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(54) **METHOD FOR CONTROLLING A STAIRLIFT**

(57) The present invention relates to a
Method for controlling a lift (1), in particular a stairlift (1), the lift (1) comprises:
- a carrier (3), which is movable along a path of travel (T) defined by a rail (2), wherein the rail (2) is designed so that an inclination angle (α) of the path of travel is changing along the path of travel (T),
- a support (4), on which a user interface is mounted, in particular a chair (5), mounted on the support (4),
- a levelling mechanism (10), adapted to keep the support (4) in a constant orientation compared to a horizontal plane (H), when the orientation of the carrier (3) is changing due to the changing inclination angle (α),
- a first lateral acceleration sensor (13) for providing lateral acceleration values (a13x, a13y);
- an angular acceleration sensor (14) for providing an angular acceleration value (a14α);
comprising the following method steps:
measuring lateral acceleration values (a13x, a13y) of the carrier (3) by the first lateral acceleration sensor (13), which is mounted at the carrier (3);
measuring an angular acceleration value (a14α) of the carrier (3) by the angular acceleration sensor unit (14), which is mounted at the carrier (3);
combining the provided lateral accelerations values (a13x, a13y) and the angular acceleration value (a14α) to calculate an absolute orientation value (α) of the carrier (3);
based on the calculated absolute orientation value (α) calculating a control signal (18) of the levelling mechanism (10), adapted to keep the support (4) in a desired orientation (θ=0°; β=-α).

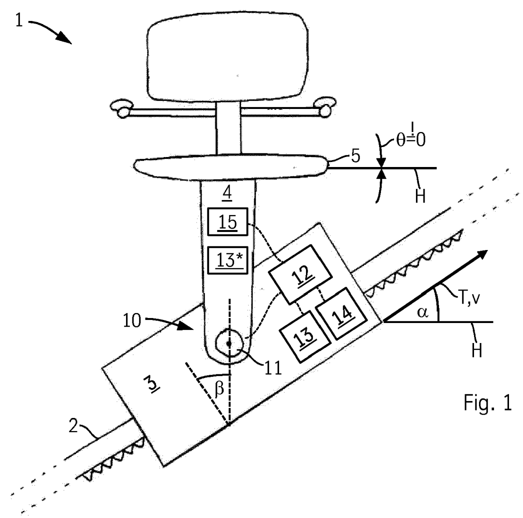

Fig. 1

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Description

Technical field

[0001] The invention refers to a method for controlling a lift, in particular a stairlift, and a lift, controlled by this method.

Background art

[0002] Such lifts may be mounted at a stairway of residential homes. Often these stairs have a curved shape. Here, only lifts having a rail with changing inclination over the path of travel can be used. Therefore, a levelling mechanism is provided within the lift, to keep the seat of the chair of the stairlift in a horizontal position. Already small deviations of the stair from the horizontal orientation would cause a feeling of unsafety to a person using the stairlift.

[0003] Within this application the terms carrier and support are used as follows:

> The term "carrier" is used for the unit of the lift, which is traveling along the rail and which orientation over the horizontal plane is changed with the inclination of the rail. The carrier connects the support with the rail.

[0004] The term "support" is used for the unit of the lift, which is mounted via a levelling mechanism on the carrier. The levelling mechanism is adapted to keep the support in a constant orientation, even if the orientation of the carrier is changing. A transport platform, in particular a chair, may be attached to the support.

[0005] EP 2 216 284 B1 discloses an apparatus for transporting load from a first to a second level, in particular a stairlift. Here, an acceleration sensor and a first gyroscope are mounted on the support. Further a second gyroscope is mounted on the carrier. With the acceleration sensor and a first gyroscope the levelling algorithm is calculating the control signal for being fed into the levelling motor. But since the orientation of the support does only change minimally over the operation, the acceleration sensor and the gyroscope output values of very low amplitude variation. The acceleration sensor and the gyroscope thus have a very poor Signal-to-Noise-ratio. To be able to use the values of the sensors mounted at the support, expensive sensors must used. Further this system tends to generate oscillations during operation, which is undesirable.

[0006] EP 1 037 846 B1 uses an orientation sensor mounted on the carrier to detect, if the carrier is traveling along a section of the rail with increasing or decreasing inclination. The kind of sensors is not described.

[0007] Absolute orientation sensors may use the magnetic earth field of registering a change in the orientation. These sensors are quite expensive if particular if these sensors are robust against electromagnetic perturbation and noise. Acceleration sensors are not capable of measuring an absolute orientation on their own since these sensors are not sensitive to the magnetic earth field, as explained below.

Summary of the invention

[0008] The object of the invention is to provide an improved method for controlling a lift, in particular a stairlift, which is robust against perturbation, at the same time the possibility to use cheaper components is desirable. This object is solved by the method according to claim 1 and the elevator according to claim 5; preferred embodiments are disclosed in the subclaims and the description.

[0009] The lift, in particular a stairlift, comprises: a carrier, which is movable along a path of travel defined by a rail, wherein the rail is designed so that an inclination angle of the path of travel is changing along the path of travel; a support, on which a user interface is mounted, in particular a chair, mounted on the support; a levelling mechanism, adapted to keep the support in a constant orientation compared to a horizontal plane, when the orientation of the carrier is changing due to the changing inclination angle; a first lateral acceleration sensor for providing lateral acceleration values; an angular acceleration sensor for providing an (at least one) angular acceleration value.

[0010] According to the invention the method comprises the following method steps: measuring lateral acceleration values of the carrier by the lateral acceleration sensor, which is mounted at the carrier; measuring an (at least one) angular acceleration value of the carrier by the angular acceleration sensor unit, which is mounted at the carrier; combining the provided lateral acceleration values and the angular acceleration value to calculate an absolute orientation value of the carrier; based on the calculated absolute orientation value calculating a control signal of the levelling mechanism, adapted to keep the support in a desired orientation.

[0011] A main aspect of the invention is to use a lateral acceleration sensor and an angular acceleration sensor on the carrier for determining the orientation of the chair, which is the main input value for the levelling mechanism. Providing the sensors on the carrier leads to a better quality of controlling since the signal-to-noise-ratio of the sensor values can be improved compared to an arrangement which uses the sensors mounted at the support. This leads also to the advantage, that cheaper components can be used. Due to the better signal quality, the control loop can be designed more stable, thus oscillations can be prevented.

[0012] In a preferred embodiment, by means of a second acceleration sensor, which is mounted at the support, the desired orientation is validated. The second acceleration sensor outputs second lateral acceleration values.

[0013] The second acceleration values may be used for setting up the starting position in the stationary state. In the stationary state, the acceleration values are not influenced by lateral acceleration of the support, caused by the drive motor. So in the stationary state (speed of lift = 0) the second lateral acceleration sensor mounted at the support is useful to calculate the absolute orientation of the support, considering the direction of gravity. The possibility of calculating any orientation with the help of only of a lateral acceleration sensor (during a period without any other acceleration) is later described with reference to figure 3b-3d, which is also applicable here.

[0014] So before starting the operation the support can be brought into the desired starting orientation by means of the second acceleration sensor, by turning the support into an orientation, in which the second acceleration sensor values indicated the desired orientation.

[0015] In particular the first and/or the second acceleration sensor is merely sensitive to lateral acceleration, in particular not sensitive to magnetic earth field, and/or in particular not sensitive to angular acceleration.

[0016] In particular the angular acceleration sensor is merely sensitive to angular acceleration, in particular not sensitive to lateral acceleration, and/or in particular not sensitive magnetic earth field.

[0017] Such components can be purchased cost efficiently. Operated in the inventive method these cheap sensors can deliver sufficient values for improved levelling.

[0018] The invention is further directed to a lift as described above. The lift comprise a control unit, adapted to control the levelling mechanism according to the method of any of the previous claims.

[0019] The term "mounted at the carrier / support" means with respect to the acceleration sensor, that this sensor is connected to the carrier / support in such way, that the sensor is capable of measuring accelerations, which originally occur to the carrier / support. The sensor may be connected directly or indirectly to the carrier / support.

Brief description of drawings

[0020] The invention is illustrated in more detail below by means of drawings.

Fig. 1 shows a stairlift according to the invention, comprising a carrier 3 and a chair support 4 with levelling mechanism 10 for controlling the levelling of the support;

Fig. 2 shows the path of the rails 20, comprising sections 21, 22, 23, 24, 25 of different inclination angles;

Fig. 3 shows schematically sensors 13, 14 of the levelling mechanism, mounted at the carrier in different sections on the rail during operation;

Fig. 4 shows the course of relevant values during operation;

Fig. 5 shows a control loop of the levelling mechanism;

Fig. 6 shows selected values from figure 4 comprising noise.

Best modus for carrying out the invention

[0021] Figures 1 and 2 show a stairlift 1 mounted at a stairway 6 of residential homes. A rail 20 follows the course of the stairway 6 and defines a path of travel T. A carrier 3 is attached to the rail 2 and is driveable along the path of travel by a non shown drive motor. Thereby an orientation angle α of the carrier 3 against a horizontal plane H follows the inclination of the rail 2.

[0022] A support 4 is mounted on the carrier 3. A chair 5 is supported by the support 4. A levelling mechanism 10 is provided, to keep the support 4 in a constant orientation and to keep the seat 5 in a horizontal orientation. The levelling mechanism 10 therefore comprises a levelling motor 11. An angle θ between the seat 5 and the horizontal plane H should be 0° during operation.

[0023] The levelling mechanism 10 comprises a levelling motor 11, capable of rotating the support 4 against the carrier 3. The levelling mechanism comprises further a number of sensors, namely a first acceleration sensor 13 mounted at the carriage 3, a gyroscope 14 mounted at the carriage 3 and a second acceleration sensor 15 mounted at the support 4.

[0024] The rail 2 comprises sections 21-25 of different inclination. In a first end section 21 and a second end section 25 the inclination angle of the rail is in this case 0°. Any other angle between 0° and 90° is possible. In a central section 23 the inclination angle α is constant at about 45° or any other angle, which is mostly pre-set by the inclination of the stairway. In a first transitional section 22 between the first end section 21 and the central section 23 the inclination angle α is increasing, in a second transitional section 24 between the central section 23 and the second end section 25 the inclination is decreasing. If the carrier 3 is traveling along the rail, an orientation α of the carrier 3 against the horizontal plane H is at first 0° (first end sections 21), then increasing (first transitional section 22), then about 45° or any other constant value above 0° (central section 23), then decreasing (second transitional section 24), and finally 0° (second end section). This course of the angle α is drawn in figure 4.

[0025] Figure 3 shows schematically the working principle and the output values of the first acceleration sensor 13 and the gyroscope 14, mounted at the carrier 3. The first acceleration sensor 13 outputs at least two acceleration values, namely a first acceleration value a13x and a second acceleration value a13y, each representing accelerations in directions perpendicular to each other. Based on these two acceleration values a13x, a13y a resulting acceleration value a13 may be calculated.

[0026] In this context an accelerometer is a compact device designed to measure gravital or non-gravitational acceleration. The lateral accelerometer is not capable to measure the absolute orientation with the help of sensing the magnetic earth field. An angular accelerometer, in particular a gyroscope, is a device that may use a freely-rotating disk called a rotor, mounted onto a spinning axis in the centre of a larger and more stable wheel. This device is only sensitive to angular accelerations and not sensitive for lateral accelerations and the magnetic earth field.

[0027] In figure 3b, the carrier 3 and the sensor 13 travel with constant speed along the first horizontal section 21, after the carrier has been accelerated by the drive means. Since gravity g in this stage is the only acceleration affecting the first acceleration sensor 13, the resulting acceleration value a13 represents the gravity which is indicated by the second acceleration value. The first acceleration value is 0.

[0028] In figure 3c the angle α of orientation of the carrier 3 and the first acceleration sensor 13 against the horizontal direction H is greater than 0°, during travel in the first transitional section 22 with a constant speed.

[0029] Since gravity g is the only acceleration, affecting the fist acceleration sensor 13, the resulting acceleration value a13 represents the gravity (here the amount of centrifugal force in the first transitional section 22 is neglected). From the first acceleration value a13x and the second acceleration value a13y, an angle α* can be calculated using the function arctan(a13x/a13y). Here this calculated angle of orientation α* constitutes the correct angle of orientation α of the carrier 3 and the acceleration sensor 13 against the horizontal plane.

[0030] Mainly same applies when the carrier is driving through central section 23 with constant speed, as shown in figure 3d. The difference to figure 3c is merely, that the angular acceleration a14α is 0 and the orientation angle α is increased.

[0031] In figure 3a, the carrier 3 is located in the first end section and is at the moment accelerated by the drive motor. Here, the first acceleration values a13x represents the acceleration, affected by the lateral acceleration by the drive motor. Additionally the second acceleration values a13y represent the gravity g. Using again the arctan-function, here a defective, apparent inclination angle α* is calculated, which does not represent the true orientation α of the carrier 3 against the horizontal plane H. To ensure proper calculation of the orientation angle α, additionally an angular acceleration value a14α is measured by the gyroscope 14. As long as the carrier 3 is traveling in a section, where the inclination angle α is constant (sections 21, 23 and 25) the angular acceleration values a14α is 0. If the carrier 3 is traveling in any of the transitional sections 22, 24, wherein the inclination of the rail 2 is increasing/decreasing, the angular acceleration values differs from 0. But since in section 21 no angular acceleration a14α is detected by the gyroscope 14, no change in the angular orientation α of the carrier is detected, even if the calculated angle α* or the relationship of the lateral acceleration values a13x, a13y fake the presence of an inclination.

[0032] Thus, to calculate a proper angle of orientation α, the acceleration values a13x, a13y are combined with the course of the angular acceleration value a14α. The levelling control unit 12 then determines an angle β between support 3 and carriage 4, based on which the levelling motor 11 is controlled.

[0033] The first acceleration sensor may be adapted to measure a further third acceleration value, which is perpendicular to the first and second acceleration values a13x, a13y. This can improve the signal-quality of the first acceleration sensor.

[0034] The additional, second acceleration sensor 15 on the support 4 is merely used to validate, that the support 4 or the chair 5 is in the desired orientation and to set a proper starting position in the stationary state. In this stationary state merely gravity is affecting the second lateral acceleration sensor. Since the drive motor is not running, only small amount of noise is affecting the sensor. In this state, the second acceleration sensor is sufficiently adapted for delivering values for calculating the absolute orientation. The method for calculating is the same as described e.g. with reference to the first sensor in figure 3d.

[0035] The course of the relevant values is drawn in figure 4. A control loop diagram is drawn in figure 5. Here additionally a Kalman-filter 16 is shown which filters noise and faults and which delivers the pure orientation angle α of the carrier 3 against the horizontal level H based on the values obtained from the sensors mounted on the carrier 3. Levelling algorithm 17 calculates the desired angle β between the support 4 and the carriage 3 which is fed to the levelling motor 11.

[0036] The advantage of using an acceleration sensor and gyroscope with respect to EP 2 216 284 B1 is explained with the help of value a13*x, drawn at the bottom of figure 4. According to EP 2 216 284 B1 the levelling mechanism is operated based on an first acceleration sensor 13*, located at the support (also indicated for comparison in figure 1). In figure 4 the amplitude of the first acceleration value a13*x, which is a relevant value for calculating the orientation of the acceleration sensor, has a main peak, when the carrier is accelerated in section 21. During the further operation, the amplitude is more or less constant, since the levelling mechanism continuously holds the support in a constant orientation. If there are deviations from the horizontal orientation (here indicated with D) the levelling mechanism quickly tries to bring the support back into the horizontal orientation. Thus, an idealized course of the first acceleration value a13*x, if sensor is mounted on the support 4, would always be a constant value (with exception during the phase of lateral acceleration). Merely from small deviations from desired orientation of θ=0° the control loop is prompted to correct the orientation.

[0037] Figure 4 shows merely idealized courses of the different values. Figure 6 shows the first acceleration value a13x (according to the invention) and a13*x (according to the embodiment as in EP 2 216 284 B1) which include also noise. As can be seen, the amplitude of first acceleration value a13x according to the invention has a wide signal range S during travel along the path T, also resulting in a relatively high signal to noise ration SNR. The amplitude of first acceleration value a13*x according to prior art has a small signal range S during travel along the path T, resulting in a relatively low signal to noise ration SNR. Merely deviations D lead to a significant amplitude; but as the quality of the control loop increases, the amplitude of the deviation D decreases, which further lead to an decreased signal-to-noise-ratio. So since the signal-to-noise-ration decreases with improved quality, it is getting more and more difficult to further achieve any improvements to the control loop.

[0038] According to the inventive arrangement of the acceleration sensor for controlling the levelling mechanism, the main relevant input value has a higher SNR compared to the prior art. Since in the prior art expensive sensors need to be used for compensating the pure SNR, in the inventive method this compensation is not necessary due to the improved SNR. So in the inventive method cheaper sensors can be used, which is the main improvement of the invention over the prior art. Also the system according to the prior art tends to produce oscillations, which is caused by the pure SNR; this problem is prevented by the inventive method.

[0039] In particular, the first lateral acceleration sensor, the angular acceleration sensor and the second acceleration sensor are the only sensors, which are used for detecting the orientation or changes in the orientation of the carrier and support.

List of reference numbers and designations

[0040]

1	stairlift
2	rail
3	carriage
4	support
5	chair
6	stairway
10	levelling mechanism
11	levelling drive
12	levelling control unit
13	first accelerometer at carriage
13*	first accelerometer at carriage (as in prior art)
14	gyroscope at carriage
15	second accelerometer at support
16	Kalman-filter
17	levelling algorithm
18	control signal for levelling motor
20	path of travel
21	first end section
22	first transitional section
23	central section
24	second transitional section
25	second end section
α	(true) orientation angle of carriage against horizontal plane
β	angle between support and carriage
θ	angle between support and horizontal plane
α^*	(defective) orientation angle calculated by lateral acceleration values only
T	transport direction
H	horizontal plane
g	gravity
T	transport direction
S	signal amplitude
N	noise amplitude
SNR	signal-to-noise-ratio
a13x	lateral acceleration value in x-direction of first acceleration sensor 13
a13y	lateral acceleration value in y-direction of first acceleration sensor 13
a13*x	lateral acceleration value in x-direction of first acceleration sensor 13*, as installed in the prior art
a13	lateral resulting acceleration vector
a14α	angular acceleration value of gyroscope at carriage

Claims

1. Method for controlling a lift (1), in particular a stairlift (1),
the lift (1) comprises:

- a carrier (3), which is movable along a path of travel (20) defined by a rail (2), wherein the rail (2) is designed so that an inclination angle (α) of the path of travel is changing along the path of travel (2),
- a support (4), on which a user interface is mounted, in particular a chair (5), mounted on the support (4),
- a levelling mechanism (11), adapted to keep the support (4) in a constant orientation compared to a horizontal plane (H), when the orientation of the carrier (3) is changing due to the changing inclination angle (α),
- a first lateral acceleration sensor (13) for providing lateral acceleration values (a13x, a13y);
- an angular acceleration sensor (14) for providing an angular acceleration value (a14α);

characterized by the following method steps:

measuring lateral acceleration values (a13x, a13y) of the carrier (3) by the first lateral acceleration sensor (13), which is mounted at the carrier (3);
measuring an angular acceleration value (a14α) of the carrier (3) by the angular acceleration sensor unit (14), which is mounted at the carrier (3);
combining the provided lateral accelerations values (a13x, a13y) and the angular acceleration value (a14α) to calculate an absolute orientation value (α) of the carrier (4);
based on the calculated absolute orientation value (α) calculating a control signal (18) of the levelling mechanism (10), adapted to keep the support (4) in a desired orientation (θ=0°; β=-α).

2. Method according to the previous claim,
characterized in
that by means of a second acceleration sensor (15) mounted on the support (4) the desired orientation (θ=0°) is validated.

3. Method according to any of the previous claims,
characterized in
that by means of a second acceleration sensor (15) the orientation of the support (4) is set to a starting position in the stationary state.

4. Method according the previous claim,
characterized in
that the first acceleration sensor (13) is merely sensitive to lateral acceleration in particular not sensitive to magnetic earth field, and that the angular acceleration sensor is merely sensitive to angular acceleration (a14α), in particular not sensitive to lateral acceleration.

5. Lift (1), comprising

- a carrier (3), which is movable along a path of travel (20) defined by a rail (2), wherein the rail (2) is designed so that an inclination angle ( ) of the path of travel is changing along the path of travel (2),
- a support (4), on which a user interface is mounted, in particular a chair (5), mounted on the support (4),
- a levelling mechanism (11), adapted to keep the support (4) in a constant orientation compared to a horizontal plane (H), when the orientation of the carrier (3) is changing due to the changing inclination angle (α),
- a first lateral acceleration sensor (13) for providing lateral acceleration values (a13x, a13y);
- an angular acceleration sensor (14) for providing an angular acceleration value (a14α);
- a control unit (12), adapted to control the levelling mechanism (11) according to the method of any of the previous claims.

6. Elevator (1), according the previous claim,
characterized by
a second acceleration sensor (15), mounted at the support (4).

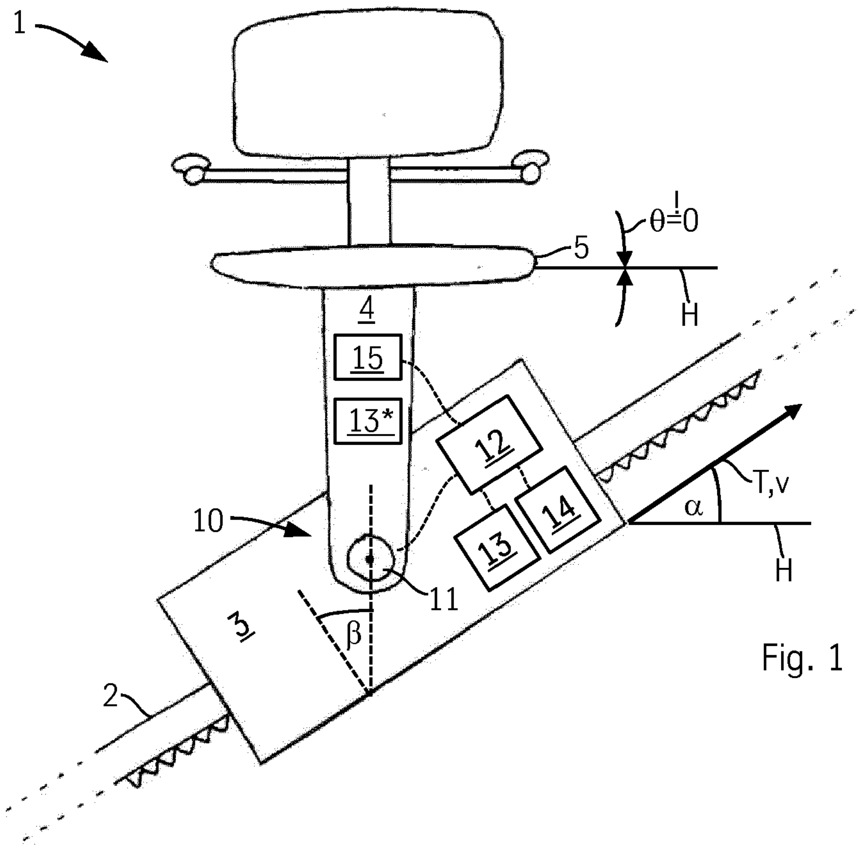
1
θ≟0
5
4
H
15
13*
12
14
13
T,v
α
H
10
11
3
β
2

Fig. 1

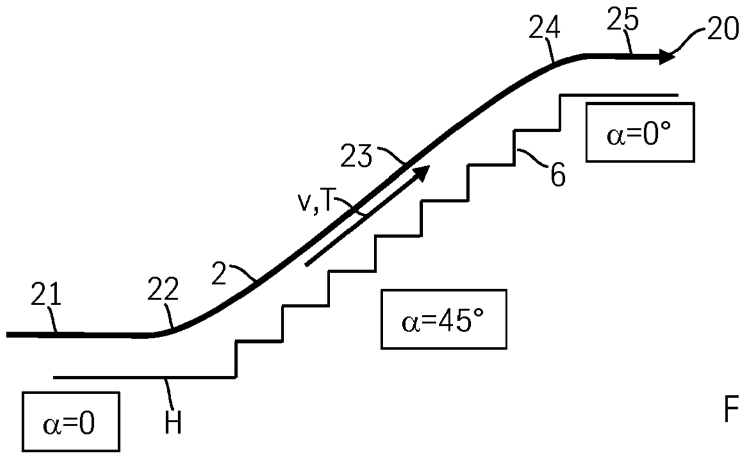
24
25
20
23
6
α=0°
v,T
2
21
22
α=45°
α=0
H

Fig. 2

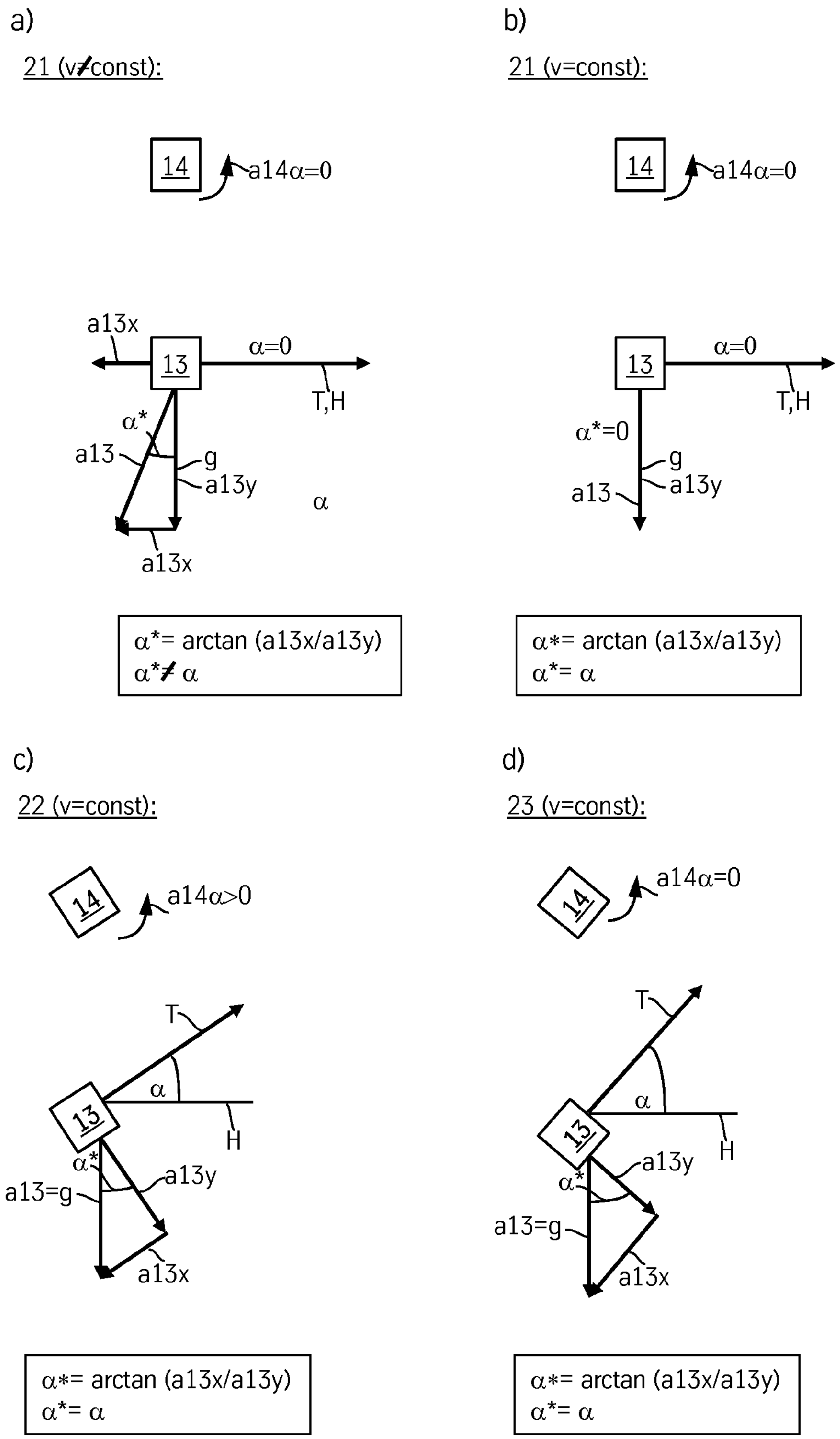
a)
21 (v≠const):
14
a14α=0
a13x
13
α=0
T,H
α*
a13
g
a13y
α
a13x
α*= arctan (a13x/a13y)
α*≠ α
b)
21 (v=const):
14
a14α=0
13
α=0
T,H
α*=0
g
a13y
a13
α*= arctan (a13x/a13y)
α*= α
c)
22 (v=const):
14
a14α>0
T
α
13
H
α*
a13y
a13=g
a13x
α*= arctan (a13x/a13y)
α*= α
d)
23 (v=const):
14
a14α=0
T
α
13
H
a13y
α*
a13=g
a13x
α*= arctan (a13x/a13y)
α*= α

Fig. 3

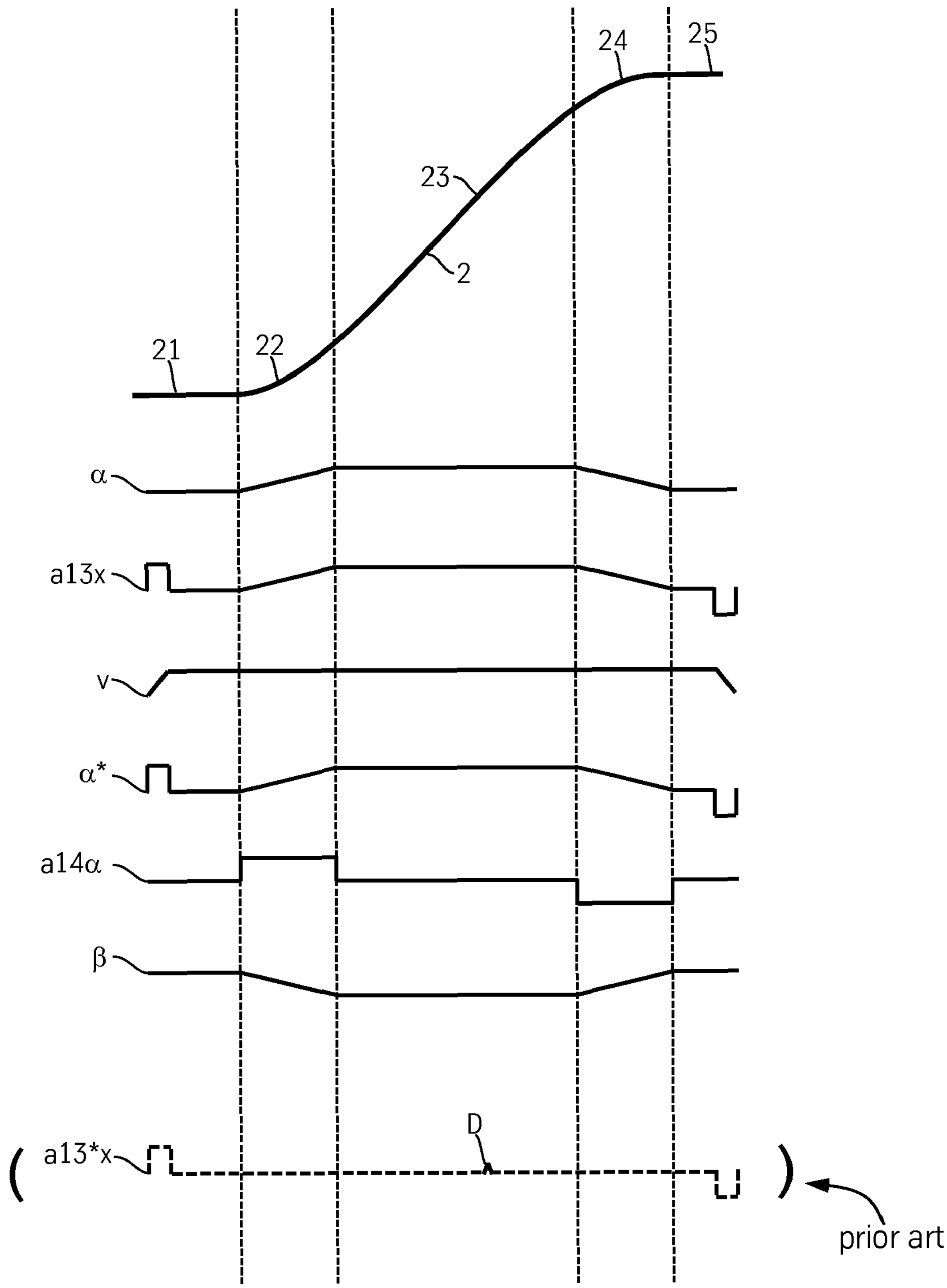

Fig. 4

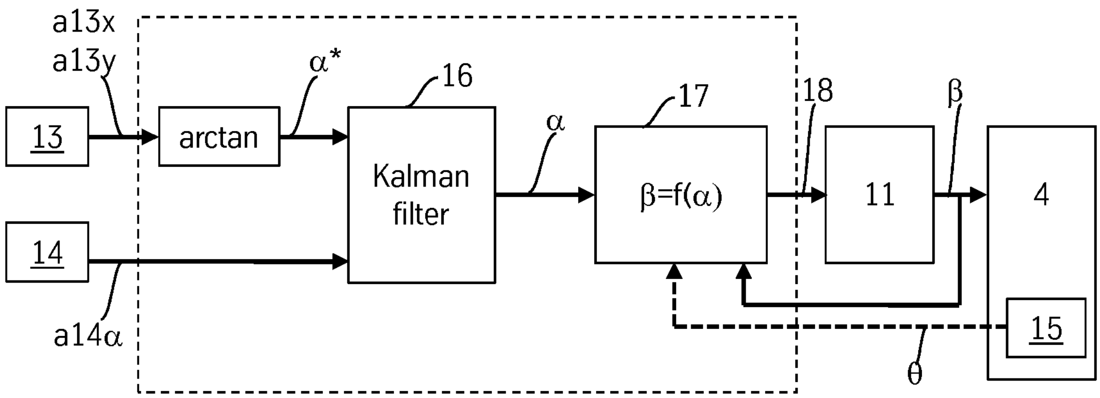
a13x
a13y
13
arctan
α*
16
Kalman filter
14
a14α
α
17
β=f(α)
18
11
β
4
15
θ

Fig. 5

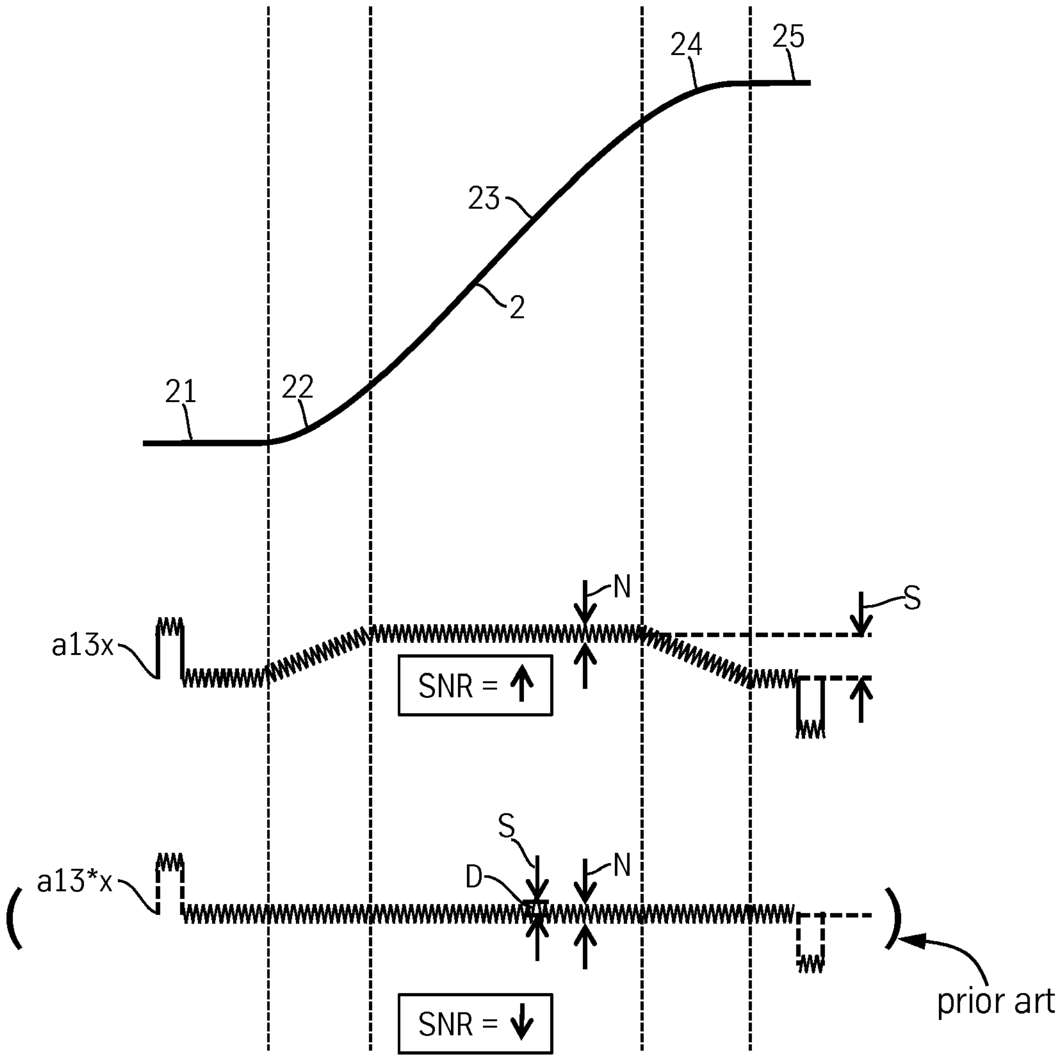
24
25
23
2
21
22
a13x
N
S
SNR = ↑
a13*x
S
D
N
SNR = ↓
prior art

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 16 15 4071

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

B66B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	13 July 2016	Bleys, Philip

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 16 15 4071

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13-07-2016

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- EP 1037846 B1 **[0006]**