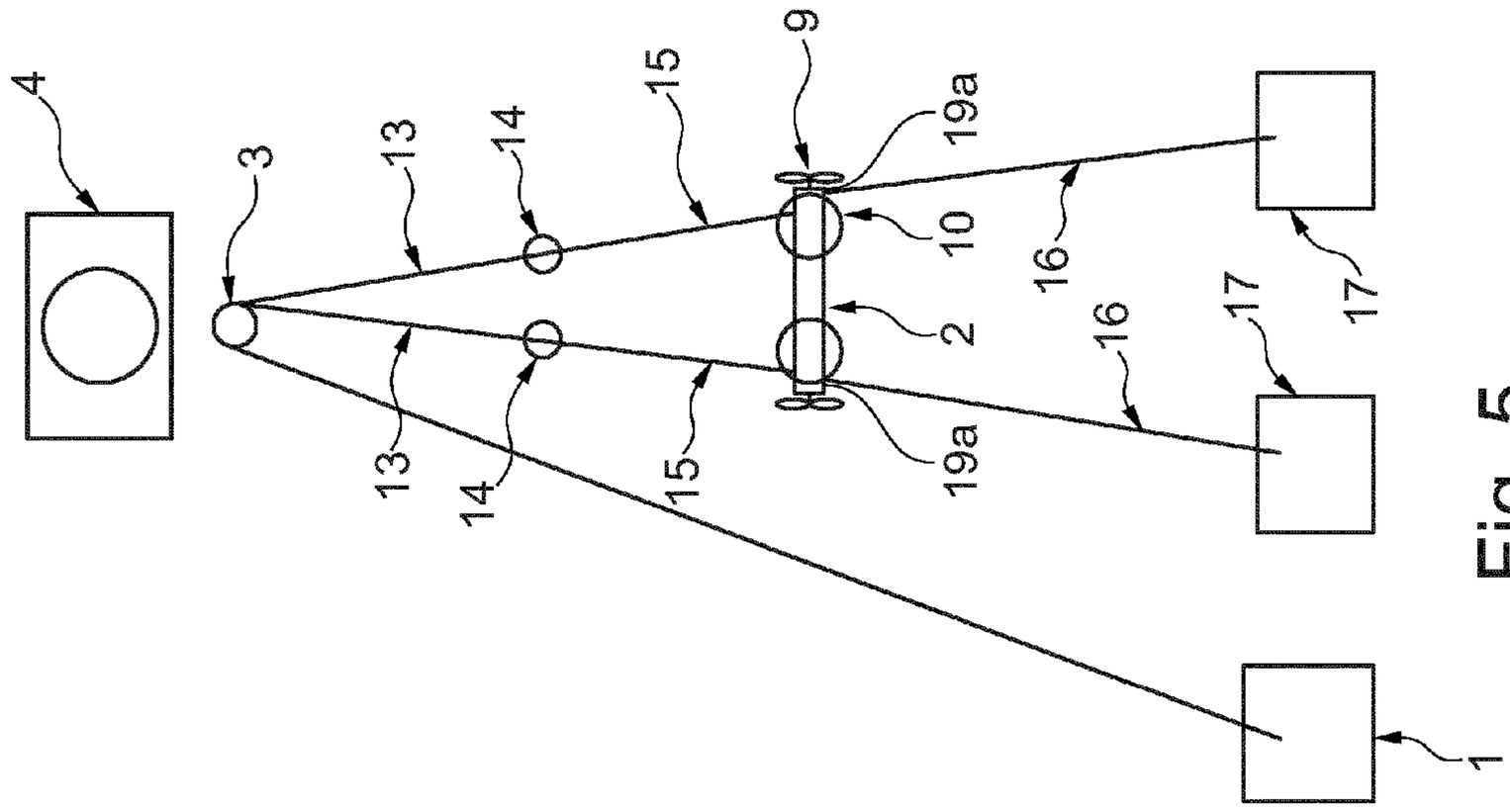

Fig. 5

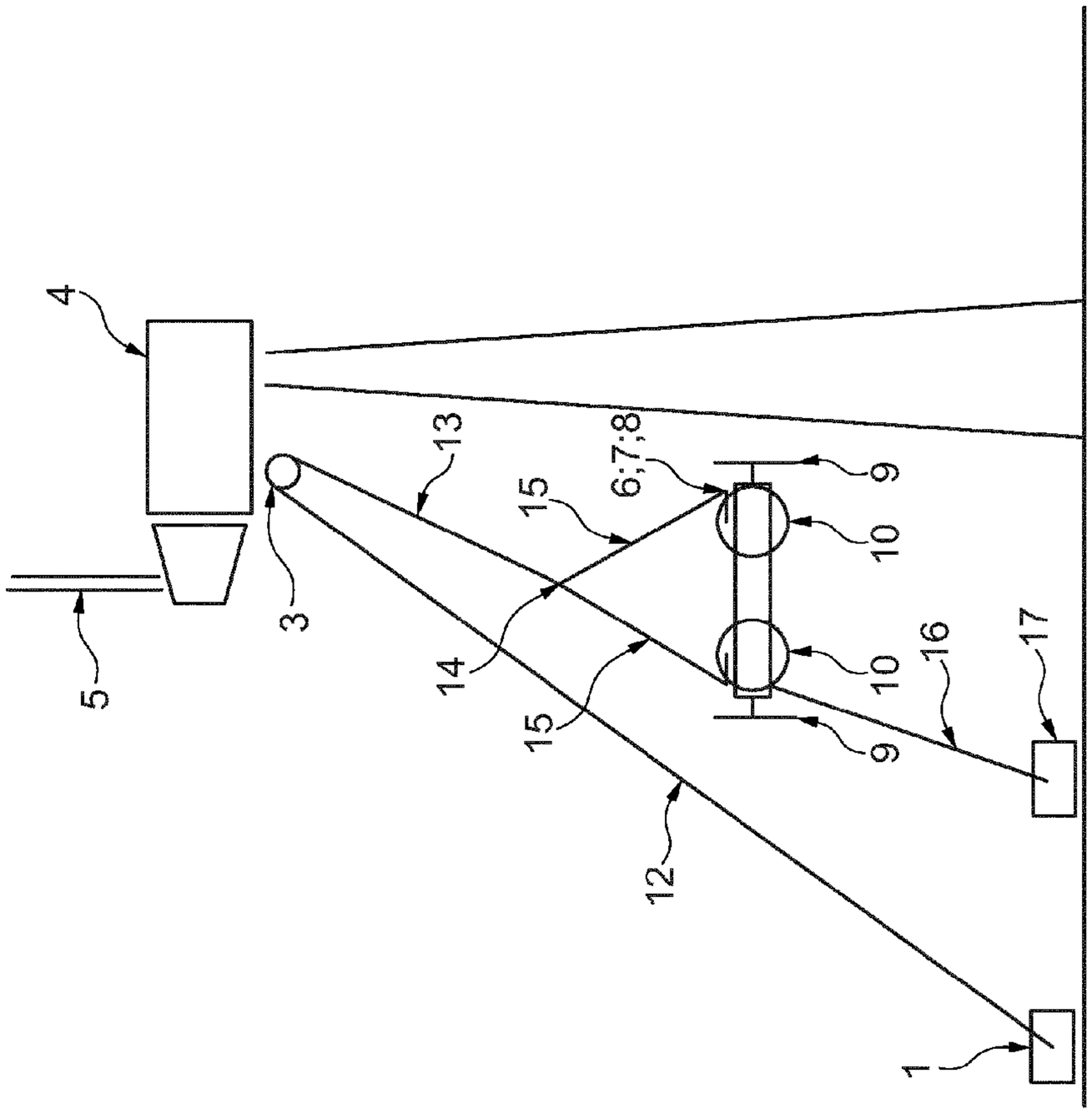

Fig. 8

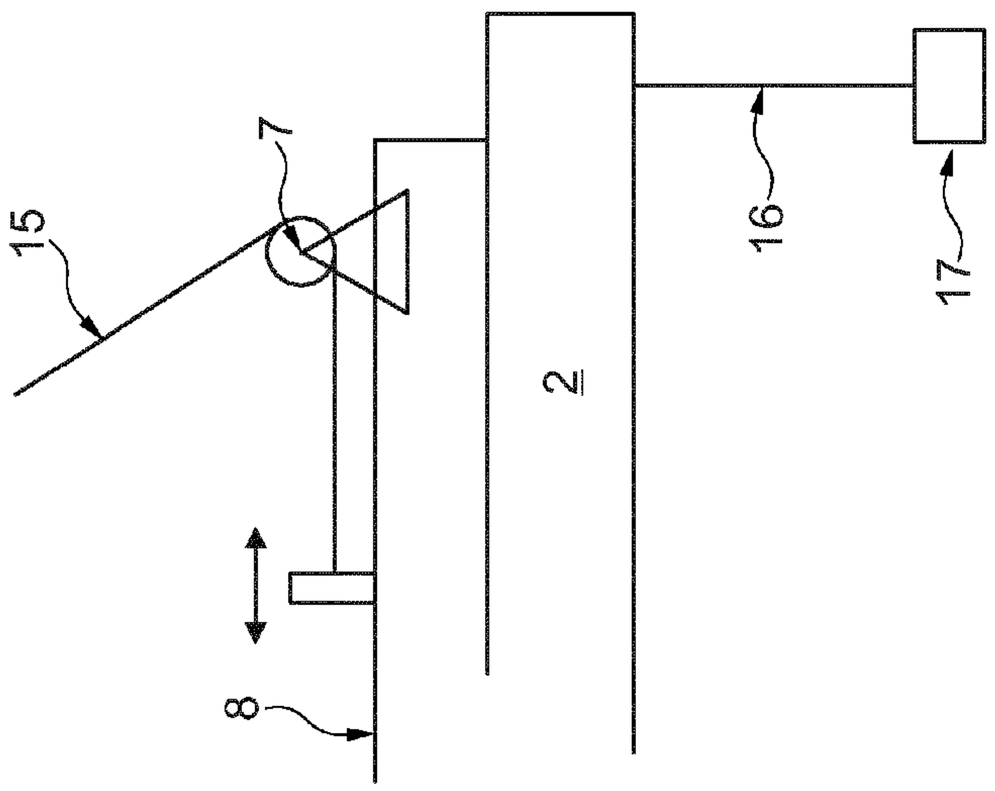

Fig. 7

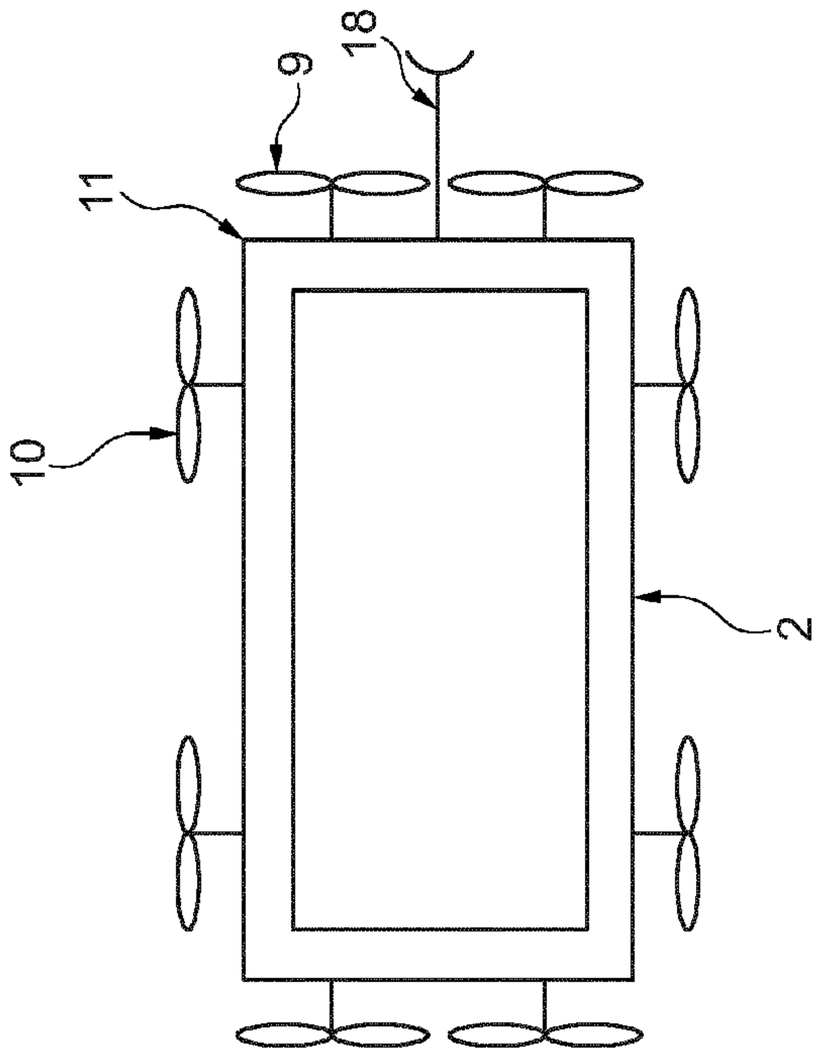

Fig. 10

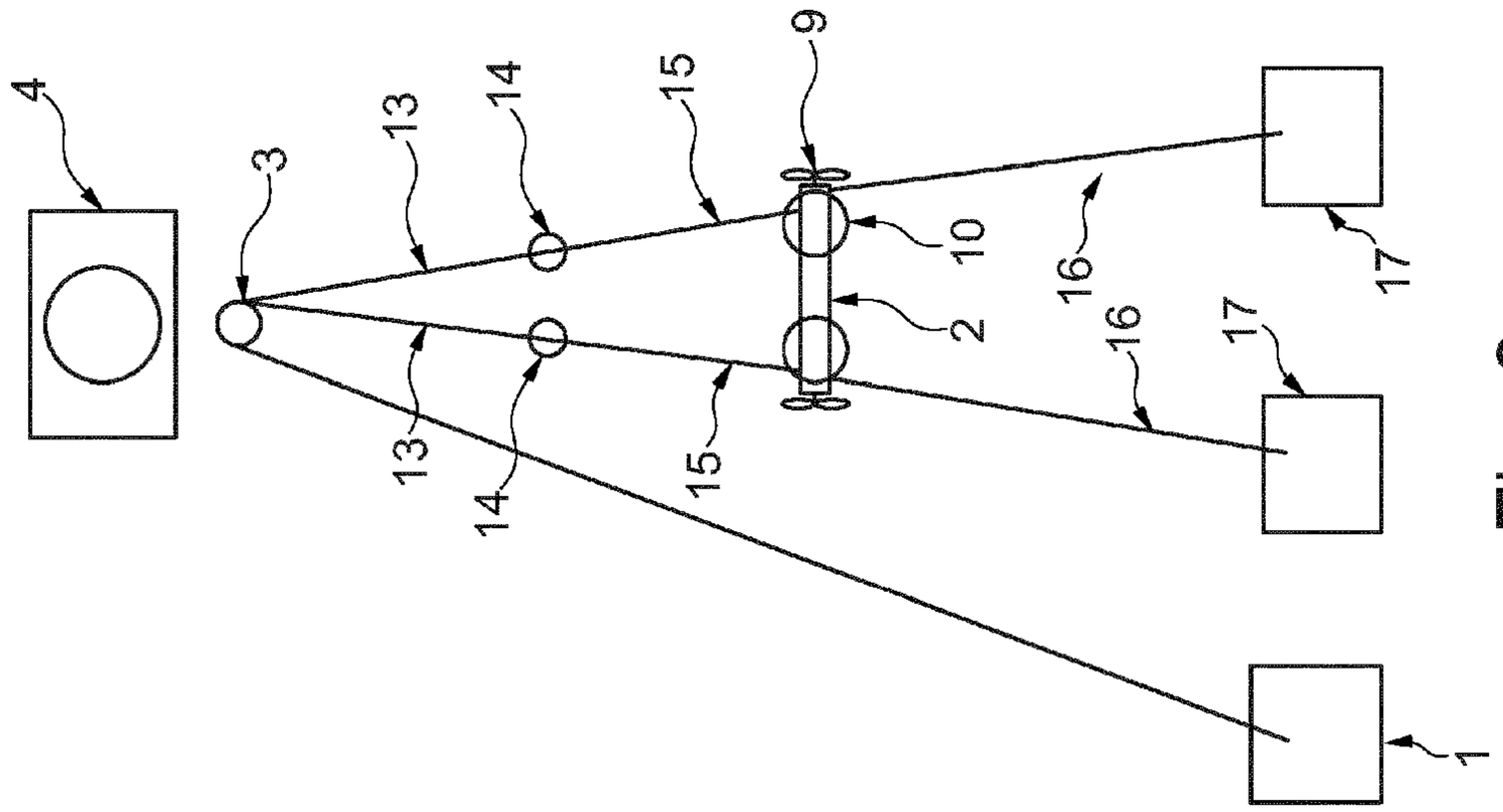

Fig. 9

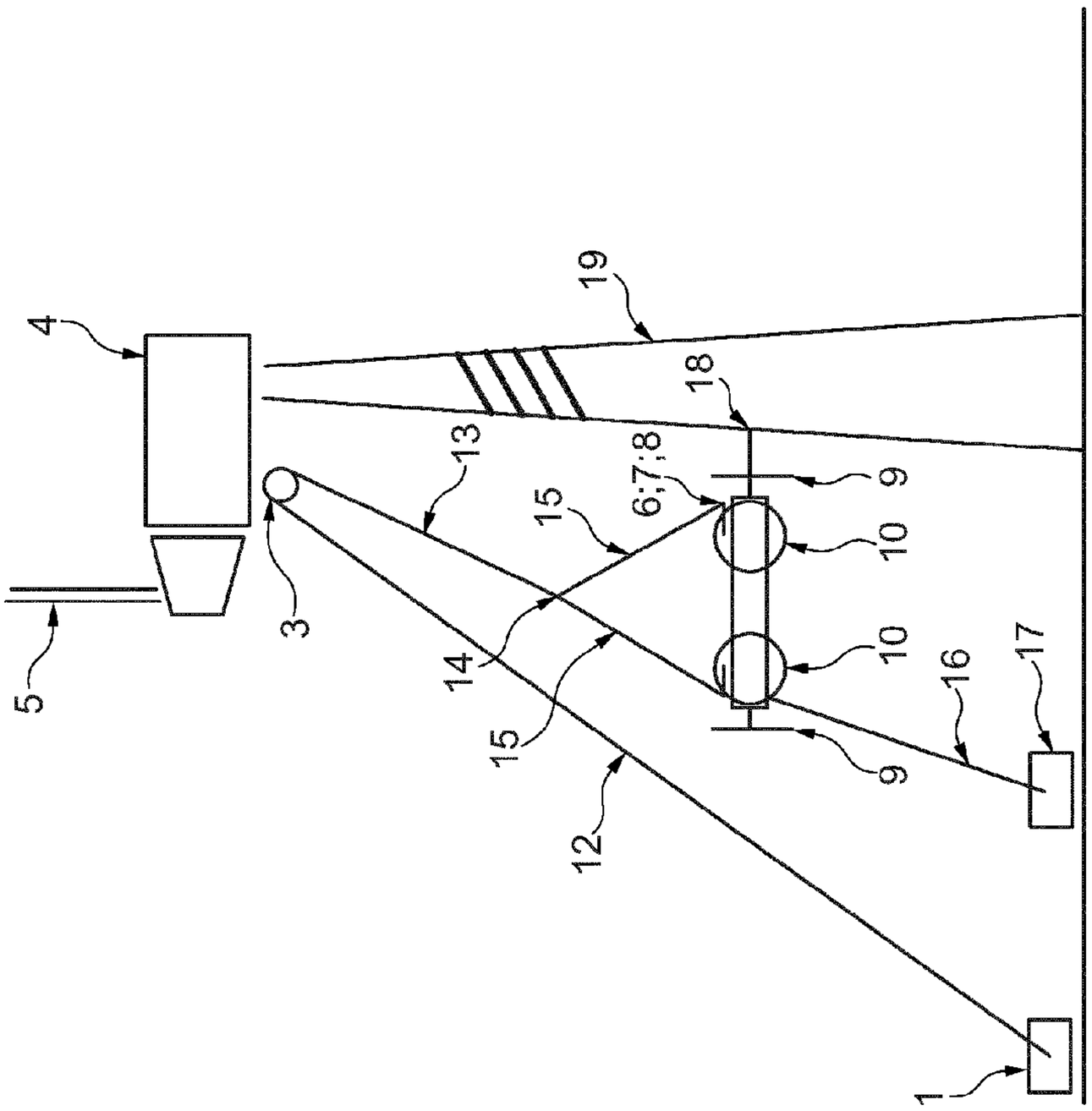

Fig. 12

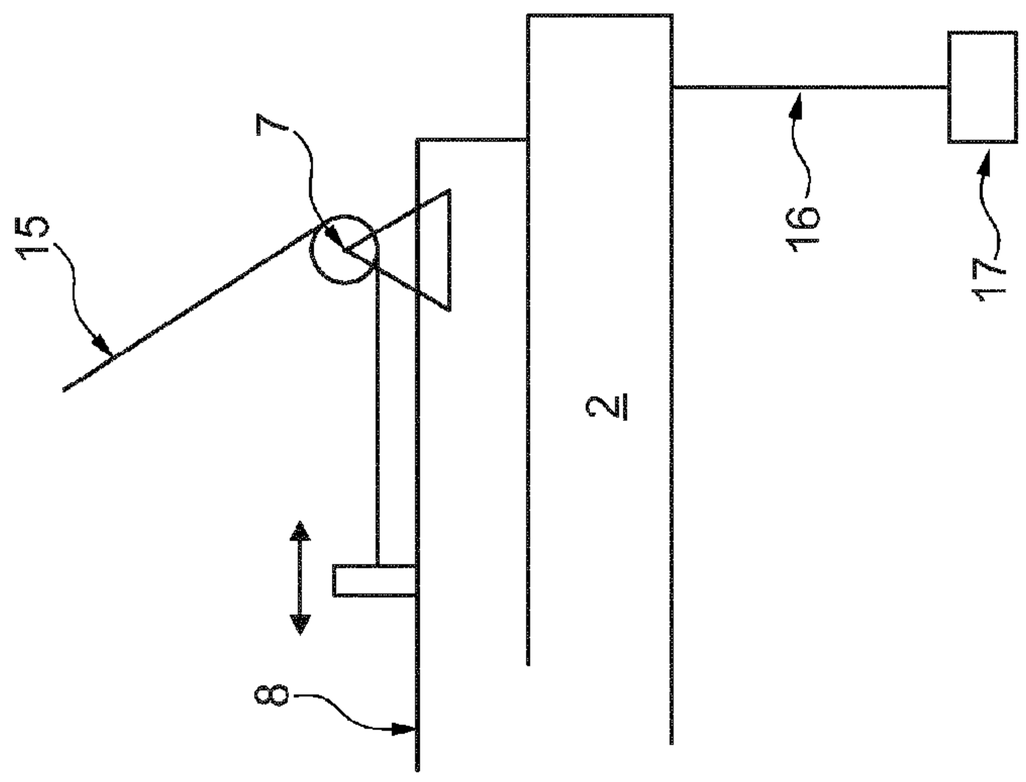

Fig. 11