

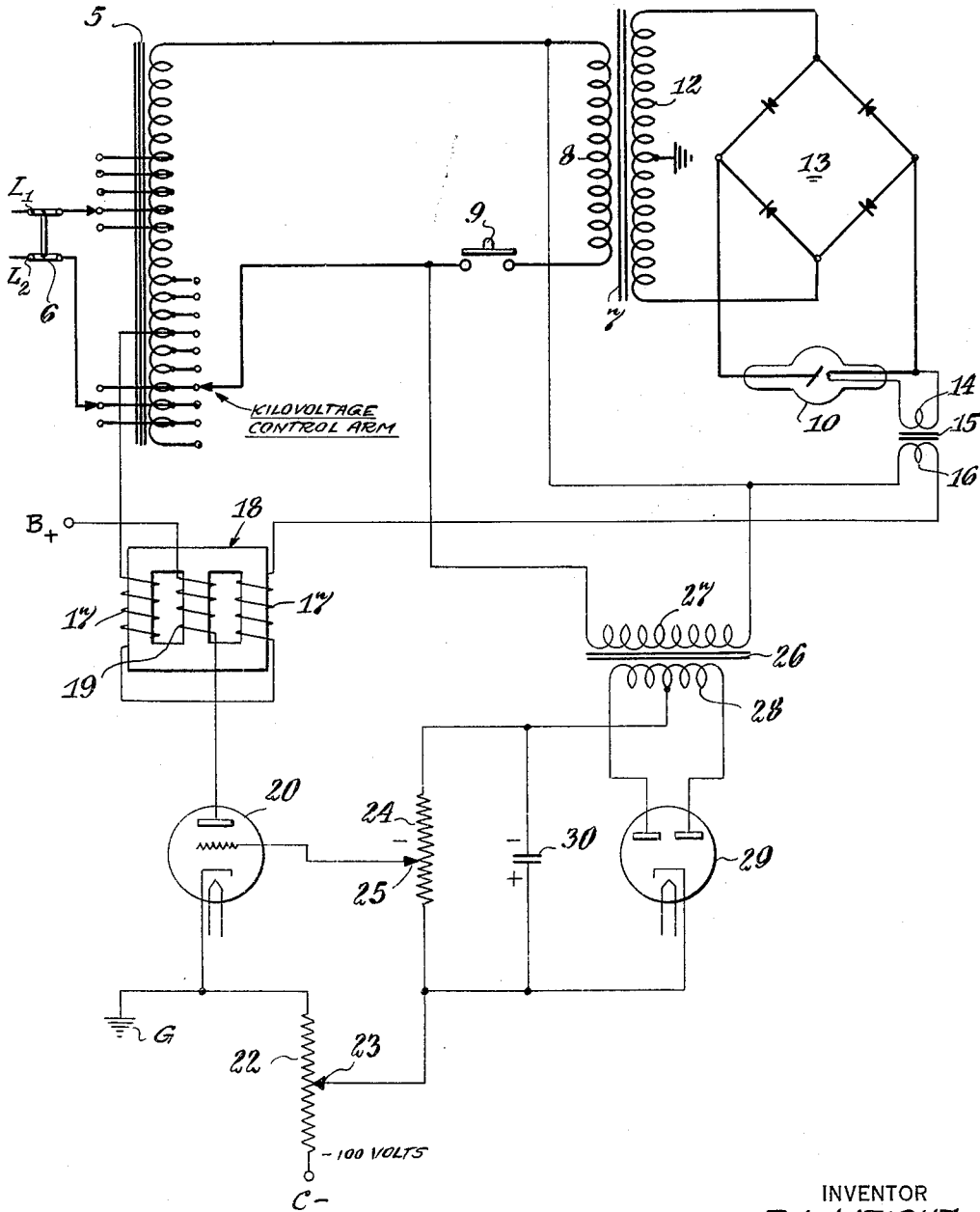
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R. L. WRIGHT

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COMPENSATOR FOR X-RAY SYSTEMS

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INVENTOR
R. L. WRIGHT.

J. F. Kelly
ATTORNEY

UNITED STATES PATENT OFFICE

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COMPENSATOR FOR X-RAY SYSTEMS

Robert L. Wright, North Linthicum Heights, Md.,
 assignor to Westinghouse Electric Corporation,
 East Pittsburgh, Pa., a corporation of Pennsylvania

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The present invention relates to X-ray apparatus and more particularly to a system for maintaining a constancy of current at all kilovoltage settings for the X-ray tube and regardless of the time period during which the X-ray tube is energized.

In all X-ray systems it is of course customary to stabilize the X-ray tube current during an exposure by maintaining the X-ray tube filament current constant. However, upon an increase in the kilovoltage supplied to the X-ray tube the milliamperage passing through the tube will also increase. In automatic controls which are intended to cause the same milliamperage to pass through the X-ray tube at a preselected setting there is a decided disadvantage to the operation of such automatic controls especially at short exposure periods. For example, these controls "look" at the milliamperage and finding it too high at high kilovoltage or too low at low kilovoltage, cause an adjustment of the X-ray tube filament current until the milliamperage desired through the X-ray tube is correct for that at which it was preset to take an exposure or treat a particular part of the anatomy.

Unfortunately, however, for short exposures ranging from about one-twentieth to one-one hundred and twentieth of a second the automatic control does not operate sufficiently rapid enough to make the necessary correction during these short exposure times. This is because the controls require one cycle ($\frac{1}{60}$ of a second) to read the milliamperage, one cycle to apply a correction and another cycle for the correction to become effective to adjust the X-ray tube filament temperature.

It is accordingly the object of the present invention to provide an X-ray system in which the X-ray tube filament current is adjusted before the X-ray exposure is started and wherein the milliamperage of the current flowing through the X-ray tube is subsequently maintained constant at its preselected value for all values of kilovoltage.

Another object of the present invention is the provision of an X-ray system in which the controls may be preset for any desired milliamperage and kilovoltage and regardless of the shortness of the exposure period the milliamperage will remain constant at all values of kilovoltage.

A further object of the present invention is the provision of an X-ray system in which compensation is made for the otherwise inherent characteristic of the milliamperage increasing or decreasing with like changes in applied kilo-

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voltage, so that the milliamperage is maintained constant at all values of kilovoltage by varying the X-ray tube filament temperature.

Still further objects of the present invention will become apparent to those skilled in the art by reference to the accompanying drawing wherein the single figure is a diagrammatical illustration of an X-ray system in accordance with the present invention.

Referring now to the drawing in detail an auto-transformer 5 is shown adjustably connected to a source of the usual commercial potential L1-L2 of 115-230 volts, by means of a switch 6. A high potential transformer 7 has its primary winding 8 adjustably connected to the auto-transformer 5 so that the voltage supplied to transformer 7 upon closure of an exposure switch 9 determines the kilovoltage applied to the X-ray tube 10. As will be noted, the high voltage secondary winding 12 of high tension transformer 7 is grounded at its center and connected through the customary full-wave rectifier arrangement 13 to the X-ray tube 10, although this full wave rectifier may be omitted if desired. The filamentary cathode of the X-ray tube 10 receives heating current from the low-voltage secondary winding 14 of a transformer 15, the primary winding 16 of which is connected to designated taps on auto-transformer 7 through a variable impedance, such as the A. C. windings 17 of a saturable reactor 18.

This impedance has a direct current winding 19 connected to one side B+ of a direct current source of constant potential while the other end of such winding 19 is connected through a grid-controlled discharge device 20 and a variable resistance 22, to the negative C- end of the D. C. supply source, with the cathode of the discharge device 20 being grounded at G. The variable-arm 23 of resistance 22 connects through a portion of a further variable resistance 24 and the adjustable arm 25 thereof to the grid electrode of the discharge device 20 so that once the arm 23 is set for a preselected voltage drop across resistance 22 a negative bias of predetermined magnitude is impressed on the grid relative to the cathode of the discharge device 20.

In order to compensate for a variation in the milliamperage upon an increase or decrease in kilovoltage, a transformer 26 is provided having its primary winding 27 parallel with primary winding 8 of high potential transformer 7 but connected ahead of exposure switch 9 so that the primary winding 27 is energized from auto-transformer 7 prior to the making of an exposure

by closure of switch 9. The secondary winding 28 has its ends connected to the respective anodes of a full wave rectifier tube 29 while the center tap of such secondary winding 28 is connected to the cathode of the rectifier tube 29, through a filter circuit comprising a parallel connected capacitor 30 and the variable resistance 24.

In the operation of the system of the present invention the adjustable arm 23 of variable resistance 22 is set for a given installation. The constant voltage D. C. supply source will accordingly apply a voltage to the D. C. winding 19 of the saturable reactor depending upon the negative bias applied to the control grid of the discharge device 20, to influence the current flowing through the A. C. windings 17 thus maintaining the X-ray tube filament at a fixed temperature which controls the milliamperage through the X-ray tube 10 during a subsequent exposure.

To compensate for the otherwise inherent tendency of the milliamperage to vary with changes in kilovoltage, the unidirectional current supplied by transformer 26 and rectified by rectifier 29, causes a slight variation in the negative bias applied to the grid of the discharge device 20 by the portion of variable resistance 24 connected in series with the grid. For example, the two sections of the secondary winding 28 generate a maximum of about 6 volts each at the maximum kilovoltage setting of the controls on auto-transformer 7. This in turn, at high kilovoltage, causes the portion of variable resistance 24 to apply a slightly more negative bias (a few tenths of a volt) on the grid of discharge device 20 than at lower kilovoltage. This accordingly makes the X-ray tube filament temperature lower at high kilovoltage setting than at lower kilovoltage and by proper adjustment of the variable resistance arm 25 the X-ray tube filament temperature is in turn adjusted so that a desired constant milliamperage is obtained through the X-ray tube at all values of kilovoltage. Moreover, since the compensating arrangement including transformer 26 is connected ahead of the high tension transformer primary 8, all adjustments are conveniently made prior to an exposure and constancy of milliamperage at all values of kilovoltage is thus assured, regardless of the shortness of time period of the subsequent exposure.

It should thus become obvious to those skilled in the art that an X-ray system is provided by the present invention wherein compensation is made for otherwise variation in milliamperage through the X-ray tube with changes in kilovoltage applied to such tube, so that a constant milliamperage is assured at all kilovoltage settings. Moreover, the compensator operates to condition the system for such assurance prior to the actual making of an exposure.

Although one specific embodiment of the present invention has been shown and described, it is to be understood that still further modification thereof may be made without departing from the spirit and scope of the appended claims.

I claim:

1. An X-ray system for maintaining constancy of milliamperage through an X-ray tube at all kilovoltage settings during the making of short exposures comprising an X-ray tube energizable from a source of supply including a high potential transformer and provided with a thermionic cathode, a source of heating energy for said thermionic cathode including a variable impedance, a control circuit for said variable impedance including a discharge device provided with a con-

trol electrode, and means comprising a transformer having its primary winding connected to the same source of supply in electrical parallel with the high potential transformer for said X-ray tube and energizable from said source prior to energization of said X-ray tube for the making of a short exposure, and said means including a rectifier tube connected to said transformer and a filter arrangement connected to the output of said rectifier and to the control electrode of said discharge device and operable to apply a predetermined voltage to the latter which varies with direct changes in kilovoltage setting to control said variable impedance with an attendant predetermined control of the temperature of the thermionic cathode and said X-ray tube and to prevent variation of the milliamperage through the latter at all values of kilovoltage applied to said X-ray tube.

2. An X-ray system for maintaining constancy of milliamperage through an X-ray tube at all kilovoltage settings during the making of short exposures comprising an X-ray tube energizable from a source of supply including a high potential transformer and provided with a thermionic cathode, a source of heating energy for said thermionic cathode including a saturable reactor provided with a direct-current winding and an alternating current winding in series with the source of heating energy, a source of direct-current for the direct-current winding of said saturable reactor including a discharge device provided with a control electrode, and means connected to the same source of supply in electrical parallel with the high potential transformer for said X-ray tube and energizable therefrom prior to energization of said X-ray tube for the making of a short exposure, said means including a rectified source of electrical energy operable to apply a predetermined voltage to the control electrode of said discharge device which varies with direct changes in kilovoltage setting to regulate the electrical energy supplied to the direct-current winding of said saturable reactor with an attendant regulation of the electrical energy flowing through the alternating current windings to predetermine the temperature of the thermionic cathode of said X-ray tube and prevent variation of the milliamperage through the latter at all values of kilovoltage applied to said X-ray tube.

3. An X-ray system for maintaining constancy of milliamperage through an X-ray tube at all kilovoltage settings during the making of short exposures comprising an X-ray tube energizable from a source of supply including a high potential transformer and provided with a thermionic cathode, a source of heating energy for said thermionic cathode including a saturable reactor provided with a direct-current winding and an alternating current winding in series with the source of heating energy, a source of direct-current for the direct-current winding of said saturable reactor including a discharge device provided with a control electrode, and means comprising a transformer connected to the same source of supply in electrical parallel with the high potential transformer for said X-ray tube and energizable from said source prior to energization of said X-ray tube for the making of a short exposure, and said means including a rectifier tube connected to said transformer and a filter arrangement connected to the output of said rectifier and to the control electrode of said discharge device and operable to apply a predetermined voltage to the latter which varies

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with direct changes in kilovoltage setting to regulate the electrical energy supplied to the direct-current winding of said saturable reactor with an attendant regulation of the electrical energy flowing through the alternating current windings to predetermine the temperature of the thermionic cathode of said X-ray tube and prevent variation of the milliamperage through the latter at all values of kilovoltage applied to said X-ray tube.

ROBERT L. WRIGHT.

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