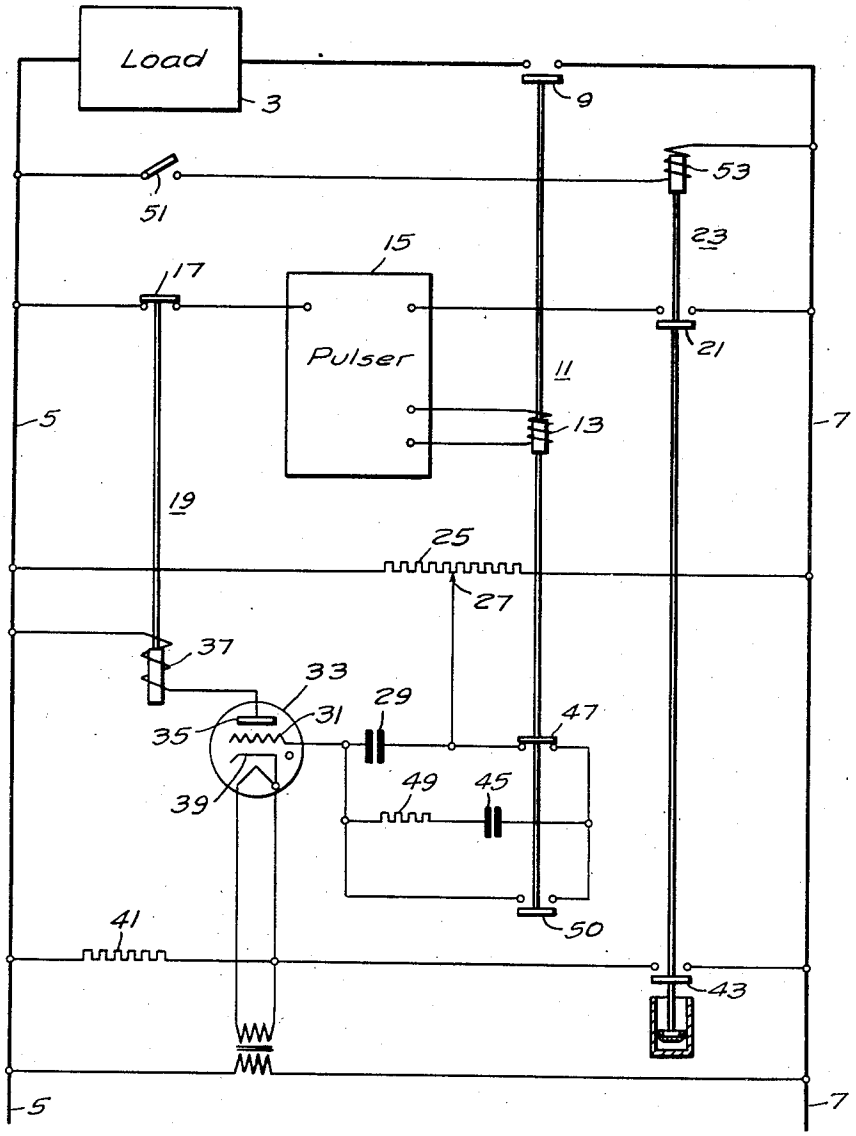
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COUNTING CIRCUIT

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WITNESSES:

E. A. McCloskey

John P. Shipman

INVENTOR

Edward C. Hartwig.

BY

Hymen Diamond

ATTORNEY

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UNITED STATES PATENT OFFICE

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COUNTING CIRCUIT

Edward C. Hartwig, Tonawanda, N. Y., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

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This invention relates to an electronic control circuit and has particular relation to a circuit for use in counting a selected number of occurrences of a repeated event.

In resistance welding apparatus, energy is sometimes supplied for welding from an alternating current source under the control of a pulsation timer. In such an arrangement, current is supplied to the welding transformer in discrete pulses, each pulse being a predetermined even number of half periods of the alternating current in length with a time interval of a predetermined number of half periods between successive pulses. In most cases, it is desirable to provide an over-all control for limiting the number of pulses supplied to the welding transformer.

Over-all control has been accomplished in prior control apparatus by means of an over-all timing circuit, operation of which is initiated at the beginning of the supply of pulses. The over-all timing circuit is not entirely satisfactory however in that frequent and careful adjustment thereof is required to provide the desired number of pulses. For example, if the length of a current pulse or of the interval between successive pulses is changed slightly, it is necessary to readjust the over-all timing circuit to obtain the desired number of pulses.

In some prior arrangements, the over-all timing circuit is replaced by counting apparatus for stopping the supply of welding current pulses after the supply of a selected number thereof. However those prior arrangements which employ an electronic counting circuit are rather expensive inasmuch as they incorporate a number of circuit elements.

The use of a stepping relay for counting has also been suggested but such relays are not very rugged and are relatively slow in operation. Moreover, these relays are not designed to open and close live circuits but only to open and close circuits in which current is not flowing at the time.

It is accordingly an object of my invention to provide new and improved apparatus for the over-all control of a pulsation timer.

Another object of my invention is to provide a new and improved counting apparatus.

Still another object of my invention is to provide a novel apparatus for use with an alternating-current source in counting a selected number of occurrences of a repeated event.

A further object of my invention is to provide novel apparatus for use with an alternating-current source in counting a selected number of occurrences of a repeated event even though the length of the period of such repeated event may vary.

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A further object of my invention is to provide novel apparatus for use in counting a preselected number of discrete pulses of current regardless of the length of a pulse or the interval between successive pulses.

More specifically, it is an object of my invention to provide novel counting apparatus which is relatively inexpensive to manufacture and rugged in construction.

The features of my invention which are believed to be novel are set forth with greater particularity in the accompanying claims. The invention itself, however, together with the advantages and additional objects thereof may be better understood from the following description of a specific embodiment of my invention when read in connection with the accompanying drawing, in which the single figure is a schematic circuit diagram of a preferred embodiment.

As shown in the drawing, a load 3 is connected across a pair of alternating-current supply lines 5 and 7 through a normally open contact 9 of a first relay 11. The operating coil 13 of the first relay 11 is arranged to be energized by a pulser apparatus 15 which is connected across the supply lines 5 and 7 through a normally closed contact 17 of a second relay 19 and a normally open contact 21 of a third time delay relay 23. When energized, the pulser 15 is adapted to supply discrete current pulses to energize the first relay 11 whereby the first relay is successively energized and deenergized. Such pulsers are well-known in the welding art though of course any suitable apparatus for alternately energizing and deenergizing the first relay 11 may be used.

A voltage divider 25 is connected across the supply lines 5 and 7 and an intermediate tap 27 thereon is connected through a first capacitor 29 to the control electrode 31 of an electric valve 33, preferably of the arc-like type such as a thyratron. The anode 35 of the valve 33 is connected through the operating coil 37 of the second relay 19 to one of the supply lines 5 while the cathode 39 is connected through a resistor 41 to the same supply line 5. The cathode 39 is also connected to the other supply line 7 through a normally open contact 43 of the third relay 23.

A second capacitor 45 is connected through a normally closed second contact 47 of the first relay 11 with a resistor 49 in a shunt circuit across the first capacitor 29. The second capacitor 45 has a substantially smaller capacity than the first capacitor 29. A suitable ratio in a circuit which I

have successfully employed being of the order of three or four to one, the exact size depending, as appears hereinafter, upon the number of operations of the pulser that it is desired to count. A normally open discharge circuit is provided across the second capacitor 45 through the resistor 49 and the normally open third contact 50 of the first relay 11.

In operating the apparatus, an initiating switch 51 is closed to complete a circuit through the operating coil 53 of the third relay 23 across the supply lines 5 and 7. The relay 23 is thus energized to complete the circuit through the pulser 15 and to connect the cathode 39 of the valve 33 to the second supply line 7.

Prior to closure of the switch 51, the first and second capacitors 29 and 45 are charged by current flowing from the second sully line 7 through a portion of the voltage divider 25, the intermediate tap 27 thereof, the parallel circuit including the first capacitor 29 on one side and the normally closed contact 47 of the first relay 11 and the second capacitor 45 and resistor 49 on the other side, the control electrode 31 and cathode 39 of the valve 33 and the resistor 41 to the first supply line 5. Such charging current, of course, flows only when the second supply line 7 is positive relative to the first supply line 5 because of the well-known rectifying action of the control electrode to cathode circuit of the valve. Thus the first capacitor 29 is charged to a predetermined maximum value.

When the third relay 23 is energized by closure of the switch 51, further charging of the first capacitor 29 from the supply lines 5 and 7 is prevented because of the connection from the cathode 39 of the valve 33 through the then closed contact 43 of the third relay 23 to the second supply line 7. The charge on the first capacitor 29 is of such polarity that it tends to make the control electrode 31 of the valve 33 highly negative with respect to the cathode 39 to prevent the valve from becoming conductive. Because of the well-known characteristics of a thyratron, a valve will be maintained non-conductive when the charge on the first capacitor 29 is above a predetermined critical value and will be rendered conductive in each half period of the source in which the anode 35 is positive with respect to the cathode 39 when the charge on the first capacitor 29 is below the critical value. This critical value, of course, is substantially less than the maximum value to which the first capacitor 29 is originally charged.

Following closure of the switch 51, the third relay 23 completes the circuit through the pulser 15 so that the first relay 11 is alternately energized and deenergized. When the first relay 11 is energized, its first contact 9 completes the circuit through the load 3. At the same time, the second contact 47 of relay 11 opens the circuit through the second capacitor 45 across the first capacitor 29 while the third contact 50 completes the discharge circuit across the second capacitor 45. As a result, the second capacitor 45 is completely discharged while a current pulse is supplied to the load 3. When the first relay 11 is subsequently deenergized, current through the load 3 is halted, the discharge circuit across the second capacitor 45 is opened and the shunt circuit through the second capacitor 45 across the first capacitor 29 is reclosed. The second capacitor 45 is then recharged completely from the charge existing on first capacitor 29 so that the

charge on the first capacitor 29 is reduced by a preselected amount.

Thereafter, when the first relay 11 is again energized, the second capacitor 45 is again completely discharged while current is supplied through the load 3. Upon the first relay 11 again being deenergized, the second capacitor 45 is again charged by current from the first capacitor 29 again to reduce the charge on the first capacitor. It is then apparent that the charge on the first capacitor 29 is reduced each time a pulse of current is supplied to the load 3 by the amount required to charge the second capacitor 45. The charge on the first capacitor is not, of course, reduced by the same number of volts each time at the voltage remaining on the first capacitor to supply the charging current for the second capacitor is less each time. However, the charge on the first capacitor is reduced by approximately the same percentage each time and so is reduced a predetermined amount each time relay 11 is energized and deenergized. Therefore, after a predetermined number of current pulses selected by the setting of tap 27 on divider 25 which determines the original charges, the charge on the first capacitor 29 is reduced below the pre-determined critical value so that the valve 33 is rendered conductive in positive half periods of the source, that is, half periods in which the anode 35 is positive with respect to the cathode 39. When the valve 33 becomes conductive, the second relay 19 is energized to open the circuit through the pulser 15 and prevent further operation thereof, the relay 19 being of the type that remains in the energized position so long as current flows through the coil thereof in one half of each period.

In the particular arrangement described it is preferable that the first relay 11 be of the type in which, with either energization or deenergization of the relay, those contacts which are to be closed by such action will be so closed before those contacts which are to be opened are so operated. Such a relay is well-known and its use in this arrangement insures a discharge of the first capacitor by only the predetermined amount with each cycle of operation of the relay.

It should be noted that the arrangement is such that the charge on the first capacitor 29 is reduced below the critical value during an interval in which current is not supplied through the load 3. Consequently, there is no necessity for an expensive interlocking or synchronizing arrangement to prevent the counting circuit from actually interrupting the supply of load current. In addition the apparatus disclosed has been found to be quite accurate and is inexpensive to manufacture and rugged in construction.

Although I have shown and described a preferred embodiment of my invention, I am aware that many modifications thereof may be made without departing from the spirit of the invention. I do not intend, therefore, to limit my invention to the specific arrangement disclosed.

I claim as my invention:

1. Apparatus for use in counting a selected number of occurrences of a repeated event comprising means adapted to function as an alternating current source, an electric valve connected in a main circuit across said source, a control circuit for said valve including a capacitor, an initiating device, means effective only prior to operation of said initiating device for charging said capacitor to a predetermined maximum value, said control circuit being effective after

operation of said initiating device to cause said valve to have one condition with respect to conduction of current therethrough when the charge on said capacitor is greater than a preselected critical value less than said maximum value and another condition when the capacitor charge is less than said critical value, and switch means actuated in response to each occurrence of said event for connecting to said capacitor a discharge path to reduce the charge on said capacitor by a preselected amount only.

2. Apparatus for use in counting a selected number of occurrences of a repeated event comprising means adapted to function as an alternating current source, an electric valve of the arc-like type connected in a main circuit across said source, a control circuit for said valve including a capacitor, an initiating device, means effective only prior to operation of said initiating device for charging said capacitor to a predetermined maximum value, said control circuit being effective after operation of said initiating device to cause said valve to be maintained nonconductive when the charge on said capacitor is greater than a preselected critical value less than said maximum value and to become conductive when the capacitor charge is less than said critical value, and switch means actuated in response to each occurrence of said event for connecting to said capacitor a discharge path to reduce the charge on said capacitor by a preselected amount only.

3. Counting apparatus comprising means adapted to function as an alternating current source, an electric valve connected in a main circuit across said source, a control circuit for said valve including a capacitor, an initiating device, means effective only prior to operation of said initiating device for charging said capacitor to a predetermined maximum value, said control circuit being effective after operation of said initiating device to cause said valve to have one condition with respect to conduction of current therethrough when the charge on said capacitor is greater than a preselected critical value less than said maximum value and another condition when the capacitor charge is less than said critical value, a second capacitor connected in a shunt circuit across said first capacitor, said second capacitor being of substantially smaller capacity than said first capacitor, a discharge circuit across said second capacitor, and switch means including a contact in each of said shunt and discharge circuits and operable to complete said shunt and discharge circuits alternately whereby said second capacitor is charged from said first capacitor when said shunt circuit is closed and is discharged when said discharge circuit is closed so that the charge on said first capacitor becomes less than said critical value after a predetermined number of complete cycles of operation of said switch means.

4. Counting apparatus comprising means adapted to function as an alternating current source, an electric valve of the arc-like type connected in a main circuit across said source, a control circuit for said valve including a capacitor, an initiating device, means effective only prior to operation of said initiating device for charging said capacitor to a predetermined maximum value, said control circuit being effective after operation of said initiating device to cause said valve to be maintained non-conductive when the charge on said capacitor is greater than a preselected critical value less than said maximum value

and to become conductive when the capacitor charge is less than said critical value, a second capacitor connected in a normally closed shunt circuit across said first capacitor, said second capacitor being of substantially smaller capacity than said first capacitor, a normally open discharge circuit across said second capacitor, and switch means operable for temporarily opening said shunt circuit and closing said discharge circuit to discharge said second capacitor and then restoring said shunt and discharge circuits to their normal condition, whereby said valve becomes conductive after a predetermined number of operations of said switch means.

5. Apparatus for use in counting a selected number of occurrences of a repeated event comprising means adapted to function as an alternating current source, an electric valve of the arc-like type having an anode connected to one terminal of said source, a cathode connected through an impedance member to said one terminal, and a control electrode, a voltage divider connected across said source, a capacitor connected from an intermediate point on said divider to said control electrode whereby said capacitor is charged to a predetermined maximum value by current through the control electrode and cathode of said valve, an initiating device operable to connect said cathode to the other terminal of said divider, said valve becoming conductive following operation of said initiating device only when the charge on said capacitor is less than a predetermined critical value which is substantially less than said maximum value, and switch means actuated in response to each occurrence of said event following operation of said initiating device for connecting to said capacitor a discharge path for partially discharging said capacitor to reduce the charge thereon by a preselected amount only.

6. Counting apparatus comprising means adapted to function as a source of alternating current, an electric valve of the arc-like type having an anode connected to one terminal of said source, a cathode connected through an impedance member to said one terminal, and a control electrode, a voltage divider connected across said source, a capacitor connected from an intermediate point on said divider to said control electrode whereby said capacitor is charged to a predetermined maximum value by current through the control electrode and cathode of said valve, an initiating device operable to connect said cathode to the other terminal of said divider, said valve becoming conductive following operation of said initiating device only when the charge on said capacitor is less than a predetermined critical value which is substantially less than said maximum value, a second capacitor connected in a normally closed shunt circuit across said first capacitor, said second capacitor being of substantially smaller capacity than said first capacitor, a normally open discharge circuit across said second capacitor, and switch means operable for temporarily opening said shunt circuit and closing said discharge circuit to discharge said second capacitor and then restoring said shunt and discharge circuits to their normal condition, whereby said valve becomes conductive after a predetermined number of operations of said switch means.

7. Counting apparatus for use with equipment arranged to provide a plurality of discrete current pulses, comprising means adapted to function as an alternating current source, an electric

valve connected in a main circuit across said source, a control circuit for said valve including a capacitor, an initiating device, means effective only prior to operation of said initiating device for charging said capacitor to a predetermined maximum value, said control circuit being effective after operation of said initiating device to cause said valve to have one condition with respect to conduction of current therethrough when the charge on said capacitor is greater than a preselected critical value less than said maximum value and another condition when the capacitor charge is less than said critical value, a

second capacitor connected in a normally closed shunt circuit across said first capacitor, said second capacitor being of substantially smaller capacity than said first capacitor, a normally open discharge circuit across said second capacitor, and a relay operable in response to each current pulse for temporarily opening said shunt circuit and closing said discharge circuit to discharge said second capacitor.

EDWARD C. HARTWIG.

No references cited.