

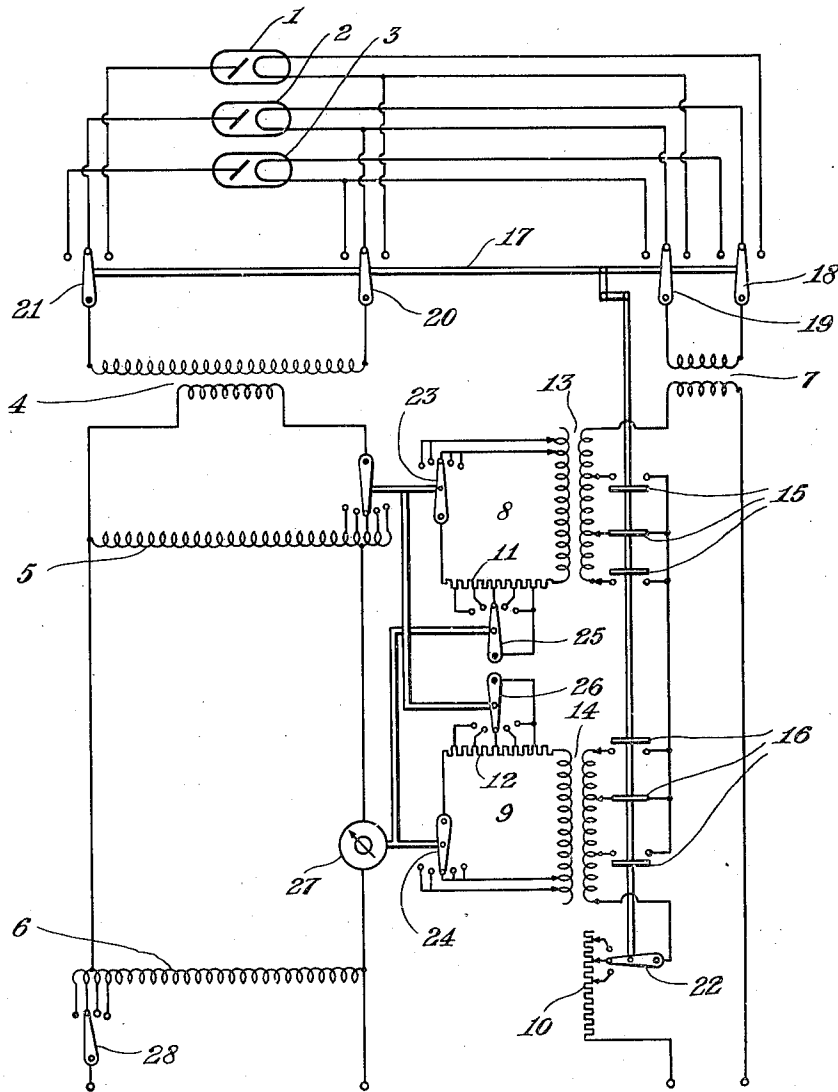
Dec. 6, 1949

J. M. LEDEBOER

2,490,140

X-RAY DEVICE

Filed April 16, 1946



JOHAN MARIE LEDEBOER.
INVENTOR.

BY *J. W. ...*

ATTORNEY.

UNITED STATES PATENT OFFICE

2,490,140

X-RAY DEVICE

Johan Marie Ledebøer, Eindhoven, Netherlands,
 assignor, by mesne assignments, to Hartford
 National Bank and Trust Company, Hartford,
 Conn., as trustee

Application April 16, 1946, Serial No. 662,427
 In the Netherlands November 17, 1943

Section 1, Public Law 690, August 8, 1946
 Patent expires November 17, 1963

3 Claims. (Cl. 250—95)

1

X-ray devices are known in which the devices regulating the voltage and the loading period are coupled with a device for regulating the current strength in such a manner that this current is adjusted to a lower value as the voltage chosen is higher or the chosen loading period is longer.

To this end the heating circuit may comprise two series-connected resistances one of which comprises a regulating member which is coupled with the voltage selector, whereas the other comprises a regulating member coupled with the time selector. The control stages of the first resistance are chosen in such a manner that in a definite position of the time selector (i. e. of the second regulating member) the power supplied to the X-ray tube is the same in all positions of the voltage selector and has more particularly such a value that the X-ray tube is just capable of withstanding during the loading period which is adjusted by means of the time selector. Consequently, as long as the time adjustment is not changed, the current strength is inversely proportional to the voltage which is adjusted by means of the voltage selector.

The control stages of the second resistance are chosen in such a manner that even in any arbitrary position of the time selector the power (which in this case must have a different value in any instance) has such a value that the X-ray tube is just capable of withstanding during the loading period then adjusted. To permit this use is made of a series resistance whose value has been adjusted permanently and is left unchanged while the voltage and the time are regulated during normal operation of the X-ray apparatus. Experimentally and by readjustment of the three resistances the operator finds a division in which the imposed condition is satisfied, with a sufficient degree of approximation in practice, for all positions of the selectors.

When replacing the X-ray tube, for instance in the case of a failure, the three resistances must be controlled, since the spare tube may exhibit such differences, in regard to the functional relation existing between anode-current strength and filament current strength, that without readjustment of the resistances it would no longer receive the desired load in every position of the selectors. Sometimes a slight modification of the series-resistance is sufficient, but it also occurs that the resistances coupled with the selectors must be adjusted anew. This is to be considered as a drawback of this device, notably in the case of regulators with continuous control.

This drawback is much more manifest when

2

tubes of a different kind are to be connected alternately to one and the same apparatus. In this case other tappings from the resistances of the filament circuit must be used for each tube, which requires an intricate changing over mechanism. Moreover, each series of tappings must be readjustable in view of replacement, if required.

This disadvantage is overcome by the present invention which has for its object to approximate with a sufficient degree of accuracy (which may still be raised by another improvement according to the invention) the maximum permissible current strength at each adjustable value of the voltage and the loading period and with every X-ray tube by means of a small number of resistance tappings.

The invention is directed to an X-ray apparatus comprising a regulating device for the tube current, which is coupled with the voltage selector, and another regulating device for the tube current, which is coupled with the time selector. According to the invention the tube current is controlled by means of resistances inserted, through the intermediary of transformers having a variable transformation ratio, in the cathode heating circuit of the X-ray tube. Consequently, the resistance stages are all varied to the same degree upon modification of the transformation ratio. We have found that this permits the retention of the result once obtained upon replacement of the X-ray tube. In a device according to the invention solely a different transformation ratio and, as the case may be, a different value of the series resistance must be chosen to match all resistance stages simultaneously to the load of the new tube according to its nomogram. Consequently, it is sufficient to provide a readjustable tap solely for the transformers and the series resistance. It is advantageous to provide it with the transformers both on the primary and on the secondary side, since in this case less connecting points are required than in the case of readjustability at only one of the windings.

Even when different X-ray tubes are to be connected alternately to the apparatus the property found may be utilized to make the interchanging of tappings of the regulating resistances superfluous and thus avoid intricate switching mechanisms. To this end, with the transformer to which the regulating resistances are connected and the series resistance a separate tapping is provided for every tube, which tapping may, in its turn, be readjustable in view of possible replacement of the tubes. Devices for changing over these tappings, consequently for modifying

3

the transformation ratio of the transformers, may be coupled electrically or mechanically with the device for selecting the tube, so that on changing over the tubes the tappings from the control transformers associated with the tube chosen are put into use simultaneously.

In practice it is mostly desirable that the voltage selector should have a linear scale division and the time selector should have a logarithmic scale division. Often this condition can be satisfied only by a non-linear division of the current regulating resistances. In this case the division can be made linear again by varying the resistance per unit length of the wire or band constituting the resistance to be regulated. This is of particular importance for continuous regulators.

When in an apparatus comprising more than one tube the division of the resistance, upon changing over from one tube to the other, is to be modified, this method is unsuitable. In the apparatus according to the invention it may also be utilized when using two or more tubes, since in this case the resistance stages steadily retain the same value. This constitutes another advantage of the invention.

The series resistance and the control stages of the resistances coupled with the selectors may, it is true, be chosen in such a manner that in no position of the selectors the power exceeds that which the X-ray tube is capable of withstanding at the most during the loading period chosen and the deviations from the optimum loading state always remain within reasonable limits, but a perfectly correct adjustment of the power with any desirable combination of voltage and time cannot be ensured without changing over of the connections of the regulating resistances. Even if one of the regulating resistances is replaced by a voltage regulator, so that the influence of the summing of the resistances is cancelled, deviations from the ideal loading state remain. One of the causes thereof is, for instance, the variation of the voltage loss in the apparatus in the case of a varying current strength. Wrong adjustments are also caused by the fact that the anode current of the X-ray tube, even within the control range, is not proportional to the filament current.

In the case of a greater accuracy of adjustment being required certain corrections are necessary in regard to the tappings from the regulating resistances. In a device according to the invention these corrections are possible in a simple manner. In fact, we have found that in the case of a suitable division of the total resistance in the cathode heating circuit over the series resistance and the two regulating resistances, the required corrections of the resistance variations necessary for the obtainment of the optimum loading states, which variations the regulating resistance coupled with one of the two selectors must undergo successively on traversing all positions of the other selector, approximately have the same ratio for all positions of the first-mentioned selector.

Consequently, according to the invention, on passing over from one position of one selector to another position of the same selector, all resistance stages of the current regulator coupled with the other selector can be corrected simultaneously, by giving the transformer, to which this current regulator is connected, a different transformation ratio. This does not require special care during operation, if the voltage selector has coupled to it its "own" current regulator and

4

in addition (electrically or mechanically) a member for varying the transformation ratio of the transformer, to which is connected the current regulator coupled with the current selector, and conversely the time selector has coupled to it a member for modifying the transformation ratio of the transformer having connected to it the current regulator coupled with the voltage selector.

In this construction the total number of tappings of the transformers and resistances required for steadily obtaining the maximum permissible load does not exceed twice the sum of the number of positions of the two selectors viz. once from the resistances and once from the transformers. However, the number of tappings from the transformers may be materially reduced without any appreciable decrease in accuracy. The series of resistance values corresponding with the control stages of one of the selectors, which is required in a definite position of the other selector, is but slightly different from that required in a neighbouring position of the last-mentioned selector. This permits the changing over of the transformers to take place in any instance after traversing a certain number of stages of voltage or time and consequently to simplify the construction of the X-ray device. In this case a few correction tappings are sufficient.

In order that the invention may be clearly understood and readily carried into effect, it will now be described more fully with reference to the accompanying drawing, representing, by way of example a wiring diagram of an X-ray apparatus according to the invention, to which three X-ray tubes 1, 2 and 3 can be connected. The supply transformer 4 is connected on its primary side to a regulating transformer 5 which, through the intermediary of an auto-transformer 6 having a variable number of primary turns, is connected to the mains terminals.

The cathode heating current for the X-ray tubes is supplied by the transformer 7 to which a stabilized voltage is fed. The primary circuit of this transformer comprises two regulating devices 8 and 9 and a series resistance 10. The regulating devices 8 and 9 each comprise a resistance (11 and 12) and a transformer (13 and 14). Two switches 23 and 24 correspond with readjustable tappings of the secondary windings of the transformers. By operating these switches or shifting the tappings themselves the transformation ratio of these transformers is changed. To the secondary windings are connected the resistances 11 and 12 which are provided with a certain number of tappings over which pass contact arms 25 and 26. The members 23 and 26 are electrically or mechanically coupled with the contact arm of the voltage regulator 5 and the members 24 and 25 are electrically or mechanically coupled with a regulator 27 by means of which the loading period is adjusted.

The primary windings of the transformers 13 and 14 also comprise a certain number of readjustable tappings which permit the transformation ratio to be modified. In the executional example are indicated three tappings in accordance with the number of tubes which must be fed alternately by means of the device. The contact arms 15 and 16, which establish the connection between one of the supply conductors and the transformer tappings are coupled, either mechanically or electrically, with the tube selector 17 also having three positions. The tube

5

selector operates at the same time as the switching arms 18, 19, 20 and 21 thus establishing all connections required for operating a definite tube.

Moreover, the switching arms 15 and 16 are coupled with the regulating member 22 of the series resistance 10. By means of this series resistance the total resistance of the filament circuit for every X-ray tube is given the value which is most suitable in view of the individual properties of the tube. The optimum division of the required resistance over the three elements 10, 11 and 12, can be found experimentally.

When the tapplings of the transformers 13 and 14 are chosen correctly, the positions of the regulators 25 and 26 are suitable for every tube connected. The tapplings are readjustable to permit correction upon replacement of a tube in order that the regulating devices for the new tube shall operate as accurately as possible.

A displacement of the voltage selector 5 or the time selector 27 involves a variation of the current regulating resistance 12 and 11 respectively. For several reasons this requires correction of the other current regulating resistance 11 and 12 respectively, which correction is brought about automatically by the simultaneous modification of the transformation ratio of the transformer 13 and 14 respectively by means of the switch 23 and 24 respectively. However, the necessary correction is small so that it is sufficient to divide the control stages into groups and to modify the transformation ratio slightly only on passing over from one group to the other. In the executional example two groups are chosen, so that two readjustable correction tapplings are provided on the secondary windings of the transformers. The correction tapplings may also be provided on a separate transformer connected in cascade with the transformer 13 and 14 respectively. As an alternative they may be provided at the primary side instead of at the secondary side.

The regulator 28 serves to adjust the feed voltage of the high-tension transformer to a definite value, prior to an X-ray exposure, and consequently for the so-called mains voltage correction.

What I claim is:

1. X-ray apparatus comprising an X-ray tube having anode and cathode electrodes, circuit means to energize said cathode electrode comprising first, second, and third variable resistance elements, first and second transformers each

6

having an adjustable primary winding to vary the transformation ratio thereof and a secondary winding, means coupling the secondaries of said first and second transformers to said first and second resistance elements respectively, means connecting said primary windings in series with said cathode and said third resistance element, circuit means for energizing said anode electrode including a voltage regulating member and a time adjusting member for adjusting the loading time of said tube, means coupling said voltage regulating member to the first of said resistance elements to adjust said first resistance element in accordance with the adjustment of said voltage adjusting member, and means coupling said time adjusting member to the second of said resistance elements to adjust said second resistance element in accordance with the adjustment of the loading time of said tube.

2. X-ray apparatus as claimed in claim 1 for controlling a plurality of X-ray tubes in which the means for adjusting the primary windings of said transformers are coupled to means for adjusting said third resistance element and a selector switch for selecting one of said tubes and connecting said tube to said cathode and anode energizing circuits.

3. X-ray apparatus as claimed in claim 1 in which the secondary windings of said transformers are adjustable to vary the transformation ratios of said transformers including means coupling the secondary winding of said first transformer to said time adjusting member to adjust the secondary winding of said first transformer in accordance with the adjustment of the loading time of the tube, and means coupling the secondary winding of said second transformer to said voltage adjusting member to adjust the secondary winding of said second transformer in accordance with the adjustment of the loading time of the tube.

JOHAN MARIE LEDEBOER.

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