March 12, 1957 W. E. LARGE 2,785,346

INTERVAL TIMER

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Fig. 1.

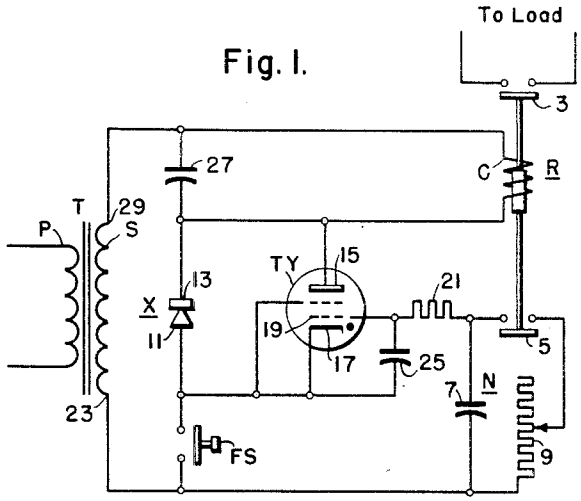
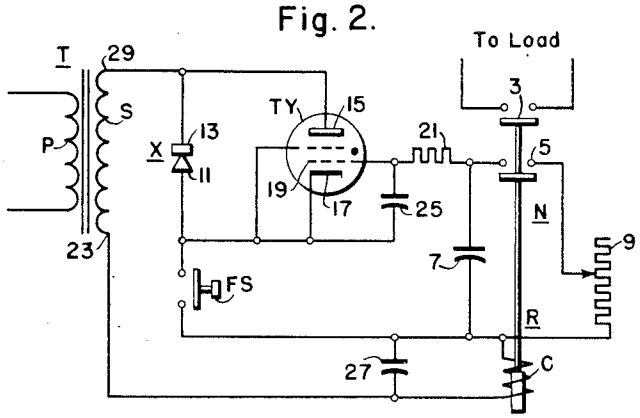


Fig. 2.



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INTERVAL TIMER

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My invention relates to electric discharge apparatus and has particular relation to interval timers for timing an industrial operation such as the various operational steps of a welding process.

It is an object of my invention to provide a highly precise timer for an industrial operation.

Another object of my invention is to provide a highly stable and reliable interval timer.

In accordance with the teachings of the prior art the timing of an interval timer is effected by controlling the conductivity of one or more valves. In its broader aspects, my invention arises from the realization that precision and reliability may be achieved in an interval timer by providing a timer in which a valve is rendered conductive both at the start and at the end of the operation timed. Thus the mechanism which is actuated at the beginning and at the end of the timing operation is positively actuated, and the timing operation is started positively and is terminated positively.

Apparatus for accomplishing the positive starting and stopping of a timing operation provided in accordance with the teachings of the prior art has been relatively complex. For a simple single interval timer, at least two relays and a discharge device, or two discharge devices and a relay have been required.

It is accordingly a specific object of my invention to provide an interval timer of simple structure the timing operation of which shall be started and terminated positively.

Another specific object of my invention is to provide an interval timer of simple structure in the operation of which valves shall become conductive at the beginning and at the end of the timing operation.

An incidental object of my invention is to provide a novel electronic circuit.

In accordance with my invention I provide an interval timer including a direct-current relay which is supplied with direct current at the beginning of the timing operation and with alternating current at the end of the timing operation. A direct-current relay is known in the art and is characterized principally by the fact that it is actuated when direct current is supplied to it and becomes unactuated, or drops out, when alternating current is supplied to it. In a direct-current relay the movable core is preferably of the solid (as distinct from laminated) soft-iron type and is highly inductive (has a large number of turns) but has a low D. C. electrical resistance. When direct-current potential is impressed on such a relay the current flow through it is substantial because of its low resistance. When alternating-current potential is impressed on such a relay the current flow through it is low because the reactive impedance is high. The relay thus operates for direct current but not for alternating current. A suitable relay for the practice of my invention is type P. R.-11D (115 volts D. C.) made by Potter-Brumfield of Princeton, Indiana.

In the practice of my invention the timing operation

is initiated by supplying direct current to the direct-current relay from an alternating current supply through rectifier means such as a simple dry rectifier, for example, and the timing operation is terminated by rendering conductive an electric discharge device such as a thyratron connected in anti-parallel with the rectifier means and thus supplying alternating current to the relay. Thus the timing operation is started and terminated positively.

In referring herein (and in the claims) to an electric discharge device I mean not only a thyratron but a discharge device of any type and I intend to include within the scope of the word "electric discharge device," in addition to thyratrons, high vacuum tubes and solid conduction devices such as transistors.

The novel features that I consider characteristic of my invention are discussed generally above. The invention itself, both as to its organization and its method of operation, together with additional objects and advantages thereof, will be understood from the following description of specific embodiments when read in connection with the accompanying drawing in which:

Figure 1 is a circuit diagram of a preferred embodiment of my invention; and

Fig. 2 is a circuit diagram of a modification of my invention.

The apparatus shown in Fig. 1 includes a transformer T, the primary P of which is adapted to be connected to an alternating current source (not shown) such as a commercial power supply. The apparatus also includes a direct-current relay R having a coil C and a pair of normally open contacts 3 and 5. One of these contacts 3 is adapted to connect a load (not shown) to a power supply (not shown) when the relay R is energized. The other, 5 is adapted to complete a time-constant network N including a capacitor 7 which is connected in parallel with a variable resistor 9 when the contact 5 is closed.

The apparatus also includes a rectifier X which may be of the dry type PS or an ordinary gaseous or vacuum diode. The rectifier X is adapted to be connected in series with the coil of the relay across the terminals of the secondary through a normally open start switch. The rectifier X has an anode 11 and a cathode 13.

The apparatus further includes an electric discharge device TY, preferably a thyratron, having an anode 15, a cathode 17 and a control electrode 19. The discharge device TY is connected in antiparallel to the rectifier. The capacitor 7 of the network N is connected through a grid resistor 21 between the control electrode 19 and the terminal 23 of the secondary S, which, when the start switch FS is closed, is electrically nearest the cathode 17. A surge suppressing capacitor 25 is connected between the control electrode 19 and the cathode 17.

A third capacitor 27 is connected in parallel with the coil C of the relay R. This capacitor 27 has a magnitude adequate to filter half-wave alternating current which may flow through the rectifier X when the start switch FS is closed.

In the standby condition of the apparatus, with the power switch (not shown) closed, the timing capacitor 7 is connected in a circuit extending from the lower terminal 23 of the secondary S through the capacitor 7, the control electrode 19 and cathode 17 of the discharge device TY, the rectifier X, the relay coil C to the upper terminal 29 of the secondary. When the lower terminal 23 of the secondary is positive relative to the upper terminal 29, the capacitor 7 is charged with its plate electrically nearest the control electrode 19 negative and the other plate positive. In the standby condition of the apparatus the capacitor is thus charged so as to impress an initial blocking bias between the control electrode 19 and the cathode 17 of the discharge device TY, when the start switch FS

is closed. The load circuit is open at contact 3 and the timing resistor 9 is disconnected from the capacitor 7 at contact 5.

To initiate the operation the start switch FS is closed. Current is now conducted through the rectifier and the relay coil C and the relay R is actuated. The current which flows through the coil C is of the half-wave type but the relay is prevented from chattering by the operation of the capacitor 27 in parallel with the coil C. When the relay R is actuated its normally open contacts 3 and 5 are closed. At one now closed contact 3 the circuit through the load is closed. In the other closed contact, the timing resistor 9 is connected in parallel with the timing capacitor C.

Initially the timing capacitor 7 is charged and as it is now connected through the start switch FS to the cathode 17, the discharge device TY is blocked and does not conduct. The capacitor 7 discharges through the timing resistor 9 during a time interval depending on the setting of the resistor. At the end of this time interval the capacitor is so discharged that the discharge device TY is rendered conductive. Since the latter is connected in anti-parallel to the rectifier, alternating current now flows through the relay coil C and the relay drops out. Thus the actuation and the deenergization of the relay are both produced by causing a valve that is a rectifier or discharge device to conduct and the start and termination of the actuation of the relay R are positive.

So long as the start switch FS remains closed, the rectifier X and discharge TY continue to conduct during alternate half-periods of the supply and the relay R remains deenergized. If the timing is to be repeated, the start switch FS must be opened to permit the capacitor 7 to charge and then reclosed to start the timing. The apparatus thus has so-called "beat" operation.

The apparatus shown in Fig. 2 is similar to the apparatus shown in Fig. 1 except that the relay coil C is connected between the secondary S and the start switch FS rather than between the cathode 13 of the rectifier X and the secondary. The operation of the Fig. 2 circuit is the same as the operation of the Fig. 1 circuit.

While I have shown and described a certain specific embodiment of my invention, many modifications thereof are possible. My invention therefore is not to be restricted except insofar as is necessitated by the spirit of the prior art.

I claim as my invention:

1. In combination, terminals for deriving an alternating current potential, a direct-current relay having an exciting coil, rectifier means, means for connecting said rectifier means in series with said coil between said terminals, an electric discharge device having an anode, a cathode and a control electrode, means for connecting said anode and cathode in anti-parallel with said rectifier means, timing means in circuit with said control electrode for maintaining said device normally non-conductive and for rendering said device conductive at the end of a timing operation, and means actuable by said relay when it is energized and cooperative with said timing means for initiating said timing operation.

2. In combination, terminals for deriving an alternating current potential, a direct-current relay having an exciting coil, rectifier means, means for connecting said rectifier means in series with said coil between said terminals, an electric discharge device having an anode, a cathode and a control electrode, means for connecting said anode and cathode in anti-parallel with said rectifier means, a timing capacitor, a timing resistor, a charging circuit for said capacitor including in series said terminals, said control electrode and said cathode, and means actuable by said relay when it is actuated for connecting said resistor in parallel with said capacitor.

3. In combination, terminals for deriving an alternating current potential, a direct-current relay having an exciting coil, rectifier means having an anode and a cathode, a normally open start switch, means for connecting said start switch, said coil and said rectifier means in series between said terminals, said start switch being connected between said anode and the terminal electrically nearest said anode, an electric discharge device having an anode, a cathode and a control electrode, means for connecting said anode and cathode of said device in anti-parallel with said anode and cathode of said rectifier means, a timing capacitor, a timing resistor, means for connecting said timing capacitor between said control electrode and said electrically nearest terminal, and means responsive to said relay when it is actuated for connecting said resistor in parallel with said capacitor.

4. In combination, terminals for deriving an alternating current potential, a direct-current relay having an exciting coil, rectifier means, means for connecting said rectifier means in series with said coil between said terminals, an electric discharge device having an anode, a cathode and a control electrode, means for connecting said anode and cathode in anti-parallel with said rectifier means, a timing capacitor, a timing resistor, means for connecting said capacitor between said control electrode and said cathode, a charging circuit for said capacitor, and means actuable by said relay when it is actuated for connecting said resistor in parallel with said capacitor.

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