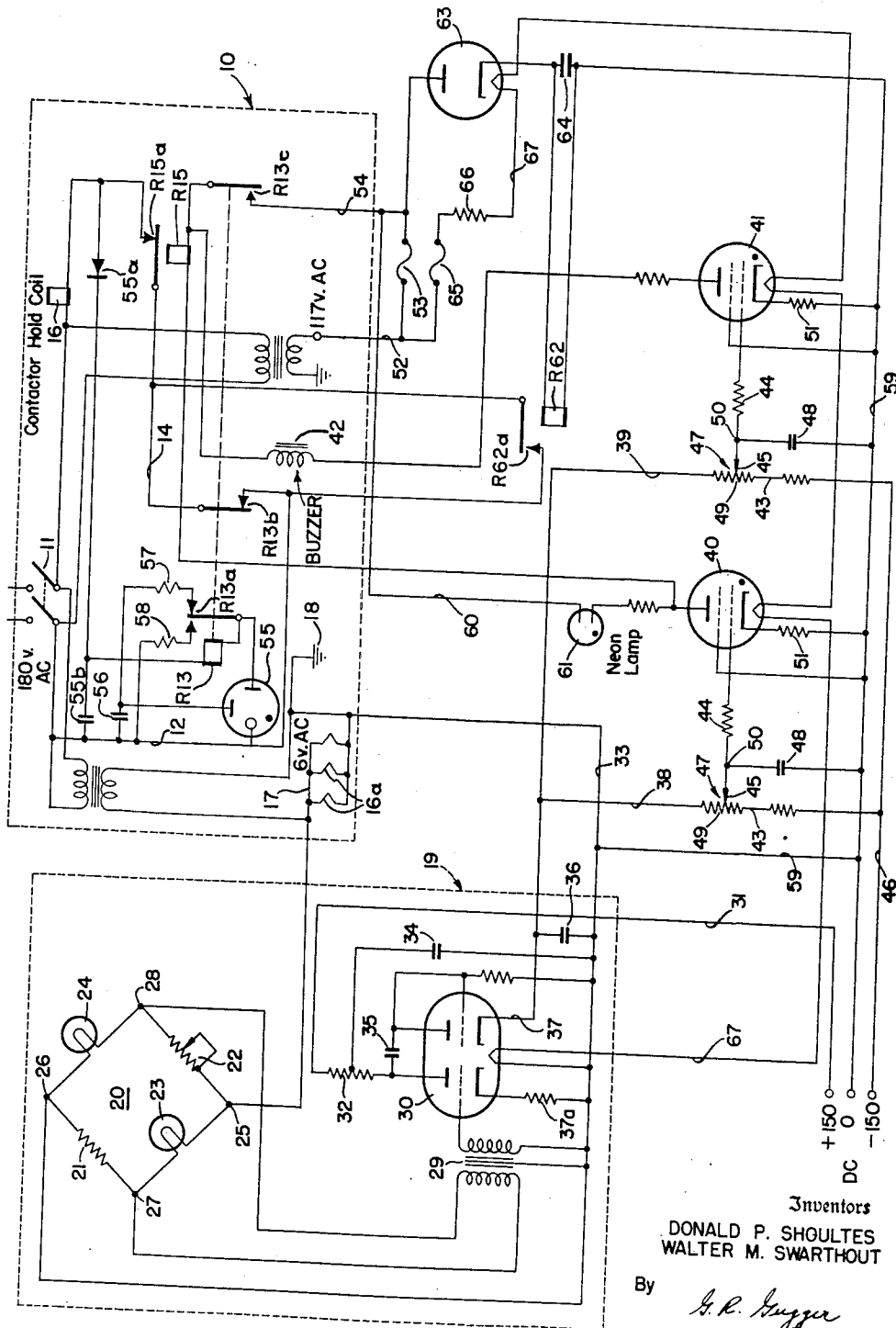


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MONITORING SYSTEM CONTROL CIRCUITS

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MONITORING SYSTEM CONTROL CIRCUITS

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This invention relates to a monitoring system for a machine control circuit and is more particularly directed to control circuits for interlocking the operation of a machine control circuit with a voltage monitoring circuit.

This application is a division of the prior copending application, Serial No. 237,642, filed July 19, 1951, issued December 20, 1955, as U. S. Patent No. 2,727,990, and entitled "System for Monitoring A. C. Voltages."

It can be readily understood that in any machine where there are a great many electron tubes in use, it is vitally important that the heater voltages to these tubes remain constant. If the heater voltages should become excessive, the tubes would be over-heated and their life greatly decreased thereby resulting in frequent tube failures. Also if the heater voltages decrease below a required value, inefficient operation of the tubes may result. In cases where such tube failures occur, due to straying heater supply voltages, faulty operation of the machine will occur. It is particularly desirable, then, to be able to detect when any one heater supply voltage strays and to initiate a warning signal to indicate that such a condition is present. Also, if any one heater supply voltage should stray and approach what is considered a dangerous level, it would be desirable to cut off the machine before any damage is done to the tubes.

It is, therefore, an object of this invention to provide a monitoring system for detecting when electron tube heater supply voltages depart from a predetermined range.

It is a further object to provide a monitoring system for detecting when electron tube heater supply voltages depart from a predetermined range including means to initiate a warning signal when such a condition occurs.

It is a further object to provide a system for monitoring the electron tube heater voltages supplied to a main machine including means for cutting off the main machine when any one heater supply voltage approaches what is considered a dangerous level.

It is still another object to provide a monitoring system for detecting when electron tube heater supply voltages depart from a predetermined range including means for preventing connection of a to-be-monitored voltage in case the monitoring system power source is cut off.

To the end that the objects of the invention may be achieved, there has been provided herein a heater voltage monitoring system in connection with a main machine in which there may be included any number of electron tubes. A single heater voltage supply or a plurality of heater voltage supplies may be included in the machine and a voltage measuring circuit is provided in the monitoring system which is responsive to voltage changes in any of the heater voltage supplies. In the preferred embodiment, the main machine also includes a control circuit which includes a pair of normally closed relay contacts. In this embodiment, the monitoring system is designed to include the control circuit and is provided with a thyatron circuit and associated relay coil to operate said normally closed contacts. Upon a voltage change in any heater supply, a cir-

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cuit is completed through the voltage measuring circuit and the thyatron circuit to energize the said relay coil and open the normally closed contacts. This opens the control circuit and cuts off the machine before faulty operation can occur due to improper heater voltages. The thyatron circuit also includes means for initiating a warning signal just prior to the opening of the control circuit and in this connection there is provided a thyatron range setting circuit for establishing a differential in the voltage necessary to operate the warning signal and the voltage necessary to disable the main machine. This feature insures against disabling the main machine until the heater voltage change has approached a level which will be determined to the operation of the machine. A safety relay circuit is provided in parallel with the machine control circuit for preventing the connection of a to-be-monitored voltage in case the monitoring system power source is cut off.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawing, which discloses, by way of example, the principle of the invention and the best mode, which has been contemplated, of applying that principle.

The invention will be more particularly understood with reference to the single drawing which is a diagrammatic representation of a main machine system having imposed thereon the monitoring system of the present invention.

There is a control circuit of a main machine shown diagrammatically within the dotted section indicated at 10 on the drawing. Upon closure of a switch 11, the circuit extends from one side of a 180 volt A. C. power source, one side of switch 11, wire 12, a normally closed contact R13b, wire 14, a normally closed contact R15a, a contactor hold coil 16, the other side of switch 11 to the other side of the power source. Contactor coil 16 is thus energized and it is to be assumed that with this coil energized the machine is conditioned for operation.

It is also to be assumed that the main machine contains a plurality of electron tubes the cathodes of which have to be indirectly heated before the tubes can operate to perform machine functions. To take care of this condition, there is provided in the machine a source of 6 volts A. C. which is to be supplied to the heaters 16a of the tubes in the machine. The source may comprise a plurality of individual 6 volt A. C. supplies, such as the one indicated at 17, along with the usual ground connection 18. Any number of the individual 6 volt A. C. supplies may be used depending on the arrangement and number of tubes that are to be supplied in the machine.

As a part of the present heater voltage monitoring system there is provided a voltage measuring circuit coupled with an amplifier rectifier circuit such as is shown within the dotted section indicated at 19 on the drawing. This particular portion of the monitoring system functions to detect when a 6 volt heater supply departs from its value of 6 volts and, upon such a departure, to measure the amount of difference voltage that will exist. The difference voltage, which is generally rather minute, is then amplified and rectified so that it may be used to perform useful work such as firing tubes and picking relays.

The voltage measuring circuit comprises a balanced bridge 20 having four legs or sides. One of the legs is constructed of an ordinary resistance element 21 while an oppositely disposed leg is constructed of a variable resistance 22. The two remaining legs are composed of resistances 23—24 which have a high positive temperature coefficient of resistance. For this purpose, we have found that ballast tubes are very effective because they increase the sensitivity of the system due to their high incremental resistance. Also they operate with a slight time lag. In the present application it is desirable to

avoid recording sudden peak voltage changes in the heater supplies and to record only those voltage changes which remain for a length of time.

This type of bridge operates on root mean square values and is not affected by distorted A. C. waves. The resistance of the tubes 23—24 increases or decreases as the R. M. S. voltage across them increases or decreases. This characteristic allows the use of this bridge with either sinusoidal or non-sinusoidal wave forms; in either case it renders a difference voltage at an R. M. S. value.

In the operation of the circuit, a 6 volt A. C. voltage supply is applied to the opposite corners 25—26 of the bridge network 20 while the remaining corners 27—28 are connected to the primary winding of a high impedance transformer 29. The variable resistance 22 is adjusted to render a drop of 3 volts across each component of the bridge and under this condition there will be no difference in potential at the remaining two points 27—28. Whenever the applied voltage is increased or decreased a difference voltage is present at the points 27—28 because of an unbalanced condition. The amount of difference voltage is proportional to the amount that the supply voltage is off.

Whenever a difference voltage appears at the points 27—28, it is amplified through the high impedance transformer 29 and fed into the grid of a twin tube 30. This half of the tube acts as a class A amplifier and is normally conducting by means of a circuit from the plus 150 volt terminal of a 300 volt D. C. source, wire 31, resistor 32, plate circuit of the left-hand side of the tube 30, and wire 33 to the ground connection 18. A condenser 34 is connected between a tap on resistor 32 and the ground wire 33 to filter undesirable A. C. components of the 150 volt supply and prevent the A. C. components of said 150 volt supply from adding to the A. C. difference voltage.

The A. C. difference voltage input to the grid is amplified considerably and fed through a coupling condenser 35 to the right-hand side of tube 30 which is connected as a diode. Condenser 35 serves to block everything but the A. C. signal and the pure A. C. voltage is fed through the diode and rectified. The resulting D. C. voltage charges a condenser 36 connected between the cathode 37 of the diode section of tube 30 and the ground wire 33. A feed back resistor 37a is placed in the cathode circuit of the amplifier half of tube 30 and serves as a means for stabilizing the gain of the amplifier against amplifier tube changes that may occur due to tube wear, changes in value of the tube components, changes in the grid or signal circuit, or changes in the 300 volt power supply.

This D. C. voltage charge is proportional to the changes in the R. M. S. voltage in the 6 volt supply 17 shown connected to the monitoring system and it has been amplified and rectified so that it may be used to control the operation of the main machine as will be later described. If it is desired to monitor additional 6 volt supplies 17, an additional circuit section such as was just described and shown within the dotted lines 19 on the drawing may be added to the system for each additional 6 volt supply. The cathode 37 will be common to the cathodes of the added sections and the condenser 36 will be charged with a D. C. voltage determined by the value of the highest cathode.

If a D. C. voltage charge appears at condenser 36 it will be fed by means of wires 38 and 39 into a pair of thyatron range setting circuits which control the firing of a pair of thyatron tubes 40 and 41. The thyatron tube 41 is used to operate an audible alarm or buzzer 42 to give warning that the heater supply voltage is straying. If the supply voltage deviation should approach a dangerous level, then, the thyatron tube 40 will be caused to fire to operate an A. C. relay R15 whose normally closed points R15a are used to open the machine control circuit and cut off the main machine.

Each thyatron range setting circuit includes a voltage divider 43 and resistor 44 in the grid circuit of its related

thyatron tube. A point 45 on each voltage divider receives a negative bias by means of a wire 46 from the minus 150 volt terminal of the 300 volt D. C. source and normally holds its related tube beyond cut-off. Potentiometers 47 in the dividers cover a considerable range so that each thyatron tube can be set to fire at whatever value thought necessary. Thyatron tube 41 is set to fire at a lower voltage than tube 40 so that the buzzer 42 will operate first; and if the voltage charge at condenser 36 increases still further, then, thyatron tube 40 will be caused to fire to stop the machine.

A capacitor 48 is connected between each grid circuit and the ground wire 33 to form an R. C. coupling with resistor 49 of the dividers for the purpose of acting as a time constant to control how fast the thyatron tubes will respond to the D. C. voltage charge on condenser 36. It is desirable to have the thyatron tubes respond only to those supply voltage changes which continue to exist for a time because it would not be necessary or desirable to sound a warning or stop the machine for sudden peak voltage changes which do not exist long enough to be detrimental to the tube heaters in the machine. The resistors 44 function to limit current from the thyatron tube grids from charging the capacitors 48. If grid current were allowed to charge capacitors 48, then the voltage dividers could no longer be used to reliably control the firing of the tubes because there may be a higher voltage at point 50, due to the charge on condenser 48, than that which would be caused by the voltage on condenser 36.

A resistor 51 is placed in the cathode circuit of each thyatron and acts in combination with the resistor 44 to aid in stabilizing the turn off potential required at the grids of the thyatrons.

It has been pointed out in the range setting circuits, just described, how the thyatron tubes 40 and 41 may be conditioned for operation from a predetermined range of voltage charge at condenser 36. For the tubes to actually fire there must be a potential applied to their anodes and this would be accomplished by means of a circuit from a 117 volt A. C. source in the main machine, wire 52, fuse 53, wire 54, normally open points R13c upon closure of same, and through the buzzer 42 and the relay R15 to the anodes of tubes 40 and 41.

However, the normally open R13c points have not as yet been closed even though switch 11 was previously closed to turn on the main machine and, hence, the thyatron tubes will not operate. Under such circumstances the monitoring system has the effect of being disconnected from the main machine when the machine is turned on. This condition is necessary because after the main machine is turned on, it takes some time for the 6 volt supplies 17 to reach their full value of 6 volts. If the monitoring system were allowed to operate before the heater supplies reached their full value of 6 volts, the bridge 20 would be unbalanced indicating a voltage difference and the monitoring system would cut off the main machine before it could get started.

Accordingly, there is provided in the control circuit of the main machine a time delay circuit for calling in the monitoring system as soon as the main machine has had a chance to warm up and the supply voltages have had a chance to reach their full value. This circuit comprises a cold cathode gas triode 55 in series with a time delay relay R13. The triode 55 and relay R13 circuit is energized from a rectifier and condenser circuit connected in parallel with the machine control circuit and when switch 11 is closed, the 180 volt A. C. line voltage is fed through a rectifier 55a and condenser 55b and the resulting D. C. voltage is applied across the tube. However, this line voltage is insufficient to fire the tube itself and so it is also applied across a capacitor 56 through the normally closed R13a points of the relay R13 and a resistor 57. The resistor 57 is large enough to prevent the charge on capacitor 56 from building up to a potential great enough

to fire the triode 55 until the machine has warmed up and the supply voltages have reached their full value. When the capacitor reaches firing potential, triode 55 will fire causing relay R13 to become energized. When relay R13 energizes, the R13a points will transfer to complete a holding circuit for R13 through a resistor 58. Transfer of the R13a points will also open the circuit to the capacitor 56 and the triode starter.

With the R13c points now closed, there is a 117 volt A. C. potential on the anodes of the thyratrons 40 and 41 and when a charge appears on condenser 36, indicating a voltage change in the 6 volt supplies, a circuit is completed from the 117 volt A. C. source, wire 52, fuse 53, wire 54, the closed R13c points, buzzer 42, plate circuit of tube 41, wire 59, and wire 33 to the ground connection 18. The buzzer 42 sounds a warning signal to indicate that the heater supply voltages are straying.

If the heater supply voltages stray beyond a predetermined range, the increased charge on condenser 36 will cause a parallel circuit to be completed through relay R15, plate circuit of tube 40, wire 59, and wire 33 to the ground connection 18. Relay R15 will open the normally closed R15a points in the control circuit of the main machine thereby dropping out the contactor hold coil 16 and stopping the machine before any damage can be inflicted by the heater voltages.

When thyatron tube 40 fires, a parallel circuit is completed from the 117 volt A. C. source, wire 52, fuse 53, a wire 60, neon lamp 61, plate circuit of tube 40, wire 59, and wire 33 to the ground connection 18. The neon lamp gives a visual indication that tube 40 has fired and caused the main machine to stop. It provides a checking means when adjusting the firing point of tube 40 with respect to the firing point of tube 41.

In the operation of the time delay circuit, previously described, it will be noted that upon energization of relay R13, a pair of normally closed R13b points in the control circuit of the main machine were opened. This would normally result in dropping out the contactor hold coil 16 and stopping the machine when it is desired to have the machine running. To prevent the control circuit from being broken at this time, there is provided a shunt circuit around the R13b points. This shunt circuit includes a pair of normally open R62a points which are under control of a D. C. relay R62 located in the plate circuit of a diode rectifier tube 63.

The diode tube circuit is provided as a means for interlocking the monitoring system with the control circuit of the machine to insure against operation of the main machine in the event that the monitoring system should become disabled. For example, should any of the tube heaters or fuses in the monitoring system fail, it is desirable to stop the main machine because the monitoring system would not be operating and the main machine could become damaged if the heater voltages should stray.

When switch 11 was closed to turn on the main machine, a circuit extended from the 117 volt A. C. supply, wire 52, fuse 53, the plate circuit of the diode rectifier tube 63, D. C. relay R62, wire 59, and wire 33 to the ground connection 18. It takes some time for the tube 63 to respond, but the relay R62 is picked up prior to the time that tube 55 in the time delay circuit fires. The R62a points will close before the R13b points open thereby maintaining the main machine in operation and interlocking the diode tube circuit of the monitoring system with the control circuit of the machine. A condenser 64 is placed across the coil of relay R62 to keep it energized during the negative half cycle of the A. C. supply.

The R13b points are in the control circuit to allow for immediate starting of the main machine. Without the R13b points, a suitable starter button would have to be manually held in long enough to fire the diode tube 63 and energize relay R62 to close the R62a points.

Also, at the time that the main machine was turned on, a circuit was completed from the 117 volt A. C. supply,

wire 52, a fuse 65, resistor 66, a wire 67 which connects in series all of the tube heaters in the monitoring system, and wire 33 to the ground connection 18.

It is clear that if any one tube heater in the monitor system should fail, the heater circuit will be broken and the diode tube 63 will fail to conduct. Relay R62, then, will drop out opening the R62a points and stopping the main machine.

In the event that fuse 65 should fail, the same circuit would become effective to stop the machine. A failure of fuse 53 will open the plate circuit of tube 63 to cause the machine to be stopped.

Such safety features provide protection against fuse and heater openings and minimize the possibilities of the main machine running without the monitor system in operation.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. In a system of the class described, a source of alternating current heater voltage, a monitoring circuit comprising a balanced bridge circuit connected to said alternating current voltage so that a change in the value of same will unbalance said bridge circuit to render an output voltage corresponding in value to the voltage change, an amplifier-rectifier device responsive to said output voltage to change said output voltage into a proportional direct current voltage, an electron discharge device operable in response to said direct current voltage, a machine control circuit, a main source of voltage for operating said control circuit, means controlled by the operation of said discharge device for disabling said machine control circuit upon the occurrence of a change in said heater voltage, a delay circuit connected in parallel with said machine control circuit and including a delay relay, an interlock circuit connected to said machine control circuit and comprising an auxiliary power source, an electron discharge device, and an interlock relay, heaters for said amplifier-rectifier device and said discharge devices connected in series to said auxiliary power source, said machine control circuit including open contacts of said interlock relay and closed contacts of said delay relay shunting said open contacts, switch means operable to connect said main source of voltage to said machine control circuit and to said auxiliary power source thereby energizing said interlock relay and delay relay, means included in said delay circuit for delaying the energization of said delay relay so that said open contacts of the interlock relay will transfer to a closed position before said closed contacts of the delay relay transfer to an open position, the delay relay contacts when closed serving to allow for initial operation of said control circuit and the interlock relay contacts when closed serving to maintain operation of said control circuit and to place same under control of said monitoring circuit whereby failure of any of said heaters will drop out the interlock relay to disable said control circuit.

2. In a system of the class described, a source of alternating current heater voltage, a monitoring circuit comprising a balanced bridge circuit connected to said alternating current voltage so that a change in the value of same will unbalance said bridge circuit to render an output voltage corresponding in value to the voltage change, an amplifier-rectifier device responsive to said output voltage to change said output into a proportional direct current voltage, an electron discharge device operable in response to said direct current voltage, a ma-

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chine control circuit, a main source of voltage for operating said control circuit, a delay circuit connected in parallel with said machine control circuit and including a delay relay, a stop relay and open contacts of said delay relay connected in series between the output of said electron discharge device and an auxiliary power source, closed contacts of said stop relay connected in said machine control circuit and adapted when transferred to disable said control circuit, switch means operable to connect said main source of voltage to said machine con-

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trol circuit and to said auxiliary power source thereby effecting energization of said delay relay, and means included in said delay circuit for delaying the energization of said delay relay so that the machine control circuit can operate for a time before said open delay contacts are transferred to render said stop relay operable by said electron discharge device for disabling said control circuit.

No references cited.