C. THEORETICAL CALCULATIONS & INSTRUMENT DEVELOPMENT & TEST

CHARACTERIZATION OF LOW INTENSITY X-RAY IMAGING DEVICES

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The search for a high resolution imaging device to detect electromagnetic radiation in the 20 Kev to 300 Kev energy range lead researchers at the National Aeronautics and Space Administration (NASA) to the development of the Lixiscope (acronym for Low Intensity X-ray Imaging Scope). A detailed description of the component parts and the principle of operation of this unique instrument is given elsewhere.[1] The device is essentially the combination of a scintillator to convert impinging X-rays to visible light; a photocathode to produce an electron image; a multichannel plate (MCP) to intensify the electron image; and a phosphor screen to reconvert the intensified image to visible light. Fiber optic plates, which are employed to transmit images between component parts, prevent degradation in resolution of the image.

Radioisotopic sources have been used[2] to excite the Lixiscope in preliminary experimental attempts to evaluate the usefulness of this instrument for industrial and medical applications. The purpose of this study is to explore the characteristics of the Lixiscope when excited by X-rays produced by conventional electrically powered X-ray generators. The broad goal is to determine the optimum X-ray spectrum, and mode of operation of the generator, which yields satisfactory Lixiscope images of medical and industrial specimen.

EXPERIMENTAL PROCEDURE

The experimental arrangement employed with the Lixiscope is shown in Figures 1 and 2.

X-Ray Source

The source of radiation used to excite the Lixiscope is a radiographic inspection system (Faxitron Model 8050–310, manufactured by Field Emission Corporation, McMinnville, Oregon). This self-rectified X-ray system produces a continuously variable output voltage whose range is 10–130 kv, with a maximum current of 3 ma. The X-ray spot size is 0.5 mm.

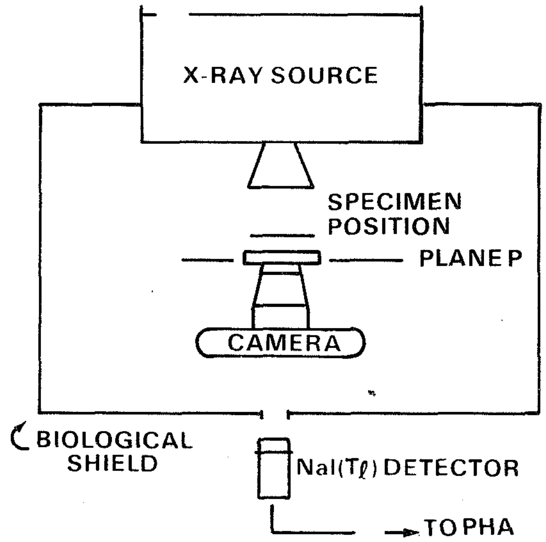

Figure 1. Diagram of Experimental Arrangement used for Lixiscope Investigation

The photon energy distribution of this source, shown in Figure 3, was experimentally measured using a two-inch Na I (Tl) scintillation detector arranged as depicted in Figure 1. The energy scale for Figure 3 was obtained using radioisotopic sources whose radiations are well known.[3]

Image Standards

Exposures of selected specimen were obtained using a standard medical radiographic unit*. The specimen were placed above, and in direct contact with, an 8″ × 10″ film cassette, then irradiated using standard techniques employed by radiologists. The specimen selected were (a) a skeletal hand, (b) a portion of a finger of an Alderson phanthom patient and (c) a composite wire. The composite wire consisted of a small diameter (0.062″ o.d.) inconel tube in

**Medical Radiographic and Fluoroscopic Unit (manufactured by Picker Instrument Corp.), focal point spot 1.4 mm.*

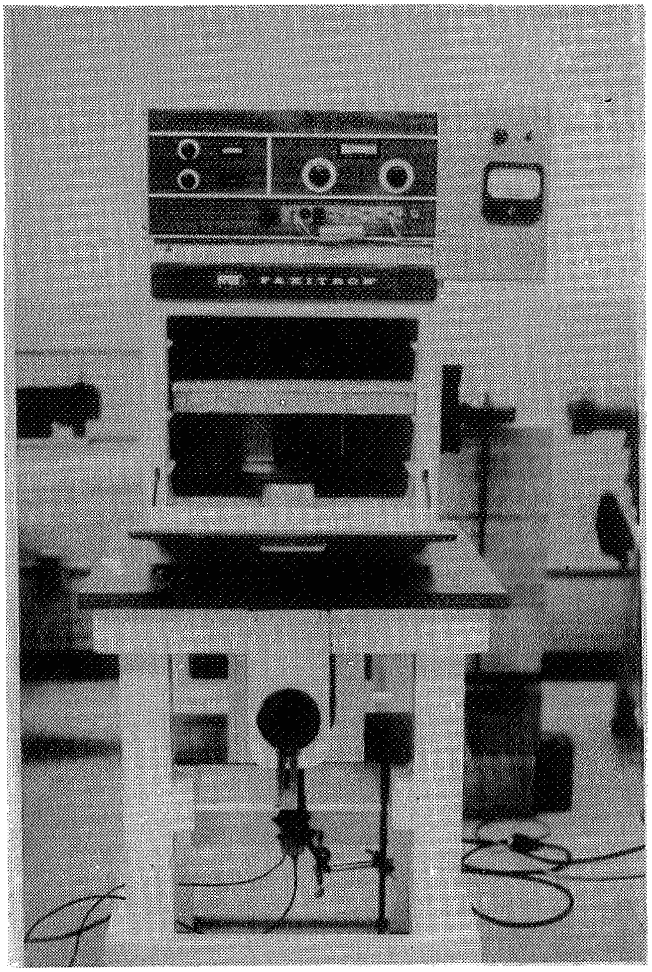

Figure 2. Photograph of Experimental Arrangement

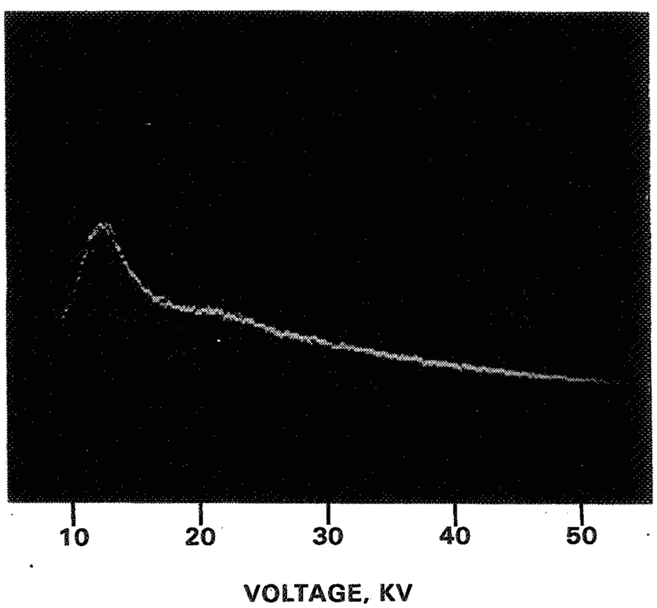

Figure 3. Photon Energy Distribution of X-Ray Source-30 KVP (Faxitron Radiographic Inspection System)

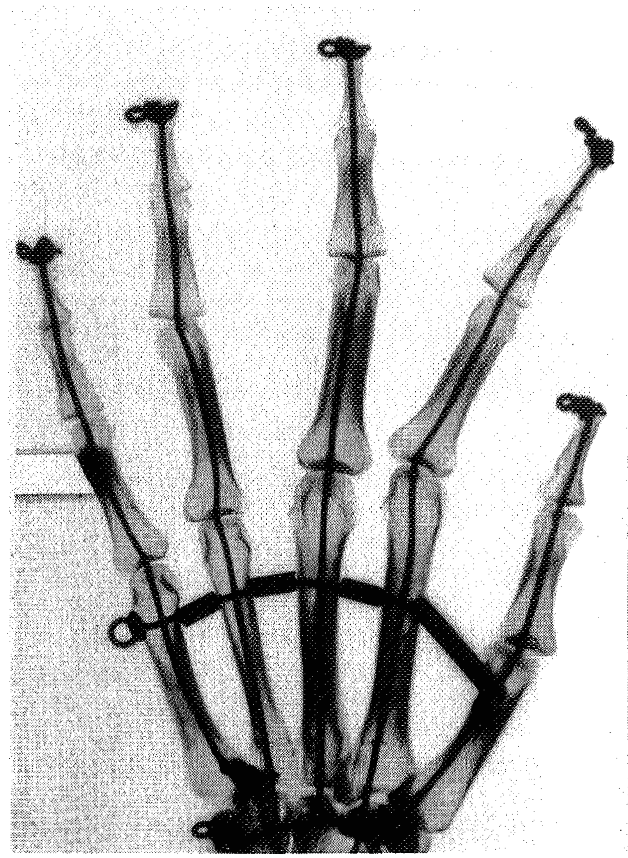

Figure 4. Image of a Skeletal Hand using a Medical Radiographic Unit

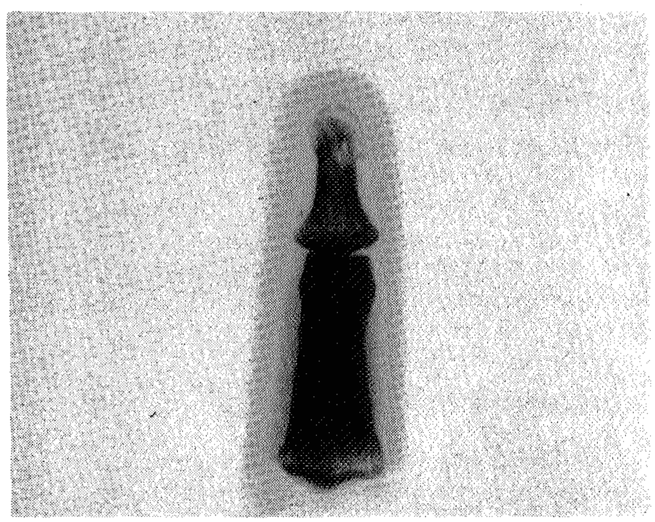

Figure 5. Image of an Alderson Phanthom Finger using a Medical Radiographic Unit

which had been inserted rhodium and zirconium wires of two diameters (0.062" o.d. and 0.013" o.d., respectively) and an Al_2O_3 spacer to fill voids. Images of these specimen, as given in Figures 4, 5 and 6 were used as "resolution standards" against which images obtained by other means were compared. Figures 7, 8

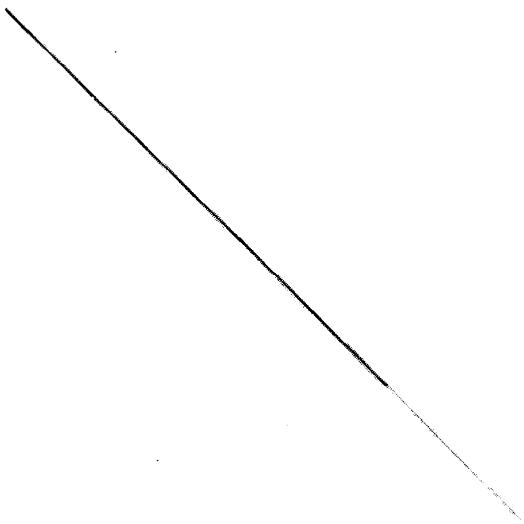

Figure 6. Image of a Composite Wire using a Medical Radiographic Unit

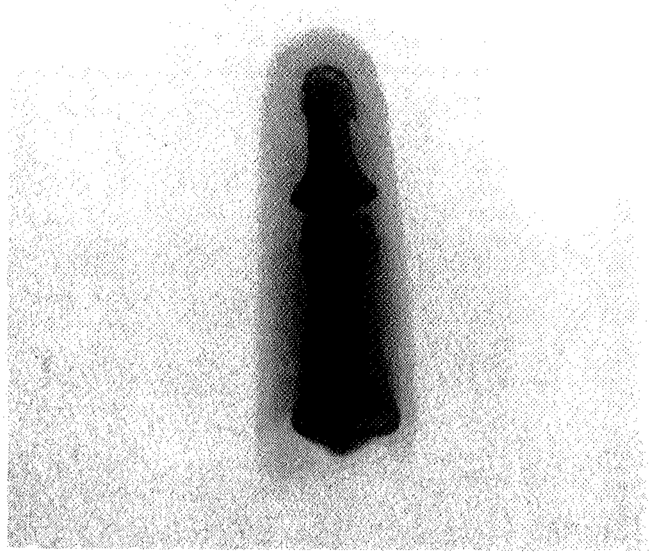

Figure 8. Image of an Alderson Phanthom Finger using the Radiographic Inspection System (Faxitron)

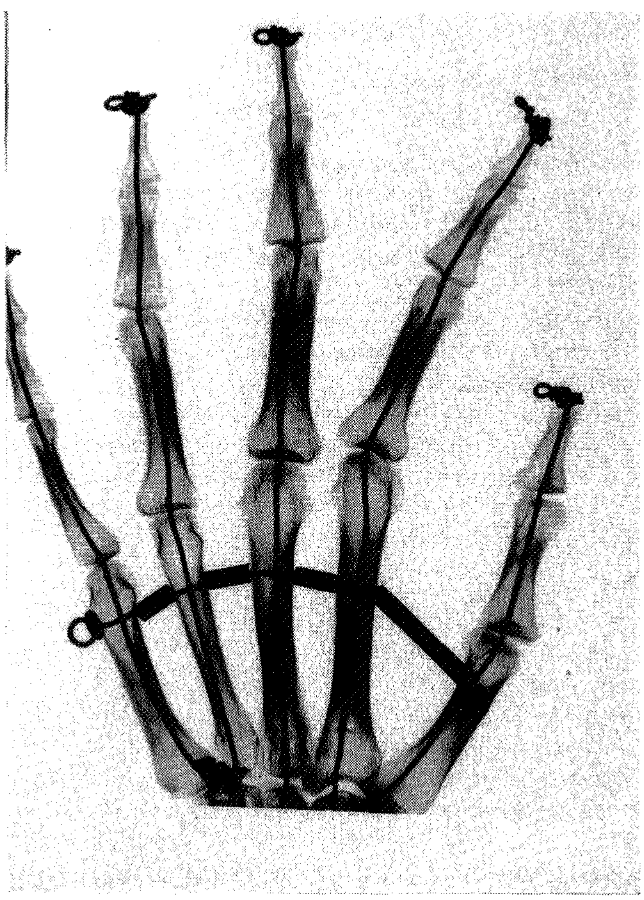

Figure 7. Image of a Skeletal Hand using the Radiographic Inspection System (Faxitron)

and 9 are images of the specimen obtained in the same manner as above, except that the radiation source used was the Faxitron X-ray generator to be employed in the Lixiscope study. A moderate increase in resolution is seen due to the smaller (0.5 mm) spot size for this generator.

Camera Recording System

Photographic images were obtained using a CU-5 Polaroid Close-Up camera (75 mm focal lens at f/4.5, 2× magnification). Measurements indicated negligible darkening of film due to direct exposure to X-rays in the experimental arrangement shown.

Lixiscope Images

Having ascertained that high quality radiographic images are achievable using the Faxitron X-ray system and that sharply focussed photographs (free of background fogging) can be obtained with the camera employed, the Lixiscope images were obtained of specimens (a), (b) and (c) as given in Figures 10, 11 and 12. The resolution of these images is deemed to be acceptable and the Lixiscope could become a useful diagnostic instrument.

Further Studies

The preliminary measurements given above have encouraged us to plan further studies of the characteristics and utility of the Lixiscope. Our plan is to study the response of the Lixiscope as the incident spectral distribution is varied, that is, as the character

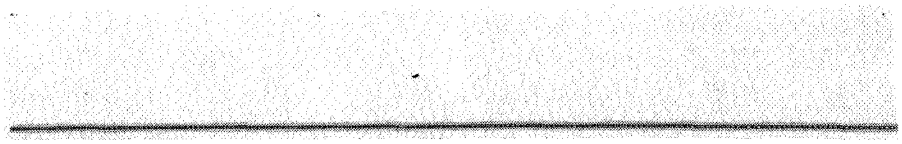

Figure 9. Image of a Composite Wire using the Radiographic Inspection System (Faxitron)

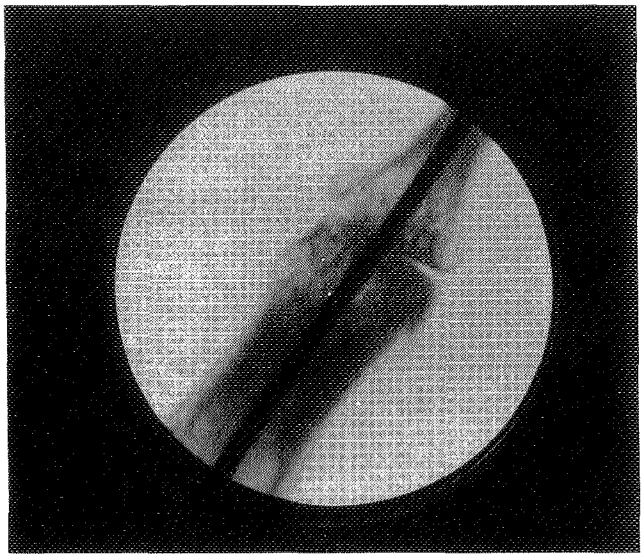

Figure 10. Photograph of Lixiscope Image of a Skeletal Hand (Portion of Index Finger Only)

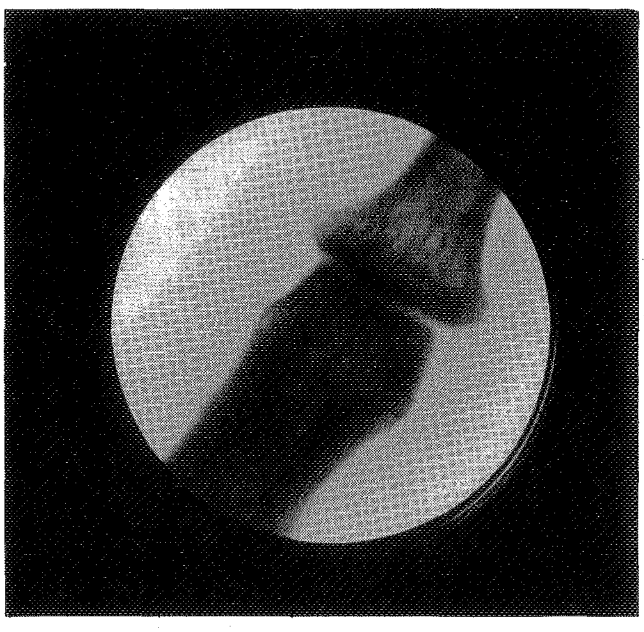

Figure 11. Photograph of Lixiscope Image of an Alderson Phanthom Finger (Portion of Index Finger Only)

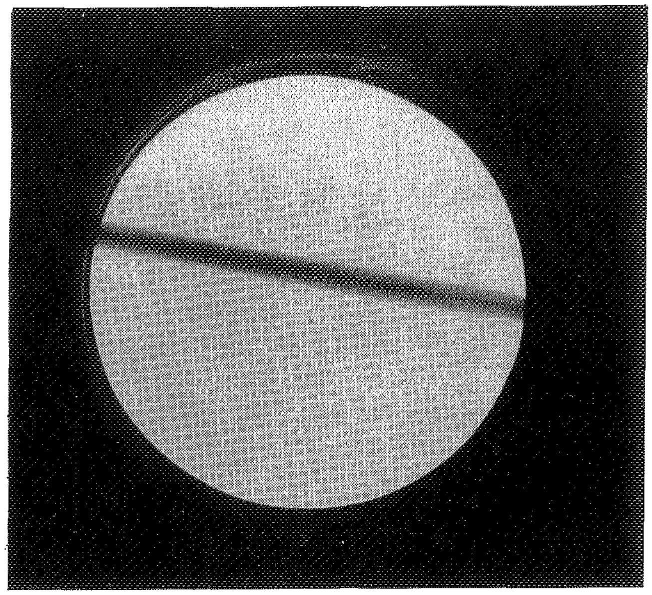

Figure 12. Photograph of Lixiscope Image of a Composite Wire

and magnitude of the incident radiation is changed. We shall further attempt to investigate the response of the Lixiscope when excited by monochromatic radiation (energy range 20–100 Kv) using an X-ray diffractometer available to us. From these studied we will determine the optimum X-ray spectrum recommended for several categories of specimen being analyzed (i.e. medical specimen, industrial specimen, etc.). In addition, we will investigate the preferred mode of operation of the X-ray generator (i.e. continuous vs. pulsed) which minimizes radiation dose to the specimen and the energy consumed in the operation of the X-ray generator.

REFERENCES

1. NASA Technical Memoranda 78064 (January, 1978) and 79634 (September, 1978)
2. Private Communication: R. L. Webber, Lo I Yin
3. See for example: Heath, *Table of Isotopes*