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Amtmann et al.

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[54] **X-RAY DIAGNOSING DEVICE WITH MEANS FOR CHANGING X-RAY TUBE VOLTAGE**

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[52] **U.S. Cl.** **250/314;** 250/320; 250/405

[51] **Int. Cl.** **G01n 23/00**

[58] **Field of Search** 250/313, 314, 320, 323, 250/405, 408, 402

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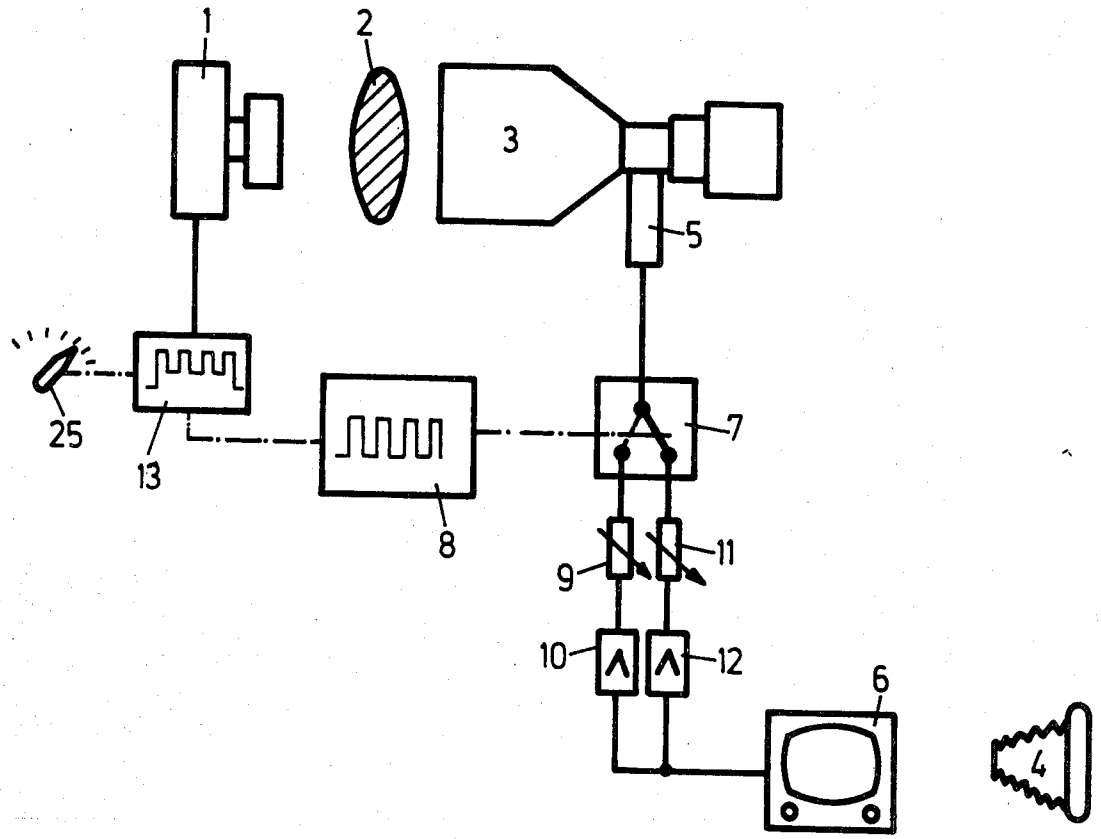
[57] **ABSTRACT**

An X-ray diagnosing device has means for changing the X-ray tube voltage during illumination or photographing. The invention is particularly characterized by a device influencing the X-ray tube voltage during illumination or photographing so as to superpose at least one hard ray image and at least one soft ray image, whereby the ratio for the hard ray image and the soft ray image can be set manually.

6 Claims, 7 Drawing Figures



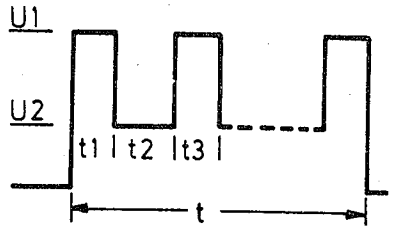


Fig.1

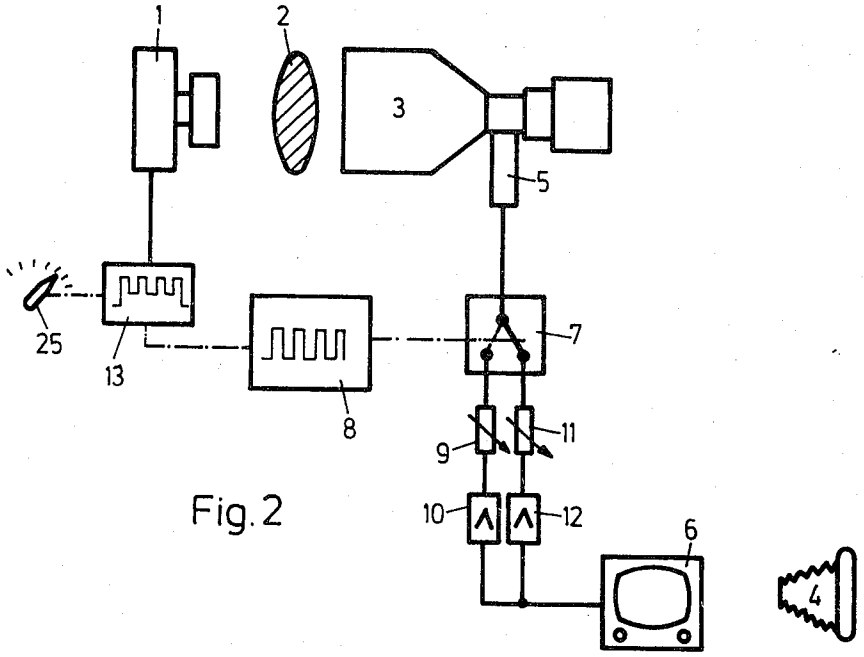


Fig.2

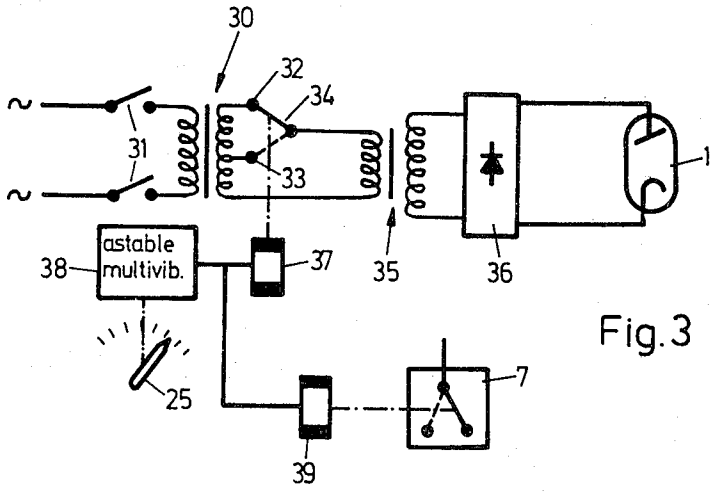


Fig.3

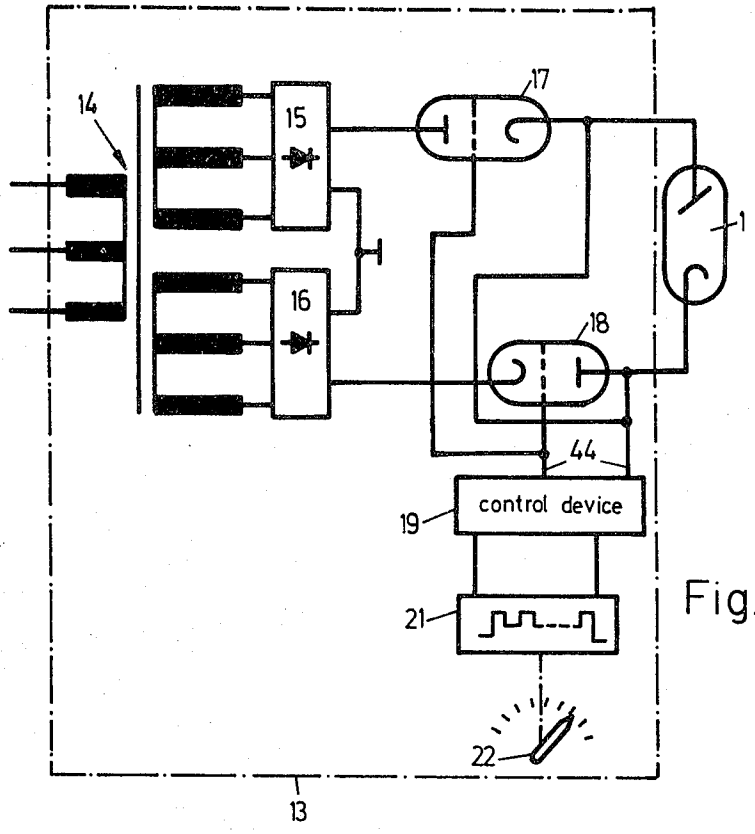


Fig.4

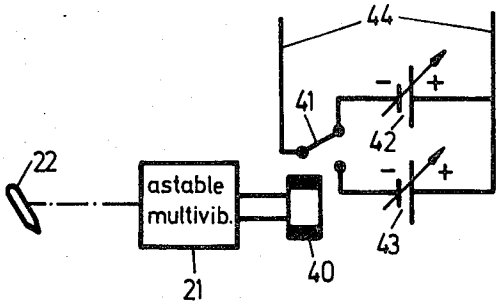


Fig.5

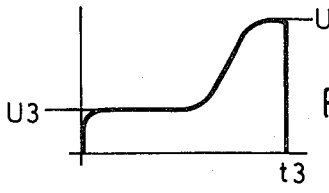


Fig.6

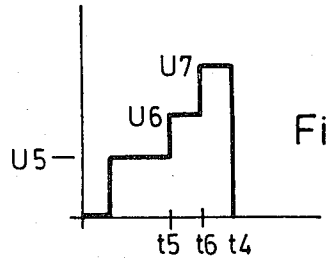


Fig.7

X-RAY DIAGNOSING DEVICE WITH MEANS FOR CHANGING X-RAY TUBE VOLTAGE

This invention relates to an X-ray diagnosing device with means for changing X-ray tube voltage.

The X-ray tube voltage which is used for making X-ray illumination or photographs depends upon the extent of the patient to be illuminated and the image contrast desired by the user. In order to make it possible to diagnostically evaluate upon an X-ray picture of body parts or organs of great thickness, such as bones, or covered body parts or organs, it is necessary to use high X-ray tube voltages. However, the use of high X-ray tube voltages has the drawback that the image contrast is small and that those body parts and organs for the representation of which a lower X-ray tube voltage would be adequate, are not reproduced in the best possible way. On the other hand, if a lower X-ray tube voltage is used to produce a good image contrast, then those parts or organs of the human body which have a high thickness or which are covered are not sufficiently penetrated by X-rays, and then are badly reproduced.

Thus, in order to provide a clear picture of the part of the patient penetrated by rays for the doctor, it is often necessary to make several X-ray pictures with different X-ray tube voltages. Particularly for thorax photographing, the making of a single photograph is often insufficient, since, on the one hand, a low X-ray tube voltage is desired to produce a good image contrast while, on the other hand, high X-ray tube voltages are required for penetration of all body parts.

An object of the present invention is to provide an X-ray diagnosing device of the described type, which will make it possible to produce X-ray pictures of substantially better quality than those of prior art.

In the accomplishment of the objectives of the present invention, it was found desirable to provide a device influencing X-ray tube voltage during illumination or photographing so as to superpose at least one hard ray image and at least one soft ray image, whereby the dose for the hard ray image and the soft ray image can be set manually.

The present invention makes it possible to produce pictures which better comply with the requirement of a good image contrast and thus good detail identification and sufficient ray penetration of body parts or organs of great thicknesses than the known X-ray diagnosing devices.

X-ray diagnosing devices are known, however, wherein the X-ray tube voltage is not precisely constant during illumination or photographing, but is variable. To such devices belong, for example, X-ray diagnosing devices for two-pulse operation, wherein there is a voltage at the X-ray tube which runs corresponding to row arrangements of sinus half-waves. However, in these X-ray diagnosing devices, the course of the X-ray tube voltage, during illumination or photographing, cannot be infuenced manually, but is fixed. The known X-ray diagnosing devices do not provide means improving the picture quality, which is the object of the present invention, since, in these devices, the X-ray tube voltage does not flow to produce the best possible X-ray picture, but is determined by the measurement of the X-ray diagnosing device or the network voltage.

The invention will appear more clearly from the following detailed description when taken in connection with the accompanying drawings, showing, by way of

example only, preferred embodiments of the inventive idea.

In the drawings:

FIG. **1** is a diagram showing the course of the X-ray tube voltage in an X-ray diagnosing device of the present invention.

FIG. **2** shows the circuit of an X-ray diagnosing device of the present invention.

FIG. **3** is a circuit showing details of the parts **8** and **13** of the device of FIG. **2.**

FIG. **4** shows a circuit of a different embodiment of the X-ray diagnosing device of the present invention.

FIG. **5** shows details of a switch connection of the device shown in FIG. **4.**

FIGS. **6** and **7** are diagrams illustrating different courses of the X-ray tube voltage during illumination or photographing.

FIG. **1** shows an example of the course of X-ray tube voltage according to the present invention during illumination or during the making of an X-ray picture. The X-ray tube voltage then swings in rectangular impulses between a maximum value U1 and a minimum value U2 during illumination or photographing time period t. The voltage U1 is so selected that all body *t.* and organs are properly penetrated by X-rays. The voltage U2 is so selected that those body parts and organs which have a small thickness are represented with good contrast. The relationship of the time *t*1, during which the voltage U1 is present at the X-ray tube, to the time *t*2, during which the voltage U2 is at the X-ray tube, is so selected that the best possible image quality is produced. Investigations have shown that this image quality is considerably better than when illumination or photography takes place with the voltage U1, or with the voltage U2, or with an intermediate constant voltage. The ratio of the time periods *t*1 and *t*2 is determined empirically.

The X-ray diagnosing device of FIG. **2** is based on the voltage course of FIG. **1.** The device includes an X-ray tube **1** extending rays through a patient **2,** an X-ray image amplifier **3,** a film camera **4,** a remote vision camera **5** and a viewing device **6.** The image amplifier-remote vision chain **3** to **6** is also connected with a known remote vision central device for producing synchronous signals, which is not illustrated.

A switch **7** is located between the remote vision camera **5** and the viewing device **6.** It is periodically actuated by a synchronizing device **8** and transmits the outgoing signal of the remote vision camera **5** to the viewing device **6,** either through the actuating member **9** and the amplifier **10,** or through the actuating member **11** and the amplifier **12.** The X-ray apparatus **13** feeding the x-ray tube **1** is also connected to the synchronizing device **8.** It is provided with an adjusting member **25** for the time ratio *t*1/*t*2 and the amount of the voltages U1 and U2.

As already stated, the feeding of the X-ray tube **1** takes place with a voltage according to FIG. **1.** In synchronism with the course of this voltage, the synchronizing device **8** produces the switching of the switch **7.** Thus, for example, the switch **7** has a position shown in full lines during the time periods *t*1 and a position shown by broken lines during the time periods *t*2. Due to this arrangement, a signal embodying the hard ray image is transmitted through the members 11 and 12, and a signal embodying a soft ray image is transmitted through members 9 and 10. Thus, the two pictures ap-

pear alternately upon the viewing device 6. Their intensity is adjustable by adjusting members 9 and 11. Thus, the adjusting members provide the best possible adjustment of the picture in the viewing device 6. In addition, for the best setting, the ratio of the X-ray tube voltage according to FIG. 1 and the voltages U1 and U2 in the X-ray apparatus 13 are also adjustable. The impulse sequence frequency of the X-ray tube voltage, and thus of the pictures upon the viewing device 6, are so selected that the hard ray image and the soft ray image are superposed for the viewer upon the viewing device 6. The viewer has the possibility of freely adjusting the X-ray diagnosing device between a complete suppression of one of these two images and its equal transmission. When the best possible setting has been found, X-ray photographing by the film camera 4 can be provided at the viewing device 6.

As shown in FIG. 3, the X-ray apparatus **13** contains a step transformer **30**, which can be connected by a main switch **31** to the a.c. network. The transformer **30** has two contacts **32** and **33**, which can be connected by a relay contact **34** to the primary winding of a high voltage transformer **35**. The secondary winding of the transformer **35** feeds through a high voltage rectifier **36** the X-ray tube **1**. The relay contact **34** is actuated by a relay **37**, which is periodically excited by an astable multivibrator **38**. The frequency of the outgoing voltage of the astable multivibrator is adjustable by adjusting means **25**.

The relay **37** switches on periodically a high inlet voltage and a low inlet voltage at the high voltage transformer **35** corresponding to FIG. **1**. A relay **39** is excited in synchronism with the relay **37** by the outgoing voltage of the astable multivibrator **38**, and it actuates the switch **7**.

FIG. 4 shows that the X-ray tube **1** is supplied by an a.c. high voltage transformer **14** which has two groups of secondary windings and two high voltage rectifiers **15** and **16**, which are connected in series. Two triodes **17** and **18** extend in series with the X-ray tube **1**, their steering lattices being connected with a steering device **19**. An impulse producer **21** causes, through the steering lattices of the triodes **17** and **18**, a periodic change of the resistances of these triodes in such manner that voltages U1 and U2 lie alternately at the X-ray tube **1**. The key ratio of the impulse giver **21** is adjustable by a handle **22**.

As shown in FIG. 5, the actuating device **19** includes a relay **40**, with a switch over contact **41** which selectively can connect one of the two voltage sources **42** and **43** to conduits **44** leading to the steering lattices of the triodes **17** and **18**. The periodic excitation of the relay **40** takes place through the impulse giver **21**, which is constructed as an astable multivibrator. The voltages of the voltage sources **42** and **43** are different, so that the resistances of the triodes **17** and **18** are large or small, depending upon the location of the switching contact **41**. The amount of these resistances, and thus the amount of the corresponding X-ray tube voltage, can be adjusted by changing the voltages of the voltage sources **41** and **43**.

However, within the scope of the present invention, it is not necessary that the course of voltage at the X-ray tube should correspond to FIG. **1**, namely, that a high and a low voltage value alternately follow each other, corresponding to a rectangularly shaped impulse course. As shown in FIG. **6**, the X-ray tube voltage can also rise according to a predetermined function during the making of a photograph from zero to a maximum value. According to FIG. **6**, the end of an X-ray photographing takes place at the time instant $t3$. The function producing the rise of the X-ray tube voltage is so selected that the X-ray photographing consists of at least two individual images, namely, a soft ray image and a hard ray image. The voltage U3 corresponds to the soft ray image, and the voltage U4 corresponds to the hard ray image.

FIG. 7 shows that the X-ray tube voltage can rise step-like during the taking of a photograph, and also after the termination of photographing at the time point $t4$, whereby the voltages U5, U6 and U7 are so selected that there are three superposed images — one hard ray image, one soft ray image, and one image of middle quality. In this case, it is also important that X-ray tube voltages for at least two partial images which are superposed, should be adjustable manually. The amount of the voltages U5 to U7, and the time duration during which these voltages are applied to the X-ray tube, are so fixed that the desired picture quality is produced.

The course of the X-ray tube voltage, according to FIG. **6** or FIG. **7**, for making an X-ray photograph, can be produced while using an X-ray apparatus of FIG. **4**, in that the impulse generator **21** and the actuating device **19** are replaced by a function generator which operates the resistances of the triodes **17** and **18** according to the desired course of the X-ray tube voltage during the making of a photograph.

In the case of the step-like course of FIG. **7**, the voltage change can also be carried out by an illumination automat, in which the desired dose is set for each voltage. Then, the illumination automat produces, at the time $t5$, the changing of the voltage U5 to the voltage U6, and at the time $t6$, the changing of the voltage U6 to the voltage U7. The photographing is automatically finished at the time $t4$.

In accordance with the present invention, the change of the X-ray tube voltage for the making of an X-ray picture can also take place by adjusting means in the primary circuit of the high voltage transformer. In this connection, the preliminary contact time of the photographing relay can be measured corresponding to the desired switching time period from a low X-ray tube voltage to a high X-ray tube voltage. The preliminary contact time is then that time period during which the primary winding of the high voltage transformer is connected by a series resistance to the network.

What is claimed is:

1. An X-ray diagnosing device having an X-ray tube, a fluorescent screen and a film camera for producing X-ray photographs, step-wise voltage-varying means varying the voltage of said tube during fluoroscopy or photography, means for superposing at least one soft ray image and one hard ray image, and dosage setting means for manually setting the dose for each of said images.

2. An X-ray diagnosing device according to claim **1**, comprising an X-ray image amplifier, a television camera connected with said amplifier, a switch connected with said television camera and operable in synchronism with the varying of said voltage, said switch having two outlets, separate amplifiers connected with said outlets and having adjustable amplifications, and a viewing device connected with said outlets, said hard

ray and soft ray images being superposed for the viewer in said viewing device.

3. An X-ray diagnosing device according to claim **1**, wherein the voltage-varying means vary said voltage in the form of rectangular impulses between a high value and a low value, and wherein the setting means set the time ratio $t1/t2$.

4. An X-ray diagnosing device according to claim **1**, wherein the voltage-varying means comprise an automatic exposure timer, and wherein the second-mentioned means adjust all voltage values in said timer.

5. An X-ray diagnosing device according to claim **1**, wherein the voltage-varying means comprise a function generator varying said voltage corresponding to a predetermined function.

6. An X-ray diagnosing device according to claim **1**, wherein the voltage-varying means comprise a triode connected in series with said X-ray tube and regulating the X-ray tube voltage, said triode having a control grid, and wherein the setting means are connected with said grid.

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