United States Patent [19]

Soeda

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[45] **May 29, 1973**

[54] **SPEED CONTROL DEVICE FOR SINGLE PHASE MOTORS**

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[21] Appl. No.: **188,273**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 139,567, May 3, 1971, abandoned.

[30] **Foreign Application Priority Data**

May 31, 1971 Japan 46/44923

[52] **U.S. Cl.** **318/245**, 318/345, 318/480

[51] **Int. Cl.** **H02p 5/28**

[58] **Field of Search** 318/331, 345, 480, 318/245

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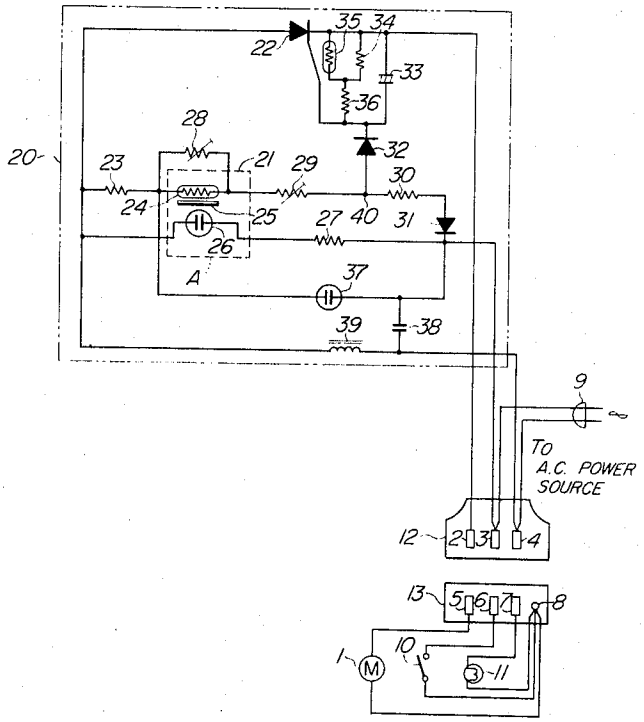
Primary Examiner—Gene Z. Rubinson

Attorney—James E. Armstrong and Harold C. Wegner

[57] **ABSTRACT**

A speed control device for single phase motors is disclosed, which comprises a thyristor connected in series with a motor, and a trigger signal generator means for controlling the triggering phase of the thyristor, said trigger signal generator means including a series circuit of a variable resistor means, a resistor and a rectifier connected between both terminals of an a-c source and a capacitor connected between the cathode of said thyristor and the connection of said variable resistance means and said resistor and also across the cathode and the anode of said thyristor. The variable resistor means includes a light source, a light-sensitive element facing the light source and having its resistance varied in accordance with the amount of incident light from the light source, and a movable shutter plate interposed between the light source and the light-sensitive element and capable of being moved between a position to interrupt the light from the light source and a position not to interrupt the light from the light source.

6 Claims, 5 Drawing Figures



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FIG. 1

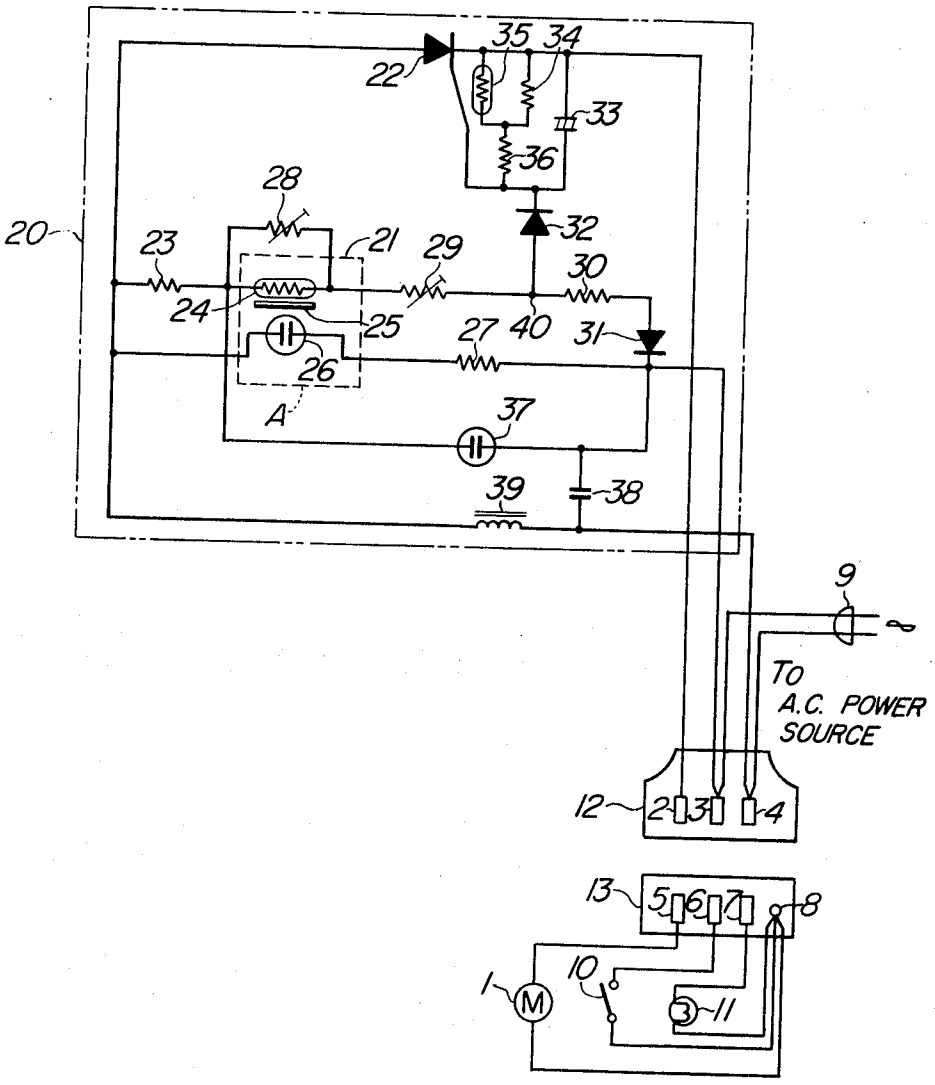


FIG. 2

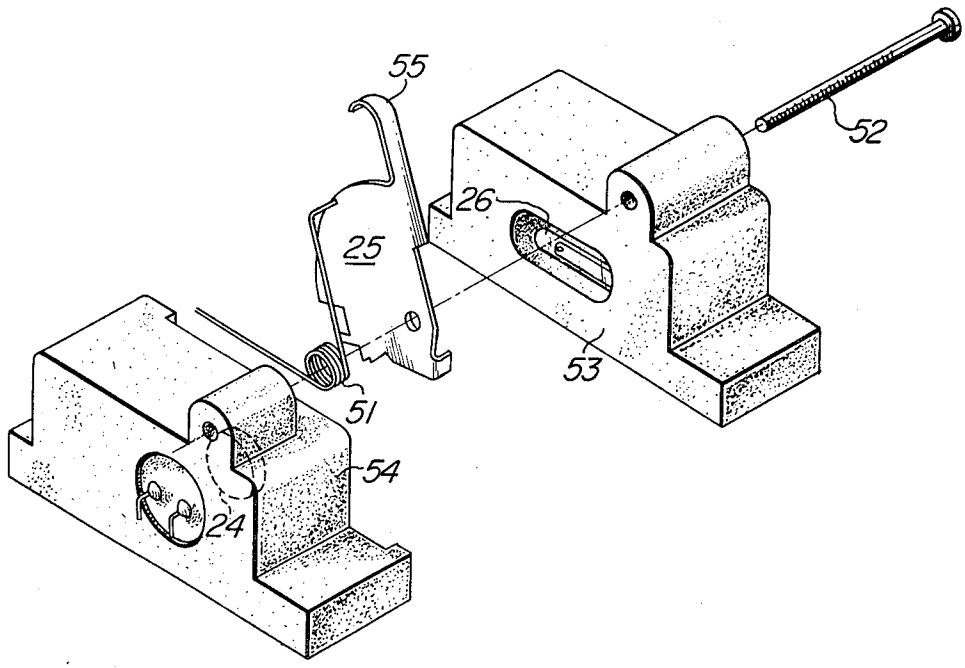


FIG. 3

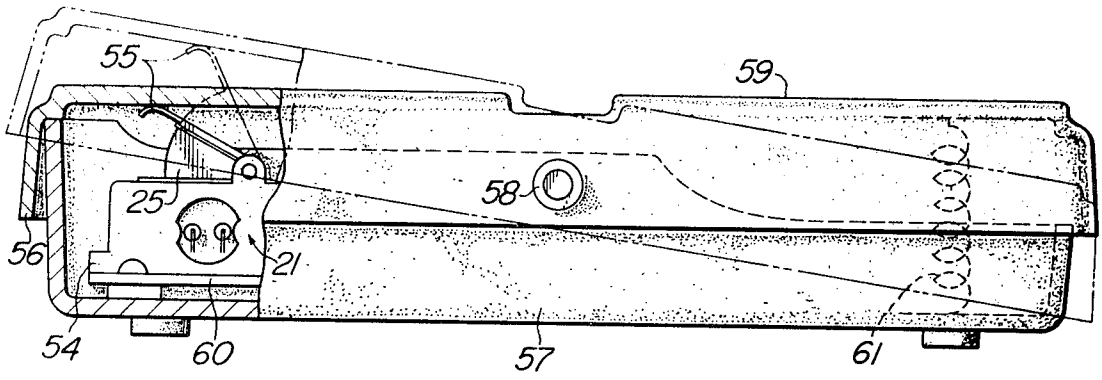


FIG. 4

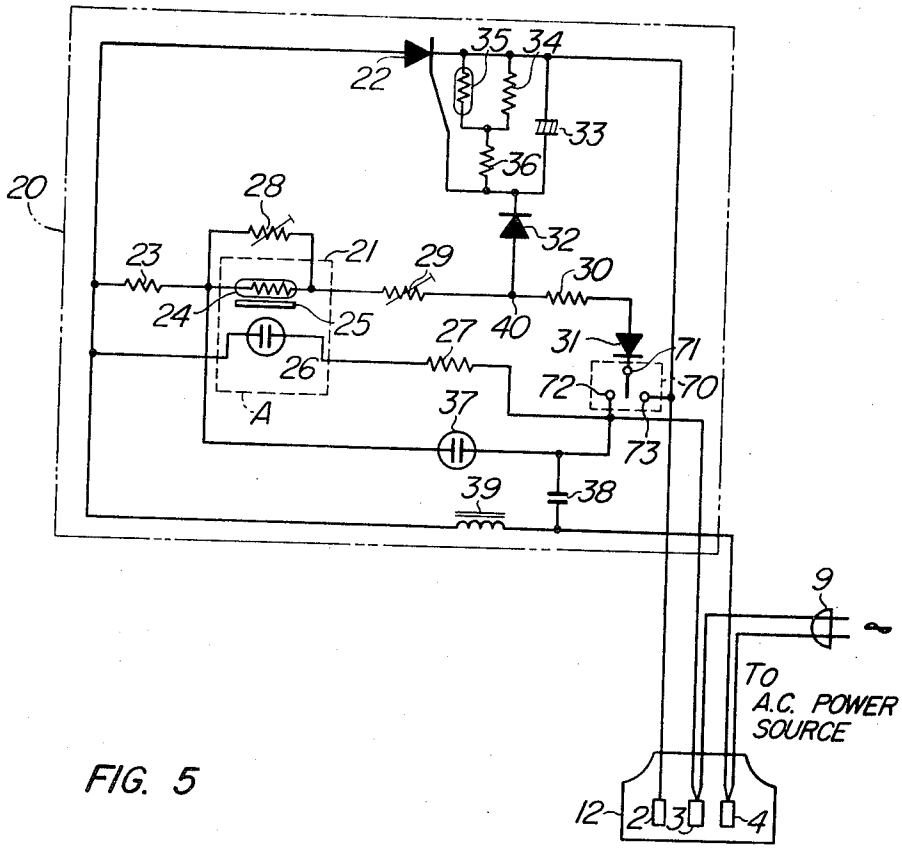
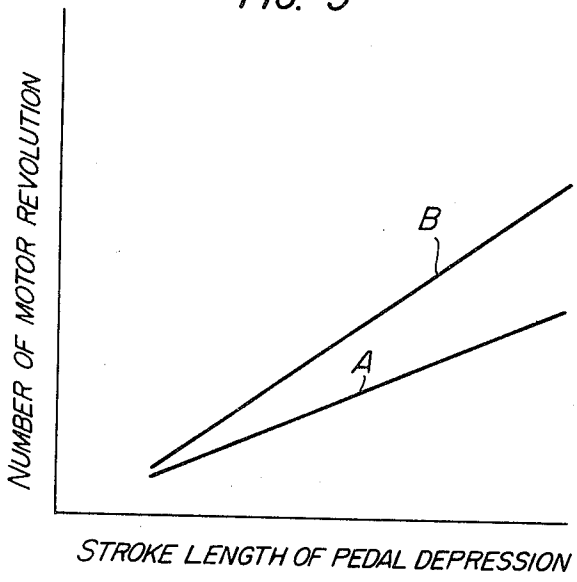

35
34
22
33
36
20
28
32
23
21
29
30
24
25
27
40
31
71
26
72
70
A
37
73
39
38
9
TO
A.C. POWER
SOURCE
12
2
3
4
13
5
6
7
8
1
10
M
3
11

FIG. 5


NUMBER OF MOTOR REVOLUTION
B
A
STROKE LENGTH OF PEDAL DEPRESSION

SPEED CONTROL DEVICE FOR SINGLE PHASE MOTORS

CROSS-REFERENCES TO RELATED APPLICATIONS

This application is a continuation-in-part of a co-pending U.S. Pat. Application Ser. No. 139,567 filed on May 3, 1971 by the same applicant and now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a speed control device for single phase motors and, more particularly, to speed control systems for controlling the speed of series-wound motors and universal motors by controlling the triggering phase of a thyristor.

2. Description of the Prior Art

Series-wound motors and universal motors have been extensively used as the drive of motor-driven household apparatus such as motor-driven sewing machines. Usually, the speed of these motors is controlled by varying the resistance of a carbon pile or coiled resistor connected between the motor and a power source.

However, this type of motor speed control by varying the source voltage by means of a series resistor inevitably leads to large power losses. Also, the speed control unit itself tends to be relatively large in size.

SUMMARY OF THE INVENTION

An object of this invention is to provide an improved speed control for single phase motors, which is compact in construction and is capable of reducing power losses.

The speed control system for single phase motors according to this invention comprises a thyristor connected in series with a motor, and a trigger signal generator for controlling the triggering phase of the thyristor, said trigger signal generator including a variable resistor means connected to an a-c source and adapted to provide a controlled voltage waveform and a series circuit having a rectifier and a capacitor, said thyristor being triggered in accordance with said controlled voltage waveform prevailing at its gate electrode.

In accordance with this invention, the afore-said variable resistor means is constituted by a light source, a light-sensitive element having its resistance varied in accordance with the quantity of incident light from said light source and a movable shutter plate intervening between said light source and movable between a position to interrupt the light from said light source and a position not to interrupt the light from said light source.

According to this invention, there is no need to connect a variable resistive means between the motor and a power source, so that the size of the speed control unit and the power loss may be reduced compared to the prior art speed control unit for single phase motors.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a circuit diagram of an embodiment of the speed control unit for single phase motors according to this invention.

FIG. 2 is an exploded perspective view of an example of the variable resistor means.

FIG. 3 is a side view, partly in section, showing the speed control unit according to this invention.

FIG. 4 is a circuit diagram of another embodiment of the speed control unit for single phase motors according to this invention.

FIG. 5 shows relation between the stroke length of pedal depression and the number of motor revolution.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows a preferred embodiment of the speed control according to this invention. Reference numeral **1** designates a series-wound motor or universal motor as the sewing machine drive. On the sewing machine proper, there are provided a power source switch **10** and a pilot lamp **11**. The leads of these parts are taken to a connector **13**. The main parts of the control unit are assembled in a casing as shcematically indicated by a dashed rectangle **20**. Leads from the speed control unit and leads from a connection plug **9** for connection to a power source are taken to a connector **12**. For the operation of the sewing machine, for instance, the connectors **12** and **13** are connected together and the connection plug **9** is inserted into a receptacle leading to a power source. The connector **12** has terminals **3** and **4** connected to the connection plug **9**. A circuit leading from the terminal **3** through a terminal **6** of the connector **13**, the power source switch **10**, a terminal **8** of the connector **13**, the motor **1**, a terminal **5** of the connector **13**, a terminal **2** of the connector **12**, a thyristor **22**, and a noise elimination coil **39** to the terminal **4** constitutes a power circuit for the motor **1**. Between the terminals **3** and **4** is connected a series circuit of a resistor **23**, a light-sensitive element (C*d*S) **24**, a variable resistor **29**, a resistor **30** and a diode **31**. The connection point **40** between variable resistor **29** and resistor **30** is connected through a diode **32**, a capacitor **33** and the connector terminals **2** and **5** to one side of the motor **1**. The capacitor **33** is connected between the cathode and gate of the thyristor **22**. It is also connected in parallel with a circuit of a thermistor **35** and resistors **34** and **36**. A variable resistor **28** is connected in parallel with the C*d*S **24**.

The C*d*S **24**, a fluorescent lamp **26** connected between the terminals **3** and **4** of the connector **12** and a movable shutter plate **25** are assembled together to constitute a variable resistive means as is enclosed within a dashed rectangle **21**.

FIG. 2 shows the variable resistive means in detail. The C*d*S **24** and fluorescent lamp **26** are mounted in respective mounts **54** and **53** such that they face each other. Interposed between these mounts **54** and **53** is the movable shutter plate **25** which is secured to an arm member **55** rotatable about a pin **52**. When the arm **55** is rotated by a spring **51** in the clockwise direction, a movable shutter plate **25** is moved to a position not to interrupt the light flux from the fluorescent lamp **26** directed toward the C*d*S **24**. With the clockwise rotation of the arm member **55**, the movable shutter plate **25** comes to assume a position to interrupt the light directed from the lamp toward the C*d*S. The internal resistance of the C*d*S being varied by varying the quantity of light incident on the C*d*S.

In the operation of the motor speed control unit of the above construction, when the power source switch **10** is closed after connecting the connectors **12** and **13** and inserting the connection plug **9** into a power source receptacle, the pilot lamp **11** is turned on, indicating that the power source voltage prevails.

At the same time, current is caused to pass through the resistor **23**, C*d*S **24**, variable resistor **29**, resistor **30** and diode **31**, so that a predetermined voltage appears on the connection point **40**. Since the motor **1** remains still at this time, the voltage drop across it is zero and the terminals **2** and **3** are at the same potential. Thus, during the half source cycle during which the potential of the terminal **4** is positive, the potential on the connection point **40** is higher than that of the terminal **2**, so that the capacitor **33** is charged. The voltage developed across the capacitor **33** has a phase and an amplitude determined by the capacitance of the capacitor **33** and the resistance values of the resistors **23, 29, 30** and the C*d*S **24**. This voltage is applied to the gate of the thyristor **22**.

Meanwhile, the movable shutter plate **25** normally assumes a position to interrupt the light flux from the fluorescent lamp **26**, so that the C*d*S **24** normally offers a maximum resistance. Under this condition, the potential on the connection point **40** is too low to develop a sufficient voltage across the capacitor **33** to trigger the thyristor **22**. This is so arranged by appropriately selecting the resistance of the resistor **23**, variable resistors **28** and **29** and resistor **30**.

With the movement of the movable shutter plate **25** as the arm member is rotated by the spring force in the clockwise direction in FIG. **2**, the quantity of light incident on the C*d*S **24** progressively increases to decrease the resistance thereof, thus increasing the potential on the connection point **40** to increase the voltage across the capacitor **33** and simultaneously to lead the phase thereof. Consequently, when the anode of the thyristor **22** is applied with a positive half cycle of the source voltage and simultaneously the movable shutter plate **25** is rotated to a point where the voltage across the capacitor **33**, i.e. the voltage applied to the gate of the thyristor **22**, has a value sufficient to trigger the thyristor **22**, the thyristor **22** is triggered to start the motor **1**. When the motor is started, a voltage proportional to the motor speed is induced to change the potential of the terminal **2**. With the changing potential of the terminal **2** the waveform of the terminal voltage across the capacitor **33** changes accordingly, thus changing the triggering phase of the thyristor **22**. The waveform of the voltage across the capacitor **33** depends upon the relation between the potential on the connection point **40** and the potential on the terminal **2** which depends upon the motor speed, while the motor current, which determines the motor speed, depends upon the trigger angle of the thyristor **22**, which in turn depends upon the voltage across the capacitor **33**. Accordingly, the motor speed is dependent upon the potential at the point **40**. When the movable shutter plate **25** is further revolved in the clockwise direction, the potential on the connection point **40** is raised to increase the motor speed upto a value where the above relation is satisfied.

In the embodiment of FIG. **1**, a constant voltage discharge tube **37** such as a neon lamp is provided. By virtue of this tube the peak value of the potential on the connection point **40** is constant irrespective of fluctuations of the source voltage, so that a reliable motor speed control can be ensured. The variable resistor **28** connected in parallel with the C*d*S **24** may be appropriately adjusted such that the motor **1** is started when the movable shutter plate **25** comes to a desired position. The variable resistor **29** is provided for adjusting the maximum motor speed.

As described earlier, in a half cycle of the source voltage during which the potential of the terminal **4** is positive the thyristor **22** is triggered to cause the motor current to flow. During the subsequent half cycle during which the potential of the terminal **4** is negative, the thyristor **22** is of course "off", and during this time the charge on the capacitor **33** is discharged through the discharging circuits of resistors **34, 35** and **36**.

The thermistor **35** is closely fixed to the thyristor **22**, so that a temperature rise of the thyristor **22** causes a similar temperature change of the thermistor **35**. Thus, when the trigger characteristic of the thyristor **22** changes due to a temperature rise thereof, it is compensated for by the corresponding change of the resistance of the thermistor **35**. With an increase in the temperature of the thermistor **35**, its resistance decreases to decrease the potential on the connection point **40**, thus decreasing the voltage developed across the capacitor **33**, since the charging current into the capacitor **33** depends upon the difference between the potential on the connection point **40** and the potential on the terminal **2**. In this manner, change of the operating point of the thyristor **22** due to a temperature rise thereof can be compensated for.

FIG. **4** shows a circuit diagram of another embodiment according to the present invention. In the embodiment as shown in FIG. **1**, the trigger signal of the thyristor **22** is affected by the induced voltage of the motor **1** and hence, the control characteristics of the circuit are excellent in a relatively low speed range, but not so in a high speed range. The circuit in FIG. **4** is aimed at improvement of the control characteristics in the high speed range. In FIG. **4**, a switch means **70** is provided so that the cathode of the diode **31** is selectively connected through a contact **71** to a contact **72** which is connected to the terminal **2** or to a contact **73** which is taken directly to the cathode of the thyristor **22**. When the contacts **71** and **72** are closed and the contacts **71** and **73** are opened, the circuit is entirely the same as that in FIG. **1**. When the contacts **71** and **72** are opened and the contacts **71** and **73** are closed, the cathode of the thyristor **22** is connected to the gate thereof through the diode **31**, the resistor **30** and the diode **32**. Thus, the motor circuit is not included in the gate circuit of the thyristor **22** and consequently, the trigger signal of the thyristor **22** is not affected by the induced voltage of the motor **1**, but only dependent on the resistance value of the C*d*S **24**, which results in improvement of the control characteristic in a high speed range. FIG. **5** shows the relation between the number of motor revolutions and the stroke length of pedal depression which determins the resistance value of the C*d*S **24**. When the contacts **71** and **72** are closed, the number of motor revolutions is represented by curve A and when the contacts **71** and **73** are closed, represented by curve B. Thus, the control characteristics in the high speed range is greatly improved by changing the connection of the cathode of diode **31**.

FIG. **3** shows the mechanical construction of the control unit described above. Various circuit components of the control unit are assembled on a base plate **60** and housed in a casing **57** with a cover **56**. The cover **56** is pivotally attached to the casing **57** by a pin **58** so as to be adaptable to serve as a pedal. The afore-mentioned variable resistive means **21** is secured to the casing **57**. The arm member **55** carrying the movable shutter plate **25** is urged by the spring **51** in the clockwise direction.

Its free end is urged against the inner surface of the cover **56**, and it is usually held in a position as indicated by solid lines by force of a spring **61**. In this position of the arm member **55**, the movable shutter plate **25** completely shuts the light flux from the light source **26** and no light flux is incident on the C*d*S **24**. When a portion **59** of the cover is depressed, the cover is rotated in a clockwise direction. As a result, the arm member **55** is rotated by the spring force of the spring **51** in a clockwise direction. With the rotation of the arm member **55**, the movable shutter plate **25** progressively departs from the path of the light flux from the light source **26**. Thus, the motor speed may be controlled by appropriately depressing the pedal cover **56**.

I claim:

1. A speed control device for controlling the speed of a universal motor comprising a thyristor connected in series with a universal motor to an AC power source and trigger signal generating means for supplying the gate of said thyristor with a controlled trigger signal, said trigger signal generating means comprising a capacitor connected at one end to the cathode of said thyristor and at the other end to a gate, a series circuit of a variable resistance means, a resistor and a rectifier, a constant voltage discharge element connected in parallel to said series circuit, first circuit means for connecting said other end of said capacitor to the junction of said variable resistance means and said resistor, and second circuit means for connecting said series circuit to said AC power source, said variable resistance means comprising a light source, a light-sensitive resistance element having a resistance value variable responsive to light rays of said light source and a movable shutter adaptable to continuously change the amount of light rays incident to said light-sensitive element.

2. A speed control device according to claim **1**, wherein said second circuit means comprises switch means selectively changeable between a first position where said series circuit is connected directly between said both terminals of said AC power source and a second position where said series circuit is connected through said motor between said both terminals.

3. A speed control device according to claim **1**, further comprising a temperature-sensitive resistance means thermally coupled to said thyristor and connected in parallel with said capacitor.

4. A speed control device according to claim **1**, wherein said movable shutter of said variable resistance means is urged in one direction of the movement of the same by a spring means.

5. A speed control device according to claim **3**, wherein said thyristor and said trigger signal generator means are accommodated in a casing provided with a cover pivoted to said casing, the movement of said movable shutter being interlocked to the pivotal motion of said cover.

6. A speed control unit to be used for controlling the speed of a universal motor comprising a speed control device which comprises a thyristor connected in series with a universal motor to an AC power source and trigger signal generating means for supplying the gate of said thyristor with a controlled trigger signal, said trigger signal generating means comprising a capacitor connected at one end to the cathode of said thyristor and at the other end to the gate, a series circuit of a variable resistance means, a resistor and a rectifier, a constant voltage discharge element connected in parallel to said series circuit, first circuit means for connecting said other end of said capacitor to the junction of said variable resistance means and said resistor, and second circuit means for connecting said series circuit to said AC power source, said variable resistance means comprising a light source, a light-sensitive resistance element having a resistance value variable responsive to light rays of said light source and a movable shutter adaptable to continuously change the amount of light rays incident to said light-sensitive element; a casing having an open space for mounting therein said control device, a cover mounted on said casing so as to enclose said open space and to be pivotally movable in a pedal action, spring means for biasing said cover in one direction of said pedal action, means for movably mounting said movable shutter in said casing, and means for mechanically transmitting the movement of said cover to said movable shutter thereby causing said movable shutter to move with said pedal action.

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