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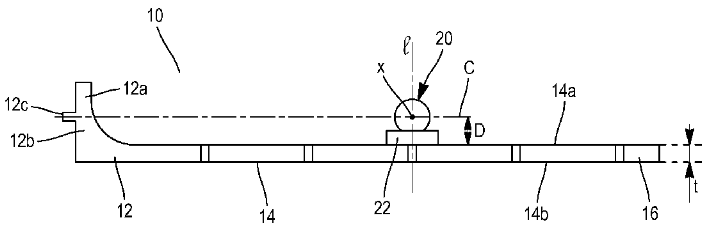

FIG. 3

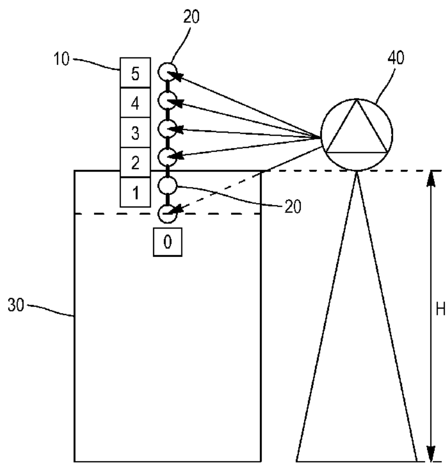

FIG. 4

(57) Abstract: An apparatus (10) is provided for determining the coordinates of a hidden point during a tire production cycle. A method is also provided for measuring, during a tire production cycle, a distance between coordinates of a target measurement location and a distance between the target measurement location and a hidden point to be measured. An assembly is also provided for measuring a hidden point relative to a support of a tire building drum installation.

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HIDDEN POINT MEASURING APPARATUS AND METHOD

TECHNICAL FIELD

The invention relates generally to tire production and more particularly to an apparatus and method for measuring a hidden point during a tire production cycle.

BACKGROUND

In tire production cycles, laser triangulation is often utilized to ensure proper alignment of a tire building drum (or "drum") relative to one or more tire components to be positioned thereon. Triangulation devices (including but not limited to tachymeters, theodolites and complementary and equivalent measuring instruments)(collectively "measurement instruments") can measure distances with high accuracy upon emitting a laser beam toward a retro-reflective target surface (e.g., a corner cube). If the emitted beam strikes the target surface off-center, the reflected beam is displaced. A sensor, offset from the beam's axis of projection by a baseline distance, views the emitted beam and detects the beam's displacement. Proportional signals that are generated by the sensor's detector communicate the extent of the displacement as an offset distance. The lasers are thus used as measuring instruments that measure default measurement points on the drum. The measured points are compared with established data to ensure the accuracy of the measurement process and thus proper alignment of the drum.

Multiple tire building processes are realized upon the tire building drum, thereby subjecting the drum to vibrations that can impart an offset in comparison with an emitted laser beam. This offset can negatively affect the centering of the drum relative to the incoming tire components as the drum rotates.

Moreover, when, upon such offset, the default measurement points are masked by other obstacles, they become "hidden points" that remain inaccessible to the measurement instrument. The measurement data of these hidden points cannot be directly collected, lending to diminished measurement accuracy and potential deleterious effects on the tire building process. A solution is therefore demanded for measurement of an inaccessible hidden point relative to a tire building drum.

SUMMARY

The invention provides an apparatus for determining the coordinates of a hidden point during a tire production cycle. The apparatus includes a generally elongate member having a coupling extent and a longitudinal body of predetermined length that depends normally therefrom toward an opposed free extent, with the longitudinal body having a predetermined thickness defined between a pair of opposed planar support surfaces. The apparatus also includes a coupling element provided at the coupling extent that facilitates detachable and adjustable securement of the apparatus with a support that comprises the hidden point to be determined. The apparatus includes a ruler that identifies multiple target measurement locations along the longitudinal body intermediate the coupling extent and the free extent. The target measurement locations are designated by a primary marker that indicates a position of the hidden point and one or more consecutive dependent markers that are disposed intermediate the primary marker and the free extent. The primary marker and a first dependent marker are separated by an initial predefined interval that designates a known distance therebetween. The dependent markers are separated one from the other by consecutive predefined intervals that designate a known distance between each pair of dependent markers such that the initial predefined interval and the consecutive predefined intervals together establish a constant predefined distance between the primary marker and each of the target measurement locations.

In some embodiments, the coupling element includes a planar surface with an axial fastener of predetermined length projecting normally therefrom and positioned along the planar surface such that a centerline of the fastener is disposed at a known distance relative to the support surface.

In some embodiments, the apparatus includes one or more magnets disposed proximate the fastener, selected from one or more magnets that are integral with the coupling extent such that the planar surface remains flush with the support upon coupling of the apparatus thereto, one or more magnets that are disposed in corresponding recesses defined along the planar surface.

In some embodiments, the apparatus includes one or more apertures defined through the thickness of the longitudinal body and in correspondence with respective dependent markers, with each aperture having a centerline that delineates at least one boundary for one of the initial predefined interval and one or more of the consecutive predefined intervals.

In some embodiments, the apparatus includes a retro-reflective target surface that is movable along the longitudinal body for placement at a selected target measurement location. In some such embodiments, the retro-reflective target surface is a corner cube disposed upon a displaceable base having fastening means integral therewith for corresponding engagement with at least one aperture.

In some embodiments, a target point is provided at an intersection of a longitudinal axis of the retro-reflective target surface and the centerline of the fastener.

The invention also provides a method for measuring, during a tire production cycle, a distance between coordinates of a target measurement location and a distance between the target measurement location and a hidden point. The method includes the step of providing a hidden point measuring apparatus that includes a generally elongate member having a coupling extent with a coupling element and a longitudinal body of predetermined length that depends normally therefrom toward an opposed free extent. The hidden point measuring apparatus also includes a ruler that identifies multiple target measurement locations along the longitudinal body intermediate the coupling extent and the free extent. The target measurement locations are designated by a primary marker that indicates a position of the hidden point and one or more consecutive dependent markers that are disposed intermediate the primary marker and the free extent. The primary marker and a first dependent marker are separated by an initial predefined interval that designates a known distance therebetween. The dependent markers are separated one from the other by consecutive predefined intervals that designate a known distance between each pair of dependent markers such that the initial predefined interval and the consecutive predefined intervals together establish a constant predefined distance between the primary marker and each of the target measurement locations.

The method also includes the steps of positioning the coupling extent relative to a support that comprises the hidden point to be determined; positioning a retro-reflective target surface at a selected target measurement location designated by one of the dependent markers; measuring one or more target measurement locations on the basis of a position of the retro-reflective target surface; determining a vector that passes through each measured target measurement location; and obtaining a sum of distances represented by the initial predefined interval and the consecutive predefined intervals.

In some embodiments, the step of measuring one or more target measurement locations includes emitting a laser beam from a laser beam source toward a target point on the retro-reflective target surface and determining a lateral displacement of the emitted laser beam from the target point. In some embodiments, the target point is provided at an intersection of a longitudinal axis of the retro-reflective target surface and a centerline of a fastener that is displaced by a known distance relative to a support surface of the longitudinal body.

In some embodiments, the method also includes the step of calibrating the apparatus with respect to the support such that the target measurement locations lie precisely along a straight line.

In some embodiments, the method also includes the step of providing a measurement instrument at a location having known spatial coordinates relative to the support, with the measurement instrument including the laser beam source.

In some embodiments, the step of measuring one or more target measurement locations is performed iteratively by moving the retro-reflective target surface among the dependent markers and maintaining the fixed position of the measurement instrument.

The invention also provides an assembly for measuring a hidden point relative to a support of a tire building drum installation. The assembly includes the disclosed apparatus and a measuring instrument provided at a location having known spatial coordinates relative to the support and having a laser beam source for measuring distances between coordinates of a target measurement location and a distance between the target measurement location and the hidden point.

Other aspects of the disclosed invention will become readily apparent from the following detailed description.

BRIEF DESCRIPTION OF DRAWINGS

The nature and various advantages of the presently disclosed invention will become more apparent upon consideration of the following detailed description, taken in conjunction with the accompanying drawings, in which like reference characters refer to like parts throughout, and in which:

FIG. 1 shows a front perspective view of an apparatus for determining the coordinates of a hidden point during a tire production cycle.

FIG. 2 shows a cross-sectional view of the apparatus of FIG. 1 along line I-I.

FIG. 3 shows the apparatus of FIG. 2 together with a retro-reflective target surface used therewith.

FIG. 4 shows a front schematic view of the hidden point measuring apparatus of FIGS. 1 to 3 in use with a measurement instrument.

DETAILED DESCRIPTION

Now referring further to the figures, in which like numbers identify like elements, FIG. 1 shows an apparatus 10 for determining the coordinates of a hidden point during a tire production cycle. By employing the apparatus 10, a method is provided for measuring a hidden point by measuring a distance between the coordinates of a target measurement location and a distance between the hidden point and the target measurement location.

The apparatus 10 is provided as a generally elongate member having a coupling extent 12 and a longitudinal body 14 of predetermined length that depends normally therefrom toward an opposed free extent 16. The longitudinal body 14 has a predetermined thickness *t* defined between a pair of opposed planar support surfaces 14a, 14b.

A coupling element 12a that is provided at the coupling extent 12 facilitates detachable and adjustable securement of the apparatus 10 with a support that comprises the hidden point to be determined (for example, a support of a tire building drum installation). The coupling element 12a includes a planar surface 12b having an axial fastener 12c of predetermined length projecting normally therefrom. The fastener 12c is positioned along the planar surface 12b such that a centerline C of the fastener is disposed at a known distance D relative to the support surface 14a (see FIG. 3).

In some embodiments of the apparatus 10, one or more magnets (not shown) may be disposed in corresponding recesses 12d in the planar surface 12b. Alternatively, such magnets may be integral with the coupling extent 12 such that the planar surface 12b remains flush with a corresponding support upon coupling of the apparatus 10 therewith. The disposition of the magnets proximate the fastener 12c facilitates coupling and uncoupling of the apparatus 10 relative to the support without the need for additional fastening tools.

Still referring to FIG. 1 and referring further to FIGS. 2 and 3, the apparatus 10 includes a ruler or scale that identifies multiple target measurement locations along the longitudinal body 14 intermediate the coupling extent 12 and the free extent 16. The target measurement locations are designated by a primary marker 0 and one or more consecutive dependent markers 1 to 5. The primary marker 0 indicates a position where a straight plane that runs along the planar surface 12b runs perpendicularly relative to the centerline C of the fastener 12c. When the apparatus 10 is coupled with the support, the primary marker 0 identifies the hidden point (i.e., the point whose position is sought). The primary marker 0 and the first dependent marker 1 are separated by an initial predefined interval I_1 that designates a known distance therebetween, taking into account the presence of the coupling element 12a.

The consecutive dependent markers 1 to 5 are disposed intermediate the primary marker 0 and the free extent 16. The dependent markers 1 to 5 are separated one from the other by consecutive predefined intervals I_2. Each predefined interval I_2 designates a known distance between each pair of dependent markers. In this configuration, the initial predefined interval I_1 and the consecutive predefined intervals I_2 together establish a constant predefined distance between the primary marker 0 and each of the target measurement locations. Although the apparatus 10 is shown as having up to five dependent markers, it is understood that any number of dependent markers may be provided along the longitudinal body 14.

Further referring to FIG. 3, a retro-reflective target surface is provided that is movable along the longitudinal body 14 for placement of a laser target surface at a selected target measurement location. The retro-reflective target surface is shown herein as a corner cube 20 that is optionally embedded within a sphere as is known in the art. It is understood that equivalent laser target surfaces may be substituted therefor.

The corner cube 20 is disposed upon a displaceable base 22 having fastening means integral therewith (not shown). The fastening means may include an elongate pin that enables securement of the corner cube 20 relative to a selected aperture O_1, O_2, O_3, O_4, O_5 defined through the thickness t of the longitudinal body 14. Each aperture, corresponding to a respective dependent marker 1, 2, 3, 4, 5, has a centerline that delineates at least one boundary for one of the initial predefined interval I_1 and one or more of the consecutive predefined intervals I_2 (see FIG. 2). Upon selection of a desired viewing angle, the corner cube 20 is readily secured within a corresponding aperture and therefore easily placed as a selected target measurement location. Upon adjustment of the viewing angle, the corner cube 20 can be moved from one aperture to another aperture as needed to determine a precise location of the hidden point.

Now referring further to FIG. 4, a method of using the apparatus 10 will be described.

The apparatus 10, and namely the coupling extent 12 thereof, is positioned relative to a support 30 of a tire building drum installation. The coupling element 12a is detachably coupled with the support 30 by placing the fastener 12c proximate a hidden point to be measured (designated by the primary marker 0). It is understood that the hidden point may be a cylindrical hole, a conical hole, a screw thread, a cylindrical pin or any other equivalent configuration. It is understood, therefore, that, although the fastener 12c is shown herein as a generally cylindrical element of predetermined diameter, the fastener 12c can assume any suitable cross-sectional geometry.

Before determining the location of the hidden point, the apparatus 10 is calibrated with respect to the support 30 to ensure that the longitudinal body 14, and therefore the target measurement locations (designated by the markers 0 to 5), lie precisely along a straight line. After selecting a desired viewing angle, the corner cube 20 is positioned and secured with respect to a corresponding target measurement location along the longitudinal body 14 as designated by a dependent marker 1, 2, 3, 4 or 5.

Once the apparatus 10 and the corner cube 20 are in position to commence measurement, a measurement instrument 40 is employed to define a vector along the apparatus 10. The measurement instrument 40 is provided at a location having known spatial coordinates, including a maximum height H, relative to the support 30. The measurement instrument 40 includes a laser beam source that emits a laser beam toward the selected target measurement location. The selected target point is designated at a target point X at an intersection of a longitudinal axis *l* of the corner cube 20 and the centerline C of the fastener 12c (see FIG. 3). The emitted laser beam reaches the target point X and generates voltages that are proportional to a lateral displacement of the emitted beam from the target point X.

Since the centerline C of the fastener 12c is displaced by a known distance D relative to the support surface 14a of the apparatus 10, it is possible to determine an approximate center of the hidden point in each of the X and Y axes relative to an approximate center of the corner cube 20 in the X and Y axes. Using software that is embedded in the measurement instrument 40, the vector is known and the geometrical characteristics of the apparatus 10 are used therewith to determine the position of the hidden point. To refine the precision of the effected measurement, measurements may be effected at each target measurement location simply by moving the corner cube 20 among the dependent markers 1 to 5 while maintaining the fixed position of the measurement instrument 40.

<u>EXAMPLE:</u>

In the example shown in FIG. 4, the initial predefined interval I_1 is defined to be 125mm and each consecutive predefined interval I_2 is defined to be 100mm. The target measurement locations designated by dependent markers 2, 3, 4, and 5 are measured, and a straight line (i.e., a vector) is drawn that passes through these measured points. The desired viewing angle is selected, and, as a function of this selected viewing angle, the corner cube 20 is placed at the target measurement locations indicated by the dependent marker 3.

According to the direction vector passing through the dependent markers 2, 3, 4 and 5, it is possible to shift from an offset and determine the location of the hidden point designated by the primary marker 0. Starting from the dependent marker 3, this offset is determined to be:

$$I_1 + I_2 + I_2 = \text{Offset}$$
$$125\text{mm} + 100\text{mm} + 100\text{mm} = 325\text{mm}$$

Using the apparatus disclosed herein, the measurement of the hidden point can be converted into the measurement of the target measurement locations on the ruler. The spatial coordinates of the hidden point can be directly converted as a function of the spatial coordinates of the target measurement locations and the distances between these target measurement locations and the hidden point. This conversion is effected without changing the hidden point and without assigning any auxiliary measuring lines.

The apparatus 10 is an easily machined device that may be modified for a variety of tire building drum installations. By enabling the measurement of multiple points with a single device positioned in a single location, the apparatus 10 enhances the precision of the measurement of the hidden point, regardless of its spatial location.

The apparatus 10 and the corner cube 20 may be provided together as an assembly that complements a measurement instrument. Alternatively, one or both of the apparatus 10 and the corner cube 20 may be provided in multiple versions that are provided in one or more kits from which the apparatus and/or corner cube may be selected as a function of the parameters of the tire building drum installation.

As used herein, the term "method" or "process" may include one or more steps performed at least by one electronic or computer-based apparatus having a processor for executing instructions that carry out the steps.

Ranges that are described as being "between a and b" are inclusive of the values for "a" and "b."

While particular embodiments of the disclosed apparatus have been illustrated and described, it will be understood that various changes, additions and modifications can be made without departing from the spirit and scope of the present disclosure. Accordingly, no limitation should be imposed on the scope of the presently disclosed invention, except as set forth in the accompanying claims.

CLAIMS

1. An apparatus (10) for determining the coordinates of a hidden point during a tire production cycle, comprising:

a generally elongate member having a coupling extent (12) and a longitudinal body (14) of predetermined length that depends normally therefrom toward an opposed free extent (16), with the longitudinal body (14) having a predetermined thickness (*t*) defined between a pair of opposed planar support surfaces (14a, 14b);

a coupling element (12a) provided at the coupling extent (12) that facilitates detachable and adjustable securement of the apparatus (10) with a support (30) that comprises the hidden point to be determined; and

a ruler that identifies multiple target measurement locations along the longitudinal body (14) intermediate the coupling extent (12) and the free extent (16), with the target measurement locations being designated by a primary marker (0) that indicates a position of the hidden point and one or more consecutive dependent markers (1, 2, 3, 4, 5) that are disposed intermediate the primary marker (0) and the free extent (16), with the primary marker (0) and a first dependent marker (1) being separated by an initial predefined interval (I_1) that designates a known distance therebetween, and with the dependent markers (1, 2, 3, 4, 5) being separated one from the other by consecutive predefined intervals (I_2) that designate a known distance between each pair of dependent markers such that the initial predefined interval (I_1) and the consecutive predefined intervals (I_2) together establish a constant predefined distance between the primary marker (0) and each of the target measurement locations.

2. The apparatus (10) of claim 1, wherein the coupling element (12a) includes a planar surface (12b) with an axial fastener (12c) of predetermined length projecting normally therefrom and positioned along the planar surface (12b) such that a centerline (C) of the fastener (12c) is disposed at a known distance (D) relative to the support surface (14a).

3. The apparatus (10) of claim 2, further comprising one or more magnets disposed proximate the fastener (12c) and selected from:

one or more magnets that are integral with the coupling extent (12) such that the planar surface (12a) remains flush with the support upon coupling of the apparatus (10) thereto; and

one or more magnets that are disposed in corresponding recesses (12d) defined along the planar surface (12a).

4. The apparatus (10) of claim 2 or claim 3, further comprising one or more apertures (O_1, O_2, O_3, O_4, O_5) defined through the thickness (*t*) of the longitudinal body (14) and in correspondence with respective dependent markers (1, 2, 3, 4, 5) with each aperture having a centerline that delineates at least one boundary for one of the initial predefined interval (I_1) and one or more of the consecutive predefined intervals (I_2).

5. The apparatus (10) of claim 4, further comprising a retro-reflective target surface that is movable along the longitudinal body (14) for placement at a selected target measurement location.

6. The apparatus (10) of claim 5, wherein the retro-reflective target surface is a corner cube (20) disposed upon a displaceable base (22) having fastening means integral therewith for corresponding engagement with at least one aperture (O_1, O_2, O_3, O_4, O_5).

7. The apparatus (10) of claim 5 or claim 6, wherein a target point (X) is provided at an intersection of a longitudinal axis (*l*) of the retro-reflective target surface and the centerline (C) of the fastener (12c).

8. A method for measuring, during a tire production cycle, a distance between coordinates of a target measurement location and a distance between the target measurement location and a hidden point, the method comprising the following steps:

providing a hidden point measuring apparatus (10) comprising:

a generally elongate member having a coupling extent (12) with a coupling element (12a) and a longitudinal body (14) of predetermined length that depends normally therefrom toward an opposed free extent (16); and

a ruler that identifies multiple target measurement locations along the longitudinal body (14) intermediate the coupling extent (12) and the free extent (16), with the target measurement locations being designated by a primary marker (0) that indicates a position of the hidden point and one or more consecutive dependent markers (1, 2, 3, 4, 5) that are disposed intermediate the primary marker (0) and the free extent (16), with the primary marker (0) and a first dependent marker (1) being separated by an initial predefined interval (I_1) that designates a known distance therebetween, and with the dependent markers (1, 2, 3, 4, 5) being separated one from the other by consecutive predefined intervals (I_2) that designates a known distance between each pair of dependent markers such that the initial predefined interval (I_1) and the consecutive predefined intervals (I_2) together establish a constant predefined distance between the primary marker (0) and each of the target measurement locations;

positioning the coupling extent (12) relative to a support (30) that comprises the hidden point to be determined;

positioning a retro-reflective target surface at a selected target measurement location designated by one of the dependent markers (1, 2, 3, 4, 5);

measuring one or more target measurement locations on the basis of a position of the retro-reflective target surface;

determining a vector that passes through each measured target measurement location; and

obtaining a sum of distances represented by the initial predefined interval (I_1) and the consecutive predefined intervals (I_2).

9. The method of claim 8, wherein the step of measuring one or more target measurement locations includes emitting a laser beam from a laser beam source toward a target point (X) on the retro-reflective target surface and determining a lateral displacement of the emitted laser beam from the target point (X).

10. The method of claim 9, wherein the target point (X) is provided at an intersection of a longitudinal axis *l* of the retro-reflective target surface and a centerline (C) of a fastener (12c) that is displaced by a known distance (D) relative to a support surface (14a) of the longitudinal body (14).

11. The method of any of claims 8 to 10, further comprising the step of calibrating the apparatus (10) with respect to the support (30) such that the target measurement locations lie precisely along a straight line.

12. The method of any of claims 9 to 11, further comprising the step of providing a measurement instrument (40) at a location having known spatial coordinates relative to the support (30), with the measurement instrument including the laser beam source.

13. The method of claim 12, wherein the step of measuring one or more target measurement locations is performed iteratively by moving the retro-reflective target surface among the dependent markers (1, 2, 3, 4, 5) and maintaining the fixed position of the measurement instrument (40).

14. An assembly for measuring a hidden point relative to a support (30) of a tire building drum installation, the assembly comprising:

an apparatus (10) according to any of claims 1 to 7; and

a measuring instrument (40) provided at a location having known spatial coordinates relative to the support (30) and having a laser beam source for measuring distances between coordinates of a target measurement location and a distance between the target measurement location and the hidden point

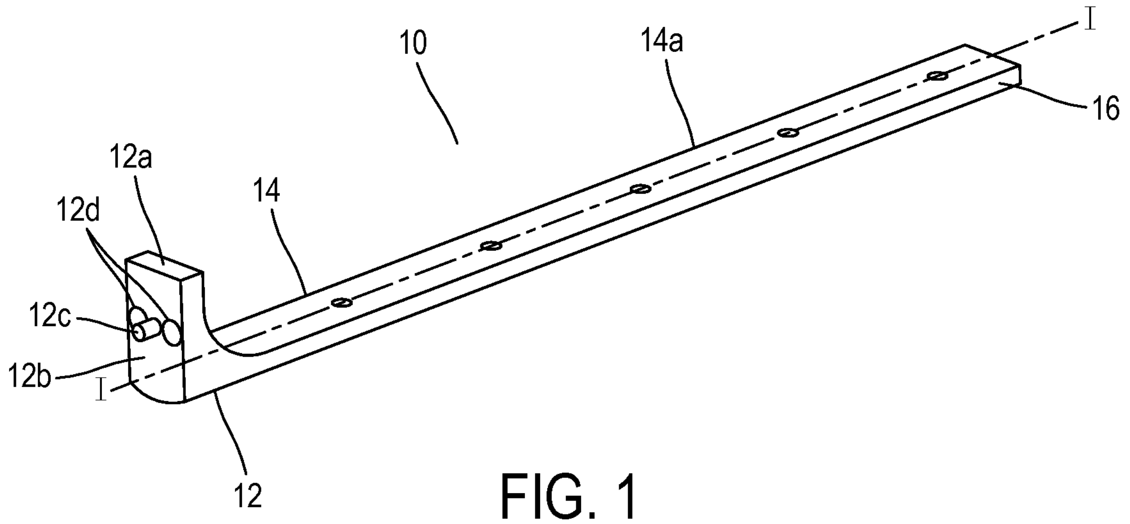
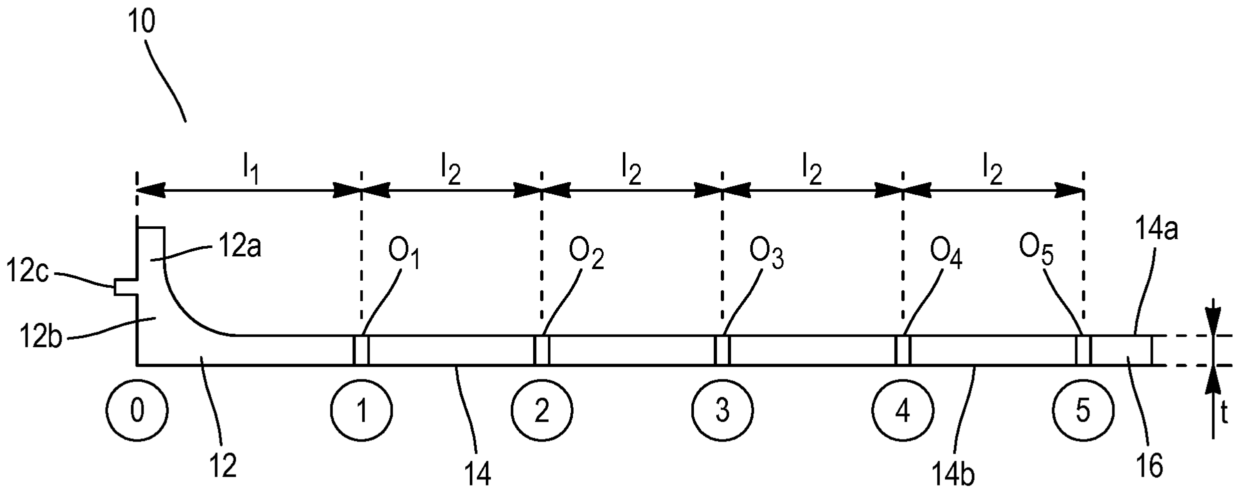

10
14a
I
16
12a
14
12d
12c
12b
I
12

FIG. 1


10
l1
l2
l2
l2
l2
12c
12a
O1
O2
O3
O4
O5
14a
12b
t
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12
1
14
2
3
4
14b
5
16

FIG. 2

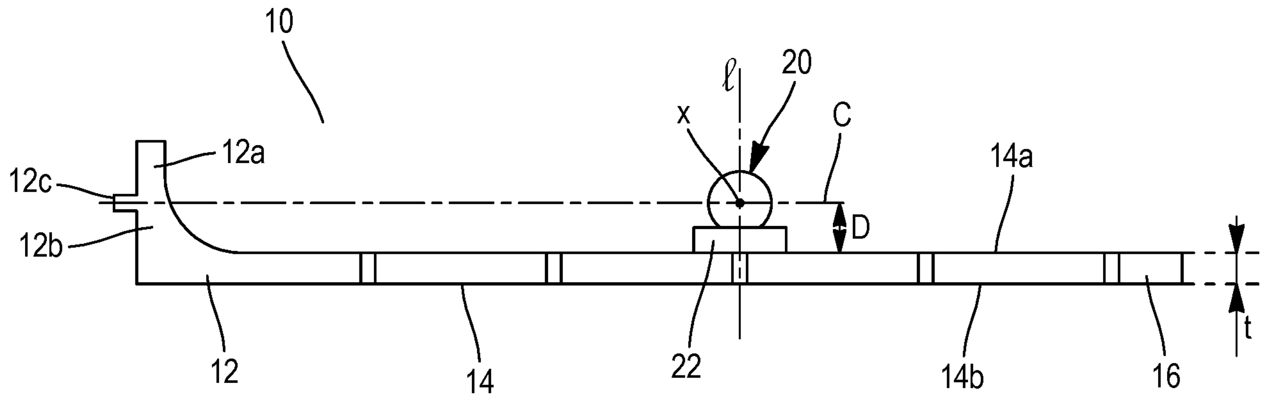

FIG. 3

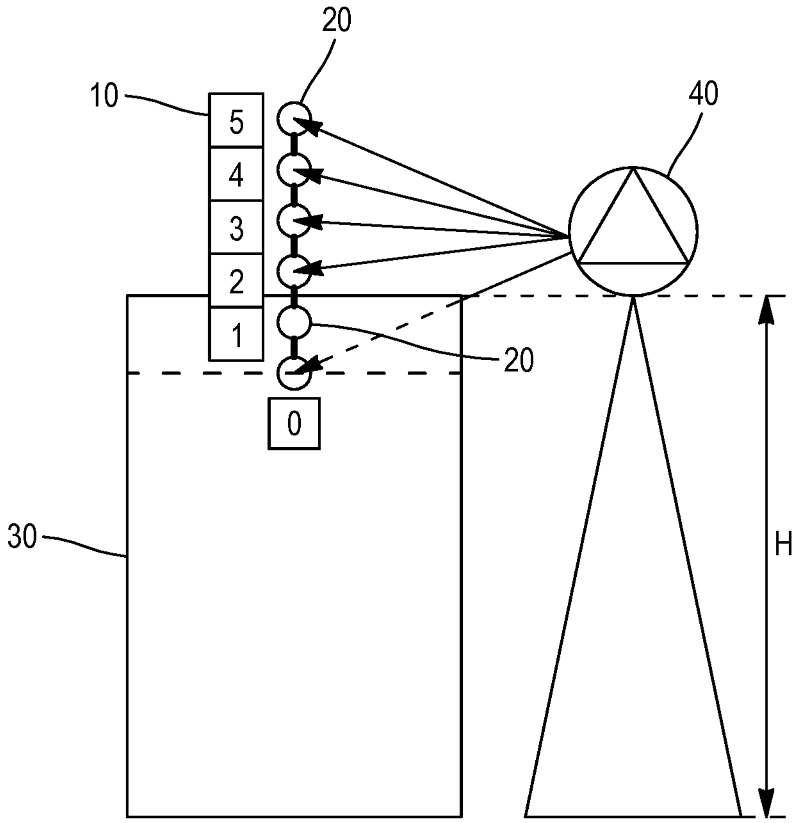

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/068130

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01B5/00 G01B21/04 B29D30/00 G01C15/02
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01B G01C G01S B23C B29D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	EP 1 746 383 A1 (METRONOM AG [DE]) 24 January 2007 (2007-01-24) abstract paragraphs [0002] - [0006] paragraphs [0009] - [0015], [0019], [0027] - [0057], [0070] - [0088] pages 1,3,5,7 -----	1-7,14 8-13
X	US 2007/049819 A1 (STIFTER JAN [CH] ET AL) 1 March 2007 (2007-03-01) abstract figures 1,2 paragraphs [0014] - [0021] ----- -/--	1,2

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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3 August 2018	14/08/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Poizat, Christophe

1

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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