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[54] **GAS HANDLING SYSTEM FOR ELECTRONRADIOGRAPHY IMAGING CHAMBER**

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

[58] **Field of Search** 250/315, 288, 289, 428, 250/430, 431, 432, 435, 437, 438, 323

[56] **References Cited**

UNITED STATES PATENTS

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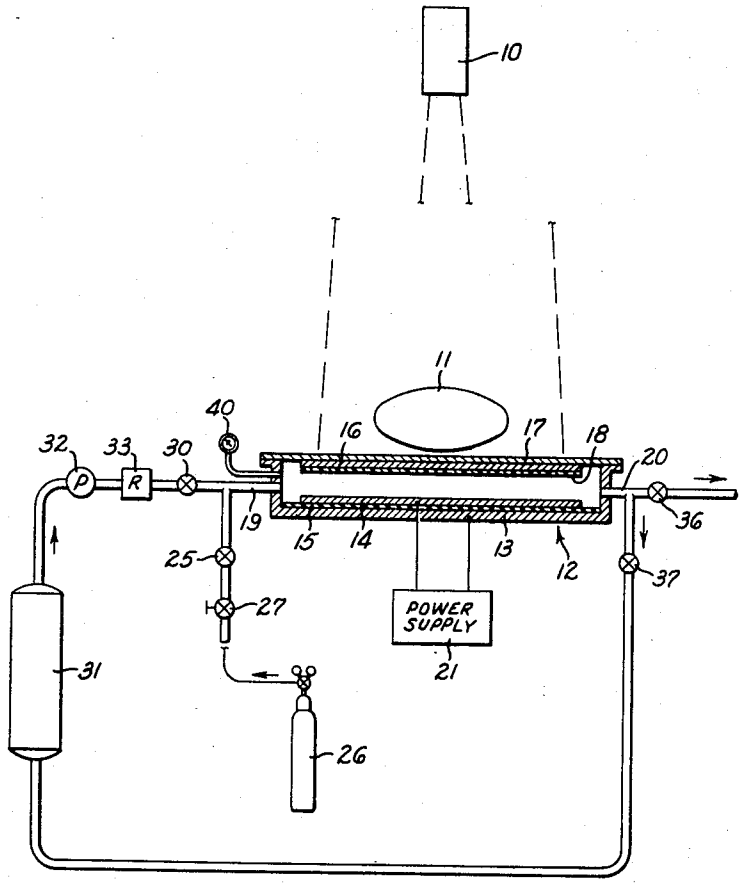
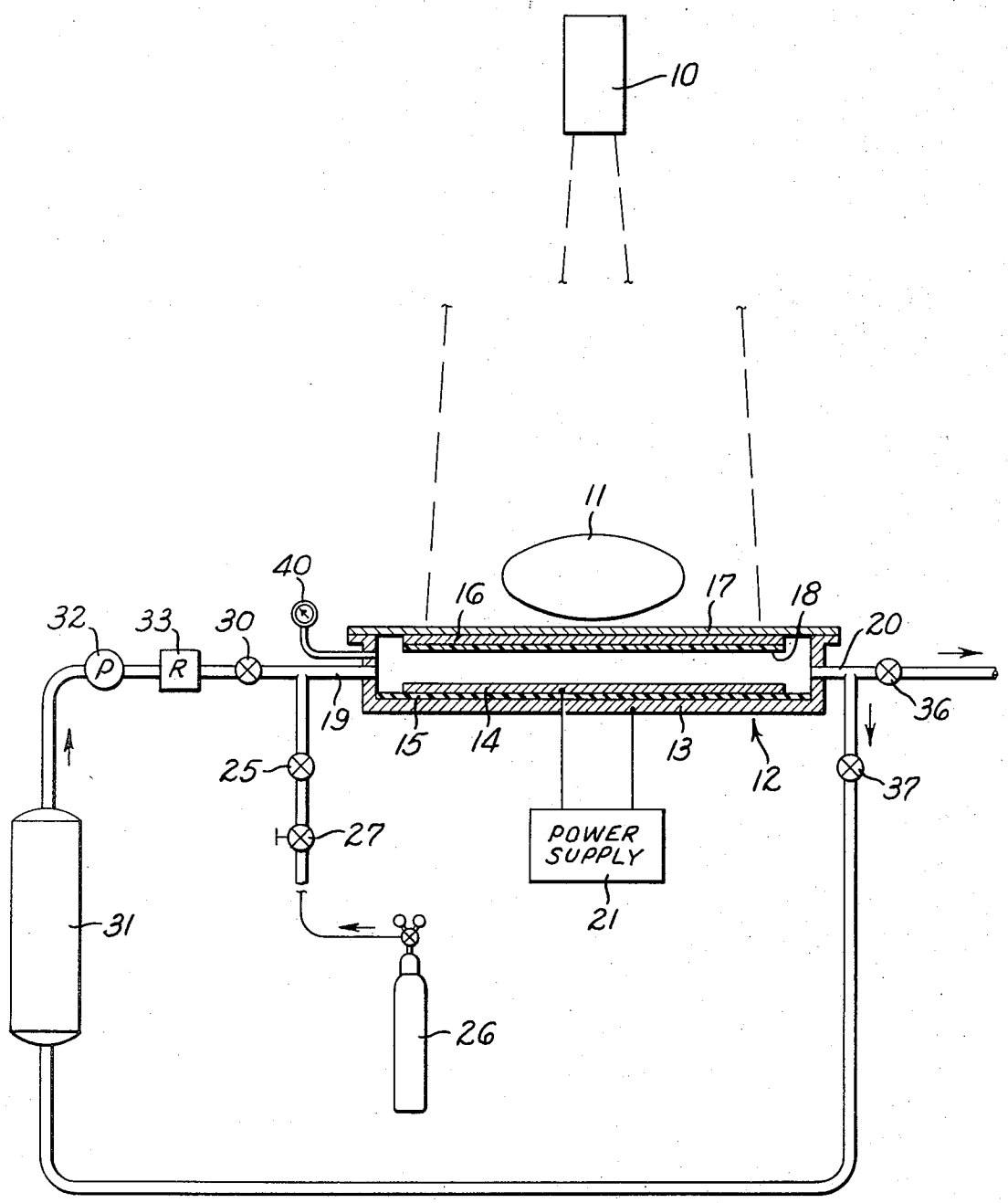
[57] **ABSTRACT**

Process and apparatus for providing imaging gas under pressure to the imaging chamber of an electronradiographic system. A pump for providing imaging gas under pressure to the imaging chamber, a source of carbon dioxide gas under pressure for flushing air from the chamber to exhaust and for flushing imaging gas from the chamber to a recovery reservoir, which reservoir includes a supply of lime for reacting with the carbon dioxide gas, leaving the imagaing gas for recycling to the imaging chamber.

10 Claims, 1 Drawing Figure

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POWER SUPPLY
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GAS HANDLING SYSTEM FOR ELECTRONRADIOGRAPHY IMAGING CHAMBER

This invention relates to the creation of X-ray images without the use of conventional X-ray film, sometimes referred to as ionography or electronradiography, such as that described in the copending application of Muntz et al., U.S. Pat. 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 such a system, an X-ray opaque imaging gas at high pressure is used between two 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 receptor. The latent image is then made visible by xerographic techniques.

A 14 by 17 inch electron radiography imaging chamber has a volume between the electrodes of nearly one liter. The X-ray sensitive imaging gas is pumped into this volume to a pressure of 20 atmospheres or more. The gas is much too costly to discard after each exposure; yet between exposures it is necessary to open the chamber to transport the exposed receptor to a development station and insert a new receptor. The obvious solution is to pump the gas out of the imaging chamber into a reservoir after the exposure, and then, after opening and closing the chamber, to pump the air out of the chamber before re-admitting the sensitive gas.

The most serious difficulty with this solution is the electrical breakdown which occurs when the chamber is pumped out after the exposure. The voltage required for breakdown decreases as the pressure is lowered, and at pressures below one atmosphere the electrical potential from the charge deposited during the imaging process can be large enough to permit breakdown between the receptor surface and the electrode opposite the receptor. This electrical breakdown of the gas can completely obliterate the image.

Another difficulty with this solution is the tendency for the insulating receptor to be lifted off its support when the pressure in front of the receptor is reduced below the pressure of the gas behind the receptor. It is known from experience with this problem that if the front of the receptor touches the opposing electrode, there will be a number of small spots on the pictures, even if the touching occurs during the pump-out before the exposure. In addition the time required for the pump-out can be undesirably long.

Another solution to the problem of moving the receptor in and out without losing the imaging chamber gas is to move the receptor through a close-fitting slot. If the gas pressure is reduced to precisely one atmosphere before the receptor transfer operation, one might hope that the only loss of gas would be the predictable loss associated with the viscous interaction between the moving receptor surface and the gas in the narrow clearance space. However, the effect of gravity on the heavy gas increases the loss appreciably, and long experience with the system has taught that dust particles caught at the slot exit leave streaks on the exposed image. In addition, the effects of electrical breakdown between the charged receptor and the slot edge have been observed. This breakdown occurs even

though the slot edge is made of an insulating material.

Liquid seals and roller seals at the imaging chamber have also been considered. However all of these proposals have disadvantages and it is an object of the present invention to provide a new and improved process and apparatus for handling the high pressure imaging gas in an electronradiography imaging chamber. The invention contemplates the use of flushing gas to flush air from the imaging chamber after loading and use of the flushing gas to flush the imaging gas from the chamber to a recovery system after exposure. The imaging gas is used to flush the flushing gas from the chamber prior to the exposure, with the gases going to the recovery system. In the recovery system, the flushing gas is separated from the imaging gas, as by a reaction forming a precipitate leaving the imaging gas for recycling to the imaging chamber. Other objects, advantages, features and results will more fully appear in the course of the following description. The single FIGURE of the drawing illustrates an electronradiographic system incorporating the presently preferred embodiment of the gas handling apparatus of the invention.

X-rays are directed from a source **10** past the object **11** being x-rayed to the imaging chamber **12,** which may be conventional in design such as set out in the aforementioned copending application. A typical imaging chamber includes a housing **13** carrying an electrode **14** on an insulator **15,** with another electrode **16** carried on the housing cover **17.** The dielectric sheet receptor **18** may be carried on the electrode **16,** with gas being introduced into the chamber at an inlet **19** filling the gap between the electrodes. Gas may be removed from the chamber through an outlet **20.** A field is produced across the gap by an electrical power supply **21** connected across the electrodes.

A source of carbon dioxide gas under pressure is connected to the chamber inlet **19** through a valve **25.** Typically the carbon dioxide source comprises a bottle **26** charged with carbon dioxide and connected to the valve **25** through a needle valve **27** which provides a control for rate of flow.

A source of the imaging gas, typically argon or xenon, is connected to the chamber inlet **19** through a valve **30.** The imaging gas may be stored in a reservoir **31,** with a pump **32** serving to pump imaging gas from the reservoir **31** to a high pressure reservoir **33,** with the valve **30** controlling the outlet of the reservoir **33.**

The chamber outlet **20** is connected to exhaust by a valve **36** and is connected to the reservoir **31** by another valve **37.**

The reservoir **31,** which may be referred to as the low pressure reservoir, contains material for separating the carbon dioxide from the imaging gas, such as pellets of lime. The lime ($Ca(OH)_2$) reacts with the carbon dioxide (CO_2) to form calcium carbonate ($CaCO_3$) plus water. The water is eliminated by a hydration reaction with the calcium carbonate, leaving the inert imaging gas as the only gas or vapor in the reservoir **31.** In a typical system with the imaging gas stored at atmospheric pressure in the reservoir **31,** the reservoir will hold enough lime to absorb the carbon dioxide flush gas from more than 1,000 exposures at the imaging chamber.

In operation, a new receptor sheet **18** is placed in the imaging chamber and the chamber is closed. The valves

25 and 36 are opened, with the valves 30 and 37 closed. Carbon dioxide flows through the imaging chamber at a rate controlled by the needle valve 27 and flushes air from the chamber to exhaust. Valves 25 and 36 are then closed.

Next, valves 30 and 37 are opened, with imaging gas from the high pressure reservoir 33 flushing the carbon dioxide from the imaging chamber, with both gases being recovered in the reservoir 31. Valve 37 is then closed to increase the gas pressure in the imaging chamber. When the desired chamber pressure chamber is obtained, typically 20 atmospheres, the valve 30 is closed and the chamber is ready for an exposure. The chamber pressure may be indicated on a gauge 40.

After the x-ray exposure, valve 37 is opened to bleed the high pressure imaging gas to the reservoir 31. When the pressure in the imaging chamber is reduced to about atmospheric, valve 25 is opened to flush the remaining imaging gas into the reservoir 31.

Valves 25 and 37 are now closed and the cassette may be opened to remove the exposed receptor sheet and insert a new receptor sheet.

In the embodiment illustrated, the pump 32 is operated as needed to maintain the desired gas pressure in the high pressure reservoir 33. The pump operation may be manual or automatic and conventional pump controls can be utilized. In an alternative embodiment, the high pressure reservoir 33 may be omitted, with the pump 32 being turned on when the valve 30 is opened to provide the flow of imaging gas at the chamber inlet 19, with the pump being turned off manually or automatically when the desired chamber pressure is obtained.

In the preferred embodiments of the system and process described above, carbon dioxide is used as the flushing gas and calcium hydroxide is used as the reactant, with the flushing gas and reactant reacting in the reservoir 31 to form a precipitate. Other gases which react chemically and form an inactive precipitate may be used as the flushing gas, including chlorine, fluorine, oxygen and air. However carbon dioxide is preferred because it is non-toxic and non-flammable and inexpensive. Also other reactants may be used with the carbon dioxide flushing gas, such as barium hydroxide, lithium hydroxide, magnesium hydroxide, and combinations thereof. A combination of barium hydroxide and calcium hydroxide has been used because the barium hydroxide hydrolizes more readily and provides better control of the water produced in the reaction.

We claim:

1. In a gas handling system for an electronradiographic imaging chamber having spaced electrodes with a gap therebetween for an imaging gas and having a gas inlet and a gas outlet for gas flow into and out of said gap, the combination of:
- a source of flushing gas under pressure;
- a first reservoir having an imaging gas and a flushing gas reactant therein, said reactant being capable of reacting with said flushing gas to form a precipitate;
- a pump having an input and an output;
- first valve means for connecting said gas outlet to exhaust;
- second valve means for connecting said source of flushing gas to said gas inlet;
- third valve means for connecting said gas outlet to said first reservoir;
- fourth valve means for connecting said pump output to said gas inlet; and
- means for connecting said first reservoir to said pump input;
- whereby said chamber is flushed to exhaust by flushing gas by opening said first and second valve means with said third and fourth valve means closed, and said chamber is charged with imaging gas by opening said third and fourth valve means with said first and second valve means closed, and imaging gas is flushed by flushing gas from said chamber to said first reservoir by opening said second and third valve means with said first and fourth valve means closed, and flushing gas is separated from imaging gas in said first reservoir by reaction with the reactant therein.

2. A system as defined in claim 1 including a second reservoir connected between said pump output and said fourth valve means with said pump providing imaging gas at increased pressure from said first reservoir to said second reservoir.

3. A system as defined in claim 1 wherein said flushing gas is carbon dioxide.

4. A system as defined in claim 3 wherein said flushing gas reactant comprises one or more of barium hydroxide, calcium hydroxide, lithium hydroxide and magnesium hydroxide.

5. A system as defined in claim 3 wherein said flushing gas reactant is calcium hydroxide.

6. A process of providing imaging gas under pressure to an imaging chamber of an electronradiographic system, including the steps of:
- loading a receptor sheet into the imaging chamber;
- flushing air from the imaging chamber by means of flushing gas under pressure;
- flushing the flushing gas from the imaging chamber by means of imaging gas under pressure;
- retaining imaging gas in the chamber at increased pressure;
- exposing said receptor to imaging X-ray radiation;
- flushing imaging gas from the imaging chamber by means of flushing gas under pressure; and
- unloading the receptor sheet from the imaging chamber.

7. The process as defined in claim 6 including:
- collecting the flushing and imaging gases flushed from the imaging chamber; and
- separating the flushing gas from the imaging gas by reacting the flushing gas with a reactant to form a precipitate, leaving the imaging gas for recycling to the imaging chamber.

8. A process as defined in claim 7 using carbon dioxide as the flushing gas.

9. A process as defined in claim 8 using one or more of barium hydroxide, calcium hydroxide, lithium hydroxide and magnesium hydroxide as the reactant.

10. A process as defined in claim 8 using calcium hydroxide as the reactant.

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