Sept. 14, 1943. W. R. YOUNG, JR 2,329,504

ELECTRIC TIMING DEVICE

Filed Jan. 6, 1940

FIG. 1

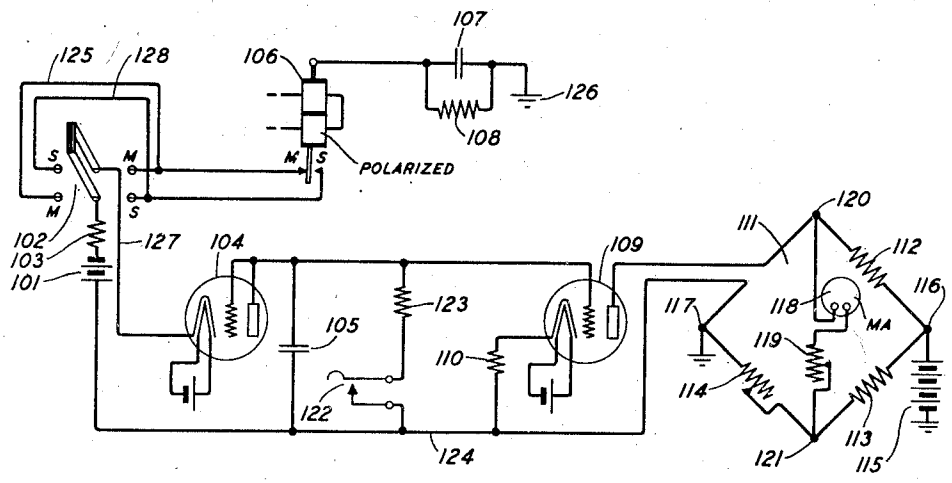
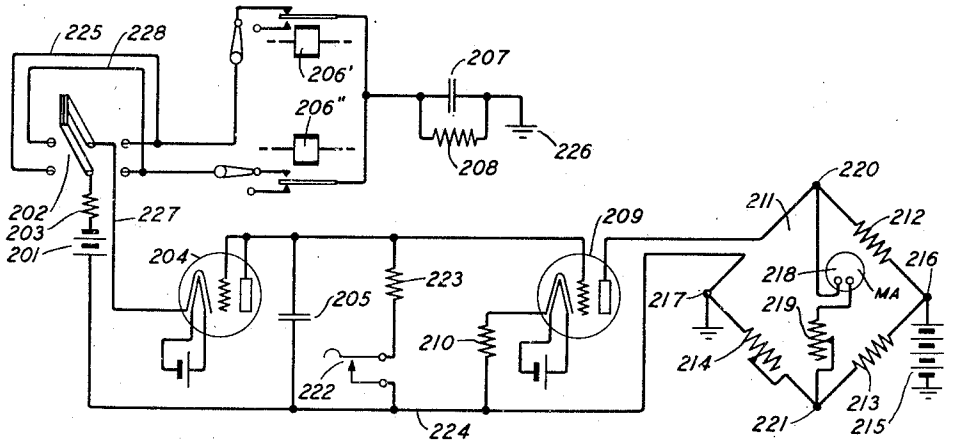


FIG. 2



INVENTOR
W. R. YOUNG, JR.

BY J. W. Schmied

ATTORNEY

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ELECTRIC TIMING DEVICE

William Rae Young, Jr., New York, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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13 Claims. (Cl. 175—183)

This invention relates to time measuring devices and in particular to those devices used for measuring the duration of operating intervals of electromagnetic relay armatures.

An object of the invention is to measure the time elapse between the disengagement of a relay armature with either one of its contacts and the engagement of the armature with the other of its contacts.

Another object is to measure the time elapse between the disengagement of a relay armature with either one of its contacts and the interengagement of an armature and contact on a second relay, in a circuit arrangement wherein the armatures of both relays are interconnected or bear a similar relation to a shunted condenser.

According to the present invention a condenser is charged to a definite potential when an electromagnetic relay armature is in one stationary position, the condenser charge is adjusted when the armature travels to its other stationary position and the adjusted charge is discharged over an indirectly heated cathode and plate circuit of a vacuum tube through a second condenser to ground. The charge on the second condenser after several transitions of the relay armature acquires a potential equal to the adjusted charge on the first condenser. Connected across the plate circuit of the vacuum tube is a second vacuum tube of the amplifier type and included in series with the plate circuit of the second-mentioned vacuum tube is a Wheatstone bridge arrangement for measuring the duration of the adjusted charge that may be impressed on the first-mentioned vacuum tube after the charge on the second-mentioned condenser has reached a potential equal to the adjusted charge on the first-mentioned condenser.

A feature of the invention is an arrangement adapted for measuring, first the duration of travel time of a relay armature from one to the other of its associated contacts and vice versa, and, secondly, the duration of time between the disengagement of a relay armature from one of its contacts and the interengagement of an armature and a contact on a second relay when both armatures are connected in parallel to a shunted condenser.

Another feature of the invention is the provision of means for reversing the order in which the relay contacts serve in charging and discharging the shunted condenser.

Another feature is the provision of means to reset, at will, the output condenser for the purpose of making new tests either on the same or another relay, or another pair of relays.

In the drawing:

Fig. 1 shows an arrangement for measuring the duration of travel time on an electromagnetic relay armature from one to the other of its contacts; and

Fig. 2 shows a modification of Fig. 1 wherein the duration of time elapsed between the disengagement of an armature and contact of one relay and the engagement of an armature and contact of a second relay when the armatures of both relays are interconnected to a shunted condenser.

Referring to Fig. 1, battery **101** is shown with its negative pole connected to one side of the operating member of switch **102** through surge limiting resistance **103** and its positive pole connected to ground at connection **117** and to the plate of vacuum tube **104** of the rectifier type through condenser **105**. Switch **102** is of the double-throw double-pole type. The right-hand fixed contacts of switch **102** are respectively connected to the marking and spacing contacts of polarized relay **106** and the left-hand fixed contacts are respectively connected to the same relay contacts but in the reversed order. To the armature of relay **106** is connected grounded condenser **107** which is shunted by leak resistance **108**.

The voltage across condenser **105** is connected directly to the input circuit of vacuum tube **109**, the input circuit of vacuum tube **109** including resistance **110**. The plate circuit of vacuum tube **109** includes a Wheatstone bridge arrangement **111**, one arm of which includes the impedance of vacuum tube **109** and the resistance of resistive element **110**, two other arms include resistances **112** and **113**, respectively, and the fourth arm includes an adjustable resistance **114**. Grounded battery **115** is connected across the horizontal apices **116** and **117** of the bridge arrangement and milliammeter **118** and regulating resistance **119** are connected in the bridge across the vertical apices **120** and **121**.

Connected across the input circuit of vacuum tube **109** is a path including switch **122** and resistance **123**. Switch **122** serves to quickly discharge condenser **105** whenever desired whereby the timing device is reset for a new test.

Method of operation

The operation of Fig. 1 now to be described, determines the travel time of the armature of relay **106** from its marking to its spacing con-

tact and vice versa. A source of signaling current (not shown) is connected to the relay winding. When relay 106 is in the position shown and it is desired to measure the travel time of its armature from its marking to its spacing contact, the operating member of switch 102 is moved into engagement with the left-hand fixed contacts of the switch and switch 122 is in an open position as shown. Immediately a voltage is impressed on condenser 107 in a circuit traceable from ground connection 117, conductor 124, battery 101, resistance 103, switch 102 closed at its lower left-hand fixed contact, conductor 125, left-hand, or marking, contact and armature of relay 106, condenser 107 to ground connection 126. Condenser 107 charges to nearly the voltage of battery 101 while the armature of relay 106 is on its marking contact. In response to a change in the signal current in the winding of relay 106, the relay armature leaves the marking contact and the voltage across condenser 107 and resistance 108, decays exponentially. This voltage will be some particular value, depending, with other conditions remaining unchanged upon the time elapsed when the relay armature moves into engagement with its right-hand, or spacing, contact. The relay armature upon engaging its spacing contact causes the voltage across condenser 107 at this time to be impressed on the indirectly heated cathode of vacuum tube 104 in a circuit traceable from ground connection 117, conductor 124, condenser 105, plate and cathode of vacuum tube 104, conductor 127, switch 102 on its upper left-hand fixed contact, conductor 128, spacing contact and armature of relay 106, condenser 107 to ground connection 126. Should the charge across condenser 107 be greater than the charge across condenser 105, a current will flow in the plate circuit of vacuum tube 104 thereby impressing a voltage on the input circuit of vacuum tube 109. After several transitions of the armature of relay 106 from its marking contact to its spacing contact, the voltage across condenser 105 will equal that across condenser 107 when the armature engages its spacing contact. This voltage across condenser 105 is built up by the intermittent surges of current supplied through vacuum tube 104 during the first few transitions of the relay armature, and condenser 105 retains this voltage because a vacuum tube 104 cannot pass current in the opposite direction so as to discharge it.

Since this voltage across condenser 105 is a function of the time of travel of the armature of relay 106 from one contact to the other, and since the voltage is related to the current flowing through meter 118, this meter current is a measure of the armature travel time. If the elements, resistances 103 and 108 and condenser 107, of the charging and discharging circuits are properly proportioned, the reading on the milliammeter 118 will not be affected by chattering or bouncing of the armature of relay 106 before the armature leaves one contact and after it arrives at the other. A steady reading on milliammeter 118 after several transitions of the relay armature from one contact to the other will indicate the travel time of the armature between contacts. The meter 118 may be calibrated and furnished with a scale arbitrarily with reference to some relay 106 of known or satisfactory nature or it may be calibrated in terms of travel time by using a high speed camera to measure the transmission time or by other known means.

In order to reset the device for taking readings when the operating member of switch 102 is in its right-hand position, switch 122 is momentarily operated to its alternate position so that condenser 105 may be completely discharged.

With the switch 102 in its right-hand position, the operation of the device is substantially the same as hereinbefore described for the condition when the switch 102 was in its left-hand position, except that the travel time measured is that of the armature traveling from its spacing to its marking contacts and consequently the charging and the discharging circuits with respect to the relay contacts will be reversed. For example, when switch 102 is in its right-hand position, the charging circuit for condenser 107 will be from ground connection 117, conductor 124, battery 101, resistance 103, operated member of switch 102 in engagement with its lower right-hand contacts, spacing contact and armature of relay 106, condenser 107 to ground connection 126. The discharge circuit for condenser 107 will be from ground connection 117, condenser 105, plate and indirectly heated cathode of vacuum tube 104, operated member of switch 102 in engagement with its upper right-hand contact, marking contact and armature of relay 106, condenser 107 to ground connection 126.

Referring to Fig. 2, there is provided a means for measuring the time interval between the disengagement of an armature with its contact on one relay and the interengagement of an armature and contact on a second relay, in a circuit arrangement wherein both armatures are interconnected, or bear a similar relation to the shunted condenser such as condenser 107 shown in Fig. 1.

Like parts in Figs. 1 and 2 have the same reference characters except that the numerical prefixes of the reference characters of the like parts correspond to the number of the figure in which such parts appear. Two neutral relays 206' and 206'' are employed in Fig. 2 in place of one relay 106 as shown in Fig. 1.

Two sources of signal current (not shown) are provided to energize the windings of relays 206' and 206'', respectively. The windings of these relays are presupposed to be connected to appropriate circuits to energize or deenergize the relays separately in the order required so that their operations are correlated to measure the elapsed time between the opening of a normally closed armature and a contact of one relay and the closure of a normally opened armature and contact of the other relay. The appropriate circuits may include in their operations two closures or two openings or an opening and closure of two circuits where these closures or openings may be the result of the operation of a plurality of other associated circuits.

Relays 206' and 206'' are shown with their respective contacts in various possible positions and wired accordingly. The contacts may be either back or front depending on their positions with respect to their associated armatures. The method of operation hereinafter described as an example, assumes that relay 206' has an armature normally engaged with a back contact and relay 206'' has an armature normally disengaged with a front contact. The contacts may be otherwise arranged as shown by the contacts connected to single throw switches as shown. Furthermore, the relays may be assumed to be nor-

mally energized simultaneously or either one or the other alone, normally energized.

Method of operation

The operation of Fig. 2 now to be described determines, first, when the operating member of switch **202** is in its left-hand position, the time interval between the disengagement of the armature and contact of relay **206'** and the interengagement of the armature and contact of relay **206''**, and secondly, when the operating member of switch **202** is in its right-hand position, the time interval between the disengagement of the armature and contact of relay **206''** and the interengagement of the armature and back contact of relay **206'**. In the first case it is assumed that relays **206'** and **206''** are in the positions shown and that the armatures of the relays are as shown connected to full lines. When switch **202** is operated to its left-hand position and condenser **207** is charged in a circuit traceable from ground connection **217**, conductor **224**, battery **201**, resistance **203**, switch **202** in engagement with its lower left-hand fixed contact, conductor **225**, back contact and armature of relay **206'**, condenser **207** to ground connection **226**. When the relay **206'** operates and its armature and contact disengage each other whereby the charge on condenser **207** adjusts itself as hereinafter described. Relay **206''** operates and a circuit is closed to discharge condenser **207**, said circuit being traceable from ground connection **217**, conductor **224**, condenser **205**, plate and indirectly heated cathode of vacuum tube **204**, conductor **227**, operating member of switch **202** in engagement with its upper left-hand fixed contact, conductor **228**, front contact and armature of relay **206''**, condenser **207** to ground connection **226**. During the interval whereof the armature of relay **206'** disengaged its contact and the armature relay **206''** engaged its contact, the voltage across condenser **207** and resistance **208** decays exponentially as in Fig. 1 and thereby adjusts itself. The discharge of condenser **207** is utilized to operate Wheatstone bridge arrangement **211**, as hereinbefore described as for Wheatstone bridge arrangement **111** of Fig. 1, to measure the time interval between the disengagement of contact and armature of relay **206'** and the interengagement of contacts and armature of relay **206''**.

In the second case it is assumed at the beginning of operations of the measuring device that the armature of relay **206''** is in engagement with its front contact, the armature of relay **206'** is disengaged with its back contact, and operating member of switch **202** is operated into its right-hand position. The description of the operation is substantially the same as that just given for the condition when the switch **202** is operated to its left-hand position except that the interval to be measured is the alternate to that measured when the operating member of switch **202** was in its left-hand position.

It is obvious that the present invention may be applied to a device for measuring the duration of any interval that might occur between different instants of engagement of two spring members with their respectively associated contacts on a key, switch or jack, particularly when it is desired that the instants of engagement of both spring members be simultaneous, and a difference or variation occurs.

What is claimed is:

1. The method of indicating the average time elapsing between the breaking of one electrical contact and the making of another electrical contact which comprises causing repeated breaks of one respectively followed by repeated makes of the other, establishing a difference of potential which is a function of the average time elapsing between each break and the subsequent make, and continuously indicating the value of the difference of potential.

2. A system for measuring the elapsed time between the breaking of one contact and the making of another which comprises means for repeatedly storing charges which are a function of the elapsed time, a condenser, means for charging the condenser to a voltage which is a function of the charges, and a meter for indicating the value of a difference in said voltage and consequently the average elapsed time.

3. An electric timing device comprising vibrating means and stationary contact points therefor, a condenser, means for charging said condenser to a certain potential when said vibrating means are stationary, a second condenser, means responsive to the discharge of said first-mentioned condenser for charging said second condenser in successive steps to a potential equal to that on said first-mentioned condenser when said vibrating means are operated, and measuring means responsive to an additional charge of a certain value on said second condenser in said charged condition for indicating the duration of operation of said vibrating means between said stationary contact points.

4. An electric timing device comprising vibrating means and contact points therefor, a condenser, a source of staccato electric current signals for operating said vibrating means between said contact points, a source of voltage, manually operable means for connecting either of said contact points to said source whereby said condenser is charged from said source of voltage every time said vibrating means is in engagement with one of said contact points, a second condenser, unidirectional means responsive to the discharge of the first-mentioned condenser for charging said second condenser in successive steps to a potential equal to that of the first-mentioned condenser when said vibrating means is operated into engagement with the other of said contact points, and measuring means responsive to the charge on said second condenser for indicating the time of travel of said vibrating means from one to the other of said contact points.

5. An electric timing device according to claim 4 wherein said vibrating means is the armature of an electromagnetic relay connected to said source of staccato electric current signals, said manually operable means is a double-throw double-pole switch for reversing the connection of said contact points to said source of voltage, and said measuring means comprises a vacuum tube amplifying device and an indicating meter arranged in the bridge of a Wheatstone arrangement connected in the output circuit of said amplifying device for measuring the desired time intervals.

6. An electric timing device according to claim 4 wherein the measuring means comprise a vacuum tube amplifying device with normally opened operable means connected across its input for discharging said second condenser at will.

7. An electric timing device comprising, means capable of being energized by variable currents, operative means arranged to assume a plurality of conditions in response to said energized means, a source of potential, energy storing means arranged to be charged to a potential of a maximum value by said source of potential when said operative means assumes one condition, means tending to neutralize the potential charge on said energy storing means when said operative means is undergoing a transition from one condition to another, but effective to adjust the potential charge, and measuring means responsive to the adjusted charge for determining the duration of the transition of said operative means when said operative means assumes another of a plurality of conditions.

8. An electric timing device comprising a relay having an operative element for assuming two conditions, means for causing said element to repeatedly assume said conditions in succession, a condenser for storing a charge to establish a reference potential when said element is in one condition, means tending to modify the charge on said condenser when said operative element is undergoing a transition between its two conditions but effective to modify the potential charge by an amount proportional to the time of transition, and measuring means responsive to the average modified potential charges for indicating the average duration of the transitions of said operative element when said element assumes the other of its two conditions.

9. An electric timing device according to claim 7 wherein the first-mentioned means is an electromagnetic relay, said operative means is the armature of said relay and the fourth-mentioned means is a resistance shunting said energy storing means.

10. An electric timing device comprising a source of variable current, a plurality of means capable of being energized by currents from said source, a plurality of operative means respectively responsive to said energized means and respectively arranged to assume a plurality of conditions depending upon the currents from said source, a source of potential, energy storing means arranged to be charged to a potential of a maximum value by said source of potential when one of said operative means assumes one condition, means tending to neutralize the potential charge on said energy storing means when said one operative means is undergoing a transition from one condition to another but effective to adjust the potential charge, said energy storing means being further arranged to be discharged when the other of said operative means assumes the opposite to its normal condition, and measuring means responsive to the discharge of the adjusted charge for determining the duration of the interval between the transition of said one operative means in assuming one condition and the transition of said other operative means in assuming its off-normal condition.

11. The method of testing relays which have movable means actuated by current or voltage changes applied to an actuating circuit thereof, said movable means being actuated in its movement to open one electrical contact and thereafter close another contact, which method comprises causing repeated closures of said one contact followed by repeated transitions to the other contact, establishing a difference of potential during said closures, changing said difference of potential by an amount which is a function of the time elapsed between opening said one contact and the making of said other contact, and causing a continuous indication proportional to the value of the changed difference of potential.

12. A system for continuously indicating as an indicator reading the average transition time from one contact to the opposing contact of a relay having contact means moving back and forth from one contact to another which comprises a path for repeatedly establishing a standard difference of potential upon electro-capacitative storage means during the making of said one contact, means for repeatedly varying said standard difference of potential during the elapsed time from departure from one contact to the making of another and in a manner proportional thereto, means for repeatedly transferring the varied charge to other electrocapacitative means, and an indicator associated with said other electrocapacitative means by interconnections whereby said indicator continuously indicates the charge thereof.

13. The method of testing a relay system which comprises one actuating means to open an electrical contact and another actuating means to close an electrical contact to indicate the elapsed time between said opening and closing which method comprises repeated openings of said one contact followed by repeated closings of the other contact, establishing a difference of potential during the closed time of the first contact, changing said difference of potential by an amount which is a function of the elapsed time between opening said one contact and the closing of said other contact, and continuously indicating the value of the changed difference of potential.

WILLIAM RAE YOUNG, JR.