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A PERISCOPE FOR VIEWING AND PHOTOGRAPHING RADIOACTIVE OBJECTS UNDERWATER

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A PERISCOPE FOR VIEWING AND PHOTOGRAPHING RADIOACTIVE OBJECTS UNDERWATER

by

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INTRODUCTION

Nuclear fuel elements are being developed by the Savannah River Laboratory to improve reactor performance and to establish a basis for the design of an economical power reactor. In this program, the ability to inspect and photograph irradiated fuel elements quickly and conveniently is of utmost importance in expediting the experimental irradiations which support the development work. This report describes a periscope that was developed by the Savannah River Laboratory for the viewing and photographing of irradiated reactor fuels or other radioactive components which are underwater.

SUMMARY

A periscope was developed by the Savannah River Laboratory and is currently being used for the visual examination of irradiated reactor fuel in a water-filled basin. Of the several advantages which this instrument has over those periscopes commercially available, the most notable are its low cost and its ease of maintenance because of the above-water placement of all precision optical components. Its optical quality has proven satisfactory for both visual and photographic work.

The periscope, shown in Figure 1, consists of a vertical view tube welded perpendicularly to a short horizontal tube, on the front of which is a sealed glass window. A first-surface mirror, placed at the intersection of the two tubes, reflects light from the window to a telescope and camera mounted at the upper end of the vertical tube. The periscope can be raised, lowered, and rotated manually to provide a large viewing area. Four 500-watt lamps are attached to the lower end of the vertical tube for spot illumination of the viewing area.

DISCUSSION

A basin periscope was one of several pieces of special handling and examination equipment that were developed by the Savannah River Laboratory and built for the SRL room in the Receiving Basin for Off-Site Fuel[1] to allow the expeditious underwater examination of irradiated reactor fuels. The periscope was designed to provide an inexpensive optical device that is simple and easily maintained, but capable of producing sharp photographic images. The design offers several outstanding features which are advantages over periscopes that are commercially available:

1. All parts were either fabricated from standard materials or were purchased as "off the shelf" items. The total cost, including installation in the basin and testing ready for use, was less than $6000.00.

2. Dismantling and mounting in a new location can be acccomplished without special handling procedures or equipment, and without danger of damage to the delicate parts of the optical system.

3. All precision optical components are at the top of the instrument where they are not susceptible to damage by water or radiation.

4. Those optical components which are underwater are inexpensive, and can be replaced by personnel with average mechanical skill.

5. The optical system functions satisfactorily under normal atmospheric conditions without need for pressurizing the body of the instrument with dry gas.

6. At the normal subject-to-eyepiece distance of about twenty feet, the depth of field is about one inch for all magnifications.

The periscope, installed as shown in Figures 2 through 4, is rigidly mounted to eliminate vibration. Photographic exposures of five to ten seconds produce clear, sharply defined images on either negative or Polaroid type photographic materials that have an emulsion speed rating of ASA 200.

Mechanical Construction

The periscope is mounted in a recess in the wall of the Inspection Basin in the SRL Room, as shown schematically in Figure 1. It is constructed of an aluminum view tube four inches in diameter and fourteen feet long, to the lower end of which a short length of tubing six inches in diameter is welded at a right angle. The back end of the short tube is sealed with a flat metal disk, and the front end is closed by a cell that carries an optically-flat glass window four inches in diameter. O-rings around the cell flange and the glass window seal the tube against the entry of water. The view tube is supported in a vertical position, with its top end above water, by a carriage assembly that rides on tracks attached to the basin wall. Two rings welded to the view tube engage semicircular slots in the top and bottom carriage plates to carry the weight of the tube, while leaving it free to be rotated around its vertical axis. The carriage and view tube may be moved up and down over a distance of 32 inches by an elevating handwheel which operates a lead screw through a gear reducer. As the view tube moves vertically, its top end telescopes into an extension tube that excludes light and dirt. A slotted bushing inside the bottom end of the extension tube engages two longitudinal keys on the view tube body. The extension tube, supported on a bushing that is mounted on the operator's table at the floor level, may be rotated manually to move the view tube through an angle of about 90° around its vertical axis as a means of increasing the field of vision.

Four 150-watt spotlights are attached to brackets on the bottom of the carriage, and are aimed at a spot about 20 inches in front of the periscope window. Two of the lights are at the same elevation as the window, and two are about 30 inches above. The lights are controlled by switches that are mounted on the operator's table.

Optical System

The underwater portion of the optical system consists of the glass window that excludes water from the periscope, and a first-surface mirror which is mounted at the intersection formed by the vertical view tube and the short horizontal tube. The remainder of the optical system, mounted on the table above the extension tube, is comprised of a "Questar"* telescope and a 4" x 5" view camera which are coupled together and aligned with the long axis of the view tube. It has a three-inch aperture and is of the modified Schmidt-Cassegrain type; the light path is reflected twice internally to give an effective focal length of about four feet in a barrel eight inches long. Light that is transmitted through the glass window is reflected from the mirror through the view tube and into the telescope. On the control box of the telescope are a side opening for the attachment of the viewing eyepiece and an axial opening which is coupled with the camera. Light is directed to one or the other of these openings by a star diagonal prism which also serves as the camera shutter by excluding all light from the axial opening when the prism is in position for viewing through the eyepiece. The prism is moved by a lever on the control box. The periscope is normally used to view objects that are placed about two feet in front of the glass window, which makes the object-to-eyepiece distance about twenty feet. At this viewing distance optical images of 2X, 4X, and 8X object size can be obtained by means of interchangeable eyepieces and an internal Barlow lens. If necessary, the telescope can be focused on objects at distances of from eight feet to infinity. Photographic images of 1X to about 10X can be obtained by extending the camera bellows; however, because the limited amount of light that is usually available

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* Product of the Questar Corp., New Hope, Pa.

makes focusing difficult at greater magnifications, most photographs are taken at a maximum magnification of 2X. The optical quality of the periscope is entirely satisfactory for both visual and photographic work. A typical underwater photograph of a reactor component is shown in Figure 5a. The only noticeable deviation in photographic accuracy is the slight pincushion effect which is illustrated in Figure 5b.

The engineering drawings for fabrication and installation of the periscope are on file at the Savannah River Laboratory.

BIBLIOGRAPHY

1. F. C. Locke, "A Basin Facility for Examining Irradiated Nuclear Fuel", USAEC Report DP-922, E. I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, S. C. (1964).

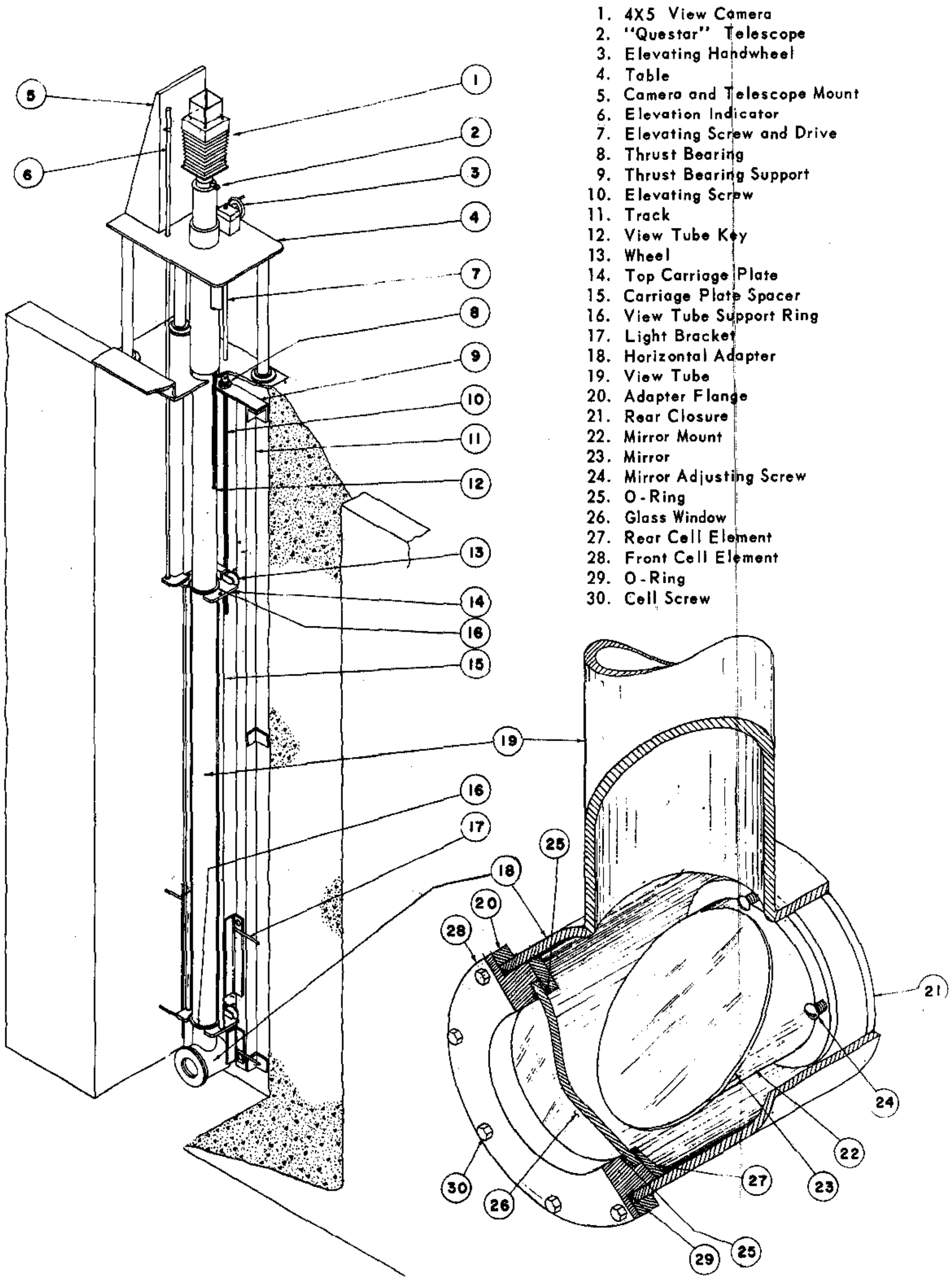


FIG. 1 PERISCOPE

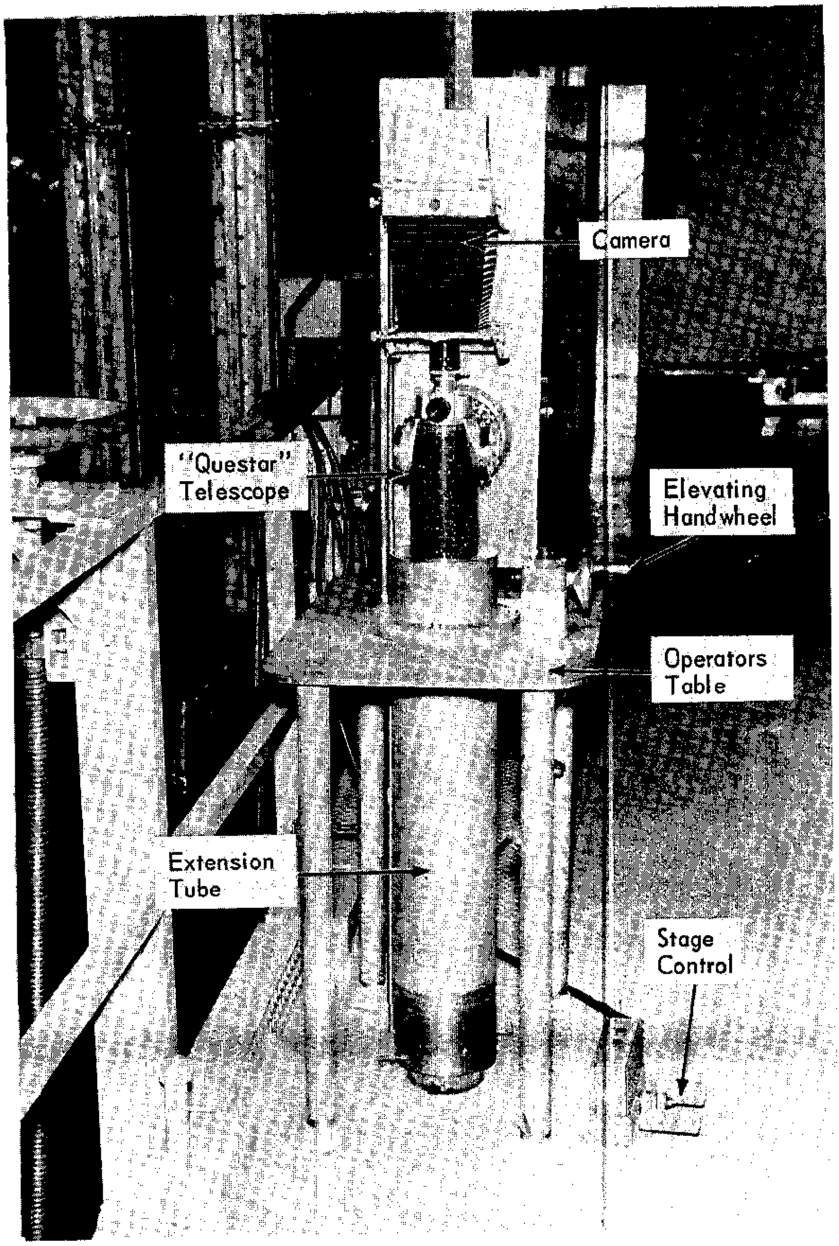


FIG. 2 TOP SECTION OF PERISCOPE, FRONT VIEW

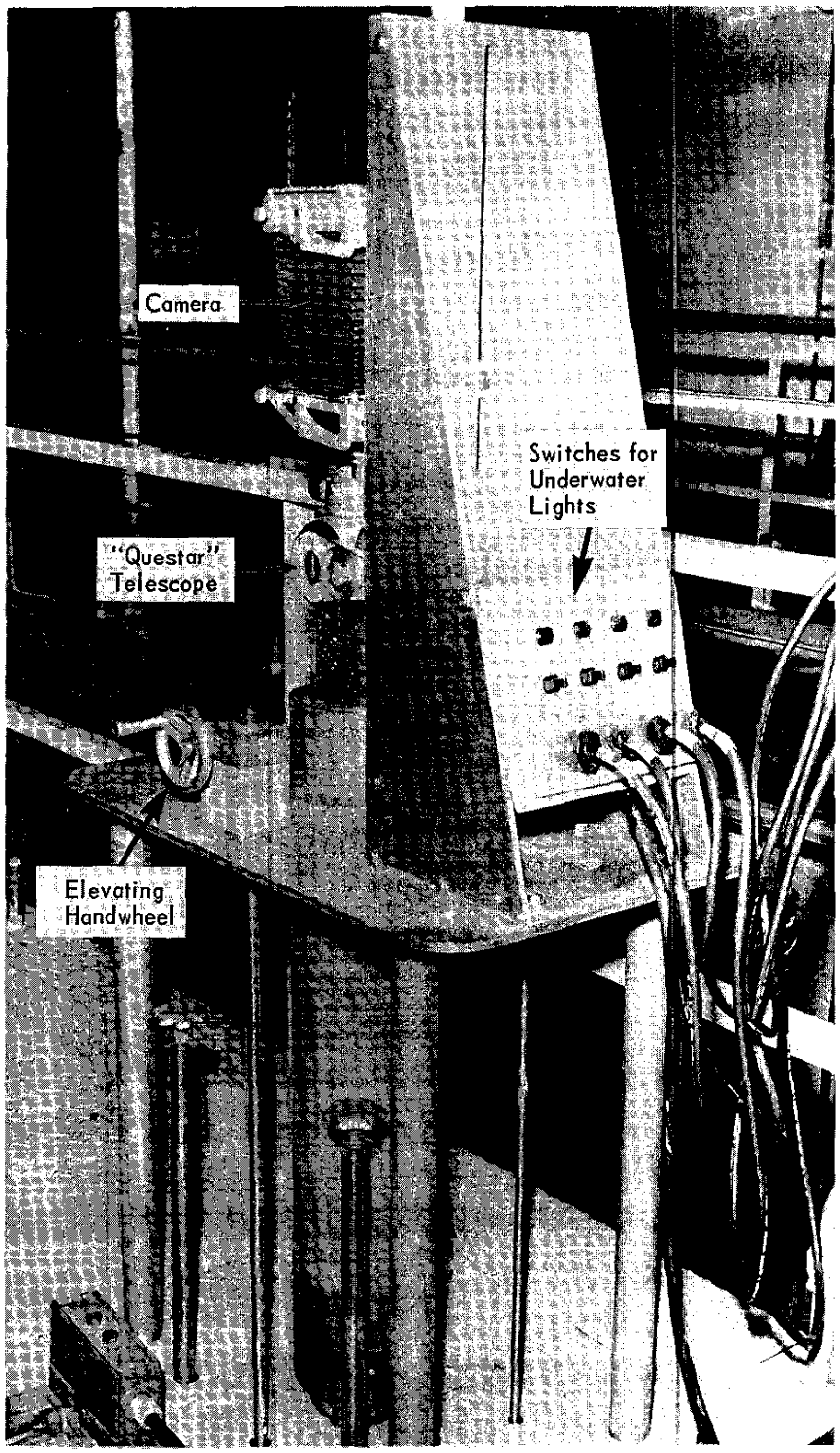


FIG. 3 TOP SECTION OF PERISCOPE, REAR VIEW

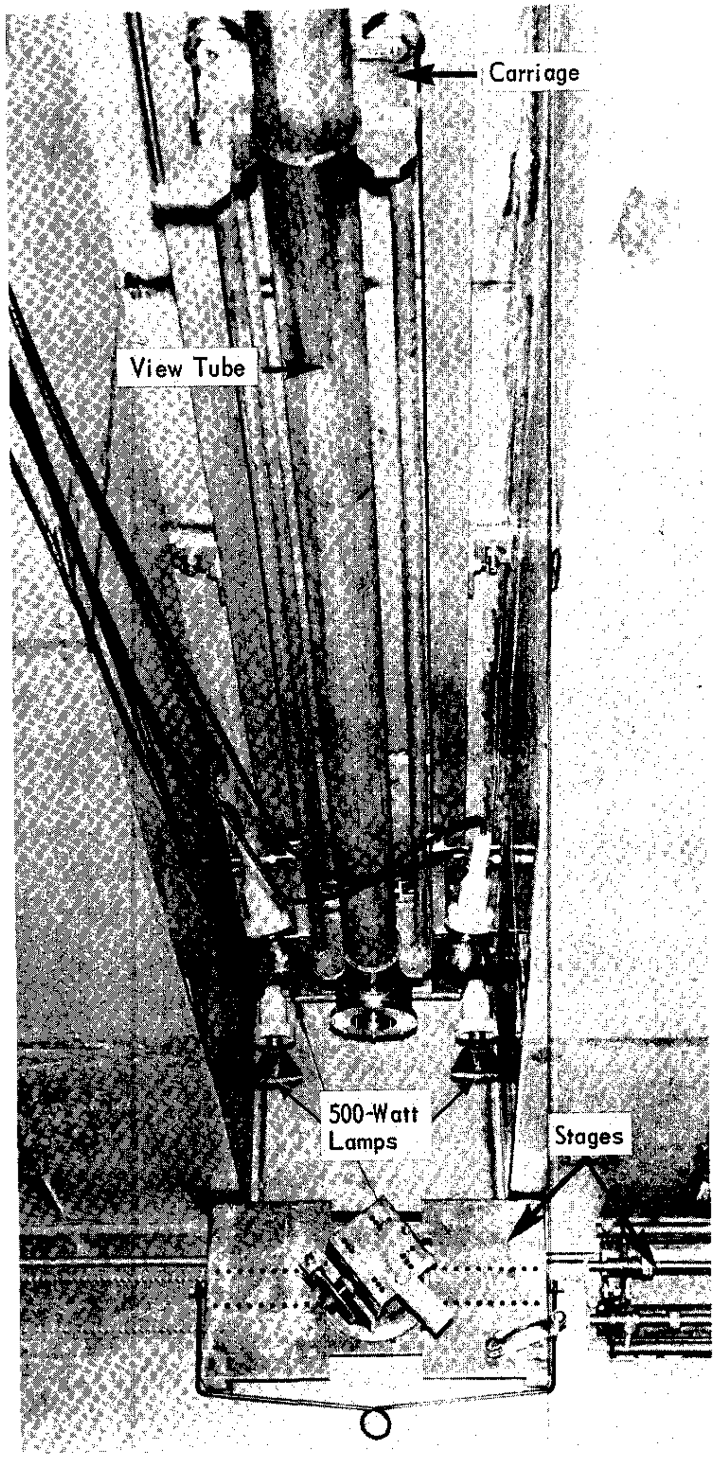
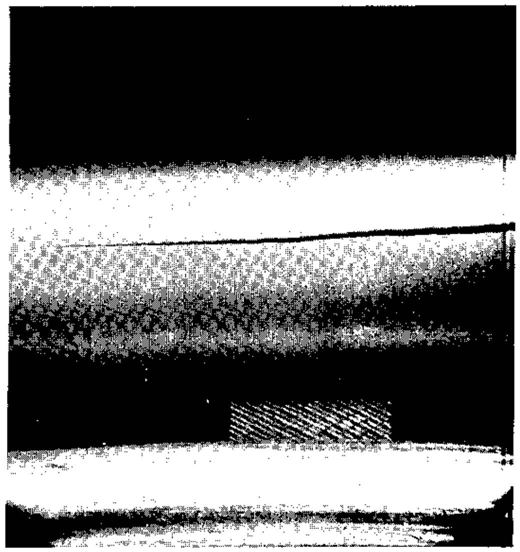
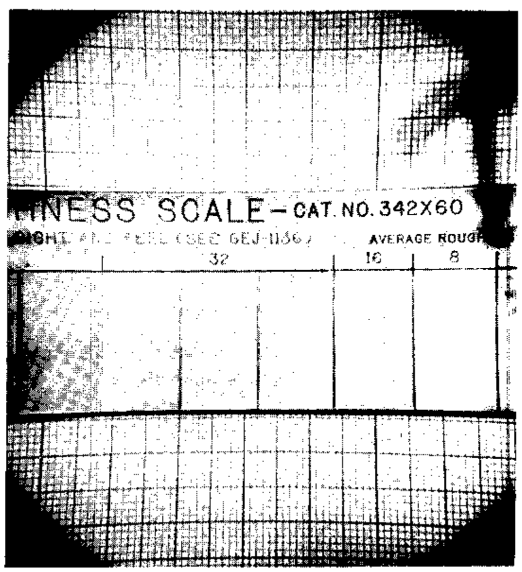


FIG. 4. BOTTOM SECTION OF PERISCOPE



a. Cracked Zircaloy Tube 1X



1X

b. Pincushion Effect

FIG. 5. ILLUSTRATIONS OF PERISCOPE PHOTOGRAPHY