ORION • SERVICE digest

issue 40 OCTOBER 1982

LOCKHEED • CALIFORNIA COMPANY

P-3 AIRCRAFT FIBEROPTIC INSPECTION EQUIPMENT/OSD INDEX

ISSUE 40 OCTOBER 1982
LOCKHEED-CALIFORNIA COMPANY

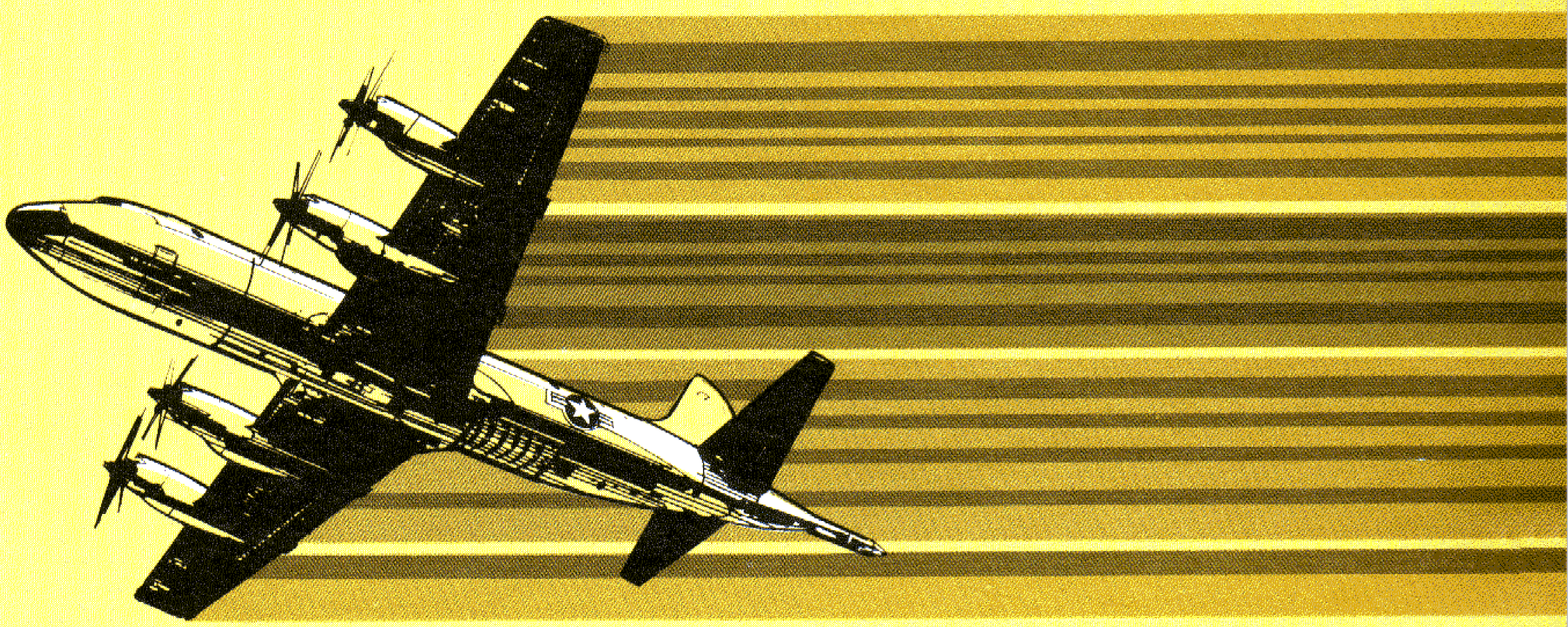
CONTENTS

NOT FOR PUBLIC RELEASE

FRONT AND BACK COVERS

Fleet Air Reconnaissance Squadron ONE is based at NAS Agana, Guam and operates two basic types of aircraft – the EP-3 *Orion* and the EA-3B *Skywarrior.* The primary mission of VQ-1 is to conduct electronic reconnaissance in support of U.S. Seventh Fleet operations, obtaining information and intelligence on areas and targets of naval interest.

The squadron traces its origin back to October 1951 at NS Sangley Point, R.P., when it was formed as an Electronic Countermeasures Group in the Air Operations Department of the Pacific Fleet. In May 1953 the group was assigned to Airborne Early Warning Squadron ONE (VW-1) as Detachment "ABLE." This detachment was reorganized in June 1955 and designated Electronic Countermeasures Squadron ONE (VQ-1). Within months, VQ-1 moved to NAS Iwakuni, Japan. During these early years the squadron flew P4M-1 *Mercators* and P2V-5 *Neptunes.*



In 1960 the squadron was redesignated Fleet Air Reconnaissance Squadron ONE and moved to NAS Atsugi, Japan. This year saw VQ-1 reequipped with WV-2 *Warning Stars,* A3D-2 *Skywarriors,* and F9F-8 *Cougars.* In 1963 the squadron received EC-121 *Super Constellations,* and in 1969 it received its first EP-3B *Orion.*

FAIRECONRON ONE moved from Japan to Guam in June 1971, at which time it absorbed Airborne Early Warning Squadron ONE (VW-1) and Heavy Photographic Squadron SIXTY-ONE (VAP-61), assuming their tasks of weather reconnaissance and high altitude photography. The squadron discontinued its weather mission at the end of 1971, but retained its photographic and mapping capabilities until mid-1974. Since then, the squadron has concentrated upon electronic reconnaissance.

Today, VQ-1 operates throughout the Western Pacific, and has become known as the "Westpac World Watchers." The squadron has detachments based at Atsugi, Japan; Cubi Point, R.P.; and aboard carriers operating with the Seventh Fleet. It also regularly flies in fleet operations from such far-flung bases as San Diego, Moffett Field, Wake, Adak, and Korea. Recently, VQ-1 carrier detachments have also visited Hobart, Tasmania and Karachi, Pakistan.

editor WAYNE CRADDUCK

art and production by ALLEN LUDLOFF

Lockheed ORION Service Digest

The Lockheed Orion Service Digest is published by Lockheed-California Company, Burbank, California. Material is not officially approved by the FAA, CAB, or any of the military services unless specifically noted. Military personnel are advised that direct use of the information in this publication may be restricted by directives in their organization. Material contained herein is not classified, but strictures against unauthorized and indiscriminate dissemination of military information apply. Republication of material is not sanctioned unless written permission is granted by Lockheed-California Company. Regulations require that republished material conform to the latest information and changes.

COPIES REQUIRED OR CHANGE OF ADDRESS – Please send your name; present address; occupation; your organization's name; and, if applicable, your old address as imprinted on a Digest envelope to:

YOUR LOCAL LOCKHEED-CALIFORNIA COMPANY SERVICE REPRESENTATIVE OR LOCKHEED ORION SERVICE DIGEST, DEPT. 64-18, BURBANK, CALIFORNIA 91520.

P-3 AIRCRAFT FIBEROPTIC INSPECTION EQUIPMENT

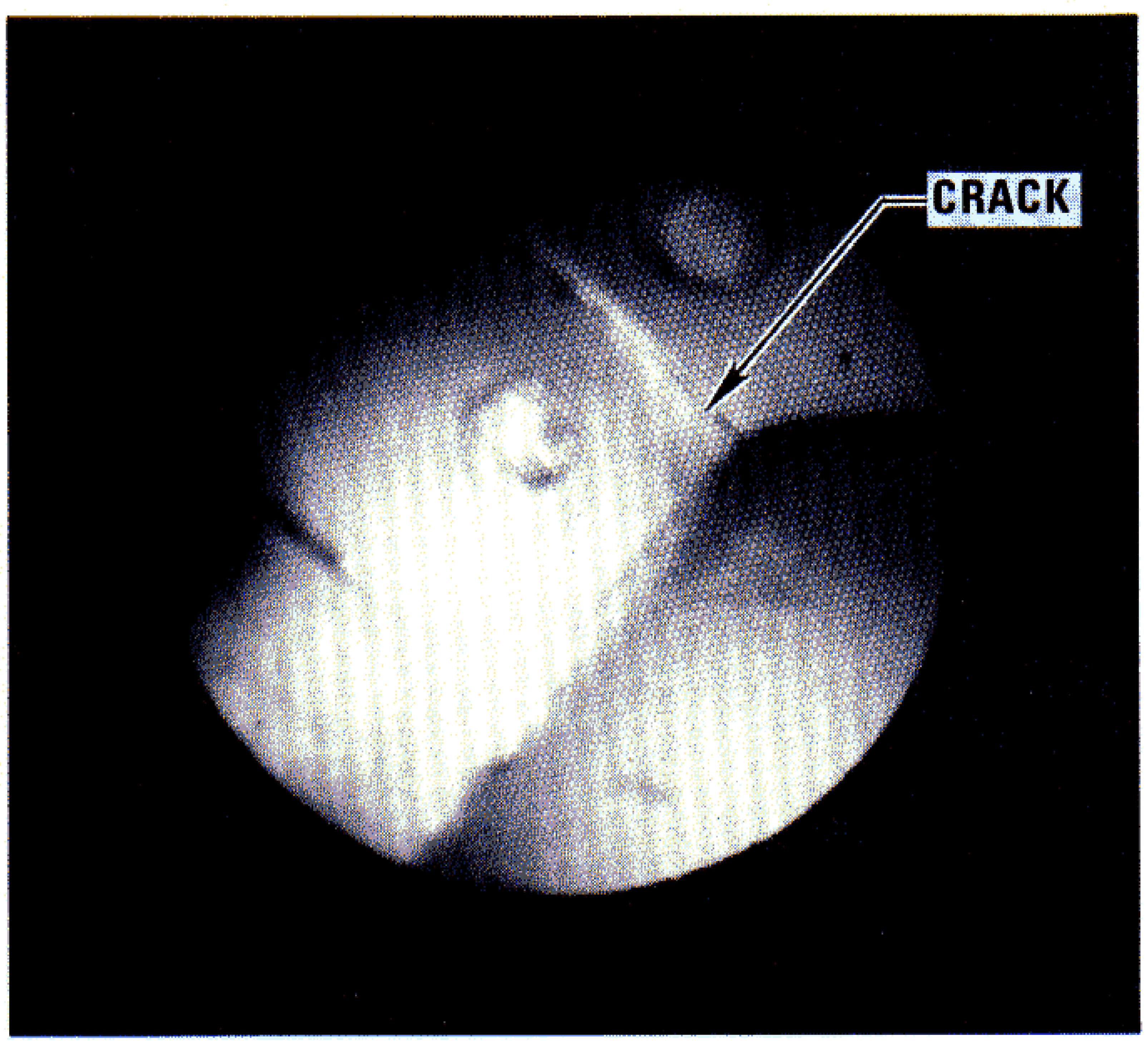
by Albert T. Harcarik, Group Engineer
Logistics Engineering Department
Ground Support Equipment Group
and
Olaf G. Shipstead, Lead Engineer
Logistics Engineering Department
Ground Support Equipment Group

INTRODUCTION

Recent advances in the applications of fiber optics have led to the development of fiberoptic inspection equipment for aircraft. With this equipment, it is possible to examine areas of the airframe and its components where access limitations otherwise would prevent close viewing. Often, the alternative is extensive disassembly to perform a visual inspection. Fiberoptic inspection equipment usually has its own light source, and presents the viewer with an illuminated, erect and magnified image. This is a great improvement over the old-style flashlight and mirror inspection technique with its inherent reverse image, dim lighting, and distant viewing. The photographs in Figure 1 are views of aircraft structure as seen through a fiberoptic borescope.

WHAT IS FIBER OPTICS? Fiber optics is the application of optics in which fibers of transparent material are used to transmit light by a series of internal reflections. Figure 2 illustrates the principle of light transmission by fiber optics. These fibers are usually made of glass or plastic. Bundles of these fibers can be used to transport or "pipe" light from one point to another. Flexible fiber bundles can be designed which can be routed through openings and structure to illuminate and view areas where access is awkward or perhaps otherwise impossible.

The medical field employed some of the first applications of fiberoptic inspection equipment to make diagnostic examinations within the human body. Naturally, this equipment is quite delicate, since it was designed to enable the medicine man to view some remote nooks and crannies of the human interior without disassembling the patient. Sturdier fiberoptic inspection equipment has since been developed for aerospace maintenance applications, an example of which is the flexible fiberoptic borescope.



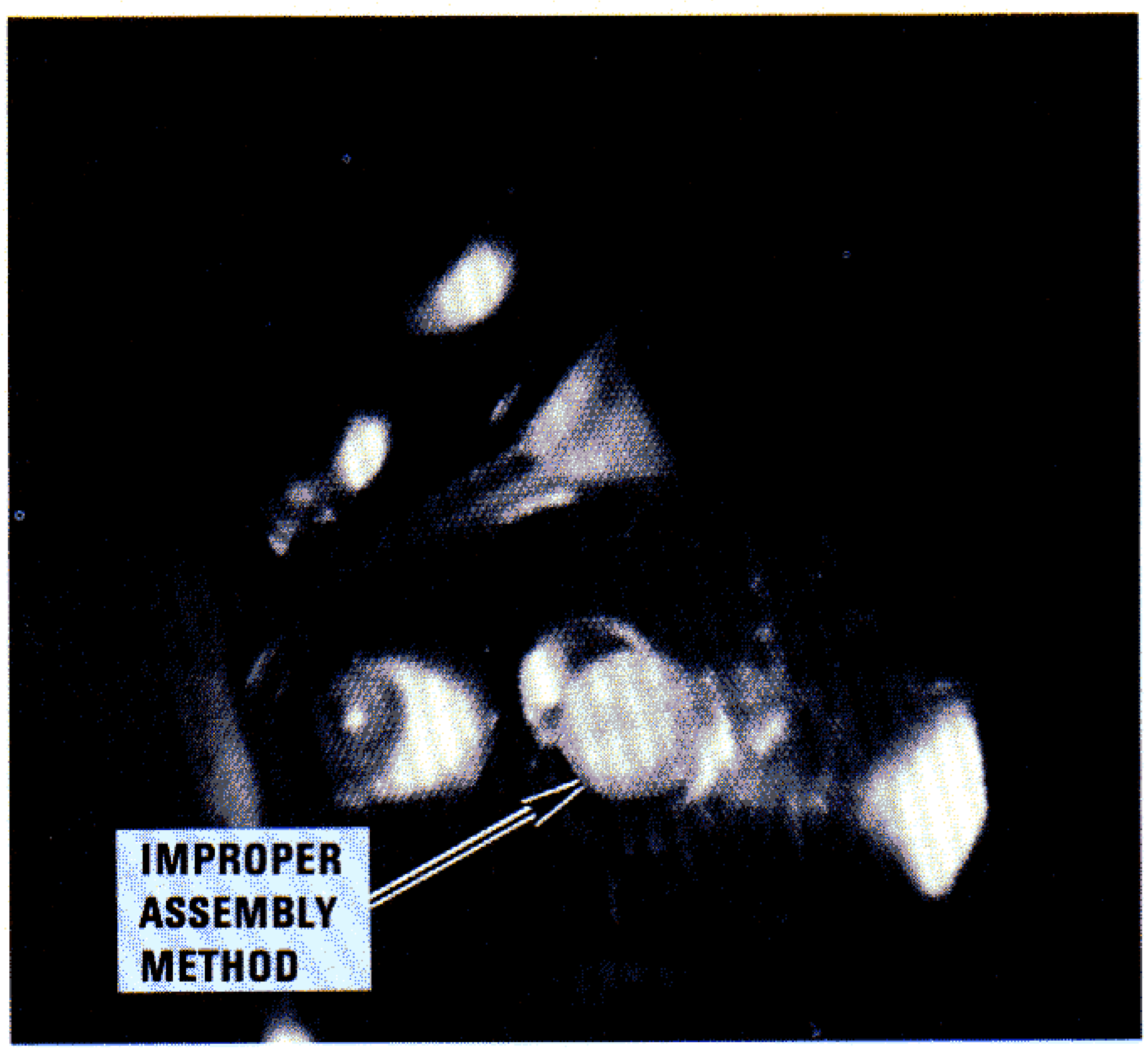
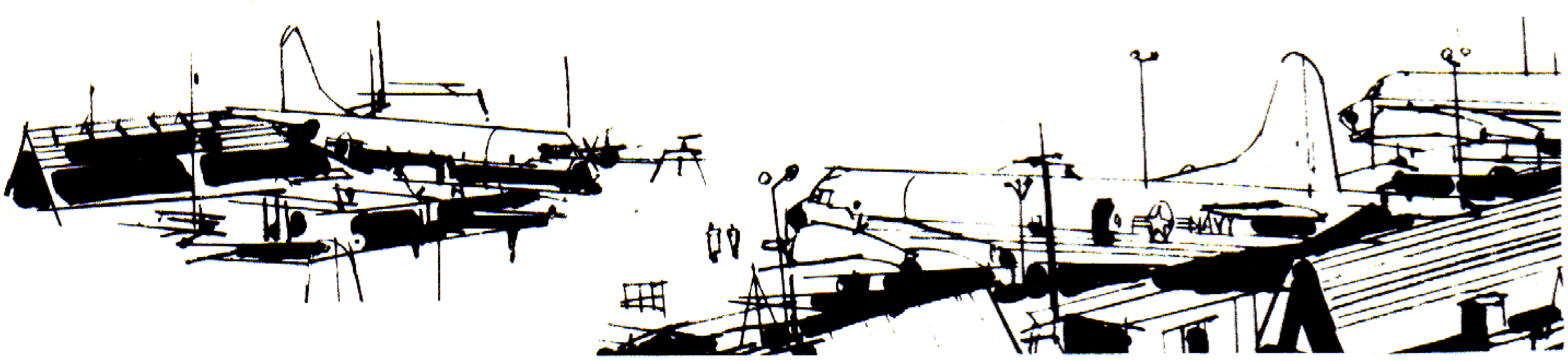


Figure 1. Views of Aircraft Structure as Seen Through a Fiberoptic Borescope.



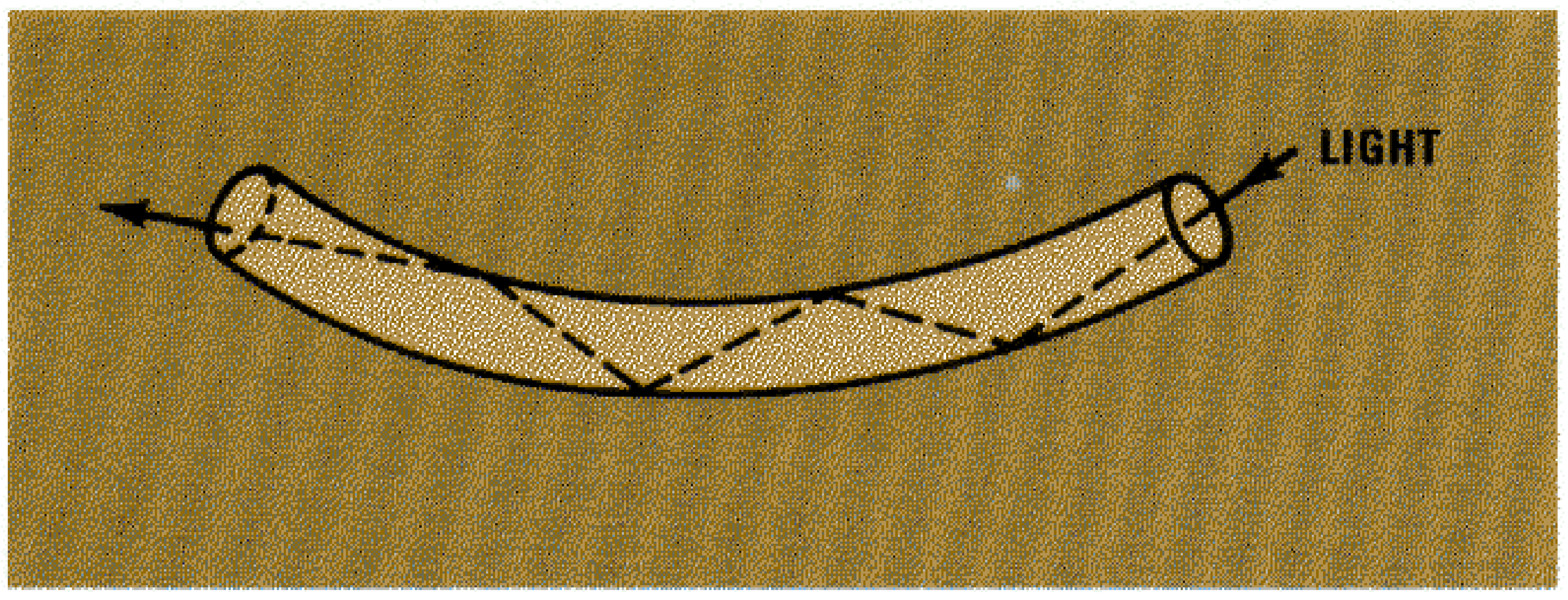


Figure 2. Light is Transmitted Through an Optical Fiber by a Series of Internal Reflections.

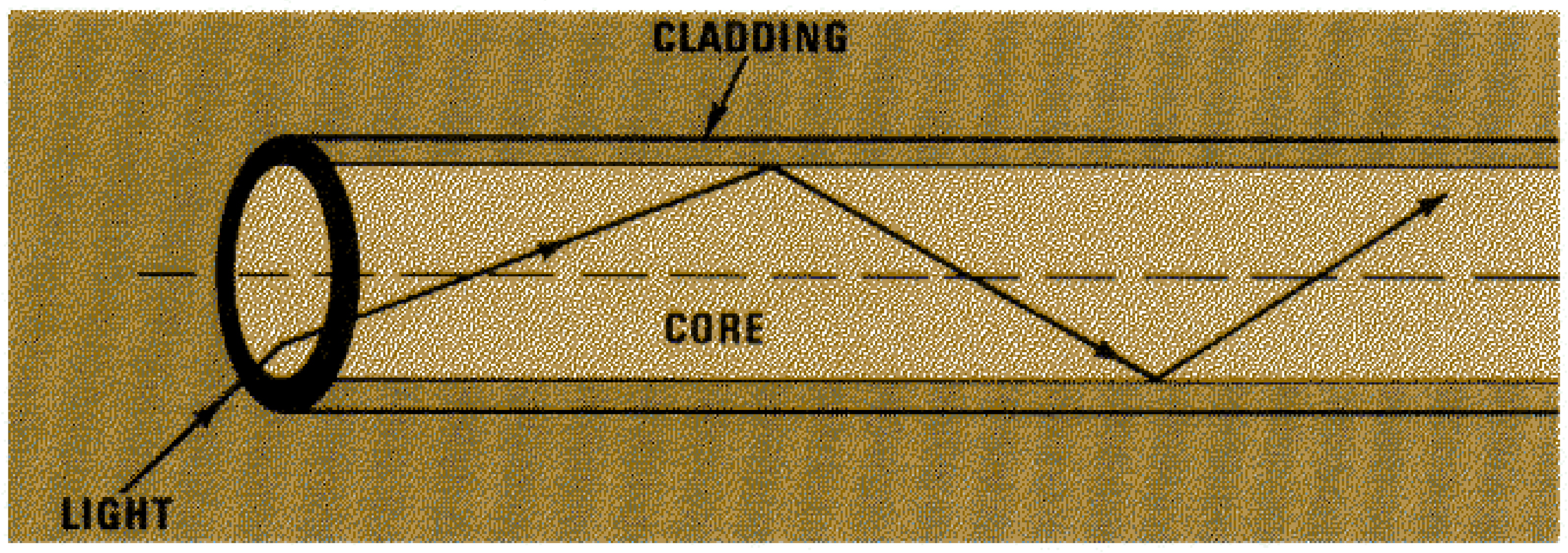


Figure 3. Basic Optical Fiber Consists of the Core and Outer Cladding Material.

The fibers that are used in fiberoptic inspection equipment each have an inner core and an outer coating or "cladding" (see Figure 3). Glass-coated, glass core fibers are most commonly used for image transfer applications. The fiber conducts light by reflecting it along the wall of the core material. The physical characteristics of the cladding material enable the core to conduct the reflected light with almost no light loss. The fiber's cladding also protects the core from scratches and dust, and separates neighboring fibers to prevent light leakage from one fiber to another.

Some fibers are used to transport light, while others are used to transport images. Those fibers that transport light are called light guides, and bundles of fibers put to this use are called light guide cables. The individual fibers usually have no systematic arrangement within the light guide bundle or cable, other than close packing for maximum efficiency.

When bundles of fibers are used to transport images, they become the "fiber" part of the fiberoptic scope or borescope. Each fiber transports one part or component of the image. Together, the optical fiber bundle transports a composite image of the subject. To do this, the fibers at both ends of the optical bundle must be precisely and systematically aligned so that the composite image displayed to the viewer is the same as the subject that is viewed from the tip of the borescope. The image is actually a mosiac of the illuminated ends of the thousands of individual fibers that make up the borescope fiberoptic bundle, a typical presentation of which is shown in Figure 4.

FIBEROPTIC BORESCOPES The typical fiberoptic borescope uses one bundle of systematically arranged optical fibers to transport an image, and another bundle of fibers as a light guide to illuminate the viewing area. The two fiber bundles are enclosed in a protective covering to form the flexible optical viewing bundle of the fiberoptic borescope. Figure 5 shows a schematic of a typical fiberoptic borescope connected to a light source.

An objective lens is installed on the end of the borescope optical viewing bundle that is routed to the area that is to be examined. This is called the *distal* end of the borescope (see Figure 5). A magnifying lens is installed on the other end of the optical viewing bundle. This is called the *proximal* end of the borescope. On most borescopes, the magnifying lens can be adjusted to focus the image for the viewer.

Light is piped from an independent light source by a light guide cable to the borescope, where it is directed by the light guide fiber bundle to illuminate the viewing area. We refer to such

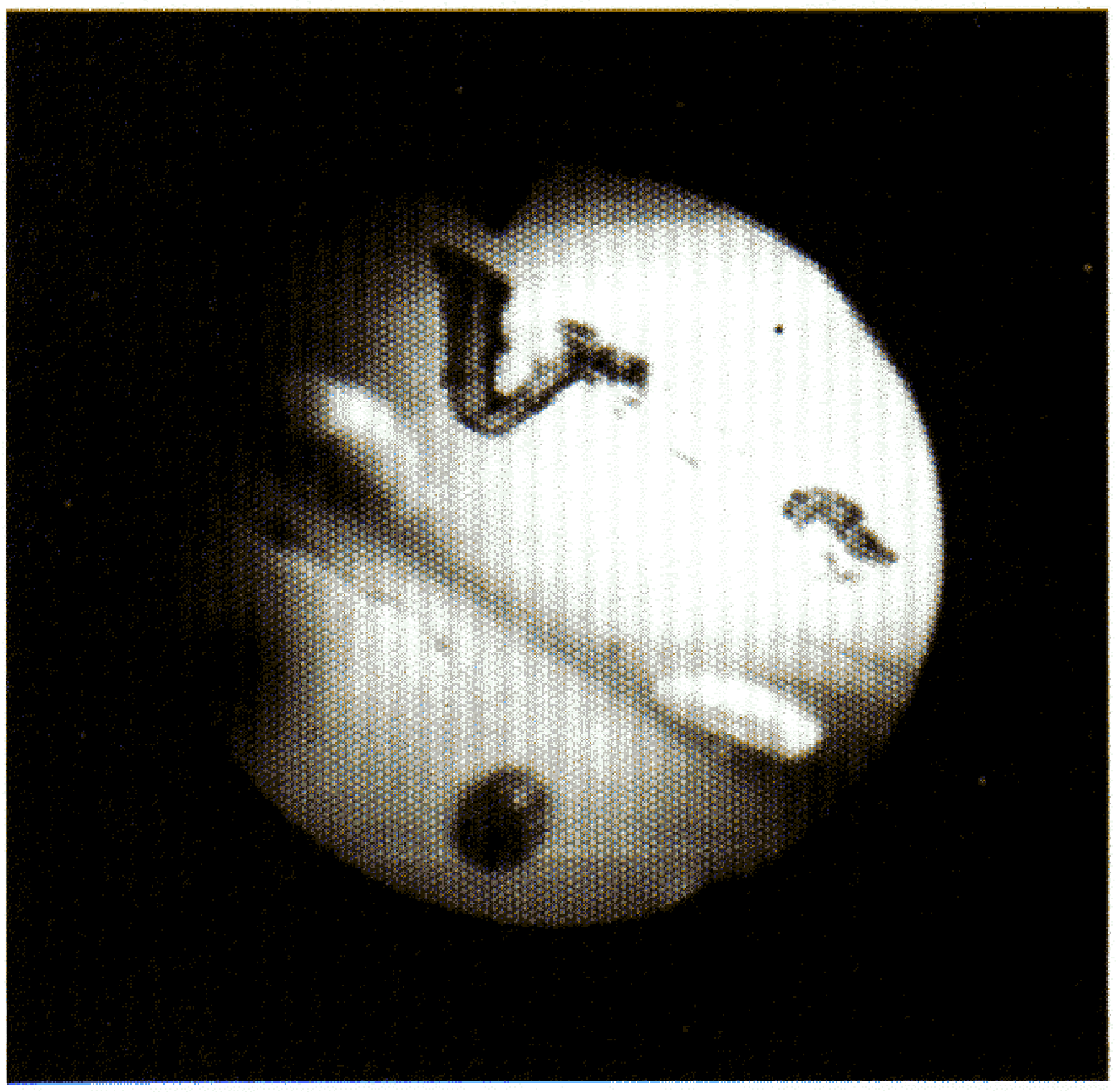


Figure 4. Borescope Image is a Mosaic Made Up of the Illuminated Ends of Optical Fibers.

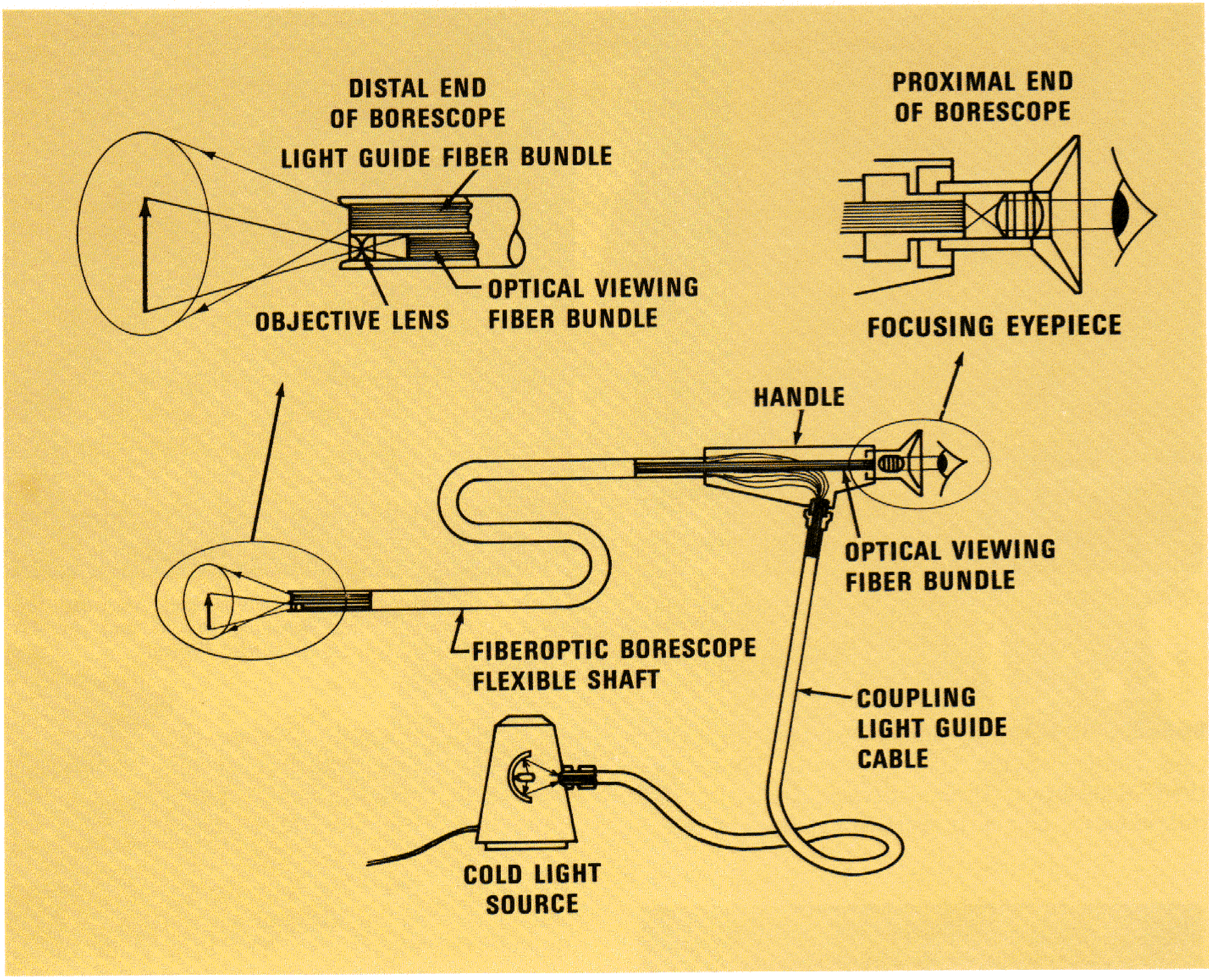


Figure 5. Schematic of Typical Fiberoptic Borescope and Light Source.

illumination as "cold light", because the light source is located remotely from the area being illuminated and no heat is being conducted from the light source to the illuminated area.

P-3 FIBEROPTIC INSPECTION SET

The P-3 fiberoptic inspection set consists of three fiberoptic borescopes sized 4 mm, 6 mm and 11 mm in diameter, a cold light source, a lecture adapter, and a light guide extension cable. Inspection can be made through holes as small as 3/16-inch diameter with the 4 mm borescope. The larger 6 mm and 11 mm fiberoptic borescopes have special operating features such as tip movement, side viewing heads, long fiberoptic elements, and light-weight hand controls. The viewer can select the most appropriate combination of scope size, viewing head and light source power for inspecting a particular location. The set includes individual suitcases for storage of each fiberoptic borescope and the lecture adapter. This equipment, properly stored in the suitcases, can be stowed with the light source equipment in two transit/storage cases. The P-3 fiberoptic inspection set is made up of the borescope set and case, and the borescope light set and case.

Figure 6. 6 mm Fiberoptic Borescope Stored in Suitcase. Storage of 4 mm and 11 mm Fiberoptic Borescopes is Similar.

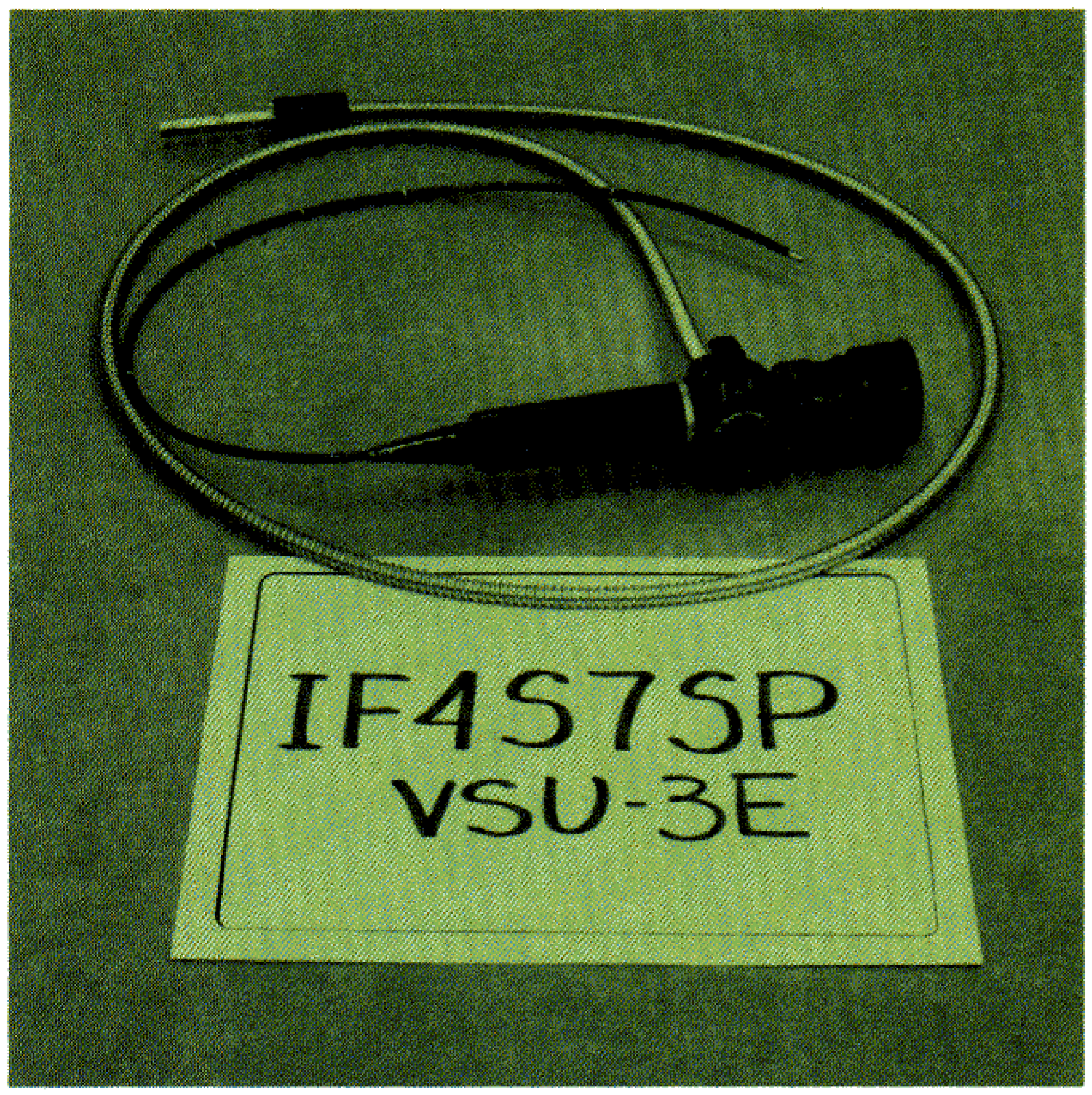


Figure 8. 4 mm Fiberoptic Borescope, Showing the Darker Optical Viewing Bundle and the Armored Light Guide Cable (Typical).

BORESCOPE SET AND CASE The borescope set and case consist of the three fiberoptic borescopes, their accessories, three suitcases (one for each borescope) , and a transit/storage case in which this equipment can be stowed. Figure 6 shows a 6 mm borescope stored in its suitcase (typical), and Figure 7 shows the three borescope suitcases stowed in the borescope set case.

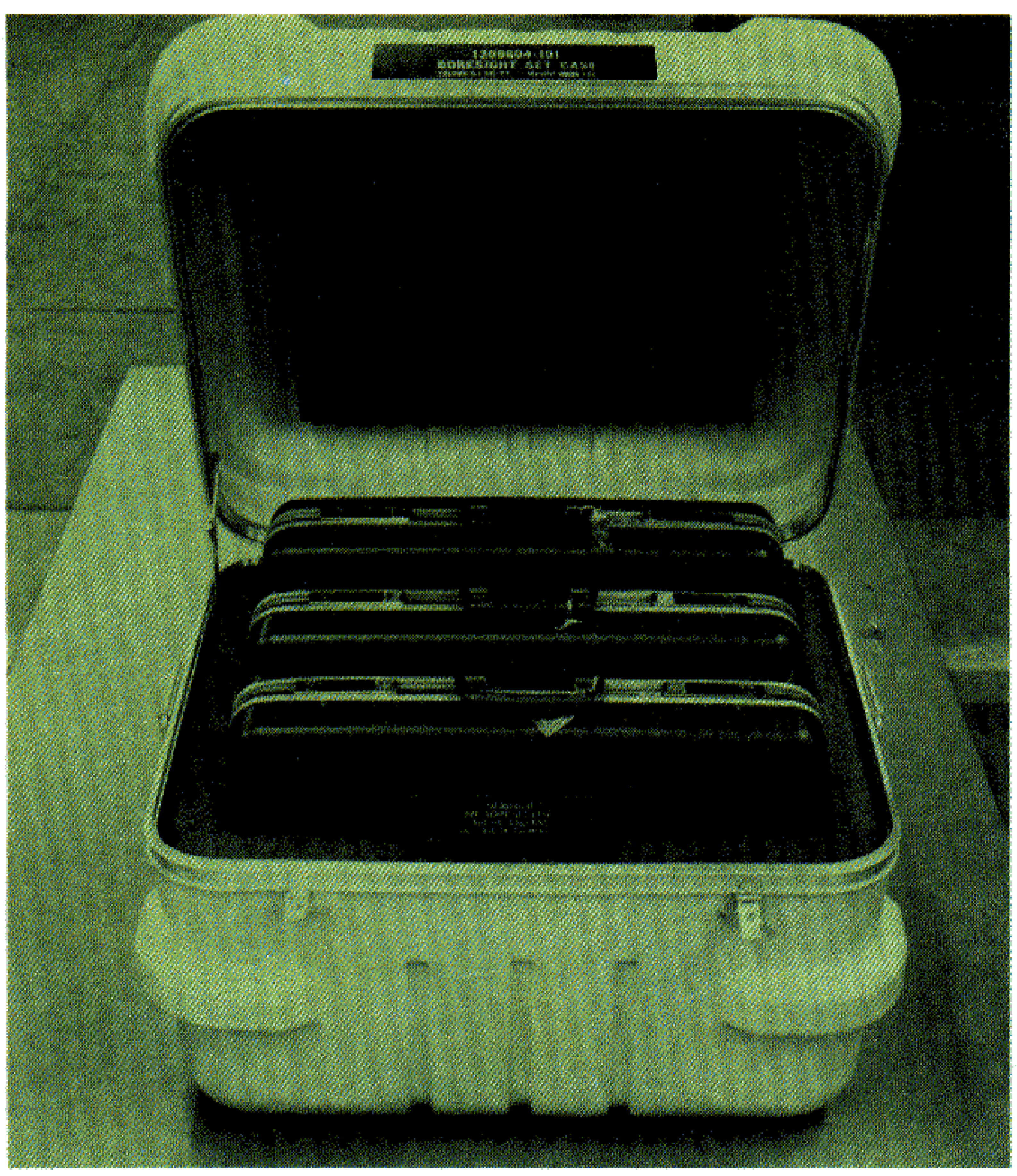


Figure 7. Fiberoptic Borescope Set and Suitcases Stowed in the Borescope Set Transit/Storage Case.

The 4 mm fiberoptic borescope has a 22-inch optical viewing bundle and a 60-inch light guide bundle (see Figure 8). The light guide bundle connects to the borescope cold light source, the operation of which is discussed later in this article. The distal tip of the optical viewing bundle is 0.180 inch diameter. It is a side-viewing tip with a field of view of 52^{o}. The tip may be moved about 120^{o} to the left or right with a thumb control lever on the borescope body. The image is focused with the borescope eyepiece. The 4 mm borescope is recommended for viewing into inspection holes, drain holes, tube interiors, and other areas with very limited access (see Figure 9). The technician should be cautioned that the 4 mm fiberoptic borescope viewing bundle is very delicate. Before inserting or withdrawing the fiberoptic viewing bundle from the inspection area, be certain to straighten the viewing tip by returning the tip thumb control lever to the center position.

The 6 mm fiberoptic borescope has a 70-inch optical viewing bundle, and a 60-inch light guide

Courtesy, U.S. Navy

Figure 9. Maintenance Personnel Using 4 mm Fiberoptic Borescope to Inspect Internal Structure of P-3 Wing.

bundle that connects to the borescope cold light source (see Figure 10). The distal tip is 0.235 inch diameter, and may be moved about 120° left or right with a thumb control lever on the borescope body. The distal tip has a straight-view lens with a field of view of 65°. An adapter fitting may be attached to the distal tip to permit side viewing with a field of view of 65°. The image is focused with the borescope eyepiece. The 6 mm borescope is recommended for use as a general purpose inspection tool. It is light-weight, flexible, and easy to carrry. The 70-inch optical viewing bundle will reach almost all areas that normally require inspection. The two-way articulated viewing head permits side-viewing and can be inserted into narrow passages. The 6 mm viewing bundle is relatively strong, but it requires reasonable handling care during insertion and extraction from the inspection area.

The 11 mm fiberoptic borescope has a 110-inch optical viewing bundle, and a 60-inch light guide

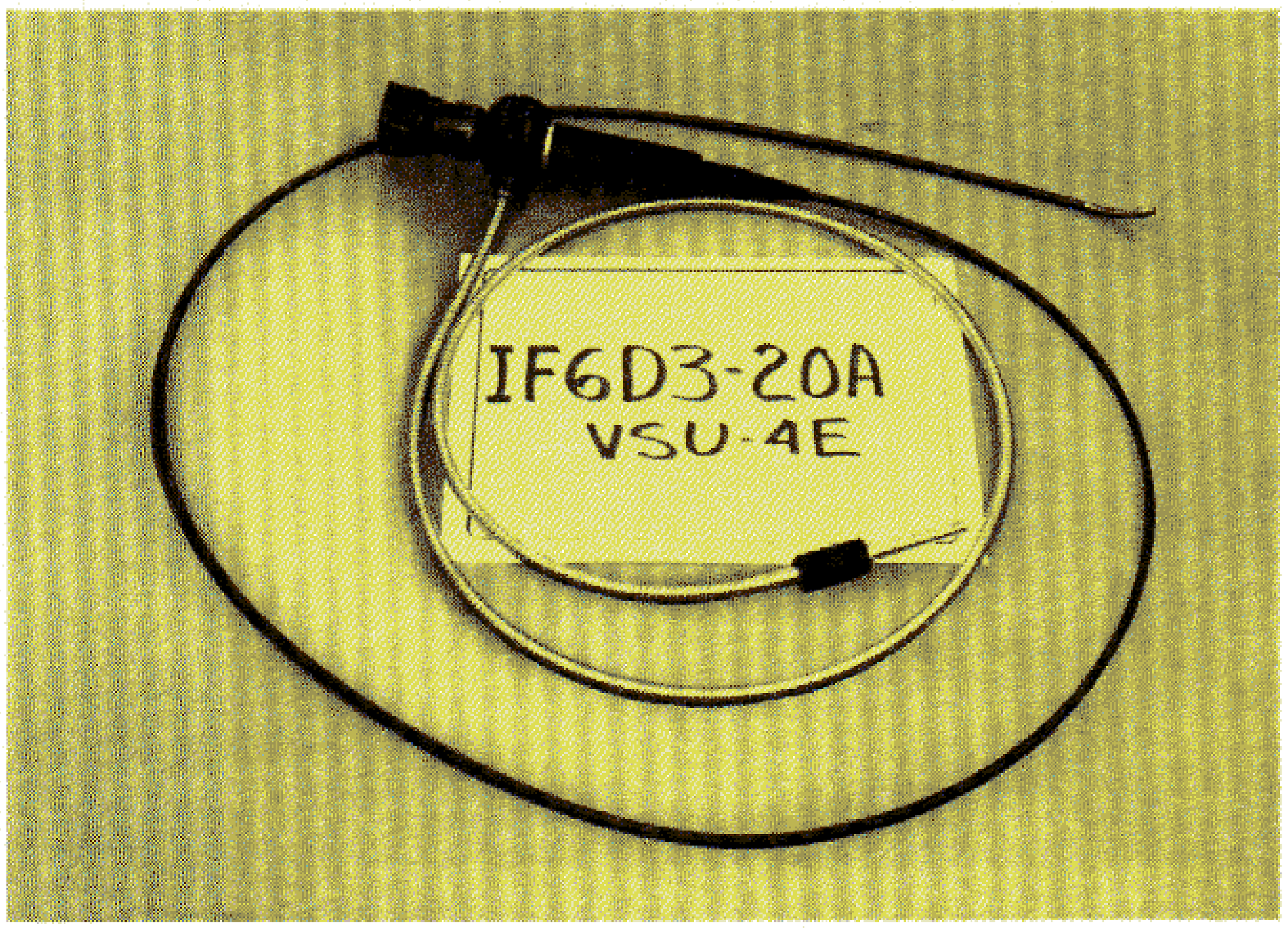


Figure 10. 6 mm Fiberoptic Borescope.

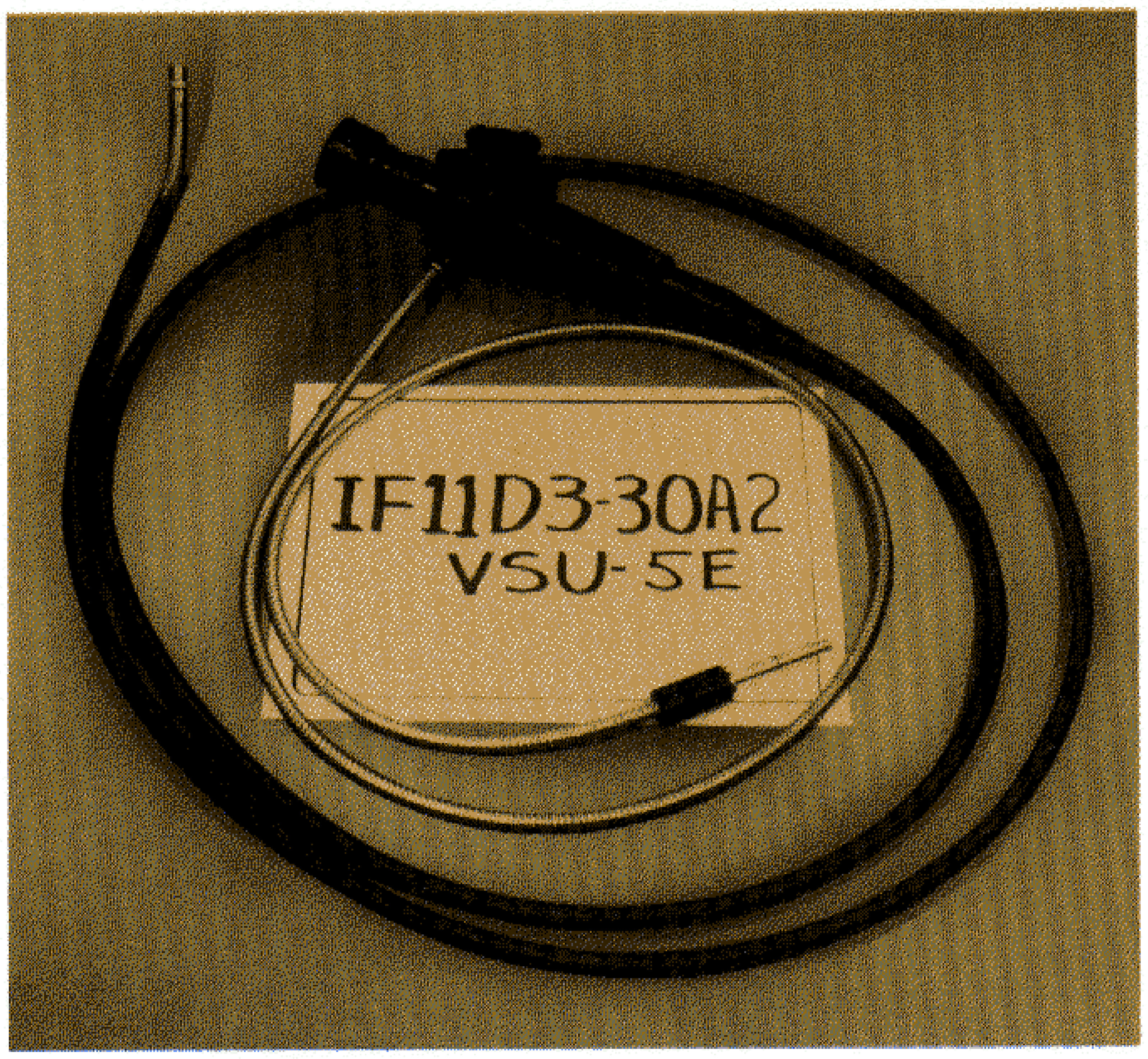


Figure 11. 11 mm Fiberoptic Borescope.

bundle that connects to the borescope cold light source (see Figure 11). The distal tip is 0.450 inch diameter, and may be moved about 100° left or right and up and down (four-way articulation) by using wheel controls on the borescope body. The distal tip is straight-viewing, with a field

Figure 12. Borescope Light Set and Suitcase Stowed in Transit/Storage Case.

Figure 13. Fiberoptic Borescope Cold Light Source Unit and Carrying Strap with Power Cords.

of view of 40°. A wide angle adapter tip provides an 80° field of view straight forward. The image is focused with the borescope eyepiece. The 11 mm fiberoptic borescope is recommended for use during heavy-duty structural inspections, where viewing from a distant remote location is necessary. The four-way articulated distal tip facilitates entry of the borescope into structural areas when large areas are to be illuminated and viewed. The 11 mm fiberoptic viewing bundle is strong, but it still requires reasonable handling care during insertion and extraction from the viewing area.

BORESCOPE LIGHT SET AND CASE The borescope light set consists of the light source unit, a light guide extension cable, four spare bulbs, the borescope lecture adapter, a suitcase, and a transit/storage case. Figure 12 shows the borescope light set stowed in its storage case.

The borescope light source is a cold light-type unit that provides high intensity illumination. Light is piped from the source, through the borescope light guide cable, and directed on the viewing area. The light source unit is shown in Figure 13. The light source unit has a female receptacle on the front panel, to which the borescope light guide cable or the light guide extension cable is connected. The light source uses a 150-watt halogen lamp of the type used in motion picture projectors. Brightness may be adjusted by a control knob on the light source panel. A spare lamp is installed on a turret in the light source and can be rotated into operating position if the other bulb burns out. Lamps may be replaced through a door on the bottom of the light source unit. Spare lamps are stored in the borescope light set case.

The borescope light source unit may be operated on either 115V a.c. or 230V a.c. power, from 50 Hz to 400 Hz. A voltage selector switch is located on the rear of the unit. The light source is furnished with a standard electric power cord, complete with three-prong wall plug, for hookup to 60 Hz base power, a 60 Hz mobile power plant, or to aircraft 400 Hz two-prong power receptacles. A second power cord is supplied without a wall plug connector, which permits maintenance personnel to fabricate a power cable assembly that mates with other suitable electrical power sources.

The light source is equipped with a shoulder strap so that the unit can be easily carried from one inspection location to another. The technician may also elect to carry the light source while using the fiberoptic borescope. If the light source is placed on a table, floor or other surface, be certain that the surface is free of vibrations in order to protect the lamp filament. Also, be certain that the unit is positioned so that its ventilation ducts are not obstructed.

Since the light source is *not* explosion-proof, certain precautions must be observed when using the borescope. This equipment may be used in and around aircraft only in those areas that have good ventilation, that are free of all explosive vapors, or that have been certified as safe and gas-free by an authorized engineer.* Lockheed is investigating the availability of a compatible explosion-proof light source for P-3 fiberoptic inspection equipment.

The lecture scope adapter snaps on to the eyepiece of any of the three fiberoptic borescopes and permits a second person to view the inspection image. Figure 14 shows maintenance personnel

---

**Explosive gas detectors are available to authorized personnel through normal Navy supply channels.*

Courtesy, U.S. Navy

Figure 14. Maintenance Personnel Using a Fiberoptic Borescope (left) and Lecture Adapter (center) to Examine an Engine Air Inlet Duct.

Figure 15. Borescope Light Guide Cable Extension.

using a fiberoptic borescope (left) and a lecture scope adapter (center) to examine an engine air inlet duct. The lecture scope adapter permits the second viewer to be up to three feet from the borescope, and its eyepiece can be focused to suit the vision of the second viewer. A colored dot on the borescope and a corresponding dot on the mating adapter are aligned when the adapter is installed properly.

The light guide cable extension shown in Figure 15 enables the borescope cold light source to be located up to 15 feet from the technician. The light guide cable extension is a 10-foot optical fiber bundle enclosed with a flexible stainless steel cover. It has a male connector that attaches to the light source unit, and a female connector that attaches to the borescope light guide cable.

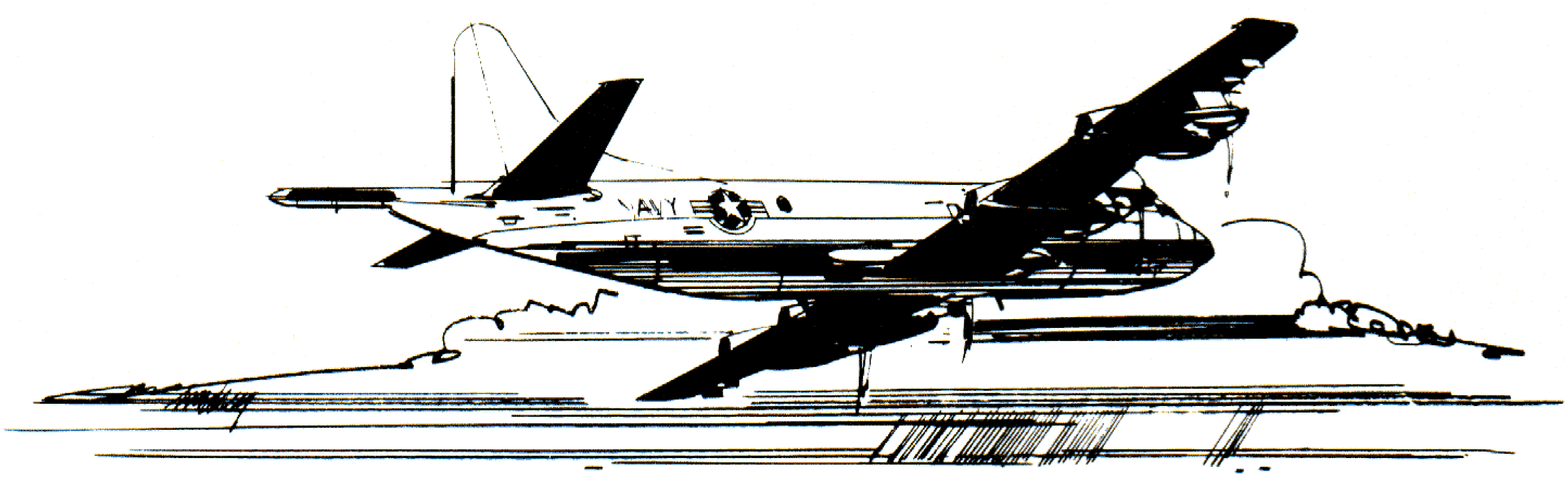
Although there is some loss of light transmission from the source when the light guide cable extension is used, it is a valuable tool when confined areas do not permit the light source to be located close to the borescope.

WHERE TO USE A FIBEROPTIC BORESCOPE

P-3 fiberoptic borescope inspection equipment is primarily intended for viewing areas where limited access makes visual inspections difficult. This permits the viewer to readily examine such areas without resorting to extensive disassembly of structure or components. Indeed, some locations may be so difficult to inspect that fiberoptic equipment may offer the only practical means of performing an inspection. Figure 16 shows a technician using P-3 fiberoptic inspection equipment to view areas beneath an electronics rack that are obscured by structure and equipment. Note that the technician has elected to carry the borescope cold light source with the convenient shoulder strap.

The aircraft systems, components and installations listed in Table I require both scheduled and unscheduled inspections. They are important candidates for examination using the P-3 fiberoptic inspection equipment because of the difficulties that they present for visual inspecions. Doubtless, maintenance personnel will find further applications for fiberoptic inspection equipment as they gain experience with it.

Lockheed ORION Service Digest



Courtesy, U.S. Navy

Figure 16. Maintenance Technician Using Fiberoptic Borescope to Inspect Areas Beneath an Electronics Rack.

AIRCRAFT SYSTEMS REQUIRING SCHEDULED AND UNSCHEDULED INSPECTION

- PNEUMATIC RESERVOIRS
- WING SPAR CAPS
- WING LEADING EDGE AND TRAILING EDGE INTERNAL AREAS
- QEC UNIT INTERNAL AREAS AND ENGINE MOUNTS
- NACELLE INTERNAL AREAS UNDER THE ENGINE SHROUD
- EMPENNAGE LEADING AND TRAILING EDGE INTERNAL AREAS
- FLIGHT STATION UNDERFLOOR
- CABIN UNDERFLOOR
- CONTROL CABLES IN WING LEADING EDGE
- EXTERIOR SURFACES OF WING LEADING EDGE DUCTS
- SONOBUOY LAUNCH TUBES
- RUDDER AND ELEVATOR CONTROL CABLES
- QEC BLEED AIR DUCTS
- EXHAUST SWIRL STRAIGHTENER
- ENGINE DRIVEN COMPRESSOR
- APU BLEED AIR DUCTS AND AIR CONDITIONING DUCTS

Table I. Suggested Areas for Conducting Inspections with Fiberoptic Borescopes

LOCKHEED ORION SERVICE DIGEST
ALPHABETICAL INDEX, ISSUES 1 THROUGH 40

LOCKHEED-CALIFORNIA COMPANY
PRODUCT SUPPORT – GOVERNMENT PROGRAMS

R. L. MOORE, VICE PRESIDENT

DIRECTOR INT'L SUPPORT PROGRAMS	DIRECTOR P-3 SUPPORT	DIRECTOR S-3 SUPPORT
A. B. Stacey	H. A. Franck	B. F. Bernstein

FIELD SUPPORT DIVISION – W.C. BOWDEN, MANAGER

P-3 Services	**D.R. Steele, Manager**
S-3 Services	**A.J. Neibauer, Manager**
Military Field Modifications	**J.N. Shovald, Manager**
Advanced Systems and Administration	**P. M. Hemberg, Manager (Acting)**
Weapon System Analysis Board	**W.H. Rice, Jr., Manager**

FIELD SERVICE OFFICES

MAJOR LOCATION	MAILING ADDRESS AND BUSINESS TELEPHONE
NARF Alameda P. H. Gerard	P.O. Box 1363 NAS Alameda, CA 94501 (415) 869-4696/521-2283
NAVAIRSYSCOM, Arlington E. O. Skidmore F. A. Warner (PMA-240)	Lockheed-California Co. 1745 Jefferson Davis Hwy Suite 400, Crystal Square, Bldg. 4 Arlington, VA 22202 (202) 872-5929
NAS Barbers Point A. W. Vitaglin	P.O. Box 268 NAS Barbers Point, HI 96862 (808) 681-3444/682-3671
NAS Brunswick K. M. Prideaux	P.O. Box 38 Brunswick, ME 04011 (207) 921-2472/921-2521
NAS Cecil Field E. S. Skultety	P.O. Box 162 NAS Cecil Field Jacksonville, FL 32215 (904) 772-8517/ 772-0369
NS Cubi Point. R.P. D. L. Lannigan	P.O. Box 47 FPO San Francisco, CA 96654 Cubi Point 63-8-885-6163
Greenwood CFB, Canada E. C. Joslen	P.O. Box 1300 Greenwood, Nova Scotia Canada B0P 1N0 (902) 765-3385/765-3386
NAS Jacksonville S. L. Solomon	P.O. Box 31300 Jacksonville, FL 32230 (904) 772-3535/772-1527
NAS Moffett Field R. Pond	P.O. Box 159 Moffett Field, CA 94035 (415) 966-5461

MAJOR LOCATION	MAILING ADDRESS AND BUSINESS TELEPHONE
NS Naples, Italy T. E. Stratton	Lockheed-California Co. COMFAIRMED/NSA Box 2 FPO New York, NY 09521 Naples 081-724-4434
CNAVRES New Orleans G. A. Seipp	P.O. Box 3906 New Orleans, LA 70177 (504) 948-1220
NAS Norfolk W. H. Beydler	P.O. Box 15148 U.S. Naval Base Norfolk, VA 23511 (804) 423-8321
NAS North Island D. K. Payne	P.O. Box 5, NAS North Island San Diego, CA 92135 (714) 435-8910
Ottawa, Canada R. S. Blake	LAC of Canada, Ltd. 255 Albert St. Suite 603 Ottawa, Ontario Canada K1P 6A9 (613) 238-8141
NATC Patuxent River M. D. Garino	P.O. Box 218 NATC Patuxent River, MD 20670 (301) 863-8186
NADC Warminster J. A. MacMullen	196 West Street Rd. Warminster, PA 18974 (215) 674-3550
ASO Philadelphia J. P. Murphy	P.O. Box 7051, Blvd Station Philadelphia, PA 19149 (215) 697-3287

FAIRECONRON · 1

LOCKHEED-CALIFORNIA COMPANY • A DIVISION OF LOCKHEED CORPORATION