

[54] **INSULATING ELECTRODE FOR  
BREAKDOWN INHIBITION IN  
ELECTRONRADIOGRAPHY IMAGING  
CHAMBER**

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#### Related U.S. Application Data

[63] Continuation of Ser. No. 365,971, June 1, 1973.

[52] U.S. Cl. .... **250/315; 250/327**

[51] Int. Cl. .... **G03b 41/16**

[58] Field of Search ..... 250/315, 327

#### References Cited

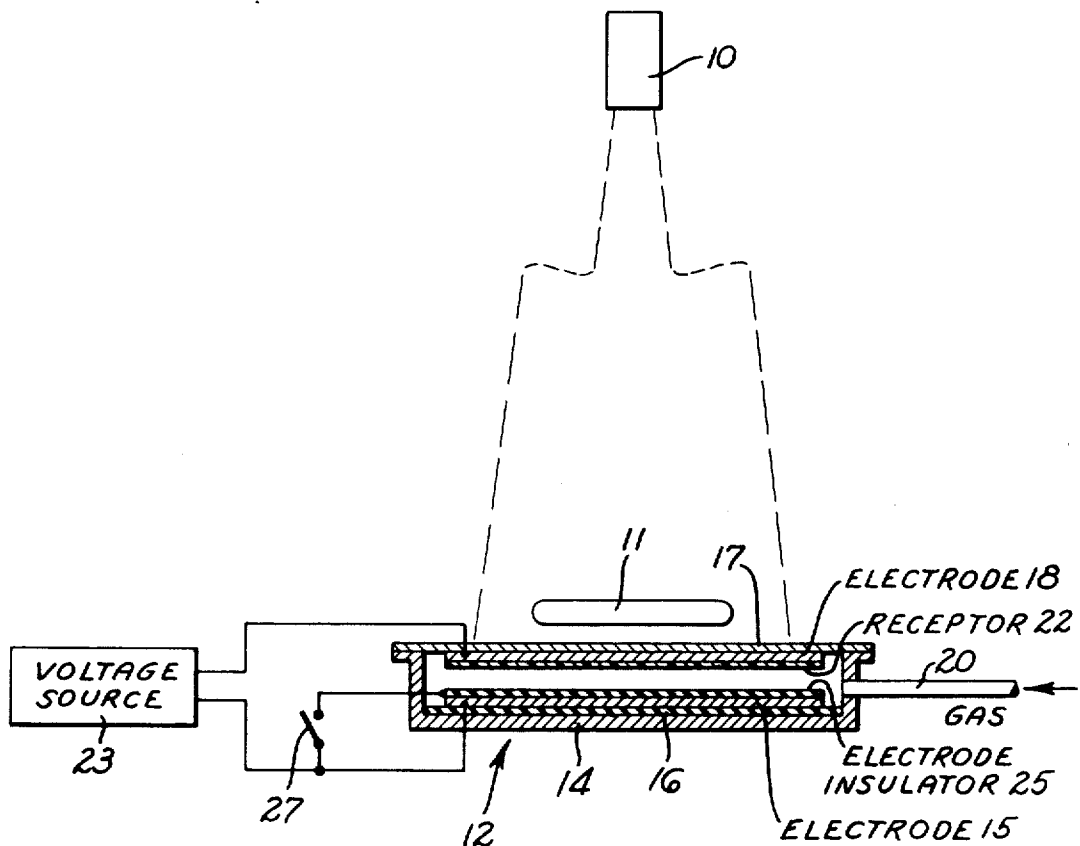
##### UNITED STATES PATENTS

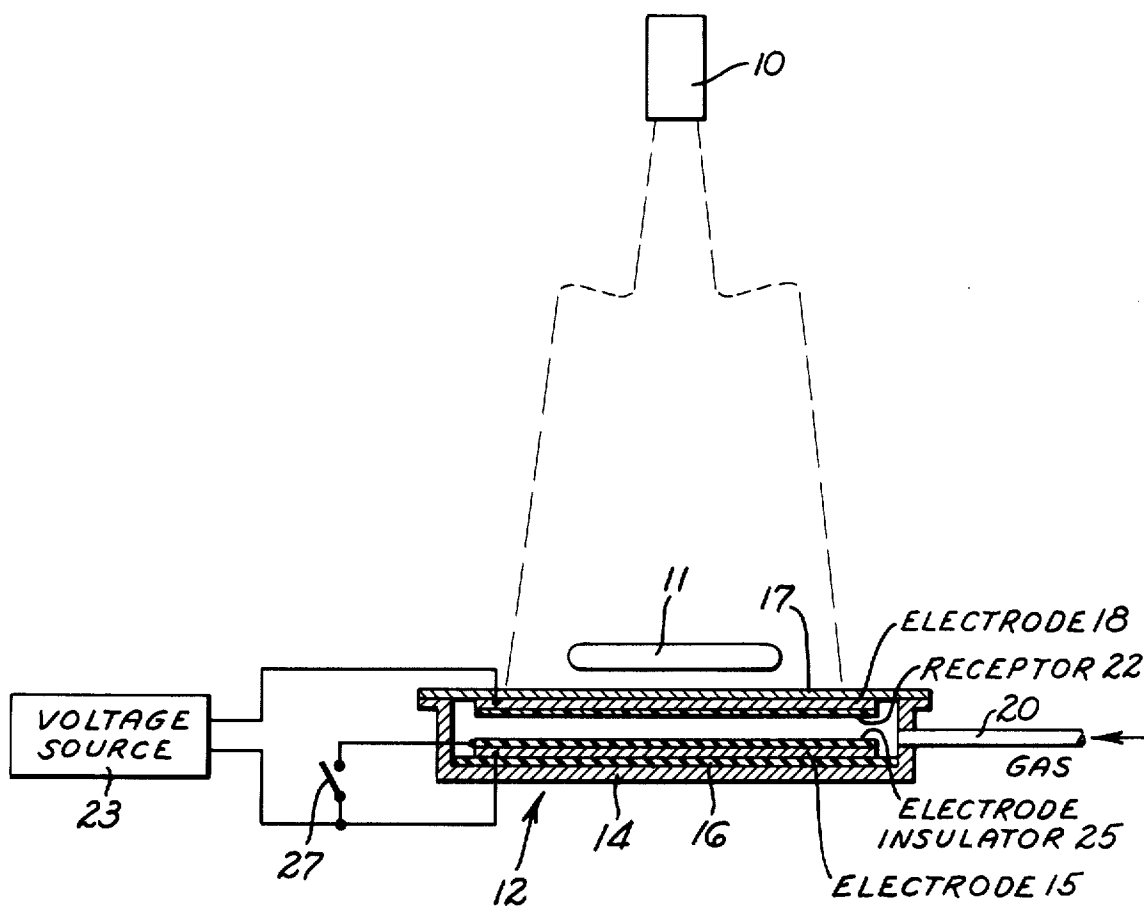
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#### [57] ABSTRACT

An imaging chamber for an electronradiography system, the chamber having spaced electrodes with a gap there-between for an imaging gas, and an electrostatic charge image receptor sheet at one of the electrodes, and an insulating layer such as antistatic polyethylene plastic film covering the other electrode for production of an electrostatic charge image at the gap surface of the insulating layer the reverse of the image on the receptor sheet, and for discharging the charged gap surface.

**6 Claims, 1 Drawing Figure**





# INSULATING ELECTRODE FOR BREAKDOWN INHIBITION IN ELECTRONRADIOGRAPHY IMAGING CHAMBER

This is a continuation of application Ser. No. 365,971, filed June 1, 1973 now abandoned.

This invention relates to the creation of X-ray images by electronradiography, such as the technique described in the copending application of Muntz et al, Ser. No. 261,927, filed June 12, 1972, entitled Radiographic Systems with Xerographic Printing and assigned to the same assignee as the present application. In electron radiography, an X-ray opaque gas is used in a gap between electrodes in an imaging chamber to produce a photoelectric current within that chamber as a function of X-rays entering the chamber. The current is collected on a dielectric receptor sheet placed on one of the electrodes, resulting in a latent electrostatic image on the sheet. This latent image is then made visible by xerographic techniques.

A high electric field is maintained in the gap between the electrodes during X-ray exposure and problems are encountered due to avalanche breakdown in the gas resulting from dust particles present in the gap. Concentrated electric fields occur at the site of a dust particle causing electron emission from the electrode surface, with the intensity of emission being a function of the electrode material. All of this results in a visual marking in the developed image.

One approach for reducing the breakdown spots in the finished picture is to reduce the voltage across the gas gap. However this of course lowers the sensitivity of the system and requires an increased X-ray radiation dose to the patient in order to achieve the desired picture.

Accordingly it is an object of the invention to provide a new and improved imaging chamber which substantially eliminates the breakdown spots caused by dust particles and the like in the gas gap.

The electronradiography system of the present invention does not rely upon an electrode as a photoemitter the primary photoelectrons being created by the X-rays absorbed in the interelectrode gas filled gap, with secondary electrons being created by collisions of the primary electrons with gas atoms. With the system of the present invention, electron emission from an electrode surface normally resulting from the presence of dust particles can be prevented without reducing the gap potential, by utilizing an insulating layer covering the normally exposed electrode. This insulating layer, typically a plastic sheet, is provided with means for discharging the charges which are produced on the gap surface of the sheet, with the discharge occurring within a few seconds after the X-ray exposure. Two specific configurations for accomplishing the discharge are described herein.

Other objects, features and results will more fully appear in the course of the following description. The single FIGURE of the drawing illustrates a typical imaging chamber incorporating the presently preferred embodiment of the invention, which is given by way of illustration or example.

X-rays are directed from a source 10 through the object 11 to be X-rayed, to an imaging chamber 12. The imaging chamber includes a housing 14 with an electrode 15 carried on an insulating sheet 16. A cover 17 for the housing carries another electrode 18. An imag-

ing gas may be introduced into the housing through an inlet 20.

A dielectric receptor sheet 22 on which the electrostatic image is produced by the X-ray exposure, is carried on one of the electrodes, here the electrode 18. A voltage source 23 is connected across the electrodes to provide the field in the gap between the electrodes, with the voltage source being turned on at the time the X-ray source is turned on.

The apparatus described in the preceding paragraph is conventional and may be constructed and operated in the manner described in the aforesaid copending application. In addition, an electrode insulator 25 is applied as a layer covering the electrode 15. During the X-ray exposure, an electrostatic charge image is formed on the gap surface of the insulator 25, which image is the reverse of the electrostatic charge image formed on the receptor sheet 22. The receptor sheet 22 is a good dielectric material which will retain the electrostatic charge image when the receptor sheet is removed from the imaging chamber for subsequent development and fixing, following conventional xerographic techniques.

The electrode insulator layer 25 is provided with means for discharging the electrostatic charge generated at the gap surface so that the charge is dissipated within a few seconds after the X-ray exposure. In one embodiment, the electrode insulator 25 is formed of an antistatic film, that is, a film or layer of antistatic agents, typically a plastic having the antistatic agents incorporated therein and preferably substantially uniformly distributed throughout the body of the film. Such an electrode insulator has a high resistance but does provide some conductivity, permitting the electrostatic charge at the gap surface to be discharged through the insulator 25 to the electrode 15 in a few seconds, typically in the order of one to five seconds. Electrode 15 is at circuit ground potential when the x-ray source is not on. It has been found that a preferred range for the resistivity of the electrode insulator is in the order of  $10^8$  to  $10^{12}$  ohms per square.

Antistatic agents are widely known and generally available, and a number of antistatic agents are identified in Modern Plastics Encyclopedia 1972-1973, pp. 446-449. A typical antistatic plastic sheet suitable for use in the invention is antistatic polyethylene, available from Richmond Corp.

In an alternative embodiment, the electrode insulator 25 is provided with antistatic agents at least at the gap surface of a layer or film of plastic. A switch 27 is connected in a circuit with one switch terminal connected to the electrode 15 and with the other switch terminal connected to the gap surface of the electrode insulator 25. The switch 27 is maintained open during the X-ray exposure. The switch is closed immediately after completion of the exposure and the electrostatic charge on the gap surface of the insulator 25 is discharged. The electrode insulator 25 may be maintained in position on the electrode by bonding with a conducting adhesive or, in the case of the antistatic agent, by coating the electrode with the liquid antistat, and letting it dry, as is common in the art of applying antistatic coatings.

The electrode insulator layer 25 serves to inhibit breakdown by two mechanisms. The secondary electron emission from the layer 25 is greatly reduced compared to that of the metal electrode 15. As electrostatic charge, generated in the gas, builds up on the receptor

22, charge of the opposite polarity is deposited on the insulator layer electrode. This causes the magnitude of the accelerating field across the gas gap to decrease, at the rate twice that without the insulator layer present. Hence, the amount of charge swept across the gap is reduced in an uncontrolled discharge, or breakdown, which reduces the effect of the discharge artifacts.

We claim:

1. In an imaging chamber for an electronradiography system, the chamber having spaced electrodes with a gap therebetween for an ionizable imaging gas which absorbs incoming x-ray photons during an x-ray exposure and produces electrons and positive ions, and an electrostatic charge image receptor sheet at one of the electrodes for receiving one of said types of charged particles and production of a first electrostatic charge image,

the improvement comprising an insulating layer covering the other electrode for collecting the other of said types of charged particles and building up and maintaining an electrostatic charge at the gap surface thereof during the x-ray exposure reducing the magnitude of the accelerating field across the gap, and including means for discharging said charged gap surface of said insulating layer after the x-ray exposure.

2. The improvement as defined in claim 1 wherein said insulating layer has antistatic agents at least at said gap surface thereof, and switching circuit means for electrically connecting said gap surface to said other electrode.

3. The improvement as defined in claim 1 wherein said insulating layer has antistatic agents distributed throughout said layer providing a high resistance path from said gap surface to said other electrode.

4. The improvement as defined in claim 1 wherein said insulating layer has a resistivity in the range of about  $10^9$  to  $10^{12}$  ohms per square.

5. The improvement as defined in claim 1 wherein said insulating layer is antistatic polyethylene plastic film with antistatic agents substantially uniformly distributed therethrough.

6. A method of reducing electronic field emission while making an electronradiograph in an imaging chamber having spaced electrodes defining a gap therebetween with an electrical insulating layer at each electrode, including the steps of:

exposing the chamber to x-ray radiation for a period of time generating electrons and positive ions in the gap;

applying an electrical potential across the gap and collecting and retaining the charged particles of opposite polarity on each of said insulating layers during the exposure thereby reducing the magnitude of the accelerating field across the gap;

after the exposure, discharging one of the insulating layers removing the electrostatic charge thereon; and

applying a toner to the other of the insulating layers and developing the electrostatic charge image into a visual image.

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