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(54) Lift truck with extensible mast

(57) The invention relates to a swing mast truck particularly designed for warehouse operations, comprising a mast structure that includes a fixed mast (I), an intermediate carriage (II) movable with respect to the mast, a top carriage (III) movable with respect to the intermediate carriage and a lifting carriage (19) movable in the top carriage, two hydraulic cylinders (14, 20) for moving the carriages and power transmission chains (29, 25, 26) for transmitting the thrusting motion of the cylinder pistons to the carriages. In the mast truck according to the invention, the truck length in the driving direction is reduced, the turning radius and agility in general is improved, the blind area is reduced and the torque balance is ensured. This has been achieved by placing the hydraulic cylinders (14, 20) at the sides of the structure and by turning the transmission wheel (13) located at the free end of the free-lifting jack piston (14_m) to be parallel with the driving direction.

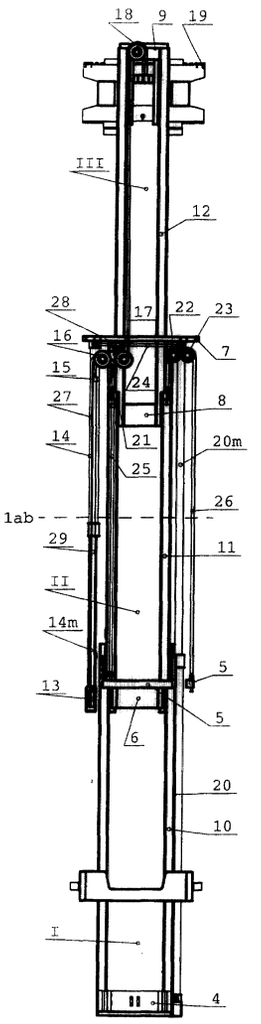

FIG. 1a

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Description

[0001] The invention relates to a mast truck according to the preamble of the appended claim 1.

[0002] In particular, the invention relates to swing mast trucks meant for warehouse operations, said trucks being used for transporting containers, boxes and similar items to warehouse racks and for unpacking said items from the racks. The features required of these trucks are agility in operation, small size, particularly small dimensions in the moving direction of the machine, and good visibility for the driver.

[0003] A mast truck suitable for warehouse operation is a truck moving on at least three wheels and provided with a mast structure comprising a fixed mast structure, as well as two movable carriages and a lifting carriage. The mast and carriages are rectangular structures formed of vertical profiles and transversal supports welded thereon. The mast is connected to the truck either in stationary fashion or so that it can be inclined around an axis. Inside the mast there is arranged a moving carriage, an intermediate carriage that moves vertically along the mast profiles by intermediation of guiding wheel bearings. Inside the intermediate carriage there is arranged another moving carriage that moves with respect to the intermediate carriage by intermediation of guiding wheel bearings. The lifting carriage moves in a similar way with respect to the top carriage. Hydraulic cylinders are generally used for lifting and lowering the carriages. In the first operational step of the mast truck, i.e. the free lifting step, the lifting carriage is lifted to the top end of the top carriage, and in the next step, the lifting step proper, the intermediate carriage and the top carriage are lifted to their top positions.

[0004] The thrusting motion of the cylinders, i.e. jacks, as well as the motion of the carriages to their top positions cause power torques that should be more or less in balance.

[0005] Known free-lifting mast trucks generally include at least three lifting jacks, two at the sides of the mast structure and one in the middle, in which case both the middle jack and the side jacks obstruct the driver's range of vision when the driver is sitting behind the mast structure. Other elements obstructing the view are the power transmission means of the jacks, pipes connecting the hydraulic cylinders and tubes required by various auxiliary devices.

[0006] The critical measure is the length of the mast truck. The longer the mast truck, the larger its turning radius, and the more difficult it is to drive the truck in narrow aisles in between the racks. Here the term 'mast truck length' means its length dimension in the driving direction.

[0007] The object of the invention is to reduce the length of a swing mast truck, and thus also to reduce the truck's turning radius, and to improve the visibility through the mast structure while keeping the power torques in balance.

[0008] From the patent GB-2 264 282 there is known an arrangement where the gap between the mast structures is open, and the lifting operation is carried out by two jacks only. The jacks are, however, placed behind the mast when seen in the driving direction, which means that the truck has a normal length. Owing to the placing of the jacks, the power transmission chains proceed in a way that disturbs visibility and increase the blind area. In the mast truck according to said invention, the power torques created during the lifting operation are not sufficiently balanced from the point of view of ideal operation.

[0009] The object of the invention is achieved by realizing the lifting operation of the truck by means of two jacks that are placed in the transversal direction of the truck, i.e. transversally to the driving direction, at the sides of the mast structure, and by turning the power transmission wheel provided at the end of the free-lifting jack for 90°, so that the direction of its axis is perpendicular to the driving direction. In order to balance the power torques, the power transmission wheels attached to the upper structure of the intermediate carriage are arranged, with respect to each other and the axis of symmetry, so that a balance of torque is achieved.

[0010] By placing both jacks outside the mast structure, the power transmission means can be aligned, so that the blind areas are minimized. Likewise the tubes required by the auxiliary devices can be arranged so that they do not obstruct the view.

[0011] The most important novel features of a swinging mast truck according to the invention are apparent from the characterizing features set forth in the appended claim 1.

[0012] An essential factor for reducing the length of the mast truck and for minimizing the blind areas is the placing of two jacks at the sides of the mast structure and the turning of the power transmission wheel, located at the free end of the free-lifting jack piston, to be parallel with the driving direction, so that the wheel surface is turned by 90°. This means that the mast truck dimensions are reduced in the driving direction. The direction of the power transmission wheel located at the free end of the free-lifting jack requires that the power transmission band is respectively turned for 90° before it reaches the transmission wheel at the fixed end of the jack. This is arranged by means of a band turning element which is arranged in said band, in the section between said wheels.

[0013] In the structure according to the invention, the power transmission wheels attached to the upper structure of the intermediate jack can be arranged, with respect to each other and to the symmetry axis, so that during the lifting step the power transmission chains passing through the power transmission wheels create power torques that are in balance. This is something that a man skilled in the art can do on the basis of his experience.

[0014] Owing to the structure according to the inven-

tion, the tube or tubes of the mast truck can be arranged to proceed outside the driver's field of vision, mainly along the same path as the power transmission chains.

[0015] A few preferred embodiments of the invention are explained in more detail below, with reference to the appended drawings, where

figure 1a illustrates the mast structure of a mast truck according to the invention, seen in a vertical illustration from behind, from the driver's point of view and as extended to the working position,

figure 1b illustrates the top part of figure 1a, cut at the line 1ab and shown in an enlarged scale;

figure 1c illustrates the bottom part of figure 1a, cut at the line 1ab and shown in an enlarged scale;

figure 2 illustrates the mast truck according to figures 1a - 1c, seen in a larger scale and in the initial position;

figure 3 illustrates the mast truck according to figure 1, seen in a larger scale in a vertical illustration and in the same direction after the free-lifting step, when the lifting carriage is lifted to the top end of the top carriage;

figure 4 illustrates the mast truck according to figure 1, seen in a vertical illustration from the side and in the rest position;

figure 5 illustrates the mast truck according to figure 2, seen in a top-view illustration;

figure 6 illustrates the mast truck of figure 2, seen in a 3D illustration, in a smaller scale and in the initial position;

figure 7 illustrates the band turning element in a 3D illustration, seen in a larger scale; and

figure 8 illustrates the top part of a mast truck according to another embodiment, seen from the driver's point of view and in the initial position.

[0016] The embodiment illustrated in the drawings represents a mast structure that is attached to the truck. The truck housing is supported by at least three wheels, at least one of which is a traction wheel.

[0017] In figure 1a, there are seen three separate mast sections I, II and III that are roughly of the same height. In the width direction of the truck, the mast sections are installed in a telescoping fashion and connected slidably to each other. Each section I, II, III of the mast structure is made of vertical profile pairs 10, 11 and respectively 12, which are welded together at the bottom and top ends by means of transversal supports 4 and 5, 6 and 7, and respectively 8 and 9. The mast I is connected to the truck either in a stationary fashion or so that it can be inclined in the direction of the lengthwise axis of the truck, i.e. in the driving direction. The middle mast section is the intermediate carriage II that moves vertically by intermediation of guide wheel bearings with respect to the profiles 10 of the mast section I. The innermost mast section is the top carriage III, which moves in similar fashion in the profiles 11 of the intermediate carriage II. The lifting carriage is realized in the form of a fork lift 19, figure 6, and it moves with respect to the top carriage III. The profiles 12 and 11 of the top and intermediate carriage III, II, as well as the profiles 10 of the mast I are I-profiles. As an alternative, the profiles of the mast I can be U-profiles.

[0018] The mast structure, figure 1a, comprises two hydraulic cylinders, 14 and 20. The cylinders operate in two steps. The first operation step is carried out by the free-lifting jack 14, which lifts the fork lift 19 to the top end III of the fork lift 19, whereafter another lifting jack 20 pushes the intermediate carriage II upwards in the vertical direction. At its top end, the free-lifting jack 14 is attached to the top support 7 of the intermediate carriage, in which case the piston 14_m thereof performs a downwardly thrusting direction and shifts the fork lift 19 to the top end of the top carriage III, figure 3. The motion of the piston is transmitted by means of power transmission elements comprising a chain 29, a chain wheel 13 located at the free end of the piston 14_m of the free-lifting jack, a chain turning element 15, figure 7, chain wheels 16 and 17 attached to the top support 7 of the intermediate carriage II and a chain wheel 18 attached to the top support structure 9 of the top carriage III. In the power transmission chain 29, there is used a chain turning element 15 that turns the chain coming from the chain wheel 13 by 90° with respect to its lengthwise axis, so that the chain enters the chain wheel in the correct position, i.e. at an angle of 90° with respect to the chain wheel 1, figure 6. At the other end, the chain 29 is fixedly attached to the mast top support structure 5, of which the cut sections 5 are illustrated in the drawings. The chain passes around the chain wheel 13 located at the free end of the piston 14_m of the free-lifting jack 14, around the chain wheels 16 and 17 located in the top support structure 7 of the intermediate carriage II and via the chain wheel 18 located in the top support structure 9 of the top carriage III to the fork lift 19. The chain alignment has been selected so that it causes a minimal blind area, figure 1a.

[0019] The free-lifting piston 14_m and the chain 29 moved thereby cause a counterclockwise torque at the top end of the intermediate carriage II, while the chain passes over the chain wheels 16 and 17. Said counter-

clockwise torque is balanced in the top support structure 7 of the intermediate carriage II by means of chains 25 and 26. One end of the chain 25 is attached to the top support structure 5 of the mast I and proceeds via the chain wheel 21 to the bottom support structure 8 of the top carriage III. The chain wheel 21 is turned by 90° with respect to the chain wheels 16 and 17, figure 6, so that its axis is transversal to the truck driving direction. One end of the chain 26 is attached to the top support structure of the mast I and proceeds over the chain wheels 22 and 23, attached to the top support structure 7 of the intermediate carriage II, to the bottom support structure 8 of the top carriage, being attached thereto at the other end, figures 2 and 3. The fastening points of the bottom ends of the chains 25 and 26 in the bottom support structure 8 of the top carriage III are arranged so that in the bottom position of the mast, the chain alignments proceed between the profiles 10 and 12, so that the blind area is minimal. On the other hand, the fastening points of the top ends of the chains 25 and 26 in the top support structure 5 of the mast I are asymmetric with respect to the central axis A-A, figure 1c. Hence the asymmetric positioning of the chain wheels 21 and 22, 23 causes a clockwise torque for the intermediate carriage II.

[0020] Thus the chain wheel 21 fits in a small space transversally to the driving direction, and does not increase the blind area in the driver's view. The fastening points of the ends of the chain 25 in the top support structure of the mast I and respectively in the bottom support structure 8 of the top carriage III are located directly underneath the chain wheel 21, and consequently do not enlarge the blind area. The chain 2 in turn is at one end attached to the top support structure 5 of the mast I, mainly at the same distance from the central axis A-A of the mast I as the chain 25, and it passes around the chain wheels 22 and 23 attached to the top support structure of the intermediate carriage II to the bottom support structure 8 of the top carriage, to outside the second jack with respect to the central axis A-A of the mast truck, according to figures 1a, 2 and 3. Thus the asymmetric positioning of the chain wheels 21, 22 and 23 causes in the intermediate carriage a torque in the opposite direction.

[0021] The chain 26 passes over both wheels 22, 23. The chain wheels 22 and 23 can also be replaced by a single chain wheel with a larger diameter than the wheels 22 and 23, figure 8.

[0022] The bottom end of the jack 20 that performs the second step in the lifting operation is attached to the mast structure I, and the top end thereof is attached to the top support structure 7 of the intermediate carriage II. The jacks 1 and 20 are hydraulically coupled in series by means of a pipe 2, figure 5. The area of the piston 14_m of the jack 1 is larger or at least equal to the area of the piston 20_m of the jack 20. The ratio of the areas is utilized for controlling the order of the operation of the jacks, so that the free-lifting jack is operated first owing to its smaller weight level.

[0023] The continuous operation of the mast structure is best understood from figures la-3. In figure 2, the mast is in its initial position, i.e. in the rest position. Now the chain turning element 15 is near the chain wheel 16 located in the top support structure 7 of the intermediate carriage II. In the first step of the lifting operation, the piston of the free-lifting jack 14_m moves vertically downwards, at the same time moving the chain wheel 13 attached thereto. Over the chain wheel, there passes the free-lifting chain 29 which is at one end attached to the top support structure 5 of the mast I, and at the other end to the fork lift 19. The motion of the chain wheel lifts the fork lift 19 in the proportion of the motional lengths 1:2, i.e. the length proceeded by the fork lift is doubled with respect to the length proceeded by the chain wheel 1. At the end of the stroke of the piston 14_m of the free-lifting jack 14, the situation corresponds to figure 2. The chain turning element 15 has proceeded to the vicinity of the chain wheel 1 attached to the piston 14_m of the free-lifting jack. The chain wheels 16 and 17 cause a counterclockwise torque in the top support structure of the intermediate carriage II. In the next step of the lifting operation, the piston 20_m of the lifting jack 20 moves upwards, at the same time moving the intermediate carriage II and the free-lifting jack 14 attached thereto, in the proportion 1:1 of the motional lengths. The chain wheels 21, 22 and 23 attached to the top support structure of the intermediate carriage II transmit the stroke of the piston 20_m of the lifting jack 20 to the top carriage III, thus lifting the carriage to the top position. In the second step of the lifting operation, the asymmetric alignment of the power transmission chains 25 and 26 causes a clockwise torque in the intermediate carriage II, and thus balances the counterclockwise torque created during the first step of the lifting operation. At the end of the stroke of the second lifting jack, the chain turning element 15 has moved to the vicinity of the chain wheel 1, located in the top structure of the intermediate carriage II, figure 2. Thus the chain turning element 15 moves back and forth between the extreme position of the initial position, located near the chain wheel 16, to the extreme position according to the truck working position, which is situated near the chain wheel 13.

[0024] The return of the mast structure to the rest position takes place in reversed order.

[0025] The controlling of the tubes 27, figure 3, can be realized so that it causes as little blind area as possible. The tubes are fixedly attached to the top support structure 5 of the mast I, wherefrom they pass via the chain 13, 16, via the tube wheel 28 and the chain wheel 18 to the fork lift 19. At the chain wheel 13, the tubes proceed in parallel with the chain 29, but at the chain wheel 16 they proceed over it, while the chain 29 passes underneath; then they pass underneath the tube wheel 28 attached to the top support structure 7 of the intermediate carriage II, so that they are directed on top of the free-lifting chain 29 according to figure 2.

[0026] The minimum length of the mast structure is

formed of the dimensions of the profiles 10, 11 and 12. The length of the mast structure according to the above described embodiment is formed, in addition to the profiles 10, 11 and 12, of the width of the power transmission chain 25, figure 5. The space taken up by the chain 29 in the lengthwise direction of the mast can be reduced by shifting the location of the free-lifting jack 14 somewhat forward in the proceeding direction of the truck. Therefore the profiles 10, 11 and 12 are worked at the top end, so that the chain wheels 16, 17 and 18 can be placed in line with the free-lifting jack.

[0027] The extendable mast structure specified above, comprising two moving carriages, is not restricted to the figures and described embodiments exclusively, but it can be modified within the scope of the appended claims and according to the know-how of a man skilled in the art.

Claims

1. A mast truck, particularly a swing mast truck meant for warehouse operations, comprising

- a mast structure including a fixed mast (I) and at least two moving carriages (II and III), one of which is an intermediate carriage (II) and movable vertically with respect to the fixed mast (I), and the other is a top carriage (III) and movable vertically along the intermediate carriage (II), and further including a lifting carriage (19), which is supported by the top carriage (III) and movable vertically along the top carriage;
- two hydraulic cylinders (14, 20) for moving the carriages (19, II, III), the first of which is a free-lifting jack (14), causing the lifting carriage (19) to be shifted to the top end of the intermediate carriage (II), and the second is a lifting jack (20), causing the intermediate carriage (II) and the top carriage (III) to be shifted to their top positions, while the free-lifting jack (14) is arranged to operate first, and the lifting jack (20) is arranged to operate thereafter;
- and band-like power transmission elements (29, 25, 26), passing through transmission wheels (13, 16, 17, 18, 21, 22, 23) and transmit the thrusting motions of the cylinder pistons (14_m, 20_m) to the carriages (II, III, 19);

so that the first band-like power transmission element (29), which is arranged to transmit the thrusting motion of the piston (14_m) of the free-lifting jack, is at one end attached to the top support structure (5) of the fixed mast (I), passes around the wheel (13) located at the free end of the piston (14_m) of the free-lifting jack (14) and further passes around the wheels (16, 17), attached to the top support structure (7) of the intermediate carriage (II), proceeding over the outermost wheel (16) and underneath the innermost wheel (17), and further over the wheel (18) located in the top support structure (9) of the top carriage (III), wherefrom it continues to the lifting carriage, to which its other end is attached;

the second band-like power transmission element (26), which is arranged to transmit the thrusting motion of the lifting jack piston (20_m), is at one end attached to the top support structure (7) of the mast (I), passes over the at least one wheel (22, 23) attached to the top support structure (7) of the intermediate carriage (II), wherefrom it continues to the bottom support structure (8) of the top carriage (III), whereto it is attached; and

a third band-like power transmission element (25), which also is arranged to transmit the thrusting motion of the lifting jack piston (20_m), is at one end attached to the top support structure (5) of the mast (I), passes around the wheel (21) attached to the top support structure (7) of the intermediate carriage (II) and proceeds to the bottom support structure (8) of the top carriage (III), where it is attached, at a spot that is located at the same distance from the symmetry axis (A-A) of the mast truck as the fastening spot of the other band-like power transmission element (26), but on the opposite side of said symmetry axis (A-A); in which case the alignments of the band-like power transmission elements are chosen in order to achieve a balance between the opposite torques created thereby during the operational steps of the mast truck, **characterized in that**

the free-lifting jack (14) and the lifting jack (20) are both located, in a way known as such, mainly on the same level of the mast truck that is transversal to the motional direction of the mast truck, one on one side and one on the other side of the mast truck;

that the axis of the wheel (13) located at the end of the free-lifting jack (14) is transversal to the proceeding direction of the truck;

that in the first band-like power transmission element (29), there is arranged a band turning element (15) in order to turn the power transmission element by 90° around its lengthwise axis along the distance between the wheel (13) and wheel (16); and that the lifting jack piston (20_m) is arranged to move upwards.

2. A mast truck according to claim 1, **characterized in that** the band-like power transmission elements (29, 26, 25) for transmitting the thrusting motion of the jack pistons (14_m, 20_m) are chains.

3. A mast truck according to claim 1 or 2, **characterized in that** the hydraulic cylinders (14, 20) are coupled in series by means of a pipe (24).

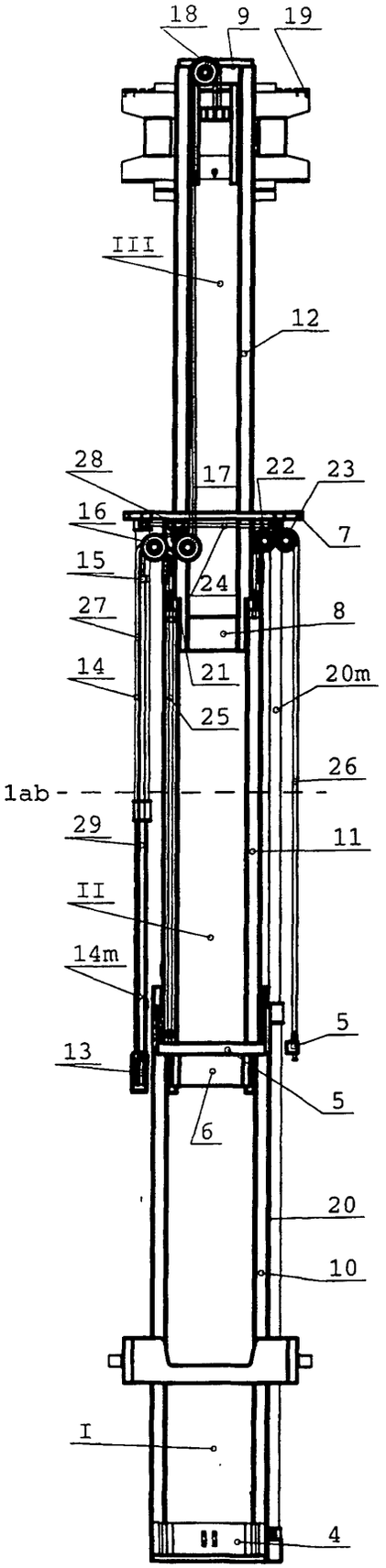
4. A mast truck according to any of the claims 1 - 3, **characterized in that** the wheels (16, 17, 22, 23, 21), surrounded by the band-like power transmission elements (29, 26, 25), said wheels being placed in the top support structure (7) of the intermediate carriage (II) are located, with respect to the proceeding direction of the truck, at right angles to the symmetry axis (A-A) of the mast structure, so that the power torques created during the operational step of the truck are mainly balanced.

5. A mast truck according to claim 4, **characterized in that** the diameter of the wheel (32) surrounded by the second band-like power transmission element (26), said wheel being placed in the top support structure (7) of the intermediate carriage (II), is so large that the clockwise power torque created by the power transmission element during the operational step of the mast truck is capable of balancing the counterclockwise torques of the first and third power transmission elements (29, 25).

6. A mast truck according to claim 5, **characterized in that** the wheel surrounded by the second band-like power transmission element (26), said wheel being located in the top support structure (5) of the intermediate carriage (II), is replaced by two adjacent wheels (22, 23) having smaller diameters, while the element (26) passes over both wheels (22, 23).

7. A mast truck according to any of the preceding claims, **characterized in that** the tube (27) or tubes required by auxiliary devices are arranged to proceed along the same route as the power transmission band (29) of the free-lifting jack (14), but so that while the power transmission band (29) passes around the wheels (16, 17) attached to the top support structure (7) of the intermediate carriage (II), over the outer wheel (16) and underneath the inner wheel (17), the tube (27) only passes over the outer wheel (16) and proceeds to a tube wheel (28) attached to the top support structure (7) of the intermediate carriage (II), passing underneath said wheel and further over the wheel attached to the top support structure of the top carriage (III), while the tube wheel (28) is located above two wheels (16, 17) surrounded by the power transmission element (29), transversally to the driving direction, on that side of the wheel (18) placed in the top structure (9) of the top carriage (III) that falls on the side of the free-lifting jack (14).

FIG. 1a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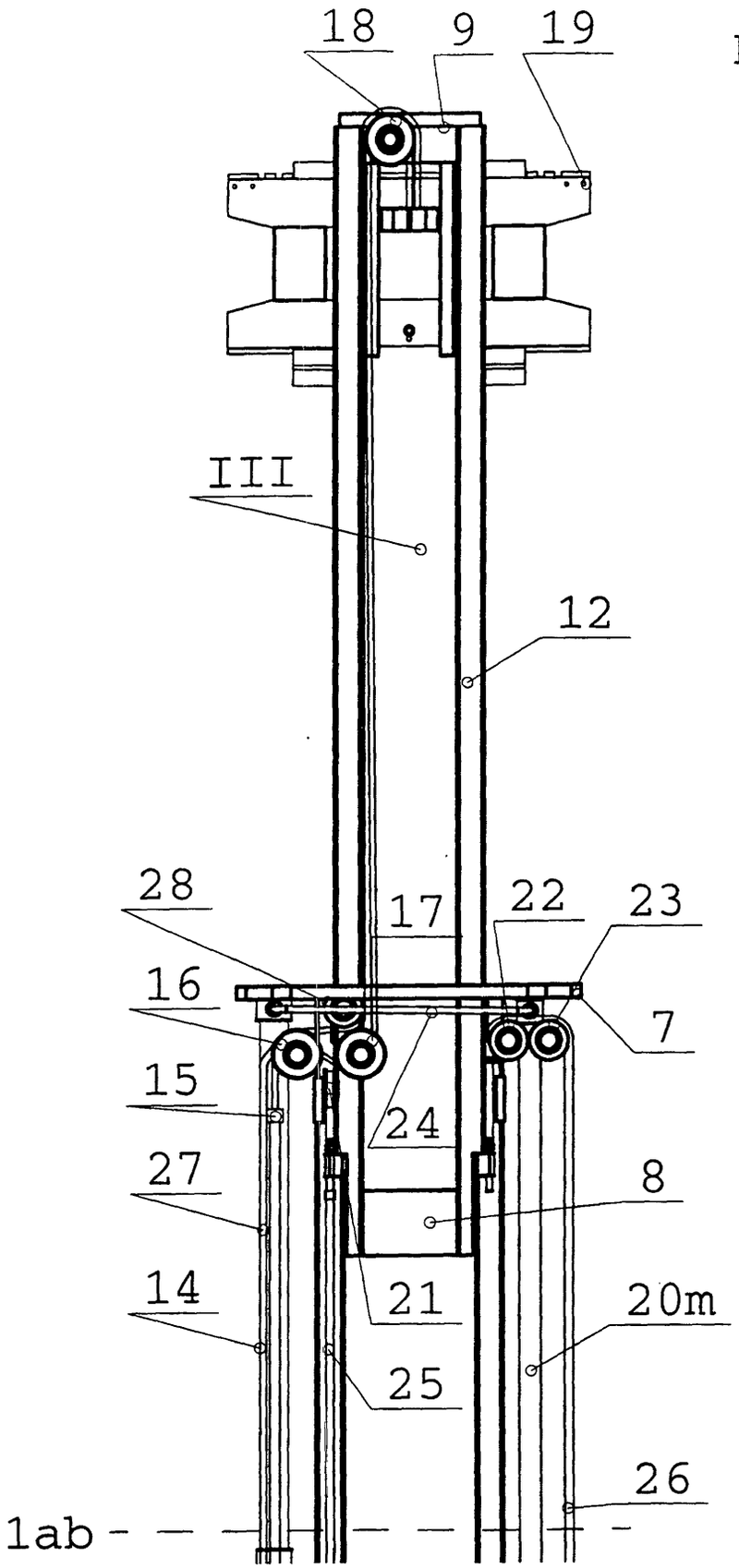


FIG. 1b

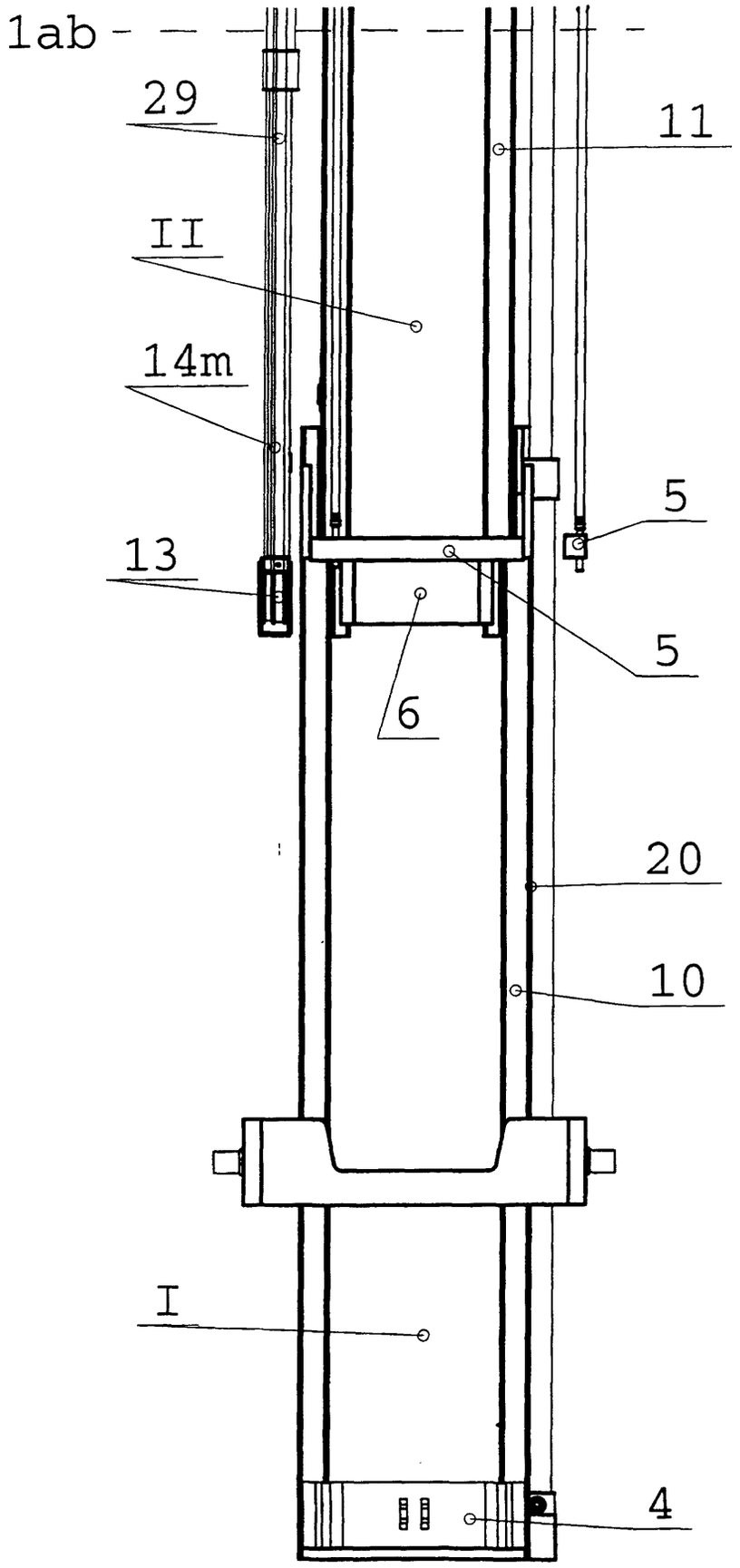


FIG. 1c

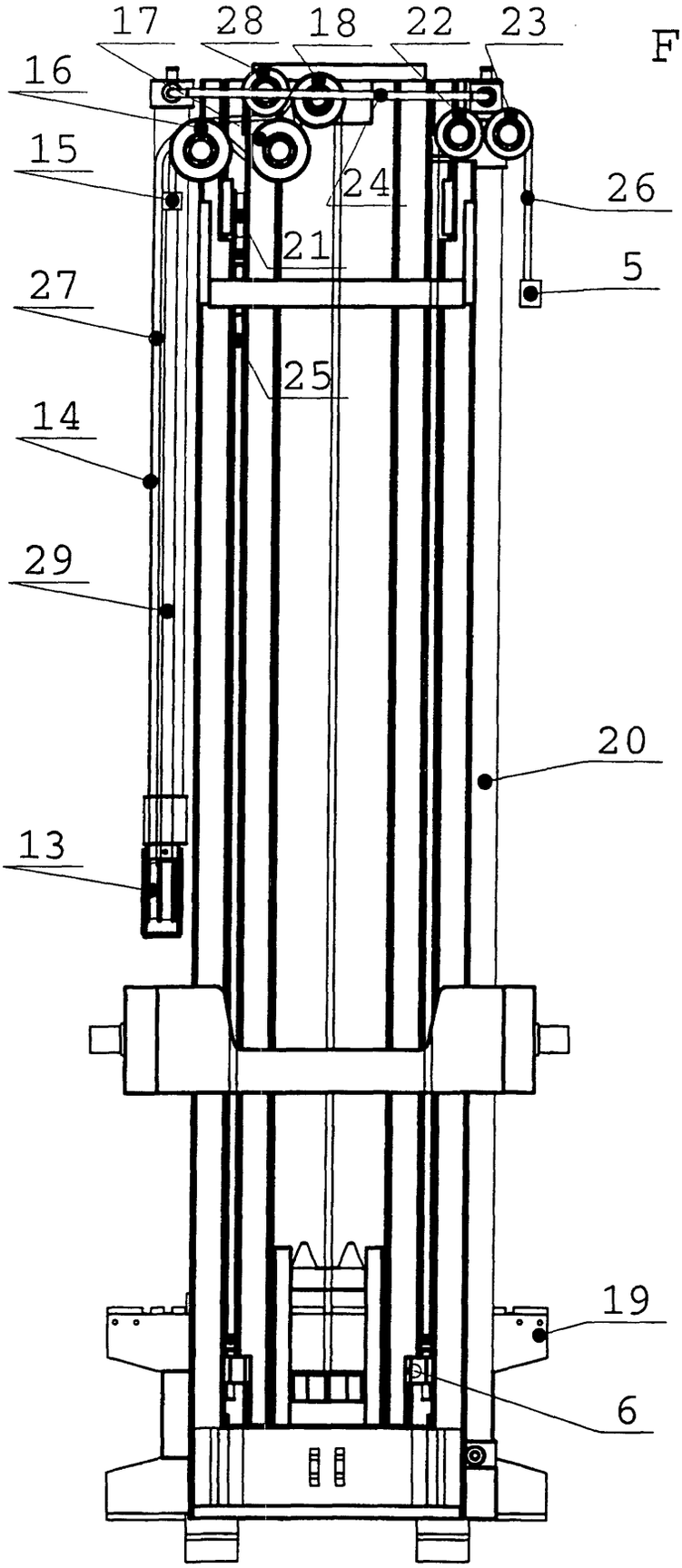


FIG. 2

FIG. 3

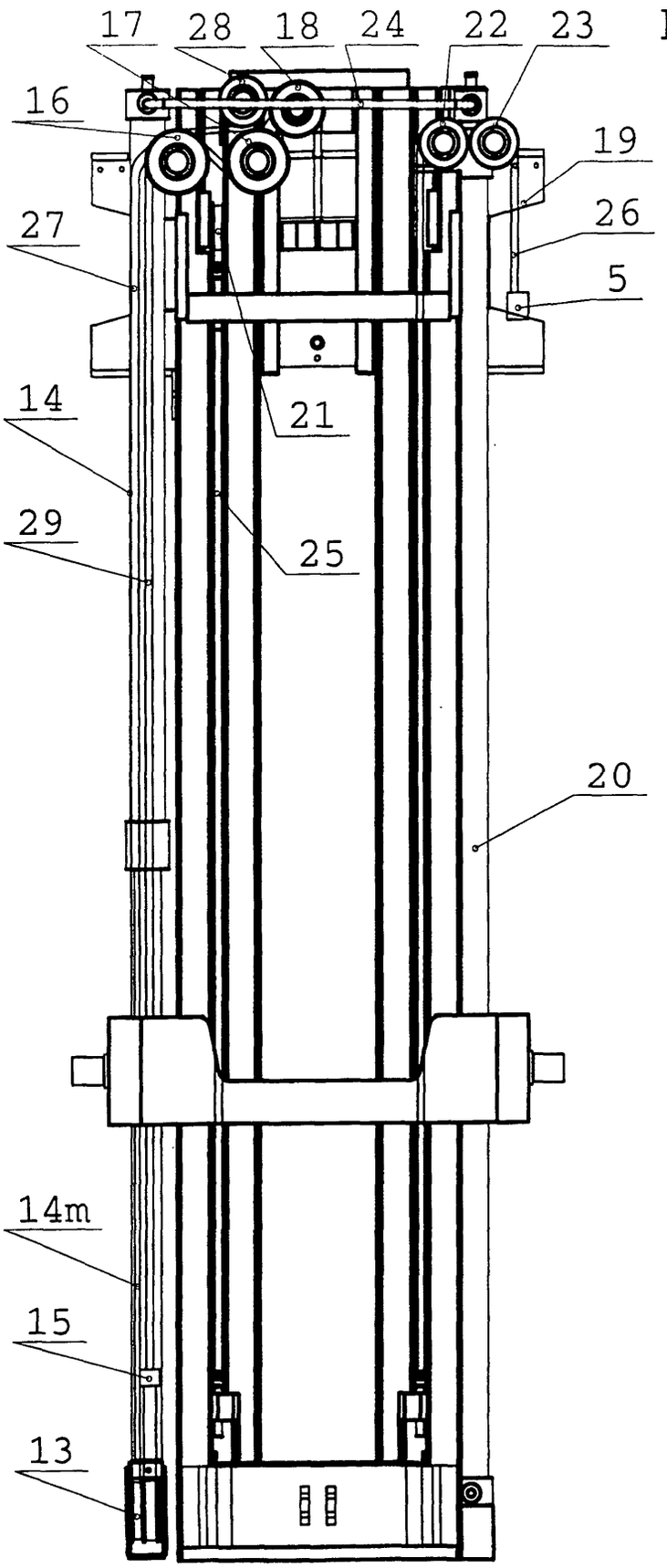


FIG. 4

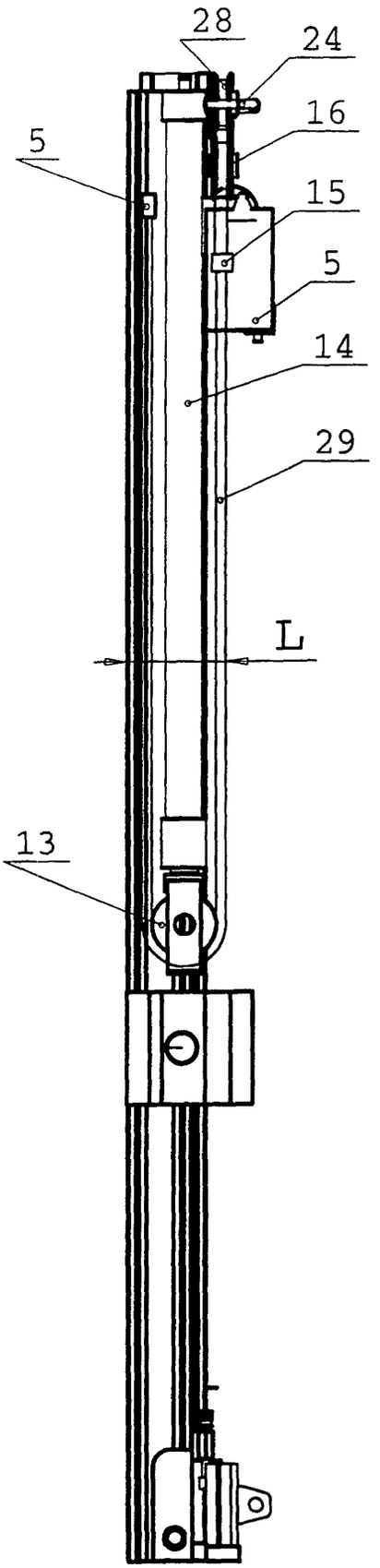


FIG. 5

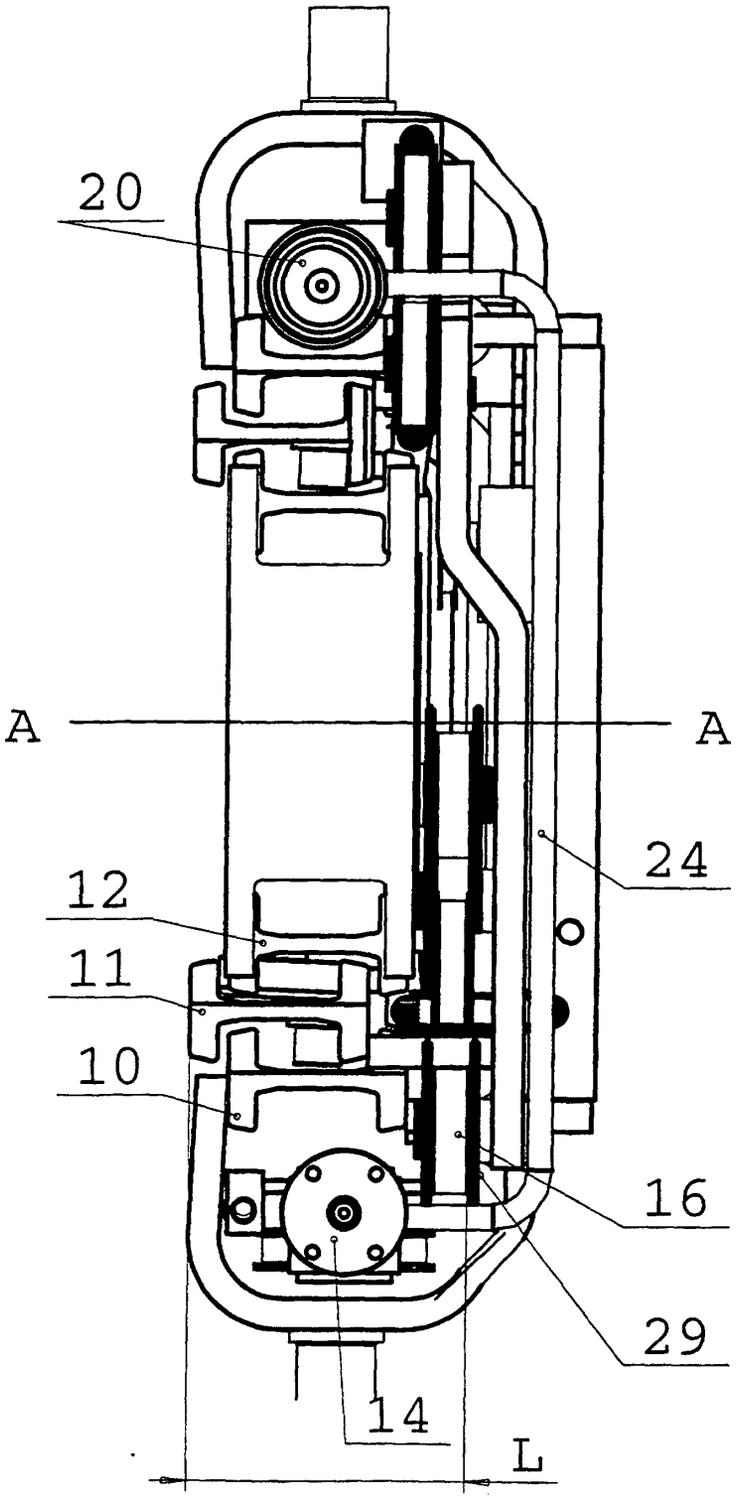


FIG. 6

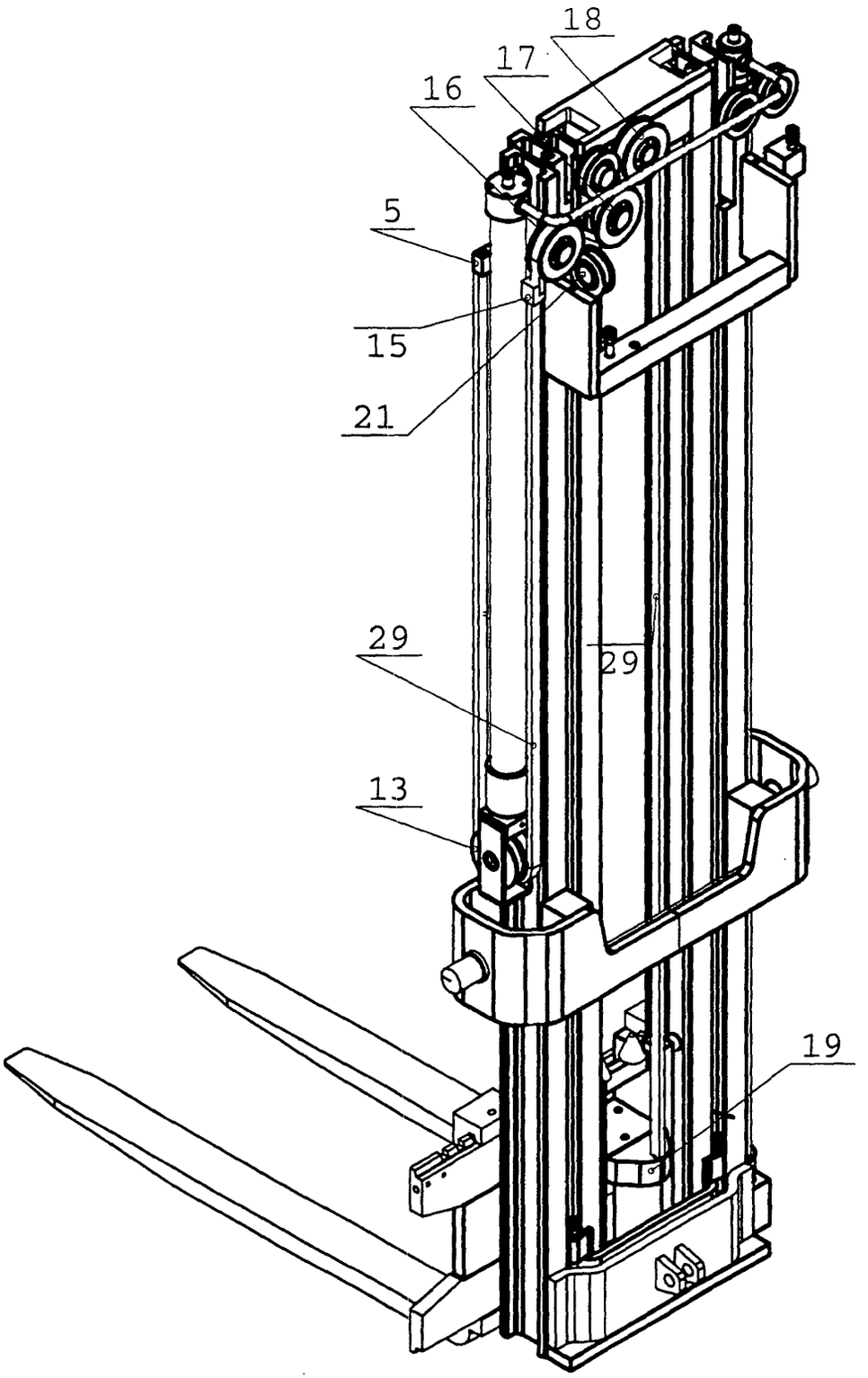


FIG. 7

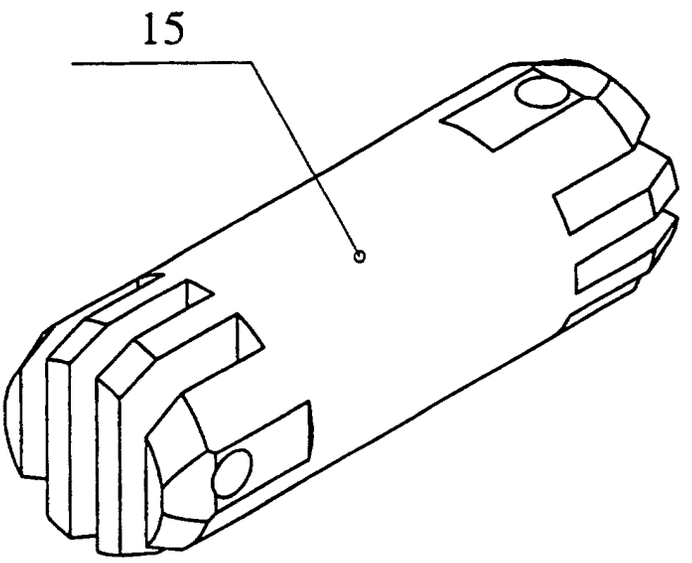
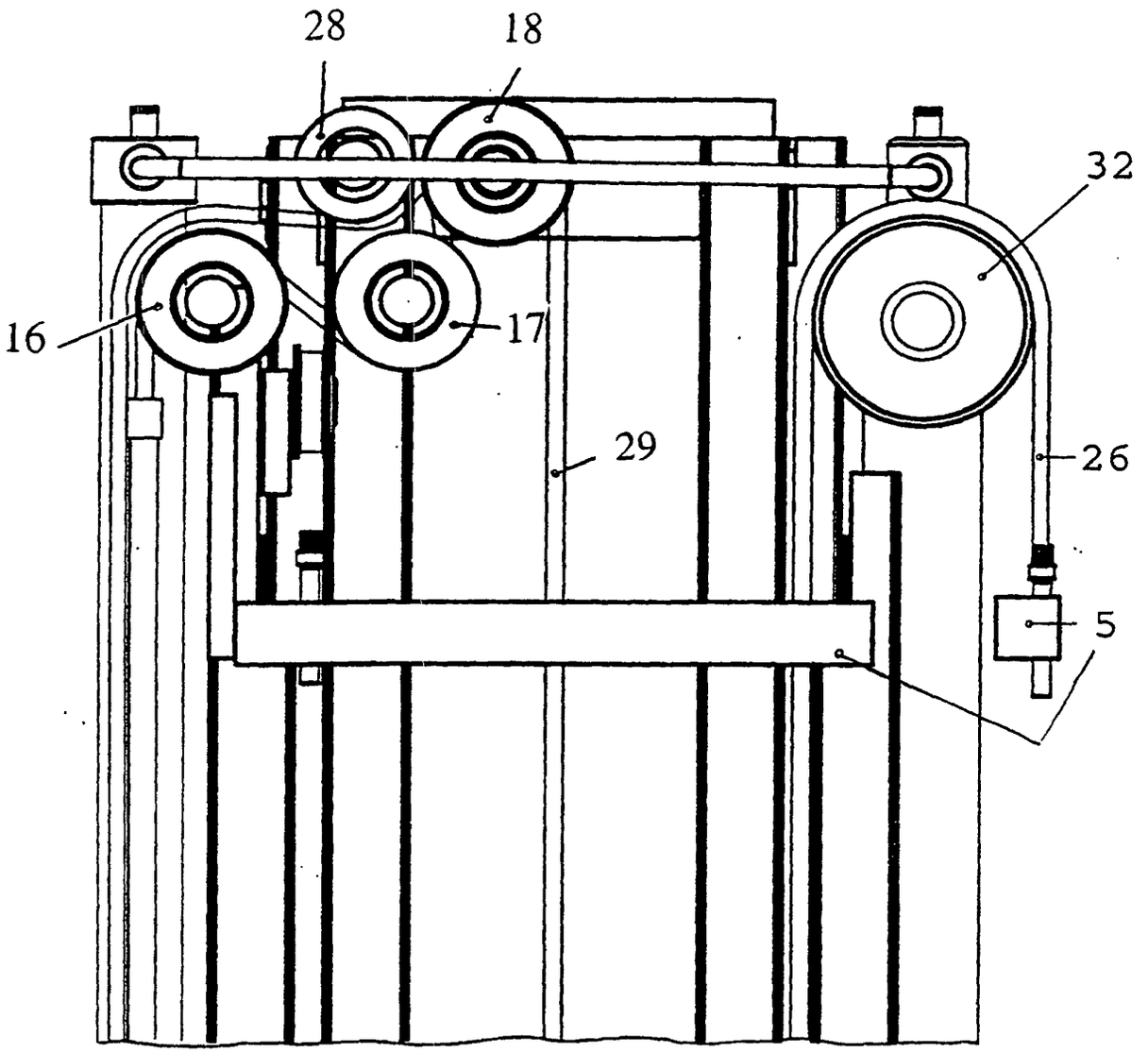


FIG. 8



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EUROPEAN SEARCH REPORT

Application Number
EP 01 66 0081

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Y	GB 2 236 091 A (LANSING LINDE LTD) 27 March 1991 (1991-03-27) * the whole document * ---	1-6	B66F9/08 B66F9/20
Y	GB 1 287 806 A (DSO BALKANSAR) 6 September 1972 (1972-09-06) * the whole document * ---	1-6	
A	US 3 894 616 A (KAWANISHI KUNIHISA ET AL) 15 July 1975 (1975-07-15) * the whole document * -----	7	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

B66F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	7 August 2001	Sheppard, B

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

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