(12) STANDARD PATENT (11) Application No. AU 2005294044 B2
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Method and measuring device for measuring an absolute distance

(51) International Patent Classification(s)
G01S 17/32 (2006.01)

(21) Application No: **2005294044** (22) Date of Filing: **2005.09.29**

(87) WIPO No: **WO06/039820**

(30) Priority Data

(31) Number	(32) Date	(33) Country
04405638.0	**2004.10.13**	**EP**

(43) Publication Date: **2006.04.20**
(44) Accepted Journal Date: **2010.05.27**

(71) Applicant(s)
Leica Geosystems AG

(72) Inventor(s)
Meier, Dietrich

(74) Agent / Attorney
Griffith Hack, Level 3 509 St Kilda Road, Melbourne, VIC, 3004

(56) Related Art
WO 2002/084327
WO 2000/063645

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
Internationales Büro

PCT

(43) Internationales Veröffentlichungsdatum
20. April 2006 (20.04.2006)

(10) Internationale Veröffentlichungsnummer
WO 2006/039820 A1

(51) Internationale Patentklassifikation: *G01S 17/32* (2006.01)

(21) Internationales Aktenzeichen: PCT/CH2005/000560

(22) Internationales Anmeldedatum: 29. September 2005 (29.09.2005)

(25) Einreichungssprache: Deutsch

(26) Veröffentlichungssprache: Deutsch

(30) Angaben zur Priorität:
04405638.0 13. Oktober 2004 (13.10.2004) EP

(71) **Anmelder** *(für alle Bestimmungsstaaten mit Ausnahme von US)*: **LEICA GEOSYSTEMS AG** [CH/CH]; Heinrich-Wild-Strasse, CH-9435 Heerbrugg (CH).

(72) **Erfinder; und**

(75) **Erfinder/Anmelder** *(nur für US)*: **MEIER, Dietrich** [CH/CH]; Leimenweg 12, CH-5015 Niedererlinsbach (CH).

(74) **Anwalt: FREI PATENTANWALTSBÜRO**; Postfach 1771, CH-8032 Zürich (CH).

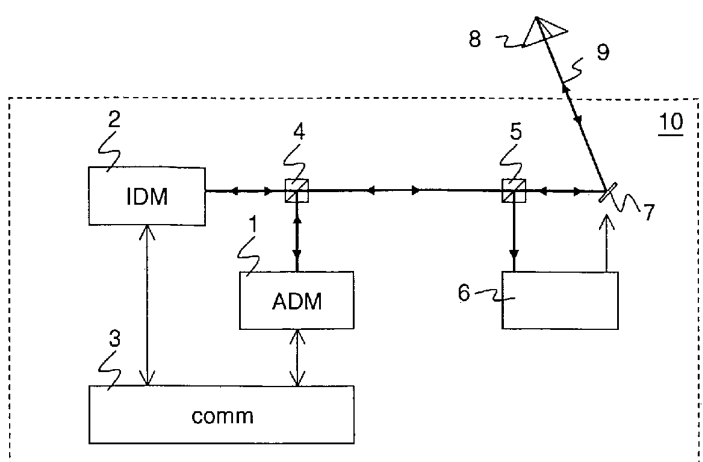
(81) **Bestimmungsstaaten** *(soweit nicht anders angegeben, für jede verfügbare nationale Schutzrechtsart)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) **Bestimmungsstaaten** *(soweit nicht anders angegeben, für jede verfügbare regionale Schutzrechtsart)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), eurasisches (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), europäisches (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC,

[Fortsetzung auf der nächsten Seite]

(54) Title: METHOD AND MEASURING DEVICE FOR MEASURING AN ABSOLUTE DISTANCE

(54) Bezeichnung: VERFAHREN UND MESSGERÄT ZUR MESSUNG EINES ABSOLUTDISTANZWERTES



(57) Abstract: The invention relates to a method and a measuring device (10) for measuring an absolute distance corresponding to a section (9) between a measuring device (10) and a target (8), the measurement of said absolute distance by means of an absolute distance measuring device (1) being carried out in several individual measuring steps. According to said method, at least approximately simultaneously with the individual measuring steps, a respective distance variation between the measuring device (10) and the target (8) is also measured with a relative distance measuring device (2) and said variation is taken into account during the determination of the absolute distance. Preferably an iterative method comprising several scanning steps is used to measure the absolute distance, for example according to the Fizeau method. In each scanning step an output value (A) is generated from an input value (f_n, f_{n+1}, f_{n+2}, ...) and is measured, said output value being dependent on the input value (f_n, f_{n+1}, f_{n+2}, ...) and the distance. A respective distance variation, which is produced between one scanning step and the following scanning step, is measured and is used during the determination of the input value (f_{n+1}, f_{n+2}, f_{n+3}, ...) for the following scanning step to compensate the distance variation.

[Fortsetzung auf der nächsten Seite]

WO 2006/039820 A1

NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Veröffentlicht:
— *mit internationalem Recherchenbericht*

Zur Erklärung der Zweibuchstaben-Codes und der anderen Abkürzungen wird auf die Erklärungen ("Guidance Notes on Codes and Abbreviations") am Anfang jeder regulären Ausgabe der PCT-Gazette verwiesen.

(57) Zusammenfassung: In einem Verfahren und einem Messgerät (10) zur Messung eines Absolutdistanzwertes entsprechend einer Strecke (9) zwischen einem Messgerät (10) und einem Ziel (8), wobei zur Messung des Absolutdistanzwertes mit einem Absolutdistanzmesser (1) mehrere einzelne Messchritte durchgeführt werden, wird mindestens annähernd gleichzeitig mit diesen einzelnen Messchritten jeweils mit einem Relativdistanzmesser (2) auch eine Distanzänderung zwischen dem Messgerät (10) und dem Ziel (8) gemessen und wird diese bei der Bestimmung der absoluten Distanz berücksichtigt. Vorzugsweise wird zur Messung des absoluten Distanzwertes ein iteratives Verfahren mit mehreren Abtastschritten verwendet, beispielsweise nach dem Fizeau-Verfahren, wobei in jedem Abtastschritt aus einem Eingabewert (f_n, f_{n+1}, f_{n+2}, ...) ein Ausgabewert (A) erzeugt und gemessen wird, welcher vom Eingabewert (f_n, f_{n+1}, f_{n+2}, ...) und von der Distanz abhängig ist, und wobei jeweils eine Distanzänderung, die sich zwischen einem Abtastschritt und einem folgenden Abtastschritt ergibt, gemessen wird und bei der Bestimmung des Eingabewertes (f_{n+1}, f_{n+2}, f_{n+3}, ...) für den folgenden Abtastschritt zur Kompensation der Distanzänderung verwendet wird.

2005294044 20 Apr 2010

METHOD AND MEASURING DEVICE FOR MEASURING AN ABSOLUTE DISTANCE

FIELD OF THE INVENTION

The invention lies in the field of the electro-optical measuring of distance. It relates to a method and a measuring device for measuring an absolute distance according to the generic term of the corresponding independent claims.

BACKGROUND OF THE INVENTION

High-resolution distance measurements are taken by using instruments for the determination of a relative distance, e.g. laser interferometer, wherein a collimated laser beam travels from a measuring device to a reflecting target. The projected beam is superimposed upon the reflected beam received in the measuring device. As the distance changes, the intensity of the superimposed beams changes according to the interference of the two rays. Such variations of intensity are detected and registered by means of a counter. The distance variation is determined according to the number of intensity changes and the frequency of the laser light. Based upon a predetermined reference value, i.e. an absolute distance in a starting position, an absolute distance of other positions can thus also be determined. In order to measure the distance to a moving reflector or target, measuring devices are designed as trackers, i.e. the laser beam automatically follows the target by means of a rotating mirror. Elevation and azimuth of the laser beam are measured, enabling the determination of the target position in three dimensions. Based on this simple measuring principle the position can be registered even at a target speed of e.g. up to 10 m/s.

The condition for such a method of determining a relative distance is that the beam between the measuring device and the target is not interrupted. If this does happen, the distance variations are no longer registered and the absolute distance between measuring device and target cannot be known. This absolute distance must therefore be determined or calibrated anew by other means. Such a combination of an absolute distance meter and an interferometer is revealed in the publication DE 195 42 490 C1.

Various methods of measuring an absolute distance are known, e.g. different variations of the Fizeau method, as also described and quoted in the DE 195 42 490 C1 mentioned above. To be suitable as a base value for an interferometer method such a distance must be of similar accuracy, i.e. e.g. in the range of micrometers at a measuring distance of up to 100 meters.

Contrary to measuring a relative distance however, measuring an absolute distance at such a distance and accuracy requires a certain minimal length of measuring time during which the distance must not change. Therefore the target cannot be held manually by an operator but has to be placed on a steady support for calibration, which entails a time-consuming interruption in the measuring procedure.

WO 02/084327 A2 describes a method of measuring an absolute distance by means of laser light, wherein the ray is guided alternately along a measuring light path and a reference light path. The measuring light path extends along the distance to be measured and the reference light path lies within the measuring device. Thus a distance variation of an internal reference light path is determined to compensate drift and temperature related changes.

An indirect determination of position by means of a tracker is described in WO 00/63645, wherein a position of a reference point of a measuring device is to be determined. The reference point is not visible from the tracker. A retro-reflector on the measuring device is moved along a known track, followed by the tracker. The position and orientation of the reference point can be determined from the measured

2005294044 20 Apr 2010

positions of the retro-reflector and from the known geometry of the measuring device.

DESCRIPTION OF THE INVENTION

According to a first aspect, there is provided a measuring device for measuring an absolute distance, comprising:

an absolute distance meter for the determination of an absolute distance corresponding to a range between the measuring device and a target; and

a relative distance meter for the determination of a distance variation between the measuring device and a target as a transient value of the target's displacement;

wherein the absolute distance meter is designed to generate the absolute distance value iteratively across a number of individual measuring steps, and the measuring device comprises means to take into account the distance variations between the measuring device and the target, arising between two sampling steps and detected by the relative distance meter, during the determination of the absolute distance by the absolute distance meter in the later of the two sampling steps.

Thus distance variations occurring during the time taken for measuring the absolute distance, in particular movements of the target, can be compensated. It is no longer necessary for the target to remain static. The target may indeed be held in the hand of an operator without necessitating substantial interruptions in a measuring sequence.

In a particular embodiment, the means to determine the absolute distance is designed to carry out an iterative method. In other words, in this embodiment the method advances towards the correct absolute distance measurement through a series of sampling steps. In each step an output value is determined from an input value, which output value depends on the input value and the distance. Any distance variation arising from a movement of the target and/or the measuring device between one sampling step and the next is detected by the means to determine the relative distance and is used to compensate the distance variation during the determination of the input value for the following sampling step.

Thus the iterative method can converge unperturbed by distance variations. Two different measuring methods are applied to the same measuring distance and combined, their advantages complementing one another: "slow" determination of the absolute value and "fast" determination of the relative value.

In one embodiment, the method of measuring the absolute distance is a Fizeau method. The input value is a modulation frequency acting upon a departing and a returning light beam and the output value is an intensity of the returning light beam after its modulation.

In another embodiment, the means to determine the absolute distance is equipped to determine a plurality of measured values. In order to eliminate noise, these measured values are filtered e.g. by integration or by averaging. For the compensation of distance variations between the individual measurements each distance variation is detected by the means to determine the relative distance while the synchronous values of the distance variation are subtracted from the measured values prior to filtering.

In other embodiments, the measurement of the distance variation is used to correct measurements of the absolute value by means of

- a phase measuring method with modulated light,
- a "chirped" signal, coherent or incoherent, or
- an interferometer of absolute values.

Here too, the principle applies that calculated values relating to an absolute distance are corrected by the measured values of a simultaneous relative distance or respective distance variations.

In a particular embodiment, the measuring device comprises means to execute an iterative method of several sampling steps, wherein an output value dependent on the input value and on the distance can be measured in each sampling step from an input value. The means to determine the relative distance is designed to determine a distance variation arising between one sampling step and the next. The measuring device further comprises means to compensate the distance variation while determining the input value for the following sampling step.

In a certain embodiment, the measuring device comprises means to measure a sequence of absolute distance values, means to measure a sequence of at least approximately simultaneous relative distance values, and means to correct each absolute distance value by the corresponding approximately simultaneous relative distance value. This means to correct forms a sequence of corrected absolute distance values, from which values a means to evaluate determines a representative absolute distance. This representative absolute distance is e.g. a weighted average or a value arrived at by other means of filtering.

The aforementioned means to compensate or means to evaluate can be designed as part of the means to determine the absolute distance, or they may be designed as part of a processing unit, which combines data from both, absolute and relative distance measurements. In the first case the measuring device comprises means to communicate relative distance values to the means to determine the absolute distance. The relative distance values relate to any predetermined start value according to any predetermined reference position.

In another embodiment, the measuring device comprises means to focus the measuring beam upon the target, as described e.g. in EP 0 313 518 A2. This makes it possible to carry out absolute as well as relative distance measurements with a non-cooperative target. A non-cooperative target is an object not particularly prepared or an object equipped with simple means only, such as e.g. a reflecting foil.

According to another aspect, there is provided a method for measuring an absolute distance corresponding to a range between a measuring device and a target, wherein a plurality individual measuring steps are executed by means of an absolute distance meter for measuring the absolute distance, comprising:

at least approximately simultaneously with said individual measuring steps measuring a distance variation between the measuring device and the target as a transient value of the target displacement by means of a relative distance meter;

the absolute distance meter determining the absolute distance value iteratively through a plurality of sampling steps; and

incorporating distance variations between the measuring device and the target arising between two of said sampling steps being detected by the relative distance meter in the control of the absolute distance meter in the later of the two sampling steps.

BRIEF DESCRIPTION OF THE FIGURES

In the following the invention is explained in more detail in connection with preferred examples of embodiments illustrated in the enclosed figures showing:

Fig. 1 schematically a structure of a distance-measuring device according to an embodiment of the invention;

Fig. 2 various variables as may occur in a Fizeau method; and

Fig. 3 variables as may occur in a filtering method.

The reference numbers used in the figures and their meaning are summarized in an index of reference numbers. In principle, same reference numbers indicate the same components in all the figures.

DETAILED DESCRIPTION

Fig. 1 is a schematic diagram of a distance-measuring device according to an embodiment of the invention, for making an absolute distance measurement according to an embodiment of the invention. Light rays projected from an absolute distance meter 1 and from a relative distance meter 2 are combined by a first beam splitter 4, and returning light is divided between these two distance meters 1,2, respectively. The first beam splitter 4 is e.g. a dichroic beam splitter. A control unit 3 is installed for the exchange of data and control signals with both, the absolute distance meter 1 and the relative distance meter 2. The control unit 3 transmits data from the relative distance meter 2 to the absolute distance meter 1, and/or combines data or measured distance values generated by these two meters 1,2. From the first beam splitter 4 the rays reach a tracking mirror revolving around two axes 7 via a second beam splitter 5. A tracking regulator 6 detects a section of the returning light by means of a position-sensitive diode (PSD) and adjusts the position of the tracking mirror 7 according to the light displacement, so that the light beam follows a reflecting target or reflector 8. The reflector 8 comprises e.g. a triangular prism or a reflecting foil. The measuring distance 9 extends along the projected and the reflected light beams respectively between a predetermined reference-zero in the measuring device 10 and the reflector 8.

The measuring device 10 also comprises certain known electrical and optical means, e.g. to deflect and collimate the rays. For the sake of simplicity these are not shown in the figure. In a preferred embodiment of the invention the measuring device 10, or parts thereof are integrated in the support of a motorised theodolite or in a measuring column. In the case of a theodolite there is no tracking mirror 7.

The relative distance meter 2 is preferably an interferometer. In order to determine the relative position by interferometer it comprises an up-down-counter registering the transient value of the reflector's displacement. Every time the target moves by half a light wavelength in measuring direction, a meter pulse is added or subtracted, depending on the direction of the displacement. In the case of e.g. an HeNe-laser this takes place every 0.32 micrometers. The count can be selected and stored any time. Due to two different counts a relative motion dL between the relevant selections can be determined as

$$dL = dM \cdot lambda \cdot \frac{n}{2}$$

wherein

dM = difference between the counter values,

lambda = wavelength of the light applied,

n = phase refraction index of the medium, usually air.

Subsequently, e.g. across a measuring distance of 0.1 to 50 m and for a target speed of up to and beyond 10 m/s, a resolution of 0.3 to 2.4 micrometers with an accuracy of ca. ±0.3ppm is possible.

The absolute distance meter 1 is preferably a distance meter according to the Fizeau principle. The measuring light beam is modulated twice by the same modulator; once as an emitting ray at the point of entering the range to be measured, and again as a returning beam or receiving ray at the point of exit. During modulation e.g. a polarisation and/or the intensity and/or the frequency of the light is modulated.

As a result the illumination changes periodically after the second modulation or reverse modulation as a function of the reflector distance and the modulation frequency: e.g. during linear changes of the modulation frequency and at a fixed distance, points of low and points of high illumination A are generated alternately at the exit of the demodulation, as illustrated in **Fig. 2**. This illumination A is measured by a photodiode. The points of minimal illumination are evenly spread across the frequency, at a frequency spacing of df = c/2D, wherein c is the velocity of light and D the distance to be measured. At least two of those minimal points at f_1 and f_0 are detected by varying the frequency f. From this the distance is determined by means of the following formula:

$$D = Round\left(\frac{f_0}{|f_0 - f_1|}\right) \cdot \frac{c_0}{2 f_0 n_g} + Add$$

wherein the function *Round*() rounds up to a whole number, and the following applies:

D = absolute distance

f_0, f_1 = frequencies of minima

ng = group refraction index

c_0 = velocity of light in the vacuum

Add = additive constant

For the exact determination of the minima, the light modulation frequency f is preferably also frequency-modulated: For example, a sinusoidal frequency modulation (FM) of 20 kHz with a range of ca. 500 kHz is performed on a base frequency f in a band between 2 and 2.3 GHz. From this, the first derivative is created from the signal detected from the photodiode, and at the minimal point of the signal without FM-modulation a zero crossing of the FM-modulated signal takes place. Such a zero crossing is easier to detect than a minimum. The determination of the amplitude of the incoming signal at a predetermined basic frequency – with or without the additional FM-modulation – is hereafter referred to as sampling.

As mentioned above, at least two minima, i.e. two adjoining zero passages of the demodulated signal, are required for the determination of the absolute distance with the relevant frequencies f_0 and f_1. These zero points are determined iteratively by variations of the basic frequency. The frequency step is adjusted at each iteration step in order to lead to the desired zero passage as rapidly as possible, and the last steps are determined according to the maximum desired resolution, e.g. 1 ppm. This results in a time optimal sampling sequence of frequency steps leading to the zero passage or minimum frequency f_0, f_1, ...

Thus a resolution of approx. 1 micrometer with an accuracy of less than ±25 micrometers is possible for stationary targets e.g. across a measuring distance of 1 to 100 m. The measuring time for a first determination of distance takes e.g. 200 milliseconds. By subsequent repetitive measuring at a zero point, approx. ten values can be determined per second. Various installations and methods for such a distance measurement are described in the aforementioned DE 195 42 490 C1. The absolute distance meter is either integrated in the beam path of the interferometer, so that both measuring methods work with light from the same source, or the two systems work with separate light wavelengths, as shown in **Fig. 1**. E.g. the interferometer uses a HeNe-Laser and the absolute distance meter a 780 nm laser diode.

The frequency steps decrease in length as they approach the zero crossing, which corresponds with increasingly shorter steps of the distance to be measured. As this iterative approach requires a certain amount of time, the state-of-the-art technology insists that the distance does not change during this period, as the iteration would otherwise continue in the wrong place and the iteration of the distance variation usually could not follow fast enough.

The same problem also arises before and after the described iteration: Previously, e.g. a rough measurement of the distance can be taken by sampling several input values within a predetermined bandwidth, as described below. After a first determination of the minimum this is preferably repeated several times in order to determine an average as the zero passage frequency f_0, f_1 from the results. In total e.g. 20 scans are needed for the rough measuring, approx. 20 scans for the iteration and 10 scans for the repeated determination of the minimum, which at 1 ms per scan implies a duration of 50 ms.

A determination of the relative distance variation, e.g. by means of an interferometer method, is therefore carried out simultaneously with the individual scans, particularly during the iteration. A new iteration step is corrected between the last and the new scan according to the relative motion of the target thus measured.

In a new measuring procedure a rough measurement of the distance is therefore taken for the determination of the absolute distance at the beginning of the measuring. To this end the zero spacing becomes $f_0 - f_1$ and the rough distance is determined from

$$D_0 = \frac{c_0}{2 \cdot |f_0 - f_1| \cdot n_g}$$

During the subsequent iteration each step correction is calibrated by this value. The rough measuring can be a scan across the modulation bandwidth of the modulator, i.e. the determination of a multiple of scanned values within the modulation bandwidth. At a basic frequency of f_a=2GHz to f_b=2.25GHz the modulation bandwidth is e.g. 250 MHz. During this scan the distance drift of the reflector should not exceed approx. c/(4*f) = 35mm (c=velocity of light), which is normally achieved with a hand-held mirror during a total measuring time of e.g. approx. 200 ms.

The correction value for the frequency Δf is calculated from the relative motion Δs to

$$\Delta f = -\frac{f_0}{D_0} \cdot \Delta s .$$

For example, f_0= 2GHz, D_0= 10m and Δs= 5mm produce a correction value of Δf = 1MHz.

The compensation of the relative drift also takes place during the preliminary rough measuring and during the subsequent repetitive determination of the minimum. The determination of the minimum is performed for at least two different frequencies f_0 and f_1. Once these values are available, the subsequent calculation of the relevant distance D also requires a certain calculation time, therefore the relative position continues to be monitored while this calculation takes place. Once the distance is known, it is corrected by the simultaneously up-dated distance variation and henceforth used as a reference value for the relative distance meter 2. E.g. the counter in the relative distance meter 2 is set according to the reference value, or a constant offset according to the reference value is added to the distance.

To summarize it may be said that for the scans for the different measurements preferably throughout the entire measuring procedure, each calculated value, which is the equivalent of the absolute distance, is corrected by measured values from simultaneous associated relative distances.

In spite of a moving reflector the method will therefore in principle converge just as well and rapidly as without movement.

Following the measuring procedure for the determination of the absolute distance said value is transferred to the relative distance determination, i.e. e.g. to the interferometer. Then the distance value follows even rapid movements, e.g. of more than 5 m/s, via the value measured by the interferometer.

In a further preferred embodiment of the invention the absolute distance meter according to the Fizeau principle uses two light wavelengths. In addition to the aforementioned 780 nm laser diodes e.g. another laser diode with a wavelength of e.g. below 450 nm ("blue") is used, whose light is coupled into the measuring ray. Thus two measurements of a distance are carried out with different wavelengths, which facilitates a compensation or elimination of the refraction index of the air.

In another preferred embodiment of the invention the interval between transmission and echo-return is timed in order to determine the absolute distance. To summarize the values of several such timings for the compensation of measuring inaccuracies, e.g. by averaging, said values are corrected according to the values of the relative drift. Fig. 3 shows an exemplary sequence of measuring values Da from an absolute distance determination, a sequence of a simultaneously detected relative position dr, and a corrected sequence of absolute distances Dac resulting from the difference Da-dr. Values of each relative position corresponding at least approximately with the position of the target at the moment of the measuring light's reflection are used as correction values dr.

The method can be similarly applied to the elimination of noise in a series of absolute values by averaging or integration.

In further embodiments of the invention the measuring of the distance variation for correction while measuring an absolute value is executed by means of

- a phase measuring method with modulated light,
- a "chirped" signal, coherent or incoherent, or
- an interferometer of absolute values.

In all these cases the distance variation during integration time is detected and compensated in the measuring procedure.

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

Index of reference numbers

1	absolute distance meter
2	relative distance meter
3	control unit
4	first beam splitter
5	second beam splitter
6	tracking regulator
7	tracking mirror
8	reflector
9	range
10	measuring device

2005294044 20 Apr 2010

CLAIMS

1. A method for measuring an absolute distance corresponding to a range between a measuring device and a target, wherein a plurality individual measuring steps are executed by means of an absolute distance meter for measuring the absolute distance, the method comprising:

   at least approximately simultaneously with said individual measuring steps measuring a distance variation between the measuring device and the target as a transient value of the target displacement by means of a relative distance meter;

   the absolute distance meter determining the absolute distance value iteratively through a plurality of sampling steps; and

   incorporating distance variations between the measuring device and the target arising between two of said sampling steps being detected by the relative distance meter in the control of the absolute distance meter in the later of the two sampling steps.

2. A method as claimed in claim 1, comprising applying an iterative method of a plurality of sampling steps for measuring the absolute distance value, wherein in each of said sampling steps an output value is generated from an input value (f_n, f_{n+1}, f_{n+2},...) and measured, the input value (f_n, f_{n+1}, f_{n+2},...) being a modulation frequency acting upon a departing and a returning ray, and the output value being an intensity of the modulated returning ray and dependent on the input value (f_n, f_{n+1}, f_{n+2},...) and on the absolute distance, wherein each distance variation occurring between one sampling step and the next is measured and used for the compensation of the distance variation during determination of the input value (f_{n+1}, f_{n+2}, f_{n+3},...) for the following sampling step.

3. A method as claimed in either claim 1 or 2, comprising correcting the frequency f_{ntheor} of an iteration step theoretically determined according to the iterative method

according to a measured distance variation Δs in the following manner in order to determine an actually used frequency f_n

$$f_n = f_{ntheor} + \Delta f$$

wherein

$$\Delta f = -\frac{f_0}{D_0} \cdot \Delta s$$

and f_0 is the measuring frequency or basic modulation frequency and D_0 is a rough distance or temporary approximation of the distance to be measured.

4. A method as claimed in claim 1, comprising:

measuring a sequence of absolute distance values,

measuring a sequence of at least approximately simultaneous relative distance values,

correcting each one of the absolute distance values by the corresponding, at least approximately simultaneous relative distance value in order to form a sequence of corrected absolute distance values, and

evaluating the sequence of corrected absolute distance values in order to determine a representative absolute distance.

5. A method as claimed in claim 4, wherein said evaluating involves filtering.

6. A method as claimed in claim 5, wherein said filtering is implemented by averaging or by integration.

7. A measuring device for measuring an absolute distance, comprising:

an absolute distance meter for the determination of an absolute distance corresponding to a range between the measuring device and a target; and a relative distance meter for the determination of a distance variation between the measuring device and a target as a transient value of the target's displacement;

wherein the absolute distance meter is designed to generate the absolute distance value iteratively across a number of individual measuring steps, and the measuring device comprises means to take into account the distance variations between the measuring device and the target, arising between two sampling steps and detected by the relative distance meter, during the determination of the absolute distance by the absolute distance meter in the later of the two sampling steps.

8. A measuring device as claimed in claim 7, comprising means to execute an iterative Fizeau method of a number of sampling steps, wherein in each of said sampling steps an output value can be measured from an input value, the input value being a modulation frequency acting upon a departing and a returning ray, and the output value being an intensity of the modulated returning ray and which depends on the input value and on the absolute distance, and wherein the means to determine the relative distance is designed to determine a distance variation occurring between one sampling step and the next, and the measuring device comprises means to compensate the distance variation during the determination of the input value for the following sampling step.

9. A measuring device as claimed in claim 7, comprising means to measure a sequence of absolute distance values, means to measure a sequence of at least approximately simultaneous relative distance values, means to correct each absolute distance value by the corresponding, at least approximately simultaneous relative distance value in order to form a sequence of corrected absolute distance values, and means to evaluate the sequence of corrected absolute distance values in order to determine a representative absolute distance.

2005294044 20 Apr 2010

10. A measuring device as claimed in any one of claims 7 to 9, comprising means to transmit relative distance values to the means to determine the absolute distance.

11. A method for measuring an absolute distance substantially as hereinbefore described with reference to the accompanying drawings.

12. A measuring device substantially as hereinbefore described with reference to the accompanying drawings.

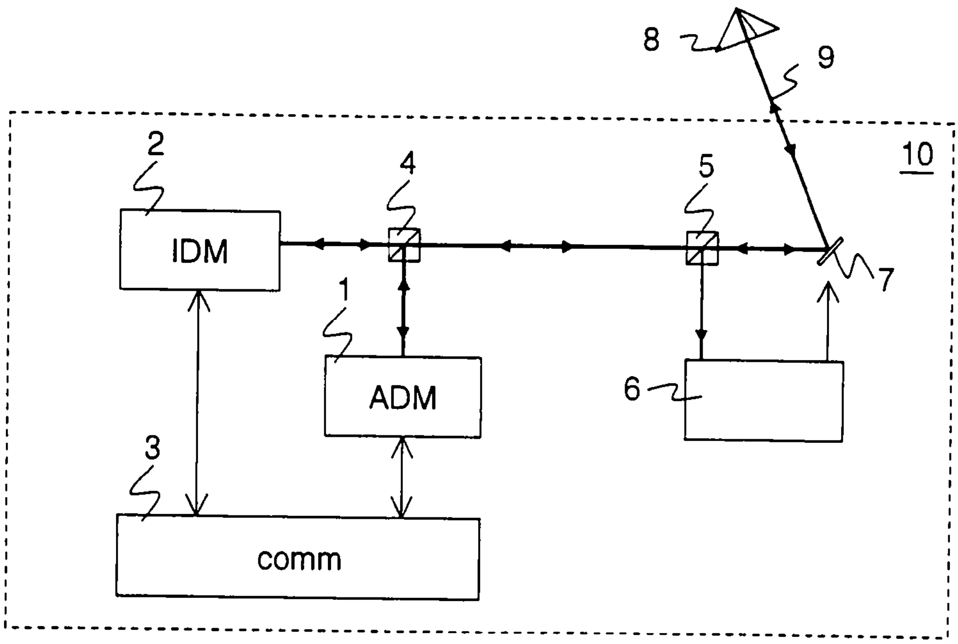


Fig. 1

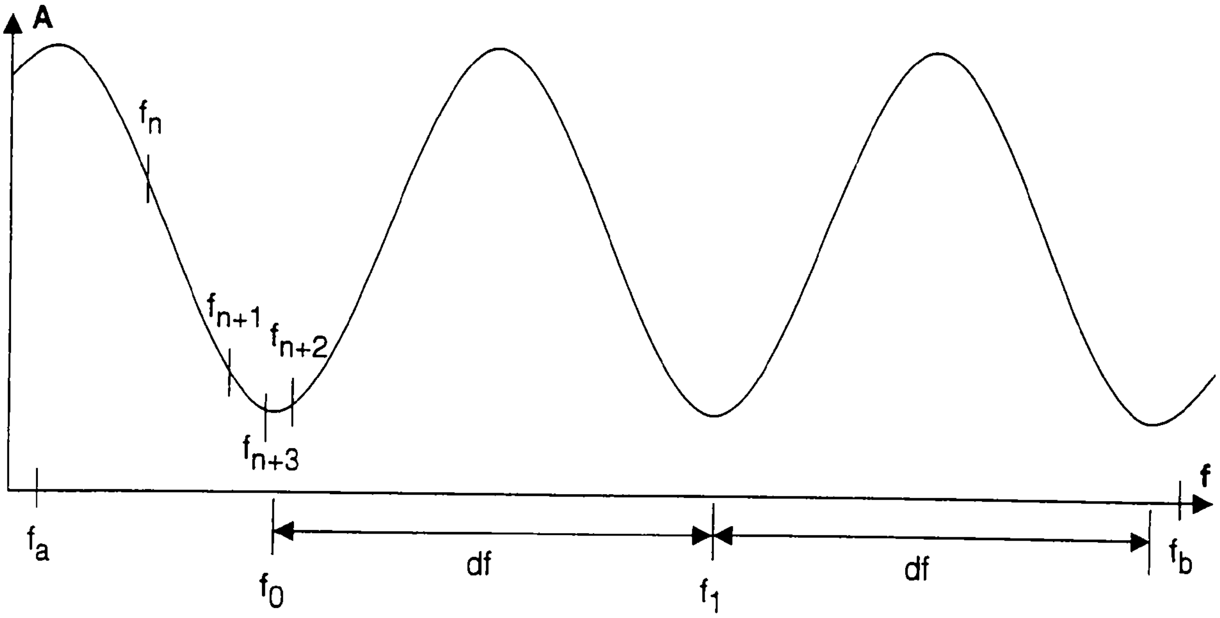


Fig. 2

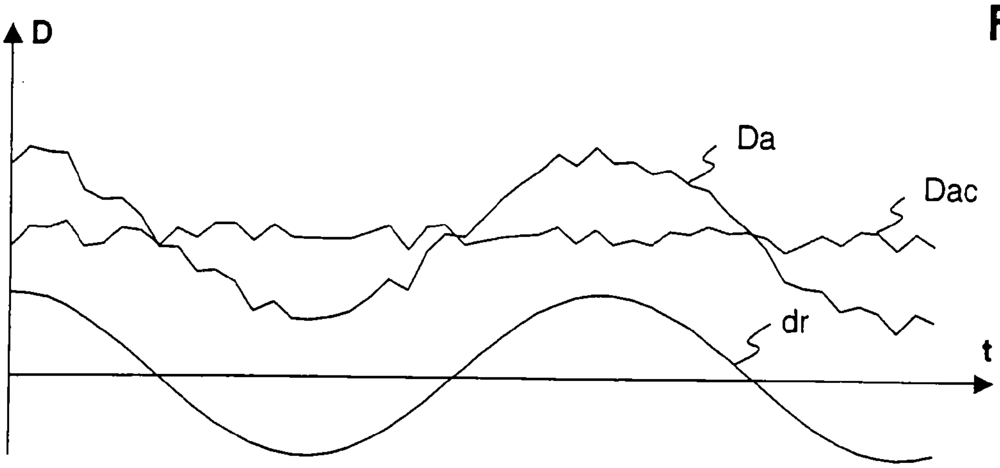


Fig. 3