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Grasser

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[54] **X-RAY DIAGNOSING APPARATUS WITH A REGULATING DEVICE FOR THE X-RAY TUBE VOLTAGE**

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[51] **Int. Cl.** **H05g 1/34**

[58] **Field of Search** 250/408, 409, 417, 418, 250/413, 414; 315/307

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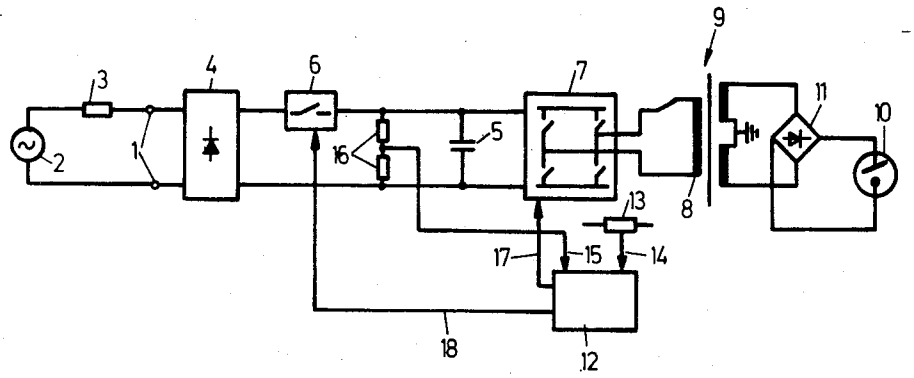
[57] **ABSTRACT**

An X-ray diagnosing apparatus has a regulating device for the X-ray tube voltage. The invention is particularly characterized by the provision of a feed device for the X-ray tube which includes a condenser and a comparison member for voltage corresponding to the actual value of the X-ray tube voltage and a voltage incorporating the required value of the X-ray tube voltage. Switching means are located in front of the condenser for interrupting the charging of the condenser when an upper condenser voltage is reached. Switching means are located behind the condenser for switching off the X-ray tube when a lower limit of the condenser voltage is reached. These switching means are operable by the comparison member which actuates them to again switch on the condenser and the X-ray tube when a condenser voltage is reached which is close to the condenser voltage corresponding to the required value of the X-ray tube voltage.

3 Claims, 4 Drawing Figures



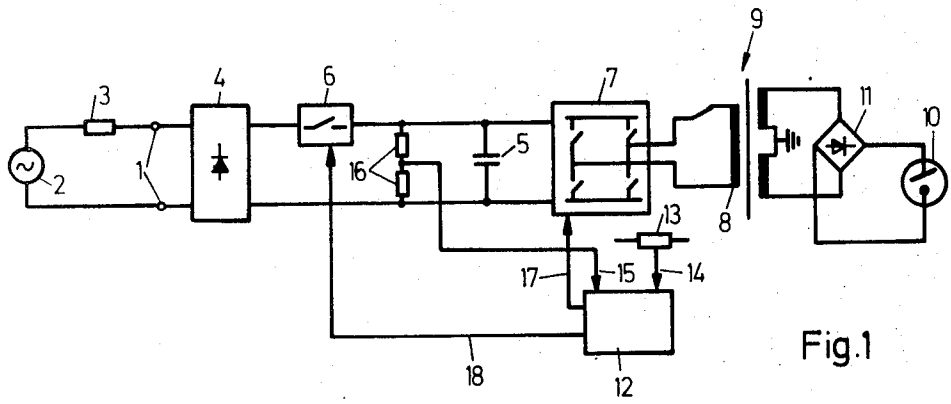


Fig.1

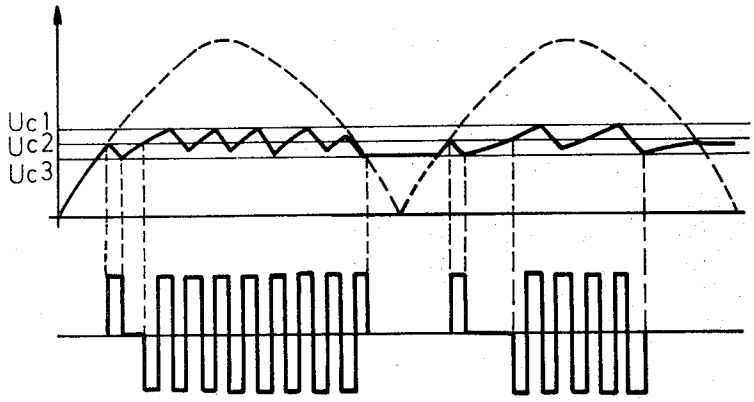


Fig.2

Fig.3

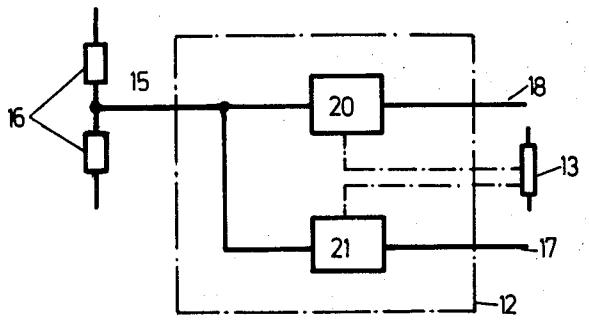


Fig.4

X-RAY DIAGNOSING APPARATUS WITH A REGULATING DEVICE FOR THE X-RAY TUBE VOLTAGE

This invention relates to an X-ray diagnosing apparatus with a regulating device for the X-ray tube voltage.

German Pat. specification No. 946,250 describes an X-ray diagnosing apparatus wherein the X-ray tube voltage is regulated by connecting in series with the X-ray tube two regulating tubes acting as variable resistances. The resistances of the regulating tubes are operated by two comparison members depending upon the difference of the actual and required values of the X-ray tube voltage in such manner that deviations of the actual value of the X-ray tube voltage from required value are automatically balanced. This X-ray diagnosing apparatus has the drawbacks that the loss output in the regulating tubes is comparatively large and that it is not possible to use the known regulating arrangement in the low voltage circuit, so that there are great requirements concerning the voltage strength of the structural elements of the regulating arrangement. The known principle due to the large switch-technical requirements cannot be used in practice for smaller X-ray diagnosing apparatus, for example, for movable units.

In known movable X-ray diagnosing apparatus means are provided for adapting it to the feed network, which include an adjusting transformer connected in front of the high voltage transformer. The adjusting transformer is then set by hand corresponding to the net voltage and possibly to the inner resistance of the network. This adjustment must be carried out anew every time the connecting plug is changed.

An object of the present invention is to provide an X-ray diagnosing apparatus of the described type having a simple regulating device with a small loss output, which can be used in a low voltage circuit as well and which can be used particularly well when the X-ray diagnosing apparatus is a movable one, so that no manual adjustment is required to the network idle voltage and the network inner resistance.

Other objects will become apparent in the course of the following specification.

In the accomplishment of the objectives of the present invention it was found desirable to provide a feed device for the X-ray tube which includes a condenser and a comparison member for voltage corresponding to the actual value of the X-ray tube voltage and a voltage incorporating the required value of the X-ray tube voltage. The comparison member operates switching means located in front of the condenser for interrupting the charging of the condenser when an upper condenser voltage is reached and operating switching means located behind the condenser for switching off the X-ray tube when a lower limit of the condenser voltage is reached. The comparison member again operates the switching means to switch on the condenser and the X-ray tube when a condenser voltage is reached which is close to the condenser voltage corresponding to the required value of the X-ray tube voltage.

In the X-ray diagnosing apparatus of the present invention the X-ray tube voltage is regulated by two switches which can assume only two conditions, namely, a low ohm condition and a high ohm condition. The loss output as compared to existing conditions is very low. The limits within which the X-ray tube voltage can swing, can be set very low. The regulating device of the X-ray diagnosing apparatus of the present invention can be also switched into the primary circuit of the high voltage transformer, so that it is not necessary to provide high voltage resistant structural elements.

A particularly advantageous embodiment of the present invention wherein the inclusion of the regulating device into the high voltage circuit can be eliminated consists in that in an X-ray diagnosing apparatus with a net rectifier and an inverter switched behind the rectifier and feeding the high voltage transformer, the condenser is located parallel to the inlet of the inverter. In that case in addition to the advantages of a simple structure and a quick and reliable operation of the regulating device, there is the further advantage that the weight of the high voltage transformer can be made considerably less than those of existing devices provided that it is operated with a feed frequency which is higher than the network frequency.

The invention will appear more clearly from the following detailed description when taken in connection with the accompanying drawing showing by way of example only, a preferred embodiment of the inventive idea.

In the drawing:

FIG. 1 is a circuit diagram of the X-ray diagnosing apparatus of the present invention.

FIGS. 2 and 3 are diagrams showing the extent of voltage at different locations of the apparatus of FIG. 1.

FIG. 4 shows a detail of the circuit diagram of FIG. 1.

The X-ray diagnosing apparatus shown in FIG. 1 is connected by diagrammatically indicated contacts 1 to a network of alternating voltage which is embodied by an alternating voltage source 2 and the network inner resistance 3. The network voltage is rectified by a net rectifier 4. The outgoing voltage of the rectifier 4 is transmitted through a condenser 5 to a switch 6, preferably a half conducting switch. The voltage at the condenser 5 serves to feed an inverter 7 which supplies the inlet voltage for the primary winding 8 of a high voltage transformer 9. The outgoing voltage of the high voltage transformer 9 is supplied to an X-ray tube 10 through a high voltage rectifier 11.

A comparision member 12 provided for regulating the X-ray tube voltage has an inlet 14 connected to the required value giver 13 and an actual value inlet 15. At the actual value inlet 15 lies a voltage taken from the voltage divider 16 which is proportional to the voltage at the condenser 5. The comparison member 12 has two outlets 17 and 18, connected to the inverter 7 and the switch 6.

The comparison member 12 produces by corresponding signals at its outlets 17 and 18 that the switch 6 opens, namely, becomes high ohm, when the voltage at the inlet 15 and thus the X-ray tube voltage reach an upper limit and the inverter 7 is still, so that the feed of the high voltage transformer 9 from the inverter 7 is interrupted during continuous charging of the condenser 9, when the voltage at the inlet 15 and thus the X-ray tube voltage reach a lower limit.

These conditions are illustrated in FIG. 2. FIG. 2 shows in full lines the extent of voltage at the condenser 5 and in broken lines the extent of the outgoing voltage

of the net rectifier 4. The two illustrated half waves of this outgoing voltage have two different apex values. FIG. 2 shows three voltages Uc1, Uc2 and Uc3. Uc1 represents the upper limit of the feed voltage of the inverter 7. When this upper limit is reached the switch 6 is opened by the comparison member 12. Uc2 is the required value of the voltage at the condenser 5 and Uc3 is the lower limit of the feed voltage of the inverter 7. When this feed voltage is reached, the inverter 7 is stopped by the comparison 12 and thus the feed to the X-ray tube 10 is interrupted.

The comparison member 12 is so set that the switch 6 after its opening after reaching the voltage Uc2 is again closed and the inverter after being stopped is again taken in operation when the voltage Uc2 is reached. Thus the voltage at the condenser 5 swings back and forth during a half wave of the outlet voltage of the net rectifier 4 between the values Uc1 and Uc3.

Since the inverter 7 is always stopped when the voltage falls below Uc3, the feed voltage of the primary winding 8 of the high voltage transformer 9 consists substantially of rectangular impulses the voltage parts of which having the shape of saw teeth are superposed at the condenser 5 (FIG. 3). For the sake of better showing only the rectangular impulses are shown in FIG. 3. The width of these rectangular impulses and their number per half wave depend upon the quality of the network, namely, upon the network voltage and the network inner resistance. The lower is the network voltage and the greater is the network inner resistance, the less energy reaches the X-ray tube during a period. It is possible to keep very small the deviation of the feed voltage of the primary winding 8 of the high voltage transformer 9 and thus also the voltage at the X-ray tube 10 from the required value. FIG. 2 shows the saw teeth curve on an enlarged scale. The set X-ray tube voltage, namely, the vortex value of this X-ray tube voltage is kept consequently constant to a great extent so that the illumination and the quality of the exposure are not affected.

If the inverter 7 is not operated from the outlet 17 of the comparison member 12 and if the network is bad, the tube voltage would drop below its minimal value (Uc3). In that case the X-ray tube voltage would deviate in an undesirable manner from the desired top value.

The present invention is carried out with the use of on and off switches, so that the loss output of the regulating device is small. Since the inverter can be switched off during a period the condenser 5 can have a comparatively small size. It is possible to eliminate high voltage from structural elements for the regulating device. The present invention is thus particularly suitable for movable X-ray diagnosing apparatus. If the frequency of the feed voltage of the high voltage transformer is increased by correspondingly measuring the inverter 7 relatively to the net frequency, then as already stated, the weight and the volume of the high volume transformer can be diminished.

In accordance with the present invention it is also possible to arrange the regulating device, consisting of structural elements 5, 6, 12, 13 and 16 in the high voltage circuit of the X-ray tube 10. In that case also the loss output in the regulating device is very small due to the use of an on and off switch 6 which in that case is located in the high voltage circuit of the X-ray tube 10. In this embodiment of the present invention instead of the inverter 7 a further switch must be located in the high voltage circuit of the X-ray tube 10 after the condenser 5.

In accordance with the present invention it is not necessary that the switch 6 be closed again when the voltage Uc2 is reached. It is advisable, however, during the saw teeth run of the condenser voltage not to go below the range between Uc1 and Uc3, since otherwise there is an undesired diminution of energy transmitted to the X-ray tube 10 and thus an undesired extension of the exposure period.

FIG. 4 shows one embodiment of the comparison member 12 of FIG. 1. According to this embodiment the comparison member 12 has two Schmitt triggers 20 and 21. The exposures of these Schmitt triggers are so selected that the Schmitt trigger 20 produces an outgoing signal when the upper limit of the condenser voltage Uc1 is reached and the Schmitt trigger 21 produces an outgoing signal when the lower limit of the condenser voltage Uc3 is reached. Thus the line 18 is connected to the Schmitt trigger 20 and the line 17 is connected to the Schmitt trigger 21.

According to the illustration of FIG. 2 the voltage Uc3 is sometimes not completely reached by the condenser voltage. The reason is that the thresholds of the Schmitt triggers are not precisely fixed but are subjected to certain fluctuations. Furthermore, these exposures are subjected to net voltage fluctuations.

I claim:

1. An X-ray diagnosing apparatus, comprising an X-ray tube, a feeding device for regulating the voltage of said X-ray tube, and means supplying electrical energy to said feeding device, said feeding device comprising a net rectifier connected with said energy supplying means, an inverter, a switch connecting the output of said rectifier with the input of said inverter, a condenser extending parallel to the input of the inverter, a high voltage transformer connected with the output of the inverter and supplying said X-ray tube, a comparison member, means for supplying a first signal to the input of the comparison member corresponding to the actual value of the X-ray tube voltage, and a second signal corresponding to the required value of the X-ray tube voltage, the output of the comparison member being connected with the switch and the inveter, said comparison member operating the switch for interrupting the charging of the condenser when an upper condenser voltage is reached, and operating the inverter for switching off the X-ray tube when a lower condenser voltage is reached, and also operating the switch and the inverter for switching on the condenser and the X-ray tube when a condenser voltage is reached which is close to the condenser voltage corresponding to the required value of the X-ray tube voltage.

2. An X-ray diagnosing apparatus according to claim 1, comprising a voltage divider connected in parallel with the condenser and forming an input signal for said comparison member corresponding to the condenser voltage.

3. An X-ray diagnosing apparatus according to claim 1, wherein said comparison member comprises two Schmitt-triggers, the inputs of said Schmitt-triggers being connected with an actual value transmitter for the condenser voltage, the outputs of the Schmitt-triggers being connected with the switch and the in-

verter respectively, the thresholds of said Schmitt-triggers being so selected that one of said Schmitt-triggers produces an output signal for switching off the condenser when the upper condenser voltage is reached and the other one of said Schmitt-triggers produces an output signal for switching off the inverter when the lower limit of the condenser voltage is reached.

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