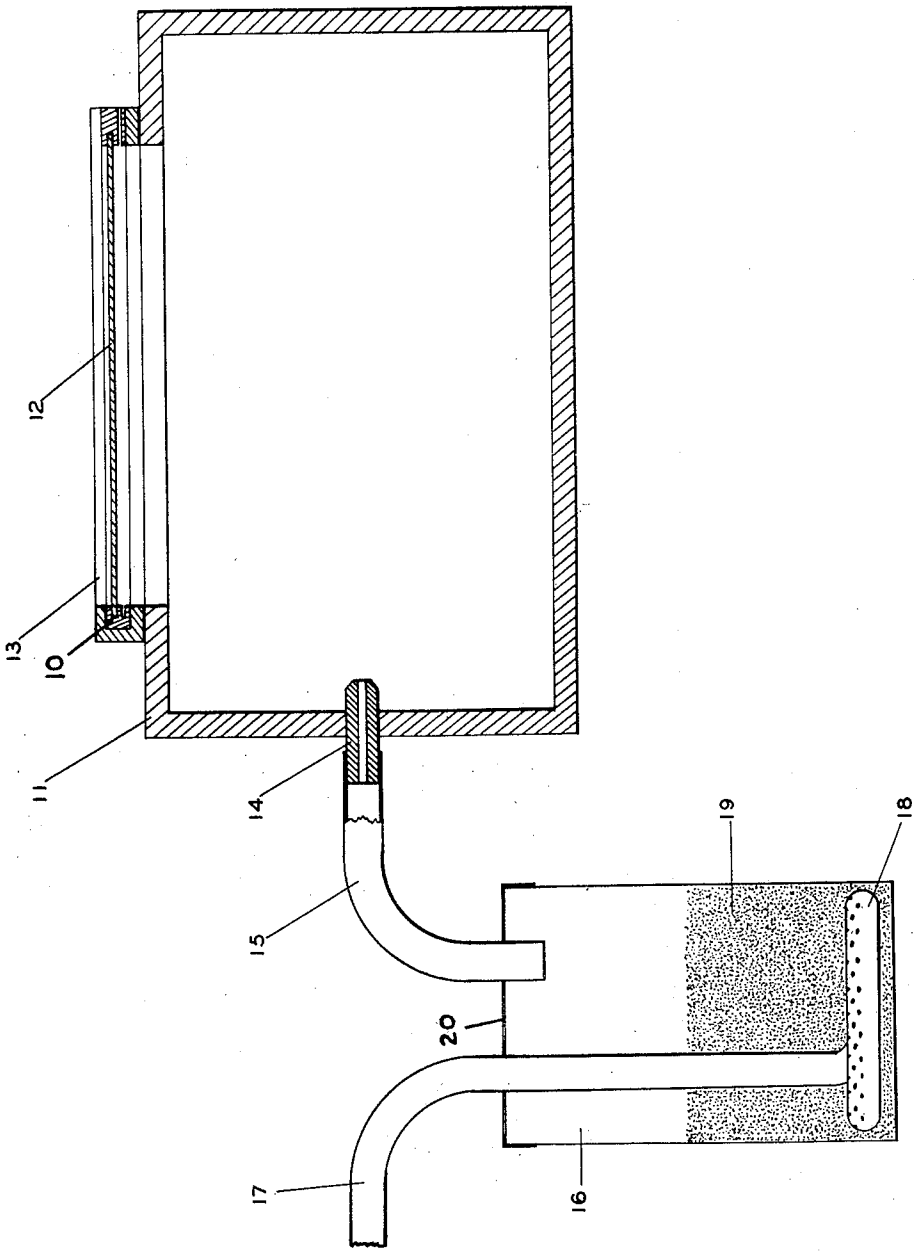
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XEROGRAPHIC DEVELOPMENT

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XEROGRAPHIC DEVELOPMENT

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This invention relates in general to xerography and in particular to xerography as applied to X-ray analyses and the like.

In electrophotography or xerography it is usual to prepare xerographic prints corresponding to visual phenomena to be recorded, including, in many instances, industrial data and the like as well as pictorial or photographic pictures. For example, it is frequently desirable to record by xerography such visual data as radiographic information corresponding to an X-ray examination of medical detail or of industrial products. In these and very many other instances, it is desirable to produce two types of records of information, sometimes producing one and sometimes the other. For example, in many cases such as X-ray examination of industrial products, it is necessary only to obtain a usable reproduction which is examined once and either passed or rejected and which, where rejected, may then require a permanent record. Similarly in the case of medical X-ray work it frequently is necessary only that the analyst be able to view the record and make a determination as to the next step to be taken. On other occasions, however, it may be necessary to prepare a permanent record, and frequently it is not known in advance whether the record required will be permanent or merely temporary.

In the case where a temporary record is all that is needed, it is highly desirable to prepare directly on the photosensitive xerographic plate a record of the visual information imposed on the plate such as, for example, the record of an X-ray exposure or the like. It is most desirable in the pursuit of simplicity to examine the image directly on the photosensitive plate and then erase the image and to use the plate for subsequent exposure or test. In other cases, however, it is critically important to prepare a permanent record, in which case the image generally will be transferred to a second surface such as, for example, a paper surface or the like. Unfortunately, these two purposes are not mutually consistent. The present xerographic photosensitive member is generally a plate or like member having a layer of vitreous selenium on its surface and this vitreous selenium is a very dark red, almost black. In contrast to this, the normal transfer member such as a sheet of paper or the like is generally white in color. Furthermore, for X-ray work and particularly for medical X-ray work the analysis of the recorded data are experienced in analyzing data appearing in the form of a white or light colored image on a dark background, and for this reason it is unsuitable to resort to conventional photographic techniques which produce a dark image on a white background. Moreover, in either case a problem confronting the art is to produce an intensified image in which detail is emphasized. For these and other reasons, it is desirable to provide a new and improved apparatus, method and mechanism for the recording of data by xerography, in a physical form which can be used directly on the plate for temporary analysis or transferred to a transfer member for permanent record purposes.

It is, therefore, an object of the invention to provide an improvement in developed image bodies, with particular reference to image bodies for radiographic analysis and for experimental and industrial test and analysis.

It is another object of the invention to provide a new method, means and apparatus for developing xerographic images.

It is a further object of the invention to provide a new method for forming an improved xerographic developed image characterized by enhanced clarity and suitability for analysis.

Other objects of the invention will in part be obvious and will in part become apparent from the following specification and drawings in which:

The figure is a diagrammatic view of development apparatus for the present invention.

Now in accordance with the present invention, there is provided a new means, mechanism and apparatus for the preparation and production of a xerographic image which is particularly suitable for immediate examination on a photosensitive xerographic member and likewise particularly suitable for transfer to form an easily evaluated permanent record. Whereas in the past it had been conventional to produce a xerographic image body of a black or highly colored powder for transfer to a paper sheet or the like to form a permanent record or, alternatively, to produce an image in a light powder for examination on the dark xerographic plate, it is now, according to the present invention, possible to form a developed xerographic image which is readily visible under appropriate conditions against either a light or dark background.

According to one feature and embodiment of the present invention, a xerographic image body is formed by the deposition on an electrostatic latent image of a charged fluorescent powder material which is brilliantly fluorescent under the action of ultraviolet radiation.

According to another form and embodiment of the invention, a xerographic electrostatic latent image is formed by charging and exposure of a xerographic plate to an image of activating radiation and the thus formed xerographic latent image is developed and made visible by deposition thereon of a charged fluorescent powder material from an air suspension of such material.

It is to be understood that development according to the present invention may be carried out by various means and methods known to the art, including the methods of Wise, U. S. 2,618,552, and by methods disclosed in Carlson, U. S. 2,297,691, and other known methods. One satisfactory development system is shown for purposes of illustration, but not limitation, in the figure.

The figure shows diagrammatically one development system suitable according to the present invention, although it is to be understood that the invention is not limited to this or any other specific development apparatus. A development chamber **11** has a receiving opening in its top wall with a plate supporting frame **10** to receive an image surface such as, for example, a xerographic plate **12** in a plate holding frame **13**, the image surface thus being exposed face down to the development chamber. Projecting into a side wall of chamber **11** is a nozzle **14** which is connected by tube **15** to a powder supply reservoir **16**. An air supply conduit **17** is operatively connected to a supply of air or other gas under pressure and leads to a jet manifold **18** which is disposed in the reservoir and optionally positioned below the level of a development powder supply **19** in the reservoir. A removable top **20** permits reloading of the reservoir.

In operation of this system, the plate is placed in posi-

tion on the chamber and any light shield or the like is removed so as to expose the image surface to the developer. Air under pressure is then supplied through the manifold to produce a cloud of suspended particles which are then carried through nozzle 14 to the development chamber where they are deposited on the image surface by electrostatic attraction.

As a specific illustration of the present invention, which is to be taken in illustration only and not in limitation thereof, the invention will herein be described in terms of medical radiography for the formation of a xerographic image corresponding to an X-ray exposure. A xerographic plate comprising a vitreous selenium layer overlying a conductive backing member was charged to a positive polarity of about 500 volts by the action of a corona discharge electrode consisting of three fine wires at a potential of about 7,000 volts and partially surrounded by a grounded electrode. The thus charged and sensitized plate was then employed in an X-ray exposure according to the following technique. The charged xerographic plate, preferably in a light tight plate holder was placed in an exposure position with the conductive backing member toward the X-ray source, and a member to be X-rayed was placed between the plate and the source in contact with the conductive backing member of the plate. In the specific instance described herein the member to be X-rayed was a human hand. This member was then exposed to an X-ray source of 100 kilovolts at an intensity level of five milliamperes for a period of three seconds.

The charged and exposed xerographic plate was then placed in the development device shown in the figure, and the development device was operated to project into the development chamber a cloud of negatively charged fluorescent powder. This cloud of powder was charged by blowing it through the powder spray nozzle into the development chamber and powder was caused to deposit on the xerographic plate by virtue of the attractive force between the positively charged latent image on the plate and the negatively charged powder. Development of the image was complete in about 20 seconds to form a clearly defined powder image on the surface of the plate. Depending on conditions and desired results, shorter or longer development time may be employed.

The developed plate was placed in a shaded room with relatively low light level and light from an ultraviolet fluorescent light member was directed on the surface of the plate. The specific light source used was a special fluorescent lamp coated with a phosphor emitting predominantly in the range of 3,500 to 3,600 angstroms, in conjunction with a filter to remove substantially all visible light. It is understood of course that other ultraviolet sources may be substituted with substantially equal effect. As a result of flooding with this light source the fluorescent powder image became brightly luminescent and was clearly visible against the relatively black xerographic plate surface.

A permanent record was formed from the developed image by placing a sheet of paper against the image and while in contact depositing on the reverse side of the sheet of paper a positive charge from the same corona charging electrode used originally for charging the plate. Alternatively, pressure transfer was accomplished by pressing against the plate a sheet coated with a material to which the powder adhered. The sheet of paper was stripped from the face of the plate, carrying with it a preponderance of the image body. When the paper bearing this image body was placed under the same ultraviolet fluorescent light source, it likewise showed a clearly visible powder image against the relatively dark paper surface. Detail of the image was somewhat clearer and the fluorescent powder stood out more sharply against the paper surface under ultraviolet than it had against the comparatively shiny black selenium surface. When examined in ordinary daylight, the powder image was just barely discernible against the paper background, and substantially no detail could be seen.

The procedure described herein was compared against the same charging and exposure steps, employing as developing powder a white calcium carbonate powder composition and, in a second comparison, a carbon black composition. Development by the same methods of an image with white calcium carbonate resulted in a developed image body clearly visible against the black selenium surface in ordinary light and substantially less clearly visible under ultraviolet light than was the fluorescent image. Under visible light, each of the fluorescent and the calcium carbonate images showed about equal detail in the xerographic print in comparison with a substantially higher degree of contrast for the fluorescent powder under ultraviolet light. In the case of development with the carbon black, transfer to a white background such as a sheet of paper was necessary in order to achieve any significant detail in the image which could be detected under either ultraviolet or visible light. In this case, presence of detail in the carbon black image was about equal with presence of detail in the calcium carbonate image against the dark selenium surface. Detail of the fluorescent powder on the paper background as viewed under ultraviolet light was far greater than detail of either the calcium carbonate or the carbon black image according to the optimum conditions for either one.

In a comparative example, a fluorescent powder image was developed on a selenium plate and transferred to the adhesive side of a permanently tacky adhesive coated transparent tape such as, for example, a photographic film base. This image was viewed by transmitted light through the film, employing a yellow filter between the image and the eye of the viewer to filter out the ultraviolet source. The developed image stood out very sharply and brightly glowing against the substantially black or colorless nonimage areas. The detail which could be seen by transmitted light in this manner, exceeded the detail obtainable by examination either against a selenium surface or against a paper surface.

It is to be understood that there is a relatively wide selection possible of developer materials according to the present invention, although certain developer materials are preferred for several and various reasons. Thus, for example, one of the very important characteristics of the developer material is its ability to show fluorescence when illuminated by ultraviolet or light radiation. It is obvious that the degree to which the developer material achieves this one of the principal advantages of the invention is exactly the degree to whihc it fluoresces under readily available radiation sources. Specifically, a material which fluoresces brightly under radiation in the near ultraviolet range is a highly desirable composition. It is to be understood that certain materials possess a faint degree of fluorescence and that these materials are operable in the invention, but that the preferred species includes those materials which fluoresce brightly. Similarly, it is to be understood that a great many materials exhibit fluorescence when illuminated by radiation of a very short wave length, but that the preferred materials exhibit fluorescence under illumination by radiation which is in the near ultraviolet range or just outside the visible range. Likewise, it is known that some materials glow or shine for a very long time after initial radiation whereas others exhibit fluorescence of only a short duration. In general it will be realized that fluorescence during or only very shortly after the initial exposure to activating radiation will be preferred for most purposes although special circumstances can be found calling for the use of long continued fluorescence. Therefore, it is noted in summary that a preferred material exhibits strong fluorescence under illumination in the near ultraviolet range and exhibits this fluorescence substantially exclusively during the time it is exposed to activating radiation.

A second characteristic of the developer material which

may be regarded as extremely important, although it does not go to operability of the invention, is the absence of toxicity or industrial hazard. Thus, for general use, it is essential that the developer composition must not be toxic in the quantities and concentrations normally encountered in the course of the operation of the invention. Likewise, dust hazard such as the danger of explosion as well as health hazards such as silicosis and the like must be taken into account. In this connection it is observed that various silicates which are in many cases otherwise desirable materials should be avoided because of health hazard as also should many cadmium compounds which likewise are otherwise well adapted to the invention.

A third characteristic of extreme importance in the present invention is the triboelectrical relationship of the developer material. It is now understood and believed that the developer material receives an electric charge when its turbulence is expelled from the spray nozzle and this electric charge may vary in polarity or strength depending on the relationship between the developer material and the material out of which the nozzle is made. Theoretically, of course, it is possible to select a specific developer material having the desired properties and then select a specific nozzle material which has the proper triboelectrical relationship to the developer. In general, however, certain structural materials are particularly well suited to manufacture of the nozzle and it is highly desirable for the developer to be in proper relationship to the nozzle material. Specifically, it is a matter of convention in the X-ray art, but it is preferred to employ a developer material which is charged to negative polarity by turbulent expulsion through the nozzle. It is specifically noted that when a xerographic plate is charged to a positive polarity and exposed to an X-ray image, the areas corresponding to the more dense portions of the object being viewed, such as the bones of a hand, will then be more highly charged positively than the other areas, attracting a negatively charged developer for preferential deposition thereon to result in photographic reversal of the image, corresponding most closely to those images conventionally experienced in the X-ray art. Thus bones, absorbing more radiation, appear white in the fluorescent print.

Other properties of the developer material which are desirable relate to physical characteristics that lead to the production of higher quality developed images. These include, for example, uniformity and fineness of particle size, the absence of stickiness or tackiness, and the absence of the tendency on the part of the material to cake, pack, or floc.

It is to be observed that a great many materials possess one or more of the desired characteristics to a varying degree but that there are general guides leading to the selection of a preferred material which out-performs other materials or types of materials. These guides, of course, are not absolute, and different materials may be preferred for different purposes. In general, however, it has been found that phosphorescent or luminescent zinc derivatives or compounds are preferred developers for the present invention and that zinc oxide materials are presently considered the most satisfactory.

Within the general outline of developer materials set forth herein the following compositions are among those which have been employed as developer materials or which possess specific requirements of operable or satisfactory developer compositions: fluorescent or luminescent metal oxides and mixed oxides such as zinc oxide, aluminum oxide, magnesium oxide, beryllium oxide, strontium oxide, silicon oxide, calcium oxide, titanium oxide, zinc-magnesium oxide, zinc-aluminum oxide, cadmium-aluminum oxide, magnesium-titanium oxide, and the like; fluorescent sulfides such as zinc sulfide, cadmium sulfide, calcium sulfide, strontium sulfide, rubidium sulfide, zinc-cadmium sulfide, calcium-strontium sulfide and other single and mixed sulfides comparable with the fluorescent oxides; fluorescent selenides, silicates, tungstates and phosphates of these same single and mixed metals, such as, for example, barium or calcium selenide, calcium silicate, zinc orthosilicate, cadmium metasilicate, magnesium, cadmium or zinc tungstate, calcium-lead tungstate, cadmium zinc, aluminum or like phosphate or halophosphate; certain fluorescent borates, halides such as, for example, cadmium, zinc, aluminum, sodium, lithium, potassium, copper, lead, mercury, manganese, thallium, halides, borates or the like; similar carbonates; nitrides platinocyanides, uranyl salts, siloxene derivatives and the like; numerous organic phosphors and fluorescent compounds including, but not limited to, fluorescein and its derivatives such as eosin and the like, naphthionic acid and its derivatives, naphthalene and its derivatives, rhodamine, riboflavin, anthracene and its derivatives, violanthene, benzopyrene, benzofuran derivatives, and many other known organic fluorescent compounds; metal-organic compounds of many sorts such as the aluminum, magnesium or other salts of 8-hydroxyquinoline and other known fluorescent metal-organic compounds; fluorescent materials such as dyes or inorganic compounds or the like in solid matrices, including, for example, calcium carbonate or the like mixed with aminoethanoic acid, uric acid, hippuric acid, or the like. It is understood that in at least most cases the principal and named component such as the metal oxide or the like is not solely the fluorescent agent, and that small concentrations of activating impurities may be present: fluorescent materials of these types are commercially available in form or composition known to be operable.

With respect to the spray nozzle, which is now understood to achieve the dual purpose of charging and deglomerating the powder material, it is observed that there is a reasonable amount of choice in both structure and selection of composition. However, certain guides can be set forth. For example, the nozzle generally will include a restricted passage through which the cloud of developer must pass, and it is preferred that this restricted passage be fine enough so that the flow of the developer cloud therethrough will be turbulent under the rate of flow and pressure in which it is employed. Likewise the particular structural material should be selected so that the proper triboelectrical relationship is retained between the developer material and the nozzle. In general, however, this result can be achieved through the use of various metals such as iron, steel and the like, and plastic materials such as various resins, hard natural rubber, hard synthetic rubber, and the like.

It is to be understood that numerous variations and modifications may be made by those skilled in the art and that those modifications will be within the scope of the invention.

What is claimed is:

1. A method of developing a xerographic image particularly useful in radiographic analyses comprising spraying a cloud of luminescent finely divide powder material through a powder spray nozzle and adjacent to a surface bearing a xerographic electrostatic latent image to present a charged cloud of said powder material to the image surface, depositing said powder on the electrostatic image in conformity therewith by electrical attraction and exciting said powder with ultraviolet illumination.

2. A method of recording X-ray patterns comprising charging a xerographic member comprising an X-ray responsive insulating layer overlying a conductive backing, said insulating layer being electrically conductive under radiation by X-rays, exposing said member to a pattern of X-ray light and shadow to be recorded to form an electrostatic charge pattern, dopositing charged fluorescent finely divided material thereon in conformity with the charge pattern and exciting said fluorescent material with ultraviolet light.

3. A method of X-ray examination comprising directing X-ray radiation through an object to be examined,

forming an electrostatic image on an insulating surface in conformity with the pattern of X-ray radiation from said object, spraying a cloud of luminescent finely divided powder material though a powder spray nozzle to charge said luminescent material to a polarity opposite to the polarity of the electrostatic image and to present the luminescent material in a powder cloud adjacent to the image-bearing surface to deposit on said insulating surface finely divided charged fluorescent powder in conformity with the electrostatic image and illuminating the deposited image with ultraviolet radiation of a wave length to cause fluorescense of said powder.

4. In the method of claim 3, the added step comprising transferring said image to a second surface and illuminating the image thereon with ultraviolet radiation.

5. An X-ray picture comprising a support surface, a pattern of finely divided charged fluorescent powder material thereon in configuration with a pattern of X-ray light and shadow to which said surface has been exposed, said fluorescent powder adhering to the support surface by electrical attraction to an electrostatic latent image formed thereon in conformity with the X-ray pattern to which the surface had been exposed.

6. The method of utilizing an electrostatic latent image of an object on a dark photoconductive insulating surface comprising developing the latent image with electrostatically attractable fluorescent powder, illuminating the powder to form a light-colored visible image on a dark background, transferring the powder to a second support, and illuminating the powder with ultraviolet light to again form a light-colored visible image on a dark background.

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