
Program for Field Validation of the Synthetic Aperture Focusing Technique for Ultrasonic Testing (SAFT UT)

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ABSTRACT

This progress report describes work performed by Southwest Research Institute (SwRI) for the Nuclear Regulatory Commission (NRC) in fulfillment of NRC Contract No. NRC-04-77-145: "Program for Field Validation of the Synthetic Aperture Focusing Technique for Ultrasonic Testing (SAFT UT)."

The purpose of the project is to validate the usefulness of SAFT UT for industrial nondestructive evaluations (NDE). SAFT UT is an ultrasonic imaging method for accurate measurement of the spatial location and extent of acoustically reflective surfaces (flaws) contained in objects such as structural components and weldments in nuclear power reactor systems. The increased measurement accuracy offered by SAFT, when compared with that provided by measurement methods now in use, will improve the reliability of flaw severity assessments with resultant safety and economic benefits to the nuclear power industry.

To accomplish the objective, SwRI is to design and construct an imaging system, suitable for field use, using the SAFT UT and to conduct sufficient tests with the system to fully characterize its performance and usefulness for the intended purpose. The ultimate goal is to produce a field-rated system for highly accurate flaw size measurements and to conduct sufficient testing of that system to promote its acceptance by industrial and regulatory authorities.

The following document is a mid-year report describing the accomplishments completed since submission of the last quarterly progress report.

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1.0 INTRODUCTION

Southwest Research Institute (SwRI) is conducting a project entitled "Program for Field Validation of the Synthetic Aperture Focusing Technique for Ultrasonic Testing (SAFT UT)." The project's purpose is to continue the development of SAFT UT and to validate its usefulness for inservice inspection applications. SAFT UT is an ultrasonic imaging method for accurately measuring the spatial locations and extent of flaws contained in objects such as structural components and weldments in nuclear power reactor systems. The increased measurement accuracy offered by SAFT UT, when compared with that provided by measurement methods now in use, will improve the reliability of flaw severity assessments with resultant safety and economic benefits to the nuclear power industry.

This project is one part of a team effort being conducted by the University of Michigan (U of M) and SwRI. Although the two groups are working under separate contracts, their efforts are integrated and synergetic. The U of M group is concentrating on theoretical aspects of SAFT UT while SwRI, working with information and advice supplied by U of M, is contributing the engineering and performance evaluations necessary to produce and validate a practical field tool.

The objectives of this program are to:

- Produce a SAFT UT system in a form useful for field test.
- Validate the performance of that system for characterizing both real and simulated flaws in realistic test specimens.
- Conduct field trials using the system on actual structures.
- Estimate the reliability and confidence level for SAFT UT examinations and compare those results with similar estimates made for conventional ultrasonic methods.

The ultimate goal is to produce a field-rated system for highly accurate flaw size measurements and to conduct sufficient testing of that system to promote its acceptance by industrial and regulatory authorities.

This report is devoted to presenting the results of work accomplished since submittal of the November 1980 quarterly report. Specifically, two areas will be covered: (1) description of the implemented color-graphics display system, which greatly enhances ease of operator interpretation of the processed data, and (2) presentation of the results of an evaluation designed to demonstrate reflector resolution capabilities of SAFT UT.

2.0 SAFT UT COLOR GRAPHICS DISPLAY SYSTEM

2.1 Display Philosophy

2.1.1 SAFT UT System General Overview

The NDE of laboratory test specimens of nuclear reactor pressure vessel components using the SwRI SAFT UT system is composed of three fundamental activities. These are: (1) operation of the scanning apparatus to provide for acquisition and storage of the ultrasonic test data, (2) processing of the ultrasonic data and storage of the processed data volume containing the reconstructed image(s), and (3) presentation of selected portions of the stored processed data to the operator in the form of visual images for data analysis. The details of operation of the scanning equipment and data processing algorithms were described in the November 1980 Quarterly Report (NUREG/CR-1885) and will not be discussed here. The considerations for presentation of the processed data volume pixels will be addressed in the following sections.

2.1.2 Processed Data Volume Reconstructed Image Representation

The SwRI reconstruction algorithm permits the system operator to specify parameters that define the volumetric region in which imaging is to be performed (see the November 1980 Quarterly Report). The volumetric region is subdivided into pixels (cells) upon which the reconstruction algorithm operates using the ultrasonic test data obtained during scanning. Upon completion of processing, every cell in the volumetric region will contain an amplitude value representing that cell's contribution to the reconstructed image. The final image is formed by displaying the computed signal amplitude as a function of cell location within the volume. The image is then interpreted by noting the locations of high signal amplitude. It should be noted that the reconstruction algorithm does not attempt to directly determine the size and location of reflectors (flaws). Flaw size and location are deduced by operators from the patterns formed by cells that show evidence of containing a reflector.

2.1.3 Display Concepts

As explained previously, reflector (flaw) image location and sizing are accomplished through the interaction of the system operator and the processed data display capabilities of the system. The data display subsystem of the SAFT UT system must be capable of providing the operator with selected data based on appropriate display parameters. Since the operator must interpret the display to analyze the reflector (flaw), a number of display options should exist to permit an effective evaluation. Three fundamental considerations to be discussed relative to the presentation of SAFT UT processed data are: (1) the operational procedures used by the system operator to select processed data displays for presentation; (2) the types of displays required by the operator to permit analysis; and, (3) relative to any selected display, the presentation format that should be used to enhance interpretation.

2.1.3.1 Operational Procedures

The processed data volume comprises a collection of cell elements, each of which contain amplitude information that must be interpreted to "form" the reflector (flaw) image. The system operator is responsible for image analysis by evaluating and integrating the information presented

in a series of selected displays. The data display capability of the system must provide convenient display options to facilitate the operator analysis.

Data display capabilities currently planned or available with the SAFT UT inspection system consist of C-scans, B-scans, and perspective-type displays. Current displays do not simulate a three-dimensional image for viewing by the operator, but provide a foundation upon which to study presentation formats for future implementation. Because a series of displays must be interpreted by the operator, convenient operating procedures must exist to permit control of the processed data display selections. The operational procedures provided in the SwRI SAFT UT inspection system are depicted in Figure 1. These procedures provide for a data display selection phase and a data display presentation phase. Separation of these two activities into distinct operating phases provides for operation viewing efficiency and, therefore, simplifies the image evaluated.

Upon completion of processing, the complete processed data volume is stored on disk. During the selection phase, the operator can select the type of display and corresponding control parameters and store the selected display on disk. One or a number of displays can be extracted sequentially from the processed data volume information. After selecting all desired displays, the operator may then perform the actual viewing. During the presentation phase, the operator selects a stored display for presentation on the color-graphics system. After initial presentation, appropriate control parameters can be modified and the selected presentation updated accordingly. Since each display is selected by the operator in any desired sequence, a volume "walk thru" can be performed. The image analysis is then performed by visually integrating all the displays to form a composite "picture" of the reflector (flaw). The individual displays provide points of reference that can be used to document specific reflector (flaw) characteristics.

2.1.3.2 Types of Displays

At the present time, two commonly used types of ultrasonic imaging displays, B- and C-scans, are operational in the SwRI SAFT UT system. With C-scan images, the processed data are presented as if viewed from normal to the front surface with all z-axis information compressed based on maximum amplitude. B-scan images can be obtained for either x-z or y-z planes, and the location of the plane on the third major axis is specified by the operator. All amplitude information presented is relative to the selected plane only (no data compression). Examples of these displays are discussed in Section 3.0 of this report.

2.1.3.3 Display Characteristics for Enhancing Interpretation

The SwRI SAFT UT display unit originally consisted of a Gould 5000 electrostatic printer/plotter. This unit was evaluated to determine the suitability of a black and white presentation for display presentation. A pseudo-gray scale was designed based on using a selected set of 12 symbols. Each symbol represented a data-dependent amplitude range. The display types previously described were produced and studied. Evaluation showed that interpretation of the displayed data was very difficult. A set of 12 amplitude ranges was not sufficient to depict subtle changes in the amplitude patterns of

the volume cells. Additionally, the pseudo-gray scale required excessive operator interpretation to correlate the symbol and amplitude range information. An example of the printer/plotter output representing a C-scan presentation of six flat, bottom-drilled holes is shown in Figure 2. The images produced by this method were very difficult to interpret and were not suitable for evaluation of SAFT UT results.

Based on display studies conducted at the U of M, SwRI implemented a color-graphics display system for use with the SAFT UT inspection system. The previously described displays were evaluated using presentation characteristics derived at the U of M. The amplitude range represented by the collection of cells composing the selected display was segmented into 32 parts. Each part was represented by a distinct color on the display screen. A rainbow-type color sequence was used to represent the amplitude, with blue colors depicting low amplitudes and red colors representing high amplitudes. Five basic colors were used - red, orange, yellow, green, and blue; and the color intensity and hue were modulated so that each color gradually transits into the next. Division of the amplitude display range into 32 parts provides enhancement of subtle amplitude changes within the display. Use of bright (red) colors for high amplitudes and dark (blue) colors for low amplitudes provides immediate enhancement of maximum amplitude cell patterns within the display. Interpretation of the displayed data by the operator is, therefore, simplified, and image definition is easier. The ease of operator interpretation for identical data displayed using the color-graphics system versus the black and white printer/plotter can be illustrated by comparing Figures 2 and 5 of this report.

2.2 Hardware Implementation of the 9351 RAMTEK System

The SAFT UT computer subsystem was enhanced by the addition of a 4351 RAMTEK color video monitor. This system was initially unpacked and set up on a temporary installation to verify operation of the color monitor. The use of RAMTEK self-diagnostic READ ONLY MEMORY (ROM) facilitated the checkout of the color monitor. The only problems encountered were interpretation of diagnostics from the RAMTEK documentation because of lack of color diagrams and photos of the diagnostic output. This deficiency caused some doubts in the diagnostic results, which had to be clarified by conference with RAMTEK representatives.

The RAMTEK system was mounted in its permanent rack, and the interface for the Data General Nova was installed. An Internal Data General I/O extender cable was installed on the CPU chassis, and the internal interrupt priority chain was reconfigured to accommodate the RAMTEK interface. A device code of 65 (octal) and an interrupt priority mask of 10 (octal) was established for the RAMTEK interface to allow proper interface action in the current SAFT UT computer system.

The Data General Acceptance test was executed to verify the operation of the RAMTEK/Data General interface with problems only occurring in the documentation of the operating procedures for the acceptance test. Conference with RAMTEK representatives overcame the difficulties, and operation of the interface was verified.

2.3 Software Capabilities Currently Available

2.3.1 General Description of Software

The SAFT UT color-graphics display software is written in the Fortran language and implemented on the Data General Nova or Eclipse line computer. Assembly language programs are only used to provide the operating system with the capability of communicating with the Ramtek color display unit. Two software modules have been implemented and provide the mechanism by which the operational procedures discussed previously are performed. One module is responsible for selection and storing the appropriate information from the processed data volume file required to produce the operator specified display. The second is designed to access the stored display data and present it on the Ramtek color-graphics display unit.

2.3.2 Display Data Extraction Module

The processed data volume file represents a collection of cells that contains the amplitude information used by the operator to define the reflector (flaw) image. Because of memory size restrictions in the computer, the processed data volume actually consists of a number of files collectively representing the total volume. Each sub-volume file represents the largest volume segment that could be stored in the computer memory at one time for processing. The data processing software automatically performs the volume segmentation, and this activity is transparent to the operator. Because of segmentation, a mechanism must exist to permit the correlation of one volume segment with another. Therefore, a set of parameters is created for each volume segment defining its size and extent and its relationship to the total volume. By using the volume parameter files and volume cell amplitude files, operator-selected display options encompassing cell data distributed throughout the entire volume can be performed.

The operator is provided with the capability of performing C- or B-scan presentations. Whenever a display is requested, the operator is required to enter the control parameters desired for the display. For a C-scan, the operator must provide the x- and y-axis lower and upper limits and the z-axis limits over which cell amplitude data compression is to occur. For a B-scan presentation, the operator must provide the appropriate limits for the selected plane (x-z or y-z) and the location of the plane on the third axis. In addition to providing the axis limits or values, the operator may specify which axis is to be displayed horizontally or vertically on the Ramtek unit. This feature is useful since the Ramtek display screen is rectangular in shape, and it may be desirable to optimize the selected display for the viewing area.

Once the operator has selected a display, a set of subroutines is responsible for automatically performing the data extraction from the volume files. This involves comparing the operator display parameters with the volume segment parameters and determining if the segment contains any data that corresponds to the display. If so, the appropriate data are extracted and stored in a memory resident array representing the selected display. The extraction process is performed for all volume file segments. Upon completion, the memory array representing the data to be displayed is stored on disk for future use by the display software. The operator can then select another display option, and the entire process is repeated. After all operator-desired displays have been stored, the Ramtek display software module can be executed to provide the actual color presentation for viewing and evaluation.

2.3.3 RAMTEK Display Module

2.3.3.1 Primitive RAMTEK INPUT/OUTPUT (I/O) Drivers

To permit use of the 9351 RAMTEK color system, the first software task undertaken was development of the basic input/output (I/O) drivers. These I/O drivers allow communication between the Nova Real-Time Disk Operating System (RDOS) and the RAMTEK color system. The I/O drivers were implemented at the application program level by use of the operating system facility .IDEF. The .IDEF function allows the user to introduce to the RDOS devices (not identified at SYSGEN time) whose "interrupts" the system is to recognize. The assembler language subroutine DIDEF was written to implement the .DIDEF system utility and is callable from Data General FORTRAN V Rev. 6. In conjunction with the DIDEF subroutine, an assembler language interrupt service routine (DINTS) was written to handle RAMTEK interrupts passed through the RDOS.

Once the DIDEF and interrupt service routine were completed, two assembler language routines were written to transfer data to (TALK) and to receive data from (LISTen) the RAMTEK color system. Two additional assembler routines were written to facilitate communications between FORTRAN and the assembler TALK/LISTen routines. The FORTRAN callable routines RAMTLK and RAMLTN perform this function. The following routines formed the core of the Data General RAMTEK I/O drivers:

- DIDEF - Assembler callable from FORTRAN
- DINTS - Assembler called by the operating system
- TALK - Assembler callable from assembler
- LIST(en) - Assembler callable from assembler
- RAMTLK - Assembler callable from FORTRAN
- RAMLTN - Assembler callable from FORTRAN

Testing began with simple FORTRAN programs to send commands to the RAMTEK. The Data General symbolic debugger was employed to debug the assembler routines. The only major problem was in the interrupt service routine arising from an idiosyncrasy of the 9351 RAMTEK and its Data General interface. The characteristics of the interface are such that the transfer of data from the Nova memory into the RAMTEK 9351 system is a rapid transfer. Upon completion of the Direct Memory Access (DMA) transfer, the interface in the Nova sets its DONE flag, which requests interrupt service from the Nova. The setting of the DONE flag and the interrupt request normally indicates a device has completed its task. In the case of the RAMTEK system, only the Data General interface has finished the data transfer; and the RAMTEK display is still busy processing the transferred data and performing display operations. Therefore, it is necessary to test the RAMTEK display status word after the interrupt is received to see if the RAMTEK has completed its display before clearing the interrupt and proceeding with the processing. Once the distinction between the interface DONE and the RAMTEK display complete was taken into consideration in the interrupt service routine, the basic I/O drivers were rapidly debugged.

2.3.3.2 Basic Color Graphic Subroutines

The following routines were written to give basic color graphics capability and employed the primitive routine.

(1) Color Selection

FGBG - select the Foreground/Background colors

LUT - Set a color into the color Look Up Table

(2) Vector Mode

MOVABS - Moves the color graphic cursor to an absolute screen coordinate

DRWABS - Draw a line in the foreground color to an absolute screen coordinate

(3) Raster Mode

WTIMG - Write a raster image starting at an absolute screen coordinate

WTTXT - Write a text string on the screen starting at an absolute screen coordinate

ERASE - Clear the video display

2.3.3.3 Color Display of SAFT UT Data

With the completion and debugging of the primitive and basic color-graphics routines, the program to display B- or C-scans of processed SAFT UT data was written. The resulting program SPLOT (SAFT Plct) was used to produce the color plots for this report.

The program has the following capabilities:

(1) Read SAFT data files. This allows different data files to be displayed.

(2) Set threshold levels. This allows the operator to adjust the color presentation to replace the color below a specified amplitude level with a neutral color.

The color scale currently in use employs 32 colors in a continuous color spectrum of blue-green-yellow-red with blues representing the lower amplitudes and the reds, the higher. The color scale is determined by a color table that is automatically read into the display program. If a change is desired in the color scheme of the display, the color table can be changed, and no program modifications are required. The color bar scale is annotated with the amplitude value associated with a particular color to allow quantitative analysis of the display.

3.0 EVALUATION OF SAFT UT REFLECTOR RESOLUTION POTENTIAL

3.1 Description of Test

SwRI designed and fabricated a test block for the purpose of demonstrating the axial and lateral resolution capability of the SAFT UT inspection system and to evaluate the effectiveness of the recently implemented RANITEK color-graphics display system. The test was performed using machined reflectors of known location, size, and shape. The aluminum test block is depicted in Figure 3. The block contains six flat, bottom-drilled holes each 0.05 inch (1.27 mm) in diameter. The hole depths vary by 0.05 inch (1.27 mm) and the lateral spacing between the holes (edge-to-edge) varies from 0.05 inch (1.27 mm) to 0.25 inch (6.35 mm). The hole spacing was varied laterally in steps corresponding to integral multiples of the wavelength (0.05 inch or 1.27 mm) of the ultrasound. The block was inspected using 0.05-inch (1.27-mm) step increments throughout the scanned surface aperture. The processed volume corresponds to the area depicted by dashed lines in Figure 3. The processed volume region was divided into cells that were 0.02 inch (0.508 mm) in x and y and 0.01 inch (0.254 mm) in z.

The test was performed using a Panametrics 5 MHz transducer with a 3/4-inch (19.05-mm) diameter and a 3-inch (76.2-mm) focal length. The transducer was positioned with the axis of the focal beam normal to the surface so that a longitudinal mode was used. The test conditions resulted in the flat, bottom portion of the holes acting as quasi-point reflectors so that the axial and lateral resolution of the system could be evaluated.

3.2 Evaluation of Processed Data Using Color-Graphics Display

The processed data was evaluated using the display capabilities previously discussed. For the purpose of this report, three display presentations were selected to represent the processed data. These displays consist of a C-scan presentation, an x-z planar slice, and an x-y planar slice. The specific volume regions represented by these displays are depicted in Figure 4. A sequence of three or four pictures for each presentation are shown with each picture representing a different cell amplitude, lower-limit display threshold. The operator has the capability of limiting the cell amplitude data shown to only those cells containing amplitude data within a specified threshold of the maximum amplitude contained within the specific display. For example, if the operator selects a threshold of -6 dB, then only cell amplitudes within 50 percent of the value of the maximum amplitude cell will be displayed. All other cell data will be shown as white. The sequence of pictures contained for each display show: (1) all cell amplitude data, (2) -6 dB threshold cell amplitude data, (3) -10 dB threshold amplitude data, and (4) -14 dB threshold amplitude data.

The coordinates shown in the displays are relative to the scan-mechanism coordinate system and the numerical units of the display legends are 0.001 inch. The test-block origin was offset from the scan mechanism origin so that the location of the holes (as shown on Figure 3) do not match the coordinates shown on the processed data presentations. The marks denoted on the horizontal and vertical axis of the display represent 100 mils. The displays, then, represent a magnification of the actual inspected test-block area.

The C-scan displays shown in Figures 5 through 7 show the tops of the flat bottom-drilled holes. The varying amplitude presentations give an indication of the lateral resolution at the selected dB levels. When measured at 6 dB down from maximum amplitude, the hole tops are shown to be 60 to 80 mils with good resolution even between the holes separated by only one wavelength (50 mils).

The B-scan displays shown in Figures 8 through 11 represent the hole tops as viewed in profile. Here the 50 mil difference in hole depths shows up clearly. The short ring time of the transducer is indicated by the small z extent of the hole top. Axial resolution is very good; and, when measured at the 6 dB down points, it can be expressed in terms of a fraction of one wavelength.

The C-scan displays shown in Figure 12 through 15 were selected so that the top of hole No. 3 was captured. The 14 dB down picture shows the amplitude response associated with hole No. 4 indicating that the amplitude response from hole No. 4 decreased by 14 dB over a distance of only one wavelength. This result is evidence of the excellent range resolution exhibited by SAFT UT.

4.0 SUMMARY

Evaluations conducted using the SwRI SAFT UT system have demonstrated the system's capability to produce good reconstructed images. For this reason, a comprehensive test program has been initiated to validate SAFT UT using fabricated test specimens containing realistic flaws. The results of the test program will be presented in subsequent progress reports.

5.0 CONCLUSIONS

Implementation of the RAMTEK color-graphics display system have greatly enhanced the ability to perform image interpretation and have permitted proper operation of the SAFT UT system to be established.

Work efforts conducted during the first half of this year's contract period resulted in validation of the original SwRI SAFT UT system design specifications established two years ago. These accomplishments are extremely gratifying. Further, they provide an excellent foundation upon which to continue more comprehensive system evaluations intended to establish SAFT UT as a viable NDE inspection technique for industrial applications.

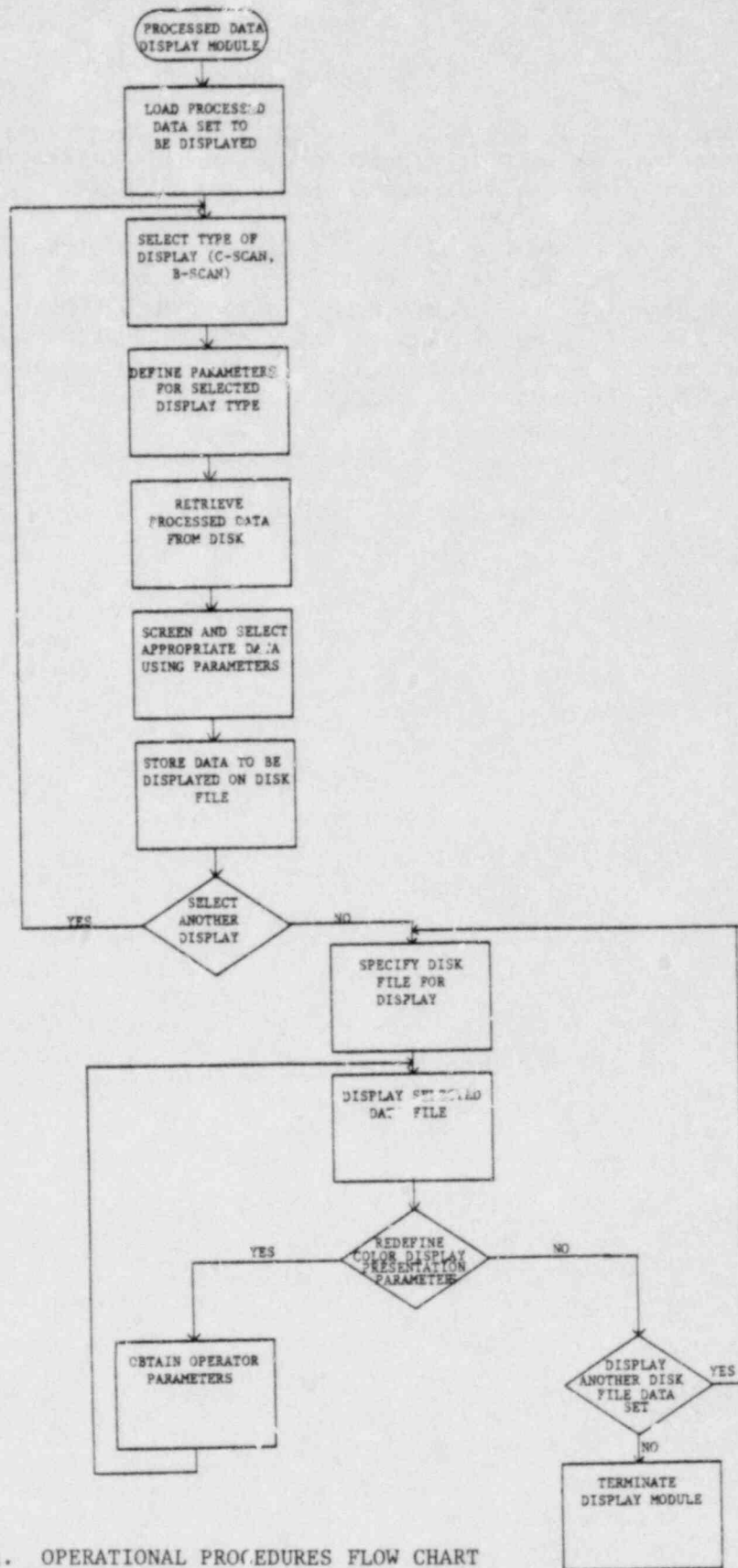


FIGURE 1. OPERATIONAL PROCEDURES FLOW CHART

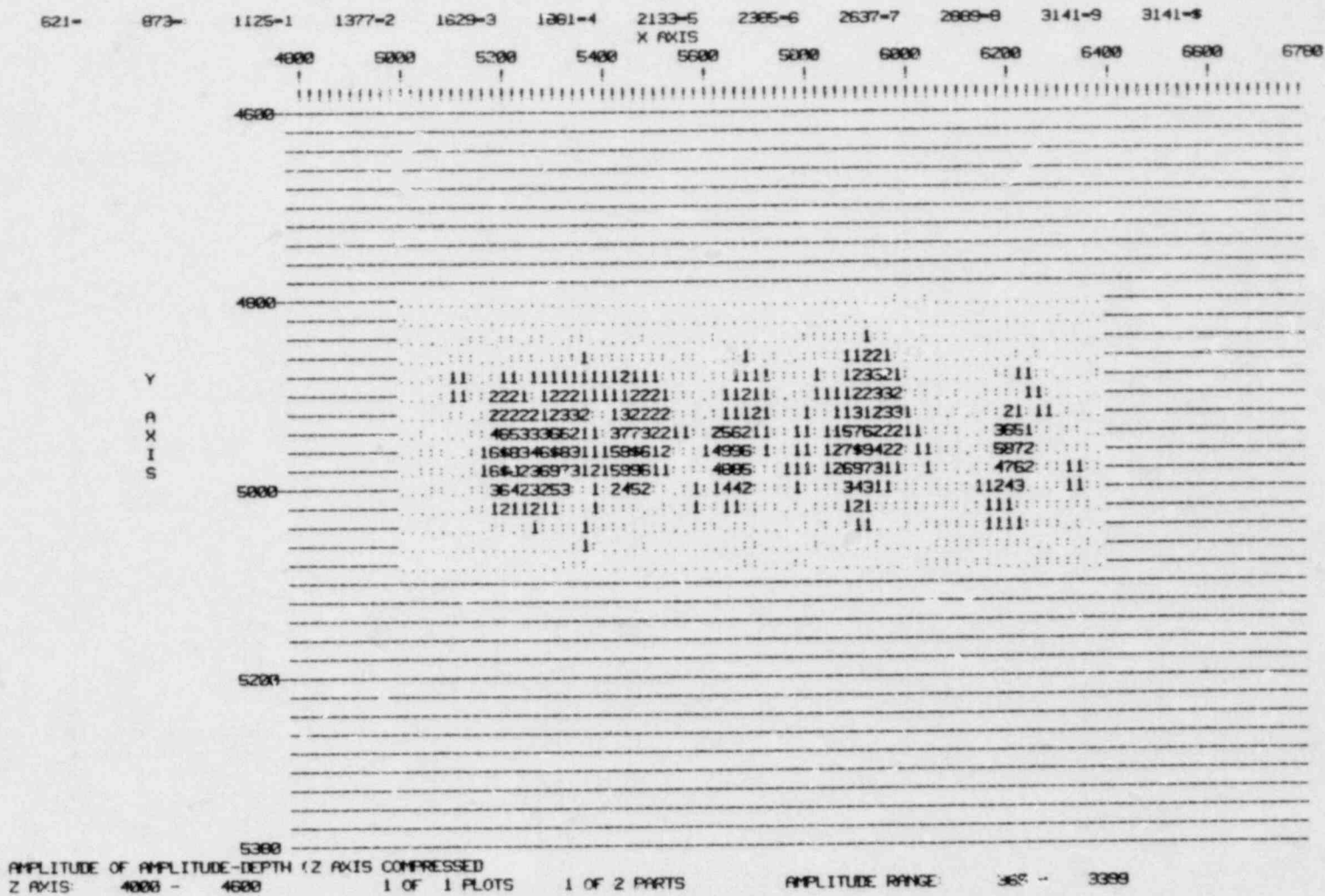


FIGURE 2. C-SCAN DISPLAY OF SIX BOTTOM-DRILLED HOLES
USING BLACK AND WHITE PRINTER/PLOTTER OUTPUT

AXES ARE DEPICTED RELATIVE TO THE SCAN MECHANISM COORDINATE SYSTEM

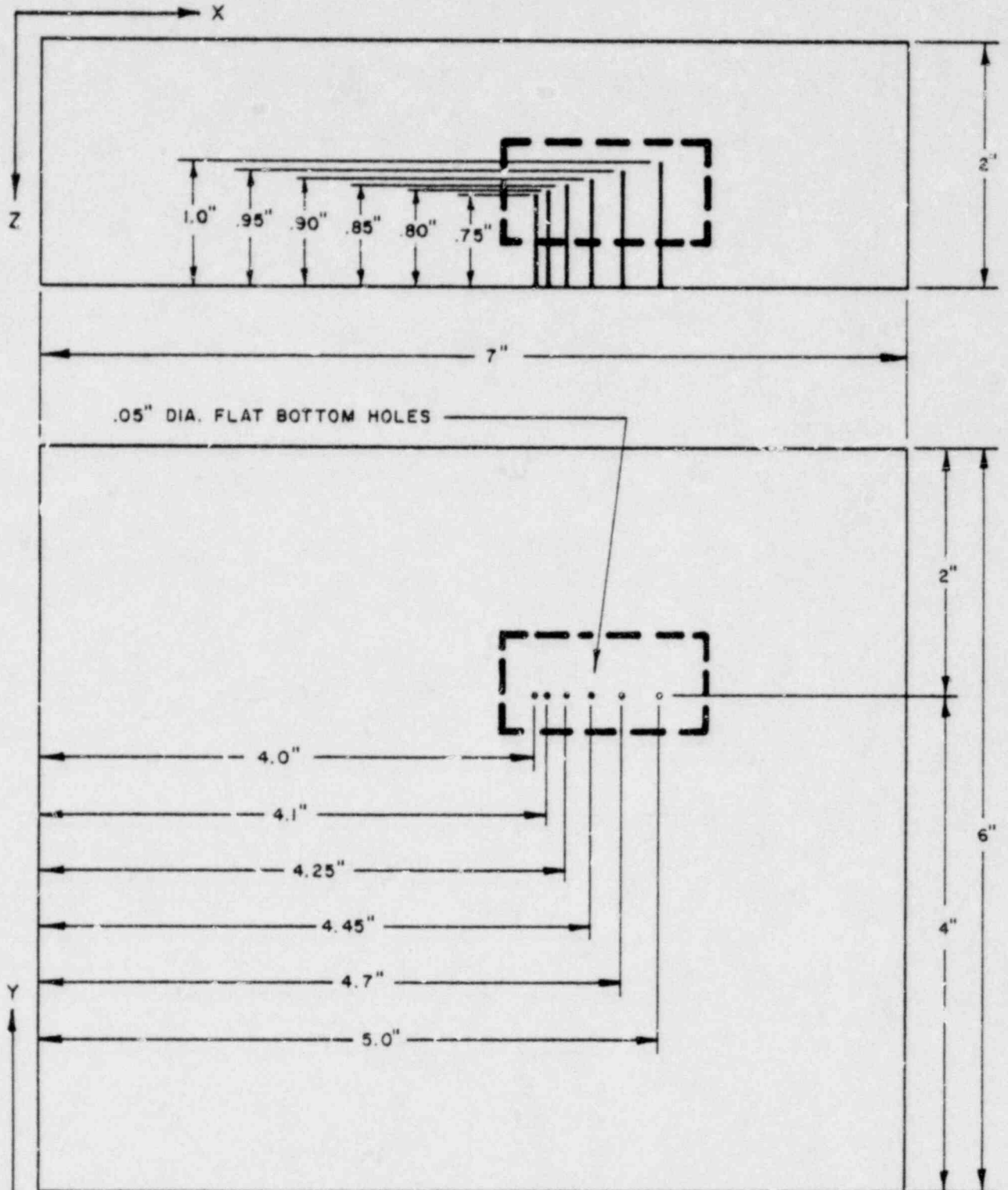
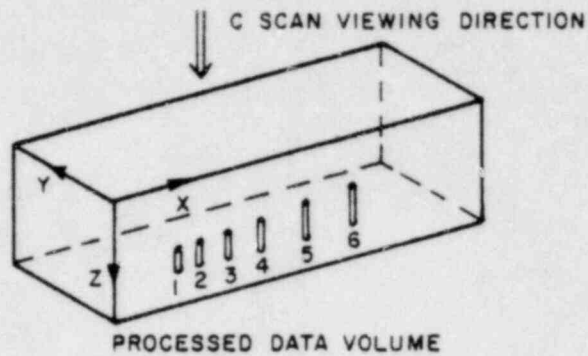


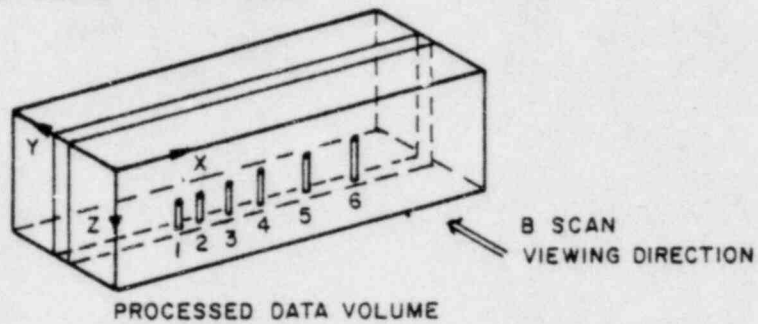
FIGURE 3. DRAWING OF ALUMINUM TEST BLOCK CONTAINING SIX FLAT BOTTOM-DRILLED HOLES

1. C SCAN PRESENTATION



2. C SCAN AND B SCAN DISPLAYS ONE PIXEL THICK

a. X-Z PLANE AT Y = 4960



b. X-Y PLANE AT Z = 4190 (TOP OF HOLE No. 5)

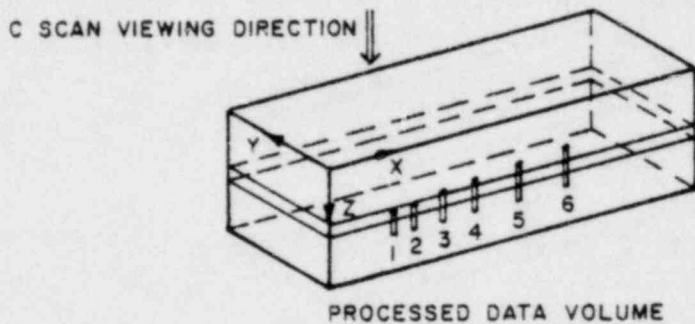


FIGURE 4. DEPICTION OF DISPLAYS PRESENTED FOR THE ALUMINUM TEST BLOCK

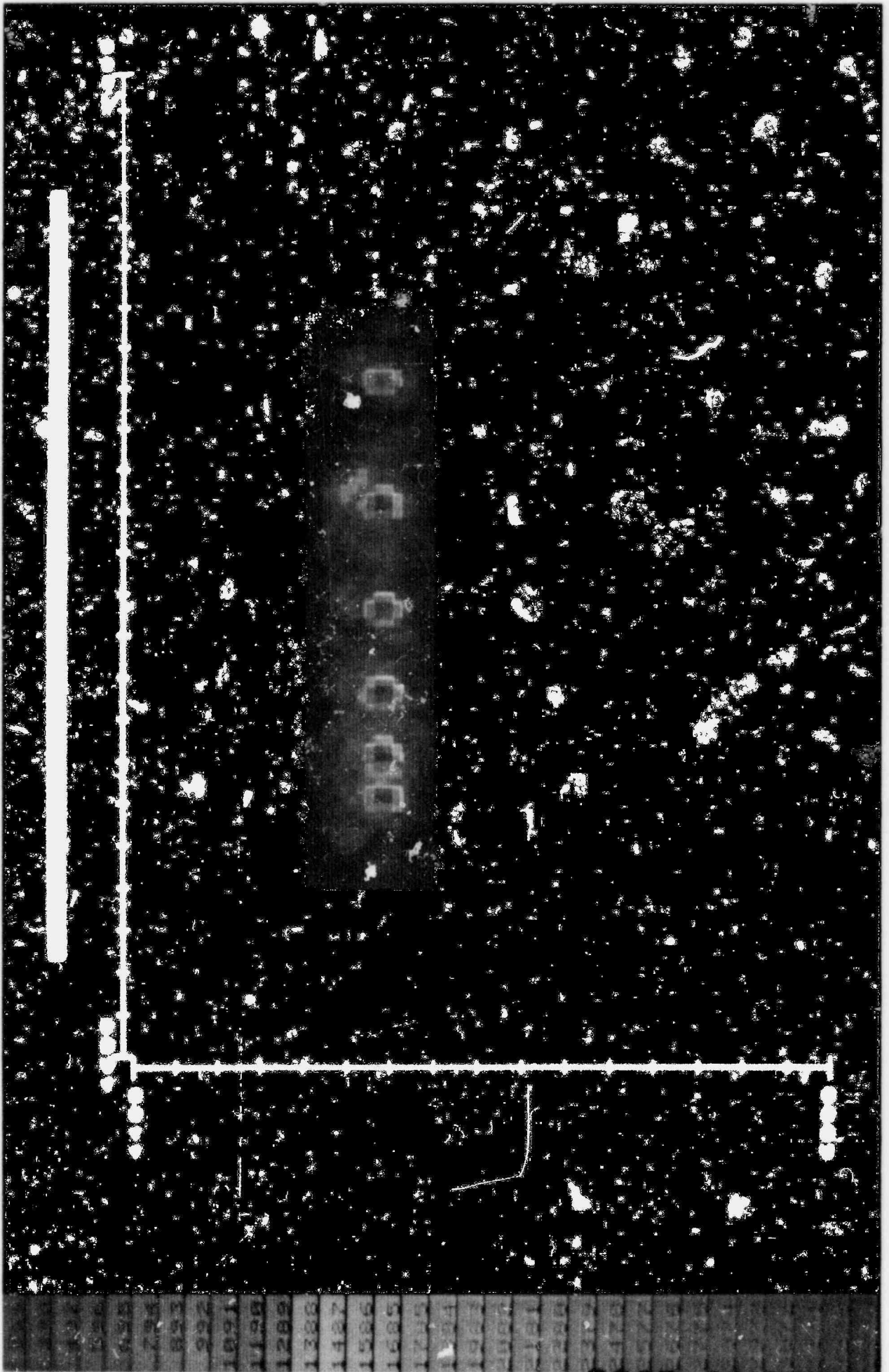


FIGURE 5. C-SCAN DISPLAY OF SIX BOTTOM-DRILLED HOLES WITH AMPLITUDE THRESHOLD REMOVED

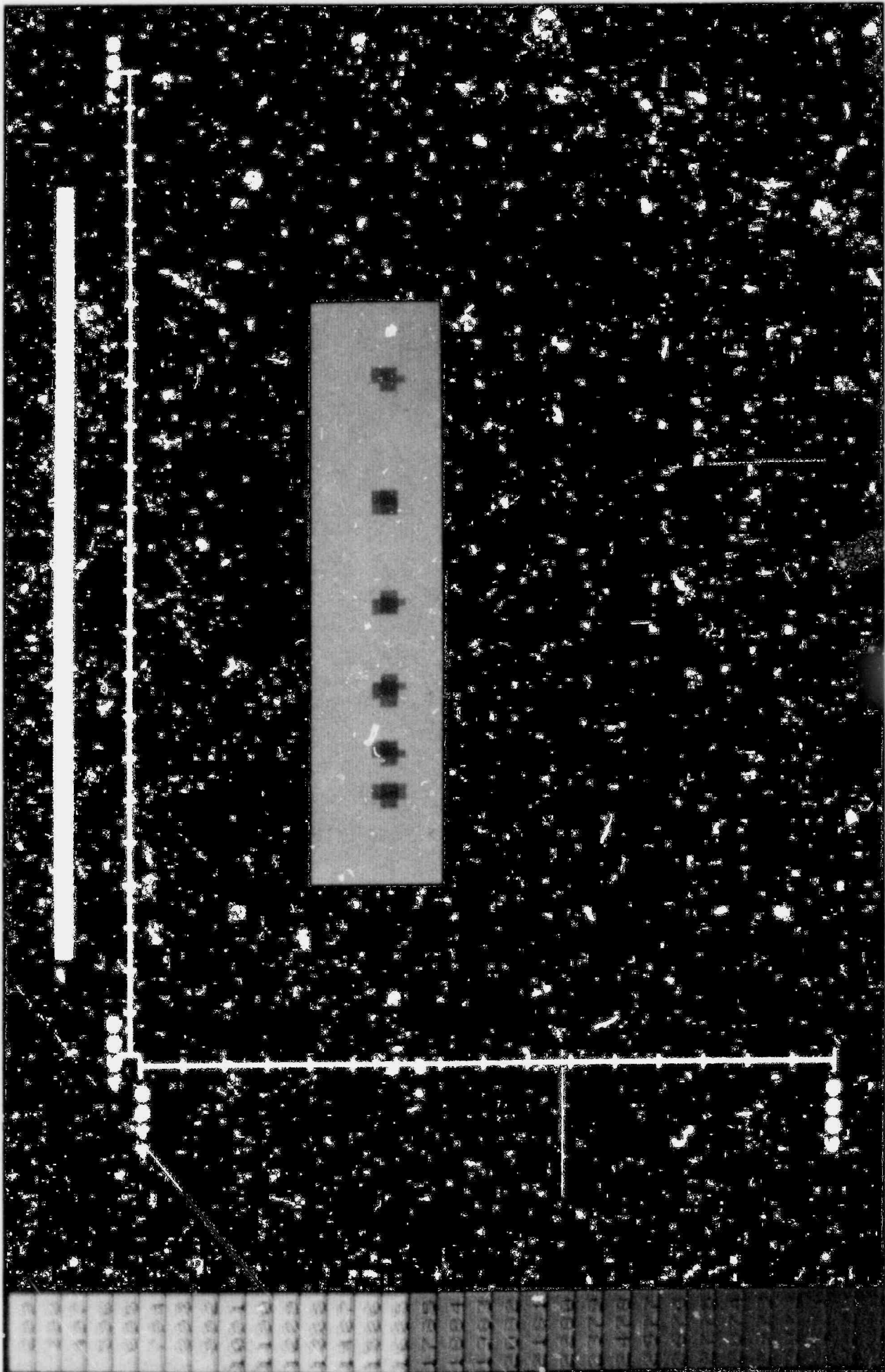


FIGURE 6. C-SCAN DISPLAY OF SIX BOTTOM-DRILLED HOLES USING -6 dB AMPLITUDE THRESHOLD

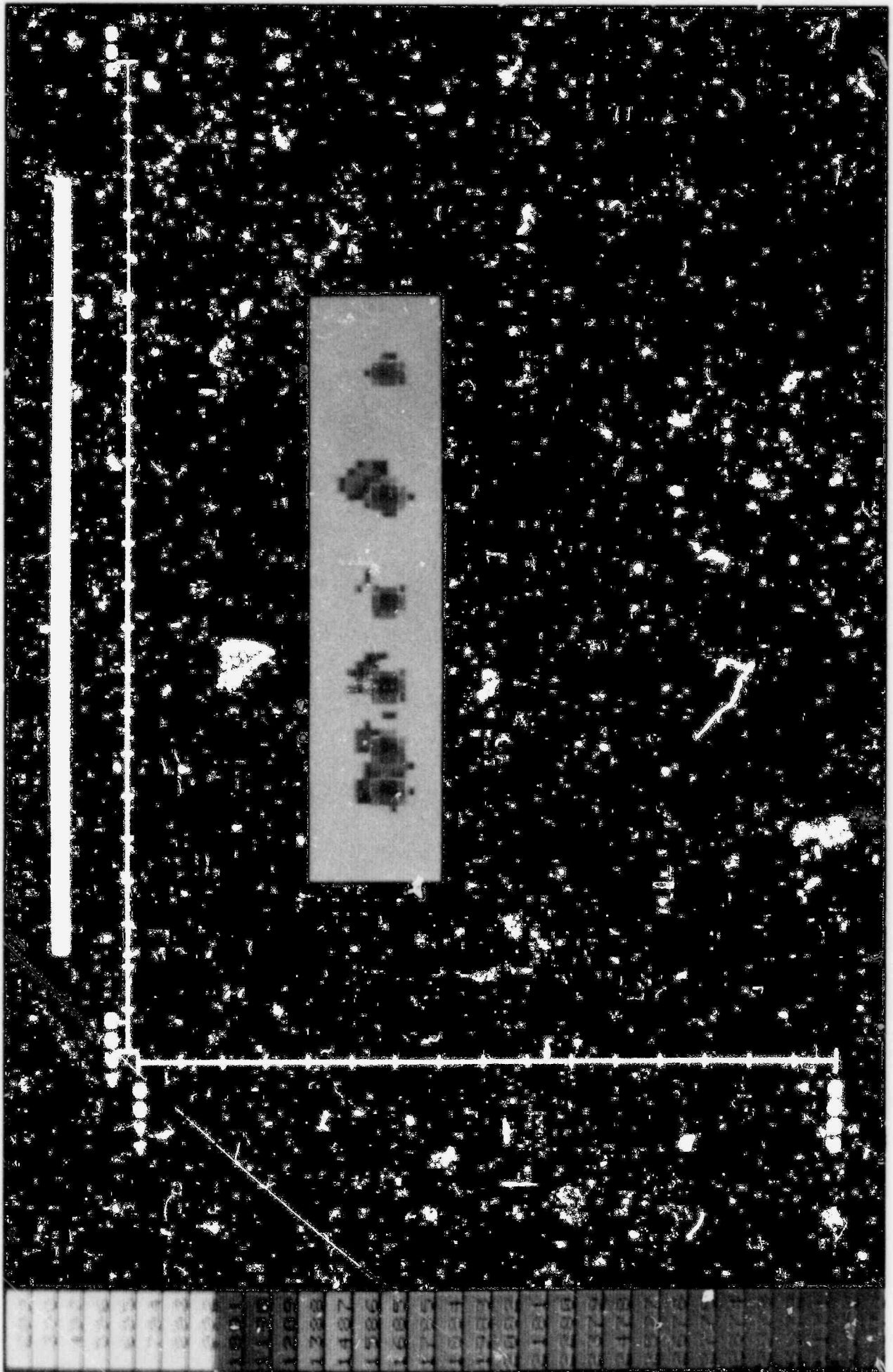


FIGURE 7. C-SCAN DISPLAY OF SIX BOTTOM-DRILLED HOLES USING -10 dB AMPLITUDE THRESHOLD



FIGURE 8. B-SCAN DISPLAY (X-Z PLANE AT Y OF 4960 MILS) OF SIX BOTTOM-DRILLED HOLES WITH AMPLITUDE THRESHOLD REMOVED

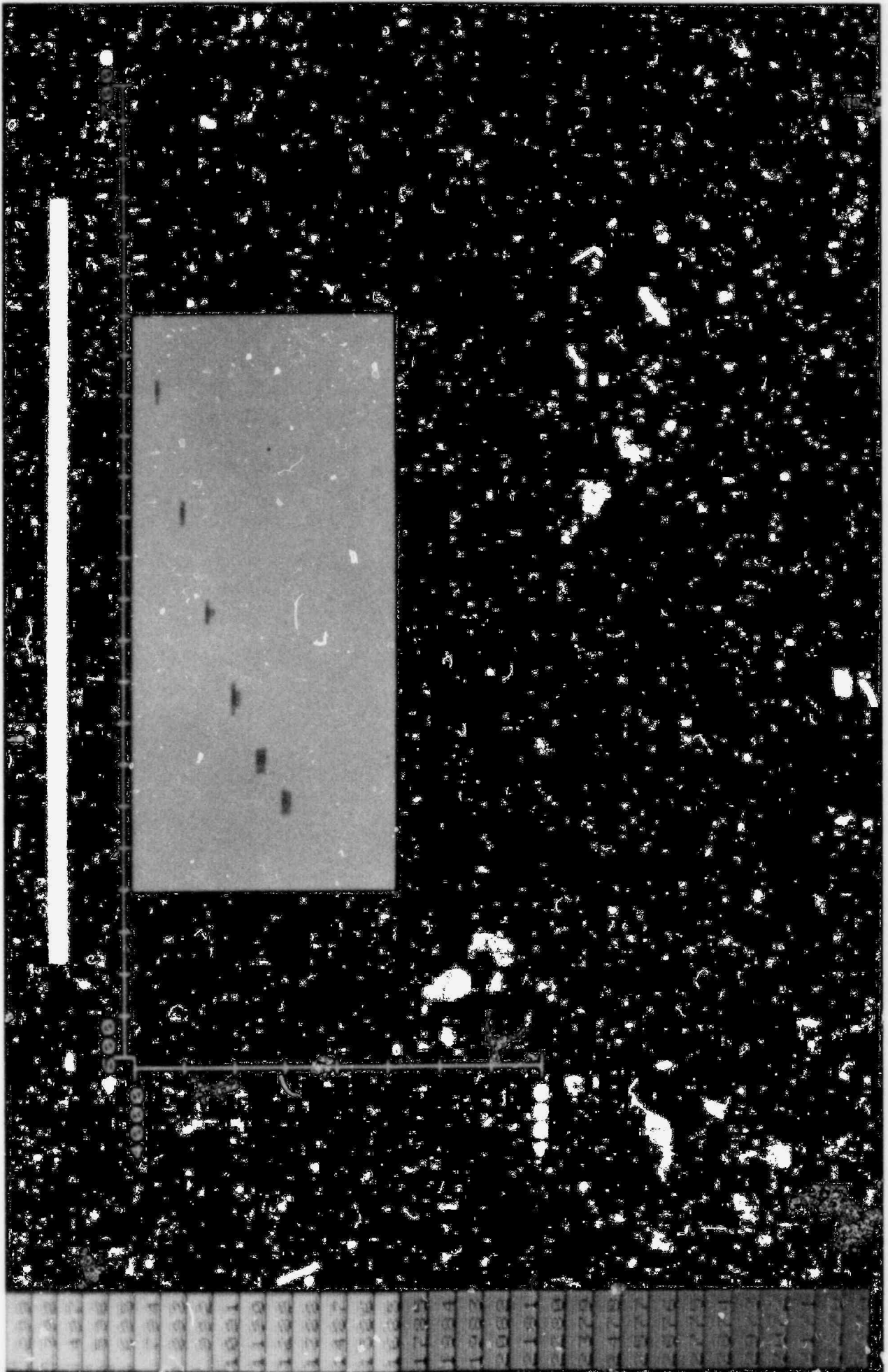
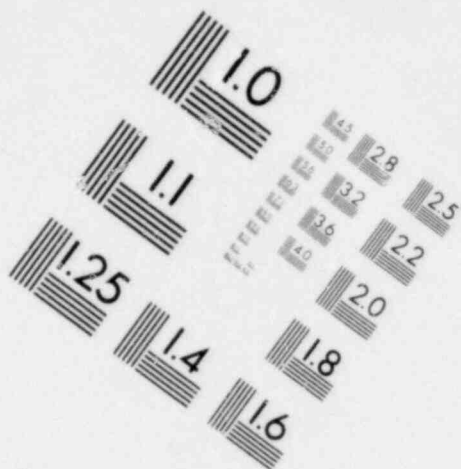
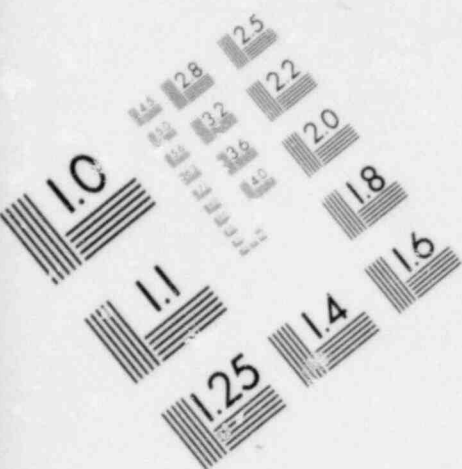
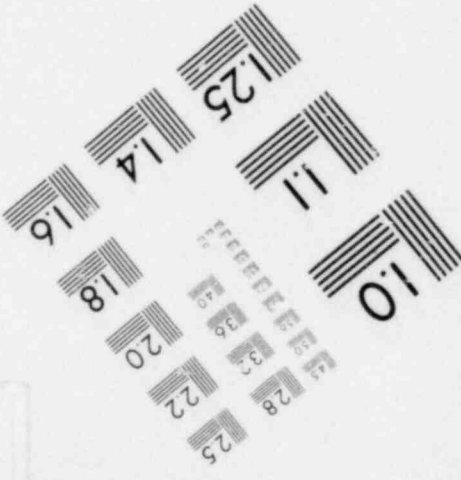
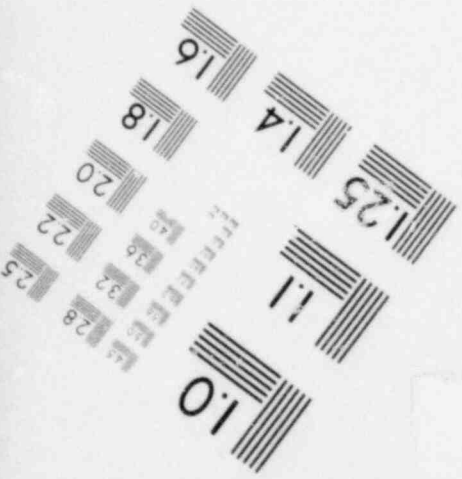
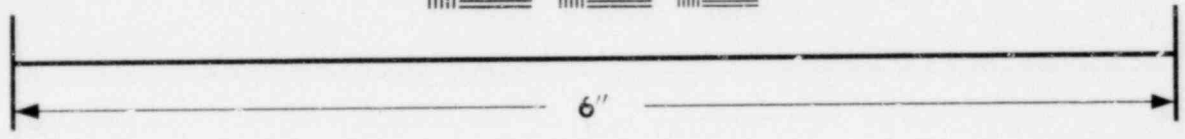
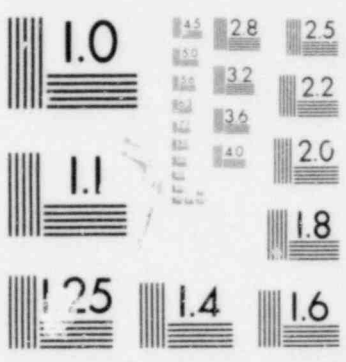
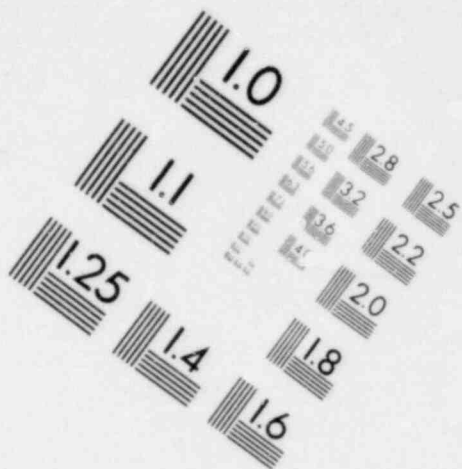
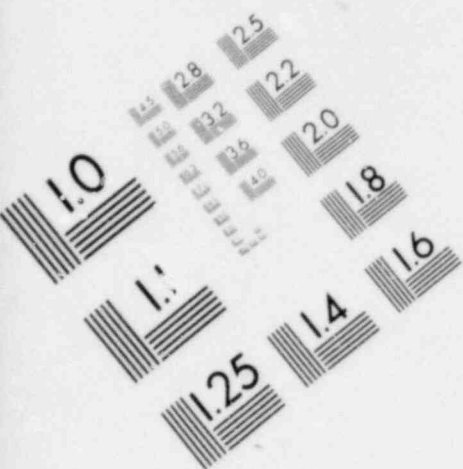


FIGURE 9. ϕ -SCAN DISPLAY (X-Z PLANE AT Y OF 4960 MILS) OF SIX BOTTOM-DRILLED HOLES USING -6 dB AMPLITUDE THRESHOLD

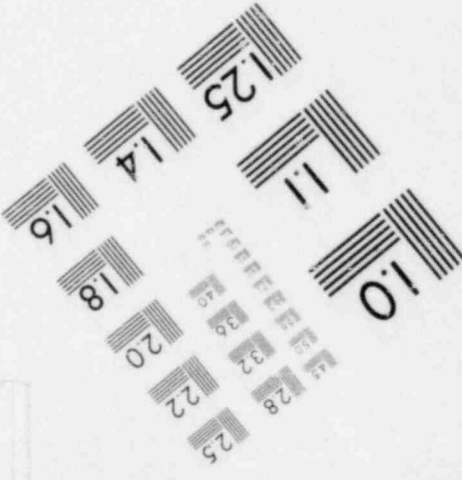
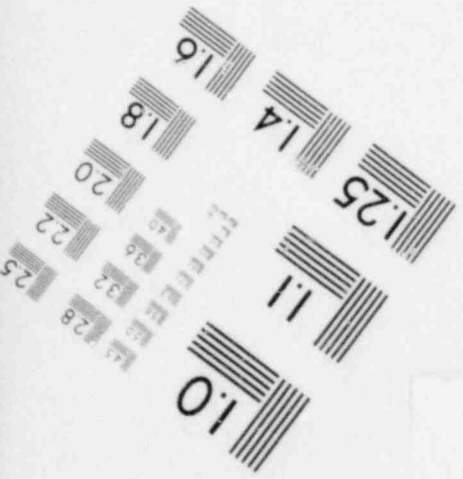
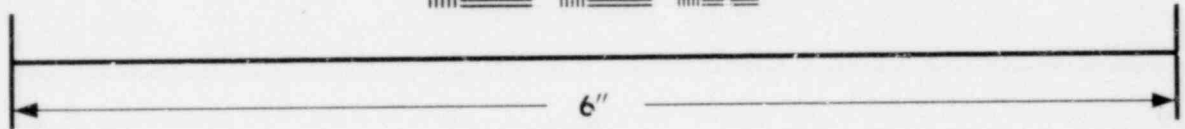
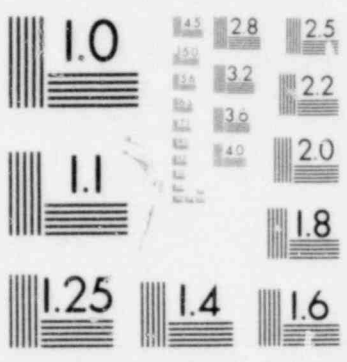


**IMAGE EVALUATION
TEST TARGET (MT-3)**





**IMAGE EVALUATION
TEST TARGET (MT-3)**



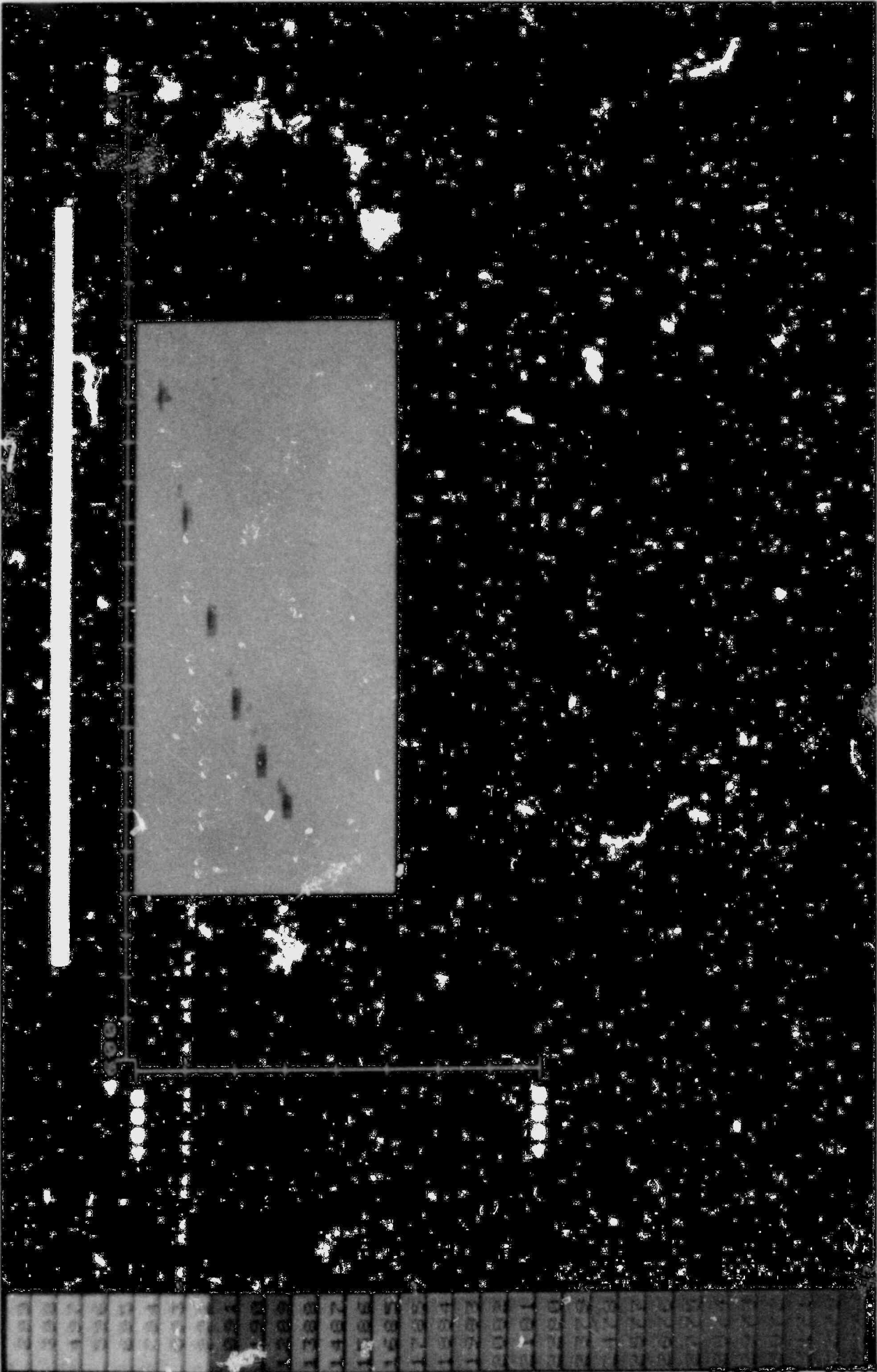


FIGURE 10. B-SCAN DISPLAY (X-Z PLANE AT Y OF 4960 MILS) OF SIX BOTTOM-DRILLED HOLES USING -10 dB AMPLITUDE THRESHOLD

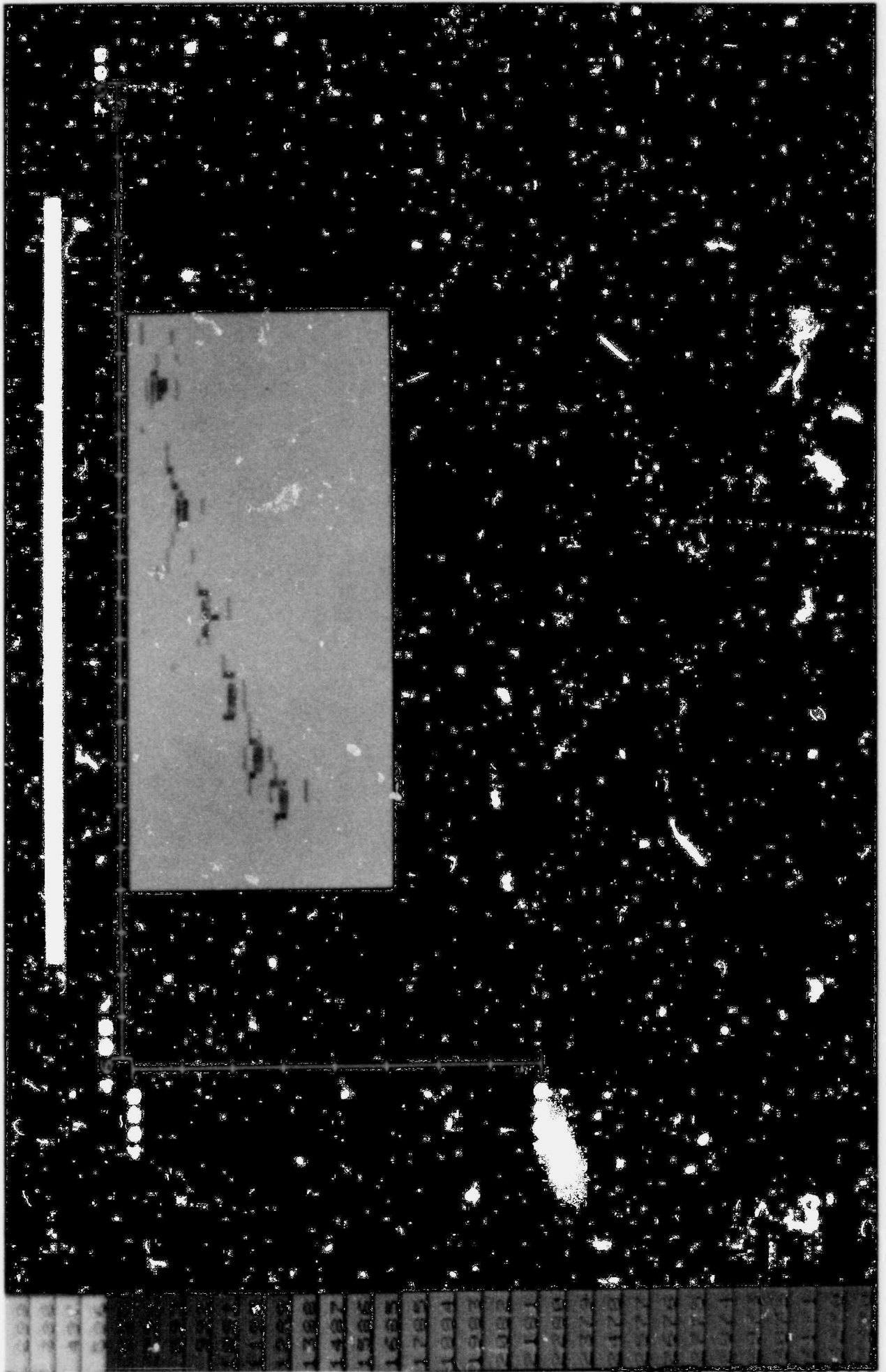


FIGURE 11. B-SCAN DISPLAY (X-Z PLANE AT Y OF 4960 MILS) OF SIX BOTTOM-DRILLED HOLES USING -14 dB AMPLITUDE THRESHOLD

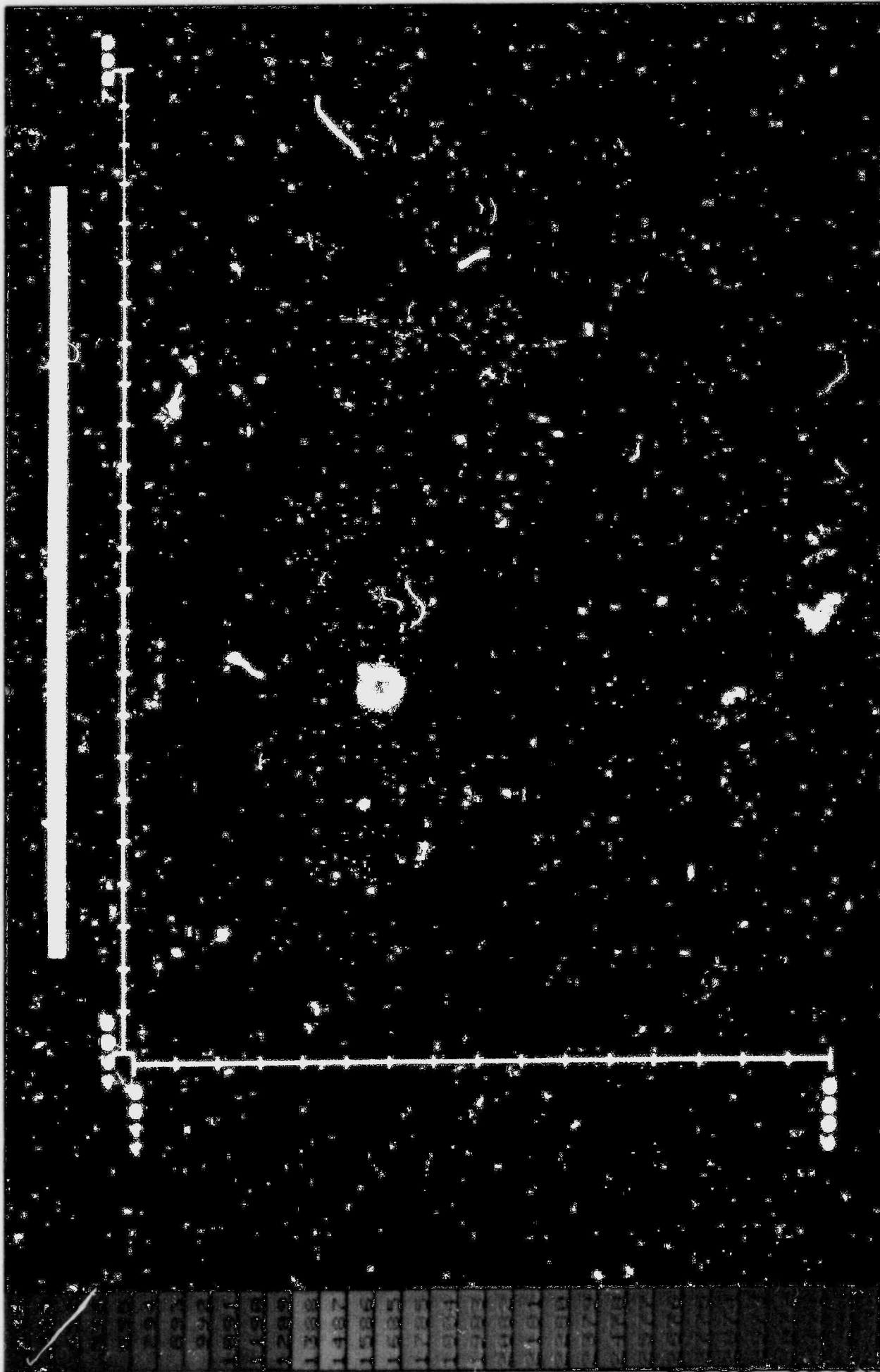


FIGURE 12. C-SCAN, ONE PIXEL DEEP ($\frac{1}{2}$ OF 4190 MILS), OF BOTTOM-DRILLED HOLE NO. 3
WITH AMPLITUDE THRESHOLD REMOVED

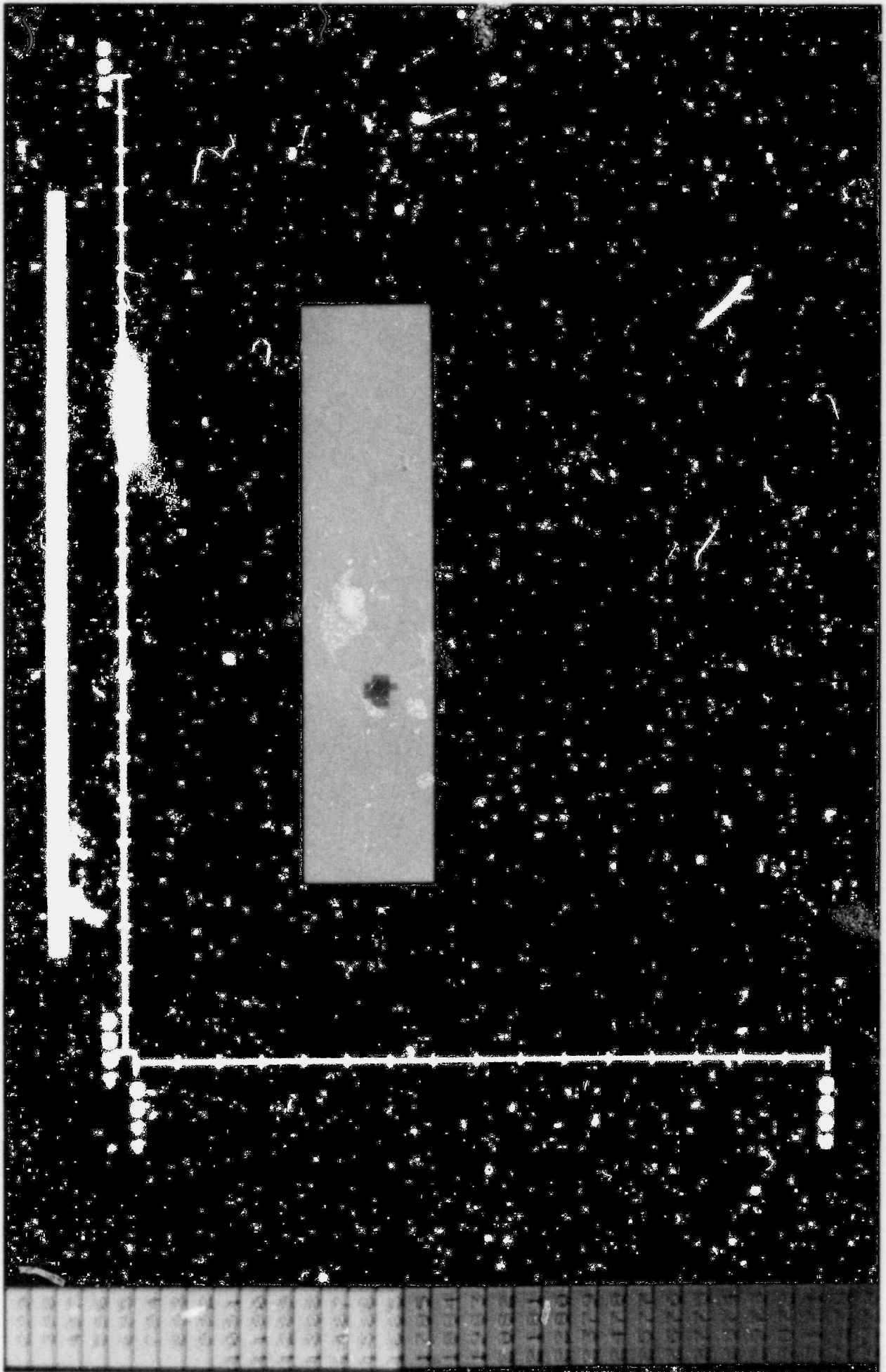


FIGURE 13. C-SCAN, ONE PIXEL DEEP (\approx OF 4190 MILS), OF BOTTOM-DRILLED HOLE NO. 3 USING -6 dB AMPLITUDE THRESHOLD

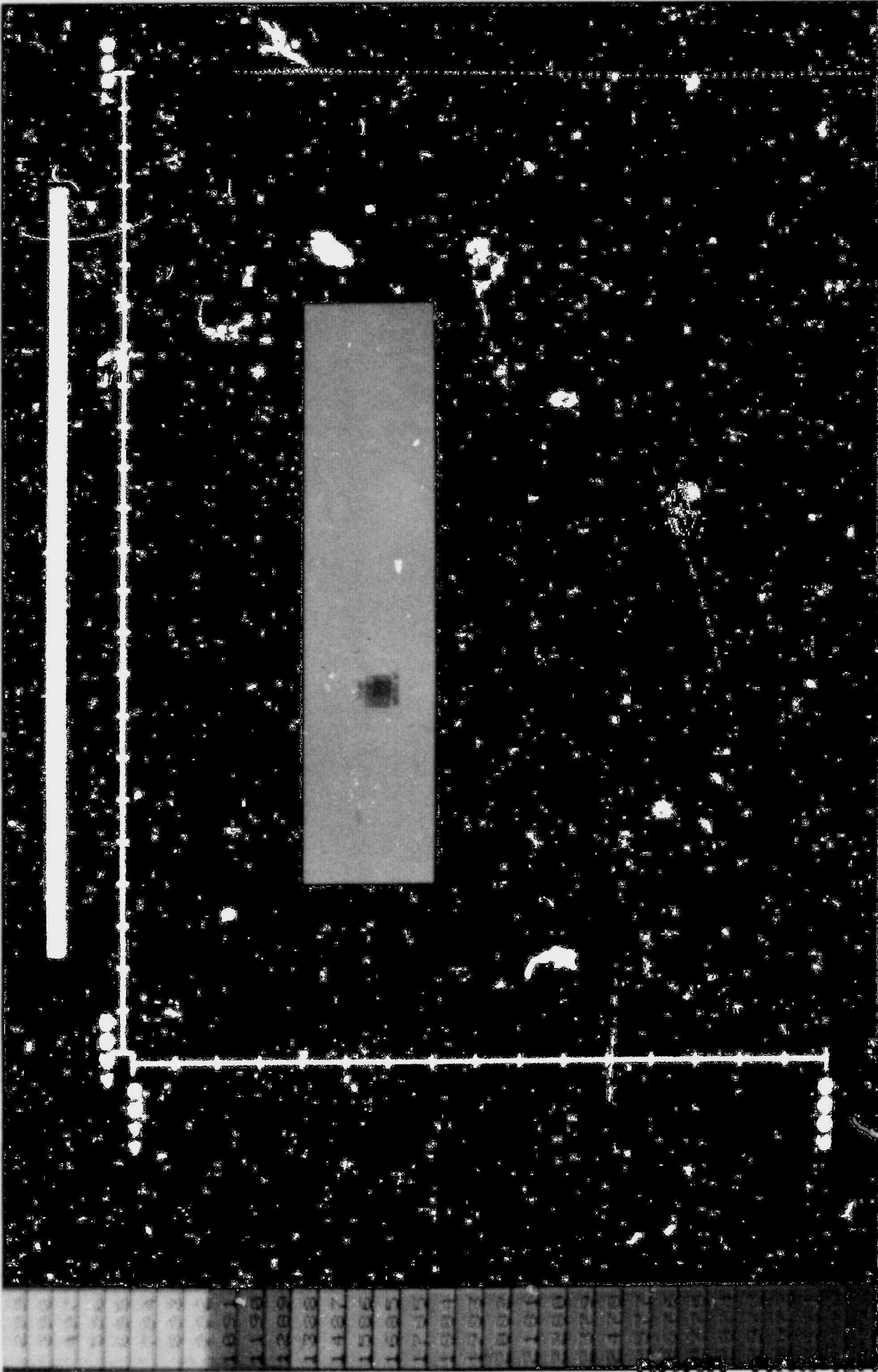


FIGURE 14. C-SCAN, ONE PIXEL DEEP ($\frac{1}{2}$ OF 4190 MILS), OF BOTTOM-DRILLED HOLE NO. 3
USING -10 dB AMPLITUDE THRESHOLD

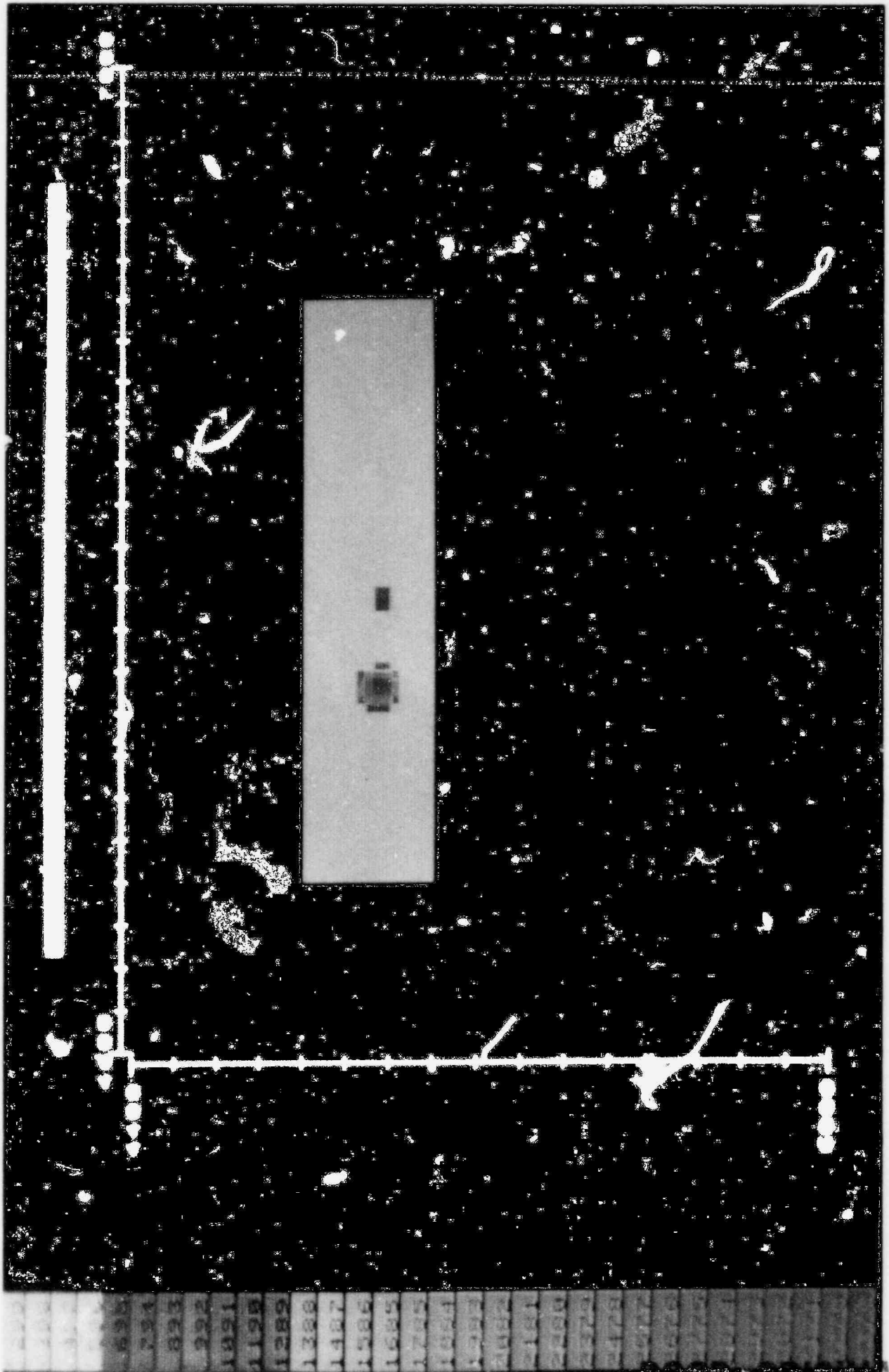


FIGURE 15. C-SCAN, ONE PIXEL DEEP ($\frac{1}{8}$ OF 4190 MILLS), OF BOTTOM-DRILLED HOLE NO. 3
USING -14 dB AMPLITUDE THRESHOLD

1280	1281	1282	1283	1284	1285	1286	1287	1288	1289	1290	1291	1292	1293	1294	1295	1296	1297	1298	1299
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16. ABSTRACT (200 words or less) The purpose of the project is to validate the usefulness of SAFT UT for industrial nondestructive evaluations (NDE). SAFT UT is an ultrasonic imaging method for accurate measurement of the spatial location and extent of acoustically reflective surfaces (flaws) contained in objects such as structural components and weldments in nuclear power reactor systems. The increased measurement accuracy offered by SAFT, when compared with that provided by measurement methods now in use, will improve the reliability of flaw severity assessments with resultant safety and economic benefits to the nuclear power industry. To accomplish the objective, SwRI is to design and construct an imaging system, suitable for field use using the SAFT UT and to conduct sufficient tests with the system to fully characterize its performance and usefulness for the intended purpose. The ultimate goal is to produce a field-rated system for highly accurate flaw size measurements and to conduct sufficient testing of that system to promote its acceptance by industrial and regulatory authorities.				14. (Leave blank)	
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