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(54) Rubber-tyred gantry crane

(57) A transporter crane or gantry crane, of the mobile type that is self-propelled on wheels (R), comprising a substantially quadrangular main body or load-bearing frame (1), mounted on at least four corner legs, is characterized in that said four legs are articulated with respect to the main body (1) and are equipped with respective means, designed to modify inclination thereof independently with respect to the others for raising/lowering said main frame (1) with respect to the terrain and to keep it levelled horizontally also in the presence of rough terrain or slopes, said load-bearing frame (1) being equipped with hooking means (8) for fixing loads to be lifted and transported and each leg having the bottom end constrained to at least one wheel (R). Said legs articulated with respect to the load-bearing frame (1), have an articulated-parallelogram structure actuated with hydraulic or pneumatic means.

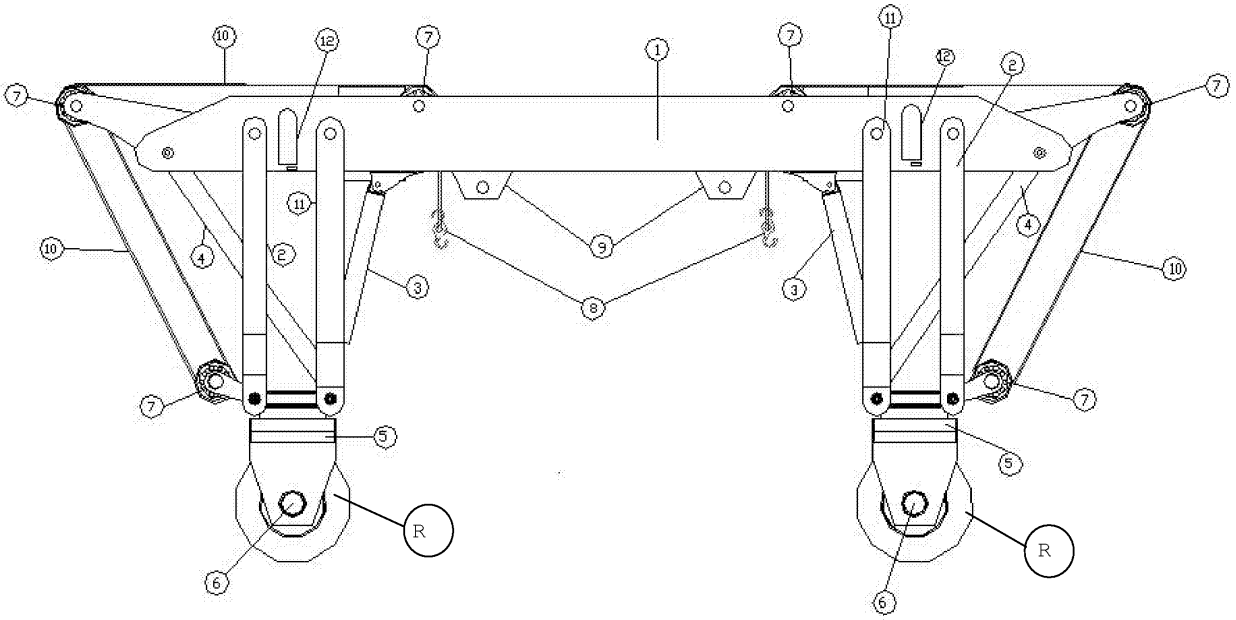

Fig. 1

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Description

[0001] The present invention relates to a new self-propelled portal crane on pneumatic-tyred wheels of the gantry-crane or transporter-crane type.

[0002] Unlike currently known mobile cranes, it is equipped with innovative force or crane legs of the articulated-parallelogram type (which can, therefore, be lowered or raised according to the need) and with four (hydraulic or electrical) motors on the four wheels that enable steering of each of them.

[0003] Translation occurs preferably by means of the same four wheels, which are also driving wheels actuated by hydraulic or electrical in-wheel motor reducers incorporated in the hub.

[0004] The possibility of varying the height from the ground of each of the force legs and the steering system made with four motors (one for each individual driving wheel) enable a series of operating advantages like the ones listed hereinafter by way of non-limiting example:

- via a commercially available hardware/software system it is possible to control the height of each individual leg, in a way absolutely independent of the others, so that the wheels will be automatically adapted to rough terrain and/or slopes, enabling the crane itself to transport the loads so that they remain constantly levelled and hence operating with a much higher speed of translation than in traditional cases;
- there is no need to install any hoist on board since to move the loads it is sufficient to raise and lower the entire machine;
- there is the possibility of perform a "correct steering" for all the steering angles, and also possible is "crab-type" steering with a consequent manoeuvrability in narrow spaces that is absolutely not comparable with other machines present on the market.

[0005] A better understanding of the invention will be obtained from the ensuing detailed description and with reference to the attached plates of drawings, which illustrate a preferred embodiment thereof, provided purely by way of non-limiting example.

[0006] In the plates of drawings:

Figure 1 is a side elevation of the crane according to the invention in the raised configuration;

Figure 2, similar to the preceding one, shows the crane in the lowered configuration;

Figure 3 is a front view of a leg of the crane of Figure 1;

Figure 4, similar to the preceding one, shows the structure of the leg without the members for movement;

Figure 5 is a 3D view of the crane according to the invention in the raised configuration; and

Figure 6, which is similar to the preceding one, shows the crane in the lowered configuration.

DESCRIPTION

[0007] With reference to the figures listed above, the self-propelled crane according to the invention comprises a central structural load-bearing body or frame 1, which is formed substantially by a quadrilateral of solid-web girders made of steel plate having a thickness and dimensions compatible with the dimensions and the loads of the machine and is supported by four force legs built along the lines of articulated parallelograms, each of which comprises a first "connecting rod" element 11 and a second "connecting rod" element 2, which are hinged, in the top part, to the central body 1 and, in the bottom part, to the rotation thrust bearing 5 that enables steering of the wheels R. Said first and second connecting rods 11 and 2 are substantially H-shaped, and the body of the first connecting rod 11 is provided with a further stiffening arm 13, which moves fixedly with respect thereto. Said first connecting rod 11 turns about a horizontal axis 14 set transverse to the central body 1.

[0008] The static determinacy of the structure is ensured by a pair of hydraulic cylinders for each leg: during the step of lowering of the structure 1, the first cylinder 3 works in compression and pushes, whilst the second cylinder 4 works in tension and pulls; whereas during the step of raising of the structure 1 the first cylinder 3 works in tension and pulls, whilst the second cylinder 4 works in compression and pushes.

[0009] From the annexed Figures 1 and 2, it immediately emerges clearly how, by actuating in parallel the two cylinders, i.e., sending oil to the opposite chambers of the cylinders themselves, each of the force legs will be inclined with respect to the vertical position of Figure 1 so as to move apart, causing lowering of the central body 1 until it reaches the configuration represented in Figure 2. Instead, by reversing delivery of the oil under pressure, hoisting of the central body 1 is obtained and return of the legs into vertical position.

[0010] In this way, according to the invention, for lifting/lowering a load to be transported that is appropriately hooked to the central body 1 of the crane by means of at least three hooks 8 of a known, non-aligned, type, it is sufficient to raise/lower said central body 1, without any need for hoists or other lifting members. In the example illustrated, said hooks 8 are double crooks (preferably four in number), arranged as a quadrilateral in a way conformable to the central body 1.

[0011] The oil under pressure, which is necessary for the steps of lowering/raising, traction, and steering is supplied by a purposely provided hydraulic assembly, with heat engine of a known, commercially available, type.

[0012] According to the invention, the movement of each of the legs from the vertical position to the substantially horizontal one and vice versa, is independent of that of the others; consequently, it is possible to level the machine even though the terrain is rough.

[0013] It should be noted that, from the calculations made, it emerges that the oil necessary for moving the

force legs to keep the frame 1 constantly levelled during the step of travel at high speed of translation leads to instantaneous flow rates that are so high as to require pumps and heat engines that are absolutely incompatible with the economy of the entire machine. According to a first peculiar characteristic of the invention, the problem has been solved by providing a hydropneumatic accumulator 12 and appropriate distributor valves of a known type in the proximity of each force leg in such a way as to supply the cylinders 3 and 4 with all the oil that is required in extremely short times.

[0014] Levelling is obtained via a PLC that reads the inclinometers and controls the distributor valves. The control of the steering imposed by the crane driver occurs always via PLC.

[0015] According to the invention, the four double hooks 8 are lifted/lowered by means of the ropes 10 that run over the sheaves 7, which, when the machine is raised or lowered, pull the ropes 10 or let them go, so forcing the hooks 8 to be raised or lowered by an amount much greater than what could be obtained if said double hooks 8 were constrained directly to the central body 1.

[0016] More specifically, the rope 10 of each hook 8 runs over at least three sheaves 7: a bottom sheave set in the proximity of the wheel R at the end of the connection rods 11 and 2 of the respective leg; an intermediate sheave is located at the respective angle of the central body 1; and a top sheave, from which the corresponding double hook 8 hangs, is set on the central body 1 of the crane.

[0017] A second peculiar characteristic of the invention consists in the fact that the top sheave and the intermediate sheave are both fixed with respect to the central body 1, whilst the bottom sheave is fixed with respect to the bottom end of the connection rods 11 and 2.

[0018] Consequently, the distance between the top and intermediate sheaves is constant, whilst the distance between the latter and the bottom sheave varies as the inclination of the respective leg varies. In particular, as shown clearly in Figures 1 and 2, the distance between the intermediate and bottom sheaves is maximum when the leg is vertical (crane raised) and minimum when the leg is completely inclined (crane lowered).

[0019] A simplified variant of the invention (not illustrated) is without the bottom sheave: in this case, the bottom end of the rope 10 is fixed directly to the attachment of the pin of the bottom sheave itself.

[0020] It is clear that, as a function of the total height of the machine it could be necessary or otherwise to wind the ropes 10 a number of times around the sheaves 7: in other words, if the legs are very long, it is advantageously possible to envisage that each rope 10 will run over more than one pair of intermediate and bottom return sheaves 7, so that if N is the number of said pairs of return sheaves 10 and if L_{Max} and L_{Min} are the maximum and minimum distances between the bottom sheave and the intermediate one, when the leg of the crane passes from the vertical position to the completely tilted one, the respective hook 8 will be lowered by $N^* (L_{Max} - L_{Min})$ with respect to the central body 1. Instead, when the leg returns into the vertical position, the corresponding hook 8 is raised by the same amount.

[0021] From what has been said, it is clear that said constructional details depend upon the overall height that it is desired to assign to the entire machine and hence to the "hook travel" required by the specific embodiment. Consequently, the present invention does not set any limit to the travel of the hook 8 given that it is possible to install in parallel a number of return sheaves 7 to wind the rope 10 on said sheaves, thus obtaining a range of the hook of any amount.

[0022] In conditions of normal use, the lowered position assumed by the crane will be intermediate between the one represented in Figure 1 and the one represented in Figure 2 and, in said situation, the loads will be secured to the hooks 8 and will be lifted by raising the entire machine by a height equal to the sum of the amount of raising of the central body 1 and of the travel of the hook 8, which is proportional to the number of returns to which the rope 10 that runs over the sheaves 7 is subjected.

[0023] At this point, it should be noted that, in the case where particular operating conditions were to require positioning of the machine in its lowest position, illustrated in Figure 2 (for example, to operate in internal environments with limited height of the ceiling), it would no longer be possible to fix the loads to the hooks 8 hanging from the top sheaves in the way described previously. In said situation, in fact, the hooks 8 would drag along the ground, so rendering the operation of anchorage problematical and certainly not operatively valid.

[0024] According to the invention, in this case it is envisaged that the hooks 8 will be constrained directly to the main body 1 via appropriate fixed supports 9, leaving the ropes 10 slack (see Figure 2).

[0025] Said operation enables the crane to:

- hook the load rigidly with respect to the main body 1;
- rise together with the load by the amount that will be deemed necessary to enable transport, without bumping against the ceiling or, in any case, against any overlying obstacle;
- exit from the area with restricted room for overhead manoeuvre, transporting the load, where necessary.

[0026] A third peculiar characteristic of the invention consists in the fact that the crane described so far is equipped with a levelling system designed to keep the load-bearing main body or frame 1 levelled so as to enable proper and safe movement of the loads.

[0027] Said levelling system comprises two electronic inclinometers of a known type commonly available on the market, which are rigidly fixed to the frame 1 with horizontal lie and with the respective axes perpendicular to one another. With said arrangement, the plane formed by the axes of the inclinometers and the plane of lie of the frame 1 are parallel by construction.

[0028] An appropriate software detects the variations of horizontality of the plane formed by the axes of the inclinometers and, via the hydropneumatic accumulators already described, actuates the cylinders 3 and 4 that control inclination of each leg of the crane, bringing the frame 1 back into the horizontal lie.

[0029] According to the invention, with said artifice, the crane is able to move about both on inclined surfaces and on rugged terrain, without the horizontality of the main frame 1 being adversely affected.

[0030] As regards the steering system, on each of the four wheels R there acts, via an appropriate motor reducer and a toothed thrust bearing 5, a hydraulic or electrical motor reducer 6 (not represented in the drawings because it is covered by the first connecting rod 11 or inner arm of the force leg), equipped with encoders or other equivalent electronic device to detect, instant by instant, the angular position of the wheel with respect to the body of the machine.

[0031] An appropriate software detects, once again via the encoders, the angles of the wheels with respect to the normal position of travel and controls each wheel, causing it to steer according to the need when the crane driver actuates the steering. It is interesting to point out that, according to the invention, the use of a hydraulic or electrical motor for each individual wheel enables the two following advantages to be achieved:

- the possibility of steering both in a "concentric" way and in a "crab-type" way; and
- the possibility of carrying out a concentric steering that is truly "correct", whatever the steering angle.

[0032] The latter possibility is absolutely unique in the sector of road vehicles since none of the steering mechanisms currently possible enables "correct" steering for any steering angle but, at most, performs correct steering only for a given angle, in general close to the maximum one allowed by the particular mechanism in question.

LEGEND OF THE REFERENCES PRESENT IN THE DRAWINGS:

[0033]

1. basic main frame;
2. connecting rod of the outer arm of the force leg;
3. telescopic hydraulic cylinder (compression);
4. simple-extraction hydraulic cylinder (tension);
5. thrust bearing for rotation of the wheel in the horizontal plane;
6. hydraulic-drive motor;
7. return sheaves of the rope (10);
8. double-crook hoisting hook;
9. supports for the hook (8);
10. hoisting rope;
11. connecting rod of the inner arm of the force leg;
12. hydropneumatic accumulators;
13. stiffening arm of the arm connecting rod (11);
14. axis of the hinge for rotation of the connecting rod (11) and of the arm (13);

R. wheels, preferably tyred.

[0034] The present invention has been described and illustrated in a preferred embodiment thereof, but it is evident that any person skilled in the branch may make technically and/or functionally equivalent modifications and/or replacements thereto, without thereby departing from the sphere of protection of the present industrial patent right, as defined in the ensuing claims.

Claims

1. A transporter crane or gantry crane of the mobile type, self-propelled on wheels (R) and comprising a substantially quadrangular load-bearing main body or frame (1), mounted on at least four corner legs, said crane being **characterized in that** said four legs are articulated with respect to the main body (1) and are equipped with respective means designed to modify inclination of each of said legs independently of the others for raising/lowering said main frame (1) with respect to the terrain and keeping it levelled horizontally also in the presence of rough terrain or slopes; said load-bearing frame (1) being equipped with hooking means (8) for fixing loads to be lifted and transported, and each leg having the bottom end constrained to at least one wheel (R).

2. The crane according to the preceding claim, **characterized in that** said legs, articulated with respect to the load-bearing frame (1), have an articulated-parallelogram structure actuated with hydraulic or pneumatic means.

3. The crane according to Claim 1 or Claim 2, **characterized in that** said wheels (R) are driving and steering (i.e., direction) wheels and are equipped with means of their own for hydraulic, or pneumatic, or electrical, actuation; said actuation means being governable individually on each wheel, thus obtaining the possibility of performing a "correct steering" for all the steering angles that the wheels may assume and being likewise able to perform also a "crab-type" steering, i.e., turning round on itself.

4. The crane according to Claim 1, **characterized in that** it is equipped with means for keeping the load-bearing frame (1) horizontal, said means comprising at least two inclinometers of a known type arranged in such a way that the respective axes are perpendicular to one another; said means for keeping the load-bearing frame (1) horizontal being designed to control the means for movement of each leg to vary the inclination thereof according to the requirements.

5. The crane according to Claim 2, **characterized in that** said actuation means of each of the articulated-parallelogram legs comprise a pair of hydraulic cylinders, of which the first (3) works always in tension and the other (4) works always in compression.

6. The crane according to Claim 2, **characterized in that** each articulated-parallelogram leg comprises a first "connecting rod" element (11) and a second "connecting rod" element (2), which are hinged, in the top part, to the main or central body (1) and, in the bottom part, to a rotation thrust bearing (5), which enables steering of the wheel (R); said first and second connecting rods (11 and 2) substantially having the shape of an H, and the body of the first connecting rod (11) being equipped with a further stiffening arm (13), which moves fixedly with respect thereto.

7. The crane according to the preceding claim, **characterized in that** said first connecting rod (11) turns about a horizontal axis (14) set transverse to the central body (1).

8. The crane according to Claim 5, **characterized in that** said cylinders are designed to be actuated in parallel, i.e., sending oil to the opposite chambers of the cylinders themselves, thus obtaining, with inclination of each of the legs with respect to the vertical position, that the respective wheels move away from one another, thus causing lowering of the central body (1), whereas, by reversing delivery of the oil under pressure, raising of the central body (1) and return of the legs into the vertical position is obtained.

9. The crane according to Claim 1, **characterized in that** it is without hoists and **in that** said means for lifting/lowering a load to be transported comprise at least three non-aligned hooks (8) of a known type, thus obtaining that for lifting/lowering a load it is sufficient to raise/lower said central body (1).

10. The crane according to the preceding claim, **characterized in that** said hooks (8) for fixing the load are constituted by four double crooks arranged as a quadrilateral in a way conformable to the central body (1).

11. The crane according to Claim 3, **characterized in that** it comprises a purposely provided hydraulic assembly with heat engine of a known and commercially available type, designed to supply the oil under pressure necessary for the steps of lowering/hoisting, traction, and steering.

12. The crane according to Claims 5 and 11, **characterized in that** for each leg there are provided a hydropneumatic accumulator (12) and appropriate distributor valves of a known type, designed to supply, in extremely short times, the cylinders (3 and 4) with all the oil that they need for keeping the main body (1) constantly horizontal during transport of the load hanging therefrom.

13. The crane according to Claim 10, **characterized in that** said four double hooks (8) are lifted/lowered by means of the ropes (10), which run over the sheaves (7), which, when the machine is raised or lowered, pull the ropes (10) or let them go so that the hooks (8) are raised or lowered by an amount much greater than what could be obtained if said double hooks (8) were constrained directly to the central body (1).

14. The crane according to the preceding claim, **characterized in that** the rope (10) of each hook (8) runs over at least two sheaves (7): a top sheave, from which the corresponding double hook (8) hangs, is set on the central body (1) of the crane; an intermediate sheave is located at the respective angle of the central body (1); there being provided, in the proximity of the wheel (R) provided at the bottom end of the connection rods (11 and 2) of the respective leg, a bottom-end attachment of the rope (10), or else a further bottom sheave.

15. The crane according to the preceding claim, **characterized in that** the top sheave and the intermediate sheave are both fixed with respect to the central body (1), whilst the bottom sheave or end attachment is fixed with respect to the bottom end of the connection rods (11 and 2), thus obtaining that the distance between the top and intermediate sheaves is constant, whilst the distance between the latter and the bottom sheave varies as the inclination of the respective leg varies.

16. The crane according to the preceding claim, **characterized in that** the articulated parallelograms of the legs are structured in such a way that the distance between the intermediate and bottom sheaves is maximum when the leg is vertical (crane raised) and minimum when the leg is completely tilted (crane lowered).

17. The crane according to the preceding claim, **characterized in that**, if the legs are very long, it is envisaged that each rope (10) will run over more than one pair of intermediate and bottom return sheaves (7), so that if N is the number of said pairs of return sheaves (10) and L_{Max} and L_{Min} are, respectively, the maximum and minimum distance between the bottom sheave and the intermediate one, when the leg of the crane passes from the vertical position to the completely tilted one, the respective hook (8) will be lowered by $N^* (L_{Max} - L_{Min})$ with respect to the central body (1) ; instead, when the leg returns into the vertical position, the corresponding hook (8) is

raised by the same amount.

18. The crane according to the preceding claim, **characterized in that**, in conditions of normal use, it is designed to be used with an intermediate configuration between those of maximum height and minimum height, thus obtaining that the loads that are hanging from the hooks (8) will be raised, for their transport by raising the entire machine by a height equal to the sum of the amount of raising of the central body (1) and of the travel of the hook (8), said travel being proportional to the number of returns that the rope (10) undergoes as it runs over the sheaves (7).

19. The crane according to Claim 16, **characterized in that**, in areas where there is a limited height for manoeuvring, it is designed to be used with a configuration of minimum height, with the load to be transported hanging from the hooks (8), which are hooked directly to the load-bearing frame (1) by means of purposely provided fixed supports (9), leaving the ropes (10) slack.

20. The crane according to Claims 4 and 12, **characterized in that** said means for keeping the load-bearing frame (1) horizontal are equipped with an appropriate software, which detects the variations of horizontality of the plane formed by the axes of the inclinometers and, via the hydropneumatic accumulators already described, actuates the cylinders (3 and 4), which control inclination of each leg of the crane, bringing the frame (1) back into the horizontal lie; with said artifice, the crane is able to move about both on inclined surfaces and on rugged terrains without the horizontality of the main frame (1) being adversely affected.

21. The crane according to the preceding claim, **characterized in that** each of the four wheels (R) is designed to be actuated, via an appropriate motor reducer and a toothed thrust bearing (5), by a hydraulic or electrical motor reducer (6) of its own equipped with encoders or other equivalent electronic device to detect, instant by instant, the angular position of the wheel with respect to the body of the machine, there being further provided an appropriate measuring software, which, via said encoders, is designed to detect the angles of the wheels with respect to the normal position of travel and to control each wheel, causing it to steer according to the need, when the crane driver actuates the steering.

22. The crane according to Claim 4, **characterized in that** said means for keeping the frame (1) horizontal and for raising/lowering the crane by tilting the legs comprise a PLC, which reads the inclinometers and controls the distributor valves, said PLC being also designed to carry out control of the steering imposed by the crane driver.

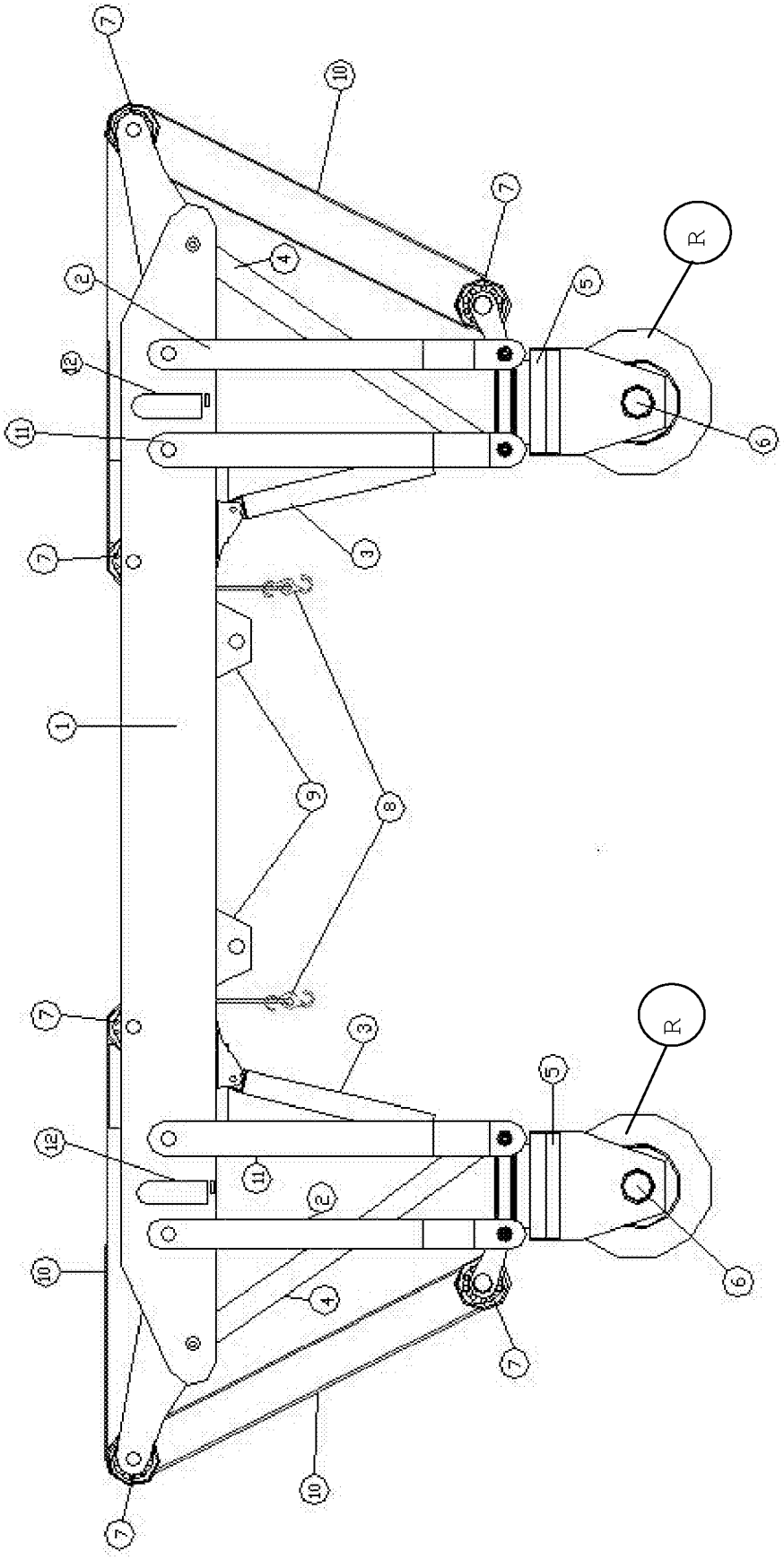

Fig. 1

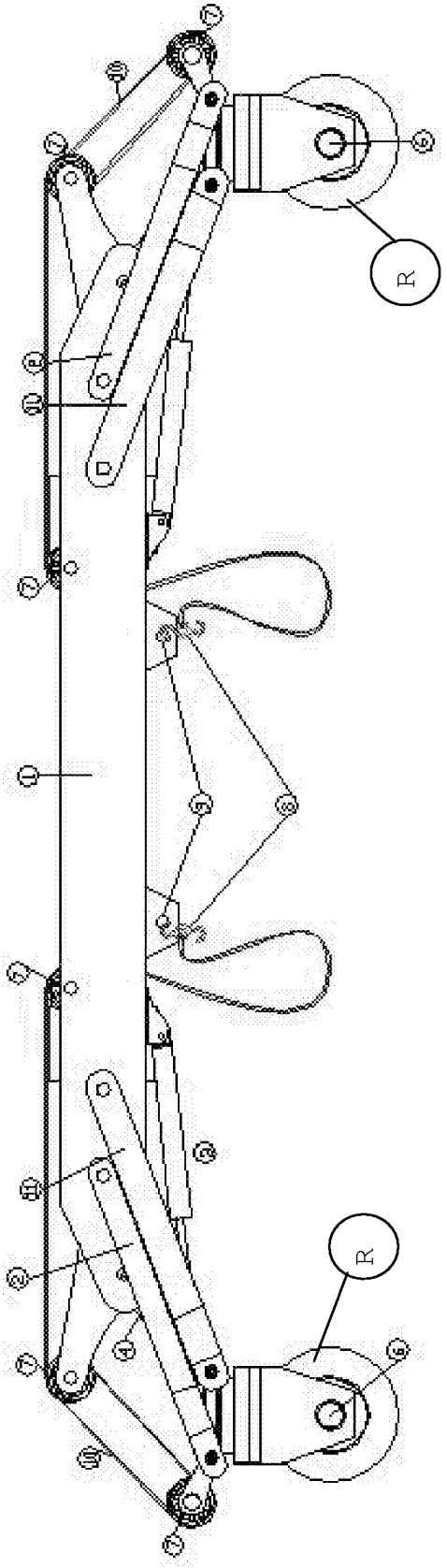

Fig. 2

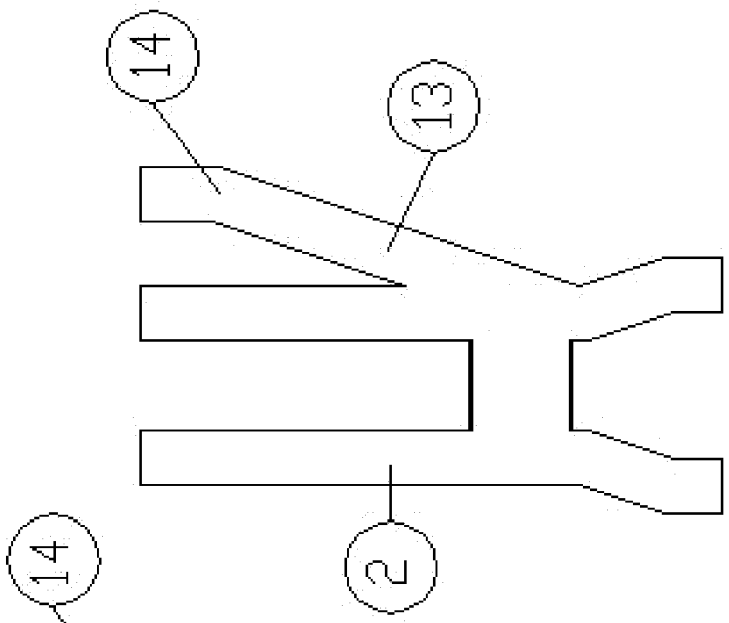

Fig. 4

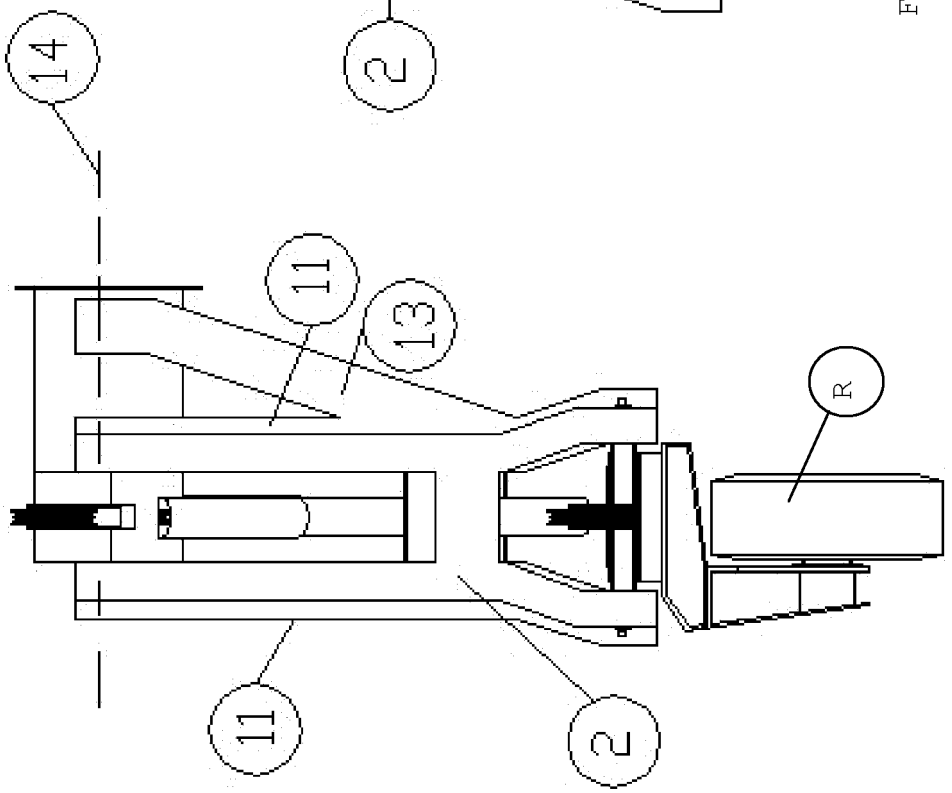

Fig. 3

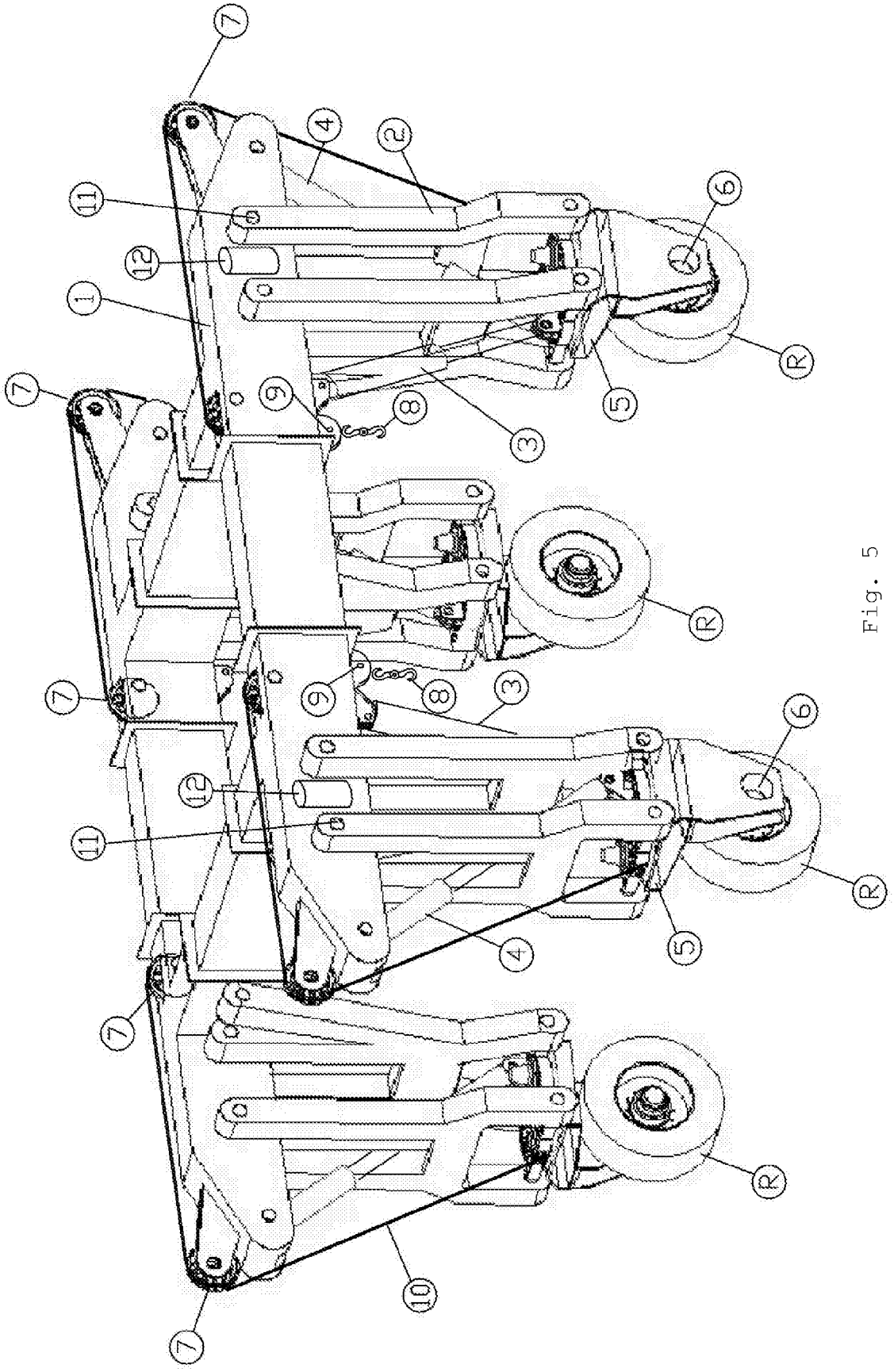

Fig. 5

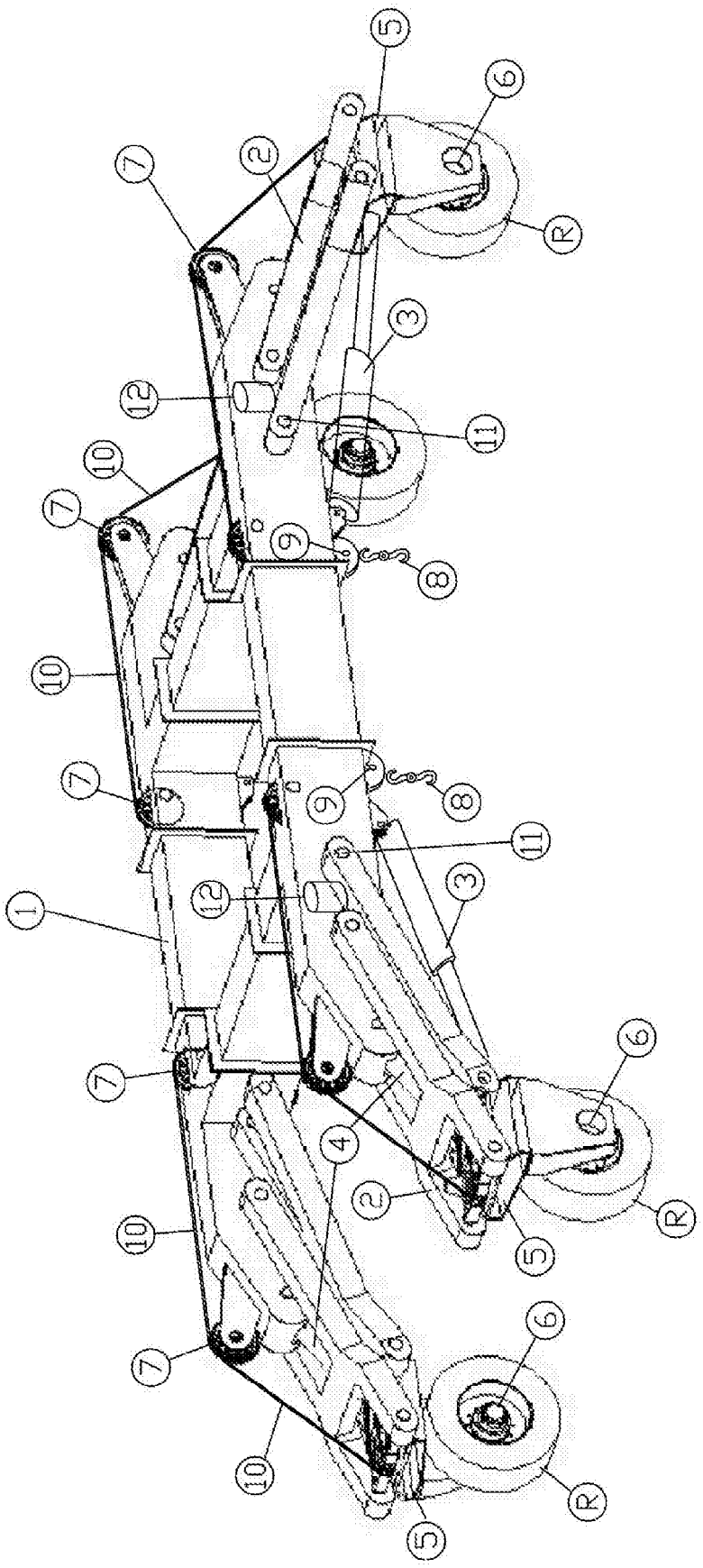

Fig. 6