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Pasmeg

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[54] WEDGE FOR VARYING CROSS-SECTIONAL INTENSITY OF BEAM OF PENETRATING RADIATION

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[52] **U.S. Cl.**.....**250/86,** 350/312

[51] **Int. Cl.**.....**H01j 5/16**

[58] **Field of Search**.....250/86; 350/312

[56] **References Cited**

UNITED STATES PATENTS

714,356	11/1902	Beckwith	350/312 X
3,248,547	4/1966	Van de Geijn	250/86
3,455,627	7/1969	Letter	350/312 X

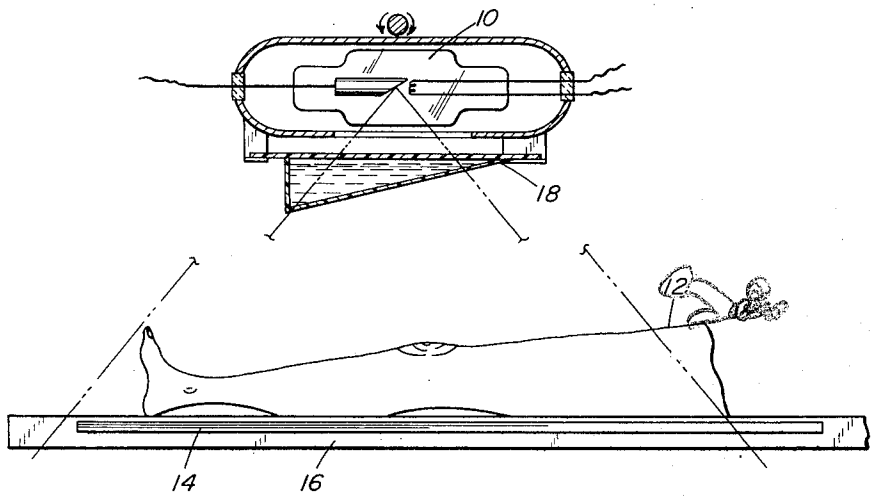
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[57] **ABSTRACT**

For use with an X-ray source, a wedge for distributing the intensity of radiation over an object area comprises a wedge-shaped enclosure partially filled with a radiation-opaque liquid. The enclosure is adapted for mounting on an X-ray tube head so as to be tiltable therewith thereby to alter the effective angle of incline of the "liquid wedge" and consequently its filtering characteristic.

2 Claims, 4 Drawing Figures



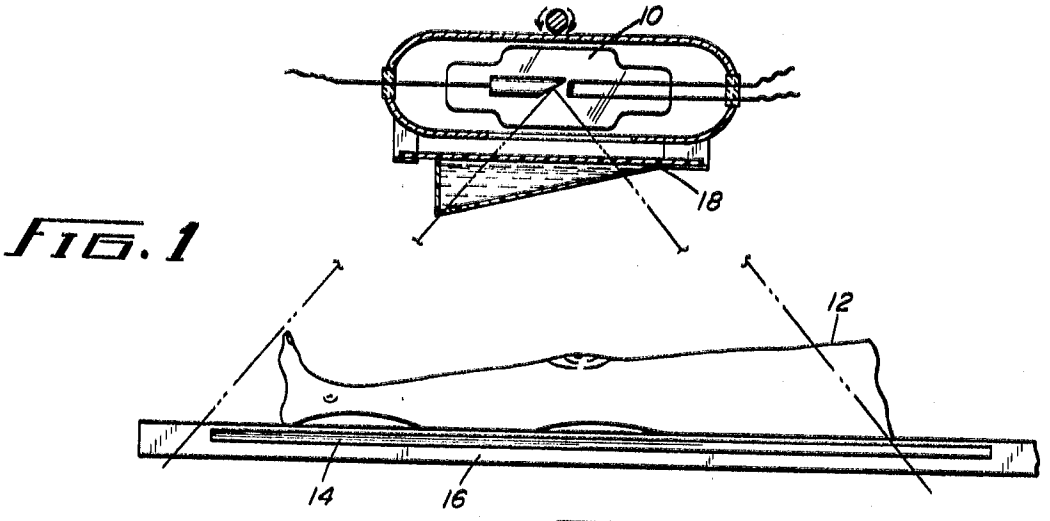


FIG. 1

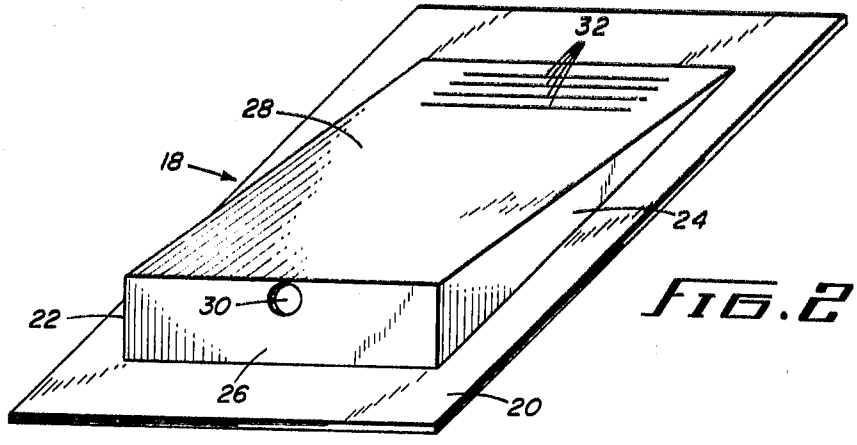


FIG. 2

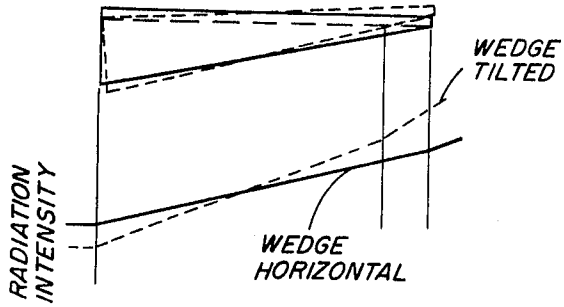
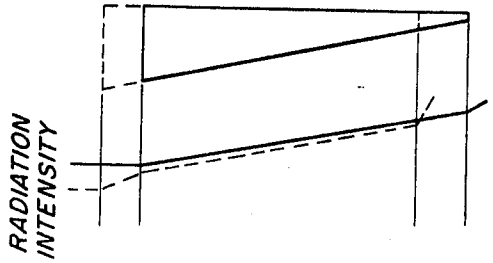


FIG. 3

FIG. 4



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WEDGE FOR VARYING CROSS-SECTIONAL INTENSITY OF BEAM OF PENETRATING RADIATION

BACKGROUND OF THE INVENTION

This invention relates generally to X-ray apparatus, and more particularly to an improved wedge for use with an X-ray source for controlling the intensity of radiation reaching an object under examination.

In many radiological procedures, it is essential that the density of the developed film after exposure to X-rays passing through a part of the body be substantially uniform throughout in spite of the fact that the part under examination is of varying thickness. In making femural arteriograms, for example, to examine the arteries of the leg for clots or other obstructions, a radiation-opaque fluid is injected into the femural artery in the region of the hip and is quickly carried by the blood to the extremity of the leg, and the entire leg, from hip to ankle, X-rayed in a single exposure. It is essential for accurate interpretation of the resulting picture that the density of the developed film be substantially uniform throughout. This result, of course, is not obtained unless the X-ray beam is modified because the hip and thigh region of the leg is much heavier than ankle region; that is, if the leg is exposed to radiation of sufficient intensity to obtain a proper exposure of the hip region, the ankle region will be overexposed and the developed film of that portion will be so dark as to be unreadable.

This problem has been partially solved, somewhat unsatisfactorily, by directing the X-rays through a wedge formed of radiation-filtering material positioned such that the X-rays directed toward the upper portion of the leg pass through its thinner portion and the radiation directed toward the ankle passes through the thicker portion. Wedges in common use today are made of aluminum, are about 6 inches square in area, and are uniformly tapered from a thickness of about three-quarter inch to a thickness of about three-sixteenths inch. These dimensions represent a compromise intended to give an acceptable uniformity of full leg exposure for the majority of patients, and while it does occasionally 37 match" a patient, more often than not, because of the wide variation in the structure of the body from person to person (heavy hips and thighs and thin ankles, slim hips and slim ankles, etc.) the exposure is not sufficiently uniform.

Consequently, in an attempt to overcome this deficiency, wedges of the type described above have been mounted on the tube head to slide in the direction of the incline, namely, parallel to the leg, into a position where the thickness of the wedge in the portion of the radiation beam incident on the hip region gives the proper exposure. Assuming that for a given patient the wedge must be moved to a position where there is less than normal wedge material in the beam in the region of the hip, there will be correspondingly less, by a fixed ratio, wedge material in the ankle region of the beam, which causes the developed film to be dark in the ankle region and progressively lighter towards the proper contrast at the hip region. Thus, to properly accommodate all patients would require a selection of wedges of various thickness and angles of incline, which are also movable; obviously this would be inconvenient and the cost prohibitive.

Quite apart from the inability of available wedges to give proper exposure for a majority of patients, the porosity of the aluminum causes internal reflections which results in diffusion of the X-ray beam. This coupled with the fact that the "soft" X-rays passed by the aluminum results in the object being examined (e.g., the leg) also causing secondaries, resulting in a lack of proper contrast between bone and tissue.

SUMMARY OF THE INVENTION

A principal object of the present invention is to overcome the foregoing deficiencies of prior art wedges. Another object of the invention is to provide a wedge whose angle of incline and effective thickness is continuously adjustable over a range of values to accommodate essentially any body structure. A further object is to provide a wedge that is relatively easy and inexpensive to fabricate.

These objects are attained in accordance with the invention by confining a radiation opaque fluid having selected filtration characteristics in a wedge-shaped container thereby to provide a liquid body of wedge-shape capable of distributing the radiation from an X-ray source over an object area in a manner similar to present solid wedges. However, the filtration properties of the wedge are readily changed by varying the concentration of the radiation opaque fluid and/or the amount of fluid placed in the container. The concentration of the radiation opaque fluid is so related to the volume of the container that a liquid wedge of proper "thickness" is provided when the container is only partially filled, whereby when the container is tilted from a normal horizontal position, say in a direction to depress the end having the larger dimension, the liquid shifts in the container to effectively increase the thickness of the wedge at the depressed end and reduce the thickness at the other end. A useful range of adjustability of the liquid wedge thickness an be achieved by tilting the container $\pm 2°$ or 3° from horizontal, which can readily be done by mounting the wedge on the X-ray tube head and tilting the head.

The filtration characteristics of the radiation opaque liquid are superior to aluminum, principally in that the liquid does not produce secondaries, so as to provide better contrast between bone and tissue in the developed picture than when an aluminum wedge is used.

DESCRIPTION OF THE DRAWINGS

An understanding of the foregoing and additional aspects of the invention may be gained from a consideration of the following detailed description, taken in conjunction with the accompanying drawing, in which:

FIG. 1 is an elevation view illustrating a wedge constructed in accordance with the invention in operative relationship with an X-ray tube;

FIG. 2 is a perspective view of the underside of the container for the radiation opaque liquid;

FIG. 3 is a diagram illustrating how the distribution of the radiation passing through the liquid wedge changes as the container is tilted; and

FIG. 4 is a diagram illustrating how the distribution of radiation passing through a prior art wedge changes with changes in position relative to the X-ray source.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 diagrammatically illustrates a typical arrangement for an X-ray examination, such as a femural arteriogram, in which a beam of radiation from an X-ray source **10** is directed downwardly through the full leg **12** (from hip to ankle) of the patient to expose a film contained in a cassette **14** carried by the X-ray table **16**. The diagram is not to scale because in this procedure the X-ray tube is normally positioned about 6 feet above the table in order to radiate the leg from hip to ankle, typically about 3 feet long.

To achieve as nearly uniform as possible density of the developed film throughout from hip to ankle so as to improve the accuracy of interpretation, a wedge **18**, tapered from thin to thicker in the direction from hip to ankle, is placed in the X-ray beam so that the radiation of greater intensity penetrates the thicker hip region of the leg than penetrates the thinner ankle portion. Heretofore, such wedges have been formed of aluminum, or other metals having the necessary X-ray filtration characteristics, and have been supported in a mounting track secured to the tube head for sliding movement in a direction parallel to the leg to attempt to accommodate variations in body structure from patient to patient.

The radiation distributing wedge according to the present invention is in the form of a wedge-shaped body of radiation opaque liquid contained within a wedge-shaped enclosure dimensioned to be received and supported on existing wedge

mounting tracks. To this end, the container for the liquid, viewed from the underside in FIG. 2, includes a cover plate which is approximately 6 inches square, which corresponds to the dimensions of the horizontal surface of conventional wedges, and of sufficient thickness to provide a rigid assembly and yet to be accepted by existing mounting tracks. To this cover plate is secured a wedge-shaped container 22 having tapered sidewalls, one of which is shown at 24, an end wall 26, and a bottom wall 28. Typically, the container is 5 inches square and centered on cover plate 20, and the end wall is 1 inch high. An opening 30 is provided in one of the walls for adding and removing liquid from the container, and is closed by a suitable stopper (not shown).

The container may be fabricated from any material transparent to X-rays, such as sheet metal or plastic, but for ease of manufacture at minimum cost it is preferably formed of a suitable plastic, desirably a clear plastic for reasons which will shortly appear.

The container is partially filled with a radiation opaque fluid, which, by way of example, and quite fortuitously, may be of the same type as that injected into the patient for X-ray examinations of the type described above. For example, the fluid may be "Hypaque" sodium sold by Winthrop Laboratories, which is sodium 3,5-diacetamido-2,4,6-triiodobenzoate ($C_{11}H_8IN_2Na0_4$) that contains 59.87 percent iodine (300 mg. iodine per ml.), and 0.8 meq. (18.1 mg.) sodium per ml. in an aqueous solution. The solution is clear and nearly colorless, and is relatively thermostable. In a successfully tested embodiment a solution consisting of 9 parts by volume of "Hypaque" 50 percent (a 50 percent solution containing calcium disodium edetate as a sequestering agent) and 10 parts by volume of water was used. In this embodiment the container, having a volume of 230 cc., contained 190 cc. of solution. It was found that the "thickness" of the "liquid wedge" provided by this volume of a liquid contained in an enclosure having the dimensions specified in the description of FIG. 2, provided filtration characteristics comparable to those of a conventional aluminum wedge at normal exposure settings of 150 mas at 80 kilovolts.

A significant advantage of using liquid as the filtration medium is that the characteristics of the wedge can be varied, without changing the dimension of the container, by altering the porportions of water and sodium diatrizoate solution and/or using different concentrations of the "Hypaque" solution, as well as by changing the amount of liquid added to the container. Liquid can be conveniently added or removed by a syringe, for example through the opening 30, making it possible to literally tailor the wedge to match the physical structure of a given patient. It has been found, too, that by decreasing the amount of "Hypaque 50 percent" to 30 cc. and increasing the proportion of water to maintain the original volume of 190 cc., good contrast film and effective wedge filtration are obtained with mas values reduced from normal by one-half and the X-ray tube voltage reduced by 14 KV; i.e., mas values of 75 and a tube voltage of 66 KV. Reducing the value of mas has the advantage of subjecting the patient to substantially less direct radiation, and reducing the tube voltage cuts down the amount of secondary radiation produced, thereby further protecting the patient from possibly harmful radiation. It follows, therefore, that the invention is not limited to the particular container dimensions, and types and amounts of radiation-opaque solution given by way of example.

Another important advantage of using liquid, and only partially filling the container, is that when the container is tilted from its normal horizontal position, the filtration characteristics of the wedge are altered in an unexpected but beneficial way. This is graphically illustrated in FIG. 3 wherein the partially filled wedge-shaped container is shown in solid lines in its normal horizontal position, and in dotted lines in a position tilted slightly to the left. Below the wedge there is depicted, in arbitrary units, the distribution of the radiation passing through the wedge for the two positions. The significance of the two curves, which it will be noted intersect each other, will best be appreciated by considering the procedure for examining a given patient.

Suppose, for example, that a patient on which a fermural arteriogram is to be taken has such heavy body development about the hips that the wedge when in the horizontal position produces a film of proper density in the region from the knee to the ankle, the film is underexposed in the hip region because of insufficient intensity of radiation. To overcome this deficiency, the container is simply tilted toward the left, by tilting the X-ray tube to which it is attached, causing the liquid to also shift to the left so that the portion of the beam directed toward the hip passes through less liquid than before. The effective increase in incident radiation intensity at the hip region does not, however, also increase the intensity at the ankle region (which would over-expose that region) but, rather, because more liquid now intercepts the portion of the beam incident on the ankle region, the intensity is actually decreased. By proper adjustment of the angle of tilt (striking differences in film exposure are obtained over a range of tilt of as little as 3° from horizontal) it is possible to obtain substantially uniform exposure of the film throughout the hip to ankle region, regardless of the body structure of the patient.

Inasmuch as an intensity of radiation sufficient to obtain a properly exposed film of the thicker hip region determines the amount, if any, by which the wedge should be tilted, it is convenient to affix calibration marks 32 on the bottom wall 28 (FIG. 2) graduated according to hip dimension, and to use the liquid as the tilt indicator. For example, for given container dimensions and solution concentration, and predetermined power to the X-ray source, the wedge in the horizontal position may give proper exposure in the hip region of patients measuring 17–19 cm. By tilting the wedge slightly from horizontal, say by ½°, the thin edge of the "liquid wedge" shifts to the next graduation mark, at which patients with hips measuring 20–23 cm. are properly exposed, and so on to a position where the tilt causes the edge of the liquid to coincide with the 28–30 cm. mark. Alternatively, such graduation marks may be affixed to one or both of the sidewalls of the container for alignment with the free surface of the liquid.

The effectiveness of the wedge according to the invention as compared to the aluminum wedge will be readily apparent from a comparison of FIGS. 3 and 4. In FIG. 4, an aluminum wedge in its "normal" position in front of the tube is shown in solid lines and the distribution of intensity of radiation passing through it is shown by the solid curve. If in this position the intensity at the hip region is insufficient to give a proper exposure, the only recourse is to slide the wedge to the left, to the position shown in dotted lines, to decrease the amount of metal in that portion of the beam. Such movement, however, also decreases the filtration of the portion of the beam incident on the ankle region, to likely result in overexposure of that region. This occurs because the radiation distribution simply shifts with the wedge, without change of slope.

It is apparent from the foregoing description that applicant has provided a simple, but highly effective, wedge for distributing the intensity of radiation from an X-ray tube or other source of penetrative radiation consisting essentially of a wedge-shaped body of radiation-opaque liquid, the slope and thickness of which may be continuously varied simply by tilting the container confining the liquid. While the invention has been described as embodied in a wedge of particular configuration, it is to be understood that this is by way of example only, and that many modifications can be made without departing from the true spirit and scope of the invention.

I claim:

1. In combination:

a head including a source of penetrating radiation for producing a penetrating beam,

a pair of parallel tracks secured to said head and disposed on opposite sides of said beam,

means pivotally mounting said head for movement in both directions about a horizontal axis transverse to said tracks from a normal position at which said tracks are disposed horizontally, and

a filtering wedge for varying the cross-sectional intensity of said beam comprising

an enclosure having a cover plate supported on said tracks across the penetrating beam produced by said source, and

a wedge-shaped container secured to and depending from said cover plate and tapered in the direction of said tracks,

said container being partially filled with a fluid opaque to said penetrating radiation which forms a wedge-shaped fluid body having a free horizontal surface and the angle of taper of which is adjustable in response to tilting of said head about said horizontal axis for selectively altering the filtering characteristics of said wedge.

2. Apparatus in accordance with claim 1 wherein said enclosure is substantially transparent to said penetrating radiation and said fluid comprises an aqueous solution of sodium diatrizoate.

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