June 3, 1941. K. BISCHOFF ET AL 2,244,137

PROTECTIVE SWITCHING MEANS FOR ROENTGEN APPARATUS

Filed Dec. 7, 1938

Fig. 1.

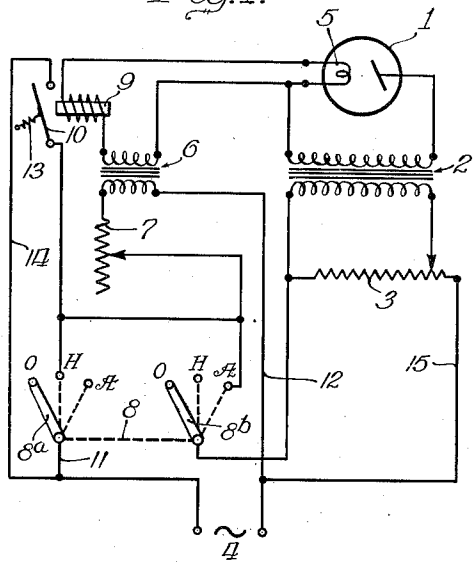


Fig. 2.

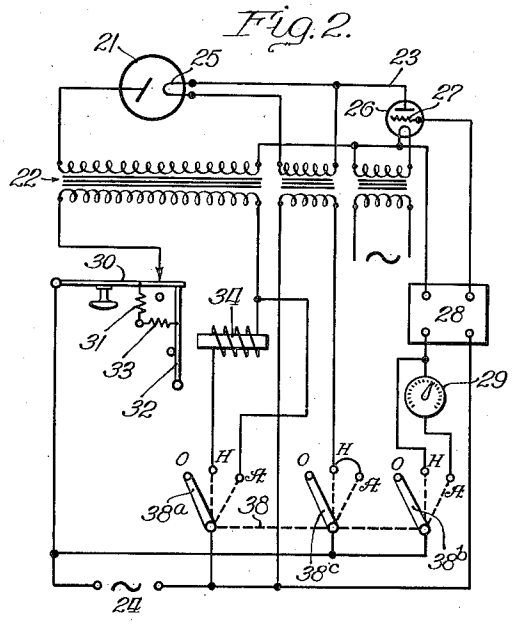
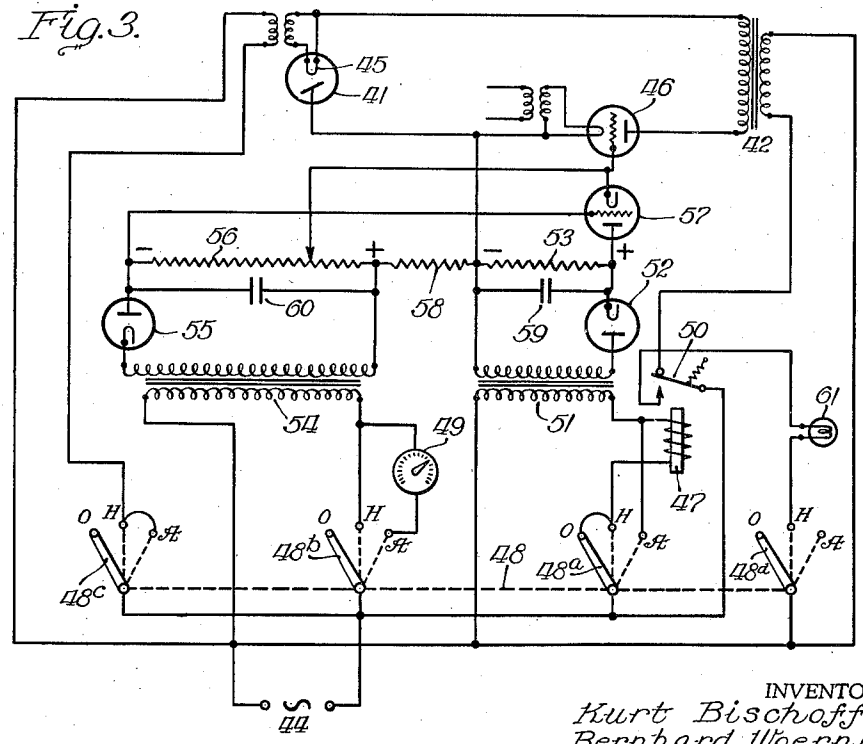


Fig. 3.



INVENTORS:
Kurt Bischoff
Bernhard Woernle
By: Richardson and Quer
ATTORNEYS. 3/10

Patented June 3, 1941 2,244,137

UNITED STATES PATENT OFFICE

2,244,137

PROTECTIVE SWITCHING MEANS FOR ROENTGEN APPARATUS

Kurt Bischoff and Bernhard Woernle, Erlangen, Germany, assignors to the firm Siemens-Reiniger-Werke Aktiengesellschaft, Berlin, Germany

Application December 7, 1938, Serial No. 244,476
In Germany December 9, 1937

16 Claims. (Cl. 250—93)

The present invention relates to switching systems, and is particularly concerned with protective switching means for Roentgen apparatus.

Prior systems of this general class employ a control switch provided with a preparatory position which is suitably marked on the control board, for example, by the designation "Heating". All the switching which prepares the apparatus for radiographing or for the Roentgen treatment, including the switching for heating the Roentgen tube and electronic valves, if such are used in the circuit, takes place in this position. These known systems do not provide for any trouble or contingency that may occur. It is, for example, possible that a fault may occur, such as an interruption in the heating circuit of the Roentgen tube. Such faults would pass unnoticed in the preparatory (heating) position of the control switch used with prior systems, and would manifest themselves only in the operative or radiographing position. This would prevent radiographing, and in the case mentioned (interruption of the heating circuit) it would expose the Roentgen tube to the danger of destruction by connecting the unheated tube to the heating transformer at the moment when the control switch is operated to the radiographing position.

The present invention recognizes the problem, and proposes to remedy the resulting disadvantages by providing means for detecting a fault, which is effective in the preparatory position of the apparatus. The switching system is therefore arranged in such a manner that a protective device (for example, a disconnect switch, an overload switch, or a signal) is connected in the preparatory position of the control switch, causing the disconnection of the current supply, or indication of the defect, in case trouble or a fault should be present that may manifest itself either by an unexpected flow of current, or absence of the required current flow, or finally, by deviation of the current flow from the required or desired value or magnitude.

The invention is of particular importance in connection with Roentgen apparatus wherein the Roentgen tube current is switched at the secondary side of the high tension transformer under the control of an electronic switching valve or by a control grid included in the Roentgen tube itself. In such an arrangement the heating transformer is connected to the Roentgen tube in the preparatory position (heating) of the apparatus, and the operative current flow is initiated in the radiographing position of the control switch by connecting positive voltage to the grid of the switching valve, or disconnecting the negative blocking voltage therefrom. The possibility of faults occurring in the relatively complicated control circuits, or in the electronic valves included therein, and therefore the likelihood of subjecting the Roentgen tube to danger of damage or destruction, is rather great and must be taken into account particularly when it is considered that very high operative loads are impressed for short periods of time.

The invention is illustrated in the accompanying drawing, Figs. 1, 2, and 3, which show three embodiments in diagrammatic representation for the purpose of supplying practical examples of ways in which the invention may be used and how it performs in practice.

Referring now to Fig. 1, numeral 1 indicates the Roentgen tube, which is supplied with current by the high tension transformer 2, the latter being connected to the current source 4 over the transformer control potentiometer 3. The glow cathode 5 of the Roentgen tube is heated over a circuit including the heating transformer 6 and the control resistance 7. The control switch 8 comprises two switch arms 8*a* and 8*b*, each having three positions, namely, position O (off), position H (heating), and position A (radiographing). The Roentgen apparatus is completely disconnected in position O of the control switch 8; in position H the glow cathode 5 of the tube is heating; and in position A the high tension transformer 2 supplies operating potential to the tube 1 while the heating of the glow cathode 5 continues.

In accordance with the invention, the coil of a magnet 9 is connected in the heating circuit of the glow cathode 5 for controlling the operation of the switch 10. The primary heating current flows in position H of the control switch 8 from the current source 4 over the conductor 11, switch arm 8*a*, and resistance 7 to the primary winding of the heating transformer 6, and back to the current source 4 over conductor 12. The armature 10 is held in disconnect position by means of a spring 13, which is so adjusted that the switch can close the circuit responsive to energization of coil 9 only if the heating current through the glow cathode 5 has a sufficient mean value in this preparatory position of the control switch 8. Upon actuation of the switch 8 into position A, line 11 is interrupted, but if coil 9 has been sufficiently energized to actuate switch arm 10, heating current will continue to flow over conductor 14 and armature 10 to the control resistance 7 and primary winding of transformer 6.

The primary circuit including the transformer control potentiometer is also closed over conductor 14, armature 10, and switch arm 8b, and back to the current source by way of conductor 15. The high tension transformer 2 is therefore made operative to supply anode current to the Roentgen tube only if the heating current is of sufficient magnitude in the preparatory position H to cause the operative energization of coil 9 and consequently the closure of the switch at armature 10.

The embodiment shown in Fig. 2 employs a switching tube 26 for connecting the Roentgen tube 21 to the high tension transformer 22. The grid 27 is controlled by means of the switching device 28, which is adapted to connect a negative blocking potential to the grid. Any suitable switching device may be used for this purpose. The control switch 38 is equipped with two switch arms 38a and 38b and with a third switch arm 38c, which are operatively coupled with each other, as indicated in the drawing. The Roentgen tube 21 as well as the switching tube 26 are heated in position H of the control switch. The high tension transformer 22 and the switching device 28 are also connected to current. However, no high tension current flows through the Roentgen tube 21 in this preparatory position because the conductor 23 leading to the cathode 25 is interrupted at the switching tube 26, the grid 27 of which is supplied with a negative blocking voltage from the switching device 28. Upon actuating the control switch 38 into position A, the timing switch 29 is connected in the circuit, and this switch disconnects the control device 28 and therewith the negative blocking voltage for a predetermined adjusted period of time.

The magnet coil 34, having an armature 32, is connected in position H of the control switch in the primary circuit of the high tension transformer 22. Spring 33 holds the armature 32 in the position shown, maintaining the switch arm 30 in closed position in the primary circuit against the pull of the spring 31. The spring 33 is so tensioned that the armature 32 can be operatively attracted responsive to energization of coil 34 if the current flow through this coil exceeds the idling current of the high tension transformer 22. This condition may arise, for example, if the control device 28 or the switching tube 26 fails to operate properly, causing current flow through the Roentgen tube in the preparatory position H of the control switch. The actuation of armature 32 into its alternate operative position would in this case cause the release of switch arm 30 to disconnect the high tension transformer 2 immediately from the current source 24. The switch arm 30 is restored to closed position by hand after the trouble has been cleared.

Referring now to Fig. 3, in a Roentgen tube system having a switching tube in the secondary circuit, the arrangement is frequently such that a positive grid voltage is supplied to the grid of the switching tube from a direct current source so as to make the tube conductive, while a second direct current source is used to supply negative voltage for the grid so as to block the tube current. Inasmuch as the positive grid voltage remains permanently connected, the negative direct current source, in addition to causing the blocking of the tube current, must also remove the effect of the positive voltage source. If a fault occurs in such a system, for example, if the control of the negative blocking tension fails to operate, the current will flow in the circuit of the positive current source. The protective means in such a Roentgen apparatus therefore preferably provides for a magnet coil in the circuit of the positive voltage source which coil receives no current in the preparatory position of the control switch so long as the current flow through the Roentgen tube is blocked, and which causes the actuation of a switching device upon current flow in the circuit of the positive voltage source due to failure of the blocking means. The switching device disconnects the current supply from the high tension transformer.

In Fig. 3, the Roentgen tube is indicated at 41, and is supplied with high tension current from the transformer 42. The anode circuit of the Roentgen tube includes the switching tube 46. The tube 57 is a control tube. The first direct current source includes the transformer 51, the rectifier 52, and a filter comprising resistance 53 and condenser 59. The terminals of the resistance 53 may be regarded as the output terminals of this direct current source and are labeled accordingly. The second direct current source comprises transformer 54, rectifier 55, and the filter comprising resistance 56 and condenser 60. The two sources are connected by resistance 58. The magnet coil 47 is connected in series with the primary winding of transformer 51.

In position O of the control switch 48, power is supplied to the primary winding of transformer 51 from source 44, and the first direct current source is rendered active, supplying direct current to the plate circuit of control tube 57. As the grid and cathode of this tube are at the same potential, the tube passes current, and a load is placed on the transformer 51, which energizes the magnet coil 47 and causes it to attract its armature 50. Thus the circuit of the primary winding of the high tension transformer 42 is held open.

When the control switch 48 is moved to position H, switch arm 48c closes a heating circuit for the cathode 45 of the Roentgen tube 41. At the same time the switch arm 48b closes a circuit for supplying power to the transformer 54, which renders the second direct current source active. Due to fall in potential across resistance 56, a negative potential is now placed on the grid of the switching tube 46 and also on the grid of control tube 57. The latter tube accordingly ceases to pass current, and magnet coil 47 deenergizes. The primary circuit of the transformer 42 is accordingly closed at 50, but the Roentgen tube anode circuit remains open at switching tube 46, due to the negative potential on the grid of this tube.

It will be clear from the foregoing that if no negative blocking potential is placed on the grid of switching tube 46 in position H of the control switch, due to failure of the second direct current source, such failure will also have the effect of allowing tube 57 to continue to pass current, with the result that magnet coil 47 will remain energized and the primary circuit of the transformer 42 will be held open. At the same time the visual signal lamp 61 will be lighted over a circuit including switch arm 48d to indicate to the operator that the equipment is not functioning properly.

Assuming now that everything is in order and that the normal operation takes place, when the

control switch is moved to position A, the heating circuit for the Roentgen tube remains closed at switch arm 48c, the primary circuit of transformer 54 is completed by way of the timing device 49 at switch arm 48b, and the circuit of the primary winding of transformer 51 is completed at switch arm 48a over a path which excludes magnet coil 47. The timing device 49 is now started, either manually or automatically responsive to advance of the control switch to position A, and functions in known manner to interrupt the primary circuit of transformer 54 for a predetermined time.

While the second direct current source is inactive, negative potential is removed from the grid of control tube 57 and from the grid of the switching tube 46. The control tube 57 accordingly becomes conductive and a positive potential from the first direct current source is placed on the grid of switching tube 46. The reversal of the grid potential at switching tube 46 in this manner renders the Roentgen tube operative and radiographing takes place.

The protective means described in the foregoing disconnects the supply current from the Roentgen tube automatically in case of trouble in the apparatus that is detected in the preparatory position of the control switch. An acoustical signal may be provided if desired in place of the visual signal 61 to indicate the actuation of the protecting means. It may be sufficient in some cases to use only a signal indicating the presence of trouble or faulty operating conditions, without automatic disconnection of the supply current.

The present invention has been disclosed in connection with Roentgen apparatus, but may be used to advantage in many other instances, in industry in general, and in electrical apparatus or systems where a control switch is operated into a preparatory position and then into the operating position. The invention is particularly useful in apparatus employing electrical discharge tubes or the like, which require heating prior to performing their proper operations.

It should be understood, in view of the foregoing, that the specific disclosures made herein are not to be interpreted in an unduly limiting and restricting sense except as pointed out in the appended claims which define what is believed to be new and what we desire to have protected by Letters Patent.

What is claimed is:

1. The combination, with a Roentgen tube, of a control switch having a preparatory position and a radiographing position, a heating circuit for the cathode of said tube completed in the preparatory position, a high tension circuit for the tube completed in the radiographing position, and means for automatically preventing the completion of the latter circuit in the event the heating circuit is defective.

2. The combination, with a Roentgen tube, of a control switch having a preparatory position and a radiographing position, means for completing a heating circuit for the cathode of said tube in the preparatory position, means in said heating circuit for preparing a high tension circuit for said tube, and means for completing said high tension circuit in the radiographing position.

3. The combination, with a Roentgen tube, of a control switch having a preparatory position and a radiographing position, means for completing a heating circuit for the cathode of said tube in the preparatory position, said means being ineffective in the radiographing position, a high tension circuit for said tube which is closed at one point in the radiographing position, and an electromagnetic switching device controlled over said heating circuit to maintain the same upon movement of said switch to radiographing position and to complete said high tension circuit.

4. In combination, a Roentgen tube, a control switch having a normal position, a preparatory position, and a radiographing position, circuit arrangements controlled by said switch for heating the cathode of said tube in the preparatory position, means for preventing flow of anode current through the tube in the preparatory position, and means responsive to such current flow, due to failure of said last means, for cutting off the source of current from the anode circuit, whereby said tube is rendered inoperative when the said switch is moved to radiographing position.

5. In combination, a Roentgen tube, a high tension transformer for supplying anode current to said tube, a circuit for the primary winding of said transformer, a switch for opening said circuit, a magnet included in said circuit for operating said switch, and a control switch for completing said circuit over a path excluding said magnet.

6. In combination, a Roentgen tube, a switching tube in the anode circuit of said Roentgen tube, means for placing a positive potential on the grid of said switching tube, means for closing a heating circuit for the cathode of said Roentgen tube, means rendered effective simultaneously with the closure of said heating circuit for placing a negative potential on the grid of said switching tube and for rendering said first means inoperative, and means effective in case the said first means is not rendered inoperative for preventing current being supplied to said anode circuit.

7. In combination, a Roentgen tube, an anode circuit for said tube including a switching tube, means for heating the cathode of said Roentgen tube, two direct current sources for controlling the potential on the grid of said switching tube while said cathode is being heated, the second of said sources being effective to place a negative potential on the grid of said switching tube and to prevent the first source from placing a positive potential thereon, and means effective in case of failure of said second source for preventing the supply of current to said anode circuit.

8. In combination, a Roentgen tube, a switching tube in the anode circuit of said Roentgen tube, means including a direct current source and a device drawing current therefrom for placing a positive potential on the grid of said switching tube, means for closing a heating circuit for the cathode of said Roentgen tube, means including a second direct current source for placing a negative potential on the grid of said switching tube and for stopping the current drain on said first source while the said cathode is heating, and means effective responsive to continuation of the load on said first source for cutting off the supply of current to said anode circuit.

9. In combination, a Roentgen tube, a switching tube in the anode circuit of said Roentgen tube, means including a control tube for placing a positive potential on the grid of said switch-

ing tube, means for heating the cathode of said Roentgen tube, means for placing a negative potential on the grid of said control tube to render the same non-conductive during heating of said cathode, and means effective during the heating of said cathode and contingent on said control tube being conductive for preventing the supply of current to said anode circuit.

10. In a Roentgen tube apparatus, a control switch having normal, preparatory and radiographing positions, a circuit effective in the preparatory position of said switch, a protective device connected up in the preparatory position of said switch, and means including said device for rendering the Roentgen tube inoperative in the radiographing position in case said circuit is defective.

11. In a Roentgen tube apparatus, a control switch having normal, preparatory and radiographing positions, a protective device connected up in said preparatory position and adapted to operate responsive to defective operation of the apparatus during the preparatory period, and means controlled by said device for actuating a signal.

12. In an electrical apparatus, a control switch having a preparatory position and an operating position, a protective device connected in said preparatory position, and means governed by said protective device for causing the disconnection of supply current in case of circuit faults in said apparatus detrimental to its operation in the operating position of said control switch.

13. In a Roentgen tube apparatus, a control switch having normal, preparatory, and operating positions, a protective relay included in a circuit which is closed by said switch in its preparatory position, and an anode circuit closed by said switch in its operating position and including contacts of said relay.

14. In a Roentgen tube apparatus, a control switch having normal, preparatory, and operating positions, an anode circuit normally effective in the operating position of said switch, a protective relay for controlling the supply of power to said anode circuit, and contacts closed in the preparatory position of said switch for causing said relay to make a test to determine if the tube is properly prepared for operation before the switch is moved to operating position.

15. In a Roentgen tube apparatus, a control switch having preparatory and radiographing positions, a circuit completed in the preparatory position of said switch for preparing the tube for radiographing, and protective means also rendered effective in the preparatory position of said switch to detect a fault in the preparation which would interfere with the proper operation of the tube in radiographing.

16. In a Roentgen tube apparatus, a control switch having normal, preparatory, and operating positions, a protective device, an anode circuit, a circuit controlled by said device over which power is supplied to said anode circuit in the operating position of said switch, a connection for the said device closed by said switch in preparatory position and means including said connection which enables the device to determine how the power supply circuit should be controlled.

KURT BISCHOFF.
BERNHARD WOERNLE.