United States Patent

Uchida

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[54] **ON-OFF SERVOMECHANISM CONTROLLED BY A WHEATSTONE BRIDGE**

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[52] **U.S. Cl.**.....**318/674,** 318/663

[51] **Int. Cl.**.....**G05b 11/14**

[58] **Field of Search**.....318/663, 674

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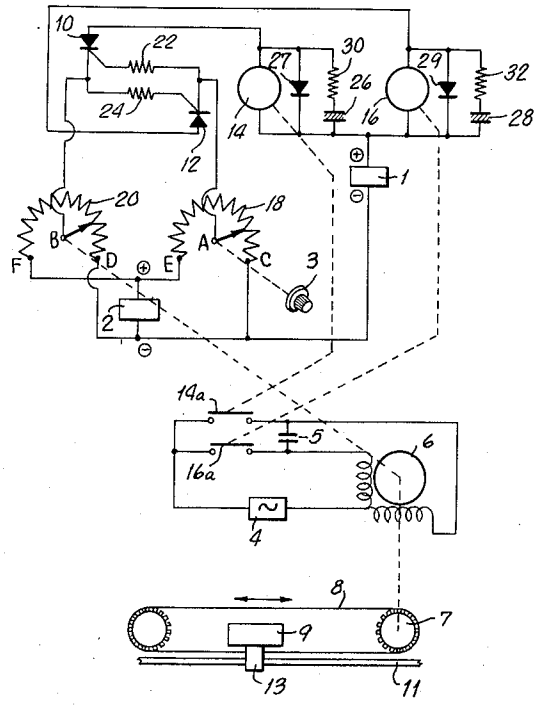
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[57] **ABSTRACT**

A pair of semiconductive switching elements connected in back-to-back relation with each other are energized by a first DC source connected to a bridge circuit including at least two adjustable-slider resistors in such a way that both of the switching elements are turned off when the bridge circuit is balanced while one of the switching elements is turned on when the bridge circuit is unbalanced. The semiconductive switching elements are connected to relays such that when one switching element is turned on, an object to be controlled is controlled through the relay and the bridge circuit is balanced.

4 Claims, 3 Drawing Figures



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SHEET 1 OF 2

Fig. 1.

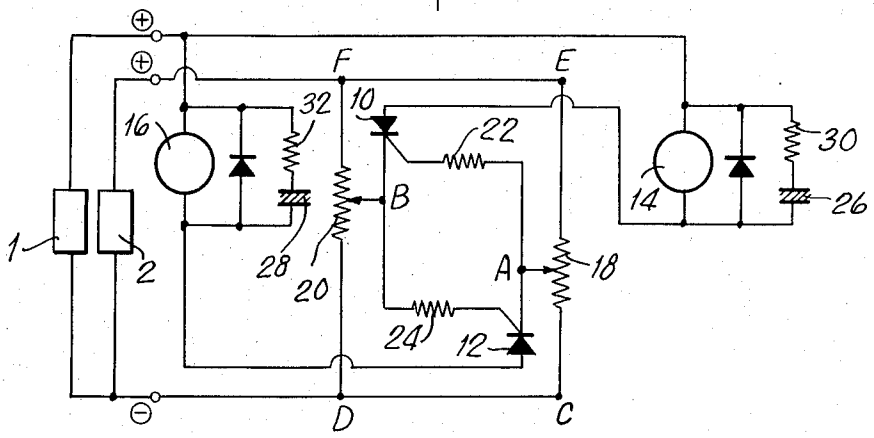
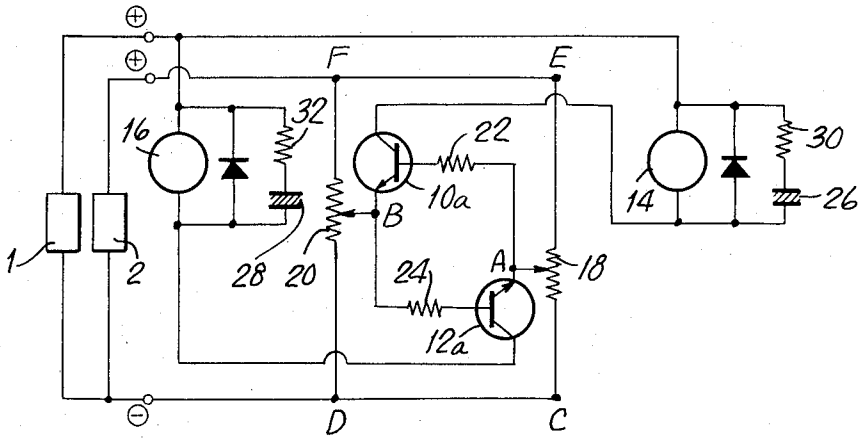


Fig. 2.

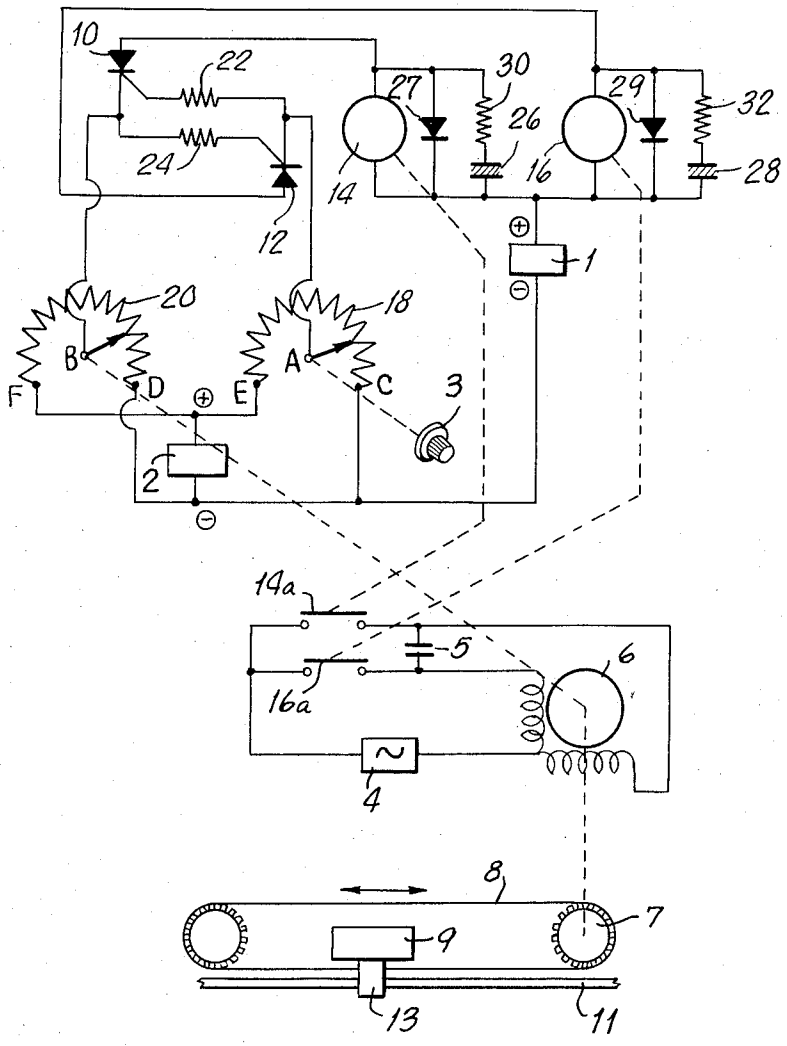


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Fig. 3.



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ON-OFF SERVOMECHANISM CONTROLLED BY A WHEATSTONE BRIDGE

BACKGROUND OF THE INVENTION

The present invention relates to a servomechanism and more particularly a simple and inexpensive servomechanism best adapted for use in a photocopying machine or the like for shifting a zoom lens or for use in an offset printing press for stepless speed change machine driven with V-belt.

In the case of servomechanisms used in conjunction with profiling machines, automatically balanced instruments and the like, high degree of accuracy, stability, quick response and the like are important factors in design and operation. Systems which are adequate in terms of these factors are often very complex in construction. Such machines require very sensitive servoamplifiers, and servomotors having low inertia and having torque which is reduced as speed is reduced. In some cases, generators are required. However, when a zoom lens of a photocopying machine is shifted, or when a heavy load is displaced by means of a stepless speed change machine driven with V-belt in an offset printing press by an electric motor through the manual operation of an adjustable resistor, the importance of factors such as accuracy, response, stability and the like of the servomechanism is reduced. Such servomechanism need improvements only in terms of simplification of construction and reduction in cost.

SUMMARY OF THE INVENTION

One of the objects of the present invention is to provide a servomechanism in which the direction of current flow may be controlled, by semiconductive switching elements such as silicon controlled rectifiers or transistors without the use of specially designed servoamplifiers or servomotors, so as to rotate a motor in a selected direction.

Another object of the present invention is to provide a simple and inexpensive servomechanism.

In brief, a servomechanism in accordance with the present invention includes a bridge circuit having at least two adjustable-slider resistors, two semiconductive switching elements connected in back-to-back relation with each other and connected to said bridge circuit in such a way that when the bridge circuit is balanced the switching elements are turned off while when the bridge circuit is not balanced one of the switching elements is turned on, and two relays connected in series to the output terminals of the switching elements respectively. The switching elements are energized by a first DC circuit while the bridge circuit is fed with the current from a second DC source. The control electrode of one of the switching elements is electrically connected through a resistor to the sliding arm of one of the adjustable-slider resistors in the bridge circuit while the control electrode of the other switching element is connected electrically to the sliding arm of the other adjustable-slider resistor. When the bridge circuit is unbalanced, one of the relays connected to one of the switching elements is actuated to close a motor driving circuit so as to drive a means for moving the slider arm of one of the adjustable-slider resistors and a device for displacing or actuating an object to be controlled. The motor is stopped when the motor-driven slider arm of the adjustable-slider resistor

is moved to a point at which the bridge circuit is balanced so that the object to be controlled is stopped.

The present invention will become more apparent from the following description of the preferred embodiments thereof taken in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a circuit diagram of one embodiment of the present invention;

FIG. 2 is a circuit diagram of another embodiment of the present invention; and

FIG. 3 is a circuit diagram of a specific embodiment of the present invention as used for shifting a zoom lens in a photocopying machine.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of a servomechanism in accordance with the present invention, as shown in FIG. 1, utilizes two silicon-controlled rectifiers **10** and **12**. There are two DC sources **1** and **2**. The output voltage E_2 of the second DC source **2** is lower than the output voltage E_1 of the first DC source **1**. Two relays **14** and **16** are connected in series with the SCRs **10** and **12** respectively. A motor (not shown in FIG. **1** but shown in and described in connection with FIG. **3**) may be connected to an adjustable slider resistor **20** such that when another adjustable-slider resistor **18** is manually operated, the adjustable-slider resistor **20** is driven by the motor. Alternately, the connection may be such that when the adjustable-slider resistor **20** is manually operated, the resistor **18** is driven by the motor. The reference numerals **22**, **24**, **30** and **32** designated resistors; **26** and **28** designate capacitors; and **27** and **29** designate diodes for absorbing the back or inverse current of the relays **14** and **16** respectively.

When the potential at the point labeled A is equal to that at the point B, that is when the circuit is balanced, no current flows into the gates of the SCRs **10** and **12**, so that they are non-conducting. Consequently the relays **14** and **16** are kept opened. It is assumed that the adjustable resistor **18** is manually operated while the adjustable resistor **20** is controlled by the motor. When the slider of the adjustable resistor **18** is moved so as to increase the voltage at point A, the voltage across the points A and C becomes higher than that across the points B and D. The potential at the point A becomes higher than that at the point B and current flows into the gate of the SCR **10** so that it is turned on, thereby energizing the relay **14**. In consequence, the motor is driven so as to move the slider of the adjustable resistor **20** so as to increase the voltage across the points B and D. Therefore, the voltage difference between the points A and B approaches zero. At the instant when the voltage difference between the points A and B becomes zero, the SCR **10** is turned off to thereby de-energize the relay **14** so that the motor is stopped.

On the other hand, when the slider of the adjustable resistor **18** is manually moved so as to reduce the voltage across the points A and C, the voltage across the points A and C becomes lower than that across the points B and D. The potential at the point B becomes higher than that at the point A so that current flows into the gate of the SCR **12** to energize thereby the

relay **16** so that the motor is driven. Upon rotation of the motor, the slider of the adjustable resistor **20** is moved so as to reduce the voltage across the points B and D so that the voltage difference between the points A and B approaches zero. At the instant when the voltage difference between the points A and B becomes zero, the SCR **12** is turned off so that the relay **16** is de-energized, thereby stopping the motor.

The output of the DC source **1** must be half-wave or full-wave rectified because it is used to turn off the SCRs **10** and **12** when their gate currents are zero. The output of the second DC source **2** may be of any waveform. Both of the output voltages E_1 and E_2 may be arbitrarily selected as far as the relays **14** and **16** are actuated in a normal manner at a voltage range between (E_1-E_2) and E_1. In order to increase the sensitivity or control ability for controlling the ON-OFF operations of the SCRs **10** and **12** in response to the movement of the slider of the adjustable resistor **18**, the output voltage E_2 can be of the order of tens of volts, while the output voltage E_1 can be somewhat higher than 100 volts when the relays **14** and **16** are of about 100 volt rating. If a high sensitivity is not required, the output voltage E_1 may be of the order of tens of volts while the output voltage E_2 may be a few volts.

The values of the resistors **18** and **20** are very small as compared with the resistance of the coils of the relays **14** and **16** so that no excessive transients are introduced in the currents through the resistors **18** and **20** because of changes between ON and OFF of the SCRs **10** and **12**.

The gate currents of the SCRs **10** and **12** are controlled by the fixed-value resistors **22** and **24**, whose values influence the sensitivity of the servomechanism. That is, the sensitivity is reduced when the values of the resistors **22** and **24** are increased while the sensitivity becomes too high when the values are so low that oscillation occurs due to the inertia of the motor and the load. The preferable value is about 1 kilo-ohm.

The capacitors **26** and **28** in series with the fixed resistors **30** and **32**, respectively, are for reshaping the waveforms to smooth the voltages applied across the coils of the relays **14** and **16**. When the SCR **10** or **12** is turned on so as to actuate the relay **14** or **16**, the capacitor **26** or **28** serves to prevent the distortion of the waveforms of the voltages across the points B and D or A and C. For this purpose, the values of the fixed resistors **30** and **32** must be suitably higher than those of the adjustable-slider resistors **18** and **20**.

Another embodiment of the present invention, illustrated in FIG. **2**, is substantially similar to the embodiment of FIG. **1**, except that transistors **10***a* and **12***a* are utilized in place of the SCRs **10** and **12**. The mode of operation is similar to that of the first embodiment. The breakdown voltages of the transistors **10***a* and **12***a* are lower than those of the SCRs **10** and **12**, so that the output voltages of the DC sources **1** and **2** must be reduced accordingly. In general, since the switching characteristic of silicon controlled rectifiers is better than that of transistors, it is advantageous in most cases to use silicon controlled rectifiers rather than transistors.

A specific embodiment of the present invention is illustrated in FIG. **3**, in which the component parts similar to those in FIG. **1** are designated by the same reference numerals. The slider arm of the resistor **18** may be moved by a knob **3**, and a reversible single-phase induction motor **6** may be driven by an AC power source **4** through a capacitor **5** so that the torque of the motor **6** may be transmitted to a timing puller **7**, which in turn drives a timing belt **8** carrying a zoom lens housing **9**. The movement of the zoom lens housing **9** is supported by a support **13** in engagement with a guide rail **11**. The adjustable-slider resistor **20** is coupled to the rotary shaft of the motor **6**.

To move the zoom lens housing **9** to a desired position to the right of the present position, the dial or knob **3** is rotated through a predetermined angle in the counterclockwise direction so that the relay **14** is actuated. In consequence the contact **14***a* of the relay **14** is closed to drive thereby the motor **6**, for example in the counterclockwise direction. The zoom lens housing **9** is moved toward the right by means of the pulley **7** and the belt **8** while the slider arm or wiper of the adjustable resistor **20** is moved in the direction increasing the voltage across the points B and D. When the lens housing **9** reaches the desired position, the voltage across the points B and D becomes equal to that across the points A and C. That is, the voltage difference across the points A and B becomes zero. Then the relay **14** is actuated to open thereby the contact **14***a* to stop the motor **6** and hence the housing **9**.

In order to move the housing **9** to a position to the left of the present position, the dial or knob **3** is rotated in the clockwise direction. In this case, the relay **16** is actuated so as to drive the motor **6** in the clockwise direction. When the voltage across the points B and D becomes equal to that across the points A and C, that is when the voltage difference between the points A and B becomes zero, the relay **16** opens the contact **16***a* to stop the motor **6** and hence the housing **9** at the desired position.

It is clear to those skilled in the art that the angle of rotation of the dial or knob **3** may be correlated with the position at which the lens housing **9** is desired to be stopped by interposing a gear train or belt (not shown explicitly in FIG. **3**) between the motor **6** and the pulley **7**.

In the embodiments described above, two adjustable-slider resistors of identical construction are used to form a bridge for reasons of economy but it is understood that a bridge may be formed with two fixed-value resistors and two adjustable-slider resistors. In addition, an AC or DC motor may be used as far as it is reversible. In order to prevent variations in sensitivity due to temperature changes, suitable diodes may be inserted in the circuit as compensators.

In summary, the servomechanism of the present invention is simple and economical in construction and is best adapted when stability, quick response and a higher degree of accuracy are not particularly important factors.

I claim:

1. A photocopying machine having a zoom lens housing (**9**) and supporting means (**7, 8, 11, 13**) therefor, wherein the improvement is in means for moving the zoom lens housing (**9**), comprising:

a. a first DC source (**1**),

b. a second DC source (**2**),

c. a bridge circuit which includes at least two adjustable-slider resistors (**18, 20**) with slider arms and

which is connected to said second DC source (2) to receive current therefrom,

d. two semiconductive switching elements (10, 12) each having a gate terminal and two main terminals, and each being normally an open circuit between its main terminals but changing to a closed circuit therebetween when turned ON, which elements (10, 12) are connected in back-to-back relation with each other, with the gate terminal of each element (10, 12) connected to a main terminal of the other element through a voltage dropping resistor (22, 24), and which elements (10, 12) are connected to said first DC source (1) and to said bridge circuit, both of said semiconductive switching elements (10, 12) being turned OFF when the bridge is balanced and one of said semiconductive switching elements (10, 12) being turned ON when the bridge is unbalanced,

e. a motor (6),

f. two relays (14, 16), each connected in series with a main terminal of one of said semiconductive switching elements (10, 12) to be turned on and off in response to the ON and OFF state respectively of the semiconductive switching element (10, 12) with which it is connected, said relays (14, 16) being connected to the motor (6) to drive the motor in one direction when one of said relays (14, 16) is turned on and to drive the motor (6) in the opposite direction when the other replay (14, 16) is turned on,

g. means (3) for manually unbalancing the bridge, and

h. a zoom lens housing (9) and means (7, 8, 11, 13) supporting the zoom lens housing, said motor being drivingly connected to the slider arm of one of said adjustable-slider resistors and to the supporting means (7, 8, 11, 13) of the zoom lens housing (9) to drive both the slider arm and the zoom lens housing (9) when the bridge circuit is unbalanced until said bridge circuit is balanced and to move thereby the zoom lens housing (9) toward a desired position.

2. A photocopying machine as in claim 1 wherein said first DC source is selected from the group consisting of a half-wave rectified current DC source and a full-wave rectified current DC source.

3. A photocopying machine as in claim 1 wherein said semiconductive switching elements are silicon-controlled rectifiers.

4. A photocopying machine as in claim 1 wherein said semiconductive switching elements are transistors.

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