(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 964 799 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
03.09.2008 Bulletin 2008/36

(51) Int Cl.:
B65H 23/18 *(2006.01)*

(21) Application number: **07004189.2**

(22) Date of filing: **28.02.2007**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK RS

(71) Applicant: **Applied Materials, Inc.**
Santa Clara, CA 95054 (US)

(72) Inventor: **Hein, Stefan**
63825 Blankenbach (DE)

(74) Representative: **Zimmermann, Gerd Heinrich et al**
Zimmermann & Partner
Postfach 330 920
80069 München (DE)

Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) Web guide control, web processing apparatus and method for operating the same

(57) A web guide control for guiding a web, the web guide control having a first guide roller (201) and a second guide roller (202) wherein the first guide roller (20) comprises an adjustment unit (310), the second guide roller (202) comprises a tension measurement unit (300), and the web guide control comprises a data connection (330) for supporting the adjustment unit with tension data from the tension measurement unit.

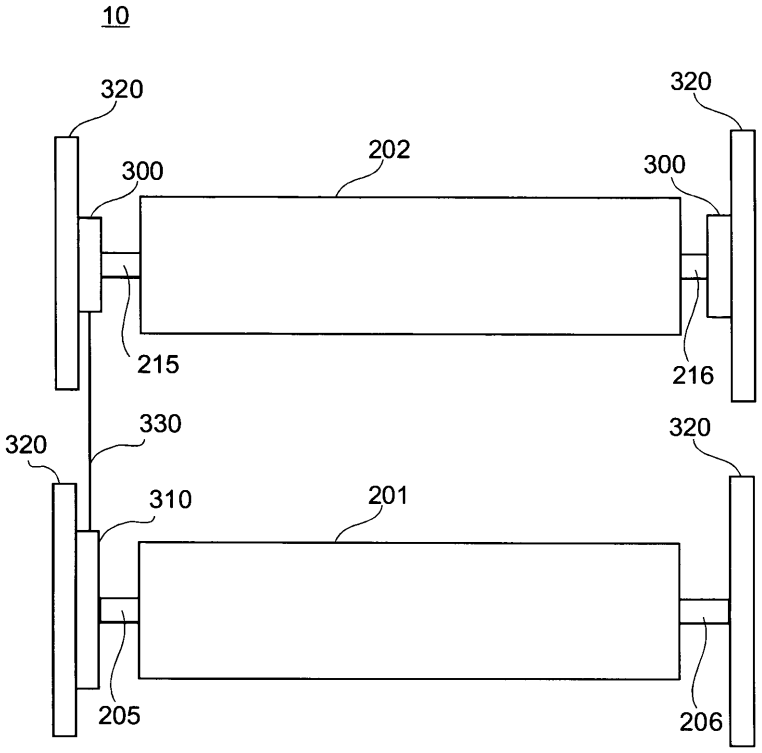

Fig. 3

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Description

Technical field of the invention

[0001] The present invention relates to a web guide control and a web processing apparatus. The present invention relates particularly to a web guide control for compensating failures in the raw material and/or the coiling installation and to a web processing apparatus for coating web in vacuum installations. The present invention also relates to a method for guiding a web and particularly to a method for compensating failures in a web during web guiding.

Background of the invention

[0002] Web handling is an important issue in installations for processing continuous web. Therein, many coils handling hundreds of metres or even kilometres of web have to be arranged and operated in such a way that no damage such as crinkles, trumlines, tear-offs, or the like occur in the web.

[0003] It is of course undesirable that failures occur during the web processing such as the web coating. These failures may lead to the total stop of production and/or to the rejection of parts or the entire web treated. In other words, a web guiding malfunction can be very expensive and time consuming.

[0004] In order to avoid malfunctions of a web processing apparatus it is known in the art to provide each guide roll of the web guiding apparatus with a specific tolerance. This way a difference up to e.g. 0.02 mm in the web's thickness along the width of the web can be handled. However, in installations with long coiling length the addition of the guide roller bearing tolerances can cause a tilted feeding in the installation. Further, in vacuum applications very small deviations in thickness can cause complications or failure which would not occur at ambient pressure.

Summary of the invention

[0005] The problems in the state of the art are at least partly overcome by the web guide control according to claim 1, the web processing apparatus according to claim 10 and the method for guiding a web according to claim 12. Further aspects, details and advantages are apparent by the dependent claims, the description and the accompanying drawings.

[0006] In view of the above, a web guide control for guiding a web is provided. The web guide control includes two guide rollers, an adjustment unit at the first guide roller, a tension measurement unit at the second guide roller, and a data connection for supporting the adjustment unit with tension data from the tension measurement unit.

[0007] According to another aspect of the present invention a web processing apparatus with at least one guide control as described herein is provided.

[0008] According to another aspect of the present invention, a method for guiding a web is provided. The method includes the steps of adjusting the position of a first guide roller by moving one side of the first guide roller and measuring the tension of the web acting on a second guide roller, thereby receiving measurement results, wherein adjusting is based on the measurement results.

[0009] A typical application of web processing apparatuses is the high vacuum web film deposition. For instance, in these applications a protective layer is deposited on a packaging substrate like thin plastic, paper, or metal foil. Thin metal or oxide films may be deposited on the packaging substrate for creating a moisture or oxygen barrier promoting freshness and extending the shelf life of the consumer products which use these films.

[0010] [00010] A further application of a web processing apparatus is the field of manufacturing electronic products. A conductive layer may be deposited on the web serving as conductive coating in applications such as capacitor and touch panels.

Brief Description of the Drawings

[0011] The above features and advantages of the present invention will become more apparent from the following detailed description of preferred embodiments thereof with reference to the attached drawings in which:

Fig. 1 shows a schematic diagram of an embodiment of a web processing apparatus according to the present invention.

Fig. 2 shows a schematic diagram in a cross-sectional view of the web guide control system according to an embodiment of the present invention.

Fig. 3 shows a schematic diagram in a plain section view of the web guide control system according to another embodiment of the present invention.

Fig. 4 shows a schematic diagram in a plain section view of the web guide control system according to another embodiment of the present invention.

Fig. 5 shows a flow chart of the method for guiding a web according to an embodiment of the present invention.

Detailed Description of the Embodiments

[0012] Reference will now be made in detail to the various embodiments of the invention, one or more examples of which are illustrated in the figures. Each example is provided by way of explanation of the invention, and is not meant as a limitation of the invention. For example,

features illustrated or described as part of one embodiment can be used on or in conjunction with other embodiments to yield yet a further embodiment. It is intended that the present invention includes such modifications and variations.

[0013] Figure 1 shows an embodiment of a web processing apparatus where web guide control 10 according to the present invention is implemented. The web processing apparatus comprises a web processing unit 100 where a web 140 is fed to. Further, a web storage unit 110 is shown where the web 140 is coiled. The web 140 enters the web processing unit 100 via the inlet port 120. The processed web 150 is guided out of the web processing unit 100 through the outlet port 130. Some installations, in particular at ambient pressure, do not use inlet or outlet port or other units which would be denoted as such. Typically, the web processing unit 100 comprises one, two, three, or more web guide controls according to the present invention for serial web processing. Synonyms to the term "web" as used within the present application are strip, flexible substrate or the like.

[0014] Typically, a web is a three dimensional solid body the thickness of which is in the range up to 1 mm, more typically between 1 μm and 500 μm, and the width of which is between 10 cm and 4,5 m, more typically between 30 cm and 3 m. In typical embodiments, the length of a web is larger than 10 m. Typically, a web consists of a continuous sheet of thin and flexible material. Typical web materials are metals, plastics, paper, or the like.

[0015] According to an embodiment of the present invention, the web 140 is fed to the web processing unit 100 from a web supply. Typically, the web supply is a web storage unit 110 where the web is coiled. Typical lengths of the web on the coil are in the range between 500 m and 50 km. In other embodiments, the web supply is continuous e.g. from a section with or without an outlet port where the web exits the section for being fed to the web processing unit 100 (not shown). Typical guiding velocities are in the range of between 0,1 and 20 metre per second. Typically, different processing steps are performed in the web processing unit 100 such as cleaning, coating, cooling, heating, or structuring the web.

[0016] After the web has been processed in the web processing unit 100, the processed web 150 exits the web processing unit 100 at the outlet port 130. Typically, the processed web 150 is fed to a second processing unit or guided out for storage.

[0017] Typically, a web processing apparatus comprising one or more web guide controls according to the present invention may be used for guiding a web in various applications. This web processing apparatus is particularly suitable for challenging webs such as a metal web, in particular aluminium web, and thin plastic web. Thin web in this context is meant to be understood as having a thickness of between 1 μm and 200 μm, in particular between 30 μm and 140 μm.

[0018] Figure 2 shows a cross-sectional view of an embodiment of the web guide control 10 of the present invention. The web guide control 10 comprises a first guide roller 201 with its corresponding shaft axis 205 and a second guide roller 202 with its corresponding shaft axis 215. The web 140 is guided through the first guide roller 201 and the second guide roller 202. The web 140 may be unprocessed or have already undergone one or more processing steps. Typically the first guide roller 201 is positioned upstream of the second guide roller 202. The terms "downstream" and "upstream" within the present application are to be understood with respect to the travelling direction of the web. The web guide control 10 of the present invention is not exclusively limited to the implementation in web processing apparatus. For example, the web guide control can also be implemented in manufacturing plants where web transport is required. In principal, it is also possible to position the first guide roller 201 downstream of the second guide roller 202.

[0019] According to the present invention the distance between both shaft axes 205 and 215 can be adjusted to compensate for transversal tension acting on the web travelling between both guide rollers 201 and 202. To allow for compensation, the second guide roller is equipped with a web tension measurement unit such as a tension sensor. A tension sensor may be a piezoresistive or piezoelectric tension sensor. Alternatively, the sensor may be equipped with a hall element or a capacitor in order to determine the tension. In other embodiments, both the first guide roller and the second guide roller are equipped with tension measurement units. According to an embodiment of the present invention which is shown in the drawings, the web tension measurement unit is enclosed in the second guide roller 202. Typically, the measurement sensor is adapted for measuring tensions of between 0 and 400 N/m. Typically this distance is adjusted using an adjustment unit placed at one side of the first guide roller 201. The "side" of the roller is to be understood as the position at or close to the end of the roller or its axis. Typical diameters of guide rollers used in the present invention are between 65 mm and 300 mm.

[0020] The advantage of using a two roller system for measurement and adjustment instead of a single roller system is, for example, a better handling of vibrations caused by the control loop.

[0021] In principle the adjustment unit may be applied for alignment of the guide rollers required to avoid transversal tension acting on the web. Typically the web guide control 10 of the present invention is particularly useful for compensating different coiling strengths at the guide rollers 201 and 202. Different coiling strength is most typically a result of different thickness of the web along its width. This could result in tilted feeding and, subsequently, varying contact between guiding rollers and web which can go along with thermal complications. Typically shorter distances of less than 1 m between the axis of adjacent guide rollers are more critical to the proper handling of the web.

[0022] In some embodiments of the present invention, the first guide roller 201 and/or the second guide roller 202 are cooling or heater rollers. Alternatively, or in addition, there might be positioned a further cooling or heater guide roller in between the first guide roller 201 and the second guide roller 202, upstream of the first and second guide roller 201 and 202, or downstream of the first and second guide roller. Other processing steps such as cleaning or coating may be undertaken before, the first guide roller, between the first guide roller and the second guide roller, or after the second guide roller.

[0023] Figure 3 shows a plain view of a typical embodiment of the present invention. The different elements of this embodiment forming part of the transversal web tension adjustment are shown in the figure: an adjustment unit 310 at the first guide roller 201, a web tension measurement unit 300 at the second guide roller 202, and a data connection 330 between both guide rollers 201 and 202 to supply tension data to the adjustment unit 310. Typically, the first guide roller 201 is positioned upstream of the second guide roller 202.

[0024] The data connection 330 is used to transmit information from the measurement unit to the adjustment unit 310. The data connection 330 can also be used to transmit information from the adjustment unit 310 to an external interface. Typically this interface consists of a personal computer which processes the data from the adjustment unit 310. Also the interface can consist of an analogue front panel comprising different element to tune the adjustment unit 310, i.e. using different potentiometers, dials, switches, and displays. Further, the interface can also consist of a digital device including numeric pads, graphical display, text commands, or a graphical user interface. Typically, all these interfaces include different features such as controller function, calibration of the system, compensation of ambient conditions, or acquisition and recording of waveforms from the tension unit 300 or the adjustment unit 310.

[0025] For connecting the data connection 330 to the different devices, different port types are used. Typically, when serial communication is used, the ports are RS232, RS422, RS485, or universal serial bus (USB) ports. Typically, parallel communication devices are used when communication between the data connection 330 and a computer is required. Most often used parallel communication devices are DB-25, Centronics 36, SPP, EPP or ECP parallel ports. The data connection 330 can be used to make the adjustment unit 310 compatible with transistor-transistor logic (TTL) or with programmable logic controllers (PLC). Additionally the data connection 330 can be used to connect the adjustment unit 310 with a network.

[0026] According to an embodiment of the present invention the tension acting on both shaft axes 215 and 216 of the second guide roller 202 will be acquired separately. The acquired data will be processed and sent to the adjustment unit 310 in the first guide roller 201. The adjustment unit 310 adjusts the position of the shaft axis at one side of the first guide roller 201. Thereby, the distance between the shaft axes of the first guide roller and the shaft axes of the second guide roller is adjusted. The adjustment unit 300 is operated in order to equalize the tension measured between the shaft axes at both sides of the second guide roller 202. It is, however, also possible to adjust the position of the shaft axis on both sides of the first guide roller 201 (not shown in drawings).

[0027] Figure 4 shows a plain view of another embodiment of the web guide control 10 of the present invention where the adjustment unit consists of a rotating shaft axis 420 and a translation element 411. The web tension measurement units 300 are placed at the bearings 431 and 432 of the second guide roller 202. Typically the translation element 411 encloses a drive 410, such as a motor, and a moving bearing 415 which can be displaced along the machine frame 452. The shaft axis 206 is attached to the moving bearing 415 enclosing the drive 410. The rotating shaft axis 420 encloses the shaft axis 205 which is attached with rotational freedom to the machine frame 451.

[0028] Different kind of motors can be used in the adjustment unit of the present invention. At the first guide roller 201 the distance between the bearings of the two guide rollers 201 and 202 can be adjusted on one side. In order to do so, a powered engine is typically used. Typically, the drive for adjustment is either an electrical or hydraulic motor according to the present invention. The position of the moving bearing 415 of the first guide roller 201 is adjusted in such a way that both tension measurement sensors in the second guide 202 roller face the same loading.

[0029] In typical embodiments of the present invention the web tension measurement units consists of a transducer and a strain gauge. Typically the transducer consists of a beam which stretches or compresses in response to varying tensions. The strain gauge measures the corresponding change in electrical resistance. Typically, the measurement performed by the strain gauge is amplified and converted to a voltage or current for further processing. In general, the web tension measurement units enclose an analogue or digital front end, for further processing of the tension measurement. Typically, the web tension measurement units are aligned in order to maximize the measurement of the tension in the travelling direction of the web between the first and the second guide rollers. Typically, the web tension measurement units are mounted in the guide rollers using different options, i.e., between pillow blocks, using cantilevered brackets, using securing via a flange or clamp, using studs, or threaded into through-holes.

[0030] Figure 5 shows a signal flow chart for the web guide control system according to an embodiment of the present invention, which includes a closed-loop controller based on a negative feedback 500 of the transversal tension measurement. The closed-loop system maintains an output of the controlled system, e.g. the feedback signal 533, equal to a setpoint 534 value by using previ-

ous values of the feedback signal 533 and a control signal 532 fed to the controlled system which is an output of the controller itself. The main elements of the flow chart are a controller 501 and a web guide system 502 constituting the web guide control 10 according to the present invention. The tension difference between both sides of the second guide roller 202 is the feedback signal 533. Typically, the setpoint 534 at the controller of the present invention has a null value in order to compensate for tension differences which correspond to transversal tensions acting on the web. Therefore, in typical embodiments of the present invention, the error 531 of the controller exactly corresponds to the tension difference measurement, i.e. the feedback signal 533. In typical embodiments of the present invention the controller compensates deviations from zero of the error 531 using the adjustment unit 310. Typically, this error 531 compensation translates to a distance adjustment of the shaft axes 205 and 215 at one side of both guide rollers 201 and 202. Therefore, the control signal 532, e.g. the controller output, typically corresponds to the distance between the shaft axes at one side of both guide rollers 201 and 202.

[0031] In principle, different control approaches can be implemented in the controller 501. Typically, a linear control approach is implemented in the controller 501 choosing from: proportional, integral and derivative (PID) control; proportional and integral (PI) control; proportional and derivative (PD) control; and proportional (P) control. However, also other advanced controls using non-linear control approaches may be implemented in embodiments of the present invention, e.g. adaptive gain, deadtime compensation, fuzzy logic, neural networks, or feedforward control. Controllers implemented in the present application can be analogue or digital interfaces including compatibility with transistor-transistor logic (TTL). Typically, digital interfaces works in a discrete manner where the values for the adjustment unit are refreshed after a certain and fixed time period Δt. Other special features can be present in controllers of the present invention such as self-tuning, signal computation or filtering, or built-in indicators.

[0032] As illustration of the functioning of a controller according to an embodiment of the present invention, in the following the implementation of a discrete PID controller is described. The feedback signal at a given control step i corresponds to the difference between both tension measurements T_i^{215} and T_i^{216}. Typically, for embodiments corresponding to the present invention, the setpoint is kept at zero since the controller has to compensate for transversal forces acting on the web, i.e. the tension at both sides of the second guide roller 202 should be equal. Therefore, the error signal at a given processing step i corresponds to

$$E_i = T_i^{215} - T_i^{216}.$$

The PID controller calculates the output value D_{i+1} by using:

$$D_{i+1} = D_i + K_p E_i + K_d (E_i - E_{i-1}),$$

where the first term corresponds to the integral part of the controller, the second to the proportional, and the third to the derivative. K_p is the proportional band and K_d is the derivative gain. Typically, values of D_{i+1}- D_i other than zero correspond to a variation in the position at one side of the first guide roller 201. In other embodiments of the present invention, this corresponds to the signal for operation of the drive 410 at the adjustment unit in the first guide roller 201.

[0033] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to make and use the invention. While the invention has been described in terms of various specific embodiments, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the claims. Especially, mutually non-exclusive features of the embodiments described above may be combined with each other. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims of they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

Claims

1. A web guide control for guiding a web, the web guide control having a first guide roller (201), and a second guide roller (202) wherein

   - the first guide roller comprises an adjustment unit (310);
   - the second guide roller comprises a tension measurement unit (300); and
   - the web guide control comprises a data connection (330) for supporting the adjustment unit with tension data from the tension measurement unit.

2. The web guide control according to claim 1 wherein the tension measurement unit (300) comprises a first tension sensor positioned at a first side of the second guide roller (202).

3. The web guide control according to claim 1 wherein the tension measurement unit (310) comprises a second tension sensor positioned at a second side

of the second guide roller (202).

4. The web guide control according to any of the preceding claims wherein the adjustment unit (310) comprises a motor for moving the first guide roller positioned at one side of the first guide roller.

5. The web guide control according to any of the preceding claims wherein the adjustment unit is controlled using a closed-loop controller and the tension data is used as variable feedback signal.

6. The web guide control according to claim 5 wherein the closed-loop comprises analogue electronics.

7. The web guide control according to claim 5 wherein the closed-loop comprises digital electronics.

8. The web guide control according to any of the preceding claims wherein the first guide roller is positioned upstream of the second guide roller with respect to the web guiding direction.

9. The web guide control according to any of the claims 1-7 wherein the first guide roller is positioned downstream of the second guide roller with respect to the web guiding direction.

10. A web processing apparatus having at least one web guide control according to any of the preceding claims.

11. The web processing apparatus according to claim 10, further comprising a coating unit for coating the web.

12. A method for guiding a web comprising the steps of:

- adjusting the position of a first guide roller by moving one side of the first guide roller;
- measuring the tension of the web acting on a second guide roller, thereby receiving measurement results; and
- wherein adjusting is based on the measurement results.

13. The method according to claim 12 wherein the measuring is undertaken at a first side of a second guide roller and at a second side of the second guide roller.

14. The method according to any of claims 12-13 wherein the adjusting is undertaken at one side of the first guide roller.

15. The web guide control according to any of claims 12-14 wherein the measuring is undertaken upstream of the adjusting with respect to the web guiding direction.

16. The web guide control according to any of claims 12-14 wherein the measuring is undertaken downstream of the adjusting with respect to the web guiding direction.

Amended claims in accordance with Rule 137(2) EPC.

1. A web guide control for guiding a web, the web guide control having a first guide roller (201), and a second guide roller (202) wherein

- the first guide roller comprises an adjustment unit (310);
- the second guide roller comprises a tension measurement unit (300) wherein the first guide roller is positioned downstream of the second guide roller with respect to the web guiding direction; and
- the web guide control comprises a data connection (330) for supporting the adjustment unit with tension data from the tension measurement unit.

2. The web guide control according to claim 1 wherein the tension measurement unit (300) comprises a first tension sensor positioned at a first side of the second guide roller (202).

3. The web guide control according to claim 1 wherein the tension measurement unit (310) comprises a second tension sensor positioned at a second side of the second guide roller (202).

4. The web guide control according to any of the preceding claims wherein the adjustment unit (310) comprises a motor for moving the first guide roller positioned at one side of the first guide roller.

5. The web guide control according to any of the preceding claims wherein the adjustment unit is controlled using a closed-loop controller and the tension data is used as variable feedback signal.

6. The web guide control according to claim 5 wherein the closed-loop comprises analogue electronics.

7. The web guide control according to claim 5 wherein the closed-loop comprises digital electronics.

8. The web guide control according to any of the preceding claims wherein the first guide roller is positioned upstream of the second guide roller with respect to the web guiding direction.

9. A web processing apparatus having at least one web guide control according to any of the preceding

claims.

10. The web processing apparatus according to claim 10, further comprising a coating unit for coating the web.

11. A method for guiding a web comprising the steps of:

- adjusting the position of a first guide roller by moving one side of the first guide roller;
- measuring the tension of the web acting on a second guide roller, thereby receiving measurement results, wherein the measuring is undertaken upstream of the adjusting with respect to the web guiding direction.; and
- wherein adjusting is based on the measurement results.

12. The method according to claim 11 wherein the measuring is undertaken at a first side of a second guide roller and at a second side of the second guide roller.

13. The method according to any of claims 11-12 wherein the adjusting is undertaken at one side of the first guide roller.

14. The method according to any of claims 11-13 wherein the measuring is undertaken downstream of the adjusting with respect to the web guiding direction.

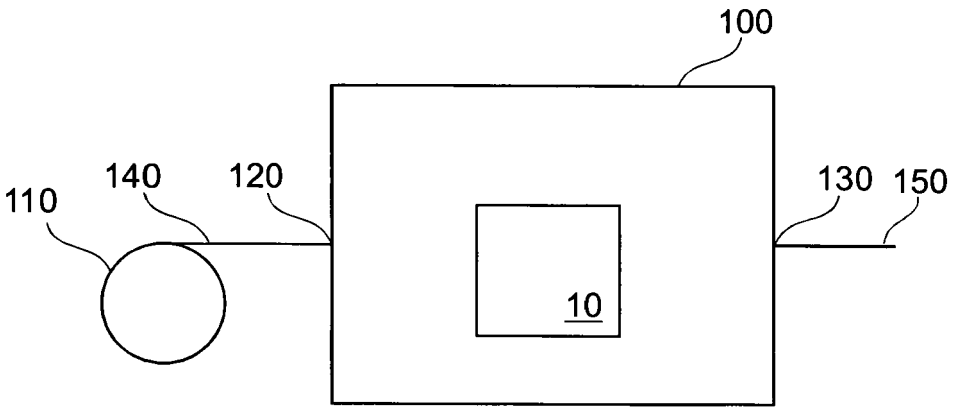

Fig. 1

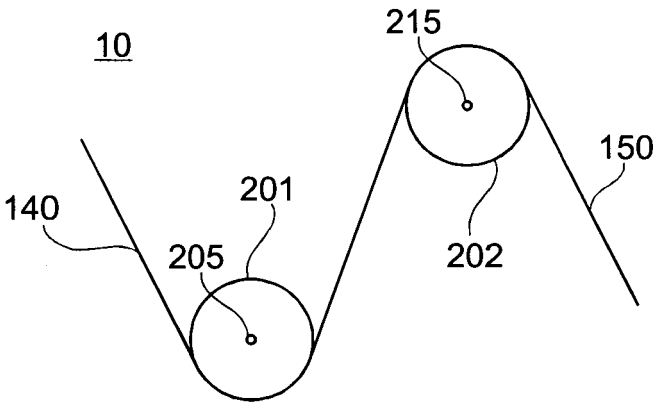

Fig. 2

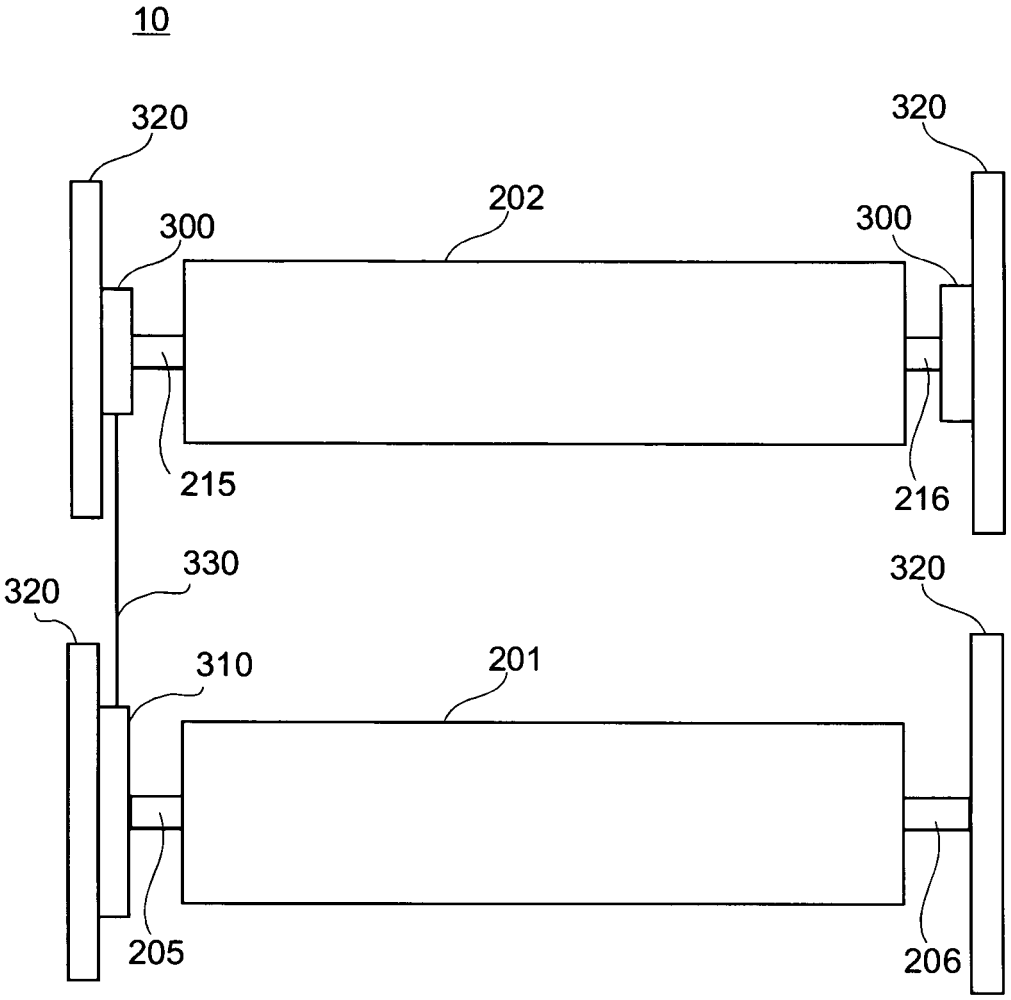

Fig. 3

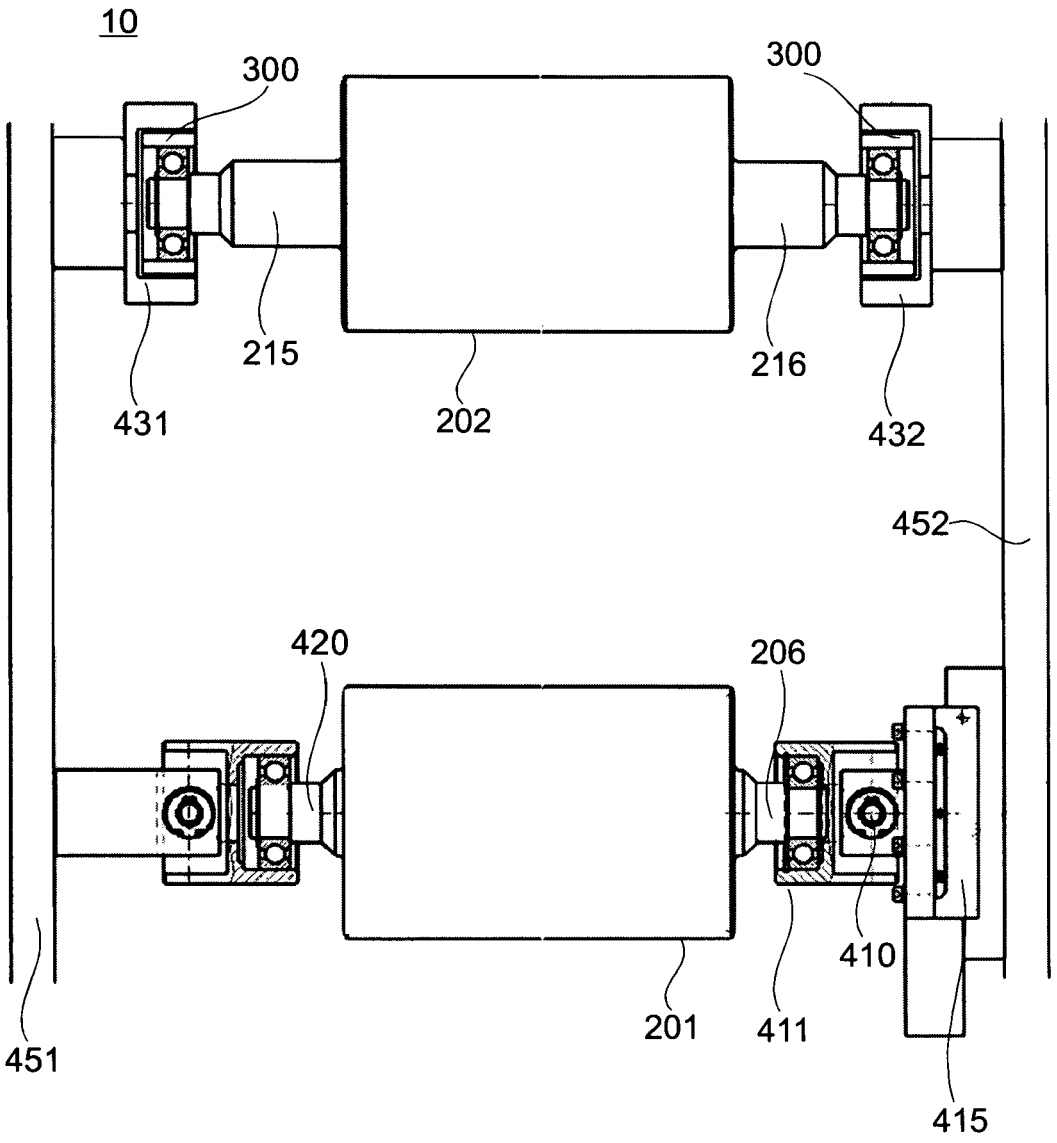

Fig. 4

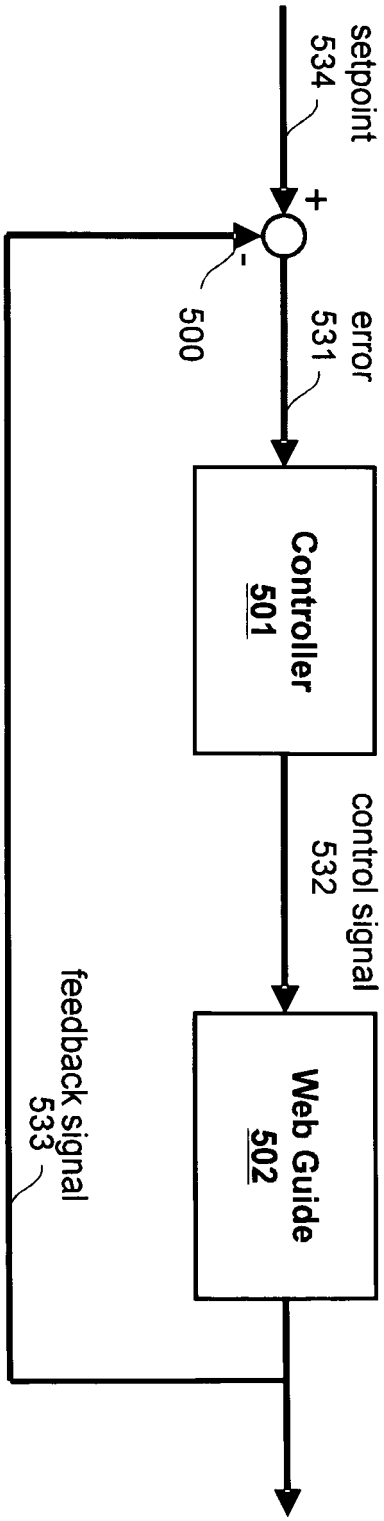
setpoint
534
+
-
500
error
531
Controller
501
control signal
532
Web Guide
502
feedback signal
533

Fig. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 00 4189

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) B65H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	26 July 2007	Haaken, Willy

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 07 00 4189

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
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26-07-2007

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