CHARACTERIZATION OF LOW INTENSITY X-RAY IMAGING DEVICES

(LIXISCOPE)

Final Report

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June 15, 1979 - December 31, 1981

Howard University

Washington, D.C. 20059

NSG
NASA Grant No. 5268

N82-19972

(NASA-CR-168584) CHARACTERIZATION OF LOW INTENSITY X-RAY IMAGING DEVICES (LIXISCOPE) Final Report, 15 Jun. 1979 - 31 Dec. 1981 (Howard Univ.) 19 p HC A02/MF A01 CSCL 20F

Unclas
G3/74 15427

INTRODUCTION

The search for a high resolution imaging device to detect electromagnetic radiation in the 20 Kev to 300 Kev energy range led 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 are given elsewhere (1, 2). 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 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 LIXISCOPE used in this study was kindly loaned to us by Drs. Jacob Trombka and Lo I. Yin of the Goddard Space Flight Center (NASA). The experimental arrangement employed is shown in Figures 1 and 2.

X-ray Source: The source of radiation used to excite the LIXISCOPE is a radiographic inspection system (Flaxitron 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.

The photon energy distribution of this source, shown in Figure 3, was experimentally measured using a two inch (2") 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" x 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 which has been inserted rhodium and zirconium wires of two diameters (0.02" o.d. and 0.013" o.d., respectively) and an Al_2O_3 spacer to fill voids. Images of these specimen are given in Figures 4, 5 and 6, and were used as "resolution standards" against which images obtained by other means were compared. Figures 7, 8 and 9 are images of the specimen obtained in the same manner as above except that the

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

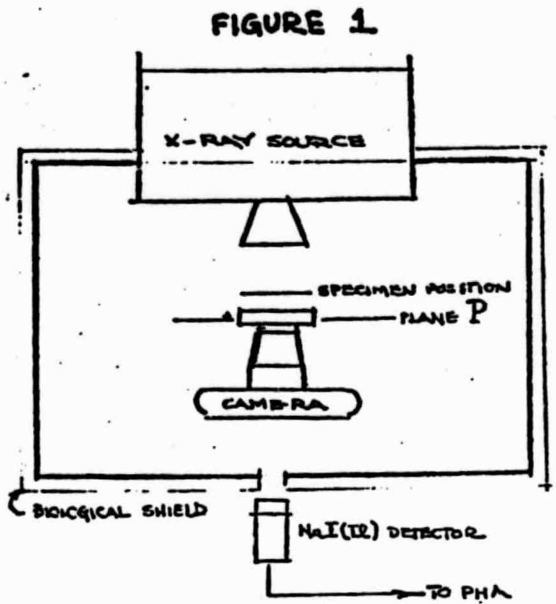

FIGURE 1

Schematic Diagram of Experimental Arrangement Employed for LIXISCOPE Investigation

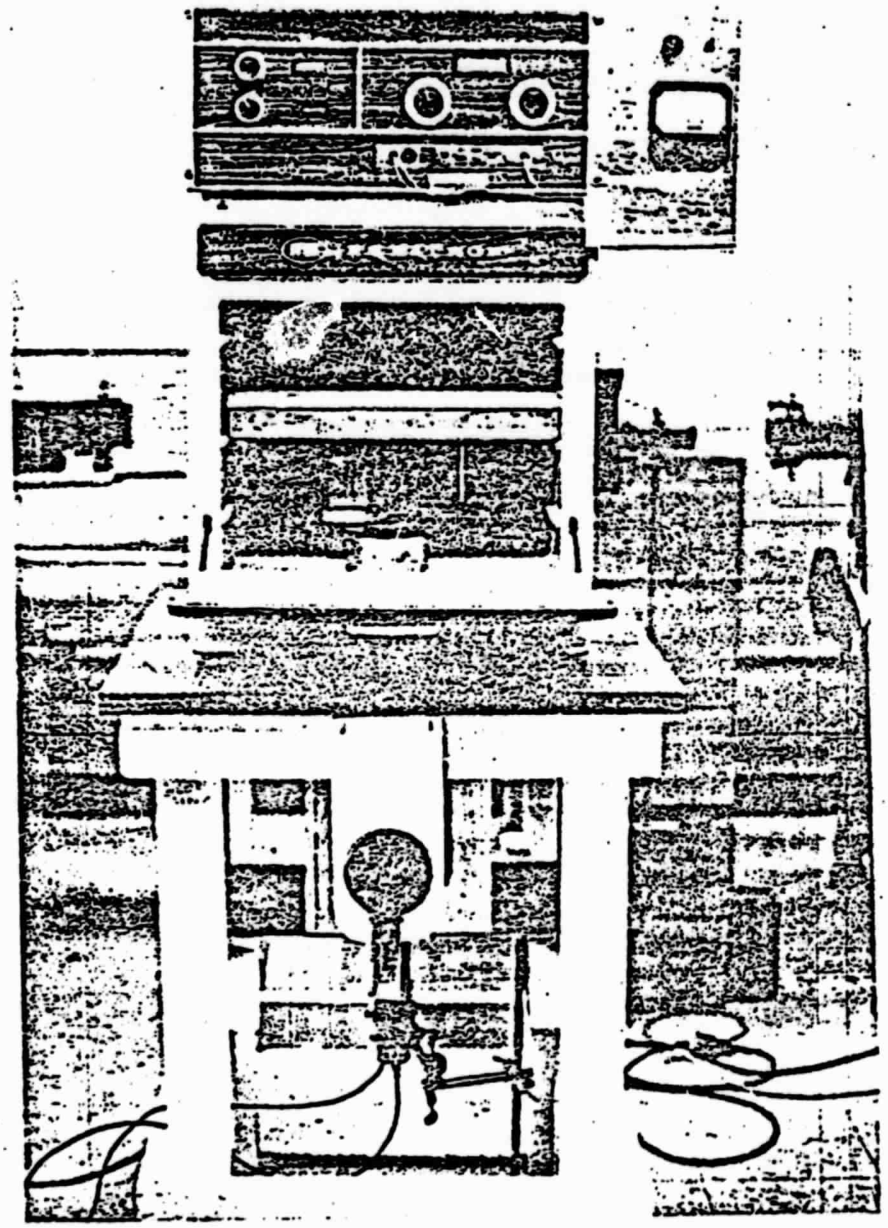

FIGURE 2

Photograph of Experimental Arrangement Employed for LIXISCOPE Investigation

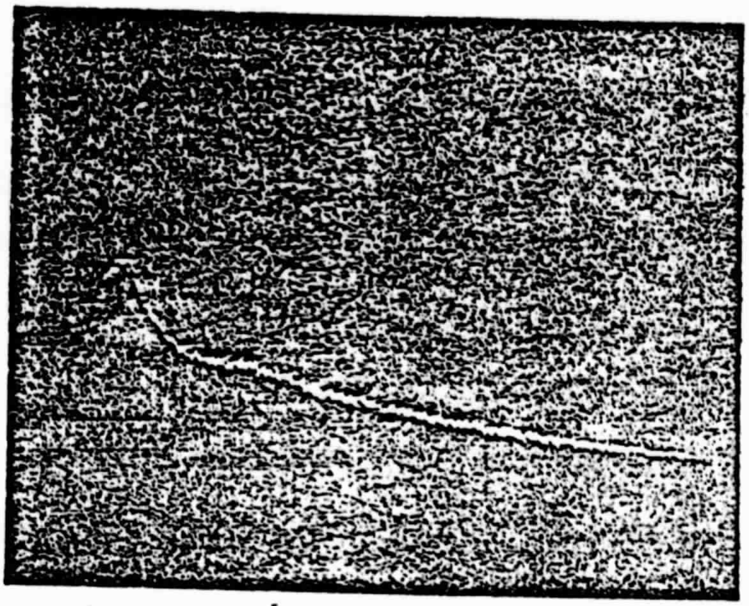

FIGURE 3

Photon Energy Distribution of X-ray Source - 30 KVP
(Flaxitron Radiographic Inspection System)

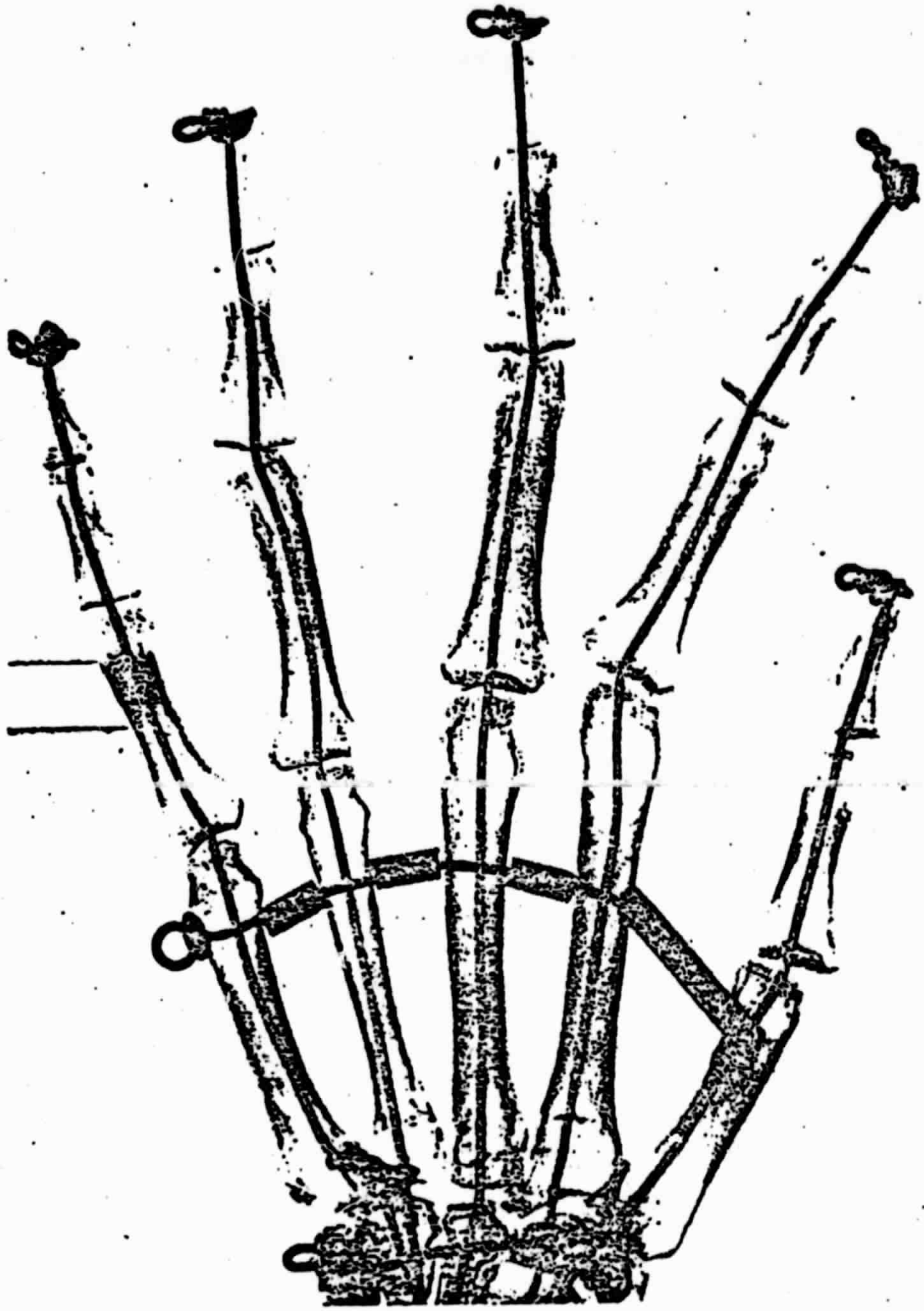

FIGURE 4

Image of a Skeletal Hand Using a Medical Radiographic Unit

FIGURE 5

Image of an Alderson Phantnom Finger Using a Medical Radiographic Unit

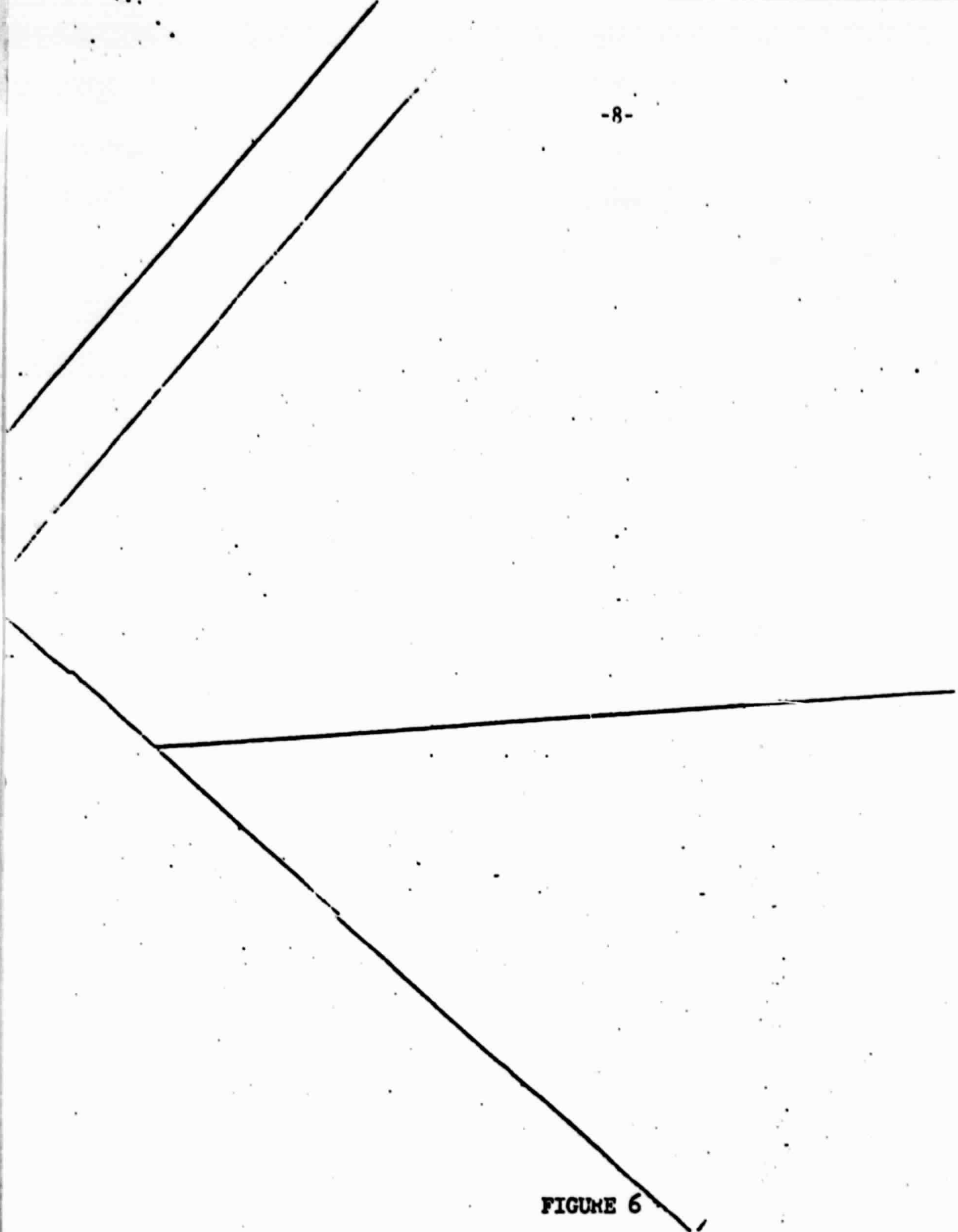

FIGURE 6

Image of a Composite Wire Using a Medical Radiographic Unit

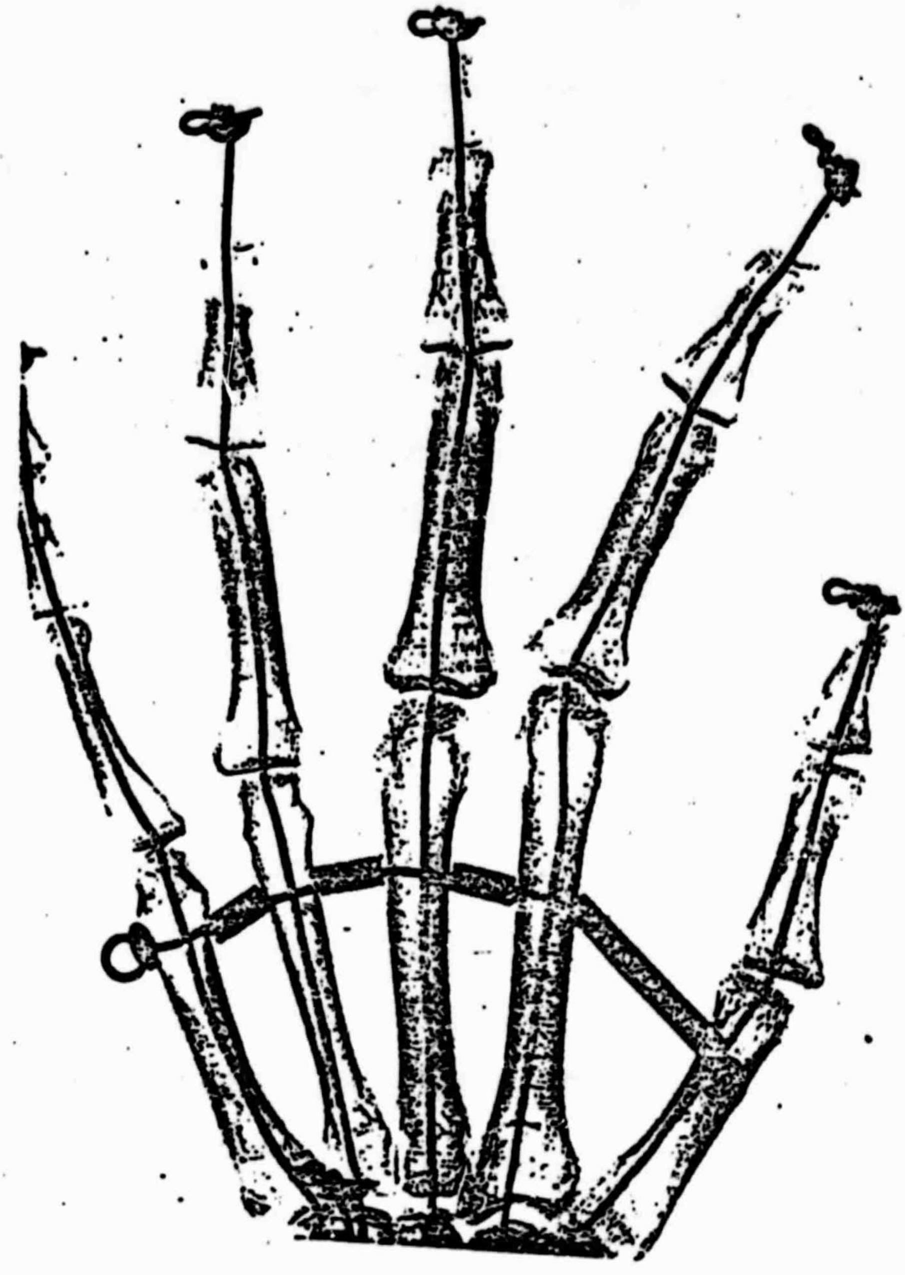

FIGURE 7

Image of a Skeletal Hand Using the
Radiographic Inspection System (Flaxitron)

FIGURE 8

Image of an Alderson Phanthom Finger Using
the Radiographic Inspection System (Flaxitron)

FIGURE 9

Image of A Composite Wire Using the
Radiographic Inspection System (Flexitron)

radiation source used was the Flaxitron 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, 2x 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 Flaxitron x-ray system and that sharply focussed photographs (free of background fogging) can be obtained with the camera employed, the LIXISCOPE was positioned within the test chamber with its image face at plane P. LIXISCOPE images obtained in specimen (a), (b) and (c) are 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 encouraged us to plan further studies of the characteristics and utility of the LIXISCOPE. Our plan was to study the response of the LIXISCOPE as the incident spectral distribution is varied; that is to say, as the character and magnitude of the incident radiation is changed. In this case, the incident distribution was changed using standard filtration techniques of the x-ray beam. Because of the limited range over which the incident beam distribution could be varied by the filtration we used, no significant change in LIXISCOPE response was measurable. We further attempted to investigate the response of the LIXISCOPE when excited by monochromatic

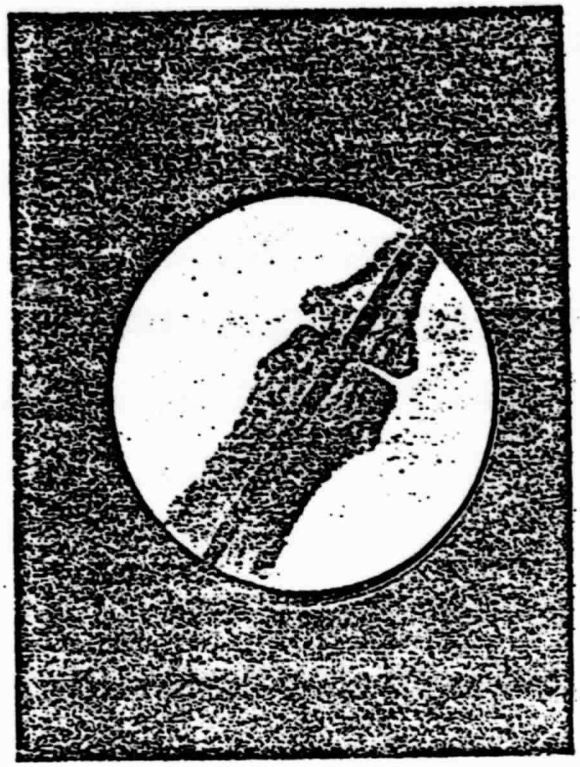

FIGURE 10

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)

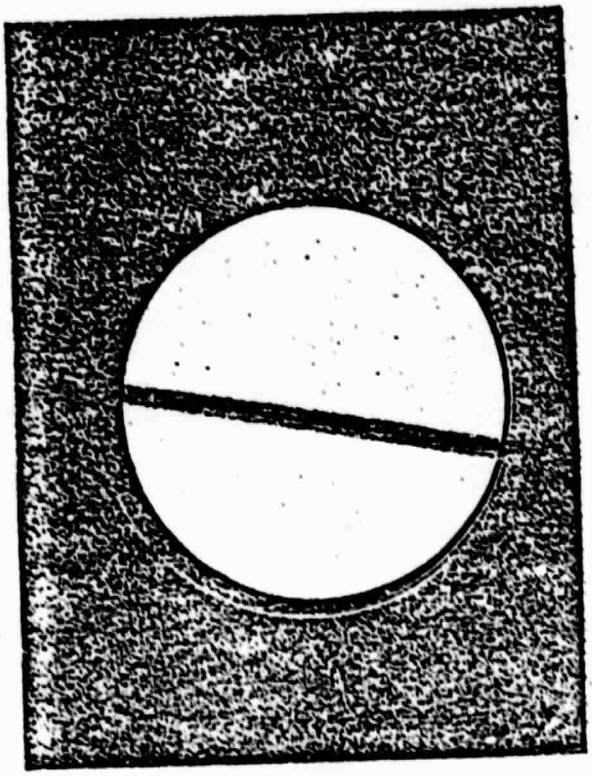

FIGURE 12

Photograph of LIXISCOPE Image of a Composite Wire radiation (energy range 20-100 kev) using an x-ray diffractometer available to us. The x-ray source on the diffractometer employed in this attempt was a Faxitron Radiographic Inspection System (maximum ratings 3 ma at 130 kvp). The primary heteroergic beam from this unit proved to be more than adequate for LIXISCOPE excitation, but it was found that the intensity of the once diffracted beam was reduced beyond the point where excitation was detectable by ordinary photographic means. In an attempt to overcome this difficulty, a higher flux x-ray source has been secured and installed on our diffractometer. This source is an Andrex X-ray Unit Model 3002 (300 kv at 6 ma).

Our technical monitors expressed interest in evaluating LIXISCOPE use in selected industrial applications and suggested that we investigate certain specimen which they provided. The specimen consisted of welded metallic sections which contain possible flaws. We determined that, in our experimental arrangement, these possible flaws could not be unequivocally detected. Nevertheless, our results suggested that the LIXISCOPE may prove useful in industrial applications of this type. In our shops we prepared several welded metallic samples for study. A detailed study was made of these samples using the LIXISCOPE technique. To assess the value of this technique, the same study was conducted using standard radiographic techniques and a comparison was made of the results obtained (3).

Additional Studies: We conducted tests to determine if sufficiently intense monochromatic x-ray beams for LIXISCOPE excitation are achievable using the new x-ray source now installed on our diffractometer. The possibility of using more sensitive methods of recording LIXISCOPE response should be explored. Such methods may include intensifying techniques suggested to us by our technical monitors. If successful in this attempt, efforts to determine the optimum x-ray spectral distribution to be recommended for several catagories of specimen which may be analyzed by the LIXISCOPE (industrial, medical, etc.) should be initiated. Furthermore, investigations similar to those begun by Kasem (3) should be continued to fully assess the advantages of the LIXISCOPE when used for inspection of industrial specimen.

It has been suggested that calcium mobilization in biological systems is an effect of interest to NASA. This effect is believed to occur under conditions of low gravitational fields. We reviewed information available to us on this effect to determine if significant measurements can be made using our present (or modified) experimental arrangement. This work is in progress.

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3. Kasem, Y. M. "The Application of the LIXISCOPE in Material Science," December, 1979 (a thesis submitted to the Graduate School, Howard University, Washington, D.C.).