

AN ELECTRONIC SUNDIAL COMPASS AND A MEASUREMENT METHOD USING THE COMPASS

TECHNICAL FIELD

5 The present invention relates to a compass, and more particularly to an electronic sundial compass and a method of measurement by the compass which accurately measures and indicates the direction or the position based on a shadow cast by the sun.

BACKGROUND OF THE INVENTION

10 Determining the direction accurately is required in many fields, for example construction, decoration, sailing, military etc. Generally, a magnetic needle such as a magnetic compass is used in the aforesaid fields to determine the direction. The magnetic compass uses the nature of the magnetic south pole and the magnetic north pole of the Earth and indicates the direction through a rotary device having a needle. In a practical
15 application, the Earth's magnetic field around the magnetic compass might be interfered with other magnetic fields or iron-containing metals nearby. Therefore, an effective magnetic field compensation is crucial for obtaining a precise direction.

 Semiconductor device KMZ52 manufactured by the company PHILIPS is a two dimensional magnetic field sensor which is specifically used for an electronic compass.
20 Semiconductor device KMZ52 uses the magnetoresistance (MR) technology and the flipping technology to eliminate any signal shift. An electronic compass which is designed to use this type of sensors can be found in the state of the art, for example, an electronic compass which uses a circuit to compensate the Earth's magnetic field and the imprecision induced by the intrinsic characteristics of the KMZ52 sensor as disclosed in *Electronic Engineering & Product World*, Volume 4, 2005.
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 Another type of devices for determining the direction is a gyrocompass. According to the principle of a rate gyroscope, the gyrocompass measures the angular velocity component of the Earth's rotation at various positions and determines the orientation of the meridian by

calculating the angular velocity of the Earth's rotation, or determines the north direction by making the rotor axis of a gyroscope approach to the meridian and swing along the meridian under the influence of the gyro moment generated by the Earth's rotation.

BRIEF DESCRIPTION OF THE INVENTION

Regardless of whether using the magnetic needle or using the electronic compass to measure the direction, the accuracy of the measurement will be affected by the characteristics of the Earth's magnetic field itself as well as the existence of other magnetic fields and the iron-containing metals. In addition, there are certain angular deviations between the Earth's magnetic pole and the real orientation. Although compensation has been performed by a method of using a circuit, the accuracy is not desirable and new factors which affect the precision are introduced by the electrical characteristics of the measuring device per se. Due to the structural complexity of gyrocompass device, the expensive costs and the existence of speed variation, there is a need for a device and a method which can still determine the direction precisely without using the geomagnetism.

According to a first aspect of the present invention, there is provided a compass device comprises: a housing, a positioning needle, a sundial needle, a sensor and a circuit device, wherein the sundial needle is a straight needle-shaped object which is secured at the rotation centre of the positioning needle and is perpendicular to the plane of rotation of the positioning needle; the sensor is secured on the housing, when the positioning needle is rotated to a position that the positioning needle overlaps with the sun shadow of the sundial needle, the sensor detects the measured angle value of an object under measurement; the circuit device configured in the compass device compares the above measured angle value with an inherent sun shadow angle, and output an difference value through a display device to indicate azimuth of the object under measurement.

Example embodiments show that said compass device further comprises a rotating disc, wherein the centre of the positioning needle and the centre of the rotating disc are on the same axis and the positional relationship between the positioning needle and the rotating disc is fixed, said sensor includes two components: a light source and a photosensitive

element.

According to a second aspect of the present invention, there is provided a compass device, comprising: a housing, a positioning needle, a sundial needle, a reference disc and an inherent sun shadow angle computing device, wherein the sundial needle is a straight needle-shaped object which is secured at the rotation centre of the positioning needle, and is perpendicular to the plane of rotation of the positioning needle, the reference disc has 1-360 degrees angle information and rotates with the positioning needle on the same axis, a measured angle value of the object under measurement is detected when the positioning needle rotates to a position that the positioning needle overlaps with the sun shadow of the sundial, said measured angle value is compared with the inherent sun shadow angle to calculate the azimuth of the object under measurement.

According to a third aspect of the present invention, there is provided a method of measuring position using a compass device comprises the steps of: placing a compass device comprising a housing, a positioning needle, a sundial needle, a sensor and a circuit device under the sunlight, and securing the straight needle-shaped sundial needle at the rotation centre of the positioning needle and to be perpendicular to the plane of rotation of the positioning needle, and rotating the positioning needle toward an object under measurement, and rotating the positioning needle again to overlap the positioning needle with the sun shadow of the sundial needle, and outputting the difference value of the angle information between the object under measurement and the inherent sun shadow angle, and using a circuit device to display the azimuth of the object under measurement.

The northern part of the Earth's axis is known as the true north. The true north is different from the magnetic north of the geomagnetism. Since the orientation measured by the example embodiments is the orientation and the angle based on the north and south directions of the Earth's axis, but not the orientation and the angle based on the geomagnetism. Therefore, the direction measured by the example embodiments is the true north direction which is the real orientation of the Earth.

Example embodiments can determine the azimuth of the measured object by using sun shadow. The position is determined with high precision and is free from interference of the

geomagnetism. The application of electronics makes the calculation faster and facilitates the readout of position data. The structure of the electronic sundial compass of the example embodiments is simple and the manufacturing cost is relatively low.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is now further described with reference to the drawings, in which:

Figure 1 is a three dimensional view of an electronic sundial compass according to the an embodiment of the present invention;

Figure 2 is a schematic diagram of structural assembly relationship of the compass device according to an embodiment of the present invention;

Figure 3 is a schematic diagram of structural disassembly of the compass device according to an embodiment of the present invention;

Figure 4 is a schematic diagram of a circuit device according to an embodiment of the present invention;

Figure 5 is a work flowchart of an electronic sundial compass device according to an embodiment of the present invention; and

Figure 6 is a schematic diagram of an electronic sundial compass device working under the sunlight according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 illustrates a three dimensional view of an electronic sundial compass device 1 according to an embodiment of the present invention, the housing of the electronic sundial compass device is a cuboid comprising a positioning needle 101 and a sundial needle 102. The positioning needle 101 is in a shape of a flat straight bar having two ends and one of them is relatively tapered. Colored straight lines 107 with a color different from that of the positioning needle are drawn from the centre of the front side of the positioning needle towards the tapered end by the various methods in the state of the art such as painting, and

preferably the straight lines are in white color. The sundial needle 102 is a fine-elongated and straight needle-shaped object which is secured at the centre of the positioning needle 101 and is perpendicular to the surface of the front side of the positioning needle 101. The sundial needle 102 can be removed from the centre of the positioning needle when the electronic sundial compass device 1 is not in operation. Preferably, the centre of the positioning needle 101 forms a water-drop shape which is silkscreen printed in white and the top of the water-drop points toward to the tapered end 103 of the positioning needle. The positioning needle 101 can be prepared from various natural or synthetic materials available in the state of the art such as organic glasses, metals, alloys, woods or bamboos, preferably poly-methyl methacrylate which can be processed by a CNC machine.

As illustrated in figure 2 and figure 3, the electronic sundial compass device 1 further includes an upper dial 201, a main housing 202 and a synchronous rotating disc 203. Both the upper dial 201 and the synchronous rotating disc 203 are disc-shaped. The back side of the positioning needle has a main pivot 204. The upper dial 201, the main housing 202 and the synchronous rotating disc 203 are connected to the main pivot 204 of the positioning needle 101 in a way as illustrated in figure 3. The end of the main pivot 204 has a shape which matches the top side of the synchronous rotating disc 203 so that the relative position between the positioning needle 101 and the synchronous rotating disc 203 remains constant, i.e., the synchronous rotating disc 203 rotates together with the positioning needle 101 when the positioning needle 101 rotates. Alternatively, the main pivot 204 is fixed on the synchronous rotating disc 203, and the main housing 202, the upper dial 201, the positioning needle 101 are sequentially mounted on the main pivot 204, combining the positioning needle 101 with the synchronous rotating disc 203 by a similar method such that the positioning needle 101 rotates together with the synchronous rotating disc 203. As illustrated in figure 3, a plurality of sensors 304 are fixed of both sides of the synchronous rotating disc 203 in the main housing 202 in the radial direction of the synchronous rotating disc 203. The preferable sensors consist of two components: a light source and a photosensitive element. One arrangement of the light source and the photosensitive element is to fix both on the separating plate 301 in the main housing 202 along the same radius but with different distance from the centre. Another arrangement of the light source

and the photosensitive element is to fix them on the other side of the synchronous rotating disc 203 (not shown) on the main housing of the compass device 1 corresponding to the previous arrangement, wherein the photosensitive element can be a photosensitive diode or a photosensitive transistor. As illustrated in figure 2, multiple sets of bar code 209 are formed by transparent and non-transparent regions on the synchronous rotating disc 203 in order to facilitate the output of gray code, binary code or BCD code. Since the synchronous rotating disc 203 and the positioning needle 101 rotates synchronously, said sensors 304 can sense the variation in the angle of the synchronous rotating disc 203 resulting from the rotation of the positioning needle 101, the angle information of the positioning needle is measured.

Optionally, reference position information are printed on the surface of the upper dial 201, for example, there are lines radiating from the centre and separating the whole circular disc into four regions evenly. The four lines for partitioning into four regions are marked in a clockwise direction with the symbols of north, south, west and east, wherein 0 degree containing "north" are marked on the line, and subsequently 1-360 degrees are marked evenly in a clockwise direction. This reference information can enable users to determine the position by reading the degree of movement of the positioning needle 101 from the upper dial 201 without using the circuit device. Optionally, the information of heavenly stems and earthly branches can also be marked on the surface of the upper dial 201. For example, multiple concentric circles can be formed on the surface of circular disc. These concentric circles are divided into 24 parts evenly starting with the first part covering 7.5 degrees from both sides of the 0 degree. Beginning from the first part covering 7.5 degrees from both sides of the 0 degree, the 24 parts are marked in a clockwise direction with: Zi (子), Gui (癸); Chou (丑), Gen (艮), Yin (寅); Jia (甲), Mao (卯), Yi (乙); Chen (辰), Xun (巽), Ji (巳); Bing (丙), Wu (午), Ding (丁); Wei (未), Kun (坤), Shen (申); Geng (庚), You (酉), Xin (辛); Xu (戌), Qian (乾), Hai (亥) and Ren (壬), 12 parts labeled with Zi, Gui, Chou, Mao, Yi, Chen, Wu, Ding, Wei, You, Xin and Xu are marked as "Yin" ("陰") and the remaining parts are marked as "Yang" ("陽"). 8 parts labeled with Qian, Zi, Gen, Mao, Xun, Wu, Kun and You are marked as "Heaven" ("天"), 8 parts labeled with Gui, Yin, Yi, Ji, Ding, Shen, Xin and Hai are marked as "Human" ("人"). The remaining 8 parts are

marked as "Earth" ("地"), wherein the Ren, Zi and Gui are marked as "Kan" (坎), the Chou, Gen and Yin are marked as "Gen" (艮), the Jia, Mao and Yi are marked as "Zhen" (震), the Chen, Xun and Ji are marked as "Xun" (巽), the Bing, Wu and Ding are marked as "Li" (离), the Wei, Kun and Shen are marked as "Kun" (坤), the Geng, You and Xin are marked as "Dui" (兑) and, the Xu, Qian and Hai are marked as "Qian" (乾). The above information marks facilitate people to refer to the information of the heavenly stems and the earthly branches when reading the position information.

The aforesaid upper dial can be prepared from any materials such as organic glasses, plastics, metals and alloys in the state of the art, preferably prepared by acrylonitrile-butadiene-styrene coated with matt silver paint, the positioning needle 101 and the main pivot 204 can be prepared in a form of unibody or in a form of separate bodies, the main housing 202 can be prepared by the plastics, any material in the state of the art which is an insulator and can mount the sensors easily can be used to prepare said separating plate 301, for example, transparent organic glasses, the synchronous rotating disc 203 can be prepared from any materials in the state of the art provided that said sensor 304 can detect the signal variation when the synchronous rotating disc 203 is moving.

The inherent sun shadow angle refers to a true anomaly at a certain time instance and at a location of certain latitude and longitude. The inherent sun shadow angle is the inherent nature of a measurement point which will be changed over the time, latitude and longitude and does not change with other factors, and said time, latitude and longitude are local information. There are many methods for calculating said angle in the state of the art, for example, using methods as disclosed in website of the Clear Sky Institute (<http://www.clearskyinstitute.com/xephem/>), or using methods as disclosed in the website of the British Sundial Society (<http://www.sundialsoc.org.uk>). The contents of the above websites were disclosed before the application date of the present application and were incorporated herein as prior art.

As illustrated in figure 3, the electronic sundial compass device 1 further includes devices for processing and displaying the output data from the sensors 304, including four parts: a computing circuit 401, a memory 402, an input (date, time, latitude and longitude)

device 403, a display 404 and a subtractor 405. The computing circuit 401 can be a single-chip microprocessor, for example, a microprocessor controller (MCU) or an application-specific integrated circuit (ASIC) for storing the formula of calculating the inherent sun shadow angle θ in order to obtain the inherent sun shadow angle θ .

5 The date, time, latitude and longitude of the measurement point are input by an input device 403 into the formula to calculate the θ . The memory 402 can be an Electrically-Erasable Programmable Read-Only Memory (EEPROM) or a nonvolatile memory to store the date, time, latitude and longitude information according to the local time zone. The input device 403 can be a button input. The display 404 can be a liquid
10 crystal display. As illustrated in figure 4, the date, time, latitude and longitude information are input into the memory 402 by the input device 403 and the memory 402 input the above information into the computing circuit 401 to obtain the inherent sun shadow angle θ . The inherent sun shadow angle θ and the angle difference ϕ between the measurement point and the sun shadow as read from the sensor 304 are input into the subtractor 405. The actual
15 azimuth α is output and displayed on the display 404. The display 404 can also display the information stored in the memory 402 and the inherent sun shadow angle θ by pressing the select buttons. A low-voltage DC power supply, preferably 9-12V DC power, is used to power said device and a switch is used to control the entire circuit device.

20 Selectively, the present invention can also use a general global positioning system (GPS) 406 to obtain local information. Subsequently, local latitude and longitude information is obtained by checking a look-up table, and the inherent sun shadow angle θ is calculated according to a given time. The advantage of using the GPS is that the users do not need to enter information and can automatically obtain latitude and longitude information when using the electronic sundial compass device.

25 In order to increase accuracy of the test, the present invention further provides an electronic sundial compass 1 which a calibrating equipment can be selectively added to, including: levels 113 are placed at the surface of the electronic sundial compass device 1, preferably spirit levels for observing the position of a bubble to determine whether said compass device 1 is placed horizontally; turntable fine tuning control wheels 114 are placed
30 at any position of the electronic sundial compass 1 except the bottom surface and are

connected to the main pivot 204; the synchronous rotating disc 203 and the positioning needle 101 rotate synchronously with the main pivot 204 as mentioned above. Therefore, by controlling the main pivot 204, the turntable fine tuning control wheel 114 causes the synchronous rotating disc 203 and the positioning needle 101 to generate a rotation with a small angle. The above function can be implemented by any levels or fine tuning control wheels in the state of the art. At least two electronic distance measurement devices (not shown), for example, ultrasonic range finders or infrared distance meters, are placed at the surface of the electronic sundial compass 1 for measuring the distance between the electronic sundial compass 1 and surface of the object respectively when the position of a nearer object is being measured so that the reference edge 116 as shown in figure 6 is ensured to be parallel to the object under measurement (e.g., a workbench).

Figure 5 and figure 6 illustrate the procedures of using the electronic sundial compass 1 of the present invention under sufficient sunlight. A measurement point 115 is marked at a position on the surface of the electronic sundial compass 1 in step 501. For measuring an object which is farther away, for example, a building, the user places the measurement point 115 of the electronic sundial compass 1 facing the object 601; while for measuring an object which is nearby, for example, a ornament, the user can keep the reference edge 116 parallel to the object based on the information of the electronic distance measurement devices. The position of the electronic sundial compass 1 is calibrated to a horizontal level via levels 113 in step 502, and the positioning needle 101 is rotated toward the measurement point 115, the aim of this step is to determine the position of the object under measurement so that the sensor 304 detects an initial value. The positioning needle 101 is rotated and the tapered end 103 is pointed toward the sundial 102 and projects a shadow under the sun in step 503. The turntable fine tuning control wheels 114 are adjusted such that the tapered end 103 of the positioning needle 101 and the colored straight line 107 overlap with the sun shadow of the sundial needle 102 projected under the sun in step 504. Step 503 and step 504 aim at making the sensor 304 detect an end value to be compared with the initial value from step 502, so that the sensor 304 can obtain the angle difference ϕ between the object under measurement and the sun shadow. The sensor 304 reads the angle difference ϕ between the sun shadow and the measurement point 115 in step 505. As mentioned above, this

angle ϕ is the difference between the inherent sun shadow angle θ and the angle of the measurement point α which is the azimuth of the object under measurement, i.e., $\phi = \theta - \alpha$, the following step is required to obtain the azimuth α of the object under measurement. The computing circuit 401 is switched on in step 506, the date, time, latitude and longitude information stored in the memory 402 are input into the computing circuit 401 or the
5 latitude and longitude information is determined through a GPS positioning system for calculating a local inherent sun shadow angle θ . Finally, the above formulae undergo transpose calculation to obtain the azimuth $\alpha = \theta - \phi$ of the object under measurement.

10 While this invention has been described in detail with reference to certain preferred embodiments, it should be appreciated by one skilled in the art that many modifications and variations and other uses are obvious. Therefore, the scope of the present invention would not be limited by the content as disclosed specifically herein.

CLAIMS:

1. A compass device comprises:

a housing, a positioning needle, a sundial needle, a sensor and a circuit device, wherein the sundial needle is a straight needle-shaped object which is secured at the rotation
5 centre of the positioning needle and is perpendicular to the plane of rotation of the positioning needle; the sensor is secured on the housing, when the positioning needle is rotated to a position that the positioning needle overlaps with the sun shadow of the sundial needle, the sensor detects the measured angle value of an object under measurement; the circuit device configured in the compass device compares the above measured angle value
10 with an inherent sun shadow angle, and output an difference value through a display device to indicate azimuth of the object under measurement.

2. The compass device according to claim 1, further comprising a rotating disc, wherein the centre of the positioning needle and the centre of the rotating disc are on the same axis and the positional relationship between the positioning needle and the rotating disc is fixed,
15 said sensor includes a light source and a photosensitive element.

3. The compass device according to claim 1 or 2, characterized in that said circuit device includes a computing circuit, an input device, a subtractor and a display, wherein an input device or a GPS system inputs local information into the computing circuit to obtain the inherent sun shadow angle, the inherent sun shadow angle obtained from the computing
20 circuit and the difference value of angle information between the object under measurement from said sensor and the inherent sun shadow angle are input into the subtractor to obtain the azimuth of the object under measurement, and the azimuth is input into the display for display.

4. The compass device according to claim 3, characterized in that said circuit device
25 further comprises a memory, said memory is installed between the input device and the computing circuit and is directly connected to the display; said memory stores the local information and provide the local information to the display for display directly.

5. The compass device according to claim 1, 2 or 4, further comprising an upper dial and a separating plate, said upper dial and said separating plate are located between the

positioning needle and the rotating disc and are respectively fixed on said compass device, the centre of said upper dial and the centres of said positioning needle and said rotating disc are on the same axis, 1-360 degrees reference angle information are recorded on said upper dial, said separating plate is used to mount said sensor.

5 6. Any one of the compass device as claimed in claim 1, 2, or 4, characterized in that said positioning needle is a flat straight bar with one tapered end and lines connecting the centre of the positioning needle and the tapered end.

10 7. Any one of the compass device as claimed in claim 1, 2, or 4, further comprising levels, fine tuning control wheels and/or electronic distance measurement devices, wherein the levels, the fine tuning control wheels and the electronic distance measurement devices are located on the housing.

8. The compass device according to claim 7, characterized in that said levels are spirit levels, said compass device has two said fine turning control wheels and at least two said electronic distance measurement devices.

15 9. A compass device, comprising: a housing, a positioning needle, a sundial needle, a reference disc and an inherent sun shadow angle computing device, wherein the sundial needle is a straight needle-shaped object which is secured at the rotation centre of the positioning needle, and is perpendicular to the plane of rotation of the positioning needle, the reference disc has 1-360 degrees angle information and rotates with the positioning
20 needle on the same axis, a measured angle value of the object under measurement is detected when the positioning needle rotates to a position that the positioning needle overlaps with the sun shadow of the sundial, said measured angle value is compared with the inherent sun shadow angle to calculate the azimuth of the object under measurement.

25 10. The compass device according to claim 9, characterized in that said positioning needle is a flat straight bar with one tapered end and lines connecting the centre of the positioning needle and the tapered end.

11. The compass device according to claim 9 or 10, comprising levels, fine tuning control wheels and/or electronic distance measurement devices, wherein the levels, the fine tuning control wheels and the electronic distance measurement devices are located on the

housing.

12. The compass device according to claim 11, characterized in that said levels are spirit levels, said compass devices has two said fine turning wheels and at least two said electronic distance measurement devices.

5 13. A method of measuring position using a compass device comprises the steps of:

placing a compass device comprising a housing, a positioning needle, a sundial needle, a sensor and a circuit device under the sunlight, and

10 securing the straight needle-shaped sundial needle at the rotation centre of the positioning needle and to be perpendicular to the plane of rotation of the positioning needle, and

rotating the positioning needle toward an object under measurement, and

rotating the positioning needle again to overlap the positioning needle with the sun shadow of the sundial needle, and

15 outputting the difference value of the angle information between the object under measurement and the inherent sun shadow angle, and

using a circuit device to display the azimuth of the object under measurement.

14. A method of measuring position according to claim 13, characterized in that comprises the steps of:

20 calculating the inherent sun shadow angle by a computing circuit in the circuit device, and

calculating the azimuth of the object under measurement according to the difference value and the inherent sun shadow angle.

15. A method of measuring position according to claim 13 or 14, comprising the steps of:

25 calibrating the position of the compass device by using levels before measurement, and

overlapping the positioning needle with the shadow of the sundial needle precisely through fine tuning control wheels, and

adjusting the position of the compass device by reading the information displayed on the electronic distance measurement devices to make the compass device parallel to the object under measurement.

An Electronic Sundial Compass and A Measurement Method Using the Compass

ABSTRACT

A compass device comprises a housing, a positioning needle (101), a sundial needle (102), a sensor (304), and a circuit device; wherein the sundial needle (102) is a straight needle-shaped object which is secured at the rotation centre of the positioning needle (101) and is perpendicular to the plane of rotation of the positioning needle (101); the sensor (304) is secured on the housing, when the positioning needle (101) is rotated to a position that the positioning needle (101) overlaps with the sun shadow of the sundial needle (102), the sensor (304) detects the measured angle value of the object under measurement; the circuit device installed in the compass device compares the aforesaid measured value with the inherent sun shadow angle, and output the difference value through a display device to indicate the azimuth of the object under measurement.

Fig. 6