April 30, 1946. P. G. EDWARDS 2,399,213

TIMING CIRCUITS

Filed July 18, 1944

FIG. 1

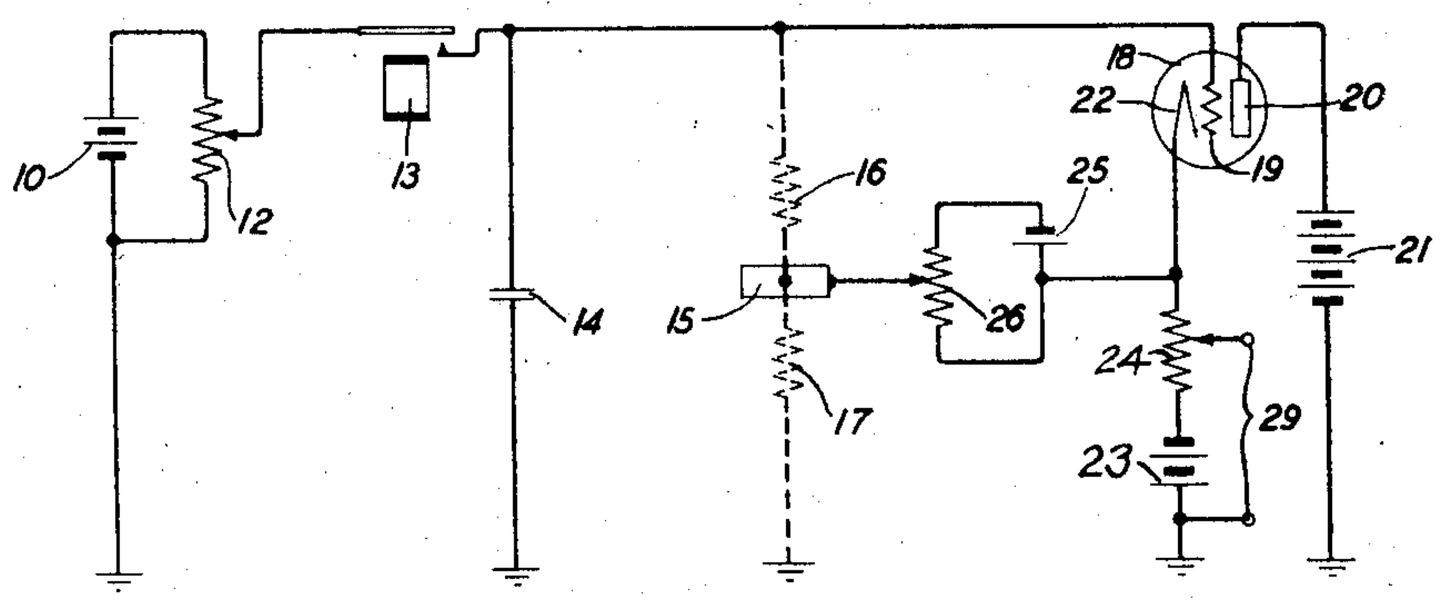
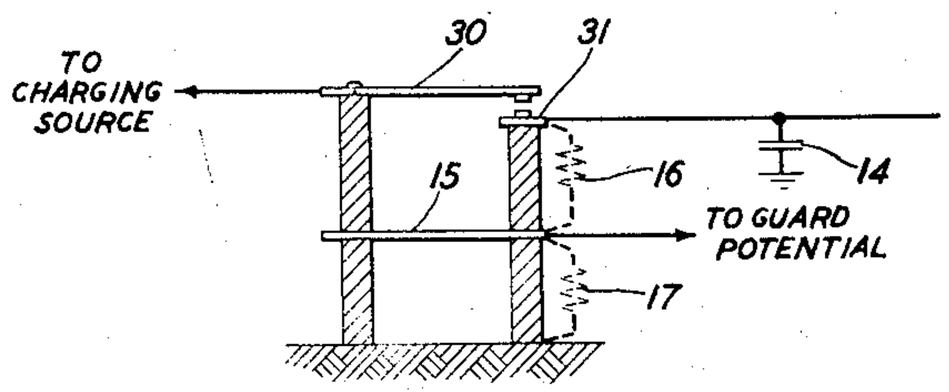


FIG. 2



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TIMING CIRCUIT

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5 Claims. (Cl. 320—1)

This invention relates principally to timing circuits involving the use of condensers for introducing large time constants, and particularly to means for sustaining the charge on a condenser.

In electric circuits it is frequently desirable to delay the operation of an electric device for an interval of time after the closure of a control circuit in which the electric device is included. Such time delays are introduced by first charging a condenser from a source of current associated with the control circuit and at some subsequent time applying the charge potential accumulated on the condenser plates to the device to be controlled. Frequently the high side of the charged condenser is connected to a contact element of a relay, or other switching apparatus, so that when the relay or switching apparatus is subsequently operated the condenser is connected to the device to be controlled and its charge is utilized to energize and operate the device.

The contacts of the relay or switching apparatus are generally insulatively mounted on the frame of the relay so that there is a relatively high impedance leakage path from the contacts to the frame and from the frame to ground. Obviously, such leakage path is connected directly in shunt with the condenser so that the charge on the condenser tends to leak off to ground over such path. When the relay, or switching apparatus, eventually operates to transfer the condenser charge to the device to be operated thereby, it is apparent that the charge available on the condenser will have been reduced, if not entirely dissipated through the leakage path with the result that the potential at the condenser terminals may be insufficient to effect the operation of the device to be controlled thereby.

It is the object of this invention to provide means whereby the charge on a condenser may be sustained for an indefinitely long period of time.

This object is attained in accordance with a feature of the invention by applying at a point in the leakage path, over which the charge on a condenser would otherwise be dissipated, a guard potential of substantially the same magnitude as that of the source from which the condenser is charged, so that the difference in potential between the high side of the condenser and the guard point is substantially zero and therefore, the flow of current over the leakage path is also of zero value.

In accordance with a particular feature of the invention means are provided whereby the guard potential applied to the leakage path is made to vary automatically with variations in the potential of the source from which the condenser is charged. Thus, irrespective of variations in the potential of the charging source, the corresponding charge applied to the condenser will be sustained for an indefinitely long interval of time. In this aspect of the invention, the condenser is charged from a variable signaling source and the charging signal is simultaneously applied to the control electrode of a vacuum tube amplifier, so that as the charging signal is varied the output of the vacuum tube is correspondingly varied and a corresponding potential is fed back from the output of the tube to the guard interposed in the leakage path. In this manner the potential applied to the leakage path follows closely the charge potential applied to the condenser, and for all values of potential to which the condenser is charged the difference of potential between the high side of the condenser and the point at which the guard potential is applied to the leakage path is automatically maintained at substantially zero value and the flow of leakage current will therefore be maintained at substantially zero value.

These and other features of the invention will be readily understood from the following detailed description when read in connection with the accompanying drawing, in which:

Fig. 1 illustrates a circuit diagram involving the fundamental principles of the invention; and

Fig. 2 is a schematic view of the contacts of a switching device to which the guard is applied and shows how the leakage is prevented after the switching contacts have been opened.

At 10, in Fig. 1 is diagrammatically indicated a source of current, in the nature of a battery, having a potentiometer 12 connected thereacross. The battery 10 and potentiometer 12 are employed for illustrative purpose only since it is obvious that any other suitable source of variable potential may be employed. A switching device in the form of a relay, is schematically shown at 13 whose armature controls the application of the potential from the source 10 to the condenser 14. This relay may be controlled in any suitable manner to effect the closure of its armature contacts and to thereby connect the condenser 14 to the charging source.

The reference numeral 15 identifies the frame of a relay or other type of switching device which, in practice, may be employed as the medium by which the charge accumulated on condenser 14 may be transferred to a work circuit or other device to be actuated by the condenser charge. In such a case, the high side, or upper terminal

of condenser 14 would be connected to an open contact of the switching device which when moved into engagement with its related stationary contact would function to transfer the condenser charge to the circuit or apparatus associated with the said related contact of the switching device. Such contacts, invariably, are insulatively mounted on the frame structure of the relay or switching device, such frame being identified on the drawing by the reference numeral 15. The insulation between the open contact connected to the high side of the condenser presents a leakage path from the high side of the condenser to the relay frame 15 and this path is indicated by the leakage resistance 16. Similarly, between the relay frame 15 and ground there is also a leakage path 17. The leakage path 16, 17 obviously is in shunt with the condenser 14 and therefore provides a path over which leakage current would travel and over which the charge on the condenser would be dissipated if precautions to guard against such leakage were not taken.

At 18 is illustrated a three electrode vacuum tube cathode follower amplifier whose control grid 19 is permanently connected to the high side of the condenser 14, so that whatever signal from the source 10 is applied to the condenser for charging purposes is simultaneously applied to the control electrode of the tube 18. The output of the tube 18, therefore, varies with the variations in the potential applied to the condenser, in other words, with variations in the potential of the charging source.

The plate electrode 20 of tube 18 is connected to the plate battery 21, whereas the cathode 22 is connected to the battery 23 by way of the resistor 24. The cathode 22 and the frame 15 are interconnected through the battery 25 and variable resistance 26 so that the output potential of the tube 18 is fed back to the frame or guard 15. The elements 25 and 26 supply the usual bias which is required to counteract the normal voltage between the grid 19 and cathode 22 assumed by the tube.

With the connections described, it is apparent that a voltage is fed back to the frame or guard 15, which voltage varies with the output of the tube 18. Since the tube output varies in accordance with the potential applied to the grid 19 of the tube, which, in turn varies with variations in the charging potential applied to the condenser 14 incident to the operation of relay 13, it follows that the guard potential applied to the leakage path at the point 15 also varies with the potential of the charging source. Therefore, as the potential of the charging source changes, so also does the potential applied to 15. The voltage fed back to the guard, or frame 15 is made as nearly equal to the charging voltage as possible. Obviously, the inequality in the guard and charging voltages determines the extent to which the condenser 14 will discharge through the leakage path. If this inequality is zero, then the condenser, insofar as leakage resistance 16 is concerned will remain at the voltage of the charging source. If the inequality is not zero, then the condenser will charge or discharge at a rate determined by the inequality and where the inequality is small the rate of change would be slow.

When relay 13 is operated to close its armature contacts, a signal from the battery 10 is impressed on the condenser 15 and simultaneously on the grid 19 of tube 18. The magnitude of the potential of this signal depends upon the setting of the potentiometer pointer and may vary from the full potential of battery 10 to any lower value. The condenser 14 is accordingly charged to the potential of the impressed signal. Without recourse to the guard potential, this charge on the condenser would leak off to ground over the leakage path represented by resistances 16 and 17, the rate of leakage depending upon the value of the resistances 16 and 17 and the capacity of the condenser 14. To preclude the possibility of the condenser charge leaking off, the guard or relay frame 15 is maintained at a potential substantially equal to that of the high side of the condenser 14, so that the potential difference between he high side of the condenser and the guard is zero. Therefore, there will be no current flow in the leakage resistance 16 since there is no potential difference between its terminals. Thus the charge on the condenser is sustained, and is maintained at the potential of the charging source. Since the voltage applied to the guard in the leakage path is a measure of the output of tube 18 which, in turn, varies with the signal voltage applied to the control electrode 19 and to the condenser 14, the guard voltage will, for all values of signal voltage, vary correspondingly, with the overall effect that for all values of charge voltage the difference of potential between the high side of the condenser and the guard will be substantially zero and there will be no leakage from the condenser over the leakage path. In this manner the charge on the condenser is maintained automatically irrespective of the magnitude of the potential of the charging source and for each change in the potential of the charging source the guard potential experiences a corresponding change.

The amplifier output is obtained between the terminals 29 and may be employed for other useful purposes.

The schematic showing in Fig. 2 illustrates the guard member 15 interposed between the operating contacts of a switching device and ground. When the switching device is operated the contact member 30 engages the stationary contact member 31 to cause the condenser 14 to be charged from the charging source indicated as connected to the contact spring 30. When the contact members 30 and 31 are disengaged the charge accumulated on condenser 14 would find a leakage path to ground over the insulation resistances 16 and 17 and the charge would be dissipated thereover. By maintaining the guard member 15 at a potential substantially that of the charging source, as described above, leakage of the condenser charge over the leakage path is prevented and the charge on the condenser is maintained indefinitely.

It is apparent that this invention provides a simple arrangement for obtaining the effect of a large time constant. The time constant obtainable is multiplied by $1/\Delta$, where Δ equals $1-K$ where K is the ratio of the original or applied voltage to the voltage fed back to the guard.

What is claimed is:

1. In combination, a condenser, means for charging said condenser to various potentials, a leakage path over which the charge on said condenser may be dissipated, a guard included in said leakage path, and means for applying potentials to said guard which vary automatically with variations in the potential of said charging means comprising a space-discharge device hav-

ing its input associated with said charging means and its output connected to said guard.

2. In combination, a condenser, a variable potential source for charging said condenser and having a connection to one plate thereof, a leakage path over which the charge on said condenser may be dissipated extending from the said one plate of said condenser, a guard included in said leakage path, and means for maintaining a zero difference of potential between the said one plate of said condenser and said guard for all values of potential of said charging source comprising a space-discharge device including an input circuit and an output circuit, means connecting the input circuit of said space-discharge device to the said one plate of said condenser and to said charging source, and means connecting the output circuit to said guard.

3. In combination, a condenser, means for charging said condenser to variable potentials, a leakage path over which the charge on said condenser may be dissipated, a guard included in said leakage path, and means for maintaining a potential on said guard which varies automatically with the potential of said charging means, comprising an amplifier tube having its input circuit connected to the output of said charging means and to a point on said leakage path, and means connecting said guard to a point in the output of said amplifier tube.

4. In combination, a condenser, means for charging said condenser comprising a generator of signals of variable potentials, a device included in circuit with said condenser and said generator and having a signal current leakage path over which the charge on said condenser when subjected to signals from said charging means may be dissipated, means for precluding the dissipation of the charge on said condenser over said leakage path comprising a guard associated with said device, and means for maintaining said guard at a potential which automatically varies with the variable potential signals of said charging means.

5. In combination, a condenser, a signal generator adapted to supply charging signals of variable potentials to said condenser, a leakage path over which the charge on said condenser may be dissipated, said leakage path being connected in shunt with said condenser, and means for precluding the loss of signal resulting from the leakage of the condenser charge over said leakage path comprising a guard interposed in said leakage path, and an amplifier having an input circuit and an output circuit, said amplifier having its input circuit connected to said generator and to said condenser, and having at least a part of the output voltage of its output circuit applied to said guard to maintain said guard at substantially the instantaneous signal potential of the signals supplied to said condenser by said signal generator.

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