



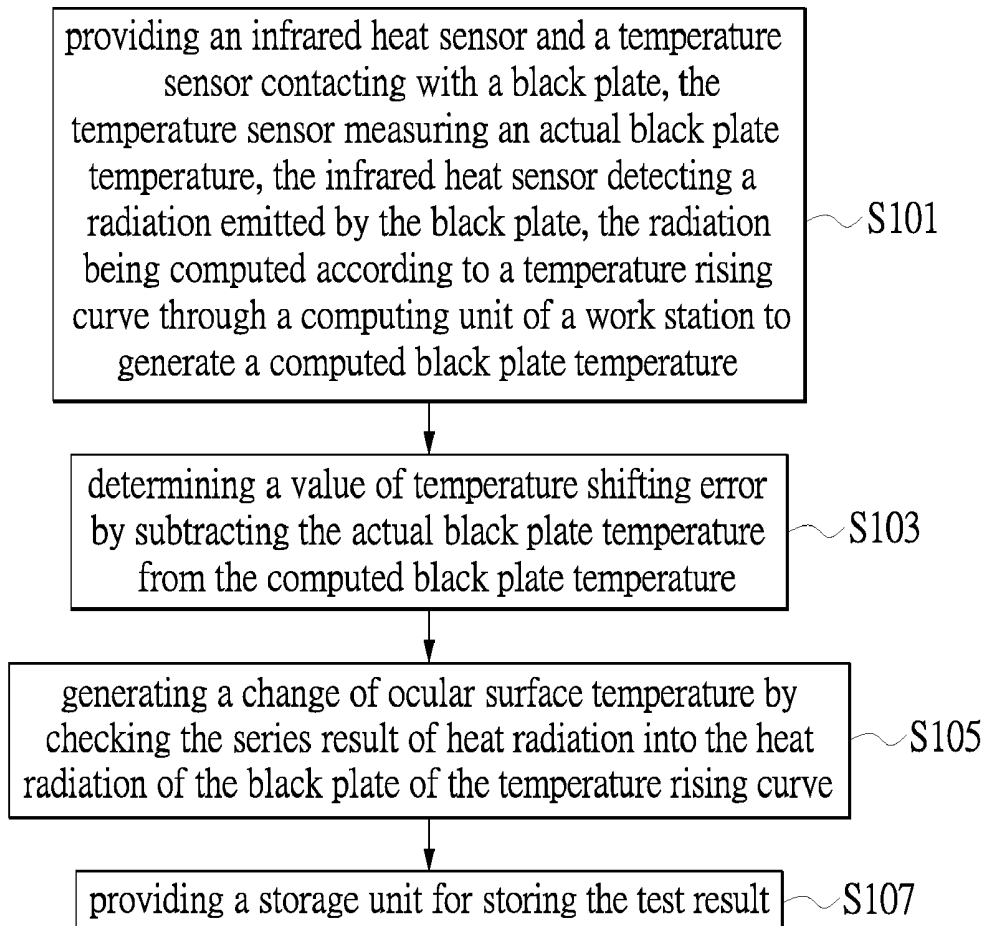
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(19) **United States**(12) **Patent Application Publication**  
**CHANG et al.**(10) **Pub. No.: US 2017/0325678 A1**(43) **Pub. Date: Nov. 16, 2017**(54) **METHOD OF MEASURING OCULAR  
SURFACE TEMPERATURE AND APPARATUS  
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(57)

**ABSTRACT**(21) Appl. No.: **15/668,105**(22) Filed: **Aug. 3, 2017****Related U.S. Application Data**(63) Continuation-in-part of application No. 14/287,357,  
filed on May 27, 2014.**Publication Classification**(51) **Int. Cl.***A61B 3/10* (2006.01)*G01K 13/00* (2006.01)

A method of measuring ocular surface temperature includes steps as follows. Using a built-in temperature sensor called a black plate herein, an infrared heat sensor is provided and the temperature sensor contacts the black plate. The temperature sensor measures an actual black plate temperature. The infrared heat sensor detects a radiation emitted by the black plate, and the radiation is computed according to a temperature rising curve through a computing unit of a work station to generate a computed black plate temperature. A value of temperature shifting error is determined by subtracting the actual black plate temperature from the computed black plate temperature.



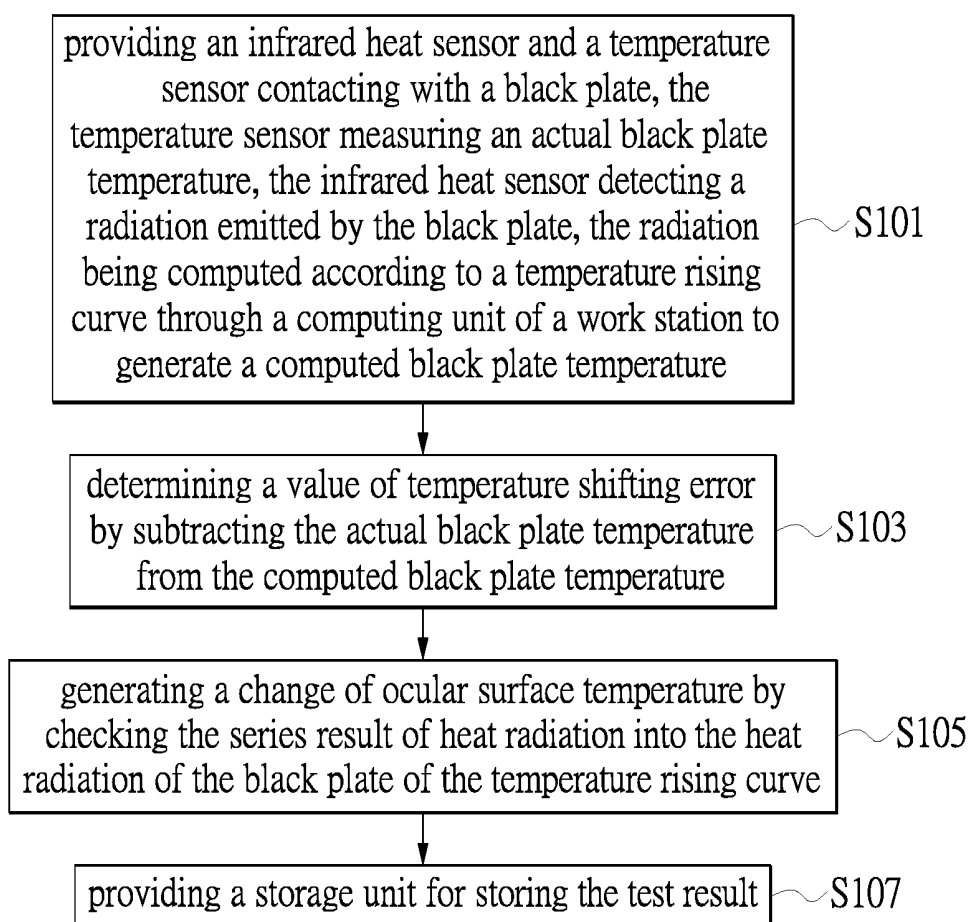


FIG. 1

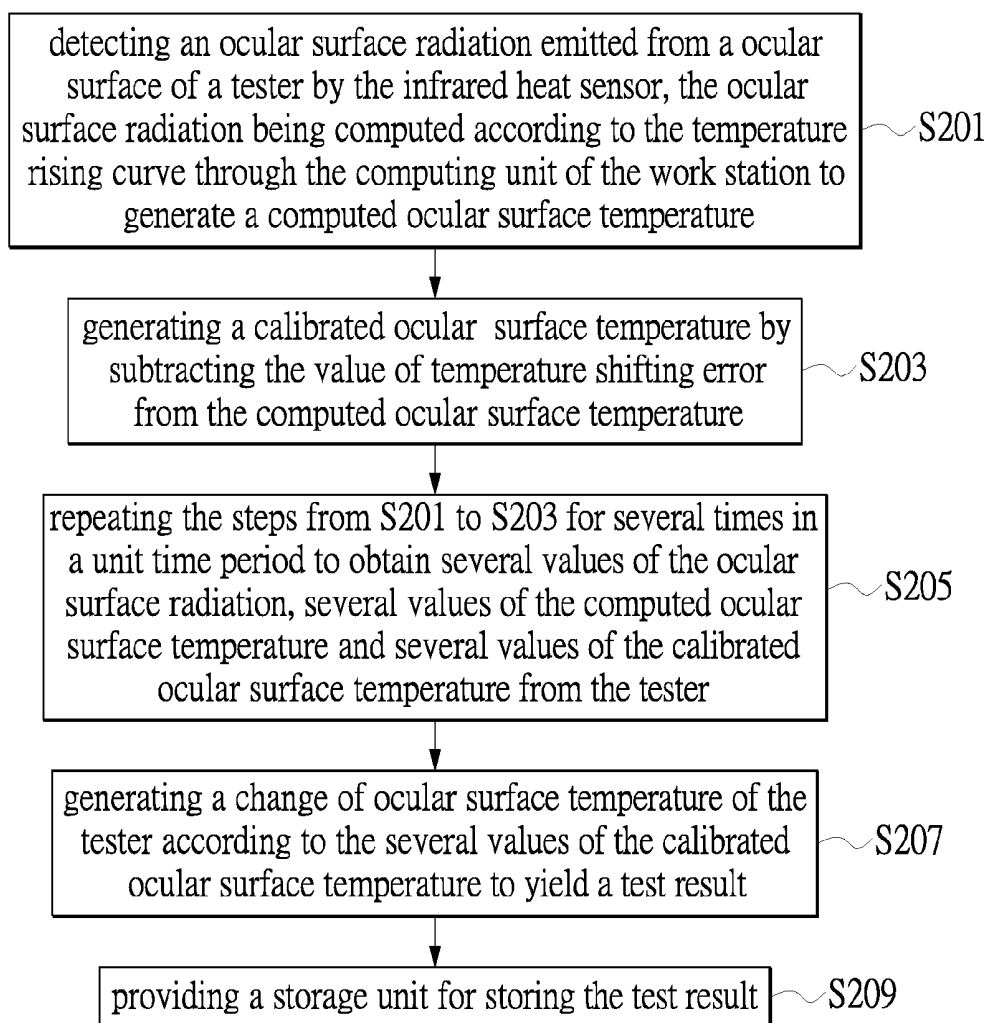


FIG. 2A

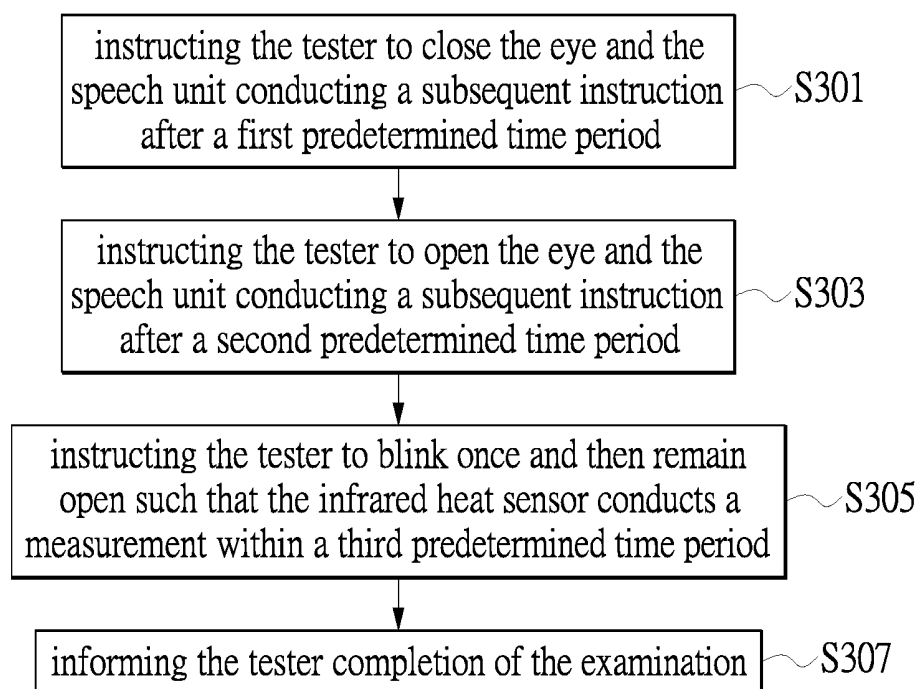


FIG. 2B

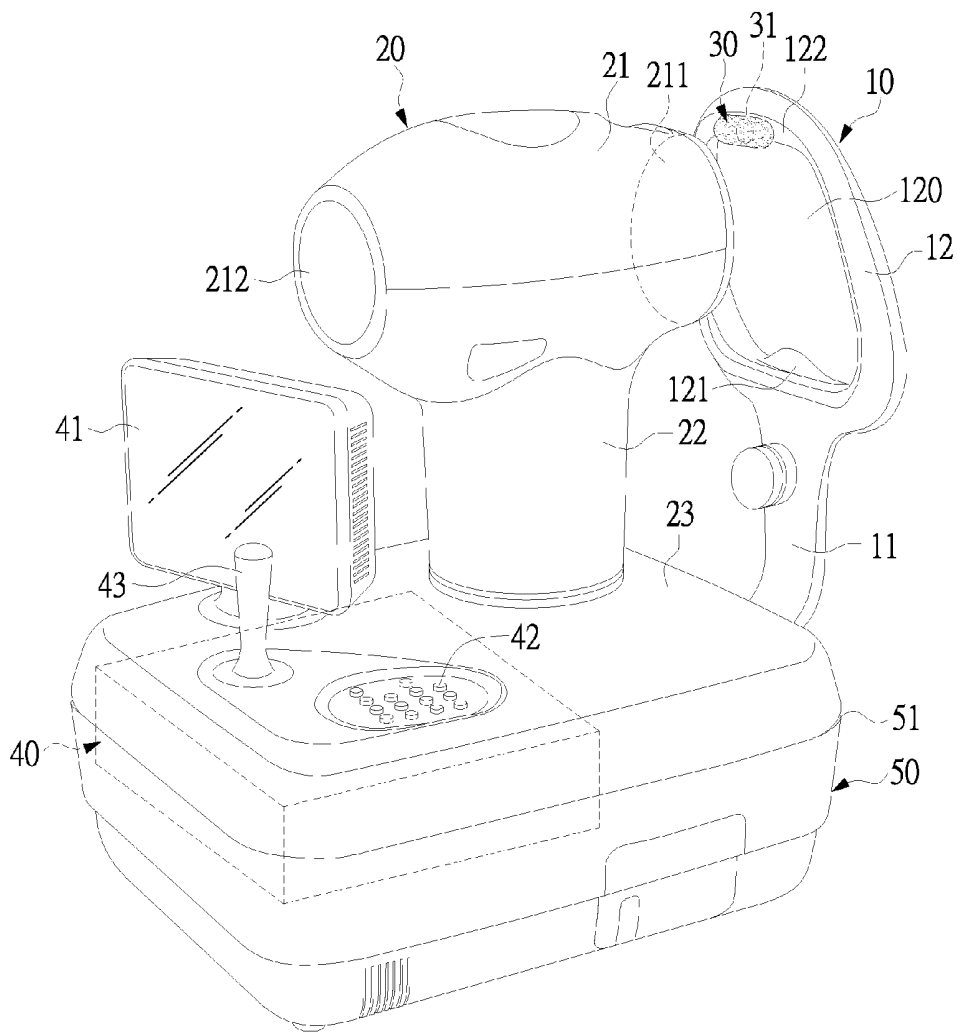


FIG. 3

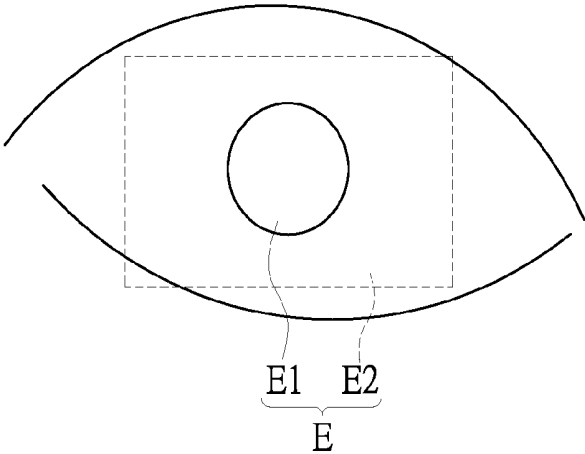


FIG. 4

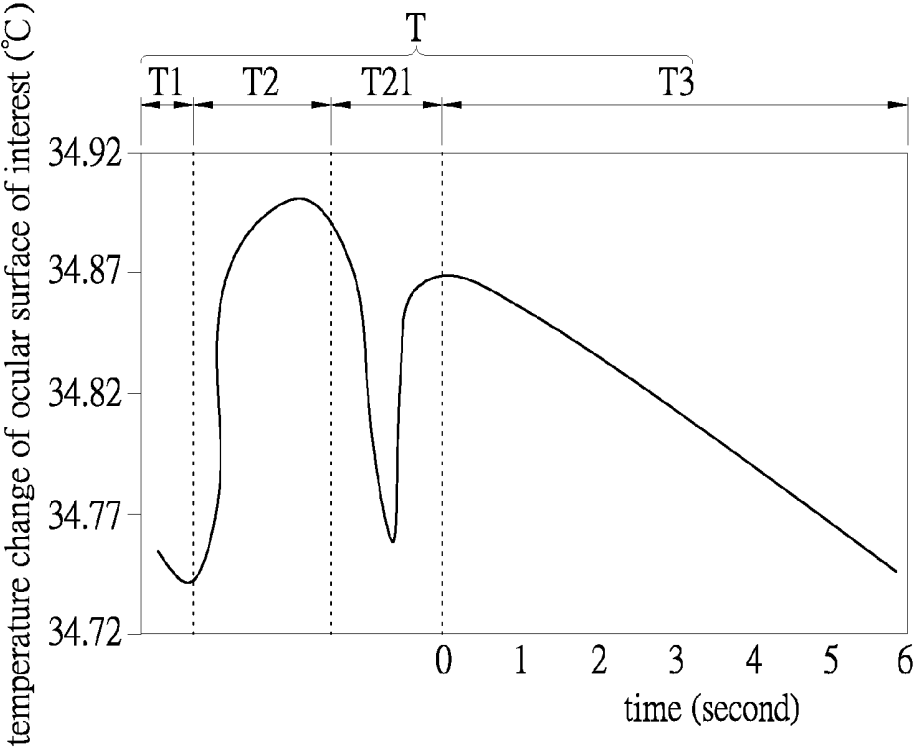


FIG. 5

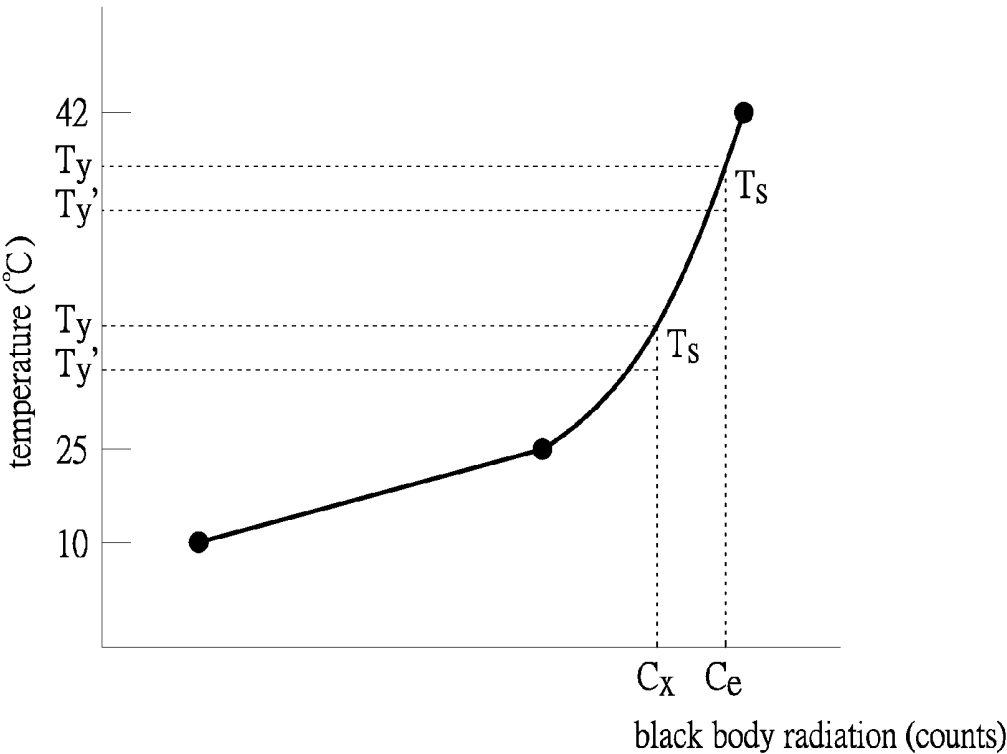


FIG. 6

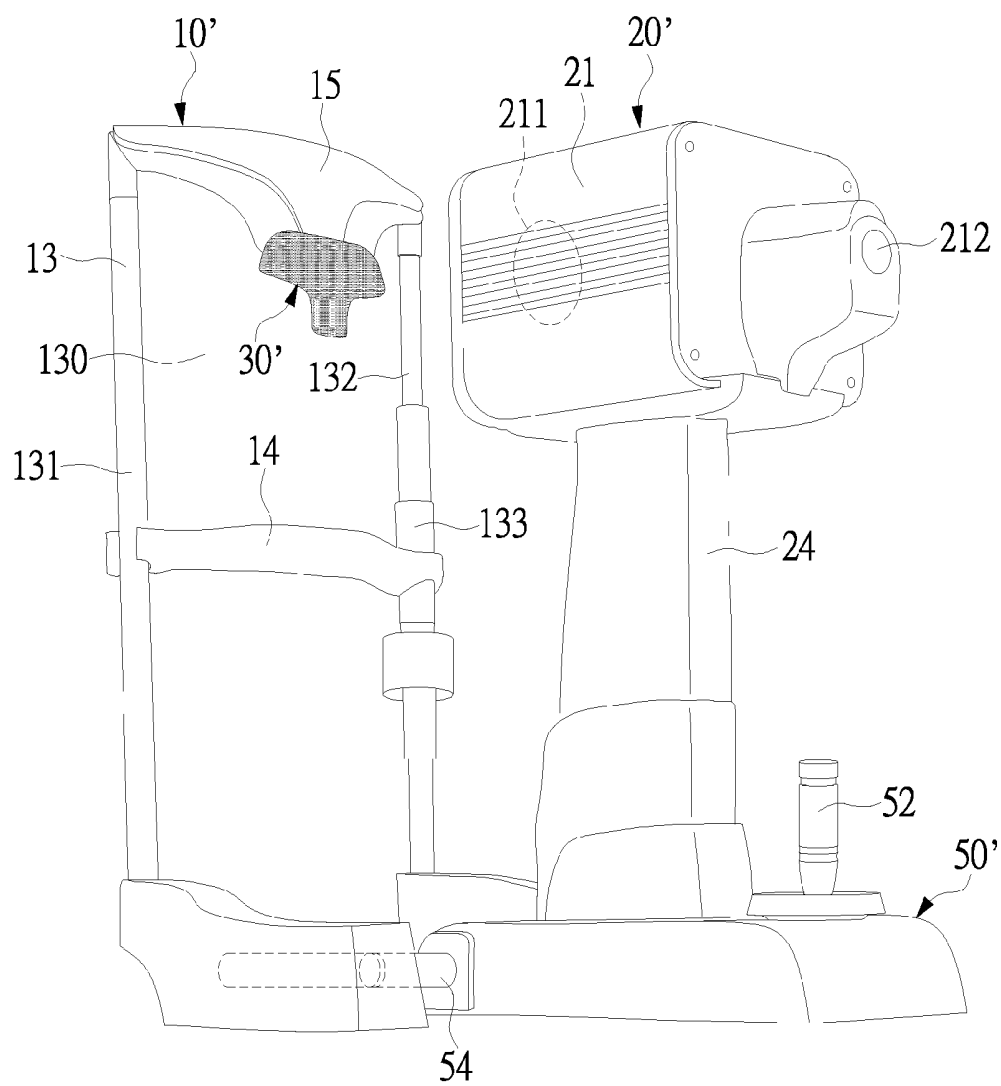


FIG. 7



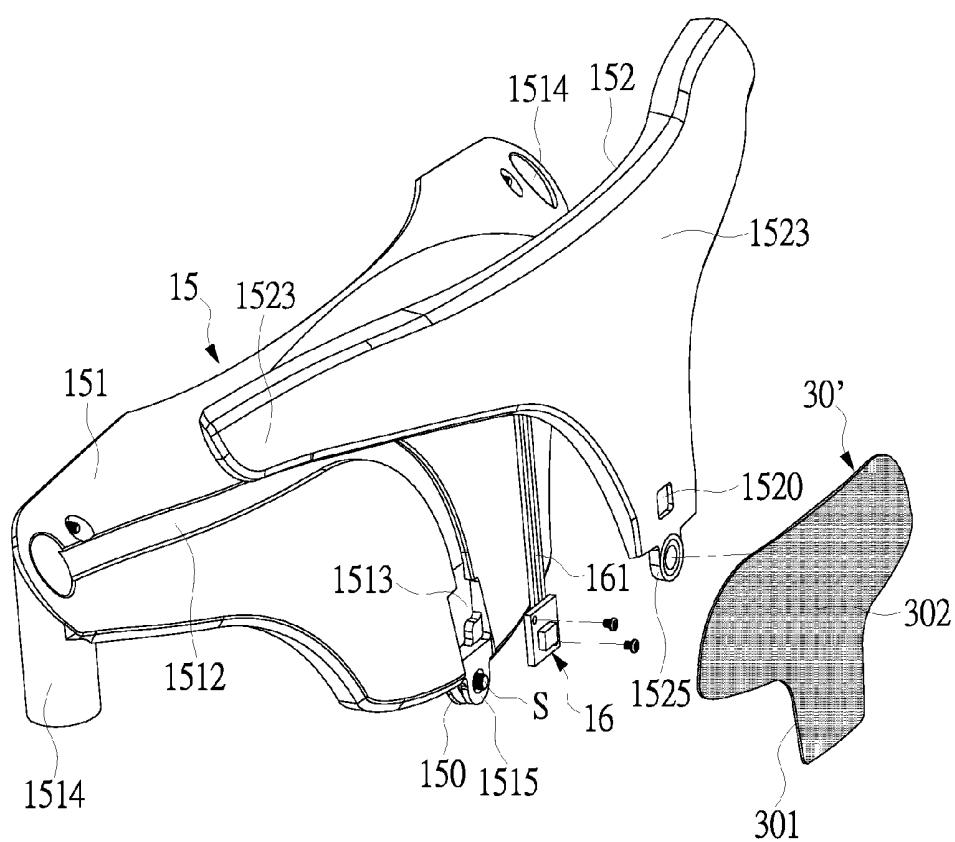


FIG. 8

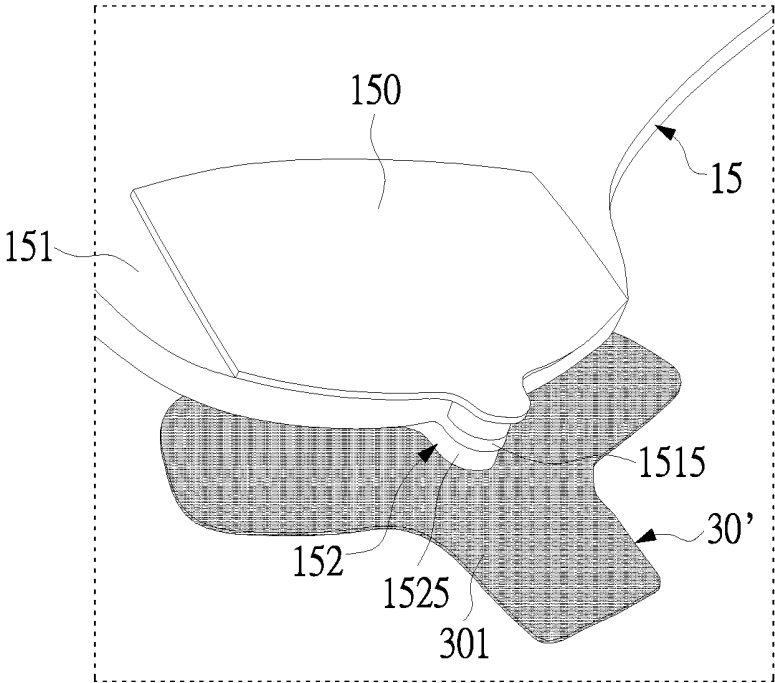


FIG. 9

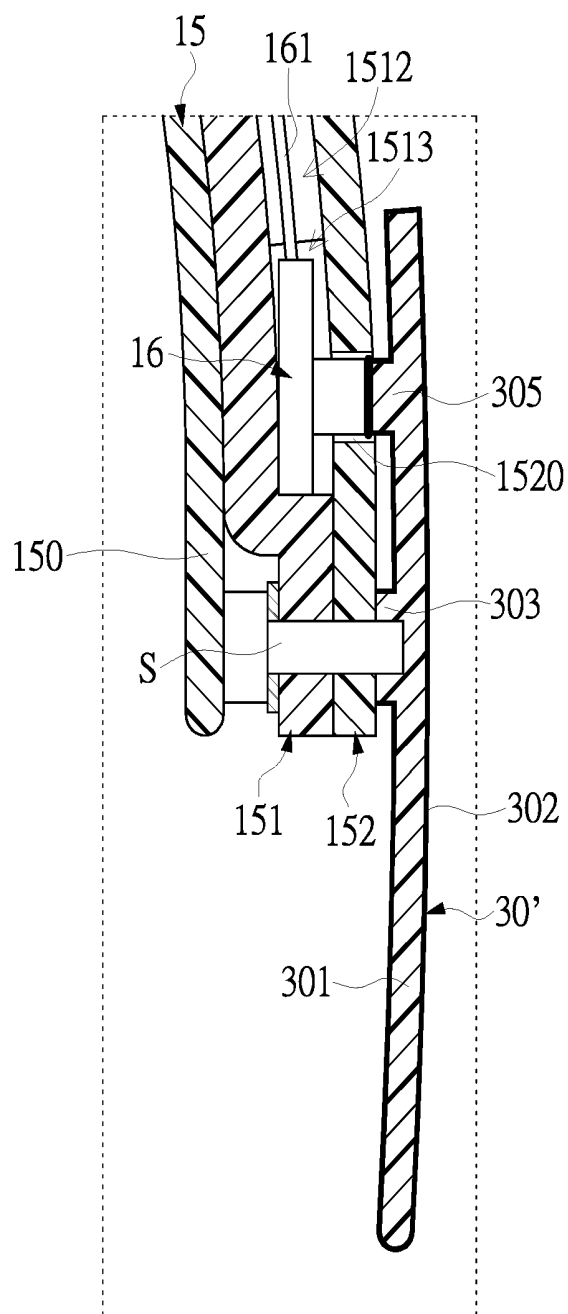


FIG. 10

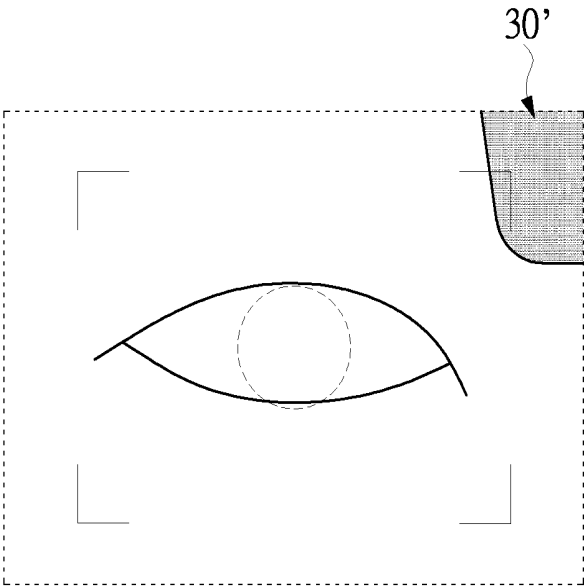


FIG. 11A

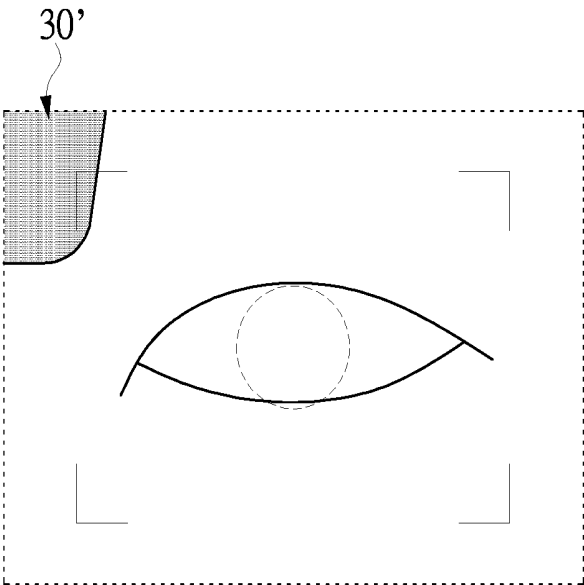


FIG. 11B

## METHOD OF MEASURING OCULAR SURFACE TEMPERATURE AND APPARATUS THEREOF

### CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This Application is a Continuation-in-Part of application Ser. No. 14/287,357, filed on May 27, 2014, now pending, and entitled "METHOD OF DETERMINING TEMPERATURE SHIFTING ERROR DERIVED FROM RADIATION SENSOR, METHOD OF MEASURING OCULAR SURFACE TEMPERATURE AND APPARATUS THEREOF".

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

[0002] The instant disclosure relates to a method of measuring ocular surface temperature and the apparatus thereof; in particular, to a method of determining temperature shifting error by using a built-in temperature sensor device herein called black plate that plays a calibration reference role for measuring ocular temperature and apparatus thereof.

#### 2. Description of Related Art

[0003] Conventional method to measure tear break up of dry eye includes intrusive or non-intrusive approach. The intrusive approach includes Schirmer and tear break up time (TBUT). Take Schirmer for example. The eyes undergo anesthesia and an elongated filter paper is put under the lower eyelid, such that the filter paper absorbs tears from the ocular surface by capillary. After a few minutes, the amount of tear can be assessed by looking at the diffusion area caused by the tear absorbed by the filter paper. The TBUT is conducted by dropping fluorescence dye into the tester's eyes, and the first tear break up timing is observed by slit lamp. However, the abovementioned approaches includes eye contact with foreign subjects. In addition to uncomfortable to the eyes, when conducting the abovementioned measure, because of the irritation to eye, the kinetics of tear break up may be altered and lead to reflective tearing. Therefore, the test result is not reliable and less reproducible. Furthermore, the result cannot achieve the idea measurement regulation proposed by the International Dry Eye Association in the 2007 annual report. The regulation said, when examining ocular surface tear change, the kinetics to the tear should be least affected.

[0004] The non-intrusive examination is primarily done by an ophthalmologist observing the tear break up of a tester and by infrared heat sensor to detect the ocular surface temperature change so as to lean the condition of tear break up. However, by looking into a patient's eyes, the result heavily relies on the clinical experience of the ophthalmologist, and there is not a quantified standard. Different doctors may have different interpretation of tear break up, and therefore misjudgment happens frequently. Especially, the degree of tear break up is the basis to determine dry eye or not, so the misjudgment is likely to happen. The infrared detection suffers from inaccuracy because the infrared sensor unit is highly sensitive to the ambient radiation (heat source). If there are other people around the tester, it becomes a source of external heat and the temperature detected by the infrared sensor drifts as well. Therefore,

before the tester undergoes the examination, a 5- to 10-minute waiting time is required so as to achieve heat balance with the ambience and reduce the error rate. However, in practical, the waiting time can hardly be enough when there are so many patients, and the error rate is usually high. The infrared examine apparatus can only detect relative temperature change but not an absolutely ocular surface temperature or other information related to the eye. Therefore the conventional infrared sensor has a considerable error rate, and it cannot obtain complete data which helps the physician to determine the eye condition. The usage of the infrared sensor is relatively limited.

[0005] To address the above issues, the inventor strives via associated experience and research to present the instant disclosure, which can effectively improve the limitation described above.

### BRIEF SUMMARY OF THE INVENTION

[0006] The instant disclosure provides a method of measuring ocular surface temperature, comprising: (A) providing an infrared heat sensor and a temperature sensor contacting with a black plate, the temperature sensor measuring an actual black plate temperature, the infrared heat sensor detecting a radiation emitted by the black plate, the radiation being computed according to a temperature rising curve through a computing unit of a work station to generate a computed black plate temperature; (B) determining a value of temperature shifting error by subtracting the actual black plate temperature from the computed black plate temperature; (C) detecting an ocular surface radiation emitted from a ocular surface of a tester by the infrared heat sensor, the ocular surface radiation being computed according to the temperature rising curve to generate a computed ocular surface temperature; (D) generating a calibrated ocular surface temperature by subtracting the value of temperature shifting error from the computed ocular surface temperature.

[0007] The instant disclosure also provides an apparatus to measure ocular surface temperature. According to one embodiment of the instant disclosure, the apparatus includes a supporting body, an infrared heat sensor, a black plate, a temperature sensor and a working station. The supporting body supports a head, and the infrared heat sensor is disposed opposite to the supporting body such that the supporting body is positioned in a predetermined view field of the infrared heat sensor. The black plate as a simulated blackbody coated with a black paint layer on a surface thereof is disposed on the supporting body and in the predetermined view field. The temperature sensor is buried in and contacted with the black plate, wherein the temperature sensor measures an actual black plate temperature from the black plate. The working station is electrically connected to the infrared heat sensor and has at least a computing unit and a storage unit. The infrared heat sensor detects a value of radiation emitted from the black plate and the computing unit transfers the value of radiation into a computed black plate temperature according to a temperature rising curve. Then, a value of temperature shifting error is determined by subtracting the actual black plate temperature from the computed black plate temperature.

[0008] In summary, the black plate is the basis for calibration reference temperature, and the presence of the black plate avoids ambient interference like heat to the infrared heat sensor, such that the temperature drifting of the infrared heat sensor may be reduced.

[0009] In order to further understand the instant disclosure, the following embodiments are provided along with illustrations to facilitate the appreciation of the instant disclosure; however, the appended drawings are merely provided for reference and illustration, without any intention to be used for limiting the scope of the instant disclosure.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a flow chart showing a method of determining temperature shifting error derived from radiation sensor of the instant disclosure;

[0011] FIG. 2A is a flow chart showing a method of measuring ocular surface temperature of the instant disclosure;

[0012] FIG. 2B is a flow chart showing a method of measuring ocular surface temperature of the instant disclosure;

[0013] FIG. 3 is a perspective view of an apparatus to measure ocular surface temperature of the instant disclosure;

[0014] FIG. 4 is a schematic diagram showing a method of measuring ocular surface temperature and an apparatus thereof of the instant disclosure in operation;

[0015] FIG. 5 shows a temperature changing curve obtained from a method of measuring ocular surface temperature and a apparatus thereof of the instant disclosure in a unit time; and

[0016] FIG. 6 shows a temperature rising curve according to the black plate radiation obtained from a method of measuring ocular surface temperature of the instant disclosure;

[0017] FIG. 7 is a perspective view of an apparatus to measure ocular surface temperature of second embodiment according to the instant disclosure;

[0018] FIG. 8 is an exploded view of a forehead abutting portion of second embodiment according to the instant disclosure;

[0019] FIG. 9 is an assembled view of the forehead abutting portion of second embodiment according to the instant disclosure;

[0020] FIG. 10 is a cross-sectional view of the forehead abutting portion of second embodiment according to the instant disclosure;

[0021] FIG. 11A is a captured image of right eye by the infrared heat sensor from a view window of the apparatus of the instant disclosure in operation; and

[0022] FIG. 11B is a captured image of left eye by the infrared heat sensor from a view window of the apparatus of the instant disclosure in operation.

#### DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

[0023] The aforementioned illustrations and following detailed descriptions are exemplary for the purpose of further explaining the scope of the instant disclosure. Other objectives and advantages related to the instant disclosure will be illustrated in the subsequent descriptions and appended drawings.

[0024] Reference is made to FIGS. 1, 3, 5 and 6. The instant disclosure provides a method of determining temperature shifting error derived from radiation sensor and an apparatus thereof. The method includes the following step: Step S101: providing an infrared heat sensor 20 and a temperature sensor 31 buried in and contacting with a black

plate 30. The black plate 30 is a simulated blackbody coated with a black paint layer on a surface thereof. The temperature sensor 31 measures an actual black plate temperature  $T_y'$ . The infrared heat sensor 20 detects black plate radiation  $C_x$  emitted by the black plate 30 and the value of the black plate radiation  $C_x$  is computed according to a provided temperature rising curve (FIG. 6) through a computing unit (such as a central processing unit, not shown) of a work station 40 to generate a computed black plate temperature  $T_y$ . Preferably, the computing unit computes according to the black plate temperature rising curve in FIG. 6, mainly by the counts of the heat radiation (black plate radiation  $C_x$ ) emitted by the black plate between 10 and 42 degree Celsius. The black plate radiation emitted by the black plate between 10 and 25 degree Celsius shows a linear trend, and the black plate radiation emitted by the black plate between 25 and 42 degree Celsius shows secondary curved correlation. In this way, when the infrared heat sensor 20 obtains heat radiation, e.g. the black plate radiation  $C_x$ , between 10 and 42 degree Celsius, and the computed black plate temperature  $T_y$  derived from a calculation of black plate radiation  $C_x$  into the temperature rising curve in FIG. 6, a value of temperature shifting error  $T_s$  can be determined by the following step: Step S103: subtracting the actual black plate temperature  $T_y'$  from the computed black plate temperature  $T_y$  ( $T_y - T_y'$ ). Calibration can be done according to the value of temperature shifting error  $T_s$  derived from ( $T_y - T_y'$ ) in FIG. 6. Therefore, the infrared heat sensor 20 is free from an ambient heat source that causes abnormal heat radiation.

[0025] According to the above method of determining temperature shifting error derived from radiation sensor, please refer to FIGS. 2A, 3, 5 and 6, a method of measuring ocular surface temperature is also provided and comprising: Step S201: detecting an ocular surface radiation  $C_e$  emitted from an ocular surface E of a tester by the infrared heat sensor 20, the ocular surface radiation  $C_e$  being computed based on the temperature rising curve through the computing unit of the work station 40 to generate a computed ocular surface temperature  $T_e$ . Step S203: generating a calibrated ocular surface temperature  $T_e'$  by subtracting the value of temperature shifting error  $T_s$  from the computed ocular surface temperature  $T_e$ . Step S205: repeating the steps from S201 to S203 for several times in a unit time period to obtain several values of the ocular surface radiation, several values of the computed ocular surface temperature  $T_e$  and several values of the calibrated ocular surface temperature  $T_e'$  from the tester. Step S207: generating a change of ocular surface temperature of the tester according to the several values of the calibrated ocular surface temperature  $T_e'$  to yield a test result. Step S209: a storage unit (such as a hard disk, or a memory card, not shown) is provided by the working station 40. The storage unit stores the test result. In order to prevent the infrared heat sensor 20 of the instant disclosure from ambient heat radiation interference, when using the instant disclosure, the infrared heat sensor 20 can be adjusted to a temperature range for detecting and displaying according to a practical requirement which has an upper and lower limit. The upper and lower limit can be represented by different colors. For example, the upper limit may be red, the lower limit may be blue, and in between in upper and lower limit may be yellow or orange, such that the ocular surface F as shown in FIG. 4 can create a heat distribution graph (not shown) with different colors. The temperature of the test result should then fall into the temperature range. For

example, as shown in FIG. 5, the temperature range is set between 34.92 and 34.72 degree Celsius, and the instant disclosure is not limited thereto. The temperature range is subject to change for the practical requirement.

[0026] In addition, in the step S205, the method may further include providing a speech unit (not labeled). The speech unit is preferably disposed in the working station 40, and the instant disclosure is not limited thereto. As shown in FIG. 2B, the speech unit can guide the tester to do the next step. Step 301: instructing the tester to close the eyes, and the speech unit gives a subsequent instruction after the end of a first predetermined time period T1. The first predetermined time T1 may be 6 seconds. In other words, in the step S301, the tester is asked to close the eyes and rest for 6 seconds, but it is not limited thereto. After resting 6 seconds, step S303 carries on. Step S303: the speech unit instructs the tester to open the eyes, and the speech unit gives another subsequent instruction after the end of a second predetermined time period T2. The maximum value of the second predetermined time period T2 may be 1.5 seconds, but the instant disclosure is not limited thereto. After the tester opens the eyes for 1.5 seconds, step S305 is carried out. Step S305: the speech unit instructs the tester to blink once and then keep the eyes open. Next, the infrared heat sensor 20 measures the ocular surface temperature change of the tester within a third predetermined time period T3. After that, the step S307: the speech unit informs the testing the measurement is complete. Preferably, the third predetermined time is longer than 5 seconds. In the instant embodiment, the third predetermined time is 6 seconds. That is to say, the infrared heat sensor 20 can perform the measurement of ocular surface temperature of the tester in 6 seconds. The test result includes the test results since the first predetermined time period T1 to the second predetermined time period T2 and to the third predetermined time period T3.

[0027] The test results of values of the calibrated ocular surface temperature  $T_e$  are stored in the storage unit and are computed by a computing unit (not shown) from the working station 40 to generate a graphical result. FIG. 5 shows the test result in graphical curve obtained by using the method of measuring ocular surface temperature of the instant disclosure and then computed by the computing unit. According to FIG. 5, the three longitudinal dotted lines divide the lateral axis into four blocks from the left to right. From the left to right are the first predetermined time period T1, the second predetermined time period T2, the blinking time period T21 and the third predetermined time period T3. At the first predetermined time period T1, the tester's eyes are closed, such that the result is relatively lower, approximately below 34.77 degree Celsius. At the second predetermined time T2, the temperature rises. In the blinking time period T21, the peak and trough are shown because of blinking. From the 0 second of the third predetermined time period T3, the ocular surface temperature gradually declines along the time (0 to 6 second). Meanwhile, the infrared heat sensor 20 can also film the eyes. The decline of the ocular surface temperature means the tear is evaporating. Because in the process of evaporation absorbs heat, the ocular surface temperature falls. Therefore, the declining trend in the third predetermined time period T3 can represent the trend of tear evaporation, and the condition of tear over the ocular surface can be understood. However, the instant disclosure truthfully displays and records the temperature without passing any judgment of diagnosis. What the medical implication

associated with the declining temperature is left to be determined by relevant personnel.

[0028] Moreover, the first predetermined time period T1, the second predetermined time period T2 and the blinking time period T21 are the preparation time before actually measuring the ocular surface temperature. The sum of the preparation time and the third predetermined time period T3 is the unit time T. The eye closing, opening and blinking in the preparation time are all recorded and saved, such that the same basic state of the tester's eyes before each of the measurement can be ensured. The test result obtained in the third predetermined time period T3 is therefore more reliable.

[0029] Reference is made to FIGS. 4 and 5. The ocular surface temperature change shown on the y axis of FIG. 5 may show the temperature change of cornea E1 as shown in FIG. 4. In other words, the method of measuring ocular surface temperature is not limited to the overall temperature of ocular surface E, it can also be used to measure a partial temperature such as the cornea E1 of the ocular surface E or the temperature of the conjunctiva E2 of the ocular surface E. Then, the temperature change of the cornea E1 or the conjunctiva E2 can be shown as the curve in FIG. 5 in a unit time T. Preferably, please refer to FIG. 4 showing the test result obtained from the method of the instant disclosure. The graphical result may be a plurality of heat distribution images (not shown) or the original ocular surface image (as shown in FIG. 4). The abovementioned filming can be displayed as heat distribution image or the original ocular surface (as shown in FIG. 4). The temperature change and distribution of all parts in the unit time T or the third predetermined time period T3 can be displayed. Therefore, within the third predetermined time period T3, it can be understood that which part of the ocular surface E reaches the lower temperature, and it can be told where the tear evaporates first on the ocular surface E.

[0030] Please refer to FIG. 3. The instant disclosure further provides an apparatus to perform the above method of measuring ocular surface temperature. The apparatus to measure ocular surface temperature includes a supporting body 10, an infrared heat sensor 20, a black plate 30, a temperature sensor 31 and a working station 40. The supporting body 10 can be used to support the head of the tester. More specifically, the support body 10 has an upwardly extending pole 11 stretching from a side portion (not shown) of a base 50. The pole 11 further extends to form a ring portion 12. A receiving space 120 defined by the ring portion 12 receives the head of the tester. The bottom and top portions of the inner circle of the ring portion 12 are a chin supporting portion 121 and a forehead abutting portion 122 respectively to accommodate the head of the tester in the ring portion 12.

[0031] The infrared heat sensor 20 and the supporting body 10 are arranged oppositely, such that the supporting body 10 is positioned in a predetermined view field of the infrared heat sensor 20. Preferably, the infrared heat sensor 20 further includes a sensor main body 21. Inside the sensor main body 21 is an infrared sensor component (not labeled). The infrared heat sensor may be a heat sensitive sensor, for example, thermopile, pyroelectric component or bolometer. In the instant embodiment, microbolometer is used as the heat sensitive component. One end of the sensor main body 21 is an image capture end 211, and the other end of the sensor main body 21 is a view window 212. The image

capture end **211** and the supporting body **10** are arranged oppositely, while the view window **212** is positioned toward an operator (not shown), such that the operator can see the image captured by the infrared heat sensor **20** from the image capture end **211** via the view window **212**. The sensor main body **21** extends downwardly to form a neck portion **22** and a secondary base **23**. The secondary base **23** resembles a platform and is disposed on a top platform **51** of the base **20**. Preferably, the infrared heat sensor **20** can be slidably disposed on the top platform **51**.

**[0032]** Reference is made to FIG. 3. The black plate **30** is a metallic plate coated with a black paint with high radiant emissivity, preferably higher than 0.94, which is schematically shown in FIG. 3, so that the black plate **30** can be simulated as a blackbody. The black plate **30** is disposed on the forehead abutting portion **122** of the supporting body **10**, and it is located within the view field of the infrared heat sensor **20**. Therefore, when the infrared heat sensor **20** measures the ocular surface temperature of a tester, the black plate **30** acts as a reference for calibration. In FIG. 3, the temperature sensor **31** is buried in the black body **30** and contacted with a back side of the black plate **30** so that the temperature sensor **31** is able to measure an actual black plate temperature  $T_y'$  from the black plate **30**.

**[0033]** Reference is made to FIGS. 1, 2A, 2B, 3 and 6. The working station **40** is preferably disposed on the secondary base **23** (but not limited thereto) and upwardly electrically connected to the infrared heat sensor **20** by the secondary base **23**. The working station **40** also includes a computing unit (not shown) and a storage unit (not shown). The infrared heat sensor **20** is used to detect a value of radiation emitted from the black plate **30** and the computing unit turns the value of radiation into a computed black plate temperature  $T_y$  according to a temperature rising curve. Consequently, a value of temperature shifting error  $T_s$  is determined by subtracting the actual black plate temperature  $T_y'$  from the computed black plate temperature  $T_y$ . Furthermore, the storage unit of the working station **40** stores the result of temperature shifting error  $T_s$ . The temperature shifting error  $T_s$  can be used for correctly measuring the ocular surface temperature and other applications as the two aforementioned method introduced. The working station **40** further includes a display **41**, a function key module **42** and a motion control unit **43**. The user can use the motion control unit **43** to adjust the position of the infrared heat sensor **20**, such that the infrared heat sensor **20** can slide to appropriate position on the top platform **51** of the base **50**. Then the infrared heat sensor **20** can aim at one eye of the tester's and focus on the ocular surface. After that, the operator can use the function key module **42** to execute "image property switch". The image property may be divided into three image property: color palette, temperature range and temperature range center. The color palette is responsible for the tone modification, the temperature range center can define the central point of the ocular surface temperature range, and the temperature range defines the temperature range shown in the image. Take FIG. 5 for example. The highest temperature of y axis in FIG. 5 is 34.92 degree Celsius, and the lowest temperature is 34.72 degree Celsius. When showing the heat distribution image (not shown), the region of the highest temperature is shown in red and the region of the lowest temperature is shown in blue. The display **41** shows the graphical result after measurement and the adjusting status done through the function key module **42**. In the

process of examination, the change of ocular surface tear in the time of examination can be recorded by function key module **42** giving a filming order.

**[0034]** The infrared heat sensor **20** of the instant disclosure has the black plate **30** in its predetermined view field. Overall, the black plate **30** is viewed as a calibration reference when the infrared heat sensor **20** measures the ocular surface temperature so as to help obtain an accurate ocular surface temperature test result. Furthermore, the test result is converted and computed by the computing unit of the working station **40** to obtain a graphical result, and the in the process of measuring, it is also recorded by filming. The graphical result includes heat distribution image, conventional ocular surface temperature and ocular surface temperature change curve of temperature against time. The apparatus to measure ocular surface temperature of the instant disclosure can fully support the abovementioned method of measuring ocular surface temperature. The instant disclosure is not intrusive and the error rate is relatively low compared to conventional infrared detector.

#### Second Embodiment

**[0035]** Reference is made to FIG. 7, which shows a perspective view of an apparatus to measure ocular surface temperature of second embodiment according to the instant disclosure. The apparatus to measure ocular surface temperature includes a supporting body **10'**, an infrared heat sensor **20'**, a black plate **30'**, and a base **50'**. The base **50'** has a motion control unit **52** and a sliding trail module **54** to move the infrared heat sensor **20'** to a proper position to observe the tester. The infrared heat sensor **20'** has an adjustable neck portion **24** to support the sensor main body **21**. The supporting body **10'** has a supporting frame **13**, a chin supporting portion **14** and a forehead abutting portion **15**. The bottom of the supporting frame **13** is fixed on the base **50'**. The forehead abutting portion **15** is disposed on a top end of the supporting frame **13**, and the chin supporting portion **14** is arranged between the forehead abutting portion **15** and the base **50'**. In the instant embodiment, the supporting frame **13** has a pair of hollow poles **131**, **132** defined with a receiving space **130**. The pair of hollow poles **131**, **132** are substantially parallel to each other. One of the poles **132** has an adjusting unit **133** which can adjust a height of the chin supporting portion **14**.

**[0036]** Reference is made to FIG. 8 and FIG. 9. In this embodiment, the black plate **30'** is fixed on the forehead abutting portion **15**. The black plate **30'** has a metallic substrate **301** and a black paint layer **302**. The black paint layer **302** is a flat black paint with a high radiant emissivity coated on the substrate **301** to increase the accuracy of measurement of the infrared temperature. The black paint can be black paint available in the market, such as IR BLACK PAINT of serial number of TAS910 THI-1B with radiant emissivity 0.94 manufactured by ICHINEN TASCO CO., LTD, but it is not limited thereto. The higher radiant emissivity of the black paint is, the higher accuracy of measure is.

**[0037]** The forehead abutting portion **15** includes an inner board **151**, and an exterior panel **152** which is fixedly covered on one side of the inner board **151**. The inner board **151** has a substantial inversed triangular shape, or is substantially T-shaped. The exterior panel **152** has a shape similar to that of the inner board **151**. In this embodiment, three screws **S** are used to screw the exterior panel **152** to a



front side of the inner board 151. The inner board 151 has two sleeve portions 1514 extended downward from two top ends thereof. The two sleeve portions 1514 are respectively sleeved on the two poles 131, 132. A cable groove 1512 and a sensor room 1513 are formed on the inner board 151.

[0038] A temperature sensor 16 is received between the inner board 151 and the exterior panel 152, and exposed from the exterior panel 152 to contact with the black plate 30'. The black plate 30' is fixed on the exterior panel 152. In detail, the temperature sensor 16 is received in the sensor room 1513 of the exterior panel 152. A cable 161, which is connected to the temperature sensor 16, is received in the cable groove 1512 of the exterior panel 152. The cable 161 passes through one of the sleeve portions 1514 and enters into the pole 131 to electrically connect to the work station. The exterior panel 152 is covered on the inner board 151 to shield the cable 161. In this embodiment, the exterior panel 152 has two wing portions 1523 covered the cable groove 1512 and end openings of the sleeve portions 1514. The exterior panel 152 has a sensor window 1520, and the temperature sensor 16 is disposed in the sensor window 1520 to contact with a back side of the black plate 30'. Therefore, the temperature sensor 16 is hidden in the forehead abutting portion 15, and is capable of detecting the temperature of the black plate 30'.

[0039] Reference is made to FIG. 10, which is a cross-sectional view of the forehead abutting portion 15 and the black plate 30'. In this embodiment, the black plate 30' has a fastening portion 303 formed on a back side thereof. A fastening element, in this embodiment a screw S, fixes a retaining portion 1515 of the inner board 151, a fixing portion of exterior panel 152 and the fastening portion 303 of the black plate 30' together. The black plate 30' has a contacting protrusion 305 protruded from its back side, and the temperature sensor 16 contacts the contacting protrusion 305 of the black plate 30'. Preferably, a thermal grease can be applied between the contacting protrusion 305 of the black plate 30' and the temperature sensor 16 for heat conducting well.

[0040] Reference is made to FIG. 11A and FIG. 11B. The black plate 30' is substantially T-shaped, and a lower part of the black plate 30' is arranged between two eyes of tester. In other words, a width of the lower part of the black plate 30' is smaller than a distance between two inner corners (medial canthus) of two eyes of tester. Further, a lower end of the lower part of the black plate 30' is not lower than the lip, and is substantially arranged at a level of the brow bone. When a tester's right eye is detected, the black plate 30' can be detected simultaneously at a right upper corner of a captured image by the infrared heat sensor from a view window of the apparatus. When a tester's left eye is detected, the black plate 30' can be detected simultaneously at a left upper corner of a captured image by the infrared heat sensor from a view window of the apparatus. Therefore, the black plate 30' as a simulated blackbody always can be detected with the tester's eyes in each detecting action, so as to provide a temperature shifting error derived.

[0041] The descriptions illustrated supra set forth simply the preferred embodiments of the instant disclosure; however, the characteristics of the instant disclosure are by no means restricted thereto. All changes, alternations, or modifications conveniently considered by those skilled in the art are deemed to be encompassed within the scope of the instant disclosure delineated by the following claims.

What is claimed is:

1. A method of measuring ocular surface temperature comprising:

(A) providing an infrared heat sensor and a temperature sensor contacting with a black plate; the black plate being a simulated blackbody coated with a black paint layer on a surface thereof, the temperature sensor measuring an actual black plate temperature, the infrared heat sensor detecting a radiation emitted by the black plate, the radiation being computed according to a temperature rising curve to generate a computed black plate temperature; and

(B) determining a value of temperature shifting error by subtracting the actual black plate temperature from the computed black plate temperature;

(C) detecting an ocular surface radiation emitted from a ocular surface of a tester by the infrared heat sensor, the ocular surface radiation being computed according to the temperature rising curve to generate a computed ocular surface temperature;

(D) generating a calibrated ocular surface temperature by subtracting the value of temperature shifting error from the computed ocular surface temperature.

2. The method of measuring ocular surface temperature according to claim 1, further comprising:

repeating the steps (C) to (D) in a unit time period to obtain several values of the ocular surface radiation, several values of the computed ocular surface temperature and several values of the calibrated ocular surface temperature from the tester; and

generating a change of ocular surface temperature of the tester according to the several values of the calibrated ocular surface temperature to yield a test result.

3. The method of measuring ocular surface temperature according to claim 1, wherein the step (A) further comprising:

adjusting a temperature range that the infrared heat sensor is effective such that the test result falls in the temperature range.

4. The method of measuring ocular surface temperature according to claim 1, wherein further comprising:

instructing the tester to close the eye and conducting a subsequent instruction after a first predetermined time period;

instructing the tester to open the eye and conducting a subsequent instruction after a second predetermined time period;

instructing the tester to blink once and then remain open such that the infrared heat sensor conducts a measurement within a third predetermined time period; and informing the tester completion of the examination.

5. The method of measuring ocular surface temperature according to claim 2, wherein computing unit continues to process the test result to generate a graphical result.

6. The method of measuring ocular surface temperature according to claim 5, wherein the graphical result includes a plurality of heat distribution images to show the temperature change and temperature distribution of each portion of the ocular surface in the unit time.

7. The method of measuring ocular surface temperature according to claim 5, wherein the graphical result is a curve graph showing the temperature change of each portion of the ocular surface in the unit time.

**8.** An ocular surface temperature measurement apparatus comprising at least:

- a supporting body;
- an infrared heat sensor disposed opposite to the supporting body, wherein the supporting body is positioned in a predetermined view field of the infrared heat sensor;
- a black plate as a simulated blackbody coated with a black paint layer on a surface thereof disposed on the supporting body and in the predetermined view field;
- a temperature sensor buried in and contacted with the black plate, wherein the temperature sensor measures an actual black plate temperature from the black plate; and
- a working station electrically connected to the infrared heat sensor, the working station having at least a computing unit and a storage unit,

wherein the infrared heat sensor detects a value of radiation emitted from the black plate and the computing unit turn the value of radiation into a computed black plate temperature according to a temperature rising curve;

wherein a value of temperature shifting error is determined by subtracting the actual black plate temperature from the computed black plate temperature.

**9.** The ocular surface temperature measurement apparatus according to claim **8**, wherein the infrared heat sensor is slidably mounted on a top platform of a base.

**10.** The ocular surface temperature measurement apparatus according to claim **8**, wherein the working station further includes a display, a function key module and a motion control unit.

**11.** The ocular surface temperature measurement apparatus according to claim **8**, wherein the black plate has a metallic substrate and a black paint layer, wherein the black paint layer is a flat black paint with a radiant emissivity higher than 0.94 coated on the substrate.

**12.** The ocular surface temperature measurement apparatus according to claim **8**, wherein the supporting body has a supporting frame, a chin supporting portion and a forehead abutting portion; wherein the forehead abutting portion includes an inner board, and an exterior panel fixedly covered on one side of the inner board; and the temperature sensor is received between the inner board and the exterior panel, and exposed from the exterior panel to contact with the black plate; wherein the supporting frame has a pair of hollow poles defined with a receiving space.

**13.** The ocular surface temperature measurement apparatus according to claim **12**, wherein the inner board has two sleeve portions extended downward from two top ends thereof, the two sleeve portions are respectively sleeved on the two poles, wherein the inner board is formed with a cable groove and a sensor room; wherein a cable connected to the temperature sensor is received in the cable groove of the exterior panel and passes through one of the sleeve portions to enter into the pole; wherein the exterior panel is covered on the inner board to shield the cable.

**14.** The ocular surface temperature measurement apparatus according to claim **12**, wherein the black plate has a fastening portion formed on a back side thereof, wherein a fastening element fixes a retaining portion of the inner board, a fixing portion of exterior panel and the fastening portion of the black plate together.

**15.** The ocular surface temperature measurement apparatus according to claim **14**, wherein the black plate has a contacting protrusion protruded from a back side thereof, and the temperature sensor contacts the contacting protrusion of the black plate.

**16.** The ocular surface temperature measurement apparatus according to claim **8**, wherein the black plate is detected simultaneously at an upper corner of a captured image by the infrared heat sensor from a view window of the apparatus, when a tester's eyes are detected.

\* \* \* \* \*

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|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------|---------|------------|
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| 外部链接          | <a href="#">Espacenet</a> <a href="#">USPTO</a>                                                                                               |         |            |

#### 摘要(译)

测量眼表温度的方法包括如下步骤。使用这里称为黑板的内置温度传感器，提供红外热传感器，温度传感器接触黑板。温度传感器测量实际的黑板温度。红外热传感器检测由黑板发射的辐射，并且通过工作站的计算单元根据温度上升曲线计算辐射，以产生计算的黑板温度。通过从计算的黑板温度中减去实际黑板温度来确定温度漂移误差的值。

