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RADIOGRAPHY BY GAS IONIZATION

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FIG.1.

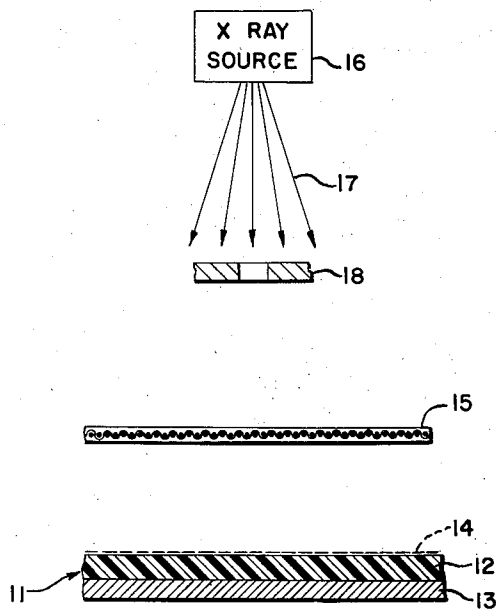
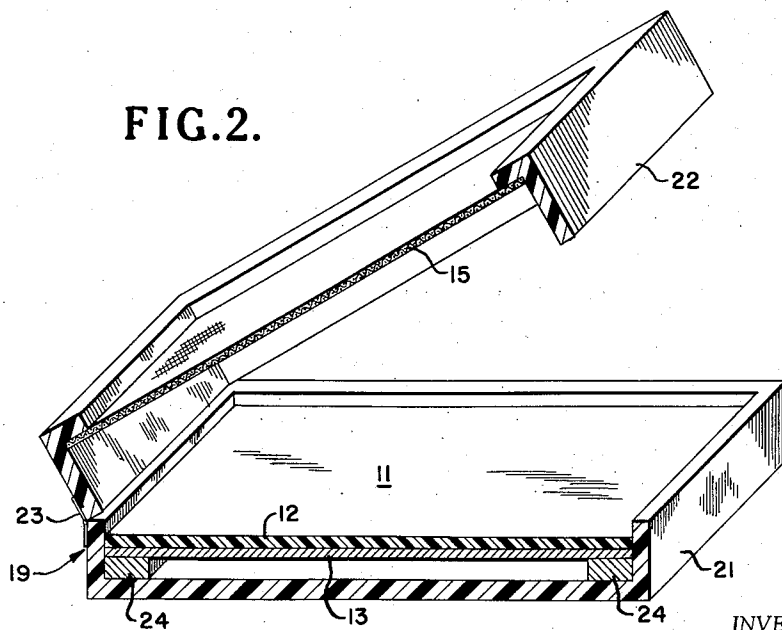


FIG.2.



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The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates to a new and improved process of radiographic imaging, hereinafter referred to as ionography, which produces an invisible or latent electrostatic image on an insulating surface, and more particularly to the manner of operation of the process as well as the apparatus involved in such operations.

An electrophotographic process has been invented which involves the formulation of a latent electrostatic image on a plate of photoconductive material having an electroconductive backing and the development of the image by the use of fine particles attracted to the surface of the plate, the process consisting essentially of the three steps of (1) sensitizing the plate by uniformly charging the face of the same in darkness; (2) exposing the plate to light rays thereby differentially discharging the plate into the backing and producing a latent electrostatic image on the plate; and (3) developing the plate by passing particles of fine powder or dust past the plate, the particles being attracted to the latent electrostatic image thereby rendering the image visible. Later, this process was improved by the use of selenium as the photoconductive material and, since selenium responds to X-rays, as well as light, the process became applicable to radiography and was referred to as xeroradiography. However, after exposure of selenium plates to high energy X-rays, the plates are slow to recover their ability to hold charge and, if used before they are fully recovered, a ghost image of the previous exposure or a flat low contrast image will be obtained. Moreover, the selenium plates are sensitive to light and the process must therefore be carried on in darkness or a very dimly lit chamber, or with the use of light-tight handling devices. Furthermore, selenium plates with large serviceable areas are difficult and costly to produce.

Essentially, the present invention is a new and improved system of X-ray imaging based upon the ionizing ability of X-rays and the utilization of a high electric field established by a layer of conductive material, such as a fine wire mesh, placed at a fixed and uniform distance above a charged plate, the plate being made up of a layer of insulating material with a backing of conductive material insensitive to light. The intensity of X-ray radiation, which is a function of the object being X-rayed, differentially ionizes the air or gas between the layer of conductive material and the plate and this differentially discharges the charged plate, whereby a latent or invisible electrostatic image is formed on the plate. To make the latent electrostatic image visible to the eye, the exposed plate is immersed in a developing medium, such as a liquid or air, which carries oppositely-charged fine particles in suspension, the particles being bound to the plate in proportion to the amount of charge remaining thereon. The present invention has the advantages that the plates are insensitive to light and do not fatigue, they are inexpen-

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sive and easy to clean and are easier to view because the liquid development produces a finer image and a high contrast may be obtained by using a white plate material and black developing particles.

One object of the present invention is the provision of a new and improved process of X-ray imaging called ionography which dispenses with the use of photosensitive materials thereby permitting operation in daylight and overcoming the indicated disadvantages of the prior art processes and means.

Another object is to provide means for carrying out the process of the present invention.

A further object of the invention is to provide a radiographic image forming apparatus of a new and improved type which utilizes a high electric field and differential ionization of a gas layer adjacent a charged insulating surface by exposure to X-rays or other high energy penetrating radiation, to produce a latent electrostatic image on the insulating surface corresponding to the differential ionization.

A still further object is the provision of an ionographic image forming plate which has a suitable insulating surface, the plate being reusable and relatively inexpensive.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings in which like reference numerals designate like parts throughout the figures thereof and wherein:

Fig. 1 is a schematic representation of the ionographic process of this invention; and

Fig. 2 is a perspective view of the apparatus in which a wire mesh is mounted and in which a plate with a charged insulating surface is supported, parts being shown in section.

A feature of the present invention resides in the use of a fine wire mesh which is placed as close as possible to the charged plate without discharging the same to establish a very high electric field on the charged plate, the wire mesh also acting as an electrostatic shield to prevent any distortion of the electric field when the object being X-rayed is metallic. The X-rays cause differential ionization of the air or other gas between the wire mesh and the charged plate in accordance with the pattern of the object. In turn, this differential ionization causes the charges to leak off the charged plate in proportion to the amount of radiation received, thereby forming a latent electrostatic image which is made visible by dipping the plate in an insulating liquid containing oppositely-charged particles.

Referring now to the drawings, wherein like reference characters numerals designate like or corresponding parts throughout the several views, there is shown in Fig. 1 a plate, generally designated by numeral 11, upon which the latent electrostatic image is formed, the plate comprising a layer of photoinsensitive insulating material 12 and a backing 13 of conductive material insensitive to light, the other surface or face of the layer of insulating material having a charge thereon, the charge on the charged surface or face being depicted by dotted line 14. The plate may be fabricated from suitable sheet insulating material having sufficient rigidity, such as Plexiglas, Lucite, Vinylite, or the like. While Vinylite is preferred because, when used with a dark developing powder, the best image having the maximum contrast was produced. The backing of the plate may be of any suitable photoinsensitive electroconductive material, such as a metallic coating; silver lacquer having been successfully used.

Supported in spaced relation, and at a uniform distance, from the plate 11 is a wire mesh 15 which functions to establish a very high electric field on the plate and also acts as an electrostatic shield to prevent dis-

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tortion of the electric field by a metallic object that is being X-rayed. Interposed between the wire mesh and a source 16 of high energy penetrating radiation, such, for example, as X-rays 17, is an object 18 whose ionographic image it is desired to obtain.

Referring now to Fig. 2, the apparatus supporting the plate and wire mesh will be described. Such apparatus comprises a box or cassette 19 made up of two portions, a base portion 21 and a lid portion 22, the portions of the box being made of suitable material, such as the insulating materials of the plastic type or the like, and may be connected together by a hinge 23, or in any other way deemed desirable. The wire mesh 15 is mounted in the lid portion of the box so as to be uniformly spaced from the bottom portion of the box when the lid portion is superimposed thereon. The plate 11 is supported in the base portion by suitable supporting members 24 so as to be disposed parallel to the wire mesh 15 when the lid portion is superimposed on the base portion.

In the use of the ionographic process or system of ionography, the following steps are involved:

a. Sensitizing the ionographic plate by depositing thereon a surface charge consisting of an excess of either electrons or protons.

b. Differentially discharging the ionographic plate, while in close proximity to a wire mesh, through ionization of the air between the screen and the plate by means of X-rays.

c. Developing the exposed ionographic plate by immersing the same in an insulating liquid containing fine particles of contrasting color.

The ionographic plate may be sensitized by passing the same through a charging unit; for example, conveying the plate at a uniform rate past the corona discharge of a wire or wires at a high potential, the plate thereby acquiring a positive charge. The charged plate is then placed in the base portion of the box or cassette, with the charged surface facing the wire mesh, and the lid portion of the box is brought into position so as to superimpose the wire mesh in proper relation to the charged surface of the plate. The plate is then exposed to X-rays, or other high energy penetrating radiation, with the object whose image is being obtained interposed between the source of the radiation and the box. Upon completion of the exposure, the ionographic plate is removed and submerged in a developer which consists of fine particles suspended in an insulating liquid, the particles being oppositely charged to the charge on the plate and of a contrasting color. Within a short time the image will become visible and may be viewed directly by reflected light. Since no photosensitive materials are used, the process may be carried on in daylight.

In the selection of a developer for the exposed plate there are several important characteristics to consider, which characteristics are electrical and chemical in nature. The liquid must be a good insulator yet not dissolve or react with the plate or the developing powder, the latter being in the form of fine particles of a contrasting color. Satisfactory results have been obtained with the use of transformer oil, varsol and carbon tetrachloride, although carbon tetrachloride is objectionable due to its poisonous nature and the varsol does not hold the particles in suspension as well as the transformer oil. The transformer oil, giving the best results, is preferred. Although many developing powders may be used, the most favorable results were obtained with carbon black, manganese dioxide and manganese.

While a liquid developer has been described in connection with the development of the latent image, it is to be understood the dry developer, such as used with xeroradiography, may be employed instead and has been successfully used with the ionographic process of the present invention.

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Furthermore, while the means for establishing a high electric field and electrostatically shielding the same has been specified as a wire mesh, other forms of electroconductive devices could be employed; for example, a roughened surface (sandblast) or a ruled knife-edge surface.

The spacing between the electroconductive device and the plate is not extremely critical but substantial parallelism therebetween must be maintained. Since this system forms a parallel-plate ionization chamber, the response is a direct function of the volume, and as the mesh is spaced further from the plate, the volume of air is increased; therefore, the speed of the system increases but the image quality deteriorates. The present spacing used with an 8,000 volt charging potential is $\frac{1}{8}$ of an inch; closer spacing causing the charge to arc over from the plate to the wire mesh, resulting in many artifacts in the image; wider spacing resulting in a blurred image.

The manner of operation of the ionographic system of the present invention should be apparent from the foregoing description and will not be further described.

Obviously, many modifications and variations of the present invention are possible in light of the above teaching and it is therefore to be understood that the invention may be practiced otherwise than as specifically described herein.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A method of producing an image on a photoinsensitive surface comprising, electrically charging an insulating plate, placing a wire mesh parallel to and in close proximity to the charged plate thereby setting up an electrical field in the air gap between the plate and the wire mesh wherein the force paths in the field are substantially parallel to each other and normal to the plate and wire mesh, ionizing certain paths through the field by exposing to X-rays to discharge said insulating plate leaving the surface of the plate charged in small areas of different concentrations of ions.

2. A method of producing an image on a photoinsensitive surface according to claim 1 wherein the wire mesh is co-extensive in area with the charged plate.

3. A method of producing an image on a photoinsensitive surface according to claim 1 and including developing the latent image on said plate by depositing finely divided particles which adhere to the plate in accordance with the intensity of the ion concentration.

4. A method of producing an image on a photoinsensitive surface according to claim 3 wherein the finely divided particles are brought into contact with the plate by means of a liquid vehicle.

5. A method of producing an image on a photoinsensitive surface according to claim 3 wherein the finely divided particles are sprayed on the charged plate in the form of a dry dust.

6. A method of producing an image on a photoinsensitive surface in accordance with claim 3 wherein the particles are composed of finely divided carbon black.

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