MEANS FOR INTERMITTENTLY DRIVING A CAM-CARRYING SHAFT
Filed July 1, 1965

FIG. 1

FIG. 2

FIG. 3

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Filed July 1, 1965, Ser. No. 468,699
16 Claims. (Cl. 317—22)

ABSTRACT OF THE DISCLOSURE

A timing device wherein the time interval between step-advance is determined electronically and the amount of advance is determined mechanically.

The present invention relates to a time sequence switch and more particularly to the means and method for providing an electronically adjustable time interval therein.

In essence, the present invention replaces the contemporary mechanical escapement mechanism which is widely used in modern timing devices with an electronic circuit that cooperates with other mechanical and electrical portions of a time sequence switch to generate time-controlled electrical impulses to energize the time sequence switch drive motor and step-advance the time sequence switch through the programmed timing cycle. This invention can be referred to as an electronic escapement.

The present invention eliminates many of the limitations involved in using mechanical escapement mechanisms, among which are the following. Mechanical failure causes limited life, designers must choose a particular escapement timing interval, and thereafter be generally confined to working with only the selected interval and multiples thereof, magnitude of angular advance is limited, and close angular tolerances must be maintained.

By using an electronically generated time interval as described in this application, each of the aforementioned limitations are overcome. In addition, the present invention is especially attractive because of the lack of moving parts which should provide a longer life, because several components serve dual purposes, and because the timing circuit reset and follows through for the drive motor are accomplished with a single normally opened contact on the time sequence switch. It is well understood that electronic components employed herein are far more reliable than the mechanical parts that they replace.

Because an electronic circuit generates a controlled time interval, the usual timer motor which drives a mechanical escapement mechanism can be eliminated. The time sequence switch can be driven through the programmed timing cycle or through a rapid advance to a particular cycle starting point by a single motor.

The variable time interval generated by the electronic circuitry of the present invention can be changed by the mere adjustment of a single resistor in the timing circuit, and is, therefore, extremely flexible. If desired, provisions can be made in the time sequence switch to automatically reselect a particular resistor, and consequently a different time interval, for different portions of the programmed timing cycle.

By-passing of the electronic circuit that generates time intervals will permit the high speed advancing of the time sequence switch to a particular cycle or to skip a cycle, by the drive motor.

The amount of rotational advance is determined mechanically by means of the control cam geometry, said advance being selectable from zero to 360 degrees. Because the camshaft drive motor is operated only intermittently, expected life thereof is substantially increased beyond that of motors in contemporary time sequence switches.
advance circuit to energize a motor, thereby advancing the time sequence switch a predetermined amount. Thus, we have presented a novel step-advance means for a time sequence switch. In general, the invention comprises an electronic switching means for energizing a motor, means for activating said electronic switching means at predetermined time intervals, and means for de-energizing the motor after the time sequence switch has advanced a predetermined amount. The electronic switching means and the control switches on the time are generally referred to as the step-advance circuit in this specification. A timing circuit, which generates time-controlled pulses, is usually referred to as a means for energizing the step-advance circuit, means for activating the electronic switching means, or means for firing a silicon controlled rectifier.

Referring now to the drawing, and particularly to the exploded perspective of FIGURE 1, the components of the time sequence switch can be visualized in conjunction with the following description. Mounting plate 10 of metallic construction, constitutes a main structural unit of the time sequence switch. Motor 11 and cam-switch assembly 12 are mounted to mounting plate 10 by means of ordinary nuts and bolts, not shown in the figure, and are mechanically coupled so that the motor 11 can drive the camshaft 19 of the cam-switch assembly 12. The method of mechanical coupling is not important to the invention and is, therefore, not shown. Cam-switch assembly 12 contains the control cams and control switches which are old to the art for time sequence switches. Also, electronic circuit assembly 13 and cover 14 are mounted to mounting plate 10 by means of machine screws 15 and nuts 16. Shaft 17 extends through cover 14 to mechanically coupled with adjustable resistor 18 in electronic circuit assembly 13.

Referring now to FIGURE 2, we see a block diagram of the circuit presented in this invention showing the functional arrangement of the motor 11, bridge rectifier 20, timing circuit 21, and step-advance circuit 22.

Referring now to FIGURE 3 we see a complete circuit diagram of the present invention. Motor 11 is connected to a first side of an alternating current source hereinafter referred to as power line 1, and to a bridge rectifier 20. The bridge rectifier 20 is old to the art and need not be discussed in this specification. It is obvious from FIGURE 3 that diodes 23, 24, 25, and 26 are interconnected to provide full wave rectification of the alternating current source. The direct current output of bridge rectifier 20 charges capacitor 27 to near peak line voltage, applying this direct current voltage to voltage dividing resistors 28 and 29. Across resistor 29 is a variable periodicity timing circuit 21 consisting of a unijunction transistor 30, compensating resistor 31, load resistor 32, adjustable resistor 18, and timing capacitor 33. The time interval generated by the timing circuit 21 is a function of the product of adjustable resistor 18 and timing capacitor 33. Thus, different time intervals may be generated merely by turning shaft 17, shown in FIGURE 1, to change adjustable resistor 18. The shaft 17 and adjustable resistor 18 are one means for varying the periodicity of the timing circuit. Other means, such as a rotary selector switch or a pushbutton switch making contact to a network of fixed and/or variable resistors may be used to obtain particular timing periods. It is easy to conceive of a sequence switch utilizing the circuit of the present invention where the time interval is changed during the programmed timing cycle by cam-switches which select different values of resistors to cooperate with timing capacitor 33. In another case, the periodicity of the timing circuit might be made dependent, in part or in whole, on the resistance presented by a sensing device, such as a temperature sensor or a reed switch. Particular values of components are not necessary to this specification because the operation of the timing circuit 21 is well known to those familiar with the art. It will suffice to say that the values of the load resistor 32 and compensating resistor 31 depend on the characteristic of the unijunction transistor 30 and the values of timing capacitor 33 and adjustable resistor 18 in the variable resistor-capacitor network of timing circuit 21 depends on the time interval requirement of a particular time sequence switch. The values of voltage dividing resistors 28 and 29 depend on the value of the line voltage presented by 1, and the voltages requiring of timing circuit 21.

Referring now to the step-advance circuit 22 portion of the circuit diagram of FIGURE 3, we see the gate-cathode junction of a silicon controlled rectifier 34 connected across load resistor 32, so that when the unijunction transistor 30 is triggered, the output pulse will fire the silicon controlled rectifier 34. There is a resistor 35 connected between the anode of silicon controlled rectifier 34 and one side of capacitor 27 and a cam operated switch 36 connected to short out the silicon controlled rectifier 34 when cam 37 rotates.

With the above description of components in mind, and by making reference to the drawing figures, the following analysis of operation will serve to convey the details of operation of the present invention. The current flowing through the motor 11 is limited to a small value by the high resistance of the circuit on the output side of bridge rectifier 20. Since the current flowing through the motor 11 is low, the motor 11 will not rotate. When the timing circuit 21 completes one period, it transmits an output pulse to the gate-cathode junction of silicon controlled rectifier 34 which will fire the silicon controlled rectifier 34. Silicon controlled rectifier 34 will remain turned on after it fires because capacitor 27 will be charged sufficiently by the voltage across the silicon controlled rectifier 34 and resistor 35 to supply holding current for silicon controlled rectifier 34 during the period that the load current is adequate for this purpose. When the silicon controlled rectifier 34 is turned on, the step-advance circuit 22 resistance becomes very low and remains that way until the silicon controlled rectifier 34 is turned off by the closing switch 34 and until subsequent opening of switch 36. When the step-advance circuit resistance is low, nearly full line voltage is applied across motor 11 so that sufficient current can flow to cause rotation. Motor 11 drives a cam-switching means consisting of cam 37 which closes the cam operated switch 36 to close the motor circuit through the cam operated switch 36 and to reset the timing circuit 21. When the cam operated switch 36 opens again, motor 11 is turned off and the timing circuit 21 starts timing again. Thus, the time sequence switch has been advanced through a given interval. The time between intervals is established by the period of the timing circuit and the amount of travel of the camshaft 19 of the time sequence switch is established by cam 37 and the cam operated switch 36. By varying the value of adjustable resistor 18 in timing circuit 21, the time interval can be changed from 1 second to as much as 1 minute.

If motor 11 is turned on through circuits other than the bridge rectifier 20, timing circuit 21 and step-advance latching circuit 22, a rapid advance feature for advancing to a particular cycle starting point or to skip a cycle may be obtained. This feature could be programmed into the cam-switch assembly to provide an automatic skip of particular portions of cycles.

The present invention is a novel combination to the extent that several of the component parts perform dual functions, thereby reducing the complexity of the device. For instance, the motor 11 operates in one instance as a load and in another it limits the current in diodes 23, 24, 25, and 26 to a value below that rated for the diodes. Capacitor 27 acts as a filter as well as providing holding current for the silicon controlled rectifier 34. Diodes 23, 24, 25, and 26 provide high voltage direct current for the timing circuit 21 as well as pass full wave power to drive motor 11 with a single silicon controlled rectifier.
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34, and the single cam operated switch 36 causes the motor 11 to continue to run after the silicon controlled rectifier 34 is fired and resets the timing circuit 21.

The bridge rectifier 20 could obviously be replaced by any rectifier circuit that could provide full wave rectification of said alternating current source and provide direct current voltage for the timing circuit 21 and the step-down circuit 22. The timing circuit 21 is, in general, means for energizing the step-down circuit 22, means for firing the silicon controlled rectifier 34 within the step-down circuit 22, or means for activating any electrical switching means at predetermined, but variable, time intervals.

The time sequence switch with the electronic time interval circuit of the present invention, as hereinbefore described in one of its embodiments, is merely illustrative and not exhaustive in scope. Since many widely different embodiments of the invention may be made without departing from the scope thereof, it is intended that all matter contained in the above description and shown in the accompanying drawing shall be interposed as illustrative and not in a limiting sense.

What is claimed is:

1. In a time sequence switch, a step-advance means comprising, a motor, said motor coupled to a first side of an alternating current source and to a semiconductor type bridge rectifier circuit, said bridge rectifier circuit coupled to a second side of said alternating current source, said bridge rectifier circuit consisting of four diodes, said diodes interconnected to provide full wave rectification of said alternating current source, a silicon controlled rectifier coupled across said bridge rectifier circuit, a capacitor coupled across said bridge rectifier circuit, said capacitor supplying holding current for said silicon controlled rectifier after said silicon controlled rectifier is fired, a resistor connected in series with said silicon controlled rectifier, said resistor functioning to limit current flow from said capacitor through said silicon controlled rectifier and to provide a voltage drop means for charging said capacitor, a timing circuit having a variable time interval output, said timing circuit consisting of a unijunction transistor, said unijunction transistor providing an output pulse, said output pulse firing said silicon controlled rectifier, a variable resistor-capacitor network triggering said unijunction transistor after a predetermined time interval, said variable resistor-capacitor network being the means for varying the time interval of said timing circuit, said silicon controlled rectifier energizing said motor, said motor driving a camshaft of said time sequence switch, said camshaft supporting and rotating a cam, said cam operating a switch, said switch shorting out said silicon controlled rectifier and said capacitor, and said switch open circuiting said motor and resetting said timing circuit, said motor advancing said time sequence switch a predetermined amount.

2. In a time sequence switch, a step-advance means comprising, a motor, said motor coupled to a first side of an alternating current source and to a rectifier circuit, said rectifier circuit coupled to a second side of said alternating current source, a silicon controlled rectifier coupled across said rectifier circuit, a capacitor across said rectifier circuit, said capacitor supplying holding current for said silicon controlled rectifier after said silicon controlled rectifier is fired, a variable periodicity timing circuit transmitting pulses to said silicon controlled rectifier at predetermined time intervals, said pulses firing said silicon controlled rectifier, said silicon controlled rectifier energizing said motor, said motor driving a cam-switching means, said cam-switching means de-energizing said motor after a predetermined amount of advance of said time sequence switch, and said cam-switching means resetting said timing circuit.

3. In a time sequence switch, a step-advance means comprising, a motor, said motor coupled to a first side of an alternating current source and to a rectifier circuit, said rectifier circuit coupled to a second side of said alternating current source, a silicon controlled rectifier coupled across said rectifier circuit, a capacitor across said rectifier circuit, said capacitor supplying holding current for said silicon controlled rectifier after said silicon controlled rectifier is fired, a variable periodicity timing circuit transmitting pulses to said silicon controlled rectifier at predetermined time intervals, said pulses firing said silicon controlled rectifier, said silicon controlled rectifier energizing said motor, said motor driving a cam-switching means, said cam-switching means de-energizing said motor after a predetermined amount of advance of said time sequence switch, said cam-switching means resetting said timing circuit.
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shaft operating said contacts of said switch of said step-
advance means, said switch shorting out said silicon con-
trolled rectifier and resetting said timing means when
said contacts are engaged, further rotation of said cam
mechanism causing disengagement of said contacts and de-
energizing said motor terminating rotation of said cam-
washing shaft.

9. In a time sequence switch, means for providing in-
termittent rotary motion of a cam-carrying shaft com-
prising, a motor connected to a first side of an alternate-
ning current source, step-advance means connected to said recti-
fier means and including a silicon controlled rectifier, a
 capacitor and switch means having fixed and movable
contacts, said silicon controlled rectifier to across said
rectifier means and to said switch means, said capacitor
coupled to said rectifier means supplying holding current
for said silicon controlled rectifier when said silicon con-
trolled rectifier is biased to conduction, timing means
having a variable time interval output providing an out-
put pulse for biasing said silicon controlled rectifier to
 conduction, said silicon controlled rectifier allowing
energizing current to flow from said source through said
motor, said energized motor rotating a cam-
carrying shaft of said motor, cam means of said cam-
carrying shaft operating said contacts of said switch of
said step-advance means, said switching shorting out
said silicon controlled rectifier and resetting said timing
means when said contacts are engaged, further rotation
of said cam means causing disengagement of said con-
tacts and de-energizing said motor terminating rotation
of said cam-carrying shaft.

10. In a time sequence switch, means for providing in-
termittent rotary motion of a cam-carrying shaft compris-
ing, a motor connected to a first side of an alternating
 current source and to a rectifier means, said rectifier
means connected to a second side of said alternating cur-
rent source, step-advance means connected to said recti-
fier means and including a silicon controlled rectifier, a
 capacitor, a resistor and switch means having fixed and
movable contacts, said silicon controlled rectifier coupled
to said rectifier means and to said switch means, said
capacitor coupled to said rectifier means supplying holding
 current for said silicon controlled rectifier when said
 silicon controlled rectifier is biased to conduction, said
resistor connected in series with said silicon controlled
rectifier limiting current flow from said source through
said motor, said energized motor rotating a cam-
carrying shaft of said motor, cam means of said cam-
carrying shaft operating said contacts of said switch of
said step-advance means, said switch shorting out said
 silicon controlled rectifier and providing a voltage
 drop means for charging said capacitor, timing means hav-
ing a variable time interval output providing an output
pulse for biasing said silicon controlled rectifier to con-
duction, said silicon controlled rectifier allowing
energizing current to flow from said source through said
motor, said energized motor rotating a cam-
carrying shaft of said motor, cam means of said cam-
carrying shaft operating said contacts of said switch of
said step-advance means, said switch shorting out said
 silicon controlled rectifier and resetting said timing
means when said contacts are engaged, further rotation of
said cam means causing disengagement of said contacts and
de-energizing said motor terminating rotation of said cam-
carrying shaft.

11. In a time sequence switch, means for providing in-
termittent rotary motion of a cam-carrying shaft compris-
ing, a motor connected to a first side of an alternating
 current source and a full wave semiconductor
rectifier means, said rectifier means connected to a second
 side of said alternating current source, step-advance means
connected across said rectifier means and including a sili-
con controlled rectifier, a capacitor, a resistor and switch
means having fixed and movable contacts, said silicon
controlled rectifier coupled across said rectifier means and
across said switch means, said capacitor coupled across
said rectifier means supplying holding current for said silici-
con controlled rectifier when said silicon controlled recti-
fier is biased to conduction, said resistor connected in
series with said silicon controlled rectifier limiting current
flow from said capacitor through said silicon controlled
rectifier and providing a voltage drop means for charging
said capacitor, timing means having a variable time inter-
val output providing an output pulse for biasing said silicon
controlled rectifier to conduction, said silicon controlled
rectifier allowing energizing current to flow from said source
through said motor, said energized motor rotating a cam-
carrying shaft of said motor, cam means of said cam-
carrying shaft operating said contacts of said switch of
said step-advance means, said switch shorting out said
 silicon controlled rectifier and resetting said timing
means when said contacts are engaged, further rotation of
said cam means causing disengagement of said contacts and
de-energizing said motor terminating rotation of said cam-
carrying shaft.
determined time interval, said conducting silicon controlled rectifier allowing energizing current to flow from said source through said motor, said energized motor rotating a cam-carrying shaft of said motor, cam means of said cam-carrying shaft operating said contacts of said switch of said step-advance means, said switch shorting out said silicon controlled rectifier and resetting said timing means when said contacts are engaged, further rotation of said cam means causing disengagement of said contacts and de-energizing said motor terminating rotation of said cam-carrying shaft.

14. In a time sequence switch, means for providing intermittent rotary motion of a cam-carrying shaft comprising, a motor connected to a first side of an alternating current source and to a rectifier means, said rectifier means connected to a second side of said alternating current source, step-advance means connected to said rectifier means and including a semiconductor means and switch means having fixed and movable contacts, said semiconductor means coupled to said rectifier means and to said switch means and providing a high impedance causing a non-energizing current to flow through said motor when non-conducting, timing means having a variable time interval output for biasing said semiconductor means to conduction, said conducting semiconductor means allowing energizing current to flow from said source through said motor, said energized motor rotating a cam-carrying shaft of said motor, cam means of said cam-carrying shaft operating said contacts of said switch of said step-advance means, said switch terminating conduction of said semiconductor means and resetting said timing means when said contacts are engaged, further rotation of said cam means causing disengagement of said contacts thereby causing said non-energizing current to flow through said motor terminating rotation of said cam-carrying shaft.

15. In a time sequence switch, means for providing intermittent rotary motion of a cam-carrying shaft comprising, a motor connected to a first side of an alternating current source and to a rectifier means, said rectifier means connected to a second side of said alternating current source, step-advance means connected to said rectifier means and including a semiconductor means and switch means having fixed and movable contacts, said semiconductor means coupled to said rectifier means and to said switch means and providing a high impedance causing a non-energizing current to flow through said motor when non-conducting, timing means having a variable time interval output for biasing said semiconductor means to conduction, said conducting semiconductor means allowing energizing current to flow from said source through said motor, said energized motor rotating a cam-carrying shaft of said motor, cam means of said cam-carrying shaft operating said contacts of said switch of said step-advance means, said switch shorting out said silicon controlled rectifier and resetting said timing means when said contacts are engaged, further rotation of said cam means causing disengagement of said contacts thereby causing said non-energizing current to flow through said motor terminating rotation of said cam-carrying shaft.

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MILTON O. HIRSHFIELD, Primary Examiner.
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Disclaimer


Hereby enters this disclaimer to claims 1–16 of said patent.

[Official Gazette January 27, 1970.]