Nov. 24, 1931. J. HOFMANN 1,833,078

RÖNTGEN APPARATUS

Filed Oct. 6, 1927

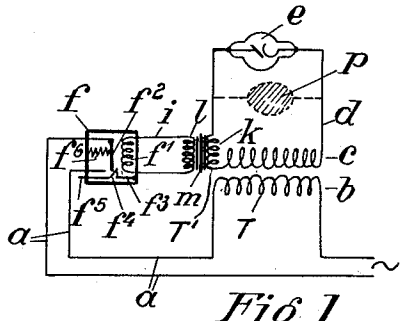

Fig. 1

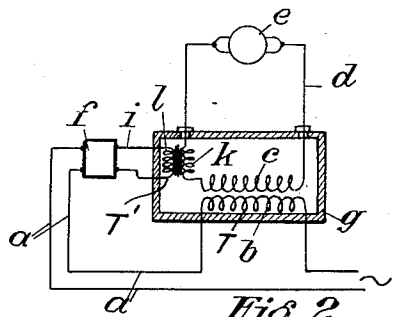

Fig. 2

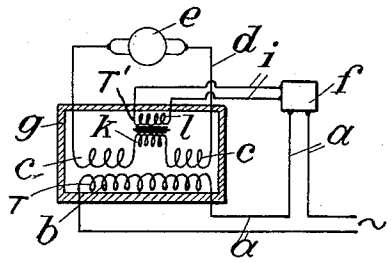

Fig. 3

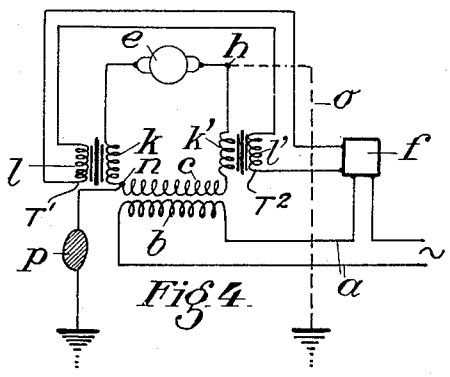

Fig. 4

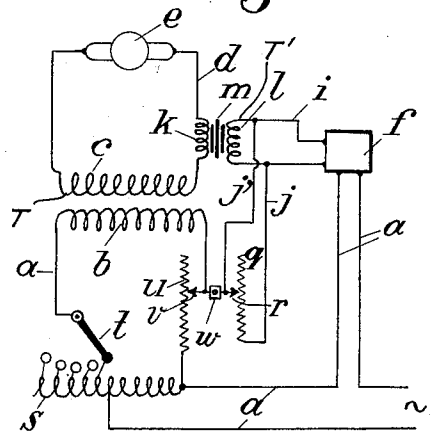

Fig. 5

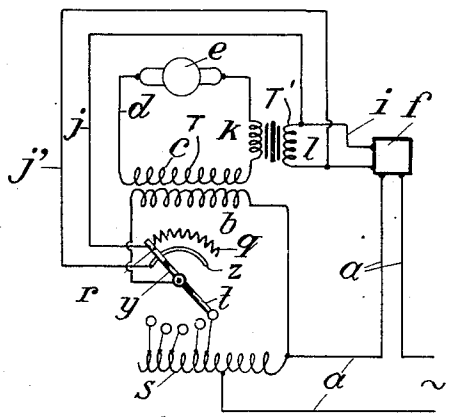

Fig. 6

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UNITED STATES PATENT OFFICE

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RÖNTGEN APPARATUS

Application filed October 6, 1927, Serial No. 224,470, and in Germany October 9, 1926.

My invention relates to improvements in Röntgen apparatus, and the object of the improvements is to provide, in connection with a Röntgen apparatus, automatic means for interrupting the current in case the intensity of the current flowing through the Röntgen tube is increased beyond a certain maximum, which may be the case for example in case of a short circuit, a break-down of the resistance of the tube, etc. The said safety device is arranged so as to act on the primary or low-voltage current of the system, and it must be controlled by the high-voltage current flowing through the Röntgen tube. Therefore, I provide means intermediate the high-voltage side and the low-voltage side of the safety device for preventing the transmission of the high potential to the low-voltage side. For this purpose the safety device is not directly included in the high-voltage circuit, but in a subsidiary circuit coupled with the high-voltage circuit by means of a transformer, the primary and secondary of the said transformer being separated from each other by an insulation preventing the transmission of the high voltage.

For the purpose of explaining the invention several examples embodying the same have been shown in the accompanying drawing, showing in

Figs. 1 to 6, several examples embodying the invention in a diagrammatical way.

Referring now to the example illustrated in Fig. 1, the primary b of a high-voltage transformed T is included in the net a, and the secondary c of the said transformer is included in the high-voltage circuit d of the Röntgen tube e. Further, the primary circuit a includes a switch arm f^2 forming a part of an electromagnetic switch apparatus f responsive to current intensity. The electromagnetic coil f^1 of the said safety switch is included in a subsidiary circuit i. The switch arm f^2 is acted upon by a spring f^6, and it is adapted to be locked by means of a nose f^4 of a spring-pressed pawl f^3, an arm f^5 of the said pawl projecting through the wall of the casing for operation of the pawl by hand. The circuit i is energized by the secondary l of a transformer T^1 the primary k of which is included in the high-voltage circuit d of the Röntgen tube close to the high-voltage terminal of the transformer T. The coils k and l are separated from each other by an insulation m adapted to prevent the transmission of high voltage. The transformer T^1 transforms the high-voltage current of the circuit d into low potential current, so that the safety switch f receives only low voltage. The switch f is regulated so that normally the current intensity within the circuit i is not sufficient for operating the same. If however the intensity of the current flowing through the circuit d increases beyond a certain maximum, for example by a short-circuit, the switch arm f^2 of the safety switch f is attracted by the coil f^1, thus interrupting the primary circuit a. Such a circuit may be produced for example by a person p making contact simultaneously with both terminals of the transformer T, as has been indicated in the figure in dotted lines. Now the spring-pressed pawl f^3 locks the switch arm f^2 in position for interrupting the circuit until it is returned into releasing position by a pressure on the arm f^5, whereupon the switch arm is returned into circuit closing position by the spring f^6.

Any known or preferred safety switch f may be provided in the system. It is important that the transformer T^1 be disposed as close as possible to the high-voltage terminal of the high-voltage transformer, so that the safety system may be operated by any part of the circuit. In Fig. 2, which is otherwise similar to Fig. 1, the transformer T^1 has been included in the box g enclosing the transformer T.

In the systems so far described the safety switch f may fail to operate in case of a short-circuit of the transformer T^1. Therefore, Fig. 3 shows a modification in which the secondary c of the transformer T is divided into two sections, and the transformer T^1 is located between the said sections. In this modification the safety system will be operative even in case of a short-circuit, because a short-circuit current will always flow through the secondary c.

When providing a transformer T^1 at one

side of the transformer T, the system may fail to act for example by a connection to the ground. Therefore, Fig. 4 shows a modification in which two transformers T^1 and T^2, the latter having its primary included in the high voltage circuit and its secondary included in the supply current are provided one at each side of the transformer T, the said transformers T^1 and T^2 being preferably connected in series with a single safety switch *f*. If a person *p* touches the high-voltage circuit *d* for example at the point *r*, the potential of the adjacent terminal of the secondary *c* is reduced to zero, while the potential of the other terminal is doubled. If now by reason of the said increase of the potential a short-circuit current flows for example from *h* over *o* to the ground, the transformer T^1 is short-circuited so that it is ineffective. But the said short-circuit current flows from ground over *p*, *n*, *c*, *k'*, *h*, *o* to ground, so that the transformer T^2 operates the safety switch f.

In Fig. 5 I have shown a modification in which the primary circuit of the Röntgen apparatus is switched out at any desired current intensity of the Röntgen tube. As shown a regulatable resistance *q* is connected in shunt to the safety switch *f*, one terminal of the said resistance being connected by a lead *j* to one terminal of the coil *l* and the movable contact *r* of the said resistance is connected to the other terminal of the coil *l*. The current generated in the transformer T^1 is divided according to the regulation of the resistance *q* at different ratios, one part flowing through the said resistance, and the other through the safety switch *f*, so that the said safety switch *f* can be operated by currents of different intensities flowing through the high-voltage circuit.

Further, in this modification the current of the net passes through an auto-transformer *s* and an ohmic resistance *u* into the primary *b* of the high-voltage transformer, the said auto-transformer having the function to regulate the voltage and being adapted to be regulated by means of a contact lever *t*, and the ohmic resistance *u* being adapted to be regulated by means of a movable contact *v*. The object of the ohmic resistance *u* is to bridge the steps of the voltage of the auto-transformer, and it is switched in when using the Röntgen system for radioscopic purposes, while it must be switched out when making photographs, because it would be broken by the high current intensity needed for taking photographs. On the other hand, when taking photographs requiring current intensities of from 20 to 100 milliampere the safety switch *f* must be regulated so as to be less sensitive. By connecting the movable contacts *r* and *v* through the member *w* the said regulating operations are made dependent on each other.

Finally, as has been illustrated in Fig. 6, the safety switch can be used for limiting the load of the Röntgen tube. Each Röntgen tube is capable of a certain load written on a shield fixed to it. If it is desired automatically to prevent breaking of the Röntgen tube by the safety switch, the said safety switch must be constructed so that the intensity of the current is smaller in case of high voltage of the tube, than in case of low voltage. For this reason the movable contact *r* of the resistance *q* is positively connected with the contact lever *t* of the voltage switch *s*, for which purpose it is connected by an insulating arm *y* with the lever *t* or the fulcrum thereof, and for making the movable connection with the lead *j'*, the said movable contact is adapted to slide on a contact segment *z* connected with the said lead *j'*.

I claim:

A Röntgen system, comprising a primary circuit including a voltage controlling switch, a secondary circuit including the Röntgen tube, a high-voltage transformer having its primary included in said primary circuit and its secondary in said secondary circuit, a safety apparatus for the control of said primary circuit and having a coil, a third circuit including said coil, a second transformer having its secondary included in said third circuit and its primary included in said secondary circuit, and a variable resistance connected in shunt to said coil, and having a regulating member being dependent upon said voltage controlling switch.

In testimony whereof I affix my signature.

JOSEF HOFMANN.