April 28, 1970 MATAICHI TAJIMA 3,509,338

METHOD FOR RECORDING A RADIOGRAPH USING A PARTICULAR HALF TONE SCREEN

Filed Dec. 15, 1965

FIG.1

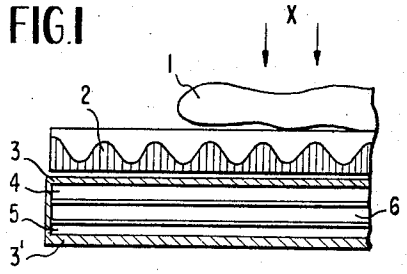


FIG.4

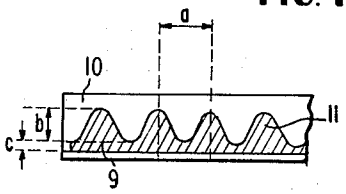


FIG.2

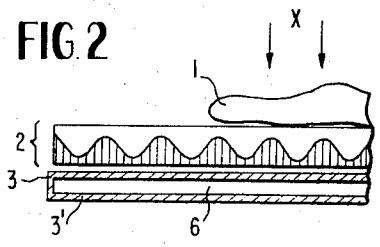


FIG.5

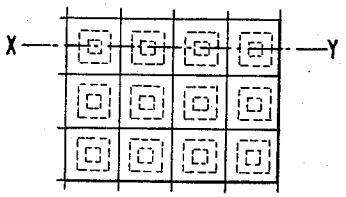


FIG.3

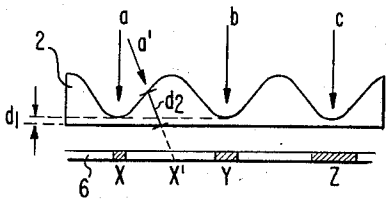
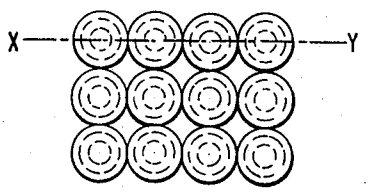


FIG.6



INVENTOR

MATAICHI TAJIMA

BY Brisbane, Rothwell, Mion, Zinn & Macpeak

ATTORNEYS

United States Patent Office 3,509,338
Patented Apr. 28, 1970

3,509,338

METHOD FOR RECORDING A RADIOGRAPH USING A PARTICULAR HALF TONE SCREEN

Mataichi Tajima, Ashigara-Kamigun, Kanagawa, Japan, assignor to Fuji Shashin Film Kabushiki Kaisha, Ashigara-Kamigun, Kanagawa, Japan

Filed Dec. 15, 1965, Ser. No. 513,958
Claims priority, application Japan, Dec. 15, 1964, 39/70,319
Int. Cl. G01n *23/04;* G03b *41/16*
U.S. Cl. 250—65 6 Claims

ABSTRACT OF THE DISCLOSURE

A process for recording, utilizing X-ray-sensitive materials, the improvement which comprises interposing a half tone screen of wave-like form at a place between the object which is under examination and the X-ray-sensitive material utilized for recording. X-ray recordings of greatly improved clarity may thereby be obtained without unwanted X-ray scattering.

The present invention relates to radiographic recording.

Previous methods for the recording of an image which was made by the penetration of energy through an object have been carried out with a radiation-sensitive material, such as an emulsion of silver halide. In such procedures, the intensity of radiation after penetration is converted into the corresponding strength of the response of the radiation-sensitive material, and the latter is further converted into the corresponding photographic densities of the radiation-sensitive material. In such cases, there was frequently used the lead strips of Potter-Bucky diaphragm for eliminating some scattered radiations, because of the fact that the image quality was injured by scattered radiations which might be generated, depending on the nature of an object to be recorded. The Bucky diaphragm comprises a number of lead foils which are of rectangular section and are arranged perpendicularly to the direction of radiations and in parallel with one another. In some cases, two sheets of the Bucky diaphragm may be crossed at an angle therebetween.

By the use of the Bucky diaphragm of such construction, no image may be formed upon the surface area of the radiation-sensitive material located below the lead foils, since no radiation penetrates the lead foils. In the case when one sheet of the Bucky diaphragm is employed, scattered radiations in only one direction are eliminated. Although scattered radiations in two directions, viz., in lateral and lengthwise directions, are eliminated in the case when two sheets of the Bucky diaphragm are employed, there occurs a defect in that surface area on which no images are formed is increased due to their shadow effects.

The present invention relates to a method of forming a radiograph, wherein the extent of the unradiated area of the radiation-sensitive material is lowered and radiation scattering is prevented by employing a screen the unit pattern of which is wave-like against the penetrating radiation. Details of the method are hereinafter mentioned.

In the accompanying drawing,

FIGURE 1 is a side view of an example according to the invention;

FIGURE 2 is a side view of another example according to the invention;

FIGURE 3 is a drawing for illustrating the mechanism for the formation of an image; and

FIGURES 4 through 6 show the construction of a half tone screen of waving form, respectively.

In FIGURE 1, a fluorescent intensifying screen or a lead foil screen **4**, both being adhered closely to a radiation-sensitive material **6** for recording, are mounted in a film

cassette **3** and **3'**, and the assembly is overlaid with a half tone screen **2** of this invention, whereby an image formed upon the penetration of radiation throughout an object **1** to be photographed is recorded thereon.

FIGURE 2 shows a principle by which an object **1** is directly recorded by means of an assembly comprising a half tone screen **2**, a film cassette **3** and **3'**, and a radiation-sensitive material **6** without using any fluorescent intensifying screen. The construction of said half tone screen will be more fully explained in FIGURES 3 through 6.

Referring now to FIGURE 3, the half tone screen **2** may be made of a material ranging from an atom having a large atomic number, such as lead, to an atom having a small atomic number, such as aluminum, and adjustment of image gradation may be possible depending on the kind of material and the control of the thickness thereof. For example, an attenuation factor (X) of X-ray is determined by atomic number (Z), density (V) of a material and a wave-length (λ) of X-ray, and an intensity (I) of X-ray after the penetration is inversely proportional to wave-length (λ) of X-ray and thickness (d) of a material. The co-relations therebetween are as follows:

$$X=KZ_2V\lambda^3 \quad (A)$$

$$I=O_0(\exp)-xd \quad (B)$$

wherein I_0 and K represents an intensity of X-ray before the penetration and a proportional constant, respectively.

The half tone screen made of a suitable material, being shown in FIGURE 3, is of controlled thickness and the section of which is of wave-like form. As the intensity of X-ray becomes greater in proportion as *a*, *b* and *c*, X-ray widely penetrates the concaved portions of the screen **2** over the width thereof, and there are formed a small dot image *x*, a mean dot image *y* and a large dot image *z*. In the case of this, if a scattered radiation *a'* is present and the screen **2** is not present, an image *x'* resulting from the radiation *a'* will be formed. On the other hand, if the screen **2** is present, the results are as follows; namely, the intensity of X-ray reaching to the position of the image *x'* is very weak, since X-ray *a* is weaker than X-ray *a'* and the thickness d_1 is less than the thickness d_2, so that scattered X-rays are eliminated. In order to overcome the defect whereby the surface area where no radiation is applied increases, as in conventional methods, as well as to eliminate scattered radiation, the elimination of said radiation being attained by means of the principle illustrated in FIGURE 3, a screen of a construction shown in FIGURES 5 or 6 may suitably be employed according to this invention.

Screen **9** shown in FIGURE 4 is preferably cased in a casement **10** for use, and the section as being taken at lines X—Y.

In FIGURE 5 showing an enlarged state of the half tone screen, each segment of dotted lines forming a regular square represent a contour line. Similarly, segments of dotted lines forming a circle in FIGURE 6 represents a contour line. Any of them is suitably employed for the achievement of the object of this invention. In addition to this, a screen of a pattern such as rhombus, an oval and so on may also be used.

The following are examples of this invention:

EXAMPLE 1

A half tone screen shown in FIGURE 5, the thickness being 1,500 microns (max.) and 2–5 microns (min.), the lattice spacing (the distance between neighboring concaved portions) being 200 microns, is made of lead, and used photographically.

The chest of a man is photographed on an X-ray film using an X-ray (80 k.v.p. and 200 ma.) for 0.08 sec., the distance between the film and an X-ray source being 150 cm. Taking a combination of a film and a developer, there

is gained an X-ray photograph of a contrast about twice times higher than that of a conventional one.

As a result of this, there are produced such mesh-like images as dotted image produced in a half tone process using a screen of 150 lines per inch. The mesh-like pattern of the image is of an extent which can be appreciated only by a careful investigation with the naked eye, so that the X-ray photograph thus gained is very clear and freef rom dullness due to scattered radiations.

Such a half tone screen as illustrated in FIGURE 4 is also constructed from lead **9** and a plastic material **10**. Where the form of the screen is not deformed by external pressure during a period of use, said material, viz., a plastic material, is not required.

EXAMPLE 2

A half tone screen of a section as shown in FIGURE 4 is produced by molding a plastic material having concaved portions **11** between portions of wave-like form, and filling it with a composition as hereinafter mentioned to meet the object of this invention. Namely, the composition comprises at least one selected from the group consisting of various kind of metal powders, a vehicle, and/or a binder. The following are exemplifications of these materials:

(1) Metal powder: iron, lead, tin, etc., the recommended dimension being less than 50 microns in diameter.
(2) Inorganic salts: mercuric sulfide (HgS), mercuric oxide, (HgO), stannic sulfide (SnS_2), trilead teroxide ($2PbO \cdot PbO_2$), barium sulfate ($BaSO_4$), bismuth oxides BiO; Bi_2O_3, BiO_2, Bi_2O_5)

Trilead teroxide is chosen from these inorganic salts, and mixed with tri-acetic-cellulose for the preparation of the screen. The dimension *a*, *b* and *c* in FIGURE 4 is determined as about 100 microns, about 200 microns and about 15 microns, respectively. The half tone screen of these dimensions is used for photography. More particularly, the half tone screen is overlaid with a lithographic film interposed between a set of intensifying screens. The X-ray tube-voltage is set to 150 k.v.p. A sheet of steel, 5 cm. in thickness, is radiated with X-rays for a nondestructive inspection. The photograph thus gained is of sharpness higher than that of a photograph gained by a conventional process. This shows the fact that smaller amounts of radiations scattered by the object to be inspected reach the photographic film.

What is claimed is:

1. In a method for recording a radiograph comprising positioning a X-ray-sensitive material for recording at a place behind an object to be radiographed, and irradiating said object with X-rays, the improvement comprising,
interposing a half tone screen of sine-wave-like form having concave and convex portions, said sine-wave-like form providing a cross-sectional variation in X-ray permeability to the screen, said screen having a lattice spacing of from about 100 microns to about 200 microns, and said screen being interposed at a place between the object and the X-ray sensitive material for recording.

2. The method of claim **1** wherein said half tone screen is molded from a material selected from the group consisting of a metal, a metal powder, a composition of a metal powder and a binder, powdered metal salts, and an admixture of powdered metal salts and a binder.

3. The method of claim **1** further comprising interposing a fluorescent intensifying screen between said half tone screen and said X-ray-sensitive material.

4. The method of claim **1** wherein said screen has a lattice spacing of about 200 microns.

5. The method of claim **1** wherein a powdered metal or powdered metal compound is filled in the concave portions of said half tone screen.

6. The method of claim **5** wherein the lattice spacing is 200μ.

References Cited

UNITED STATES PATENTS

1,447,430	3/1923	Richardson	250—63
2,344,824	3/1944	Landis et al.	250—65
2,141,193	12/1938	Mott	250—62 X

FOREIGN PATENTS

1,066,413	10/1959	Germany.

WILLIAM F. LINDQUIST, Primary Examiner

U.S. Cl. X.R.

250—62