Jan. 21, 1964 KATSUMI TAKEDA ETAL 3,118,274

SUNRISE-AND-SUNSET CONTROLLED TIMEKEEPING DEVICE

Filed Feb. 14, 1962 2 Sheets-Sheet 1

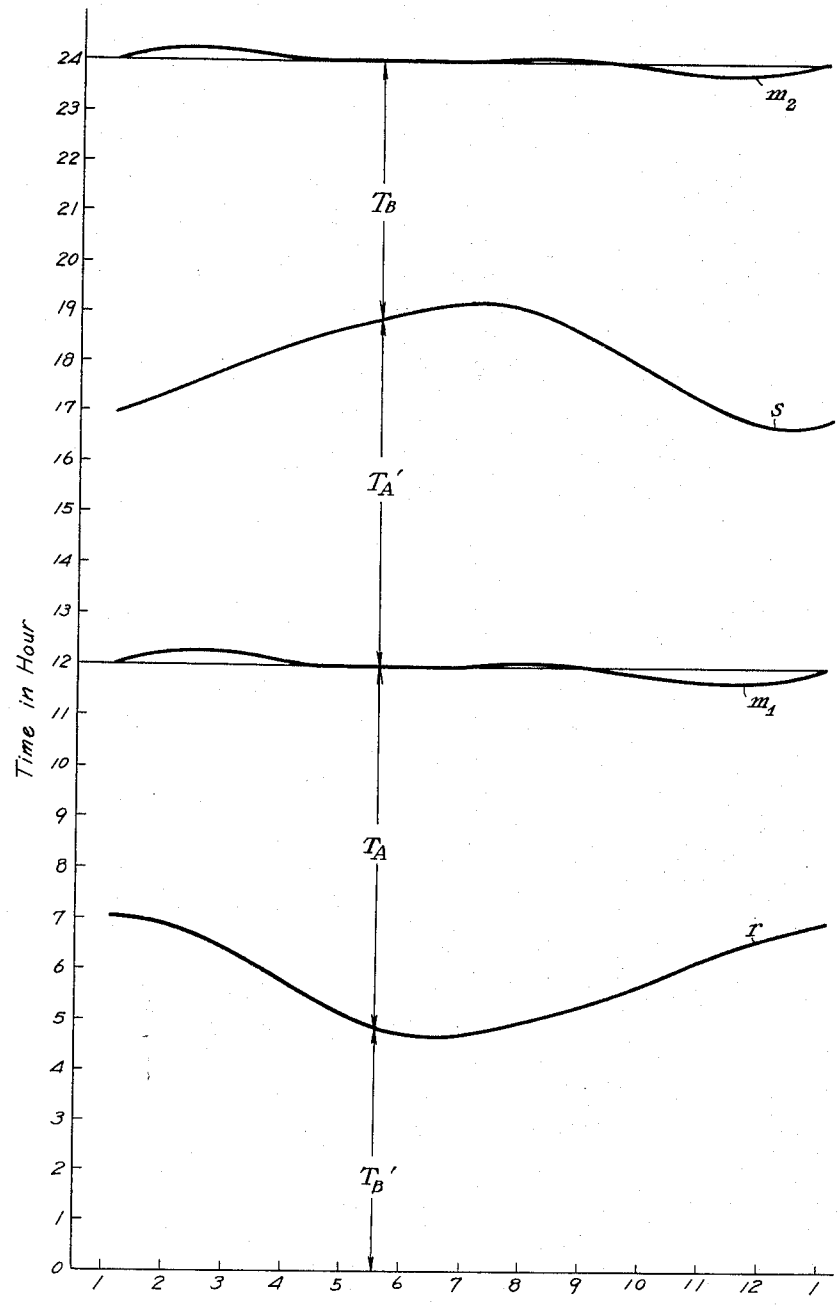


Fig. 1

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SUNRISE-AND-SUNSET CONTROLLED TIMEKEEPING DEVICE

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Fig. 2

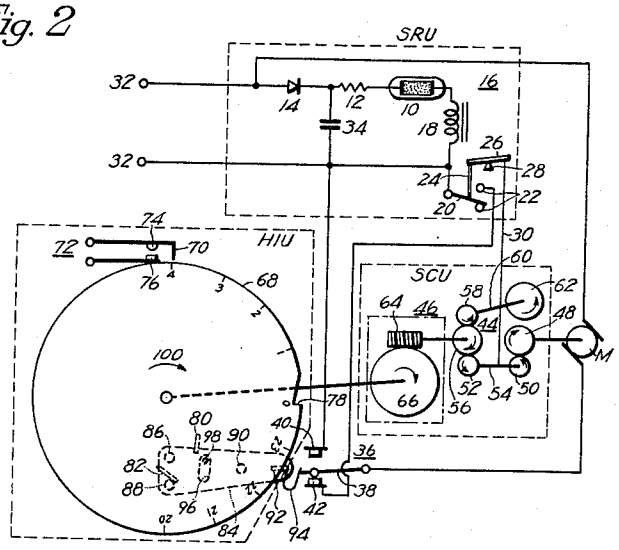
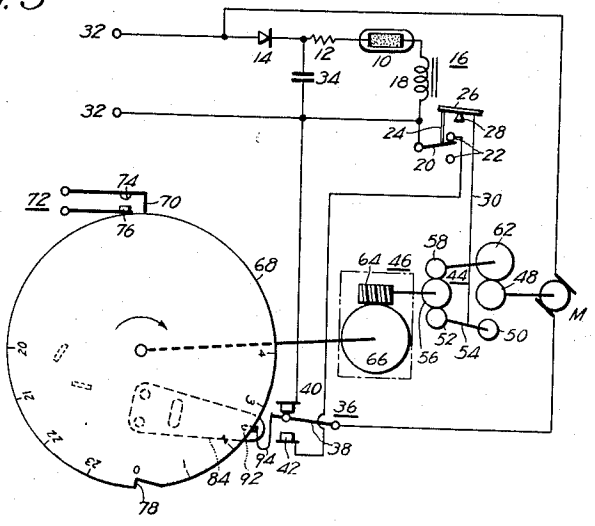


Fig. 3



United States Patent Office 3,118,274 Patented Jan. 21, 1964

3,118,274
SUNRISE-AND-SUNSET CONTROLLED TIMEKEEPING DEVICE

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Filed Feb. 14, 1962, Ser. No. 173,256
Claims priority, application Japan Feb. 18, 1961
8 Claims. (Cl. 58—23)

This invention relates to a sunrise-and-sunset controlled timekeeping device.

It is widely practiced to indicate or determine the hour by using any timekeeper including a balance wheel or a pendulum or any electric timekeeper driven by a synchronous motor or the like. However, all types of timekeepers commonly used are inherently disadvantageous in that they result in erroneous indication of the hour due to the effect of daily rates added to one another during long service.

A general object of the invention is to provide an improved timekeeper device wherein the abovementioned disadvantage is eliminated.

An object of the invention is to provide a sunrise-and-sunset timekeeper device which is controlled by every sunrise and every sunset to provide the basic hour during either daytime or nighttime to eliminate any erroneous indication of the hour resulting from the integration of daily rates effected during long service whereby the hour can be nearly correctly indicated at any moment.

Another object of the invention is to provide an electric timekeeper device which is driven by a synchronous motor and controlled by every sunrise and every sunset to provide the basic hour during daytime and nighttime, and which will automatically recover lost time due to stoppage of electric supply to the motor being operated.

With the objects in view, the invention resides in a timekeeper device comprising photoconductive means responsive to both sunrise and sunset, rotatable control means actuated by said photoconductive means to be started at either sunrise or sunset, and an hour dial member provided on said rotatable means for rotation therewith. The rotatable means is rotated with a ratio of speed of rotation during the daytime to that during the nighttime of 1:2 or 2:1 and cooperates with an hour indicating pointer member to indicate the hour at any moment in the nighttime or daytime.

In a preferred embodiment of the invention a timekeeper device comprises driving means having a predetermined fixed driving speed, means responsive to both the sunrise and the sunset including means for starting operation of said driving means at the sunrise, speed changing means, hour indicator means including a graduated member driven by said driving means through said speed changing means. The speed changing means is controlled by said sunrise-and-sunset responsive means to change the angular speed of said graduation member of said hour indicator means for a predetermined magnitude during a time interval between the sunrise and the sunset to twice said predetermined magnitude during a time interval between the sunset and the succeeding sunrise. Control means are controlled by the hour indicator means to maintain the driving means in operation for a period of time for which the driving means is to be operated and to stop operation of said driving means upon the completion of one revolution of said hour indicator means before the succeeding sunrise, and an indicating member is provided for cooperating with said graduated member of said hour indicator means to indicate nearly correctly the hour at any moment in the nighttime.

The driving means preferably comprises a synchronous motor adapted to be energized from the commercial alternating current line.

In order to indicate nearly correctly the hour in the daytime, the synchronous motor may be started to be operated at the sunset and the graduated member of said hour indicator means is driven at said predetermined magnitude of angular speed during the time interval between the sunset and the succeeding sunrise and at twice said predetermined magnitude during the time interval between the sunrise and the sunset respectively.

If the timekeeper device is desired to control a utilization device said indicating member may preferably be formed as a movable arm of a switch for controlling the utilization device. In order to activate the switch the hour indicator means may be provided with at least one notch on said graduation member at a position corresponding to the hour at which the utilization device is to be controlled.

The invention will become more readily apparent from the following exemplary description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a typical graph illustrating the sunrise and the sunset plotted against the calendar month;

FIG. 2 is a diagrammatic view of a timekeeper device constructed in accordance with the teachings of the invention; and

FIG. 3 is a diagrammatic view of the device of FIG. 2 is operation.

The invention is based upon the discovery that, with reference to any calendar day, a time interval between the sunrise and 1200 hours is approximately equal to a time interval between the midday and the sunset while a time interval between the sunset and 0000 hour is approximately equal to a time interval between 0000 hour and the succeeding sunrise.

Referring now to FIG. 1 of the drawings, there is shown a typical graph illustrating the sunrise and the sunset measured in Kobe, Japan (which is in latitude 34°41'N and in longitude 135°11'E) and plotted against the calendar month. In FIG. 1 a curve r represents the sunrise and a curve s represents the sunset. A curve m_1 indicates the hour averaging the sunrise and the sunset and a curve m_2 indicates the hour averaging the sunset and the succeeding sunrise. As shown in FIG. 1, a deviation of the curve m_1 from the horizontal line passing through the ordinate of 1200 hours is in the same direction as an approximately equal to that of the curve m_2 from the horizontal line passing through the ordinate of 2400 hours. Such deviations are relatively small in magnitude. Therefore, if it is assumed that, with reference to any calendar day, T_A represents a time interval between the sunrise and 1200 hours, T_A' a time interval between 1200 hours and the sunset, T_B a time interval between the sunset and 0000 hour, and T_B' represents a time interval between 0000 hour and the succeeding sunrise then it will be seen from FIG. 1 that T_A is approximately equal to T_A' and that T_B is approximately equal to T_B'. Therefore, we have

$$\frac{T_A+T_A'+T_B+T_B'}{2}\simeq\frac{2(T_A+T_B)}{2}=12 \text{ hours} \quad (1)$$

In other words, a half of the sum of the time interval between the sunrise and the sunset and the time interval between the sunset and the succeeding sunrise is, at all times, approximately equal to an interval of 12 hours through a year regardless of the sunrise and sunset.

Referring now to FIG. 2, there is diagrammatically illustrated a timekeeper device embodying the principle of the invention and providing the basic hour during the nighttime. However, it is to be understood that the invention is equally applicable to a timekeeper device providing the basic hour during the daytime.

As shown in FIG. 2, the timekeeper device comprises a sunrise-and-sunset responsive unit generally designated by the reference characters SRU, a drive such as a synchronous motor M, a speed changing unit generally designated by the reference characters SCU and controlled by the sunrise-and-sunset responsive unit SRU, and an hour indicator unit HIU driven by the synchronous motor M through the speed changing unit SCU.

The sunrise-and-sunset responsive unit SRU includes a photocell 10 comprising photosensitive cadmium sulfide or the like which has its internal resistance variable in response to exposure to light. The photocell 10 is connected to a resistor 12 connected in series to a rectifier 14 and is also operatively connected to a control relay 16. The relay 16 comprises an operating winding 18 connected in series to the photocell 10, a movable contact member 20 and a pair of stationary contacts 22. The movable contact member 20 has one end electrically connected to the operating winding 18 and the other end normally engages one of the stationary contacts 22 or in this case the lower stationary contact as viewed in FIG. 2. The movable contact member 20 is connected to a movable rod 24 which, in turn is connected to a lever of an electrically insulating material 26 at one end. The lever 26 is supported at its fulcrum 28 and connected at the other end to a connecting rod 30 as will be later described. The arrangement comprising the rectifier 14, the resistor 12, the photocell 10 and the operating winding 18 serially connected to each other is connected across a source of alternating current represented by a pair of input terminals 32. In order to smooth the rectified output from the rectifier 14 a smoothing capacitor 34 is provided on the output of the rectifier. The lower plate of the capacitor 34 is directly connected to the operating winding 18 and also to the lower input terminal 32.

The synchronous motor M is connected between the upper input terminal 32 as viewed in FIG. 2 and a transfer arm 38 of a holding switch 36. The switch 36 includes a pair of stationary contacts 40 and 42. The upper contact 40 is connected to the junction of the capacitor 34 and the operating winding 18 of the control relay 16 while the lower contact 42 is connected to the upper contact member 22 of the relay with the transfer arm 38 normally engaging the lower contact 42.

The speed changing unit SCU comprises a transfer gearing generally designated by the reference numeral 44 and a reduction gearing generally designated by the reference numeral 46. The transfer gearing 44 includes a first gear 48 rigidly mounted on a shaft for the motor M, a second gear 50 normally meshing a first gear 48 and a third gear 52 secured on a shaft 54 for the second gear 52. The third gear 52 is coupled through an intermediate gear 56 to a fourth gear 58 secured on a shaft 60. The shaft 60 is provided with a fifth gear 62 which is twice as large as the first gear 48 in tooth number. As diagrammatically shown in FIG. 2, the shafts 54 and 60 are operatively coupled to the connecting rod 30 in such a manner that the engagement of the movable contact member 20 of the control relay 16 with the lower stationary contact member 22 effects the meshing of the first gear 48 with the second gear 50 and the disengagement of the first gear from the fifth gear 62 whereas the engagement of the movable contact member with the upper stationary contact member effects the meshing of the first gear 48 with the fifth gear 62 and the disengagement of the first gear from the second gear. The speed changing unit is also designed and constructed such that when the first gear 48 meshes the second gear 50 the intermediate gear 56 is rotated at a speed equal to twice the speed obtained when the first gear meshes the fifth gear 62.

The reduction gearing 46 includes a pinion 64 integral with the intermediate gear 56 and a gear 66 meshing the pinion 64.

The hour indicator unit HIU comprises an hour dial 68 rotatable together with the gear 66 of the reduction gearing 46. The hour dial 68 is preferably made integrally with the gear 66 and has its front face graduated in hours throughout one half of the peripheral portion thereof. In the illustrated embodiment the graduation on the hour dial 68 includes lines designated at 20, 21, 22, 23, 0, 1, 2, 3 and 4 and disposed at an angular equidistance corresponding to 22.5 degrees or $\pi/8$ radian. If desired, the number of the graduated lines and the angular distance therebetween may be varied.

To indicate the hour an indicating pointer 70 is disposed adjacent to the periphery of the hour dial 68 at such a position that the pointer aligns with one of the outermost graduated lines or the line 4 in this case when the device is not operated.

As shown in FIG. 2, the pointer 70 is formed as a movable arm of a control switch 72 and carries a movable contact 74 of the same with its free end contacting the periphery of the hour dial 68. The switch 72 includes a stationary contact 76. Also the hour dial 68 is shown as having a notch 78 formed on the periphery, for example, at the position of the graduation line 0. Therefore, it will be seen that during the rotation of the hour dial 68 the pointer 70 can drop in the notch 78 to engage the movable contact 74 with the stationary contact 76 to thereby enable the control switch 72 to control a utilization device (not shown).

It is to be understood that more than one of notch may be provided on the hour dial in accordance with the member of predetermined hours at which the utilization device is to be controlled.

However, if the timekeeper device will be used only to indicate or measure the hour then the switch and notch structure just described may be omitted.

As shown at dotted line in FIG. 2, the hour dial 68 includes further a pair of spaced transfer pawls 80 and 82 projecting from the rear face thereof.

Opposite the rear face of the hour dial 68 a control plate of an electrically insulating material generally designate by the reference numeral 84 is disposed including on the one end portion a pair of spaced pins 86 and 88 capable of engaging the transfer pawls 80 and 82 once respectively during one complete revolution of the hour dial 68. The control plate 84 is pivotably mounted substantially at its center on a stationary pin 90 and includes on the other end portion of a supporting element 92 secured to a U-shaped spring 94 at one end which includes the other end secured to the movable arm 38 of the switch 36 at its free end. The control plate 84 is further provided with a slot 96 through which a stationary pin 98 extends in order to restrict the pivotal movement of the control plate.

The device thus far described is operated as follows:

It is now assumed that, before the sunrise the various components of the device are in the positions illustrated in FIG. 2. As the sky becomes light at the sunrise the photocell 10 internal resistance is abruptly decreased permitting a current to flow from the source of alternating current 32 through the operating winding 18 of the control relay 16. Therefore, the operating winding 18 is energized with a rectified current from the rectifier 14 which is fed by a source of alternating current 32. The energization of the winding 18 effects pulling up of the movable contact member 20 to engage the same with the upper contact 22 (see FIG. 3). This completes a circuit from the upper input terminal 32 through the synchronous motor M, the transfer arm 38 of the holding switch 36, the stationary contact 42 thereof, the upper contact 22 of the control relay 16 and the movable contact member 20 to the lower input terminal 32 to thereby start the operation of the motor.

At the same time, the pulling up of the movable contact member 20 effects disengagement of the first gear 48 from the second gear 50 and the engagement of the first gear 48 with the fifth gear 62 through the movable rod 24, the lever 26 and connecting rod 30 (see FIG. 3).

When the motor M is operated, the hour dial 68 will

be rotated in the direction of the arrow **100** in FIG. 2 through the speed changing unit SCU. It is here to be noted that the hour dial is designed to be rotated at an angular velocity of

$$\frac{22.5^\circ}{2}$$

or $\pi/16$ radians per hour by properly selecting the speed of the motor M and the gear ratios of the speed changing unit SCU. Soon thereafter, rotation of the motor M, and hence the hour dial **68**, has been initiated and the transfer pawl **80** on the hour dial forces the pin **86** on the control plate **84** to move the plate from its position illustrated in FIG. 2 to its position illustrated in FIG. 3. Thereby the transfer arm **38** of the holding switch **36** is separated from the lower contact **42** and brought into and held in contact with the upper contact **40** by the action of the U-shaped spring **94**. Thus a holding circuit for the motor M has been completed. Under these circumstances, therefore, the motor continues to be operated regardless of the deenergization of the control relay **16**.

As previously described, a half of the sum of the time interval between the sunrise and sunset and the time interval between the sunset and the succeeding sunrise is, at all times, approximately equal to the interval of **12** hours throughout a year regardless of the sunrise and sunset. It will be apparent that the hour dial **68** has been rotated through an angle of

$$\frac{22.5^\circ}{2}\times 2T_A$$

during the period of from the sunrise to the sunset or the period of $T_A+T_A'\simeq 2T_A$. That angle is equal to one through which the hour dial is rotated at twice the angular velocity as previously determined for T_A hours.

At the sunset the photocell **10** is abruptly increased in its internal resistance to deenergize the control relay **16**. The deenergization of the control relay effect the separation of the movable contact member **20** from the upper contact **22** and the engagement of the contact **20** with the lower contact **22** as well as the disengagement of the first gear **48** from the fifth gear **62** and the engagement of the first gear with the second gear **50**. Because of the presence of the holding circuit the motor M is continued to be operated and the hour dial **68** is also continued to be rotated at twice said angular velocity or at an angular velocity of

$$\frac{22.5^\circ}{2}\times 2$$

(or equal to 22.5°) per hour due to the meshing the first gear **48** with the second gear **50** until the latter will be rotated through

$$\frac{22.5^\circ}{2}\times 2\times T_B$$

for a period of from the sunset to 0000 hour. Therefore, for a period of from the sunrise through the sunset to 0000 hour the hour dial will be rotated through an angle represented by the expression

$$\frac{22.5^\circ}{2}\times 2T_A+\frac{22.5^\circ}{2}\times 2\times T_B=\frac{22.5^\circ}{2}\times 2(T_A+T_B)$$

From the Expression 1 it will be seen that the above-mentioned angle is equal to

$$\frac{22.5^\circ}{2}\times 2\times 12=270^\circ$$

This means that approximately 0000 hour is obtained at the time the hour dial which was initiated to be rotated at the sunrise has been rotated through an angle of 270° or $3\pi/2$ radians. In other words, the device provides the basic hour at the instant the hour dial **68** has been rotated through three right angles.

At 0000 hour the pointer **70** will align with the graduated line 0 on the hour dial **68**.

After 0000 hour the hour dial is continued to be rotated at the angular velocity of 22.5° per hour and the position of the pointer relative of the graduation on the hour dial indicates nearly correctly the hour at any moment.

At the instant the hour dial has been rotated through one complete revolution to return back to its starting position or at the instant the pointer **70** has again aligned with the graduated line 4, the transfer pawl **82** on the hour dial will force the pin **88** to return the control plate **84** to its original position illustrated in FIG. 2 in counterclockwise direction as viewed in the same figure through the action of the U-shaped spring **94**. This permits the transfer arm **38** of the holding switch **36** to be separated from the upper contact **40** and to contact the lower contact **42**. At that time the control relay **16** has already been deenergized to separate the movable contact member **20** from the upper contact **22** so that the motor M is stopped. In other words, the hour dial **68** whose operation has been initiated at the sunrise is stopped at 0400 hours.

From the foregoing it will be appreciated that, because the hour dial is graduated at intervals of 22.5° and that the same is rotated at an angular velocity of 22.5° per hour after the sunset, the position of the pointer relative to the hour dial indicates nearly correctly the hour at any movement after the sunset.

According to the invention any stoppage of electric supply to the motor which is in operation can be compensated for by utilizing a period of from 0400 hours to the sunrise for which the hour dial is stationary. For example, if it is assumed that electric supply to the motor has been interrupted for an interval of three hours beginning at 2200 hours then the pointer will align with the graduated line 1 on the hour dial when the actual hour is 0400 hours. Accordingly the motor will be continued to be operated until the sun will rise for example at 0500 hours. After the sunrise the motor is continued to be operated in the manner as previously described. Therefore, a time lag of the indication of the pointer due to the stoppage of electric power can be compensated for partially, namely by an interval of one hour beginning at 0400 hours and terminating at 0500 hours. Thus it will be appreciated that the time lag referred to can be fully compensated during three days.

While the invention has been described in terms of a timekeeper device designed to provide the basic hour in the night time it is equally applicable to a timekeeper device designed to provide the basic hour in the daytime. In the latter case, the motor will be started to be operated at the sunset and the hour dial will have its angular velocity in the daytime equal to twice the angular velocity thereof in the nighttime. In this manner the device provides the basic hour at 1200 hours and indicates nearly correctly the hour at any moment in the daytime.

From the foregoing it will be appreciated that the objects of invention have been accomplished by the provision of a timekeeper device comprising sunrise-and-sunset responsive means and an hour dial controlled by said responsive means and having its angular velocity in the nighttime equal to twice the angular velocity thereof in the daytime or vice versa.

While the inevntion has been described in conjunction with the preferred embodiments thereof it is to be understood that various changes in detail of the construction and the combination and arrangement of the components may be resorted to without departing from the spirit and scope of the invention.

What we claim is:

1. In a timekeeping device, in combination, photoconductive means responsive to both the sunrise and the sunset, rotatably driven means controlled by said photoconductive means and startable at sunrise, an hour dial member provided on said rotatably driven means for rotation

therewith, means for driving said rotatably driven means in operation at a predetermined angular velocity during the daytime and at twice said predetermined angular velocity during the nighttime and an hour indicating pointer member cooperative with said hour dial member to indicate the hour at any moment at least in the nighttime.

2. In a timekeeping device, in combination, photoconductive means responsive to both the sunrise and the sunset, rotatably driven means controlled by said photoconductive means and startable at sunset, and an hour dial member provided on said rotatably driven means for rotation therewith, means for driving said rotatably driven means in operation at a predetermined angular velocity during the nighttime and at twice said predetermined angular velocity during the daytime, and an hour indicating pointer member cooperative with said hour dial member to indicate the hour at any moment in the daytime.

3. A timekeeping device comprising driven means having a predetermined fixed driving speed, means responsive to both the sunrise and the sunset including means for starting operation of said driving means at the sunrise, speed changing means, hour indicator means including a graduated member driven by said driving means through said speed changing means, said speed changing means being controlled by said sunrise-and-sunset responsive means to change the angular speed of said hour indicator of said hour indicator means from a predetermined magnitude during a time interval between the sunrise and the sunset to twice said predetermined magnitude during a time interval between the sunset and the succeeding sunrise, control means controlled by said hour indicator means to maintain said driving means in operation for a period of time for which driving means is to be operated and to stop operation of said driving means upon completion of one revolution of said hour indicator means befor said succeeding sunrise, and an indicating member cooperating with said graduated member of said hour indicator means to indicate substantially correctly the hour at any moment in the nighttime.

4. A timekeeping device comprising driving means having a predetermined fixed driving speed, means responsive to both the sunrise and the sunset including means for

starting the operation of said driving means at the sunset, speed changing means, hour indicator means including a graduated member driven by said driving means through said speed changing means, said speed changing means being controlled by said sunrise-and-sunset responsive means to change the angular speed of said graduated member of said hour indicator means from a predetermined magnitude during a time interval between the sunset and the succeeding sunrise to twice said predetermined magnitude during a time interval between the sunrise and the sunset, control means controlled by said hour indicator means to maintain said driving means in operation for a period of time for which said driving means is to be operated and to stop operation of said driving means upon the completion of one revolution of said hour indicator means before the succeeding sunset, and an indicating member cooperating with said graduated member of said time indicating means to indicate nearly correctly the hour at any moment in the daytime.

5. A timekeeping device as claimed in claim 3, wherein said driving means comprises a synchronous motor, and connections for applying alternating current to said motor.

6. A timekeeping device as claimed in claim 4, wherein said driving means comprises a synchronous motor and connections for applying alternating current to said motor.

7. A timekeeping device as claimed in claim 3, comprising a control switch, said indicator member comprising a movable arm in said control switch and wherein said member is provided with at least one notch in a position in which said indicating member engages said notch at a predetermined hour at which said control switch is to be operated.

8. A timekeeping device as claimed in claim 4, comprising a control switch, said indicator member comprising a movable arm of said control switch and said graduated member is provided with at least one notch in a position in which said indicating member engages said notch at a predetermined hour at which the control switch is to be operated.

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