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[54] AUTOMATIC CONTROL OF VENETIAN BLINDS IN RESPONSE TO BOTH HEAT AND LIGHT BEING BELOW RESPECTIVE THRESHOLD VALUES

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[30] **Foreign Application Priority Data**

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Aug. 29, 1969 Germany ..... G 69 33 965.7

[52] **U.S. Cl.** **250/83.3**, 49/25, 160/5, 160/6, 250/209, 250/236, 250/239

[51] **Int. Cl.** **E05f 15/20**, G01t 1/16, H01j 3/14

[58] **Field of Search** 49/25; 160/5, 6; 250/83.3, 250/239, 236, 209

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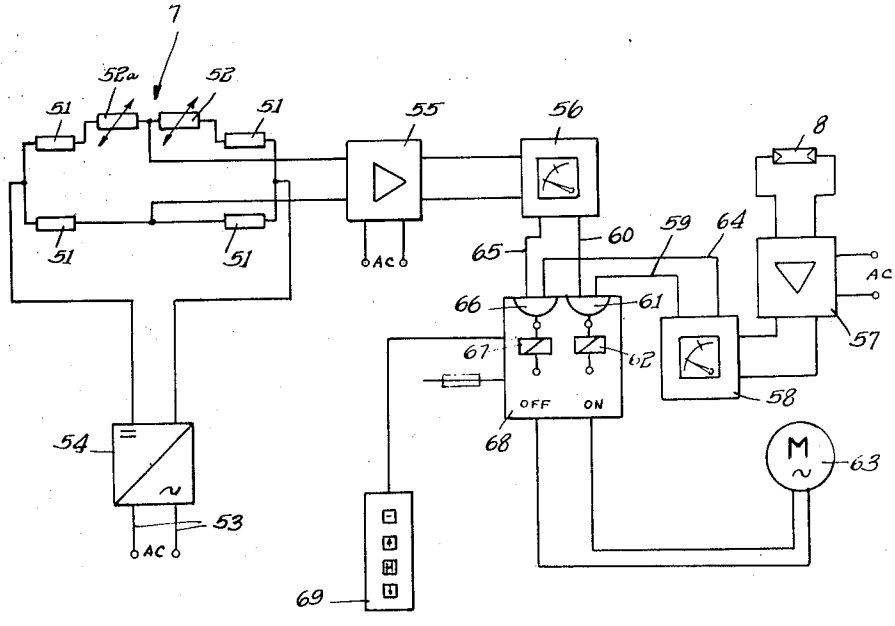
[57] **ABSTRACT**

Sensing devices respectively reacting to light intensity and to heat radiation are mounted in an exposed position such as on the top of a building. The sensing devices are oriented for direct exposure to sunlight according to the direction of the sunlight at different times of day, and operate through electronic control circuits to operate electric motors, and thereby to control the amount of sunlight admitted through windows on various sides of the building by adjusting the venetian blinds in the windows.

8 Claims, 9 Drawing Figures



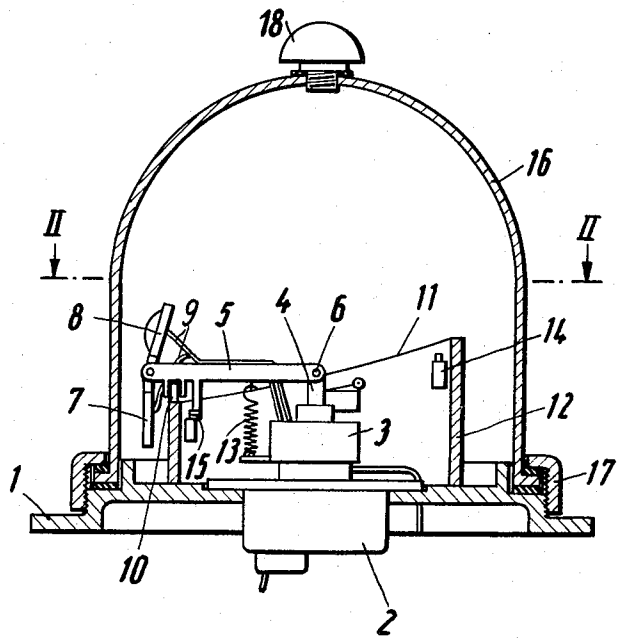


Fig. 1

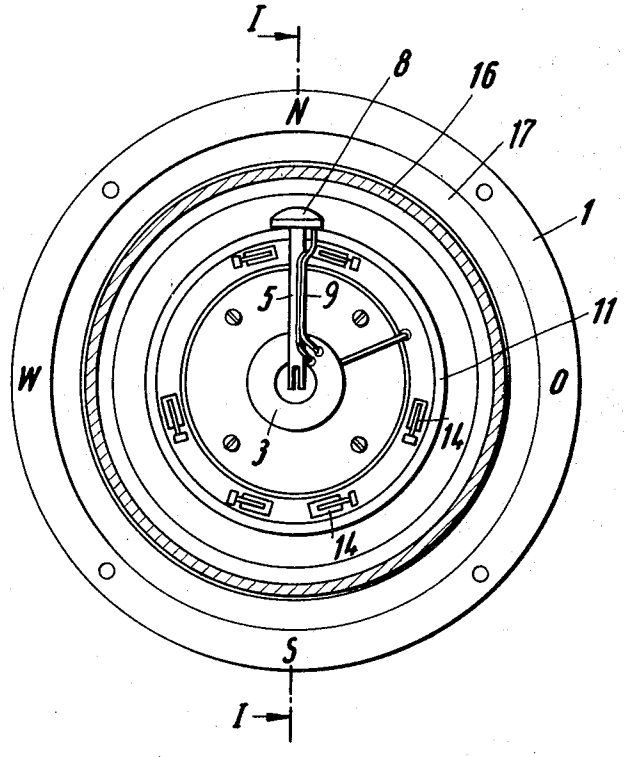


Fig. 2

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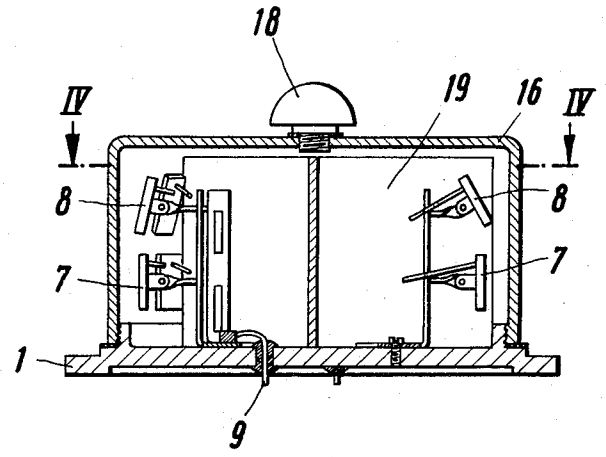

Fig. 3

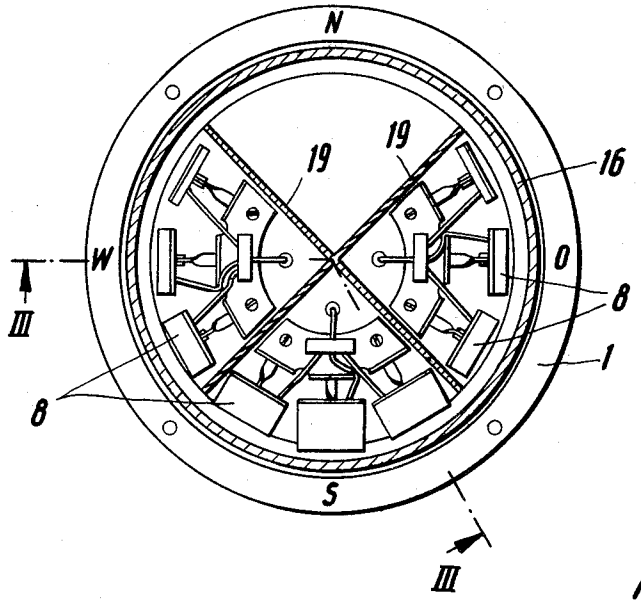

Fig. 4

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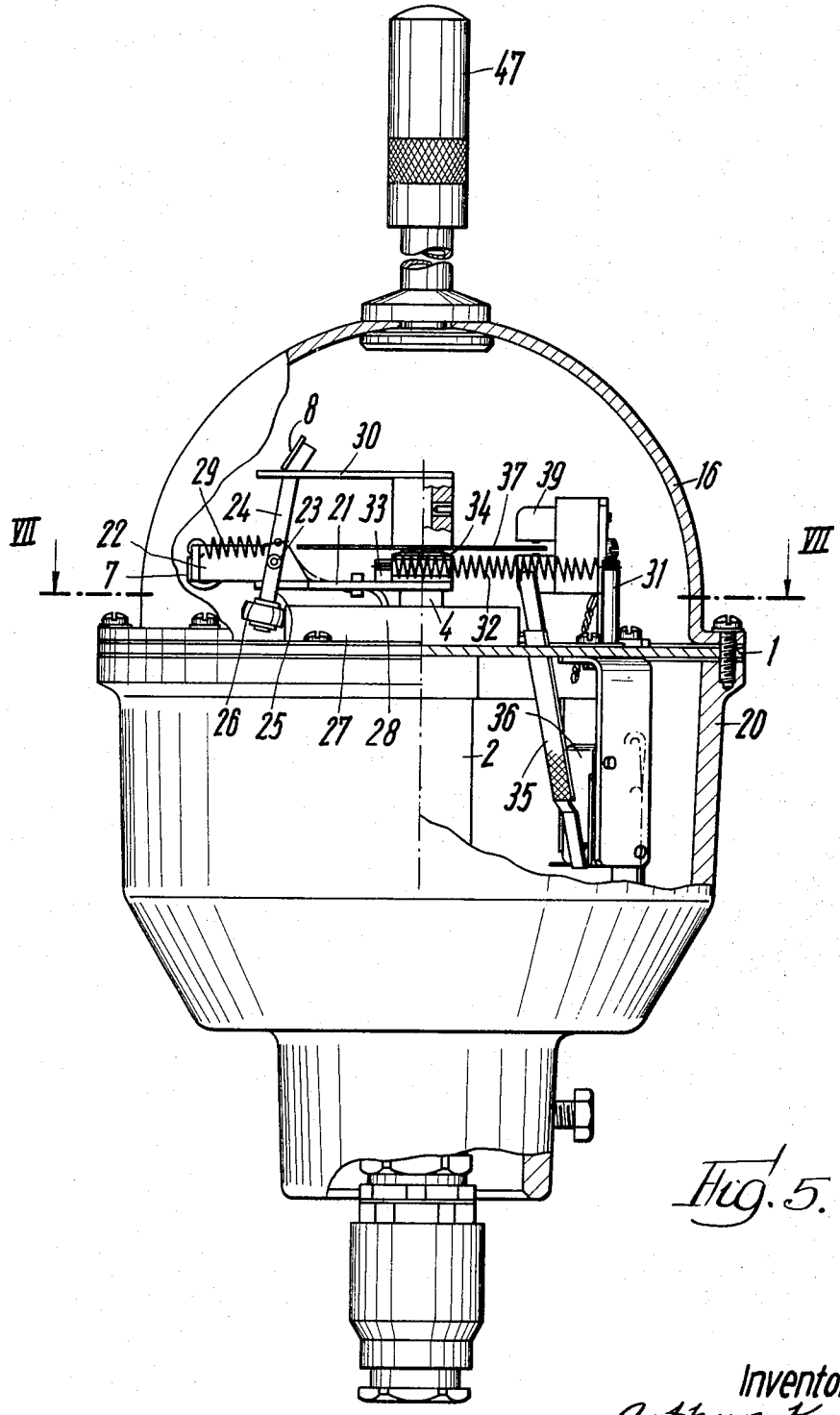

Fig. 5.

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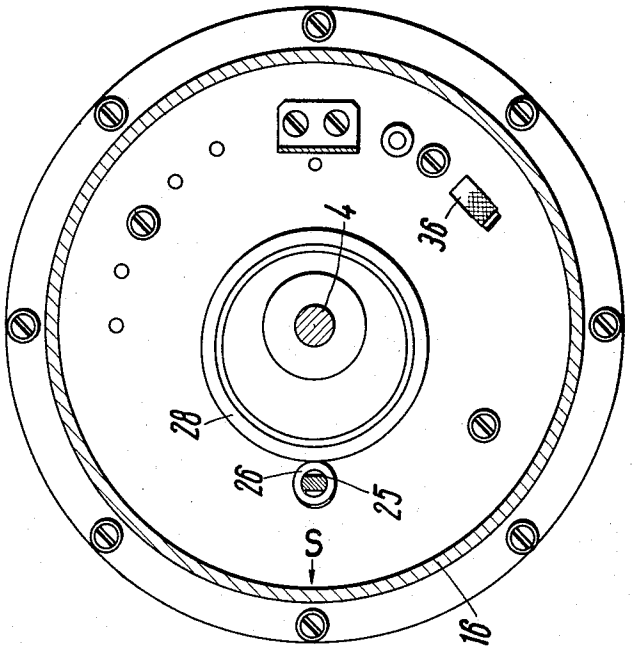

Fig. 7.

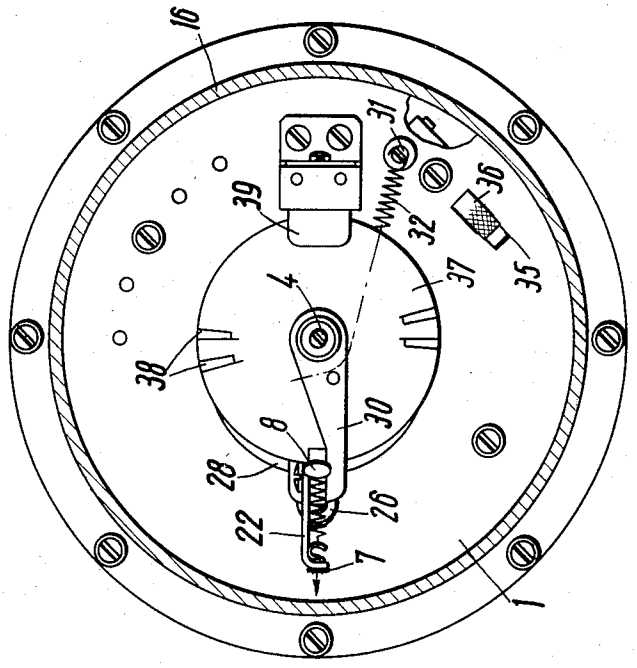

Fig. 6.

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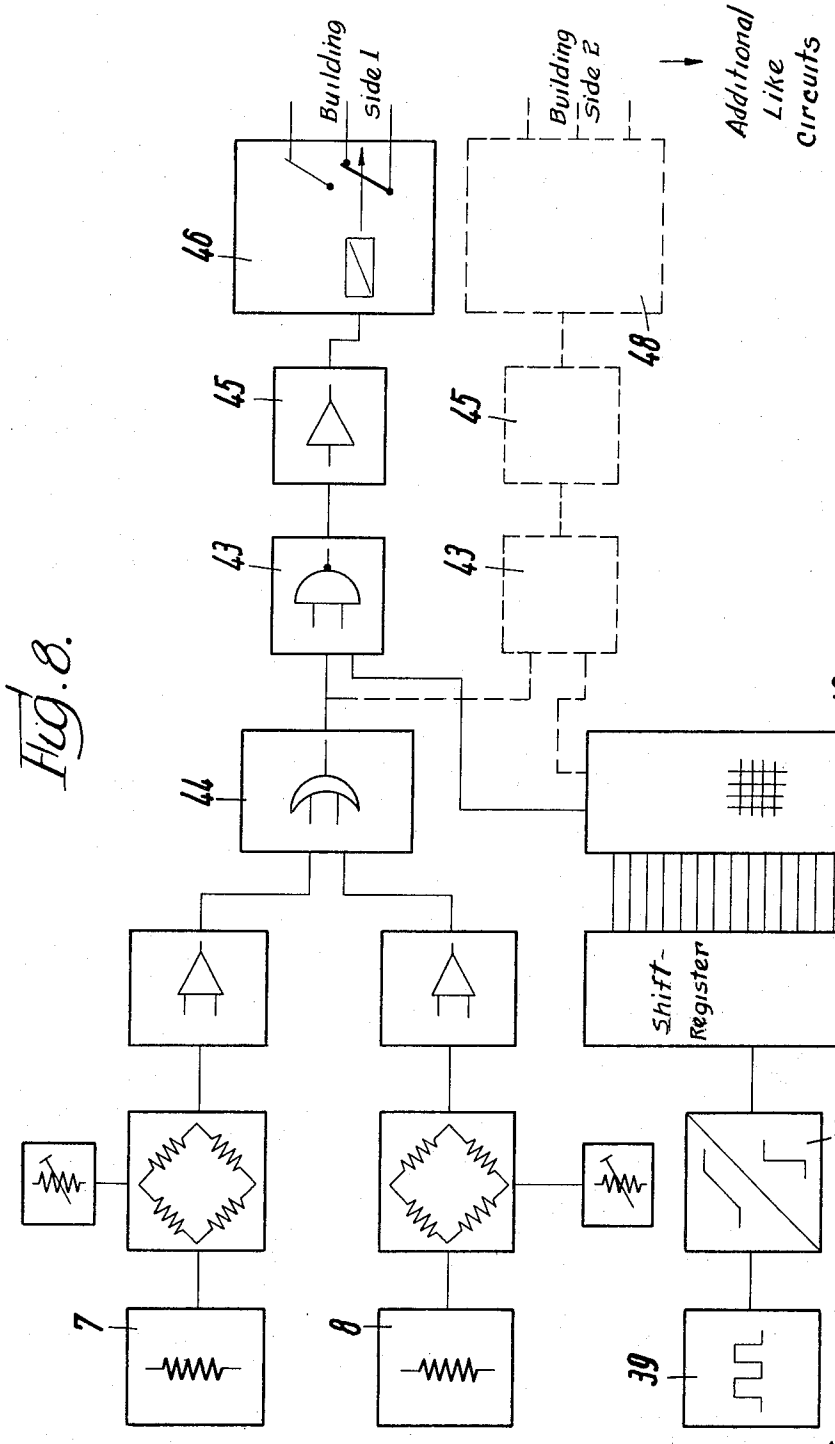

Fig. 8.

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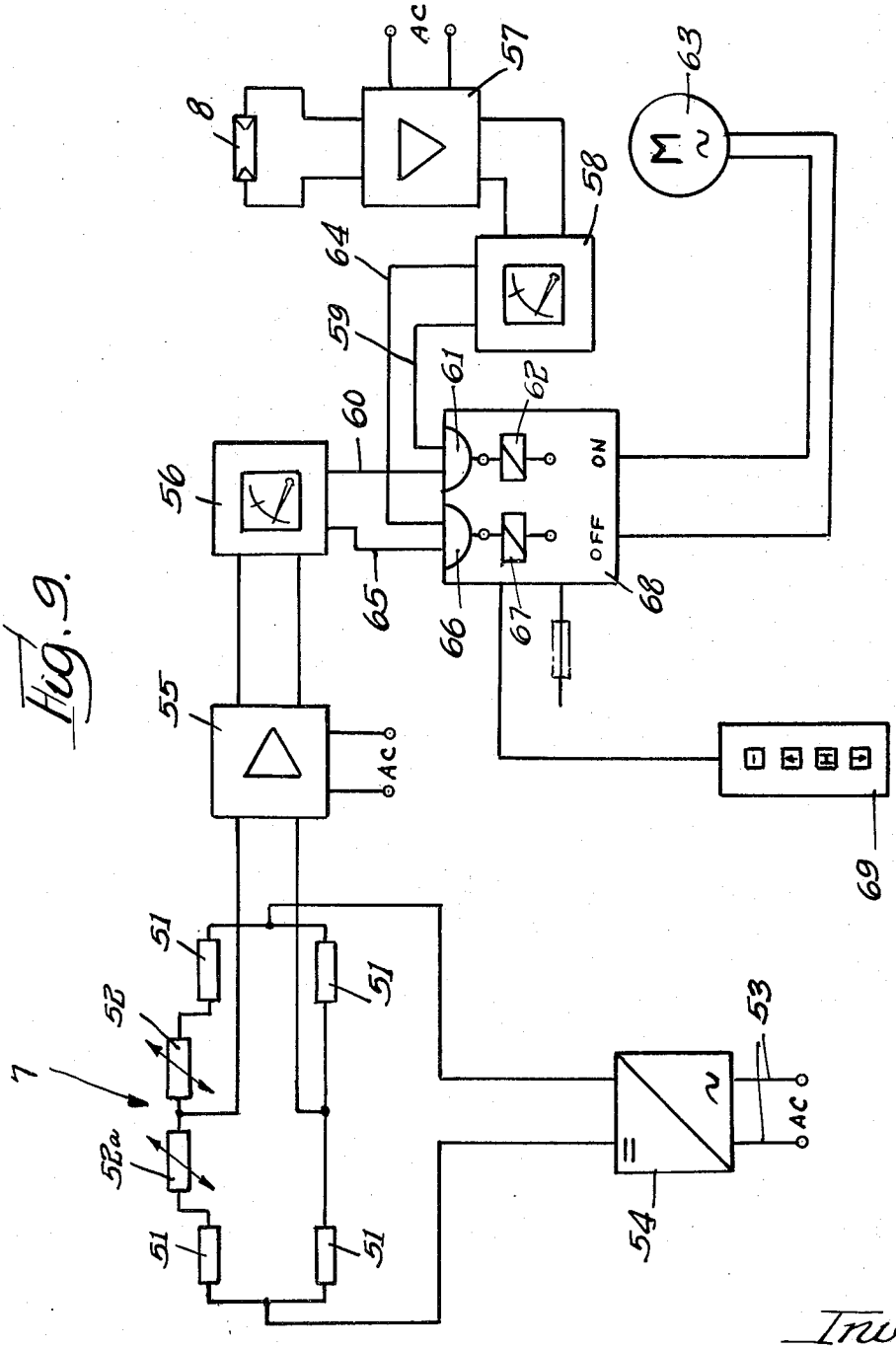

Fig. 9.

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AUTOMATIC CONTROL OF VENETIAN BLINDS IN RESPONSE TO BOTH HEAT AND LIGHT BEING BELOW RESPECTIVE THRESHOLD VALUES

As will be appreciated, sunlight entering the windows of the building varies from time-to-time throughout the day according to the direction in which the windows face. When direct sunlight is not on a particular wall, it is desired that as much light be admitted as possible (under most circumstances), while when the sunlight is streaming directly on a particular wall, it is desired that the window be shaded in some manner to prevent undue buildup of heat in a room.

Accordingly, the present invention is concerned with a measuring or sensing apparatus for the automatic control of venetian blinds or the like, whereby the blinds are automatically set to admit a maximum degree of light, or some amount of light less than the maximum, down to a minimum. Two sensing devices are employed, one of which is essentially sensitive only to light radiation, while the other is essentially sensitive only to heat radiation. The sensing devices are connected through an electronic circuit having predetermined thresholds for light intensity and for heat radiation, which thresholds are set independently, with an electric motor being operable when either threshold is exceeded to adjust the venetian blind to control the amount of sunlight passed thereby.

The intensity of light from the sun varies from day-to-day due to local atmospheric conditions, and also varies with the seasons, fluctuating between roughly 40,000 Lux and 90,000 Lux. The angle of incidence of the light radiation on the sensing device has a significant effect on the output of the sensing device.

In accordance with the present invention, two sensing devices or transmitters, respectively sensitive to light radiation and to heat intensity, are located within a housing atop one another, with the sensing devices, if desired, lying in a common vertical plane. In accordance with one preferred embodiment of the invention, the sensing devices are movably mounted on a support which is driven by a motor having an output shaft which turns one revolution in 24 hours. In this manner the sensing devices are controlled by the driving motor to follow the sun so that the direct radiation of the sun will always be located in the plane of the sensing devices.

In accordance with a second embodiment of the invention, several pairs of sensing devices are mounted in angularly spaced vertical planes so that the sunlight will successively fall in one or the other, to a greater or lesser degree, of the vertical planes and will act correspondingly upon the sensing devices.

Preferably the sensing devices are inclined so as to be aimed generally in the direction of the sun. In the embodiment of the invention wherein the sensing devices are turned about a vertical axis, the support for the sensing devices is provided with a lever tiltable about a horizontal axis. The sensing devices are carried by the lever, and the other end of the lever follows a curved path, i.e. a cam track whereby the sensing devices will be tilted toward the seasonal mean height of the sun's position in the corresponding radial direction. As an extension thereof, the lever is located at the free end of the support and is driven by an entrainment or driving arm attached to the motor output shaft. This latter arm engages the lever to turn the lever about the vertical axis of the motor shaft against the force of a spring. In due course the action of the cam causes the lever to escape from the entrainment or driving arm whereby the lever is pulled back by the spring into its rest position to be picked up by the driving arm during its next cycle of rotation. In this manner, the sensing devices do not point to the North (in the Northern hemisphere).

Development of the invention wherein the sensing devices turn about a driven shaft, an impulse transmitting disc is provided having means thereon for generating control pulses during the scanning cycle. These pulses are fed into a shift register, the output connections of which are located at the lines of a switching matrix which controls the operation of the motors for operating the various venetian blinds.

As will be appreciated, ordinary shades could be used which would be run up and down in the window. However, it is preferred in the present invention to use venetian blinds, and when venetian blinds are used, then additional shift registers are provided for controlling motors which adjust the angle of the slats in the blinds to desired values. Thus, both the height and the slat angle of venetian blinds can be adjusted.

The invention will be readily understood when taken in connection with the accompanying drawings wherein:

FIG. **1** is a vertical section through one embodiment of the control apparatus in accordance with the present invention;

FIG. **2** is a horizontal section therethrough taken along the line II—II;

FIG. **3** is a vertical section similar to FIG. **1** and taken along the line III—III in FIG. **4**;

FIG. **4** is a horizontal section taken substantially along the line IV—IV of FIG. **3**;

FIG. **5** is a vertical section similar to FIG. **1** of yet another embodiment of the present invention with portions of the housing cut away or broken away more clearly to show the interior parts;

FIG. **6** is a horizontal sectional view corresponding to FIG. **5** and generally similar to FIGS. **2** and **4**;

FIG. **7** is a horizontal sectional view taken along the line VII—VII in FIG. **5**;

FIG. **8** is a schematic or block diagram of the electronic control associated with the foregoing apparatus; and,

FIG. **9** is a further schematic or block diagram illustrating further aspects of the electronic circuitry of the present invention.

Turning now to FIGS. **1** and **2**, the sensing apparatus includes a circular base plate **1** which may be secured for example to the horizontal roof of a building according to the proper compass directions seen in FIG. **2**. A small synchronous motor **2** is mounted on the base plate **1** and is provided with a gear reducer **3** having a driven or output shaft **4** which makes one full revolution each 24 hours.

A lever **5** is mounted on the end of the shaft **4** for turning therewith and tiltable up and down about a horizontal axis **6** intersecting the axis of the shaft **4** at right angles thereto. The lever **5** is disposed radially of the driven shaft **4** and lies in a generally horizontal position. At its outer or free end the lever **5** carries a sensing device or signal transmitter **7** which is sensitive essentially only to thermal radiation, and is, for example, a lead-sulfide cell. Above the sensing device **7** and also mounted on the lever **5** is a second sensing device or signal transmitter **8** which is essentially sensitive only to light radiation, and is, for example, a cadmium sulfide photoelectric resistor, or a selenium cell. The sensing devices **7** and **8** are essentially located in a vertical plane which is determined by the vertical shaft **4** and the essentially horizontal lever **5**. Leads **9** are connected to the sensing devices and extend to an electronic circuit to be discussed hereinafter for effecting the desired control. The sensing device **8** preferably is equipped with a lens whereby the effect of the light from the sun is essentially uniform on the cell regardless of the angle of inclination of the sun, within certain limits.

Near its outer end the lever **5** is provided with a roller **10** which turns about an axis lying in the common plane heretofore mentioned. The roller **10** rides on top of the edge **11** of a cylindrical cam **12** as the lever **5** turns about the shaft **4**. The height of the cam **12** differs about its extent so that the top edge **11** is inclined with respect to the vertical. Thus, as the lever **5** turns about the shaft **4**, it is tipped up and down about the axis **6** so that the sensing devices **7** and **8** are correspondingly tipped to different inclinations with respect to the vertical. The inclination is such that the angle of the lever **5** will correspond with the average height of the sun for any given compass direction. The average height of the sun is determined by the highest and lowest angular position of the sun (rectascension) during the annual course of the sun. A spring **13** pulls down on the lever **5** and holds the roller **10** in engagement with the upper edge or cam track **11** of the cam cylinder **12**.

Several microswitches **14** are angularly positioned about the interior of the wall of the cylinder **12** to switch the control devices for the various shades or venetian blinds. These switches are successively actuated by a projection **15** carried on the lever relatively near the outer end. For example, when the sun is in the South and shines on the South side of the building, the switch or switches in the South portion of the apparatus are operated. As the sun, and also the lever **5**, move from South to West, then the switches moving from the South to the West are sequentially operated. As will be understood, the shades or blinds are opened corresponding to the switches which the projection **15** leaves, and are closed corresponding to the switches which the projection reaches.

The parts heretofore described are covered by a transparent bell or housing **16** which allows passage of both light and thermal radiation. A cap screw **17** is provided which overlies a horizontal peripheral flange on the bell housing and threads onto the base **1** for sealing the bell to the base with suitable gaskets. A ventilation device **18** is provided at the top of the bell housing **16** which excludes dust and water, and prevents condensation from forming within the housing.

A modification of the invention is shown in FIGS. **3** and **4**, and like numerals are used to identify similar parts, thereby to avoid prolixity of description. The essential difference in the embodiment of FIGS. **3** and **4** is that there is provided a plurality of pairs of sensing devices **7** and **8** in fixed, stationary position about the base plate **1**. The sensing devices are arranged so that there are three pairs of each facing toward the East, three pairs toward the South, and three pairs toward the West. No sensing devices are provided in the Northern quadrant for installations in the Northern hemisphere. Obviously, in the Southern hemisphere, the situation would be reversed and it would be the South quadrant that would be open. The groups are separated by radial right angularly disposed walls **19**. The sensing devices are differently inclined depending upon the compass direction. As will be understood, the sun is highest in the South, and is relatively low in the East and West, whereby the sensing devices in the South quadrant are tilted up at a greater angle of inclination than those in the East and West quadrants.

A preferred embodiment of the invention is shown in FIGS. **5–7** which is generally similar to FIG. **1**, like numerals again being used to identify similar parts. The base plate **1** in this instance serves as a closure for a lower portion **20** of a housing. The synchronous motor and gear drive **2** are mounted in the lower portion of the housing, and a rigid support is fixed on the output or drive shaft **4**. An upstanding flag or fin **22** is fixed on the outer end of the rigid support **21** and carries the sensing device **7** for sensing thermal radiation. A trunnion **23** is provided adjacent the outer end of the rigid support **21** and tiltably carries a lever **24** the sensing device **8** for receiving light radiation. A lower extension **25** of the lever **24** carries a roller **26** which runs along the outer face **27** of a cam **28** arranged eccentrically with respect to the axis of the shaft **4**, as best may be seen in FIG. **7**. A spring **29** biases the lever **24** about the trunnion **23** to hold the roller **26** against the cam face.

At the upper or free end of the driven shaft **4** there is fixed an entrainment or driving arm **30** which engages beneath the sensing device **8** against the lever **24**, and therefore drives the lever and hence the support **21**. As will be seen in FIGS. **5** and **6**, with the lever **24** tilted in by the cam **28** the lever is in position for engagement by the arm **30**. However, in the course of turning of the shaft **4**, the lever **24** gradually tilts outwardly, and eventually passes beyond the end of the driving arm **30**, so that the lever **24** and support **21** are no longer driven by the arm **30**. A spring **32** extends between a fixed anchor **31** upstanding from the base plate **1** and a peg **33** on the support **21**. This spring is extended as the support **21** turns. Thus, when the lever **24** passes beyond the end of the arm **30**, the support **21** is returned by the spring **32** to an initial or rest position. In this position the support **21** engages the actuating arm **35** of a microswitch **36**. The entrainment or driving arm **30** continues its rotation, and the following morning will again pick up the lever **24** and drive the lever and the support **21** in rotation, as hereto-fore noted. In this connection, it will be obvious that the support **21** is rotatable about but independently of the shaft **4**, and is not fixed to the shaft.

In accordance with the construction of FIGS. **5–7**, it is not necessary to have a slip ring for transmitting electric signals from the sensing devices to the amplifier and other electronic portions of the circuit, thereby increasing the reliability of the apparatus.

As will be appreciated, the parts are dimensioned so that the lever **24** drops off the arm **30** about at, or preferably slightly after sunset, and is picked up again about at or slightly before sunrise the next morning. Actuation of the microswitch **36** switches the control circuit described hereinafter to a starting condition.

In addition to the foregoing, an impulse transmitting disc **37** is fixed to the shaft **4** and turns with the arm **30**. The marks or indicia **38** on the disc move past the readout head of a scanning device **39**, whereby a signal is transmitted each time a mark passes the readout head. Typically, the markers **38** are spaced such that one hour will pass between two successive impulses (see FIG. **6**).

A thermostatically regulated electric heating device (not shown) is mounted in the bottom portion **20** of the housing and maintains the temperature within the housing at a predetermined degree, thereby ensuring proper operation of the sensing device.

A screw threaded cap **47** forms the upper closure of a ventilating device at the top of the bell housing **16** and may be removed to permit insertion of a screwdriver for adjusting the setting of the entrainment or driving arm **30** and of other parts.

An electronic circuit is illustrated in schematic or block diagram form in FIG. **8** showing utilization of the time impulses and also the signals from the sensing devices. The scanning device **39** provides a series of pulses, as heretofore noted, and these are provided to an impulse generating stage **40**, such, for example, as a Schmitt trigger circuit, the output of which is connected to a shift register **41** in which a positive or one signal causes the register to shift. The outputs of the shift register **41** are connected to a switching matrix **42**, the output of which is connected to an AND gate **43**. The AND gate **43** also receives a signal from an OR gate **44**. The OR gate in turn has its inputs connected to amplifiers receiving signals from bridge networks which in turn receive the signals from the sensing devices **7** and **8**, about which more will be noted hereinafter with regard to FIG. **9**.

A signal at the output side of the AND gate **43** is supplied to an amplifier **45**, and the output thereof is connected to a control mechanism **46** including a switching relay for operating a motor drive for a venetian blind.

The AND gates **43**, etc. are duplicated, there being one such AND gate and following parts for each side of the building being controlled, although only one such is shown in broken lines in FIG. **8**. The precise manner in which the venetian blinds are run up and down, or the slats thereof are tilted is known in the prior art, and therefore is not shown herein.

Turning now to FIG. **9**, the heat radiation sensor or sensing device **7** will be seen to comprise a Wheat Stone bridge having fixed resistors **51** in the four arms thereof. Two of the arms further are provided with thermal resistors **52** and **52***a*. One of the thermal resistors, such as resistor **52**, serves as a reference and has a highly polished and reflecting outer surface, while the other thermal resistor, such as resistor **52***a*, has a non-reflecting blackened surface and absorbs heat radiation so that the bridge arms including the resistors **52** and **52***a* may have different resistances. Power is supplied to the bridge from AC lines **53** through a rectifying device **54**. The bridge will have an output depending on the amount of heat radiation absorbed, and this output is applied to an amplifier **55**. The output of the amplifier **55** is applied to a limiting means **56** which preferably is adjustable.

The light sensitive device 8 comprises a photoelectric cell, and this is connected to an amplifier 57 with the output of the amplifier being connected to a limiting means 58.

When the outputs of the limiting means 58 and 56 exceed predetermined limit values, output lines 59 and 60 operate in OR-gate 61 to which they are connected to actuate a switch relay 62, and thereby to operate a drive motor 63 for controlling a venetian blind (not shown) to close the blind.

There are also output lines 64 and 65 from the limiting devices which are connected to an OR-gate 66. When the voltages applied to the limiting means drop below a predetermined limit value output voltages appear on the lines 64 and 65 to actuate the OR-gate 66 and thereby to operate the switch relay 67 to operate the motor 63 in a reverse sense, and thereby to open the venetian blind.

Gates 61 and 66 together with the switching relays 62 and 67 constitute an automatic control means 68 which is supplemented by a manual control device 69. The manual control device is provided with a plurality of push buttons to effect up and down movement of the venetian blinds, and also tilting of the slats thereof. Operation of the manual push buttons may automatically override the automatic control circuit 68, or means may be provided for first turning the automatic control circuit on or off.

The specific examples of the invention as herein shown and described are for illustrative purposes only. Various changes in structure will no doubt occur to those skilled in the art and will be understood as forming a part of the present invention insofar as they fall within the spirit and scope of the appended claims.

The invention is claimed as follows:

1. A control apparatus for motor operated venetian blinds comprising, a motor drivingly connected to the venetian blinds to be controlled to operate the same in accordance with the amount of external light to be allowed to pass such venetian blinds, a first sensing means essentially sensitive to light radiation, a second sensing means essentially sensitive to heat radiation, said first and second sensing means being disposed adjacent one another to receive light and heat radiation from the sun, control circuit means having first and second input means connected respectively to said first and second sensing means and an output means connected to said motor to control energization thereof, said first input means having a first threshold value which said first sensing means must exceed, said second input means having a second threshold value which said second sensing means must exceed, said motor being rendered operative upon exceeding either said first or second threshold values to close the venetian blinds and being rendered operative in an opposite direction to open the venetian blinds only when both said first and second sensing means produce a signal below their corresponding threshold values.

2. The control apparatus of claim 1 wherein said first and second sensing means are arranged in a plurality of pairs, each pair having one sensing unit above the other and each pair being angularly displaced relative to one another.

3. The control apparatus of claim 2 wherein said first sensing means has sensing units mounted above the sensing units of said second sensing means, and the sensing units of said first sensing means are mounted at an inclined angle in correspondence to the seasonal mean position of the sun.

4. The control apparatus of claim 2 further including a plurality of radial walls separating said plurality of pairs of first and second sensing means into at least three groups.

5. The control apparatus of claim 1 further including drive means to rotate said first and second sensing means at a rate of one revolution in 24 hours.

6. The control apparatus of claim 5 wherein said drive means includes a lever, pivotal means for tiltably mounting said lever about a horizontal axis, at least one of said first and second sensing means being mounted to said lever, at its free end, a cam surface positioned below said lever, and a cam follower extending downward from said lever to engage said cam surface, said cam surface effecting tilting of said lever and said sensing means connected thereto to be pointed up substantially to the seasonal mean height of the sun for any given arcuate position.

7. The control apparatus of claim 6 wherein said lever is mounted to a support plate which is free to rotate about a shaft of said drive means, and a driving arm secured to said shaft and extending therefrom to engage said lever to rotate the same and said support plate to a predetermined position at which said arm passes over said lever as a result of said cam surface and said cam follower, and spring means connected to said support plate to return the same to its initial position after reaching said predetermined position.

8. The control apparatus of claim 7 further including an impulse transmitting disc secured to and rotatable with said shaft, and circuit means co-acting with said disc to generate control impulses for a predetermined time interval to control respective different ones of a plurality of venetian blinds on different sides of a building depending on the time of day.

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