



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
28.07.2021 Bulletin 2021/30

(51) Int Cl.:
B66C 23/52 (2006.01) G01C 21/12 (2006.01)

(21) Application number: **20153116.7**

(22) Date of filing: **22.01.2020**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **National Oilwell Varco Poland Sp.z o.o.
80-309 Gdansk (PL)**

(72) Inventor: **Pomierski, Wojciech
80-041 Gdansk (PL)**

(74) Representative: **Håmsø Patentbyrå AS
P.O. Box 171
4301 Sandnes (NO)**

(54) **DEVICE, SYSTEM AND METHOD FOR POSITION SIGNAL FILTERING IN ACTIVE HEAVE COMPENSATION**

(57) There is disclosed an apparatus for filtering and forecasting of acceleration data from a motion reference unit, the apparatus being adapted to provide an instant output acceleration data point by:

- receiving a plurality of measured acceleration data points from a motion reference unit;
- based on the received, measured acceleration data points, calculate a deviation in acceleration between an instant, measured acceleration data point and a previous output acceleration data point;

(a) if the absolute value of the calculated deviation exceeds a predetermined value or if the instant or previous, measured acceleration data point is void, then calculate an instant, modelled acceleration data point based on average deviation between previous acceleration data points and use modelled acceleration data point as instant acceleration data point output;

(b) if the absolute value of the calculated deviation does not exceed a pre-determined value and the instant or previous acceleration data points are not void, then accept instant measured acceleration data point as acceleration data point output and use the accepted instant acceleration data point to calculate an updated average deviation between acceleration data points for forecasting of future acceleration data points under (a); and

- use the instant acceleration data point output from (a) and/or (b) to calculate an instant, measured velocity data point as input to Kalman filter.

There is also disclosed a system including the apparatus, a method for filtering and forecasting of acceleration data as well as a non-transitory computer readable medium encoded with instructions for executing the method.

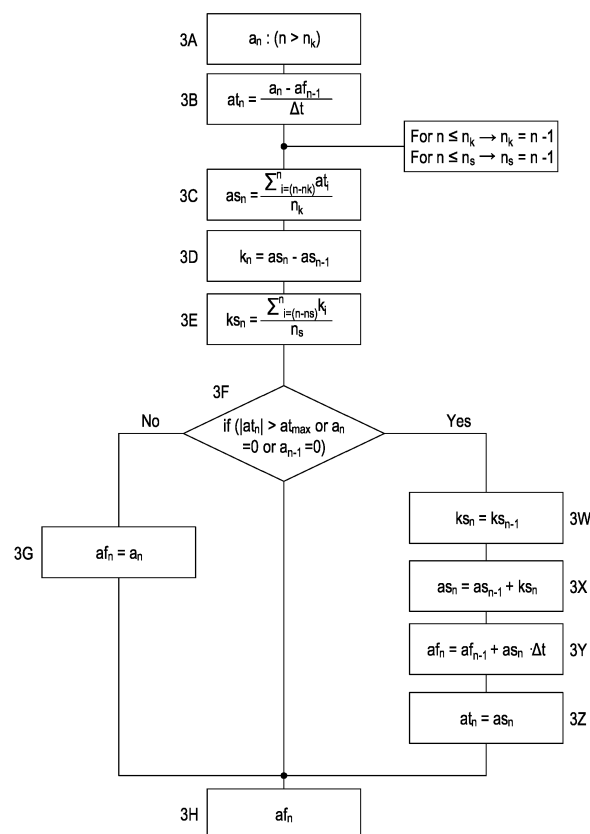


Fig. 3

Description

[0001] The present invention relates to a device, system and method for position signal filtering in active heave compensation. More particularly, the invention relates to a method, device and system where input data to a Kalman filter is pre-filtered and forecasted to improve positioning in active heave compensation. The invention also relates to a non-transitory computer readable medium encoded with instructions that, when executed by a control unit, cause the control unit to execute the method.

[0002] Wave-generated motion of floating vessels is usually measured by a so-called motion reference unit (MRU). MRUs measure vessel motion from typically 6 sensors: 3 accelerometers and 3 gyros. The accelerometers pick up accelerations along 3 perpendicular axes while the gyros measure the angular acceleration around the same axes. The sensors cover a range of frequencies spanning typically from 0 to 100 Hz. By advanced signal processing a MRU is able to estimate linear and angular accelerations, velocities and positions in any direction and at any predetermined measurement point of the vessel. The details on how sensor signals are combined to determine the heave acceleration at the vessel center of gravity, are known to the person skilled in the art but are outside the scope of this description. Instead the present disclosure will concentrate on the basic processes of pre-filtering and forecasting acceleration data for the calculation of velocity data as input to a Kalman filter. A Kalman filter is an algorithm that uses a series of measurements observed over time, containing statistical noise and other inaccuracies, and produces estimates of unknown variables that tend to be more accurate than those based on a single measurement alone, by estimating a joint probability distribution over the variables for each timeframe.

[0003] Mathematically, velocity equals the time integral of acceleration and position equals the time integral of velocity. However, because the accelerometers are not perfect but possess some small but finite noise, it is not possible to derive true velocity or positions from the accelerometer signals by pure integration. Even a tiny offset error or false low frequency component will grow to very high values during some extended integration time interval with some type of filter. A standard Kalman or extended Kalman filter will provide satisfactory results under certain conditions, but often this is not sufficient. No physical wave model is available for Kalman filters, so in case of input acceleration data noise or even void data points, predictions need to be made based on previous input acceleration data points, which causes signal delays.

[0004] The invention has for its object to remedy or to reduce at least one of the drawbacks of the prior art, or at least provide a useful alternative to prior art.

[0005] The object is achieved through features, which are specified in the description below and in the claims that follow.

[0006] In a first aspect, the invention relates to an apparatus for filtering and forecasting of acceleration data from an MRU as set forth in claim 1.

[0007] In a second aspect, the invention relates to a system for controlling the position of a load on a rig or vessel as set forth in claim 3.

[0008] In a third aspect, the invention relates to a rig or vessel including the system according to the second aspect.

[0009] In a fourth aspect, the invention relates to a method for filtering and forecasting of acceleration data from an MRU as set forth in claim 7.

[0010] In a fifth aspect, the invention relates to a non-transitory computer readable medium encoded with instructions that, when executed by a control unit, cause the control unit to execute the method according to the fourth aspect.

[0011] In the following is described an example of a preferred embodiment illustrated in the accompanying drawings, wherein:

Fig. 1 shows schematically a system according to the second aspect of the invention;

Fig. 2 shows an active heave compensation module as being controlled by the system in Fig. 1;

Fig. 3 shows a block diagram for filtering and forecasting of acceleration data from a motion reference unit;

Fig. 4 shows a block diagram for filtering and forecasting of velocity data based on filtered and forecasted acceleration data from Fig. 3;

Fig. 5 shows a block diagram for calculation of position based on the output from Fig. 4;

Fig. 6 shows input and forecasted acceleration data;

Fig. 7 shows input, forecasted and filtered velocity compared with unfiltered calculated velocity;

Fig. 8 shows a detailed view of the graph from Fig. 7;

Fig. 9 shows input and forecasted acceleration data compared with actual (real) acceleration data; and

Fig. 10 shows the simulated load position error when the load is compensated by means of an active heave compensation module according to the invention.

[0012] In the following, the reference numeral 1 will be used to denote an apparatus according the first aspect of the invention, whereas the reference numeral 10 will be used to denote a system according to the second as-

pect of the invention. The drawings, graphs and flow diagrams are shown schematically and simplified, and various features in the drawings are not necessarily drawn to scale.

[0013] Figure 1 shows, very schematically, a system 10 for controlling the position of a load on a rig or vessel. The system includes an apparatus 1, denoted "Filter & Integrator" in the figure, for filtering a forecasting of acceleration data from a motion reference unit (MRU) 2. The MRU 2 samples the acceleration, from the influence of waves and wind, of a not shown rig or vessel. The sampling frequency ($1/\Delta t$, where Δt is used in Figs. 3-5 to denote the time between two samples) may vary in different situations, but in exemplary embodiments the sampling frequency may be in the order to 100Hz or higher. In certain embodiment the sampling frequency may be in the order of 500 Hz or higher. The apparatus 1 receives the acceleration data from the MRU 2 and integrates, pre-filters and forecasts it before it is transmitted to a controller 4 provided with a Kalman filter for further processing of velocity data and ultimately for calculating the position of the rig or vessel. In addition to the filtering of acceleration data from the MRU 1, the apparatus is also adapted to build a string of values based on deviation between instant and previous acceleration data points for forecasting of acceleration data in case of noise or void data points as will be explained below with reference to Figs. 3-5. Based on the input from the apparatus 1, the controller 4 is adapted to calculate a change in position of the rig or vessel, and to operate a heave compensator 6, see Fig. 2, by regulating a pump or valve 8 of the heave compensator 6 to counteract the movements of the vessel in order to keep a not shown load fixed relative to the seabed or another reference point. In certain situations, instead of keeping the load still, it may be desirable to move the load with a fixed speed relative to the seabed, where the relative movement between load and rig or vessel may also be measured and supplied to the controller 4. The relative movement may e.g. be measured by controlling hoisting speed of a wire rope in a not shown crane or top drive, as will be understood by a person skilled in the art.

[0014] An exemplary hydraulic heave compensator 6 is shown in Fig. 2, wherein hydraulic pistons 12 are operated to counteract the movement/heave of the rig or vessel due to waves and wind. An exemplary, schematically shown load-handling device 14, is here represented by two sheaves over which a wire rope is running. The controller 4 is adapted to control the hydraulic pistons 12 to lower and raise the platform 16 to which the sheaves 14 are connected in response to the calculated change of position.

[0015] Fig. 3 shows a flow diagram exemplifying the steps taken by the apparatus according to the present invention as well as in the method according to the present invention to provide an instant output acceleration data point. A series of acceleration data points are sampled by the MRU 2 and transmitted to the apparatus

1. The latest/current acceleration data point will herein be referred to as an instant acceleration data point. Acceleration data points sampled at previous points in time, i.e. before the instant acceleration data point, will be referred to as previous acceleration data points. In step 3A an instant, measured acceleration data point a_n for point n in time is sampled and transmitted to the apparatus 1 for any n larger than n_k , where n_k is a number of samples needed to start the calculations. n_k will vary in different embodiments and will also be dependent on the sampling time, but in certain embodiments n_k may be in the order of 5 or 10. In step 3B an instant change in acceleration at_n between the instant measured acceleration data point a_n and the immediate previous output acceleration data point af_{n-1} over the sampling period Δt is calculated. The derivative of acceleration with respect to time is sometimes also referred to as "jerk", whereby at_n may be regarded as the instant jerk. An average change in acceleration as_n over n_k samples is calculated in step 3C. In step 3D the difference between the average change in acceleration and the immediate, previous average change in acceleration k_n is calculated. The average k_n over n_s samples, denoted ks_n , is then eventually calculated in step 3E. ks_n can be regarded as an arithmetic string of values that are used for forecasting acceleration values in case of void or noisy acceleration data points as will now be explained. In step 3F, the absolute value of at_n , i.e. the instant change in acceleration over Δt as calculated in step 3B, is checked towards a predetermined maximum value at_{max} . This predetermined value may be set differently in different embodiments, for different MRUs and in different weather conditions, but for any absolute value of at_n larger than at_{max} the instant, measured acceleration data point a_n in step 3A will be assumed to be noise and therefore disregarded. Similarly, if the instant measured/sampled acceleration data point a_n from step 3A or the immediate, previous sampled acceleration data point a_{n-1} is void (zero), a_n from step 3A will also be disregarded. If a_n is disregarded, then the process continues to the right in the flow diagram of Fig. 3, where the immediate previous calculated value ks_{n-1} in the arithmetic string from step 3E is used to forecast an instant output, acceleration data point. In step 3W, since the instant, sampled acceleration data point a_n had to be disregarded, the previous calculated value ks_{n-1} in the arithmetic string from step 3E is set as the instant value ks_n in the arithmetic string. Then, in step 3X an updated average change in acceleration as_n is calculated based on ks_n from step 3W and the immediate previous average change in acceleration as_{n-1} . In step 3Y the instant, output acceleration data point af_n is calculated based on the immediate, previous output acceleration data point af_{n-1} , the updated average change in acceleration as_n from step 3X and the sampling time Δt . Finally, in step 3Z the calculated as_n from step 3X is set as at_n for use as future at_{n-1} in step 3C. The forecasted acceleration data point af_n from step 3Y is thereby taken as output acceleration data point from the apparatus. Alternatively, in step 3F,

if the absolute value of at_n does not exceed at_{max} and if neither of a_n or a_{n-1} is void, then the instant, measured/sampled acceleration data point a_n from step 3A is accepted as the instant output acceleration data point af_n as shown in 3G. The acceleration forecast model, as calculated in steps 3A-E, is also then also accepted, and ks_n is accepted as an updated data point in the arithmetic string and may be used in a future ks_{n-1} in step 3W in a situation where at_n is disregarded. In step 3H the measured or forecasted af_n is taken as output from the acceleration flow diagram. The pre-filtration and forecasting of acceleration data points as exemplified in Fig. 3 will significantly improve the quality of input velocity data points to a Kalman filter in the controller 4, as will be explained with reference to the following figures.

[0016] In Fig. 4 an exemplary flow diagram shows how the acceleration output data points from Fig. 3 are used to calculate both measured and modelled velocity data points to the Kalman Filter in the controller 4. In step 4A, output acceleration data points af_n are taken from the algorithm in Fig. 3 for n larger than n_c , where n_c is a number over which the change in output velocity will later be averaged. n_c may vary between different embodiments and in different weather conditions, and it will also depend on the time between samples Δt , but in certain embodiments n_c may be in the range of 5 or 10. In step 4B an instant velocity data point vm_n , without offset, is found from the immediate, previous velocity data point and the integration of input acceleration from step 4A over Δt . Similarly, in step 4C, instant position data point $s1_n$, without offset, is found from the immediate, previous position data point $s1_{n-1}$ and integration of the velocity from step 4B. In step 4D it is checked if n is smaller than or equal to n_i , where n_i is a number/gate set to ensure a sufficient number of samples after start-up when calculating the velocity offset $v0_n$. n_i may in certain embodiments be a number that is large enough for the passing of one or more heave periods, which are typically around 12 seconds each. In one specific embodiment, n_i may be set to ensure the inclusion of around 5 heave periods, whereby n_i may be in the order of 6000 (1 minute of 100 Hz sampling frequency) or 30 000 (1 minute of 500 Hz sampling frequency). For $n \leq n_i$, then the method goes to the right in the flow diagram to step 4X, where the offset is estimated as sum of position data points from start-up at t_0 to the present time t_n over the time lapsed. If a sufficient number of data points have been sampled, i.e. if $n > n_i$, then in step 4E the same calculation is done based on position data points from time t_{n-n_i} . An actual measured instant, output velocity data point v_n , including offset $v0_n$, is then calculated in step 4F, and used as measurement input to the Kalman filter in step 4M. In addition, a velocity model is built as a further input to the Kalman filter based on previous output velocity data points from the Kalman filter, as will be now be explained. In step 4G an instant change in output velocity vt_n is calculated based on the immediate two previous output velocity data points from the Kalman filter vf_{n-1} and vf_{n-2} . An average

change in output velocity vs_n over n_c samples is calculated in step 4H, where n_c in exemplary embodiments may be in the order of 5 or 10, depending i.a. on Δt and the required accuracy. The difference in change in average output velocity dvs_n between the present value vs_n and the previous value vs_{n-1} is calculated in step 4I. In step 4J it is checked if the absolute value of dvs_n exceeds a pre-determined value dvs_{max} . If the absolute value of dvs_n exceeds dvs_{max} , then the instant calculated value of dvs_n will be disregarded, and the previous value dvs_{n-1} will be used instead as indicated in step 4K. Normally, since the acceleration data has already been filtered (as shown in Fig. 3), the absolute value of dvs_n will not be exceeding dvs_{max} . The new (or optionally previous) dvs_n from step 4J (or optionally 4K), will then be used to calculate an instant modelled velocity data point ve_n in step 4L as input to the Kalman filter in step 4M. For calculating the instant modelled velocity data point ve_n in step 4L the immediate previous output velocity data point from the Kalman filter vf_{n-1} is used together with vs_n from step 4H and dvs_n from step 4J (or optionally 4K) and Δt . The instant modelled velocity data point ve_n is then used as input to the Kalman filter together with the measured velocity v_n in step 4M. What happens "behind the curtains" of the Kalman filter is beyond the scope of the present disclosure, but will be known to a person skilled in the art. The Kalman filter produces an instant output velocity data point vf_n in step 4N.

[0017] In Fig. 5, the instant output velocity data point vf_n from Fig. 4 is used by the controller in step 5A. vf_n is then used, together an immediate previous position data point sm_{n-1} to find the immediate, instant position data point without offset sm_n in step 5B. In step 5C an instant offset variable st_n is calculated based on an immediate previous offset variable st_{n-1} and sm_n from step 5B. In step 5D, a check is made to verify if n is smaller than n_d where n_d is a number/gate set to ensure a sufficient number of samples after start-up when calculating the position offset. n_d will typically be in the range 5 times n_i in step 4E. If $n \leq n_d$, then the method goes to the right in the flow diagram to step 5X, where the position offset is estimated as the sum of position data points st_n from start-up at t_0 to the present time t_n over the time lapsed. If a sufficient number of data points have been sampled, i.e. if $n > n_d$, then in step 5E the same calculation is done based on position data points from time t_{n-n_d} . A resulting instant calculated output sf_n from the controller is finally found in step 5F based on the integrated position from step 5B and the calculated offset. The output sf_n represents the measure and calculated instant, output position of the rig or vessel on which the system 10 and apparatus 1 are placed, and is used by the controller to counteract the change in position by operating the heave compensator.

[0018] Fig. 6 shows MRU-sampled values a_n (some of which have been manually spoiled to test the algorithm) together with the output acceleration data values after filtering and forecasting. As can be seen in the figure,

"noisy" samples have been filtered out, and the algorithm of Fig. 3 still produces a smooth acceleration output data curve.

[0019] In Fig. 7, the measured velocity v_n is shown together with the forecasted velocity ve_n and the output from the Kalman filter vf_n . Velocity data output from the Kalman filter without the pre-filtering and forecasting of acceleration data has also been shown, and as can be seen from the figure, the pre-filtering and forecasting algorithm according to the present invention, significantly improves the accuracy of the results. Fig. 8 is an enlarged view of a portion of the graph from Fig. 7. As can be seen from Figs. 7 and 8, there is a very good match between measurement and model inputs to the Kalman filter and the output from the filter when the acceleration data has been pre-filtered and forecasted.

[0020] Fig. 9 shows a comparison between the input, sampled acceleration data a_n , acceleration data with filtration and forecasting af_n compared to real acceleration data as found by means of Jonswap wave model, as will be understood by a person skilled in the art and not discussed in further detail herein. As can be seen, there is a remarkably good fit between the forecasted acceleration data and the real model, despite noise in the input samples.

[0021] Fig. 10 shows load position error in active heave compensation based on input to the heave compensator from the system 10 according to the present invention. As can be seen from the figure, it is possible to keep a 100mT load fixed within an error margin of approximately ± 10 cm.

[0022] It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. Use of the verb "comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements.

[0023] The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

[0024] Aspects of invention may be implemented by means of hardware comprising several distinct elements, and by means of a suitably programmed computer. In the device claim enumerating several means, several of these means may be embodied by one and the same item of hardware.

Claims

1. Apparatus for filtering and forecasting of acceleration data from a motion reference unit, the apparatus

being adapted to provide an instant output acceleration data point by:

- receiving a plurality of measured acceleration data points from a motion reference unit;
- based on the received, measured acceleration data points, calculate a deviation in acceleration between an instant, measured acceleration data point and a previous output acceleration data point;

(a) if the absolute value of the calculated deviation exceeds a predetermined value or if the instant or previous, measured acceleration data point is void, then calculate an instant, modelled acceleration data point based on average deviation between previous acceleration data points and use modelled acceleration data point as instant acceleration data point output; or

(b) if the absolute value of the calculated deviation does not exceed a predetermined value and the instant or previous acceleration data points are not void, then accept instant measured acceleration data point as acceleration data point output and use the accepted instant acceleration data point to calculate an updated average deviation between acceleration data points for forecasting of future acceleration data points under (a); and

- use the instant acceleration data point output from (a) and/or (b) to calculate an instant, measured velocity data point as input to Kalman filter.

2. The apparatus according to claim 1, wherein the apparatus is further adapted to calculate an instant, modelled velocity data point based on average deviation between previous output velocity data points from the Kalman filter, and to use the instant, modelled velocity data point as a further input to the Kalman filter.

3. System for controlling the position of a load on a rig or vessel, the system comprising:

- an apparatus according to any one of the preceding claims;
- a motion reference unit adapted to provide acceleration data points to the apparatus; and
- a controller including a Kalman filter, the Kalman filter being adapted to calculate an instant output velocity data point based on the instant velocity data point from the apparatus;
- the controller further being adapted to:

- calculate, based on the instant output ve-

- locity data point from the Kalman filter, a position of the rig or vessel; and
 - based on the calculated position of the rig or vessel, to compensate for the change in position by sending a control signal to a heave compensator.
4. System according to the previous claim, wherein the system further is adapted to receive information about relative movement between the load and the rig or vessel, and to include this relative movement in the calculation of the position of the rig or vessel.
5. Vessel or rig including a system according to any one of the claims 3 or 4, where in the rig or vessel further comprises:
- a load handling apparatus, such as a crane or a top drive; and
 - an active heave compensator.
6. Vessel or rig according to the previous claim, wherein the active heave compensator is a hydraulic heave compensator and wherein the controller is adapted to operate a pump or a valve of the heave compensator to adjust the position of the load handling apparatus.
7. Method for filtering and forecasting of acceleration data from a motion reference unit, the method including the step of providing an instant output acceleration data point by:
- measuring a plurality of acceleration data points;
 - based on the measured acceleration data points; calculating a deviation in acceleration between an instant, measured acceleration data point and a previous output acceleration data point;
 - (a) if the absolute value of the calculated deviation exceeds a predetermined value or if the instant or previous, measured acceleration data point is void, then calculating an instant, modelled acceleration data point based on average deviation between previous acceleration data points and use modelled acceleration data point as instant acceleration data point output; or
 - (b) if the absolute value of the calculated deviation does not exceed a predetermined value and the instant or previous acceleration data points are not void, then accepting the instant measured acceleration data point as output instant acceleration data point and use the accepted output instant acceleration data point to calculate an updated average deviation between acceleration data points for forecasting of future acceleration data points under (a); and
- using the instant acceleration data point output from (a) and/or (b) to calculate an instant, measured velocity data point as input to a Kalman filter.
8. The method according to the previous claim, wherein the method further includes the step of:
- calculating an instant, modelled velocity data point based on average deviation between previous output velocity data points from the Kalman filter, and to use the instant, modelled velocity data point as a further input to the Kalman filter.
9. Method for active heave compensation of a load on a rig or vessel, the method including the steps of any one of the claims 7 or 8, and further the steps of:
- calculating an instant position of a load on a rig or vessel based on an instant output velocity data point from the Kalman filter;
 - operating a heave compensator to compensate for change in position between the instant, calculated position and a previous calculated position.
10. Method according to the previous claim, wherein the step of operating a heave compensator includes the step of operating a hydraulic pump or valve.
11. Method according to the previous claim, wherein the method further includes the steps of:
- measuring the relative movement between the load and the rig or vessel, and
 - including this relative movement in the calculation of instant position of the load.
12. Non-transitory computer-readable medium encoded with instructions that, when executed by a control unit, cause the control unit to execute the method according to any one of claim 7-11.

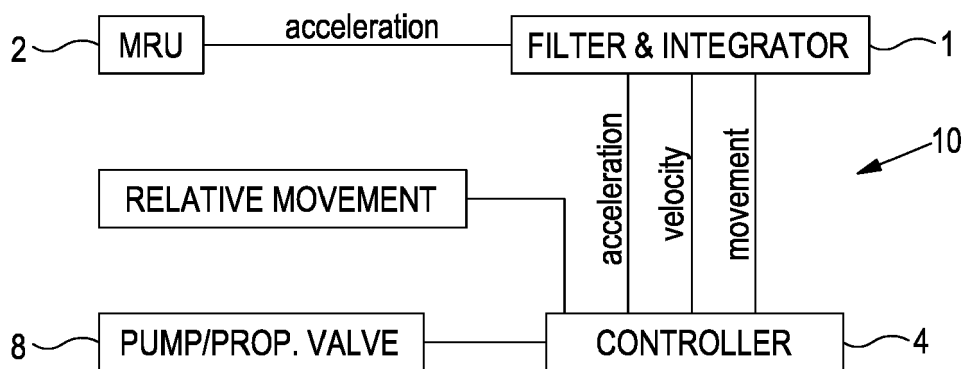


Fig. 1

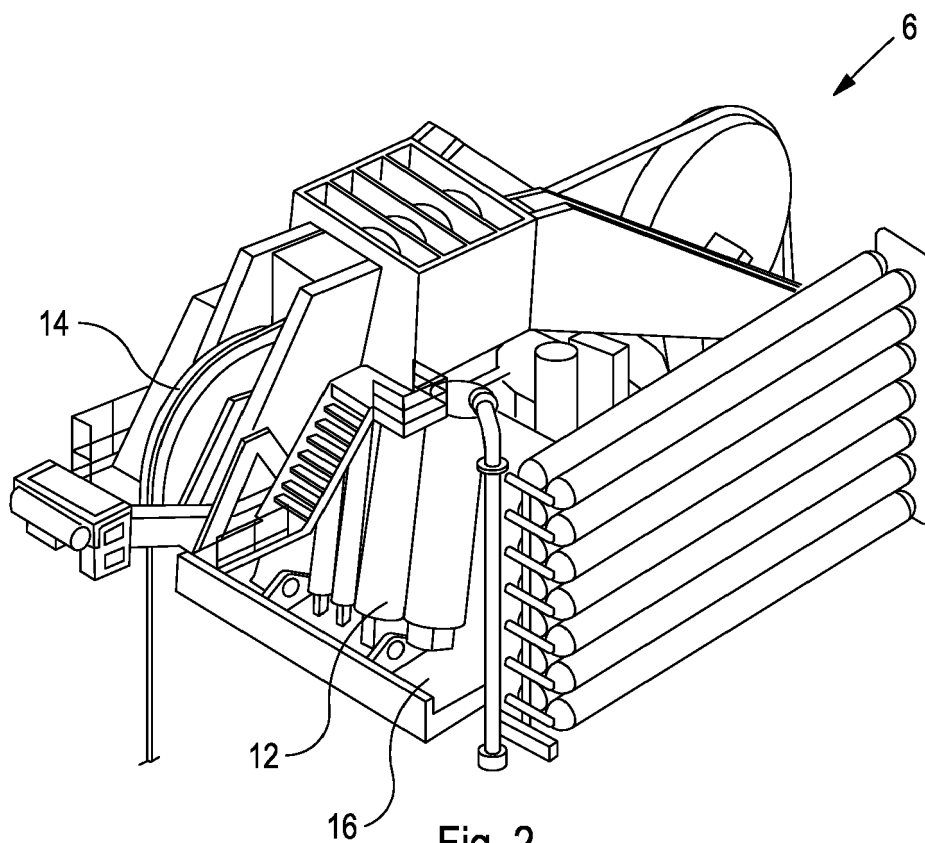


Fig. 2

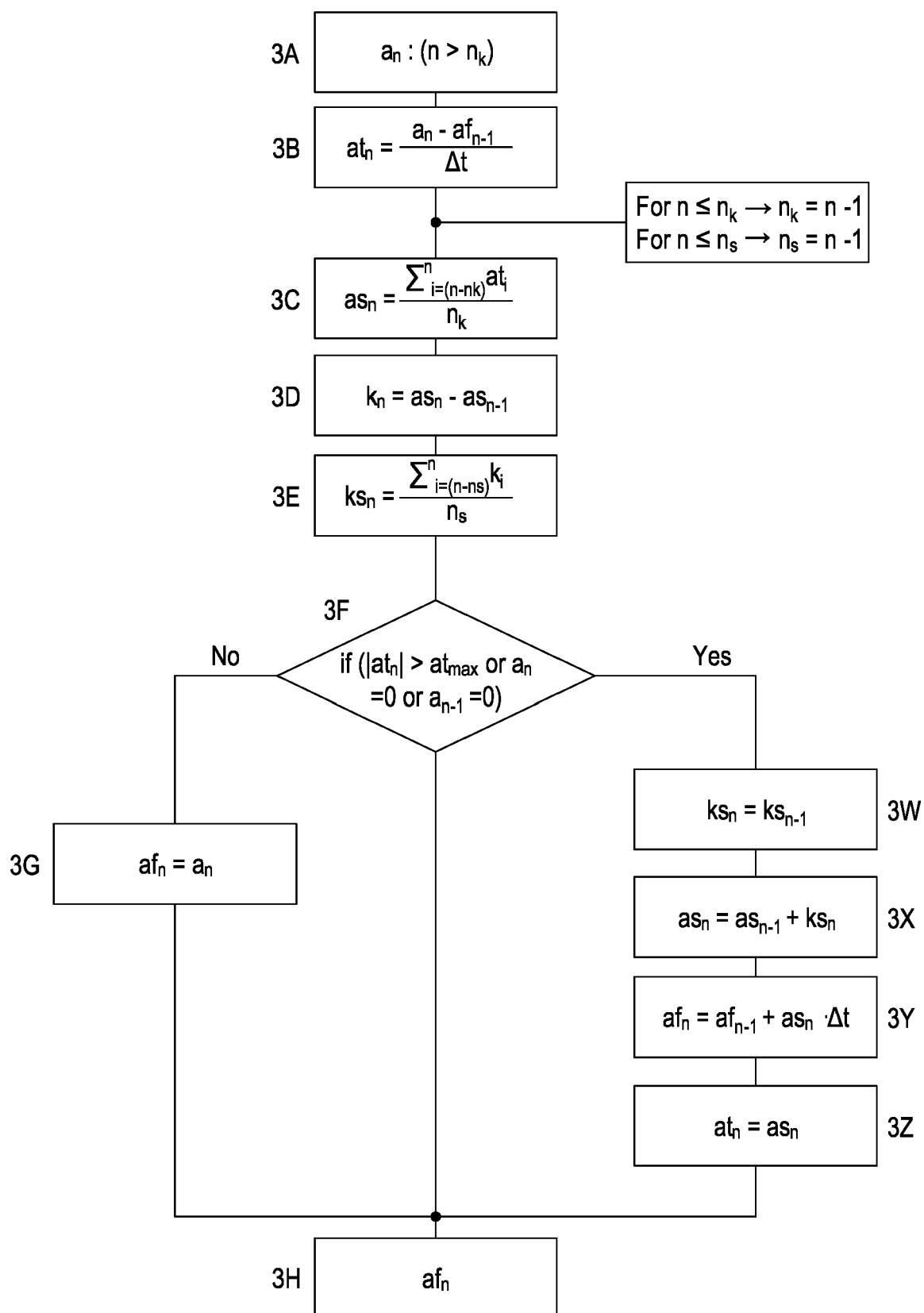


Fig. 3

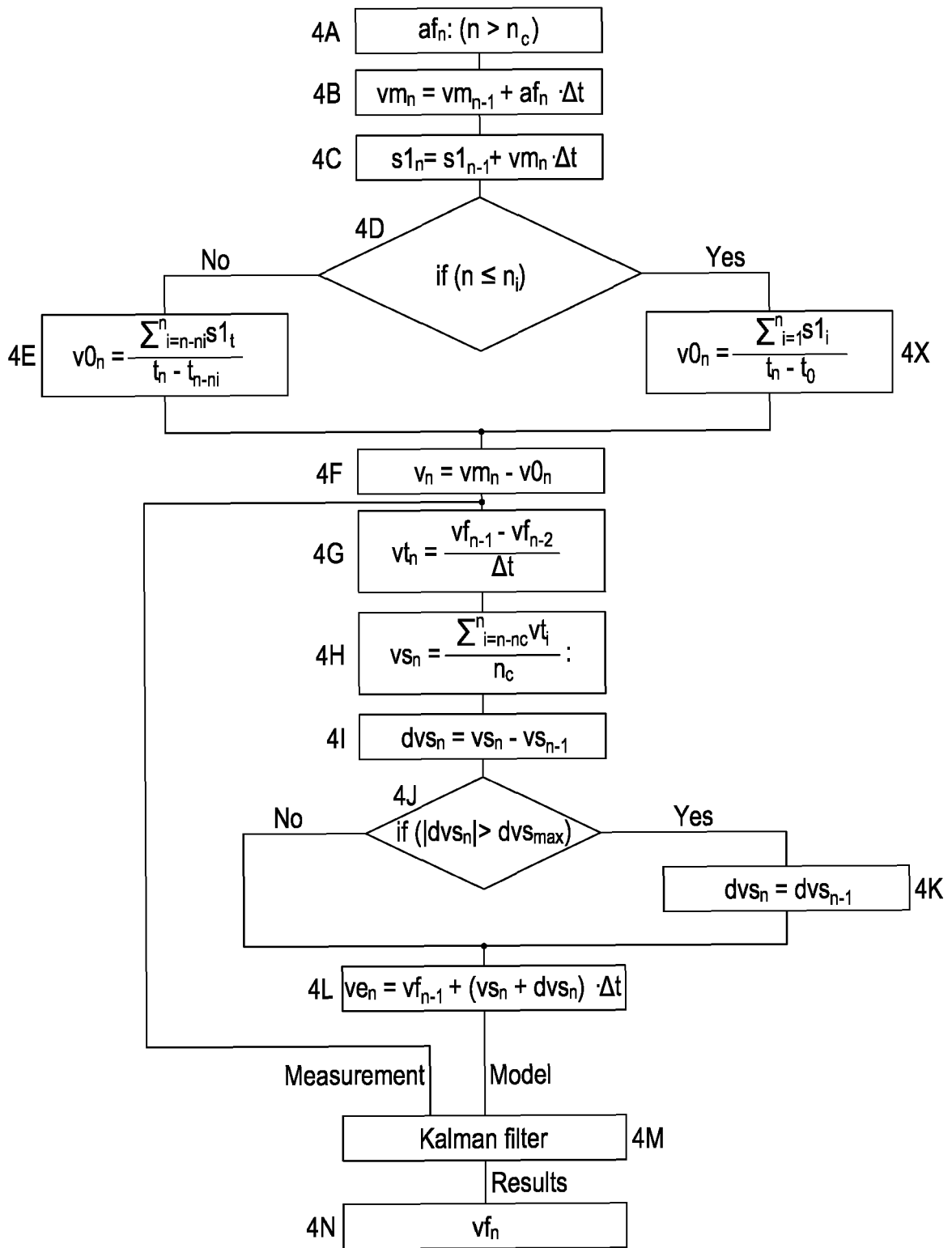


Fig. 4

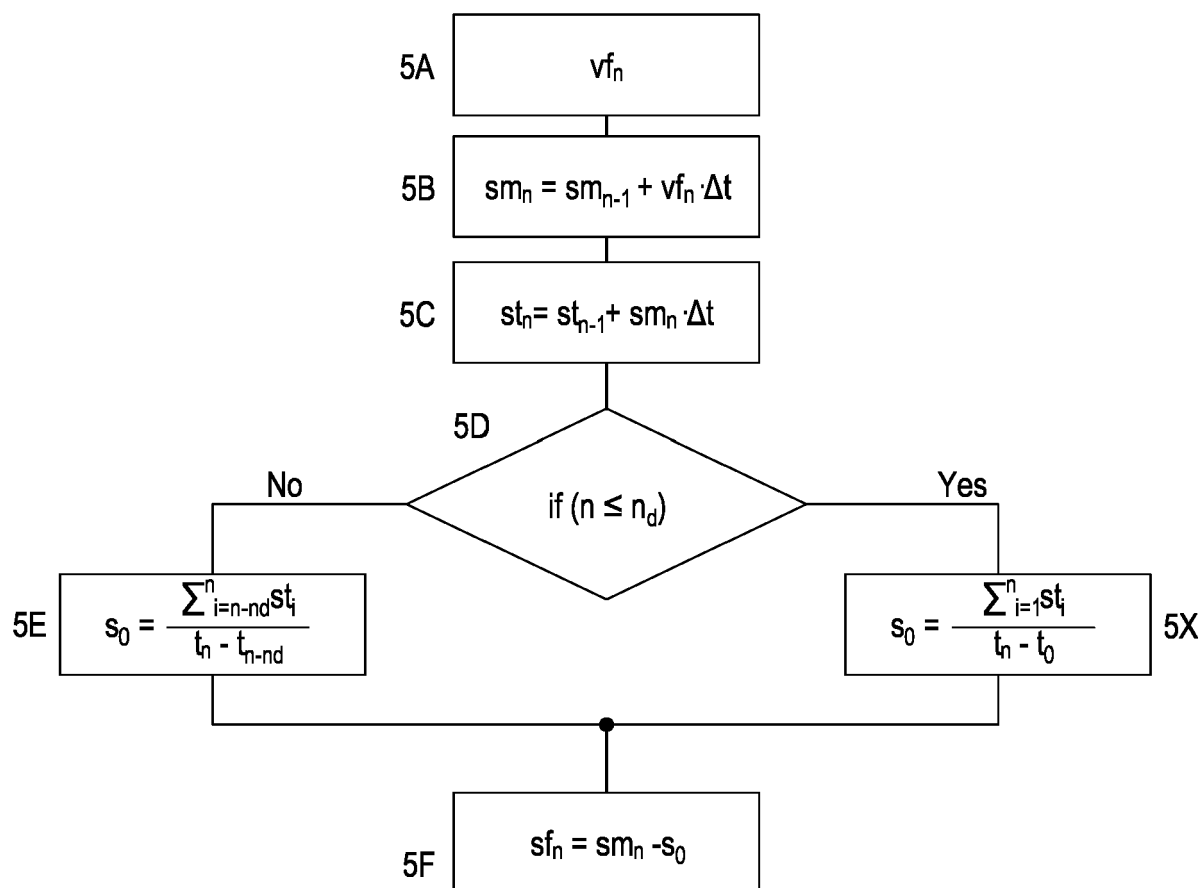


Fig. 5

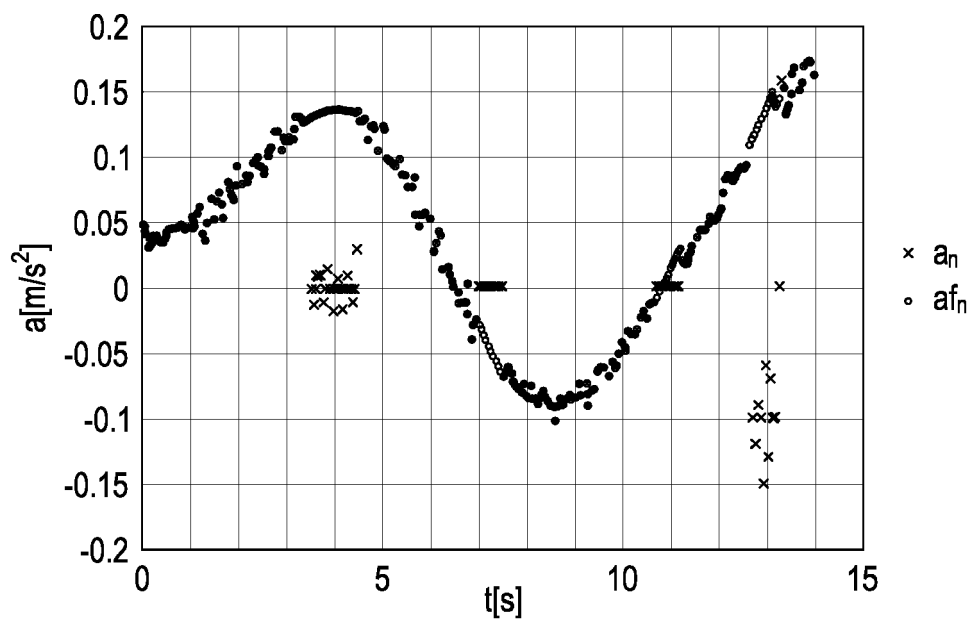


Fig. 6

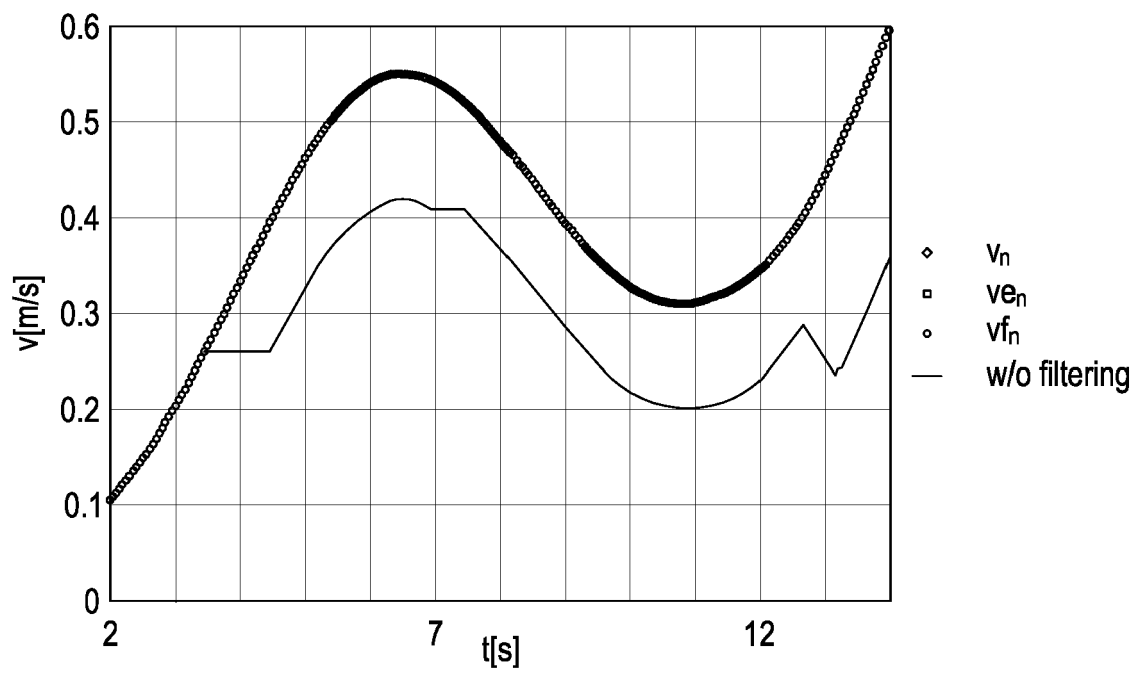


Fig. 7

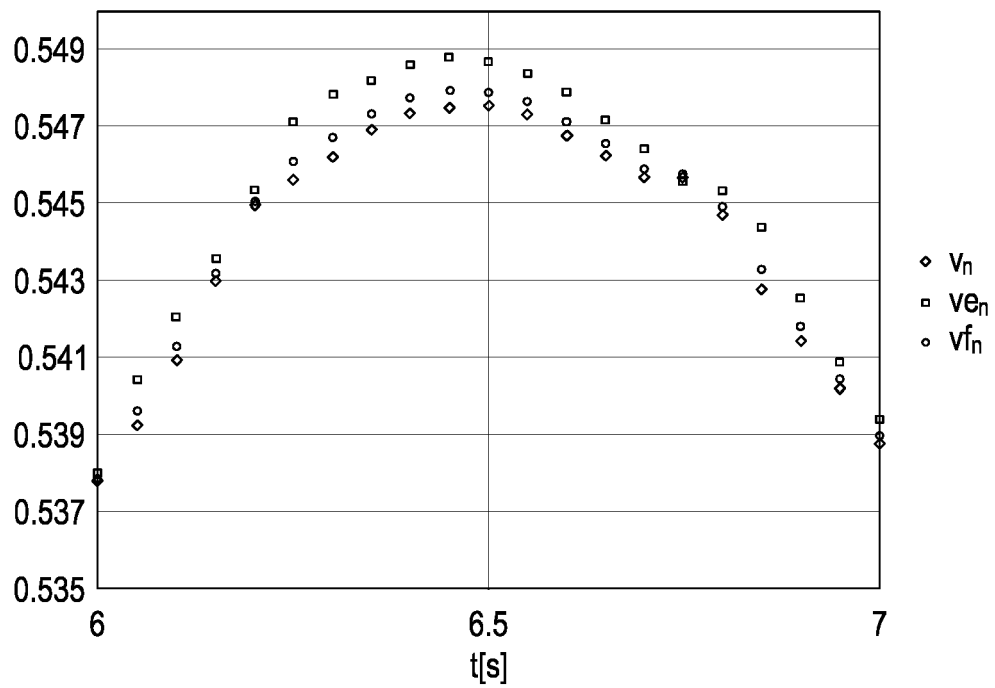


Fig. 8

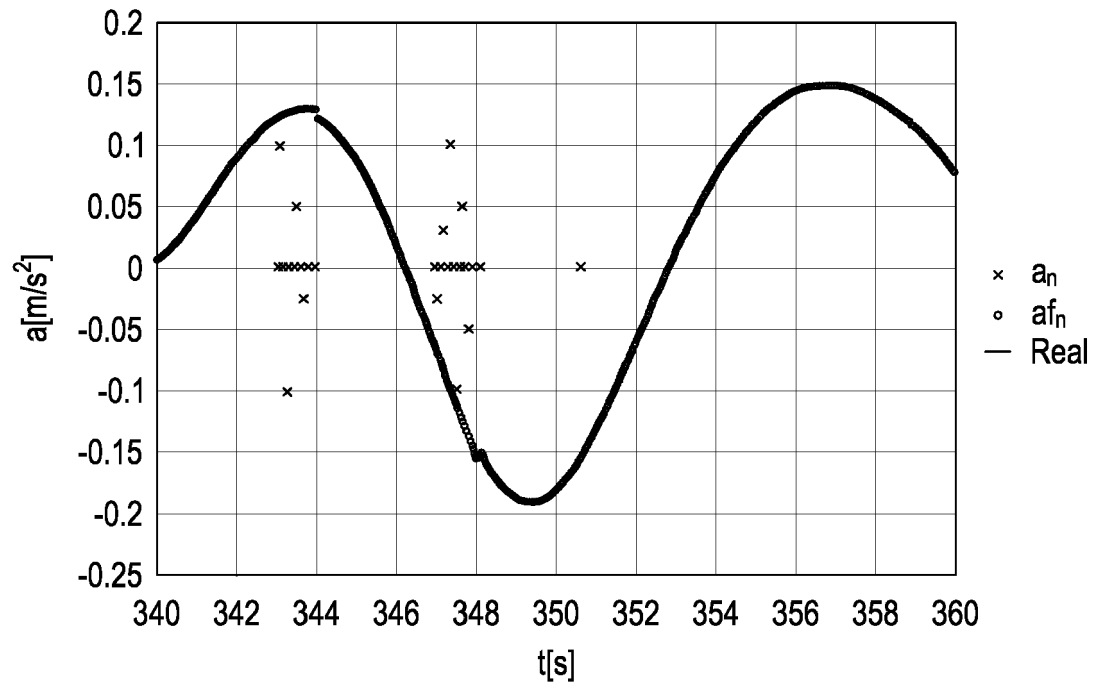


Fig. 9

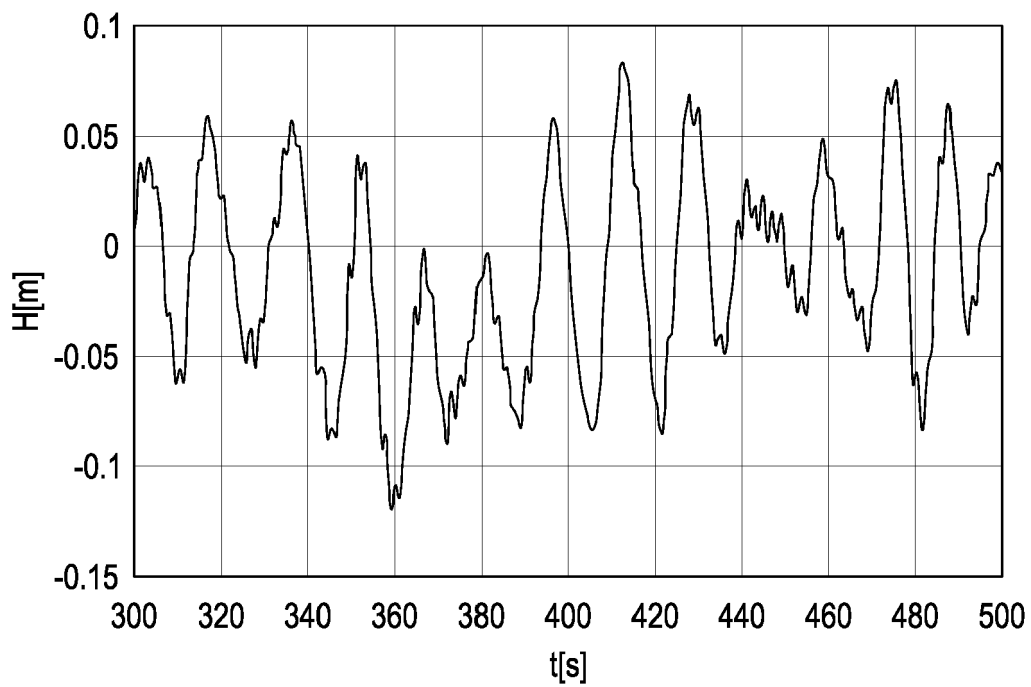


Fig. 10



EUROPEAN SEARCH REPORT

 Application Number
 EP 20 15 3116

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2011/034435 A1 (KONGSBERG SEATEX AS [NO]; RINNAN ARNE [NO] ET AL.) 24 March 2011 (2011-03-24) * page 9, line 7 - page 12, line 5; figures *	1-12	INV. B66C23/52 G01C21/12
A	EP 2 123 588 A1 (LIEBHERR WERK NENZING [AT]) 25 November 2009 (2009-11-25) * paragraphs [0038] - [0042], [0082] - [0114]; figures *	1-12	
A	WO 2012/161584 A1 (OPTILIFT AS [NO]; ENGEDAL TORBJOERN [NO] ET AL.) 29 November 2012 (2012-11-29) * page 29, lines 23-36; figures *	1-12	
			TECHNICAL FIELDS SEARCHED (IPC)
			B63B B66F G01C B66C
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 3 July 2020	Examiner Knoflachner, Nikolaus
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

 1
 EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 20 15 3116

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

03-07-2020

10

15

20

25

30

35

40

45

50

55

ORM P0459

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2011034435 A1	24-03-2011	BR PI1007176 A2 EP 2477883 A1 US 2011276305 A1 WO 2011034435 A1	23-02-2016 25-07-2012 10-11-2011 24-03-2011
EP 2123588 A1	25-11-2009	CN 101585486 A DE 102008024513 A1 EP 2123588 A1 US 2010230370 A1	25-11-2009 26-11-2009 25-11-2009 16-09-2010
WO 2012161584 A1	29-11-2012	AU 2012259523 A1 BR 112014003938 A2 CA 2836697 A1 GB 2504903 A NO 342303 B1 RU 2013156680 A US 2014107971 A1 WO 2012161584 A1	12-12-2013 13-06-2017 29-11-2012 12-02-2014 30-04-2018 27-06-2015 17-04-2014 29-11-2012