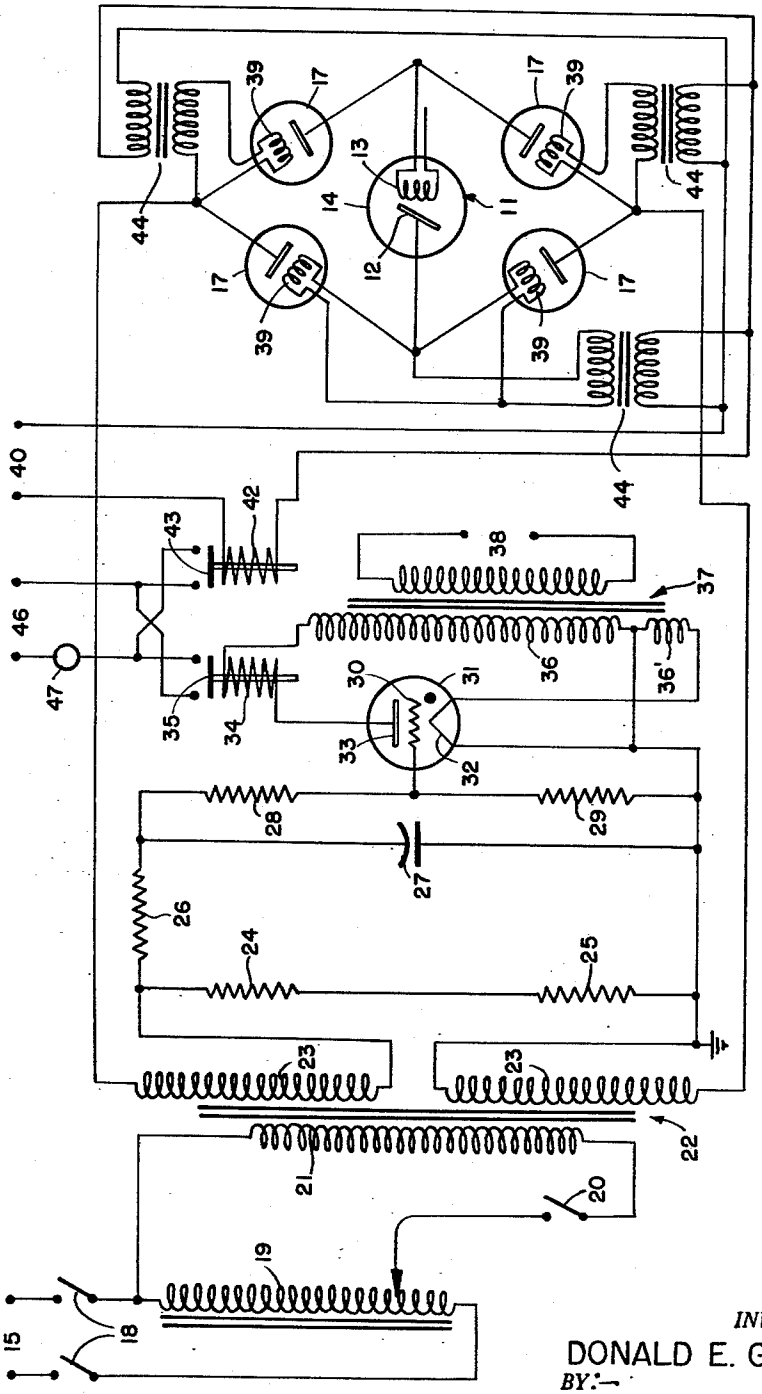
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MONITORING SYSTEM

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MONITORING SYSTEM

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The present invention relates in general to electronics and has more particular reference to apparatus adapted to function in response to and hence signal, record or otherwise indicate operational failure of electron emission means, such as electron emitting cathodic elements of the sort commonly employed in electron flow devices, including electrical current rectifiers.

Electron flow rectifiers are commonly employed in electrical power supply systems for the purpose of applying rectified or unidirectional current energy, derived from a convenient source of alternating current electrical power, for the operation or actuation of load devices, such as X-ray generating tubes. An electron flow rectifier, as is the case with other electron flow devices, may embody an anode and an electron emitting cathode, preferably enclosed in a sealed and evacuated envelope, the cathode usually comprising a filament adapted to be electrically excited for electron emission, as by connection with a suitable source of filament energizing power. Electron emission from the cathode provides a path for the flow of electrical energy, in one direction only, between the anode and cathode, whereby rectification may be accomplished in well-known fashion. Failure of electron emission at the cathode, as by the interruption of the filament exciting power circuit, of course, will render the rectifier inoperative; and it is an important object of the present invention to provide monitoring means of simple, relatively inexpensive and reliable character for indicating, recording or otherwise reacting to failure of the cathode of an electron flow device to perform its electron emitting function, particularly where the electron flow device comprises a rectifier operatively associated with an X-ray generating tube, as a unidirectional current load device, since failure of an X-ray tube energizing rectifier may result in irreparable damage to the relatively costly load device.

Another important object is to provide monitoring apparatus of the character mentioned embodying a thyratron connected in supervising relationship with respect to an electron flow device in fashion causing the thyratron to fire continuously so long as the supervised flow device is operating properly, operational failure of the supervised device serving to disable the thyratron; a further object being to provide a thyratron control network embodying a condenser and associated resistor, normally maintained in condition permitting the thyratron to fire continuously so long as a supervised flow device is in proper operating condition, the condenser becoming charged to a potential such that the control grid of the thyratron is driven negative to cut off in response to operational failure of the supervised device.

Another important object of the invention resides in applying a current relay in the filament exciting circuit of an electron flow device, the relay being operable to indicate faulty operation of the supervised device as shown by any abnormal decrease in filament exciting current.

Another important object of the invention is to provide an operable device of any preferred character for indicating, recording or signaling the operational failure of a

supervised electron flow device, either in response to the actuation of a current relay in the filament exciting circuit of the supervised device, or in response to the inactivation of a thyratron that is normally held active as the result of proper operation of the flow device.

Briefly stated, in accordance with one aspect of the invention, unidirectional electrical energy may be applied between the anode and cathode of an X-ray generating tube for the operation of the same by means of a full wave rectifying bridge comprising a plurality of electron flow rectifiers, each having an electron emitting cathode, the input side of said rectifying bridge being connected with a suitable source of alternating current electrical power, and its output side being connected with the anode and cathode of the X-ray generating tube. Electrical energy may be supplied to the rectifying bridge from the alternating current energy source through transformer means having a split secondary winding interconnected through a resistance-condenser network in which potential for charging the condenser to a negative voltage value may be developed only during half-wave rectifying operation of the bridge as the result of failure of a rectifying component thereof, the condenser remaining substantially without charge in response to normal full wave rectifying operation of the bridge. The resistance-condenser network may be connected with the control grid of a thyratron, which, in turn, may be interconnected with a suitable power source and normally maintained in continuously firing condition to thereby continuously energize the operating coil of a relay, controllingly connected with the thyratron. This relay may embody a switch that is held open so long as the relay coil is energized in response to the continuous actuation of the thyratron, said switch being adapted to close when the thyratron becomes inactive in response to the appearance of a negative voltage charge on the condenser as the result of half-wave rectifying operation of the bridge.

The cathode filaments of the rectifiers may be energized for electron emission from a suitable source of cathode exciting electrical power, through a filament exciting circuit containing the operating coil of a current relay. This relay may embody a switch adapted to be held open so long as the operating coil is energized at a predetermined level, said switch closing in response to reduction in excitation of the relay coil below a selected level. The cathode filaments of the rectifiers may be and preferably are energized through filament transformers interconnected in the filament exciting circuit.

Operational failure of any rectifier in the rectifying bridge will result in closure of the thyratron controlled relay switch. Cathode filament failure in any rectifier will result in operation of the current relay connected in the filament energizing circuit. The switch of the thyratron controlled relay and the switch of the current relay in the filament energizing circuit may both be interconnected to control associated signaling means or other load device which it may be desired to operate in response to rectifier failure.

The foregoing and numerous other important objects, advantages and inherent functions of the invention will be apparent as the same is more fully understood from the following description, which, taken in connection with the accompanying drawing, discloses a preferred embodiment of the invention.

The drawing comprises a single figure affording a diagrammatic showing of a monitoring system embodying the present invention.

To illustrate the invention, the drawing shows an X-ray generating tube **11** embodying an anode **12** and a cooperating cathode **13** enclosed in a sealed and evacuated envelope **14**. It should be understood that X-rays may be generated in such a tube as the result of impingement

on the anode 12 of electrons emitted by and at the cathode and driven thence under the influence of electrical energy applied between the anode and cathode, such electron driving energy, in the illustrated embodiment, being of unidirectional character and supplied from an alternating current power source 15 through a full wave rectifying bridge 16 comprising four electron flow rectifiers 17, the anode and cathode of the ray generating tube being connected across the energy output side of the rectifying bridge.

The power source 15 may be connected with an autotransformer 19, through suitable disconnecting switch means 18, the autotransformer, in turn, being connected, as through a control switch 20, with the primary winding 21 of a step-up transformer 22 having a split secondary winding comprising the coils 23. The outer ends of the coils 23 are connected across the energy input side of the rectifying bridge 16. The inner ends of the transformer coils 23 may be interconnected through resistors 24 and 25, providing a nonlinear resistance network which decreases its electrical resistivity somewhat with rise in current flow therethrough, the same comprising voltage limiting means so that there is a large load resistance and signal whenever current flow is small, the load resistance and signal being not unduly large when current flow therethrough is relatively high.

Interconnected between the coil connected ends of the resistance network 24 and 25 is a resistance-capacitance network comprising a resistor 26 and a condenser 27 interconnected in series, and series connected resistors 28 and 29 interconnected in parallel relationship with respect to the condenser 27, the connected ends of the resistors 28 and 29 being interconnected with the control grid 30 of a thyratron 31 having a cathode 32 interconnected with the grid 30 through the resistor 29. The thyratron also embodies an anode 33 which, with the cathode 32, is connected in an operating circuit containing the operating coil 34 of a relay switch 35, and a suitable source of anode circuit power, which may conveniently comprise a section 36 of the secondary winding of a transformer 37 having a primary winding powered from a suitable electrical energy source 38. The transformer 37 may also include an auxiliary secondary winding section 36' electrically connected to energize the cathode 32 of the thyratron for electron emission.

When the X-ray generating tube 11 is in operation and the rectifiers 17 are functioning properly, an alternating current signal will appear at the grid 30, said signal being phased to maintain the thyratron in continuously firing condition. In this connection, phasing is accomplished by providing the condenser 27 and resistors 28 and 29 with proper capacity and resistance characteristics in order to constitute the same as a phase shifting network operable to shift the phase of the signal to the extent required to maintain thyratron operation. When, as and if any of the rectifiers 17 fails to function, a half-wave pulsating potential of unidirectional character will be applied across the condenser 27 and will charge the same in fashion driving the grid 30 of the thyratron negative and thus rendering the thyratron inoperative, whereby to actuate the thyratron controlled relay to signal rectifier failure.

So long as the rectifiers 17 all operate properly to provide full wave rectification at the rectifying bridge 16, current flow in the coils 23 and through the resistors 24 and 25 will not alter the charged condition of the condenser 27. Accordingly, the thyratron will be maintained in a state of continuous activity, permitting the same to fire in response to each cycle of alternating current energy applied between the anode and cathode of the thyratron from the source 38. In the event that any of the rectifiers 17 should fail to function properly, the bridge 16 will operate as a half-wave rectifying system. The condenser 27, consequently, will become negatively charged to a potential value sufficient to cut off or disable the thyratron 31. The relay coil 34, in turn, will become de-energized and the resultant operation of the switch 35 will serve to indicate the failure of a rectifier 17. To this end, the switch 35 preferably is normally biased toward closed position, being held open so long as its associated coil 34 is energized. As a consequence, upon failure of a rectifier 17 and resulting disablement of the thyratron 31, the switch 35 will close in order to actuate any desired load device adapted to indicate or record rectifier failure.

The system thus will detect and indicate or record failure of a rectifier even though its electron emitting cathode continues to function properly. To this end, the thyratron and its associated network senses the difference between the pulsating half-wave signal delivered as the result of improper rectifier operation and the symmetrical alternating current impulse delivered when full wave rectification is being accomplished at the bridge 16.

Each of the electron flow rectifiers 17 embodies an electron emitting cathode comprising a filament 39 adapted to be energized in order to cause electron emission, said filaments being energized from a suitable energy source 40 through a filament energizing circuit 41 containing the operating coil 42 of a current relay embodying a switch 43. The filaments 39 are preferably energized from the circuit 41 through filament transformers 44. In the event that any of the filaments 39 or transformers should burn out or otherwise fail so that current flow cannot occur through the filament, current flow in the circuit 41 will be correspondingly reduced and the relay coil affected sufficiently to permit actuation of the switch 43. The switch 43 is preferably biased toward closed position, but may be held open by action of the coil 42 so long as the same is energized at a level corresponding with the delivery of normal energizing power to all of the cathode filaments 39, the switch 43 being permitted to close in the event of any material reduction in the aggregate energy normally required for the excitation of all of the filaments 39.

The operation of the switches 35 and 43 may be utilized in any desired, convenient or preferred fashion to indicate or record the failure of any of the rectifiers 17 or of any of the filaments 39. As shown, the switches 35 and 43 may be interconnected in parallel relationship in a circuit 45 including a suitable power source 46 and a load device, such as a signal lamp 47 or other operable load device, the operation of which may be desired in response to filament or rectifier failure.

It is thought that the invention and its numerous attendant advantages will be fully understood from the foregoing description, and it is obvious that numerous changes may be made in the form, construction, and arrangement of the several parts without departing from the spirit or scope of the invention, or sacrificing any of its attendant advantages, the form herein disclosed being a preferred embodiment for the purpose of illustrating the invention.

The invention is hereby claimed as follows:

1. Apparatus for supervising the operation of a plurality of electron flow rectifiers forming a full wave electrical current rectifying bridge, comprising means forming a circuit for delivering, to said bridge, electrical power to be rectified, means including a relay for monitoring faulty operation or failure of a said rectifier, and relay actuating means operable to actuate the relay in response to the pulsating unidirectional energy wave produced in said circuit as the result of half-wave operation of said bridge, when a component rectifier thereof is not functioning properly.

2. Apparatus as set forth in claim 1, wherein said relay actuating means comprises a thyratron having a control grid, and means operatively associated with said circuit for maintaining a selected thyratron controlling bias on said grid in response to full wave operation of said bridge and for altering said bias in response to half-wave operation of the bridge.

3. Apparatus for supervising the operation of a plurality of electron flow rectifiers forming a full wave electrical current rectifying bridge, comprising a transformer having a pair of coil sections forming a split secondary winding connected with said bridge for delivering, thereto, electrical power to be rectified, a relay for monitoring faulty operation or failure of a said rectifier, and relay actuating means interconnected between said coil sections and operable to actuate the relay in response to the pulsating unidirectional energy wave produced in said coil sections as the result of half-wave operation of said bridge, when a component rectifier thereof is not functioning properly.

4. Apparatus for supervising the operation of a plurality of electron flow rectifiers forming a full wave electrical current rectifying bridge, comprising means forming a circuit for delivering, to said bridge, electrical power to be rectified, a thyratron forming a relay for monitoring faulty operation or failure of a said rectifier, and thyratron control means comprising a condenser controllingly connected with said thyratron and chargeable to a negative thyratron disabling potential in response to the pulsating unidirectional energy wave produced in said circuit as the result of half-wave operation of said bridge, when a component rectifier thereof is not functioning properly.

5. Apparatus for supervising the operation of a plurality of electron flow rectifiers forming a full wave electrical current rectifying bridge, comprising a transformer having a pair of coil sections forming a split secondary winding connected with said bridge for delivering, thereto, electrical power to be rectified, a thyratron forming a relay for monitoring faulty operation or failure of a said rectifier, including means normally operable to maintain the thyratron in continuously active or firing condition, and thyratron control means interconnected between said coil sections and operable to disable the thyratron in response to the pulsating unidirectional energy wave produced in said coil sections as the result of half-wave operation of said bridge, when a component rectifier thereof is not functioning properly.

6. Apparatus for supervising the operation of a plurality of electron flow rectifiers forming a full wave electrical current rectifying bridge, comprising a transformer having a pair of coil sections forming a split secondary winding connected with said bridge for delivering, thereto, electrical power to be rectified, a thyratron forming a relay for monitoring faulty operation or failure of a said rectifier, including means normally operable to maintain the thyratron in continuously active or firing condition, and thyratron control means interconnected between said coil sections and comprising a condenser controllingly connected with the thyratron and adapted to be charged negatively to a thyratron disabling potential in response to the pulsating unidirectional energy wave produced in said coil sections as the result of half-wave operation of said bridge, when a component rectifier thereof is not functioning properly.

7. Apparatus for supervising the operation of a plurality of electron flow rectifiers forming a full wave electrical current rectifying bridge, comprising a transformer having a pair of coil sections forming a split secondary winding connected with said bridge for delivering, thereto, electrical power to be rectified, a thyratron forming a relay for monitoring faulty operation or failure of a said rectifier, including means normally operable to maintain the thyratron in continuously active or firing condition, and thyratron control means, including resistance means connected between said coil sections, and a condenser controllingly connected with the thyratron and with said resistance means, whereby said condenser may be charged negatively to a thyratron disabling potential by the pulsating unidirectional energy wave produced across said resistance means as the result of half-wave operation of said bridge, when a component rectifier thereof is not functioning properly.

8. Apparatus for supervising the operation of a plurality of electron flow rectifiers forming a full wave electrical current rectifying bridge, comprising means forming a circuit for delivering, to said bridge, electrical power to be rectified, means for monitoring faulty operation or failure of a said rectifier, and relay actuating means operable to actuate the relay in response to the pulsating unidirectional energy wave produced in said circuit as the result of half-wave operation of said bridge, when a component rectifier thereof is not functioning properly, an operable load device controlled by said relay for indicating, recording or otherwise reacting in response to faulty operation or failure of a component rectifier of the bridge.

9. Apparatus for supervising the operation of a plurality of electron flow rectifiers forming a full wave electrical current rectifying bridge, comprising means forming a circuit for delivering, to said bridge, electrical power to be rectified, means for monitoring faulty operation or failure of a said rectifier, and relay actuating means operable to actuate the relay in response to the pulsating unidirectional energy wave produced in said circuit as the result of half-wave operation of said bridge, when a component rectifier thereof is not functioning properly, means forming a cathode exciting circuit for delivering electrical energy to the cathode exciting elements of the several rectifiers, and means including a current relay operable, in response to any abnormal reduction in cathode exciting energy transmitted in said cathode exciting circuit, to indicate or record faulty operation or failure of a said rectifier.

10. Apparatus for monitoring the operation of a plurality of electron flow rectifiers forming a full wave electrical current rectifying bridge and embodying each a cathode excitable for electron emission in response to the delivery of electrical energy to a cathode exciting element, comprising means forming a cathode exciting circuit for delivering electrical energy to all of the cathode exciting elements of the several rectifiers, a current relay operable in response to any abnormal reduction in cathode exciting energy transmitted in said circuit, a load device controlled by said relay and operable to indicate, record or otherwise respond to faulty operation or failure of a said rectifier, means forming a power supply circuit for delivering, to said bridge, electrical power to be rectified, means including a supervisory relay for monitoring faulty operation of a said rectifier, and relay actuating means operable to actuate said supervisory relay in response to the pulsating unidirectional energy wave produced in said power supply circuit as the result of half-wave operation of said bridge, when a component rectifier thereof is not functioning properly.

11. Apparatus for monitoring the operation of a plurality of electron flow rectifiers forming a full wave electrical current rectifying bridge and embodying each a cathode excitable for electron emission in response to the delivery of electrical energy to a cathode exciting element, comprising means forming a cathode exciting circuit for delivering electrical energy to all of the cathode exciting elements of the several rectifiers, including transformers having secondary windings connected with the exciting elements of said rectifiers and primary windings interconnected in said circuit, a current relay operable in response to any abnormal reduction in cathode exciting energy transmitted in said circuit, a load device controlled by said relay and operable to indicate, record or otherwise respond to faulty operation or failure of a said rectifier, means forming a power supply circuit including a transformer having a pair of coil sections forming a split secondary winding connected with said bridge for delivering, thereto, electrical power to be rectified, means including a supervisory relay for monitoring faulty operation or failure of a said rectifier, and relay actuating means connected between said coil sections and operable to actuate said supervisory relay in response to the pul-

sating unidirectional energy wave produced in said power supply circuit as the result of half-wave operation of said bridge, when a component rectifier thereof is not functioning properly.

12. Apparatus for monitoring the operation of a plurality of electron flow rectifiers forming a full wave electrical current rectifying bridge and embodying each a cathode excitable for electron emission in response to the delivery of electrical energy to a cathode exciting element, comprising means forming a cathode exciting circuit for delivering electrical energy to all of the cathode exciting elements of the several rectifiers, a current relay operable in response to any abnormal reduction in cathode exciting energy transmitted in said circuit, a load device controlled by said relay and operable to indicate, record or otherwise respond to faulty operation or failure of a said rectifier, means forming a power supply circuit for delivering, to said bridge, electrical power to be rectified, a thyratron forming a supervisory relay for monitoring faulty operation or failure of a said rectifier, and actuating means operable to control said thyratron in response to the plusating unidirectional energy wave produced in said power supply circuit as the result of half-wave operation of said bridge, when a component rectifier thereof is not functioning properly.

13. Apparatus for monitoring the operation of a plurality of electron flow rectifiers forming a full wave electrical current rectifying bridge and embodying each a cathode excitable for electron emission in response to the delivery of electrical energy to a cathode exciting element, comprising means forming a cathode exciting circuit for delivering electrical energy to all of the cathode exciting elements of the several rectifiers, a current relay operable in response to any abnormal reduction in cathode exciting energy transmitted in said circuit, a load device controlled by said relay and operable to indicate, record or otherwise respond to faulty operation or failure of a said rectifier, means forming a power supply circuit for delivering, to said bridge, electrical power to be rectified, a thyratron forming a relay for monitoring faulty operation or failure of a said rectifier, including means normally operable to maintain the thyratron in continuously active or firing condition, and control means comprising a condenser connected with the thyratron and adapted to be charged negatively to a thyratron disabling potential in response to the pulsating unidirectional energy wave produced in said power supply circuit as the result of half-wave operation of said bridge, when a component rectifier thereof is not functioning properly.

14. Apparatus for monitoring the operation of a plurality of electron flow rectifiers forming a full wave electrical current rectifying bridge and embodying each a cathode excitable for electron emission in response to the delivery of electrical energy to a cathode exciting element, comprising means forming a cathode exciting circuit for delivering electrical energy to all of the cathode exciting elements of the several rectifiers, a current relay operable in response to any abnormal reduction in cathode exciting energy transmitted in said circuit, a load device controlled by said relay and operable to indicate, record or otherwise respond to faulty operation or failure of a said rectifier, means forming a power supply circuit for delivering, to said bridge, electrical power to be rectified, means including a supervisory relay for monitoring faulty operation or failure of a said rectifier, relay actuating means operable to actuate said supervisory relay in response to the pulsating unidirectional energy wave produced in said power supply circuit as the result of half-wave operation of said bridge, when a component rectifier thereof is not functioning properly, and an operable load device controlled by both of said current and supervisory relays for indicating, recording or otherwise reacting in response to faulty operation or failure of a component rectifier of the bridge.

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