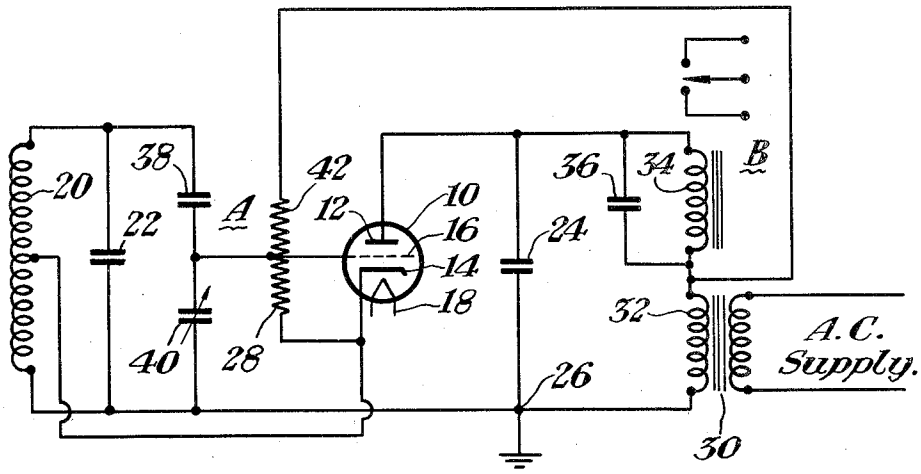
Dec. 18, 1956 R. V. COLES 2,774,919

CAPACITY SENSITIVE RELAY

Filed Oct. 22, 1952




INVENTOR.
Ralph V. Coles
BY
Albert J. Henderson
HIS ATTORNEY

United States Patent Office 2,774,919 Patented Dec. 18, 1956



2,774,919

# CAPACITY SENSITIVE RELAY

Ralph V. Coles, Radnor, Pa., assignor to Robertshaw-Fulton Controls Company, Greensburg, Pa., a corporation of Delaware

Application October 22, 1952, Serial No. 316,219

3 Claims. (Cl. 317—146)

This invention relates to capacity sensitive relays and more particularly to such relays having an oscillator forming part of the detecting system.

It is a principal object of this invention to control a relay in response to slight variations in a controlling capacity.

Another object of this invention is to vary the amplitude of the alternating current generated by an oscillator between maximum and minimum values substantially instantaneously upon slight variations of a controlling capacity.

Another object of this invention is to prevent power supply variations from affecting the sensitivity of a capacity sensitive relay.

With these and other objects in view, the invention may take the form of an oscillator circuit including an oscillatory tank circuit coupled to an electron discharge tube with a source of alternating voltage for the anode of the oscillator tube. A work circuit may be connected in the anode circuit of the electron tube and an additional circuit arranged to apply a positive bias to the grid of the electron tube during the positive half cycles of the power supply to the anode. With this arrangement, the amplitude of the alternating current generated by the oscillator will increase from a minimum to a maximum value substantially instantaneously with the initiation of oscillation.

Other objects and advantages will become apparent from the following specification taken in connection with the accompanying drawing in which the single figure is a diagrammatic showing of the essential elements of a capacity sensitive relay embodying this invention.

Referring more particularly to the drawing, the system embodying this invention is shown as comprising an oscillator A controlling the operation of a relay B.

The oscillator A comprises an electron discharge tube 10 having an anode 12, cathode 14, grid 16 and cathode heater 18. Coupled to the electron discharge tube 10 is an oscillatory tank circuit consisting of a coil 20 connected in parallel with a capacitance 22, one end of the parallel circuit being grounded at 26. The cathode 14 of the tube 10 is connected to a center tap in the coil 20. The anode 12 of the tube 10 is coupled to the one end of the oscillatory tank circuit through a blocking condenser 24 and the ground connection 26. The cathode is thus maintained at an alternating current potential above ground. A grid leak is provided and takes the form of a resistor 28 connected between the grid 16 and the cathode 14.

Power is supplied to the system by a transformer 30 the primary winding of which is connected across a source of alternating current supply. A secondary winding 32 of the transformer 30 has one terminal thereof connected to ground and the other terminal thereof connected to the anode 12 through a coil 34 of the relay B. A suitable condenser 36 may be connected in parallel with the coil 34.

Means is provided for controlling oscillations and takes



the form of a capacitative potentiometer comprising a condenser 38 connected in series with a variable condenser 40. This series circuit is connected in parallel with the oscillatory tank circuit, the variable condenser 40 being connected to the one end of the tank circuit at ground 26 and the condenser 38 being connected to the other end of the tank circuit. The grid 16 of the tube 10 is connected to the junction between the condensers 38, 40. In this arrangement, the input circuit of the electron discharge tube 10 is connected as the detector branch of an electrical bridge of which the condensers 38, 40 and coils 20 form the legs and the balanced diagonal is connected at one end to the grid 16 and at the other end to the cathode 14.

With the oscillator thus far described, oscillations will be sustained when the grid 16 is energized by a component of alternating voltage opposite in phase to the alternating voltage appearing at the anode 12. If the impedance ratio between the two halves of the coil 20 is greater than the impedance ratio between the condensers 38, 40, the grid 16 will be supplied with alternating potential of the proper phase to initiate and sustain oscillations. However, if the capacity of the condenser 40 is increased or its impedance decreased, the amplitude of the alternating potential applied to the grid 16 will be decreased and the amplitude of the oscillations will be decreased.

A gradual change of the capacitance of the condenser 40 will change the amplitude of oscillation from zero to some maximum value which depends upon the characteristics of the tube 10. Such change of capacitance in the condenser 40 will drive the grid 16 positive with respect to the cathode 14 resulting in a grid current flow and establishing a direct current bias across the grid leak 28. This bias will reach a level which will limit the amplification of the tube 10 so that a stable operating point will be reached.

Under conditions of zero oscillation, no bias is developed and the tube 10 will pass maximum plate current. However, under conditions of maximum oscillation, maximum bias is developed and the tube 10 passes minimum plate current. It will thus be apparent that in gradually increasing the feedback from zero to a maximum, the plate current is progressively reduced from a maximum value to a minimum value.

In operation of the device thus far described, assuming that the transformer 30 is connected across a 60 cycle A. C. power supply, the capacitance of condenser 40 is substantially smaller than that of condenser 38, and the tube 10 will oscillate during positive half cycles reaching maximum amplitude at the peak positive half-wave of the source. This amplitude of oscillation being controlled by the gain of the tube and the self bias generated by the self rectification of the grid and developed across the grid leak 28 is reduced when the capacitance of condenser 40 is increased since the amount of feedback is reduced due to the decrease in the impedance ratio between the condensers 38, 40. As the capacitance in condenser 40 is reduced further, the feedback is further reduced until there is insufficient feedback of the proper phase to sustain oscillation. An appreciable change in the value of condenser 40 is required to change from zero to maximum amplitude of oscillation and this change is progressive. In addition to a progressive change in the amplitude of oscillation, the plate current changes from minimum to maximum, and at the point of maximum or near maximum current, the relay B is able to operate.

It is a well-known characteristic of electrical relays that a larger current is required to move the armature to attracted position than is necessary to hold the armature in such position. Thus, if a capacity sensitive

relay is to operate between its "pull in" and "drop out" positions in response to small changes in the capacity of the variable condenser **40**, the variation in plate current must be relatively large as compared with the variation in the capacitance of the capacitor **40**. It is the purpose of this invention to eliminate this progressive effect of changes in the capacitance of condenser **40** around the operating point so that there is a snap action transition in tube **10** when the circuit changes from an oscillating to a non-oscillating state and vice versa. Such a snap action transition eliminates for all practical purposes the progressive extent of the capacitance in condenser **40**, thus making the oscillator circuit highly sensitive around the operating point. To accomplish this, means is provided for applying a positive bias to the grid **16** during the positive half-cycles of the power supply to the tube **10**. To this end, the secondary winding **32** of the transformer **30** is connected to the grid **16** through a resistance **42**. With such an arrangement, variation of the capacitance of the condenser **40** to produce an alternating potential of the correct phase to initiate and sustain oscillation will result in a substantially instantaneous increase in the amplitude of oscillation from a minimum to a maximum causing an instantaneous change in plate current of such a magnitude as to operate the relay B. Similarly, as the capacitance of the condenser **40** is reduced below the value wherein the alternating potential fed to the grid **16** is of such phase as to terminate oscillation, an instantaneous reduction in plate current results.

It is to be noted that this specific addition of means for supplying a positive bias to the tube when it is not oscillating does not overcome the negative bias generated by the oscillations when the circuit is oscillating nor does the current in the plate circuit increase from that normally developed without the addition of this grid potential.

The total effect of including an additional grid potential in phase with the plate voltage is to enable the tube **10** to become more conductive to current than would be the case without the addition of this potential, thereby allowing an instantaneous change of state from oscillating to non-oscillating or vice versa for small changes of grid potential induced from the tank circuit. From this, it can be seen that for small changes of capacitance in condenser **40** at the critical point, the change in feedback is capable of snapping the tube into an oscillating or non-oscillating condition whereby maximum or minimum current in the plate circuit is attained substantially instantaneously without the immediate stages of increasing or decreasing the current to these points.

It is to be noted that the resistance **42** produces a leakage path from the grid through the secondary **34** to ground. Thus, the grid leak resistor **28** is not essential for proper operation of the device.

It has also been found that by thus applying a positive bias to the grid of the oscillator tube **10** during the positive half-cycles of the power supply, variations in the characteristics of the circuits resulting from variations in the power supply are minimized. Therefore, with the arrangement disclosed, the ratio between the capacitor **38** and the capacitor **40** necessary to initiate oscillation will remain substantially the same despite variations in the supply voltage. The frequency of oscillation is high relative to the A. C. supply frequency. Very good results have been obtained with a frequency of oscillation in the low radio frequency range and a value of resistance **42** in the order of 100,000 ohms to several megohms.



It will be apparent to those skilled in the art that many modifications of the disclosed embodiment of this invention may be made without departing from the scope thereof which is to be measured by the appended claims.

I claim:

1. An impedance sensitive device having a source of alternating voltage, comprising in combination, an oscillator circuit including an electron discharge device having an anode, a cathode and a grid, an oscillatory tank circuit connected between said grid and one side of the source, means for connecting the other side of the source to said anode, means for connecting the electrical center of said tank circuit to said cathode, means including a variable impedance associated with said oscillatory tank circuit for varying the amplitude of oscillation in said device, and a resistance connected to the anode side of the source and to said grid for applying a voltage to said grid in phase with the anode voltage.

2. An impedance sensitive device as claimed in claim 1 wherein the anode side of the source is connected directly to said grid through said resistance.

3. An impedance sensitive device having a source of alternating voltage comprising in combination, an oscillator tube having an anode, a cathode and a grid, an oscillatory tank circuit, a connection between one side of the source and said anode, a connection between said cathode and the electrical center of said tank circuit, means for connecting said tank circuit between the other side of the source and said grid to impress a feedback voltage on said grid and thereby to cause oscillation of said tube, an impedance potentiometer associated with said tank circuit for controlling said feedback voltage and the amplitude of oscillation in said tube, and a connection including a series resistor between the anode side of the source and said grid for feeding a positive potential to said grid during the positive half cycle of said source so that the voltages to said anode and said grid are in phase.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 2,094,351 | Draper | Sept. 28, 1937 |
| 2,100,756 | Shepard | Nov. 30, 1937 |
| 2,145,124 | Mead | Jan. 24, 1939 |
| 2,505,577 | Rich | Apr. 25, 1950 |
| 2,632,086 | Hagen | Mar. 17, 1953 |