22
06/23/80
MA
NTIS
240

SAND80-0459
Unlimited Release

MASTER

Downhole Television (DHTV) Applications in Borehole Plugging

Charles L. Christensen, Robert D. Statler, Sandia Laboratories
E. W. Peterson, Systems, Science and Software

Prepared by Sandia Laboratories, Albuquerque, New Mexico 87185
and Livermore, California 94550 for the United States Department
of Energy under Contract DE-AC04-76DP00789

Printed May 1980

Sandia National Laboratories

SF 2900-Q(3-80)

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

ONWI/SUB/80
E-511-03700 TRDHTV
APRIL 1980

SAND80-0459

DOWNHOLE TELEVISION (DHTV) APPLICATIONS IN BOREHOLE PLUGGING*

C. L. Christensen and R. D. Statler
Sandia National Laboratories
Albuquerque, New Mexico 87185

and

E. W. Peterson
Systems, Science and Software
La Jolla, CA

*This work is supported by the U.S. Department of Energy

ACKNOWLEDGMENT

The authors wish to thank Bill Wilson of Sandia National Laboratories for assisting with the on-site setup and support for the DHTV system, Frank Hensley for editing the television tapes and providing the still photographs for this report, Bob Goodwin of D'Appolonia for encouraging the issuance of this document, and Janis Purcell and Wendell Smith for assisting with editing and layout.

CONTENTS

INTRODUCTION

The Borehole Plugging (BHP) Program is a part of the Sandia experimental program to support the Waste Isolation Pilot Plant (WIPP).[1] The Sandia BHP program is an Office of Nuclear Waste Isolation (ONWI)-funded program designed to provide inputs to the generic plugging program while simultaneously acquiring WIPP-specific data. For this reason a close liaison is maintained between the Sandia WIPP project and the ONWI generic program. Useful technology developed within the Sandia BHP to support WIPP is made available and considered for further development and application to the generic Borehole Plugging and Repository Sealing Program at ONWI.[2] The purpose of this report is to illustrate the usefulness of downhole television (DHTV) observations of a borehole to plan plugging operations.

BACKGROUND

The Sandia BHP includes a field test program for testing candidate plugs in situ. One such field test now in progress is the Bell Canyon Test.[3] While conducting permeability measurements during this test, a need arose to locate competent packer seats in a borehole. The nature of this testing required that locations having a minimum of five linear feet of undisturbed wellbore wall be identified. The accepted procedure to locate these seats is to identify them by use of a caliper log; however, in our case, after several failures to obtain satsifactory seats, it was decided that some technique other than a caliper log selection process was required. Accordingly, a local water-well service company, which uses a closed-circuit TV system, was hired to assist in selecting the desired packer seats. (A more detailed description of the rationale in selecting a packer seat location for a precision permeability measurement is presented in Appendix A.) The results of this service are presented here as information for those unfamiliar with the appearance of a wellbore at depth. This report is an attempt to make these results generally available.

The photographs included herein were randomly selected from a video tape of the actual wellbore DHTV survey to illustrate the types of wellbore conditions that may be encountered, especially in formations subject to dissolution effects.

EQUIPMENT

As noted, the DHTV rig was part of a hired service, generally used for logging of local water wells. Application to a field test program requiring accurate and repeatable positioning within inches was not intended. The system consisted of a van with a 3000-foot cable reel, drive and controls mounted in the rear; a nominal 6-inch OD video camera, including two lighting arrangements--one for dry holes and one for underwater operations; video monitor and a video recorder capable of superimposing the cable reel footage readings. The rig included a well-head pulley arrangement to lower the assembly into the wellbore, and the entire operation was conducted by one operator and a helper. Assembly time required about one hour.

RESULTS

The accompanying illustrations provide an indication of the wellbore conditions observed. Figures 1 and 2 illustrate the equipment and setup procedure used in the evaluation of AEC-7 for the Bell Canyon test series. Figures 3-8 present a sequence of pictures at various depths as the DHTV rig is lowered through the wellbore. Sample photographs taken with both dry and underwater lamps for illumination are included. The caliper logs for the same depth are included for comparison. Again, the reader is cautioned not to try to make depth correlations closer than 12 to 24 inches because of the uncalibrated nature of the TV cable system. General comments are provided on the illustrations.

CONCLUSIONS

The use of downhole television provides additional knowledge of wellbore conditions. While only qualitative at this stage, the potential usefulness of this technique is obvious. While in some cases the correlation to the caliper log is good, there is evidence that a one-arm caliper will miss some of the cavities picked up by the camera. Extension to three- and six-arm calipers can reduce this risk but adds complexity and expense. In those cases where knowledge of the wellbore condition is required, as in a field test program for borehole plugging, the DHTV system can be invaluable.

Sandia National Laboratories is in the process of assembling a downhole system which will provide greater depth capability for DHTV coverage and will also include a limited wire line logging capability for monitoring downhole pressures, temperatures, and other selected borehole conditions.

REFERENCES

1. Christensen, C. L. and T. O. Hunter, Waste Isolation Pilot Plant (WIPP), Borehole Plugging Program Description, January 1, 1979, SAND79-0640, Sandia National Laboratories, Albuquerque, NM 87185, August 1979.

2. Office of Nuclear Waste Isolation, Program Plan and Current Efforts in Repository Sealing for the NWTS Program, ONWI-54, p. 12, Battelle Memorial Institute, Columbus, OH, October 1979.

3. Christensen, C. L., Bell Canyon Test, WIPP Experimental Program, Borehole Plugging, SAND79-0739, Sandia National Laboratories, Albuquerque, NM 87185, June 1979.

APPENDIX A

PACKER ELEMENT/BOREHOLE INTERFACE SEALING

E. W. Peterson
Systems, Science and Software

The measurement of liquid and gas flow through geologic media possessing microdarcy-range permeabilities is recogized as an important technical consideration in the design of nuclear waste repositories and associated barrier zones. Conventional oil-field technology developed and successfully used for testing millidarcy-range formations has not addressed certain problems inherent in performing reliable, reproducible, quantitative measurements in the microdarcy range. One unresolved problem is that of forming a sufficiently tight seal along the packer element/borehole interface so that conventional pressure buildup, fluid production, and injectivity tests can be performed. While three-arm caliper logs are beneficial in identifying borehole intervals possibly suitable for packer placement, the added resolution provided by a closed-circuit TV log becomes invaluable when testing microdarcy-range media. Examples of packer/borehole sealing requirements for such testing are given below.

In conjunction with the borehole plugging program at the WIPP site, in situ testing has been performed to determine the salt bed permeability at the proposed repository level, the formation permeability at the plug emplacement position, and the capability of the borehole plug to block flow from a high-pressure aquifer. Each of these tests presents different requirements for packer/borehole sealing if quantitative data are to be obtained.

Permeabilities of the salt beds were evaluated using the guarded straddle packer system shown in Figure A-1. The protected volumes afford a means of quantitatively assessing both the horizontal and vertical flow components.

This latter quantity, which is not measured using conventional systems, must be measured when testing formations with microdarcy-range permeabilities to insure that any flow bypassing packers closing off the test interval is small compared to that entering or leaving the formation. Test intervals range from 30 to 60 meters, and their surface area is large compared to the wellbore cross-section area. As a result, this measurement has the least severe packer/borehole seal requirements of those discussed. Even so, working with air at a control-zone pressure of .8 MPa requires the leak rate past the enclosing packers be $<$ 10 SCCM (e.g., equivalent water flow $\approx 3 \times 10^{-4}$ STB/D), if formation permeabilities in the order of a microdarcy are to be measured.

The most stringent measurement requirements occur when performing plug-zone integrity tests or when evaluating plug performance. The standard configuration for performance evaluation is shown on Figure A-2. Tests performed to date evaluated either the fluid buildup or pressure buildup. With the configuration shown, a 16.0 MPa pressure is maintained in the annulus above the umbrella packer (i.e., the borehole makes water). In order to measure a flow corresponding to that occurring through a cement plug having a microdarcy permeability, the flow around the umbrella packer must be on the order of $< 10^{-5}$ STB/D.

The preceding examples illustrate some requirements that must be satisfied when performing in situ testing supporting nuclear waste isolation programs. Packer element/borehole interface seal requirements are so critical that they obviously cannot be assured pre-test even by visual examination of the borehole, since gap or fracture dimensions (i.e., see insert on Figure A-2) must be $< 10^{-5}$ cm. Final evaluation of the seal integrity can, many times, be done only through post-test data evaluation. However, it must be emphasized that visual examination of the borehole provides improved wellbore surface definition and would certainly supplement three-arm caliper logs. In that respect, use of the DHTV saves rig time by greatly increasing the chance of setting the packer in a competent zone.

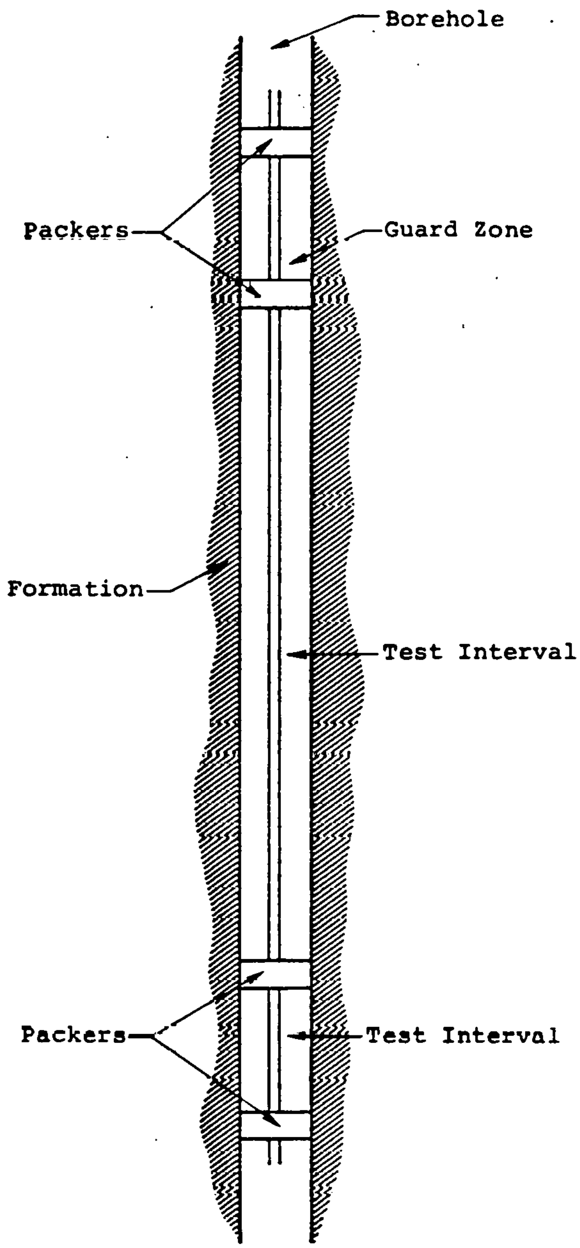


Figure A-1. Sketch Showing the S-Cubed Guarded Straddle Packer System.

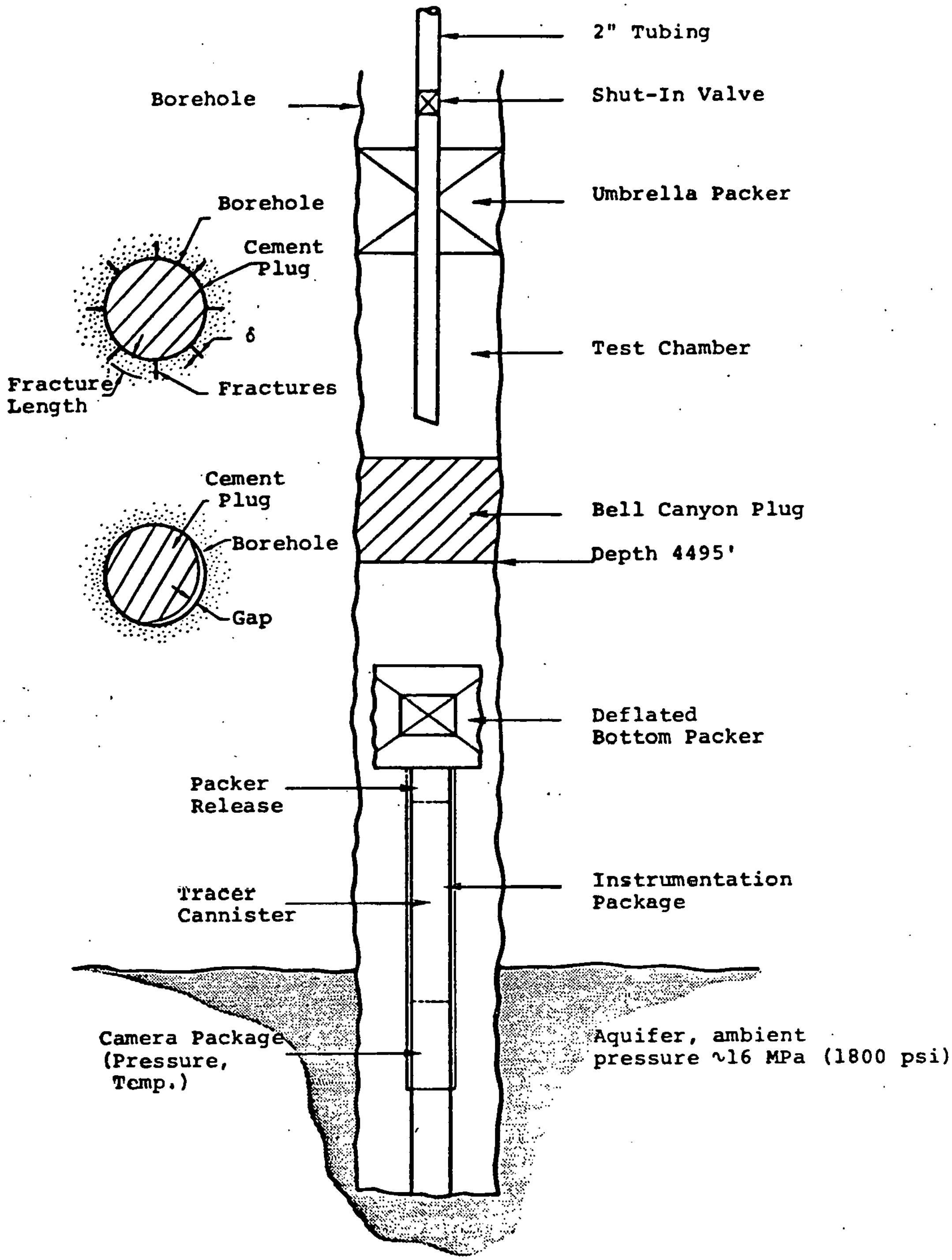


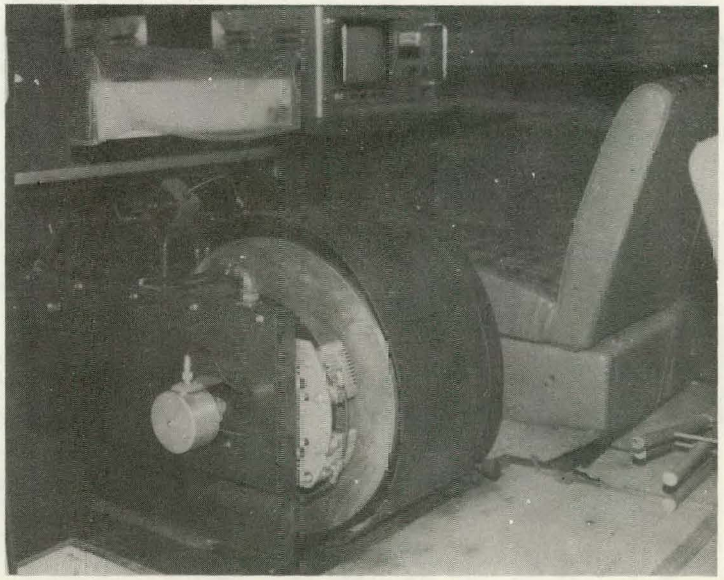
Figure A-2. Sketch Showing Configuration Used for Evaluation of Bell Canyon Plug Performance.

ILLUSTRATIONS

A

B

C



D

Figure 1 A-D. Arrival On Site and Rig Setup

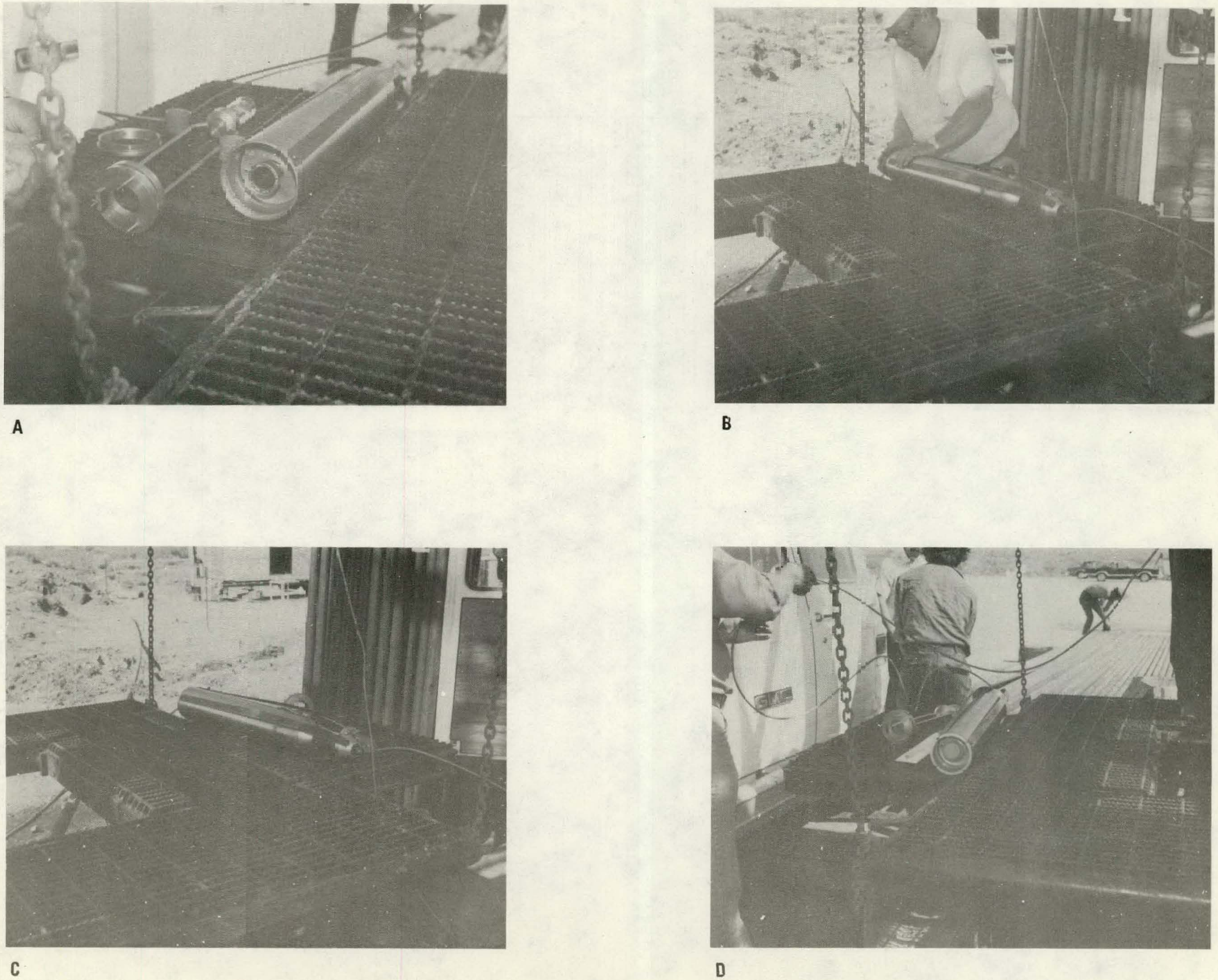
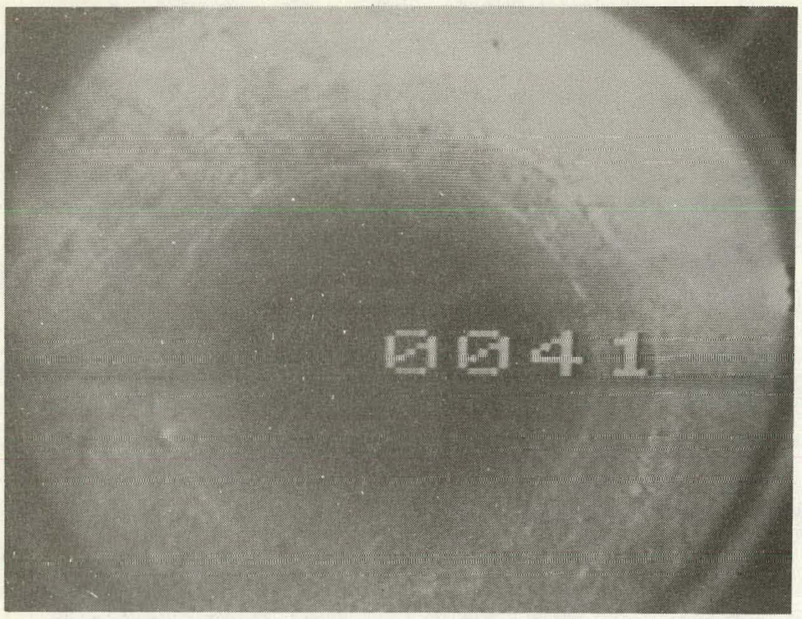


Figure 2 A-D. Close-up of Down Hole Television (DHTV) Camera Head



A

B

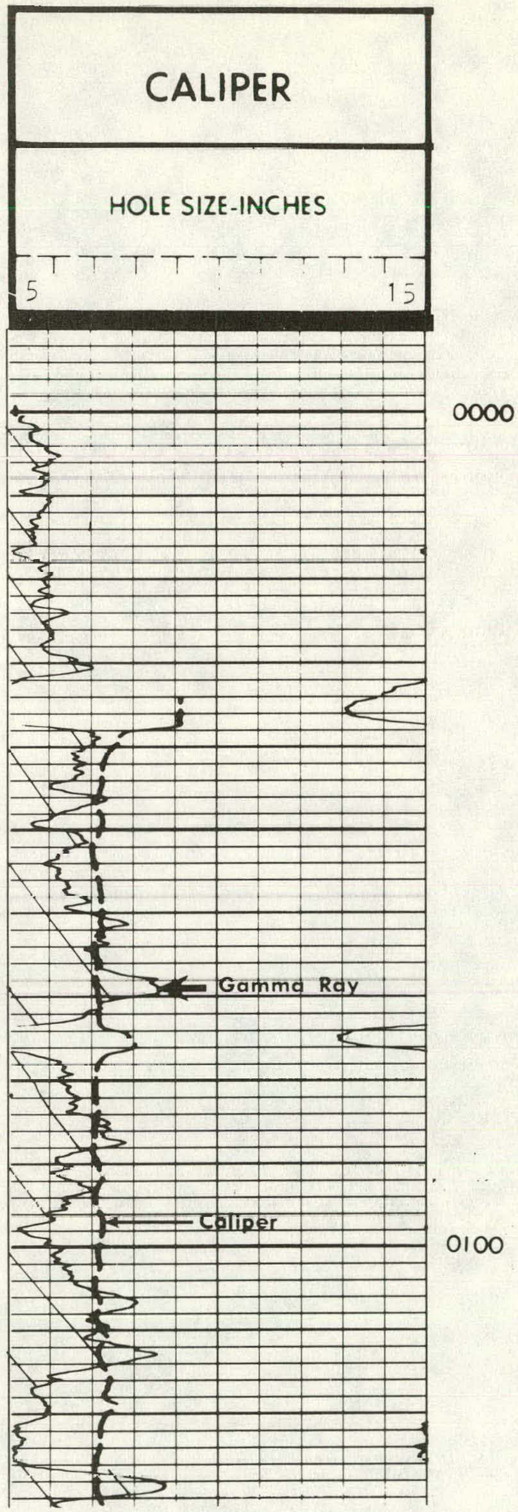
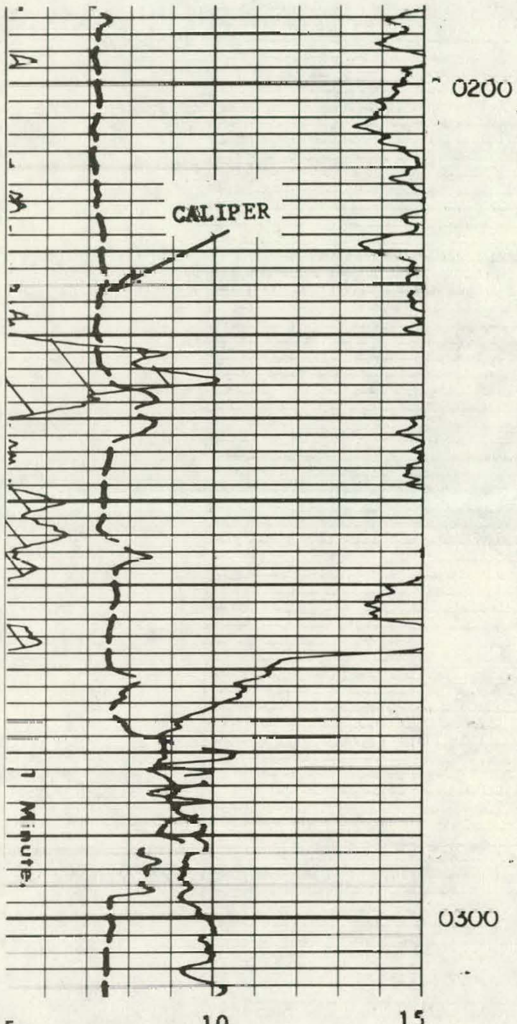
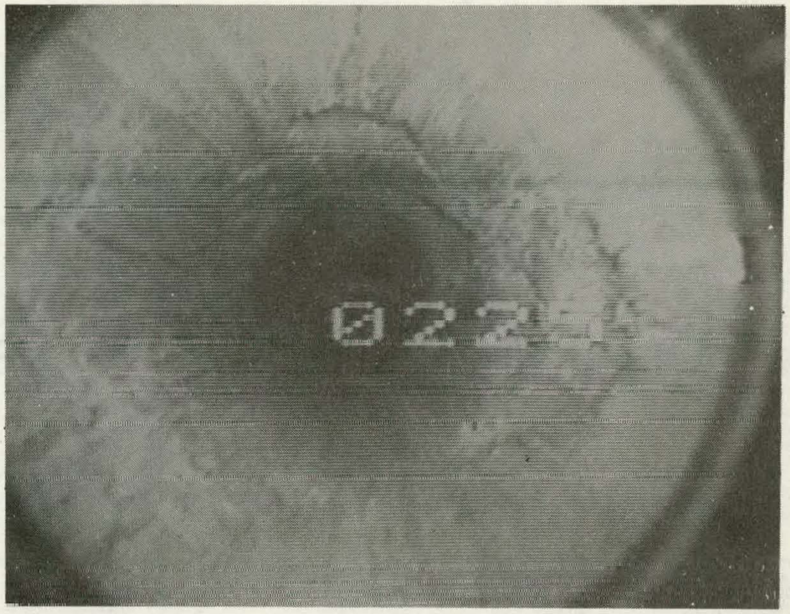
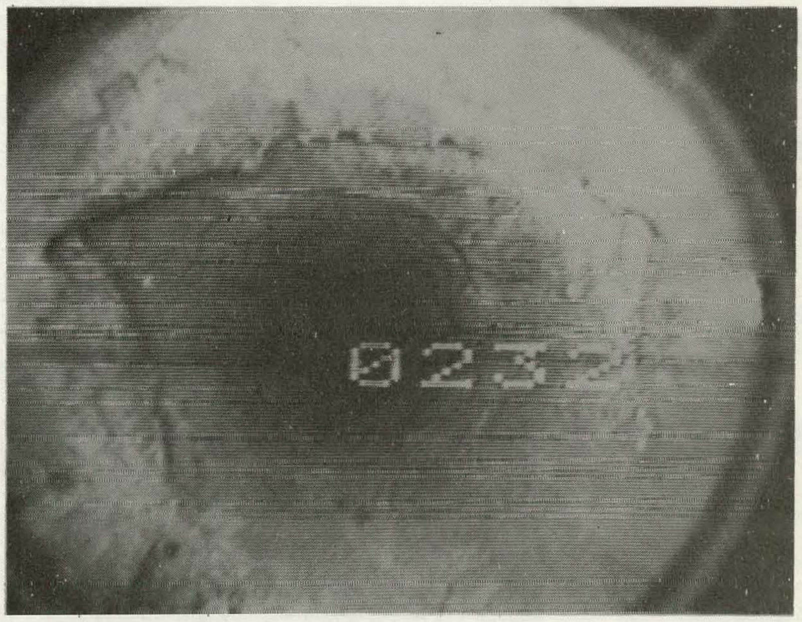


Figure 3 A-D. DHTV With Dry Lamp in Dry Environment; Lithology With Increasing Depth Typically Sandstone, Siltstone, Mudstone


0200
CALIPER
1 Minute
0300
5
10
15
HOLE DIAMETER (INCHES)


0224

C


0232

D

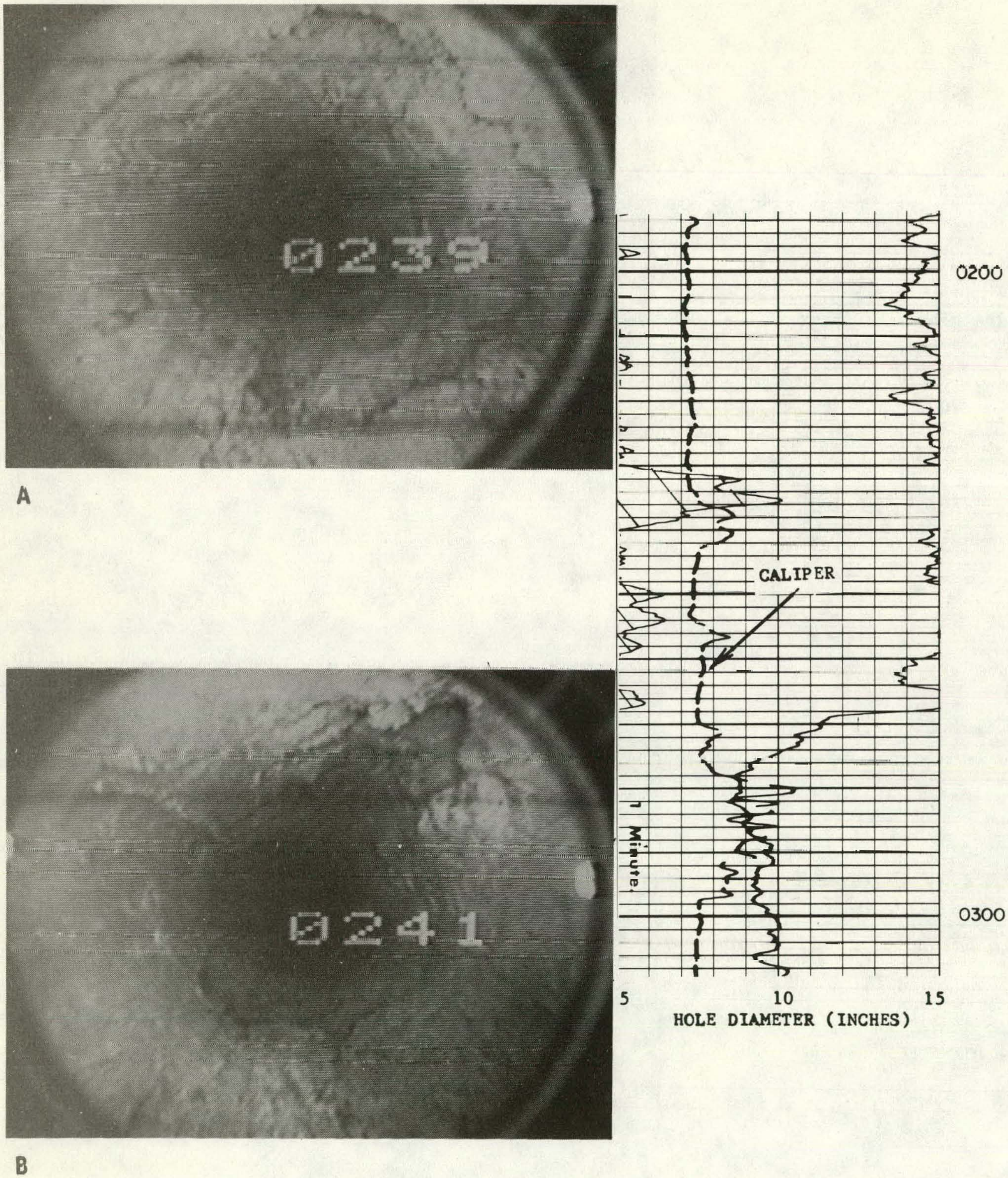
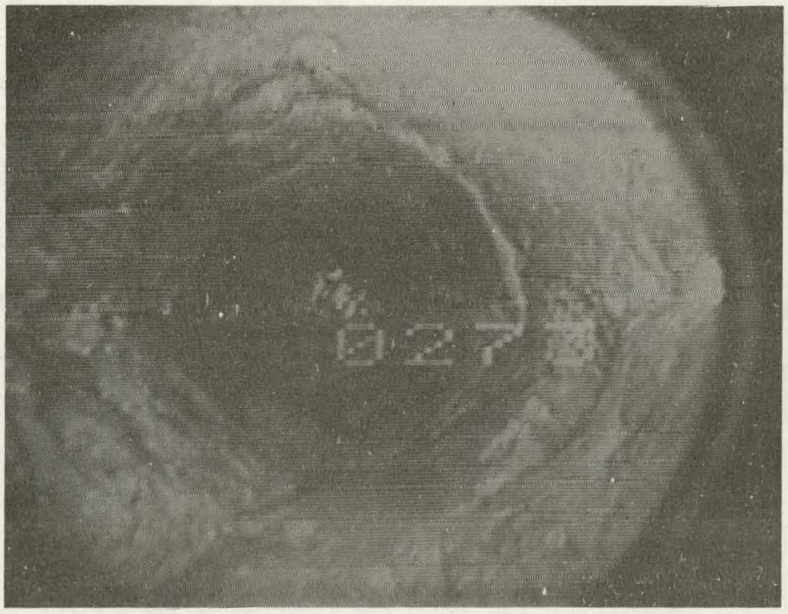


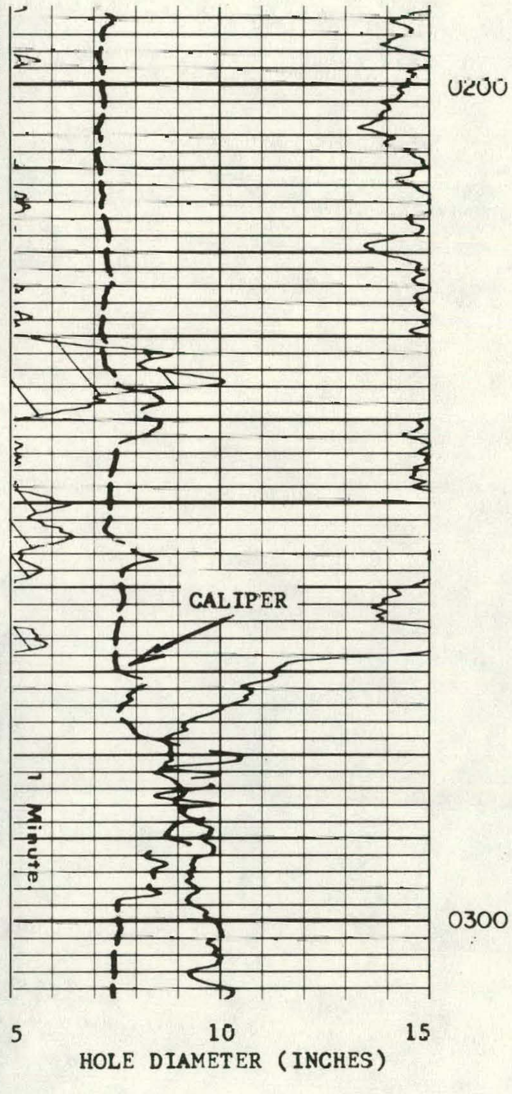
Figure 4 A-D. DHTV With Dry Lamp in Dry Environment; Lithology With Increasing Depth Typically Sandstone, Siltstone, Mudstone

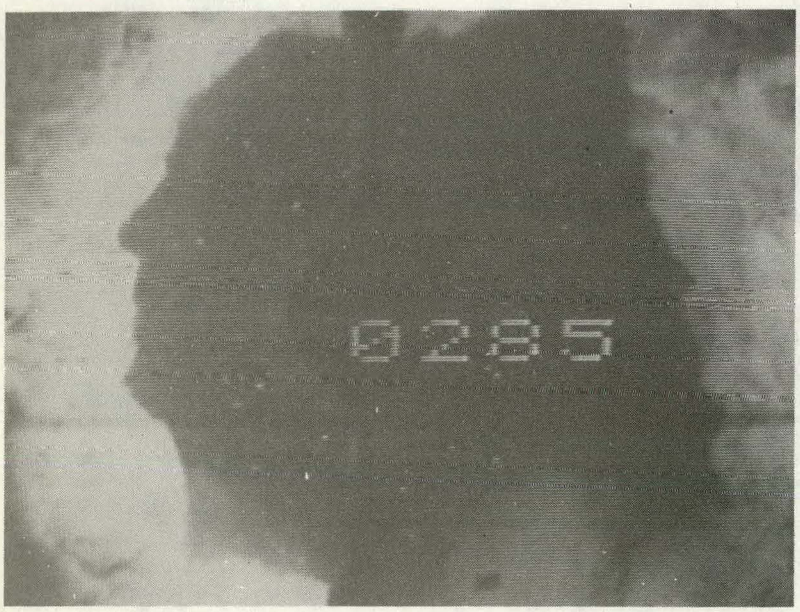
C



D

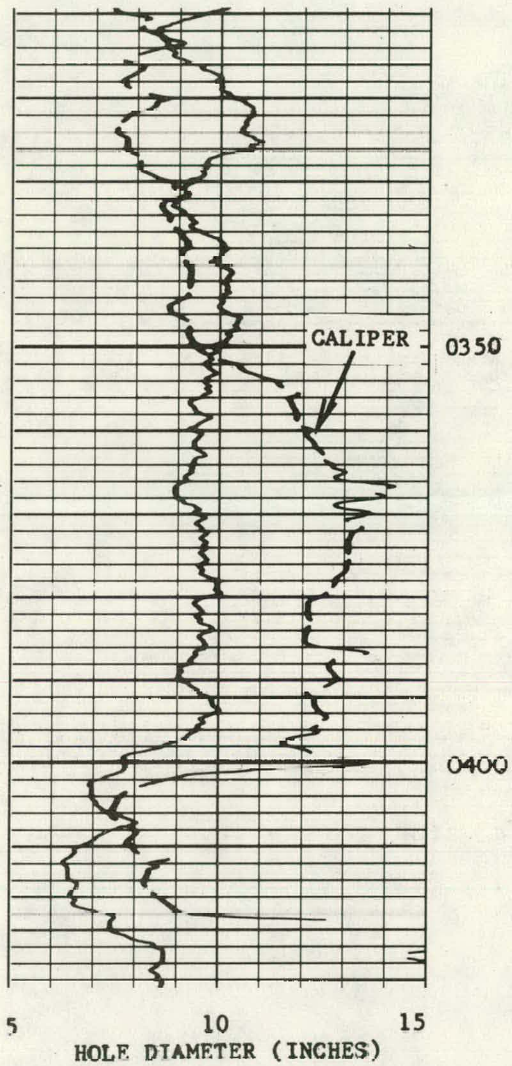
A



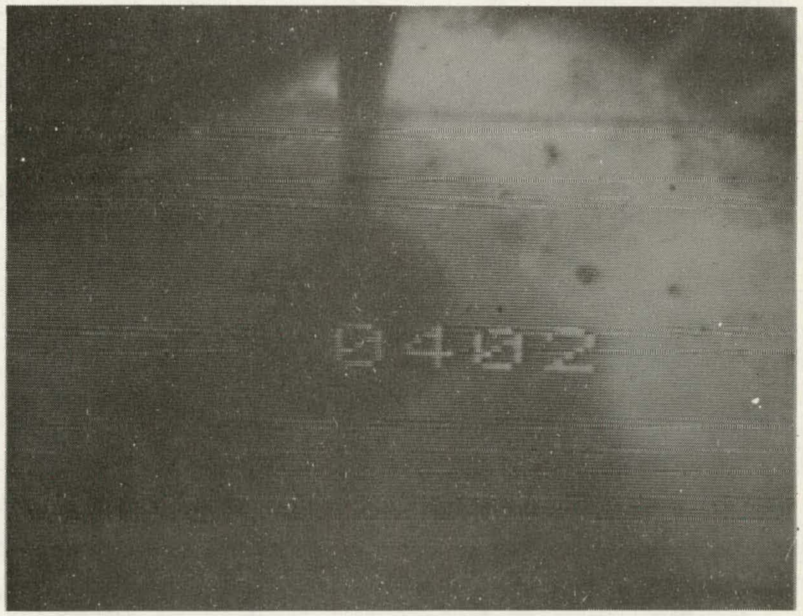


B

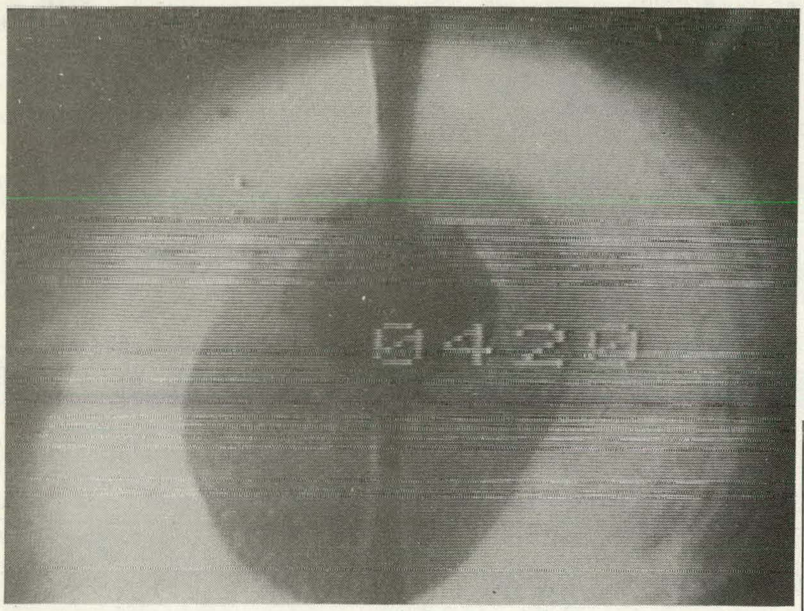
Figure 5 A-D. DHTV With Underwater Lamp in Underwater Environment; Lithology With Increasing Depth Typically Siltstone, Gypsum, Anhydrite



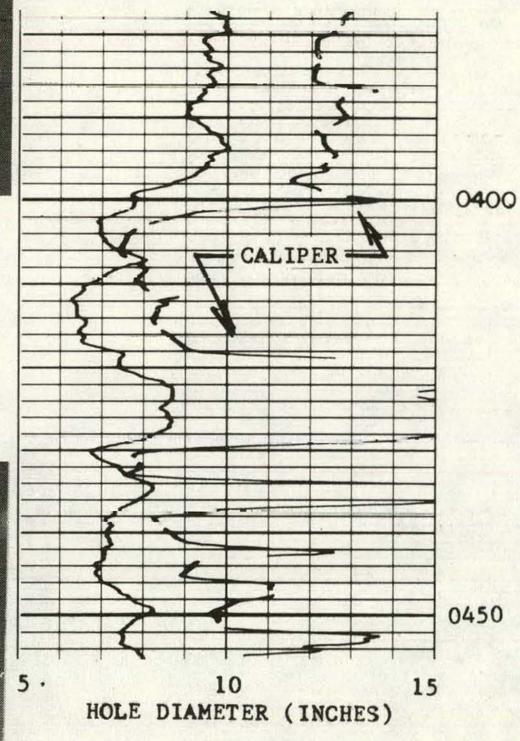
C

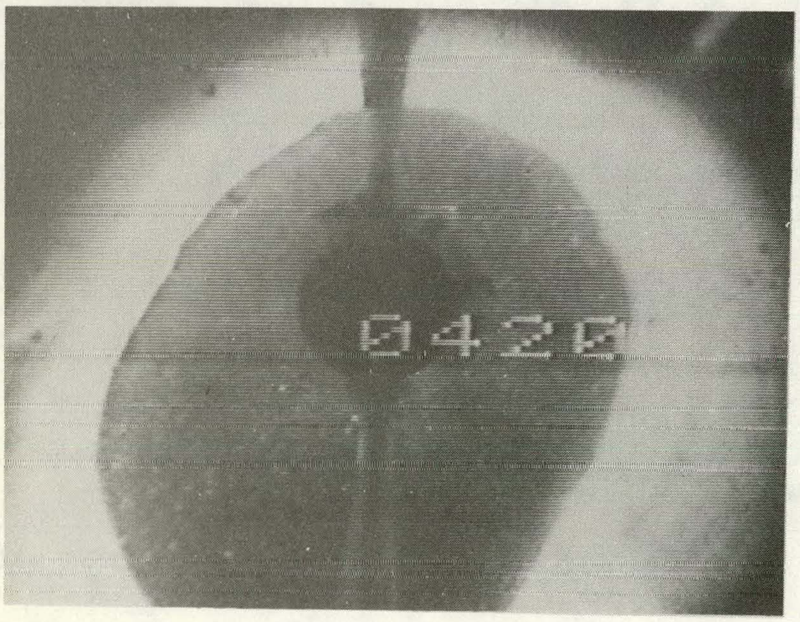


D



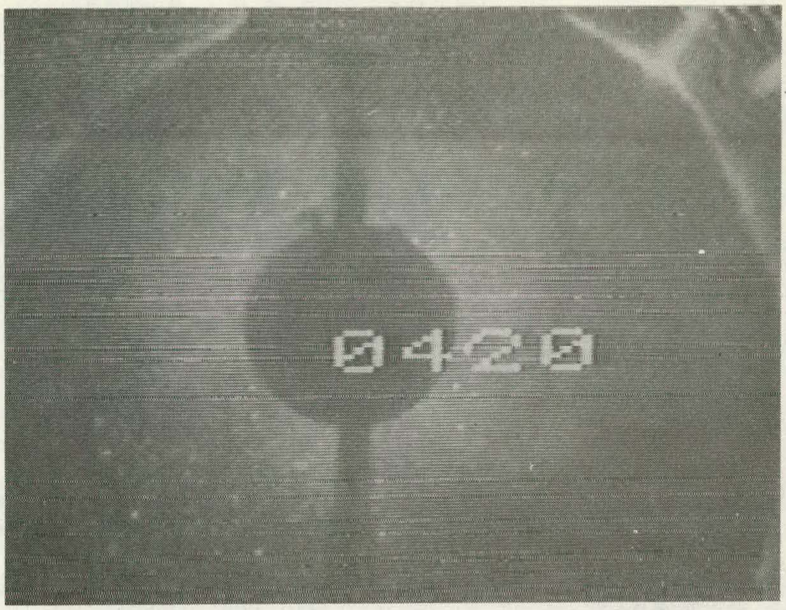
A



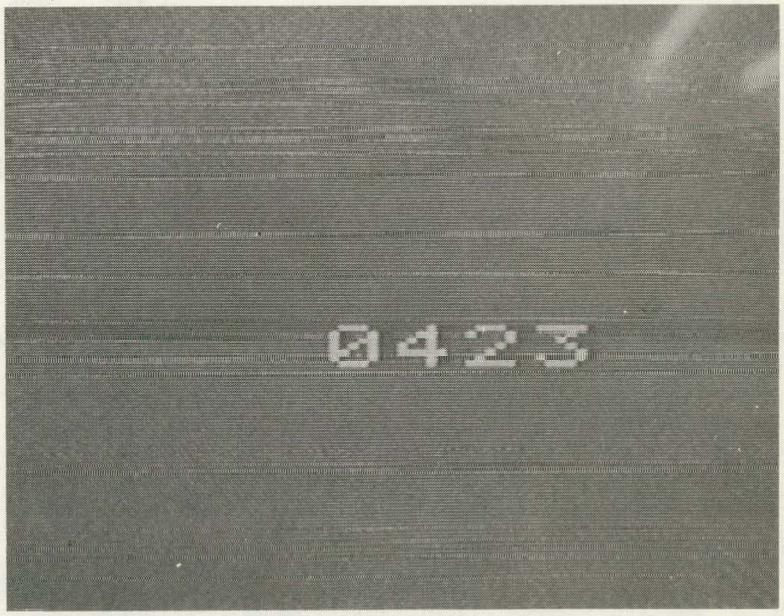


B

Figure 6 A-D. DHTV With Underwater Lamp in Underwater Environment; Lithology Typically Siltstone, Gypsum, Anhydrite Photo Sequence Shows Large Cavernous Zone



C



D

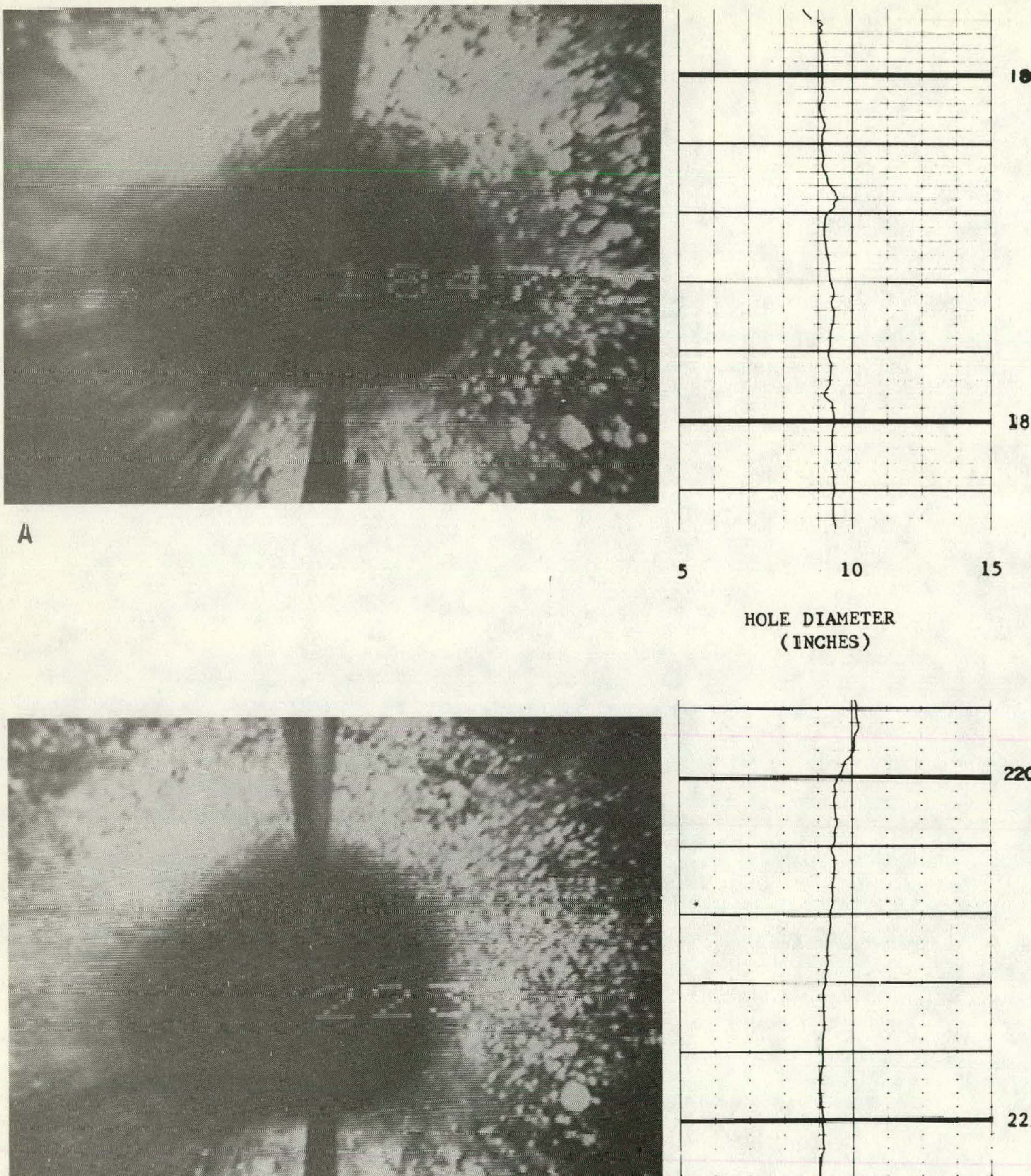
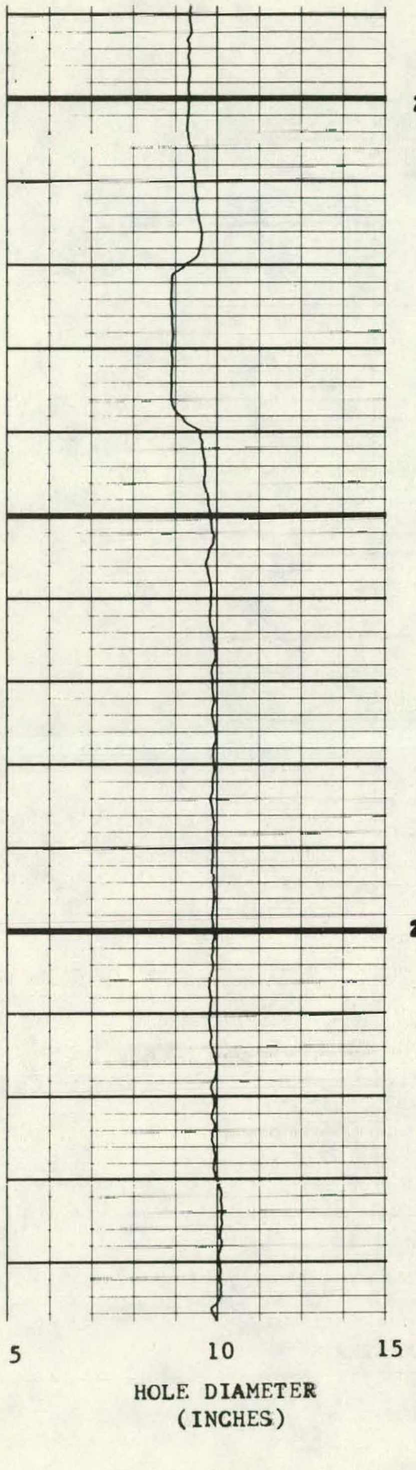
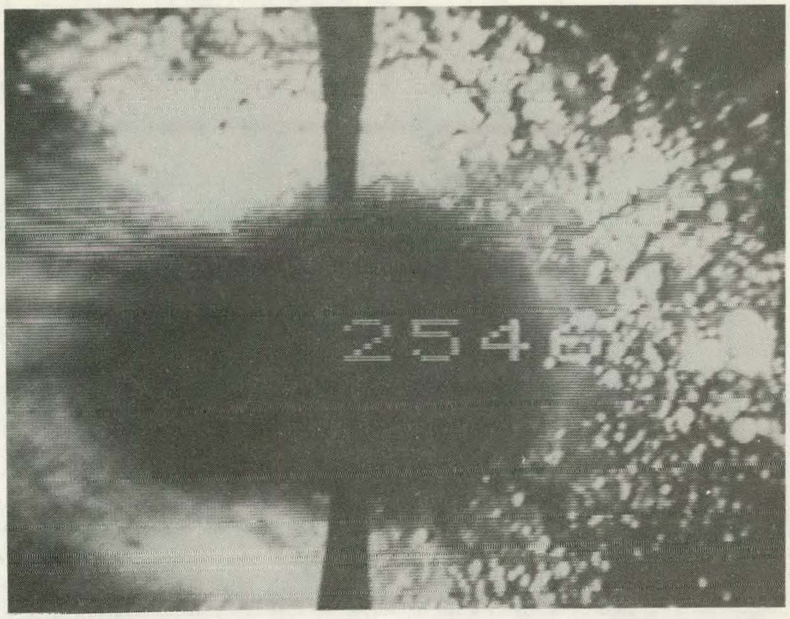
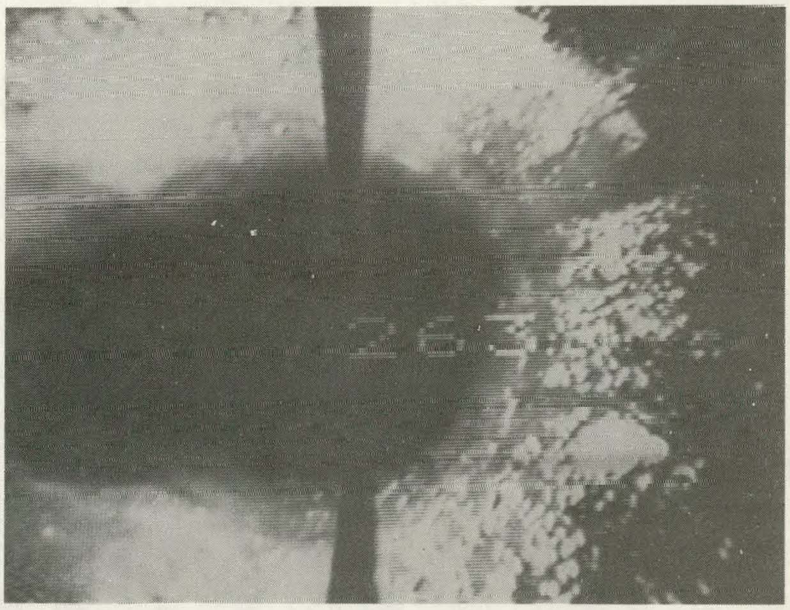


Figure 7 A-D. DHTV With Underwater Lamp in Dry Environment; Note Degradation of Picture Quality in This Configuration. Lithology Typically Rock Salt, Polyhalite, Anhydrite

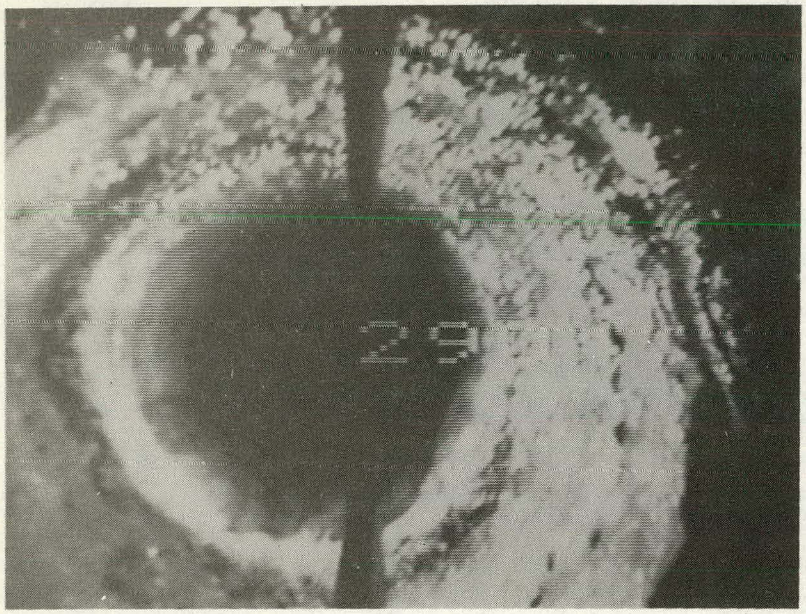




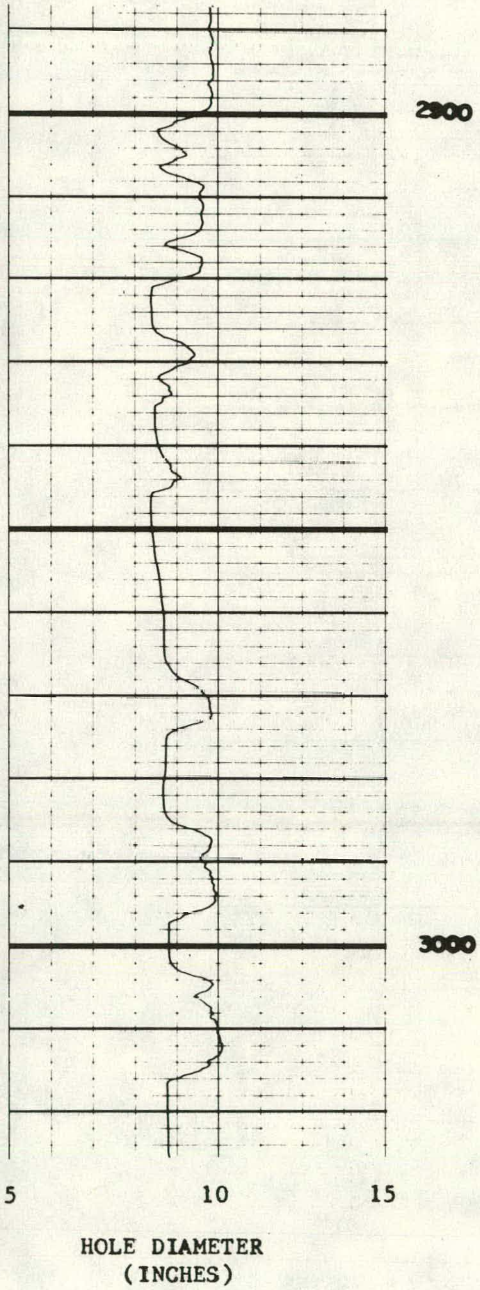
C



D

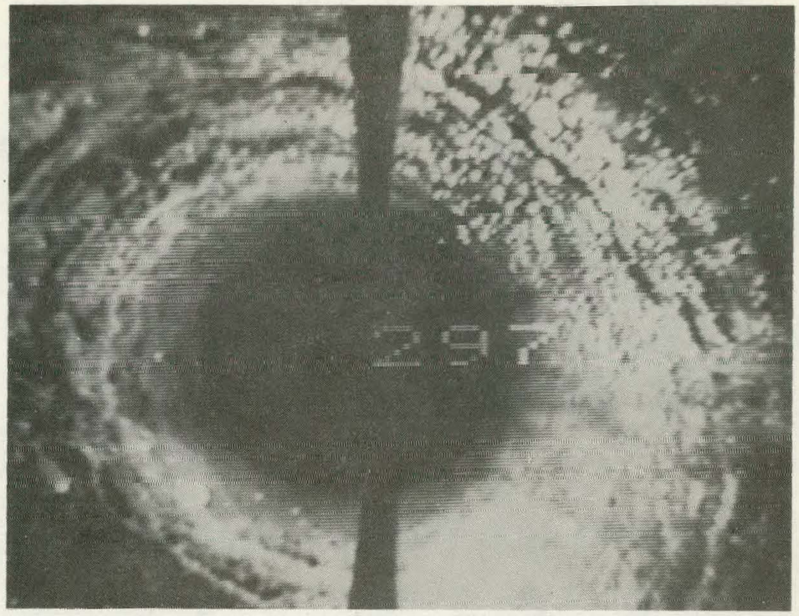


A



B

Figure 8 A-D. DHTV With Underwater Lamp in Dry Environment; Note Degradation of Picture Quality in This Configuration. Lithology Typically Rock Salt, Polyhalite, Anhydrite



C

D

DISTRIBUTION

U.S. Department of Energy, Headquarters
Office of Nuclear Waste Management
Washington, DC 20545

Eugene F. Beckett, Project Coordinator (WIPP) (1)
Colin A. Heath, Director, Division of Waste Isolation (2)
Sheldon Meyers
Raymond G. Romatowski
R. Stein

U.S. Department of Energy, Albuquerque Operations
P.O. Box 5400
Albuquerque, NM 87185

D. T. Schueler, Manager, WIPP Project Office (2)
R. Rudolph, Acting Deputy Manager, WIPP Project Office
G. Dennis, Director, Public Affairs Division
S. C. Taylor, C&TI Division (for Public Reading Rooms)

U.S. Department of Energy
Carlsbad WIPP Project Office
Room 113, Federal Building
Carlsbad, NM 88220

U.S. Department of Energy
c/o Battelle
Office of Nuclear Waste Isolation
505 King Avenue
Columbus, OH 43201

Jeff O. Neff

Battelle Memorial Institute
Office of Nuclear Waste Isolation
505 King Avenue
Columbus, OH 43201

Neil Carter, General Manager (3)
S. Basham (2)
F. Burns (7)
R. Heineman
Wayne Carbiener
S. Matthews

Westinghouse Electric Corporation
P.O. Box 40039
Albuquerque, NM 87196

R. C. Mairson

Hobbs Public Library
509 N. Ship St.
Hobbs, NM 88248
Ms. Marcia Lewis, Librarian

Lokesh Chaturvedi
Department of Civil Engineering
Box 3E
New Mexico State University
Las Cruces, NM 88003

National Academy of Sciences, WIPP Panel

Frank L. Parker, Chairman
Department of Environmental and Water Resources Engineering
Vanderbilt University
Nashville, TN 37235

Konrad B. Krauskopf, Vice Chairman
Department of Geology
Stanford University
Stanford, CA 94305

Neville G. W. Cook, Member
Dept. of Material Sciences and Engineering
University of California at Berkeley
Heart Mining Building, #320
Berkeley, CA 94720

Merril Eisenbud, Member
Inst. of Environmental Medicine
New York University Medical Center
Box 817
Tuxedo, NY 10987

Fred M. Ernsberger, Member
Glass Research Center
PPG Industries, Inc.
Box 11472
Pittsburgh, PA 15238

Roger Kasperson, Member
Center for Technology, Environment and Development
Clark University
Worcester, MA 01610

Richard R. Parizek, Member
Department of Hydrogeology
Pennsylvania State University
University Park, PA 16802

National Academy of Sciences, WIPP Panel

Thomas H. Pigford, Member
Department of Nuclear Engineering
University of California
Berkeley, CA 94720

Roger W. Staehle, Member
Dean, Institute of Technology
University of Minnesota
Lind Hall
Minneapolis, MN 55455

John W. Winchester, Member
Department of Oceanography
Florida State University
Tallahassee, FL 32306

D'Arcy A. Shock, Consultant
233 Virginia
Ponca City, OK 74601

John T. Holloway, Executive Secretary (2)
2101 Constitution Avenue, NW
Washington, DC 20418

WIPP Public Reading Room
Atomic Museum, Kirtland East AFB
Albuquerque, NM 87185

Ms. Gwynn Schreiner

WIPP Public Reading Room
Carlsbad Municipal Library
101 S. Hallagueno St.
Carlsbad, NM 88220

Lee Hubbard, Head Librarian

Thomas Brannigan Library
106 W. Hadley St.
Las Cruces, NM 88001

Don Dresp, Head Librarian

Roswell Public Library
301 N. Pennsylvania Avenue
Roswell, NM 88201

Ms. Nancy Langston

Dr. Bruno Giletti
Department of Geological Sciences
Brown University
Providence, Rhode Island 02912

Dr. Raymond Siever
Department of Geological Sciences
Harvard University
Cambridge, Massachusetts 02138

Dr. John Handin
Center of Tectonophysics
Texas A & M University
College Station, Texas 77840

John Lyons
Department of Earth Sciences
Dartmouth College
Hanover, New Hampshire 03755

George Pinder
Department of Civil Engineering
Princeton University
Princeton, New Jersey 08540

New Mexico Advisory Committee on WIPP
NMIMT Graduate Office
Socorro, NM 87801
Marvin H. Wilkening, Chairman (2)

State of New Mexico
Environmental Evaluation Group
320 Marcy Street
P.O. Box 968
Santa Fe, NM 87503
Robert H. Neill, Director (2)

NM Department of Energy & Minerals
P. O. Box 2770
Santa Fe, NM 87501
Larry Kehoe, Secretary
Kasey LaPlante, Librarian

Bechtel Inc.
P. O. Box 3965
San Francisco, CA 94119
R. A. Langley

J. E. Magruder
Sandia Carlsbad Representative
401 North Canal Street
Carlsbad, NM 88220

Brookhaven National Laboratory
Associated Universities, Inc.
Upton, Long Island, New York 11973
Cal Brewster, Bldg. 830
Paul W. Levy, Physics Dept.

D'Appolonia Consulting Engineers, Inc.
10 Duff Road
Pittsburgh, PA 15235

D'Appolonia Consulting Engineers, Inc.
2350 Alamo, SE
Suite 103
Albuquerque, NM 87106
R. H. Goodwin
D. Stephanson

Fenix & Scisson, Inc.
401 N. Canal
Carlsbad, NM 88220

The Pennsylvania State University
Materials Research Laboratory
University Park, PA 16802
Dr. Della Roy

Oak Ridge National Laboratory
P. O. Box Y
Oak Ridge, TN 37830
J. Moore

Systems, Science, and Software
Box 1620
La Jolla, CA 92038
E. Peterson (5)
P. Lagus

U.S. Army Engineers
Waterways Experiment Station
P. O. Box 631
Vicksburg, MS 39180
J. Boa
K. Mather

U.S. Geological Survey
Special Projects
MS954, Box 25046
Denver Federal Center
Denver, CO 80255
C. Jones

J. G. McCray
Department of Nuclear Engineering
University of Arizona
Tucson, AZ

Mr. Michael J. Smith
Rockwell International
Atomics International Division
Rockwell Hanford Operations
P. O. Box 800
Richland, WA 99352

Dr. R. O. Pohl
Department of Physics
Clark Hall
Cornell University
Ithaca, NY 14853

<u>Sandia Internal</u>:

1100 C. D. Broyles
1110 J. D. Plimpton
1116 C. W. Cook
1125 G. L. Ogle
1125 J. T. McIlmoyle
1130 H. E. Viney
1133 R. D. Statler (10)
1133 C. W. Gulick
1135 P. D. Seward
3310 W. D. Burnett
3141 T. L. Werner (5)
3151 W. L. Garner, For: DOE/TIC (Unlimited Release) (3)
3154-3 R. P. Campbell, For: DOE/TIC (25)
4500 E. H. Beckner
4510 W. D. Weart
4511 D. W. Powers
4511 D. D. Gonzalez
4511 S. J. Lambert
4512 T. O. Hunter (5)
4512 C. L. Christensen (20)
4512 D. R. Fortney
4512 M. A. Molecke
4514 M. L. Merritt
4540 M. L. Kramm
4541 L. W. Scully
4542 Sandia WIPP Central Files (2) (BHP)
4543 J. F. Ney
4543 H. C. Walker

Org.	Bldg.	Name	Rec'd by*	Org.	Bldg.	Name	Rec'd by*

*Recipient must initial on classified documents.