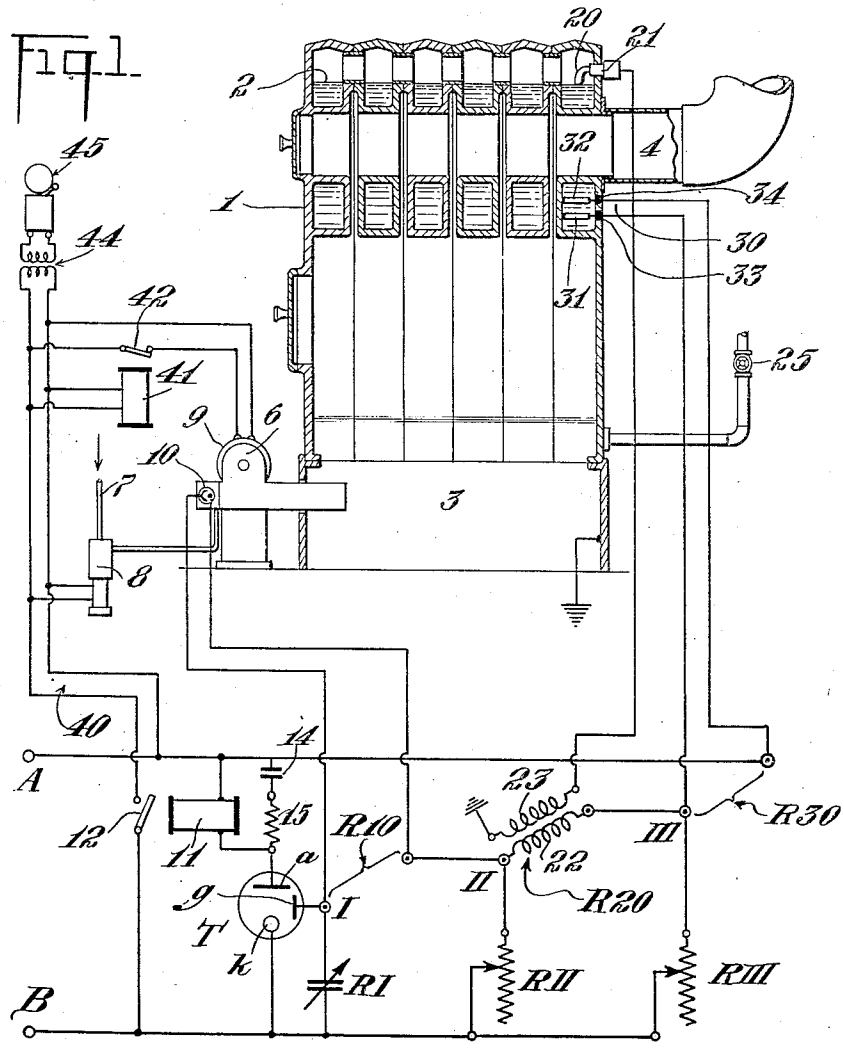
Dec. 3, 1946. J. A. LONG ET AL 2,411,888

MULTIPLE RESPONSE SUPERVISORY SYSTEM

Filed Oct. 16, 1941

Fig. 1.



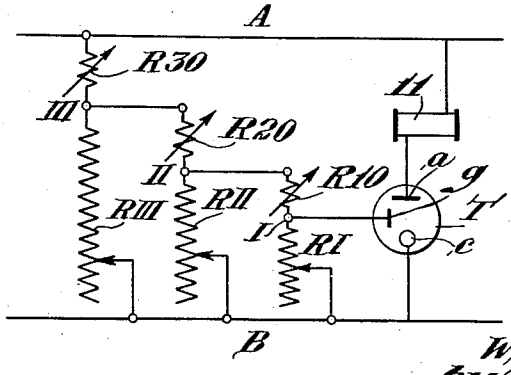


Fig. 2.

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Patented Dec. 3, 1946 2,411,888

UNITED STATES PATENT OFFICE

2,411,888

MULTIPLE RESPONSE SUPERVISORY SYSTEM

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Application October 16, 1941, Serial No. 415,260

6 Claims. (Cl. 250—27)

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The present invention relates to electronic control devices and deals especially with circuits for supervising a plurality of conditions of operation.

It is often necessary or desirable, especially in industrial plants, to provide an installation for supervising various conditions of plant operation in a manner permitting the use, without extensive special design or adaptation, of a simple device which can be installed and operated by comparatively unskilled personnel. Accordingly, one of the main objects of the invention is to provide an extremely simple electric system in which a single electronic tube responds to changes in any one of a plurality of detecting or supervising circuits.

In one of its aspects, the invention provides a rugged and yet exact device for electronically supervising various operating conditions in the simplest possible and hence inexpensive manner; in another aspect the invention provides such a device which can be easily adjusted to accommodate various detecting apparatus and which is extremely flexible and adaptable; in still another aspect, the invention provides direct electronic correlation of several detecting or supervising devices with a single receiver, as for example a signal or relay device.

These and other objects, aspects and features of the invention will appear from a detailed description of a concrete embodiment illustrating the genus of the invention; this description refers to a drawing in which

Fig. 1 shows a boiler installation incorporating the invention; and

Fig. 2 is a simplified diagram of the electric circuit according to Fig. 1.

Fig. 1 illustrates the application of the present invention to a boiler heating system. This figure shows a grounded boiler 1 with water chamber 2, a firebox 3 and flue 4. The boiler may be heated by means of an oil burner 6 having an oil supply line 7 with electrically operated safety shut-off valve 8 and electromotor 9.

The supervising arrangement according to the invention is supplied from a source of current, for example alternating current, indicated by terminals A, B. An electron tube T, for example of the cold cathode type with cathode *k*, anode *a* and auxiliary electrode or starting anode *g*, is connected to terminals A, B in series with relay magnet 11 retaining a switch 12 open so long as it is energized due to tube T being conductive; a condenser 14 and a resistance 15 are connected in parallel to magnet 11 in order to prevent chattering.

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The starting anode *g* is connected to terminal A through a series of detecting impedances; in the present instance, three such impedances are shown. One impedance is a phototube 10 mounted on the oil burner in such a manner that it can receive radiation from the oil burner flame and has a comparatively low impedance as long as the burner produces the heating flame; the second detecting impedance may be a water level probe 20 mounted in an insulating bushing 21 in such a manner that its tip is at the lowest water level permitted; and the third detecting impedance may be a salinity indicator 30 with two probe plates 31, 32 mounted in the water chamber by means of insulating bushings 33, 34. Water is supplied through conventional means indicated at 25.

Phototube 10 is connected between electrode terminal I and terminal II of a transformer primary 22 inductively coupled to secondary 23 which is connected between ground and level probe 20. The second terminal III of the primary 22 is connected to plate 31 of the salinity detector 30, and plate 32 is connected to terminal A.

Between terminal I and source terminal B is connected an adjustable control impedance RI, preferably a condenser; between point II and terminal B is connected a second adjustable impedance RII, for example a resistance, and between point III and terminal B is connected a third adjustable impedance RIII, for example another resistance.

The entire electrical circuit is shown in simplified manner in Fig. 2 which shows the three adjustable control impedances RI, RII and RIII between source terminal B and points I, II, III, and the three variable detecting impedances R10, R20, R30, corresponding control and detecting impedances constituting three detecting circuit branches. R10 represents the impedance of phototube 10 which will increase considerably if the oil burner flame extinguishes; R20 represents the impedance of primary 22 which will be considerably increased if the circuit which shorts secondary 23, namely circuit ground-23-20-water-boiler-ground, is opened upon the water level falling below the tip of probe 20; RIII represents the impedance of salinity detector 30 which will increase upon a decrease in the salinity of the water fed into the boiler. It will now be evident that further detecting impedances can be added to the circuit analogously.

For reasons which will be apparent below, the impedances RI, RII, RIII have to be so selected

and adjusted that their values are considerably higher than those of the corresponding detecting impedances. For example, a phototube of the PG30 type has an operating impedance of about 5 megohm which increases to about 1000 megohm when the tube is not illuminated. The impedance of a transformer as indicated at 22—23, with the secondary connected through the boiler water, may conveniently be selected to amount to about 5000 ohm and will increase, upon the secondary being interrupted, to about 50,000 ohm. The normal resistance of a salinity detector supervising for example a water softening equipment, may for example amount to about 500 ohm for a certain salinity and water volume between the probes, and will increase rapidly upon decrease of salinity. For detecting elements 10, 20, 30 with impedances of this order of magnitude, compensating impedance RI would be about 40 megohm with the capacitance of the condenser about 70 mmfd., impedance RII would be about 25,000 ohm and impedance RIII about 50,000 ohm.

The circuit shown by way of example in Fig. 1 further includes a controlled circuit 40 which is energized upon closure of switch 12. This controlled circuit may include connections to electrically operated oil valve 8 which closes upon energization of circuit 40, to a relay magnet 41 with normally closed motor switch 42, and to a signaling device 45 connected through transformer 44.

This system operates as follows:

Under normal conditions, the flame is burning and the phototube conducting; the water level is above the probe and the transformer primary 22 offers a low resistance; and the salinity is above a given value so that the water is comparatively well conducting. The compensating impedances RI, RII, RIII will be so adjusted that the potential at I, that is the potential of the starting anode or auxiliary electrode, will be above the value at which the tube becomes conductive. Further, the compensating impedances RI, RII, RIII are so adjusted that increase of any one of the three control impedances R10, R20, R30, due to variation of one of the detecting impedances 10, 20, 30, will drive the potential at I to a value below the starting potential. It will be evident that this adjustment can be easily accomplished and that the particular adjustment values RI, RII, RIII will depend entirely upon the normal values of impedances R10, R20, R30 which of course vary with any particular installation; it is one of the main advantages of this system that it permits easy adaptation of a circuit containing a single electronic element, to the characteristics of several values to be supervised.

It will now be apparent that supervising and compensating impedances may be interchanged, so that for example, if it should be desired to detect salinity decrease instead of increase, the probes 30 representing impedance R30 could be inserted at RIII of Fig. 2, in which case RIII would take the place of R30. Also, the control anode *g* of the tube may normally be below the starting value and the respective impedances so arranged that control anode *g* goes through the critical potential value and renders the tube conductive upon a predetermined change of any one of the impedance values.

Referring to Fig. 1, as soon as the tube is rendered non-conductive due to variation of any one of the control impedances, magnet 11 becomes deenergized and switch 12 closes causing valve 8 to shut off the oil supply, energizing relay magnet 41 to open motor switch 42, and operating signal 45.

It is a peculiar feature of the present invention that a large variety of operating conditions can be supervised with a considerable variety of detecting means selected to suit the particular type of the operating condition in question. Referring by way of example again to a boiler plant, various operating conditions may be supervised in different ways as follows.

The liquid level in tanks or boilers either regarding its maintenance at a desired normal level or its sinking below a given minimum height, can be supervised according to the invention by changing the resistance between current carrying probes by using the liquid itself as a conductor as above described by way of example, by changing inductance values by connecting through the liquid certain windings of a coil, by frequency changes through shielding with the liquid one element of a circuit from another, by changing the intensity of light falling on a phototube through the changing liquid level, by affecting a temperature-sensitive circuit element through immersion in or emergence from the liquid, by changing the intensity of an electric or magnetic field passing to varying amounts through the liquid, or by adjusting circuit elements through changes of the liquid or gas pressure with changing head.

Flames or other heating elements of a thermal plant may be supervised for example thermometrically or through detection of radiant energy by means of phototubes, thermopiles, or through changes of conductivity or capacity by the flame burning between conducting or capacitance probes or itself serving as a probe, or by absorption of high frequency oscillations due to the carbon contents of the flame.

The temperature of liquids, flames, gases or mechanical elements may for example be supervised through thermometric elements or through detection of color temperature or infra red radiation or again through changes of conductivity, capacity or inductance in detecting elements whose electric values are functions of ambient temperature.

The pressure of steam, gases or liquids may be detected manometrically, piezoelectrically, by way of the change of electrical or magnetical values due to stresses in pressure detecting elements, or by affecting the polarization of light passing through such elements on its way to the light sensitive circuit elements.

The chemistry of liquids as feed water or brine, of fuel, or of combustion gases, or physical properties as oil viscosity or atomizing characteristics may also be detected by means such as indicated above.

Although the circuit herein described by way of example incorporates a cold cathode tube, it will be understood that tubes of other types, such as tubes with heated cathodes, can be used analogously; the term "triode" as herein used includes all tubes, whether of the vacuum or gas type, having at least three electrodes including a control electrode.

It will now be evident that the above-described system provides a simple and very flexible and adaptable means of supervising any number of varying operating conditions which can be translated into varying electric impedances.

It should be understood that the present dis-

closure is for the purpose of illustration only and that this invention includes all modifications and equivalents which fall within the scope of the appended claims.

We claim:

1. Electronic multiple supervision apparatus comprising a current source providing two supply points of different potential, a triode whose anode circuit is supplied from said points, means responsive to the conductivity of said triode in said anode circuit, a plurality of detecting circuit branches, each branch including a variable detecting impedance and an adjustable control impedance connected on one side to said detecting impedance and on the other side to one of said supply points, and a triode control circuit connecting the other supply point in series through the detecting impedance of each branch to the control electrode of said triode, the values of said detecting and control impedances being correlated normally to apply to said electrode a potential varying from the control potential value corresponding to a certain conductivity of said triode, but to move said electrode potential through said value upon a change of any one of said detecting impedances, the effective amount of which change can be predetermined by adjusting said control impedances.

2. Electronic multiple supervision apparatus comprising a current source providing two supply points of different potential, a triode whose anode circuit is supplied from said points, means responsive to the conductivity of said triode in said anode circuit, two detecting circuit branches, one branch including a phototube and a control impedance connected at one side to said phototube and on the other side to the supply point of lower potential and the second branch including a water level probe and a second control impedance connected at one side to said level probe and on the other side to said supply point of lower potential, and a triode control circuit connecting the supply point of higher potential through said phototube and said level probe to the control electrode of said triode, the impedance values of said detecting circuit branches being correlated normally to provide said electrode with a potential rendering said triode conductive but to reduce said electrode potential to a conductivity blocking value upon an impedance change of either said phototube or said probe.

3. Electronic apparatus for supervising an industrial installation in response to several characteristic values thereof, comprising a current source, an electron discharge device having two output terminals connected to said source and a control terminal, installation control means responsive to the conductivity of said discharge device, a plurality of detecting impedance means connected in series between one of said output terminals and said control terminal, the values of said detecting impedance means varying individually according to respective ones of said characteristic values, and a control impedance connected between the terminal next to said control terminal, of each of said detecting impedance means, and the other output terminal of said discharge device, said control impedances being dimensioned to vary, upon a variation of any one of said detecting impedance means values, the potential of said control terminal beyond a predetermined value effective to vary the condition

of said discharge device sufficiently to actuate said control means.

4. Electronic apparatus for supervising a heating installation in response to several characteristic values thereof, comprising a current source, a triode whose output terminals are supplied from said source, installation control means connected to said terminals responsive to the conductivity of said triode, a plurality of detecting impedance means connected in series between one of said output terminals and the control electrode of said triode, the values of said detecting impedance means varying individually according to respective ones of said characteristic values, and a control impedance connected between the terminal next to said output terminal, of each of said detecting impedance means, and the other output terminal of said triode, said control impedances being dimensioned to vary, upon a variation of any one of said detecting impedance means values, the potential of said electrode beyond a predetermined value effective to vary the conductivity of said triode sufficiently to actuate said control means.

5. Electronic multiple supervision apparatus comprising a current source providing two supply points of different potential, a triode whose anode circuit is supplied from said points, means responsive to the conductivity of said triode in said anode circuit, a plurality of detecting circuit branches, each branch including a variable detecting impedance and an adjustable control impedance connected on one side to said detecting impedance and on the other side to one of said supply points, and a triode control circuit connecting the other supply point in series through the detecting impedance of each branch to the control electrode of said triode, the values of said detecting and control impedances being correlated normally to apply to said electrode a potential above the potential value corresponding to a certain conductivity of said triode, but to move said electrode potential through said value upon a change of any one of said detecting impedances, the effective amount of which change can be predetermined by adjusting said control impedances.

6. Electronic multiple supervision apparatus comprising a current source providing two supply points of different potential, a triode whose anode circuit is supplied from said points, means responsive to the conductivity of said triode in said anode circuit, a plurality of detecting circuit branches, each branch including a variable detecting impedance and an adjustable control impedance connected on one side to said detecting impedance and on the other side to one of said supply points, and a triode control circuit connecting the other supply point in series through the detecting impedance of each branch to the control electrode of said triode, the values of said detecting and control impedances being correlated normally to apply to said electrode a potential below the potential value corresponding to a certain conductivity of said triode, but to move said electrode potential through said value upon a change of any one of said detecting impedances, the effective amount of which change can be predetermined by adjusting said control impedances.

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