

18 August 1969

Materiel Test Procedure 4-2-090
Electronic Proving Ground

U. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

MINE DETECTORS

AD719671

1. OBJECTIVE

The objective of the procedures outlined in this MTP is to provide methods of evaluating the technical performance, engineering, adequacy, and technical characteristics of mine detectors, relative to criteria contained in Quality Materiel Requirements (QMR), Small Development Requirements (SDR), or other applicable documents.

2. BACKGROUND

The known or suspected use of land mines by an enemy force in ground warfare necessitates some action to neutralize or reduce the threat when new terrain is to be traveled or occupied by friendly forces. Anti-personnel and anti-vehicle land mines are produced in a variety of sizes, shapes, and operational design and may be constructed of metallic or non-metallic materiel. They are usually buried or otherwise concealed from view in roads, trails, paths, or areas likely to be traversed by friendly troops or vehicles.

In general, the most effective and safe method of exploring new terrain for the presence of mines and determining their exact location is the use of electronic devices which do not require surface contact, thus reducing the danger of accidental detonation. Mine detectors of the class under consideration are characterized by:

- a. Man-pack operation.
- b. Relatively short detection range.
- c. Precise locating capability.
- d. Electromagnetic techniques (Mutual inductance bridge type).

New types of mine detecting and locating equipment developed in response to requirements for increased capability or to incorporate new technology must be subjected to engineering tests for technical performance evaluation.

3. REQUIRED EQUIPMENT

Engineering testing of mine detectors requires the following equipment as a minimum:

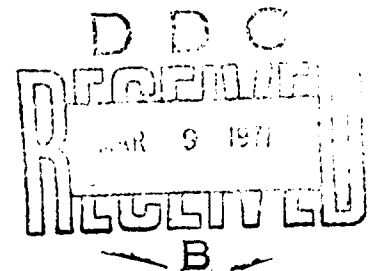
- a. Laboratory apparatus of the type promulgated in Appendix A
- b. Chart recorder or slow scan oscilloscope with camera
- c. VTVM
- d. Test targets as specified
- e. Survey instrumentation

4. REFERENCES

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- 1 -

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- A. Curtis, L. F., "Detectors for Buried Metallic Bodies", Proceedings of the National Electronics Conference, Vol. 2, P.339, October 1964
- B. Paca, F. B., "A Critical Review of Mine Clearing Research and Development to Support Army Operations in the 1970-80 Period", (U) Army Engineer Research and Development Labs, 1966 (AD 369-855L)
- C. Cooper, W. R., "Initial Production Test of Detecting Set, Mine, Truck-mounted", Development and Proof Services, Aberdeen Proving Ground, March 1967 (AD 810-223)
- D. Classen, J. P., et al, "Hidden Object Detection by Magneto-absorption and Induction Methods", Southwest Research Institute, June 1966, (AD 802-419L)
- E. Project No. 20-67-02, "Ordnance Locator, Mark 15, Mod 0; Final Report", Marine Corps Landing Force Development Activities, 16 October 1967 (AD 821-801)
- F. TM 5-6665-201-12, Mine Detector Set AN/PRS-3 (series)
- G. TM 5-6665-201-15, Mine Detecting Set, Portable, Transistorized
- H. TM 5-9541, Mine Detecting Set, AN/PRS-4
- I. MIL-STD-461, Electromagnetic Interference Characteristics, Requirements for Equipment
- J. MIL-STD-810B, Environmental Test Methods
- K. MTP 3-1-002, Confidence Intervals and Sample Size
- L. MTP 6-2-215, Public Address Set

5. SCOPE

5.1 SUMMARY

5.1.1 Technical Characteristics

The procedures outlined in this MTP provide general guidance for determining the degree to which the item under test meets the military requirements for mine detectors as expressed in appropriate QMR's, SDR's or other applicable documents. The cumulative test results, together with the results of appropriate common engineering tests will allow an estimate to be made of the degree to which the design requirements of a developmental mine detector have been met, and the suitability of the equipment to meet the operational need. The specific tests to be performed and their objectives are listed below.

- a. Sensitivity - The objective of this subtest is to obtain a measure of the overall systems ability to detect small targets as a function of the search head's height above the surface and the depth of the target below the surface.
- b. Mutual Interference - The objective of this subtest is to determine the minimum non-interference distance between two operating test items.
- c. Balance Point Drift - The objective of this subtest is to determine the stability of the test item's balance point.
- d. Target Acquisition - The objective of this subtest is to obtain a measure of the test item's ability to perform its intended function in

simulated tactical situations.

e. Environmental - The objective of this subtest is to determine ability of the test item to operate satisfactorily during and after it has been subjected to extreme environmental conditions.

5.1.2 Common Engineering Tests

Not included in this MTP are the following Common Engineering Tests which apply to these commodities.

- a. 4-1-001, Testing Ammunition and Explosives
- b. 4-2-055, Fuzes
- c. 4-2-502, Safety
- d. 6-2-015, Amplifiers, General
- e. 6-2-115, Headsets
- f. 6-2-502, Human Factors Engineering
- g. 6-2-503, Reliability
- h. 6-2-504, Design for Maintainability

5.2 LIMITATIONS

The test procedures contained herein were designed for man-pack units employing mutual inductance bridge type mine detectors. With minor modification they may also be made applicable to vehicular mounted units or devices employing radar, audio, or magnetoabsorption principles.

Specifically excluded from consideration are large-scale mine field detection systems such as airborne detection system employing infrared imaging techniques.

6. PROCEDURES

6.1 PREPARATION FOR TEST

a. Select test equipment ideally having an accuracy of ten orders of magnitude greater than that of the item under test, and that is in keeping with the state of the art, and with calibrations traceable to the National Bureau of Standards.

b. Record the following information:

- 1) Nomenclature, serial number(s), manufacturer's name, and function of the item(s) under test.
- 2) Nomenclature, serial number, accuracy tolerances, calibration requirements, and last date calibrated of the test equipment selected for the tests.

c. Ensure that all test personnel are familiar with the required technical and operational characteristics of the test items under test, such as stipulated in QMR's, SDR's and TC's.

d. Ensure that all test personnel have reviewed all instructional material issued with the test item by the manufacturer, contractor, or government, and performed such preliminary tests as necessary to assure that the

MTP 4-2-090
18 August 1969

test item is in satisfactory condition.

e. Prepare adequate safety precautions to provide safety for personnel and equipment, and ensure that all safety SOP's are observed throughout the test.

f. Prepare record forms for systematic entry of data, chronology of test, and analysis in final evaluation of the test item.

g. Prepare a test item sample plan sufficient to ensure that enough samples of all measurements are taken to provide statistical confidence of final data in accordance with MTP 3-1-002. Provisions shall be made for modification during test progress as indicated by monitored test results.

NOTE: Whatever the actual calibration or test procedure to be followed, preliminary preparation of the test item should always include:

h. Visual inspection for obvious physical defects.

i. Preliminary maintenance pointed out by the previous steps.

j. Zero setting of all indicators.

k. Determination of "intended use" position of the various instruments.

l. Sufficient warm-up time for all electronic devices.

6.2 TEST CONDUCT

6.2.1 Sensitivity

a. Set up the test apparatus as described in Appendix A, and as illustrated in Figures 1, and A1.

b. Construct the targets of graduated lengths of steel wire/bar stock ranging from approximately 0.25" to 0.01" (+30 AWG) in diameter. Target lengths shall be equal to the width of the test item search head and spacing shall be such that the test item is influenced by only one target at any given time during its transition of the test box.

c. Place dry-homogeneous soil in the test box.

d. Implant the targets flush with the surface of the soil.

NOTE: The search head velocity shall be maintained as specified in the pertinent operator's manual (nominally 5" per second).

e. Electrically balance the test item as specified in the appropriate operator's manual and test for correct phasing over the type of soil specified.

NOTE: Sensitivity, amplification, and other controls available to the operator shall be initially adjusted in accordance with operators manual and the test run subject to repetition to encompass the effects control variations to include as a minimum, the minimum, average, and maximum values afforded by the control.

f. Activate the traversing mechanism with the search head mounted 1" above the surface and record the test items output signal as it traverses each target.

MTP 4-2-090
18 August 1969

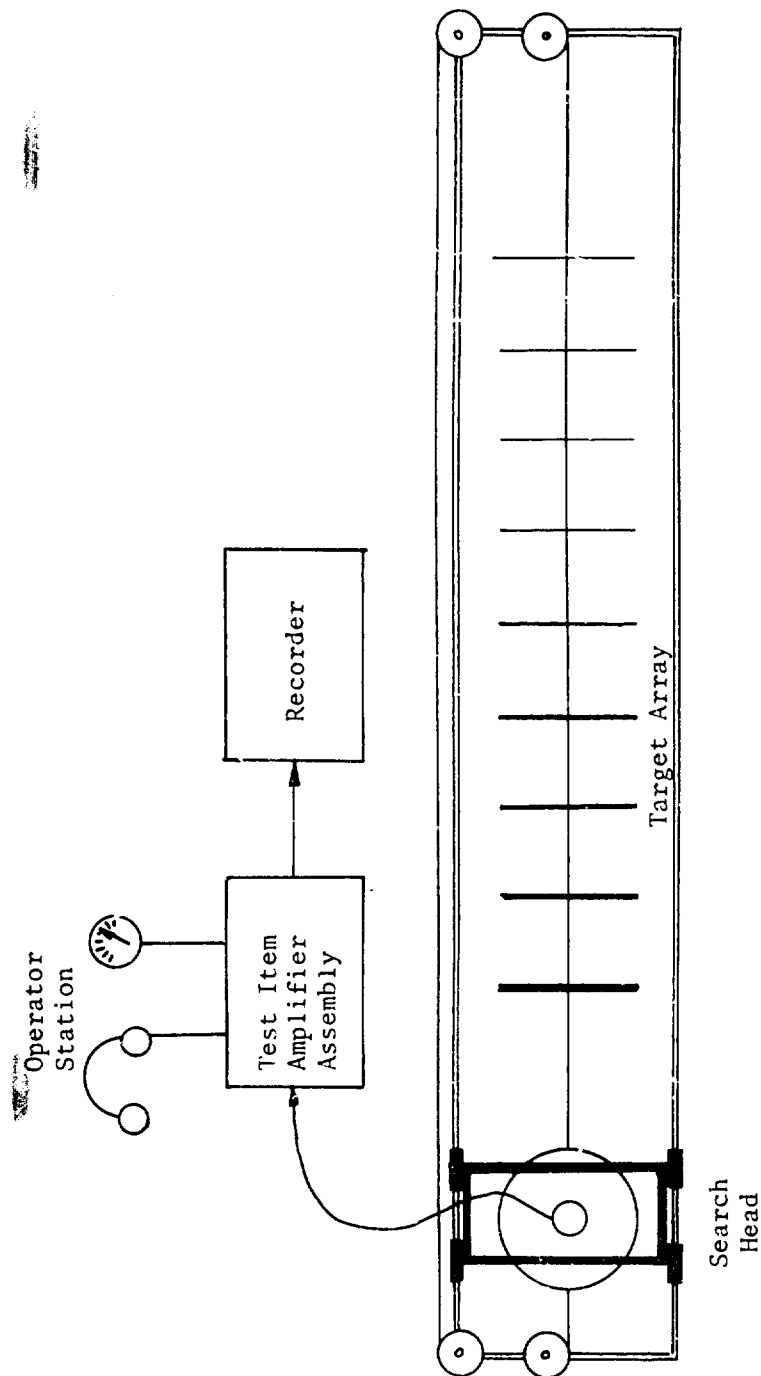


Figure 1. Sensitivity Test Apparatus Configuration

MTP 4-2-090
18 August 1969

g. Concurrent with step f. above, a trained equipment operator shall "score" the audio/visual indication as to whether the entire system (operator included) was responsive to each individual target.

h. Repeat the above search test at increased search head heights in 1" increments until the maximum specified operating height is reached and exceeded.

i. Re-establish the search head height at the initial 1" altitude and complete a series of test runs with the test targets buried in 1" increments up to the maximum detectable depth.

j. The entire test sequence shall be subject to repetition as necessary to encompass the effects of varying test item control settings or to establish a statistical base for evaluation of the central tendency of operator scores.

k. Repeat the above test sequence with false targets such as rocks of various sizes and sticks (roots) implanted at the surface and subsurface depths to determine their influence, if any.

6.2.2 Mutual Interference

- a. Select an area that is as interference free as possible.
- b. Establish and mark radials in the soil in the manner indicated in Figure 2. The initial length of the radials shall be approximately 100 feet.
- c. Locate test item number one in the center of the test area at 1" altitude. Balance and operate this detector in accordance with applicable procedures for the item.
- d. Prepare and operate test item number two in accordance with instructions and move it along each radial toward the test area center.
- e. Note and record the point at which mutual interference first occurs on each radial. Move a few additional feet toward the center to determine whether the interference continues. Backtrack along the radial and note and record the point where the interference stops.
- f. Repeat the tests for each control setting on the detectors.
- g. Conduct a sample test to determine effect of height above ground.
- h. Soak the area with water and repeat the above tests.

NOTE: Mutual interference is manifested normally by a loud beat-type signal.

6.2.3 Balance Point Drift

- a. Adjust the test items balance and phase controls in accordance with paragraph 6.2.1.e.
- b. Connect a VTVM across the test items aural indicator leads and note the balance noise level.
- c. Obtain a balance level reading on the VTVM every three minutes after the test item is turned on for the first fifteen minutes and every fifteen minutes thereafter for a total time period of four hours.

6.2.4 Target Acquisition

MTP 4-2-090
18 August 1969

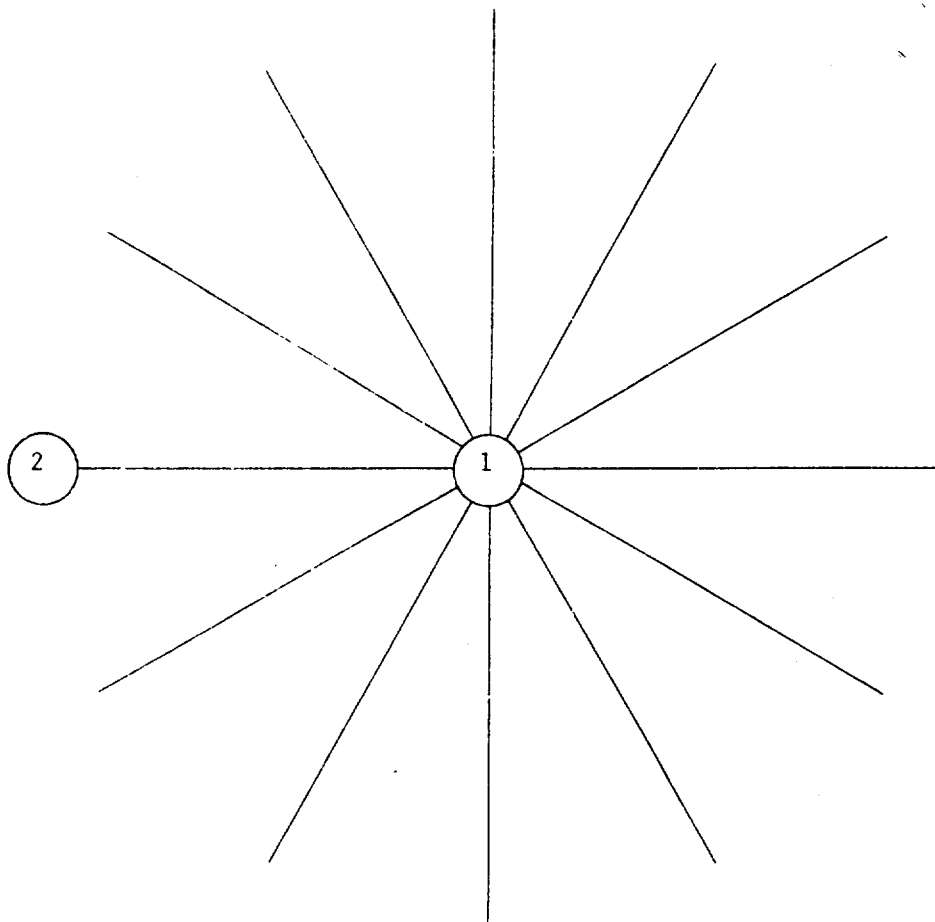


Figure 2. Mutual Interference Test Geometry

MTP 4-2-090
18 August 1969

- a. With the test apparatus set up as described in Appendix A and illustrated in Figure 1, connect a vacuum tube volt meter (VTVM) across the test items aural indicator.
- b. Place "Dry soil" in the test box.
- c. Place the targets in the soil at the minimum depth specified in the applicable ordnance manual, (flush with surface in a dry soil environment). Ensure that the target spacing is such that the test item is influenced by only one target at a given time.
- d. Balance and phase the test item in accordance with standard procedures and record the balance point noise level as observed on the VTVM.
- e. Set the test item mode of operation to search mode.

NOTE: The test item shall be tested in two modes of operation:

- 1) The search mode which is characterized by broad tuning, constant velocity, and constant height.
- 2) The point mode which is characterized by fine tuning, variable velocity, and variable height.

f. Traverse the test box with the search head in accordance with the applicable operator instructors for the search mode (nominal height =1", nominal velocity =5"/sec.).

g. Record the test items output signal waveform for each of the targets as the trained operator monitors the test item indicators and scores the test item response to each target.

h. Switch the test item to the point mode and allow the trained operator to manipulate the search head over test area and optimize the target response. Using the test item as his sole sensory mechanism, have the operator mark the indicated target dimensions in the direction of the line of search.

i. Record the optimum target signature and the test conditions (search head height, velocity, etc.).

j. Repeat the above procedure with the targets implanted in the dry soil at the maximum specified depth.

k. Repeat the entire procedure above for the following specified target environments.

- 1) Wet (saturated) soil.
- 2) Wet beach sand (saturated saline)
- 3) Magnetic soil magnetic volume susceptibility of between 6000 and 7000 micro cgs units).

6.2.5 Environmental

a. Subject the test item to environmental conditions as delineated in applicable sections of MIL-STD 810-8.

b. Repeat applicable portions of the operational tests described in this MTP, and determine any degradation in the test item performance which is contributable to environmental conditions.

6.3 TEST DATA

6.3.1 Preparation for Test

The following information, in addition to specific test data listed in subsequent paragraphs, shall be made a part of the test records:

- a. An engineering log book containing in chronological order pertinent remarks and observations which would aid in a subsequent analysis of the test data.
- b. Equipment operator(s) qualifications or previous training descriptors including hearing abilities relative to the listener standards promulgated in references D, F, H, I, & J of MTP 6-2-215, Public Address Set.
- c. Test item identification, test setup diagrams, test equipment calibration and pertinent operating conditions.

6.3.2 Sensitivity

Sensitivity test data to be preserved for reduction and presentation shall include:

- a. Suitably annotated chart recordings of test item output signal for each test run.
- b. Operator scores for each test run (i. e. detection threshold).

6.3.3. Mutual Interference

Mutual interference test data to be preserved for reduction and presentation shall include:

- a. Descriptors of interference
- b. Minimum non-interference distance along each radial for each set of test conditions.

6.3.4 Balance Point Drift

Balance point drift test data to be preserved for reduction and presentation shall consist of balance point level (VTVM readings) as a function of time.

6.3.5 Target Acquisition

Target acquisition test data to be preserved for reduction and presentation shall include the following for each test run:

- a. Target types (mine descriptors)
- b. Target environment (soil type)
- c. Target Depth
- d. Search head height
- e. Search head velocity
- f. Test item mode of operation
- g. Target "signature"
- h. Operator score (threshold of detection)

- i. Operator estimate of target dimensions
- j. Actual target dimensions

6.3.6 Environmental

Environmental data shall include:

- a. The environmental conditions to which the test item was subjected.
- b. Length of test item.
- c. Test configuration used.
- d. Variations in test item performance attributable to environmental conditions.

6.4 DATA REDUCTION AND PRESENTATION

Processing of raw test data, in general, includes but is not limited to the following steps:

- a. Marking test data for identification and correlation.
- b. Organizing data into tabular and graphical form.
- c. Modifying data to correct for nonstandard conditions.
- d. Determining the statistical variation of the results in terms of the average value and standard deviation of the particular quantities, the correlation among two or more quantities, etc.

It is noted that the test directive (or operation) itself serves to define the types and characteristics of the raw test data, and the ultimate objective of the test program defines the form of the test data desired.

Specific instructions for the reduction and presentation of individual subtest data are outlined in subsequent paragraphs.

6.4.1 Sensitivity

Sensitivity test data shall be examined to determine the correlation between the recorded signal to noise ratio (as derived from the target signatures) and the operator score (detection threshold). Subsequent to this examination, graphical presentations of the test results may be constructed in the manner illustrated in Figure 3. The graph indicates the measured signal to noise ratio as a function of target diameter with search head height (or target depth) as the family parameter.

Detection threshold - height (depth) intercept points shall be extracted from the graph and a derived presentation constructed to show search head height (target depth) versus target diameter for a constant detection threshold (signal to noise ratio). Height (depth) - target diameter combinations resulting in system response/no response shall be marked as indicated in Figure 4.

6.4.2 Mutual Interference

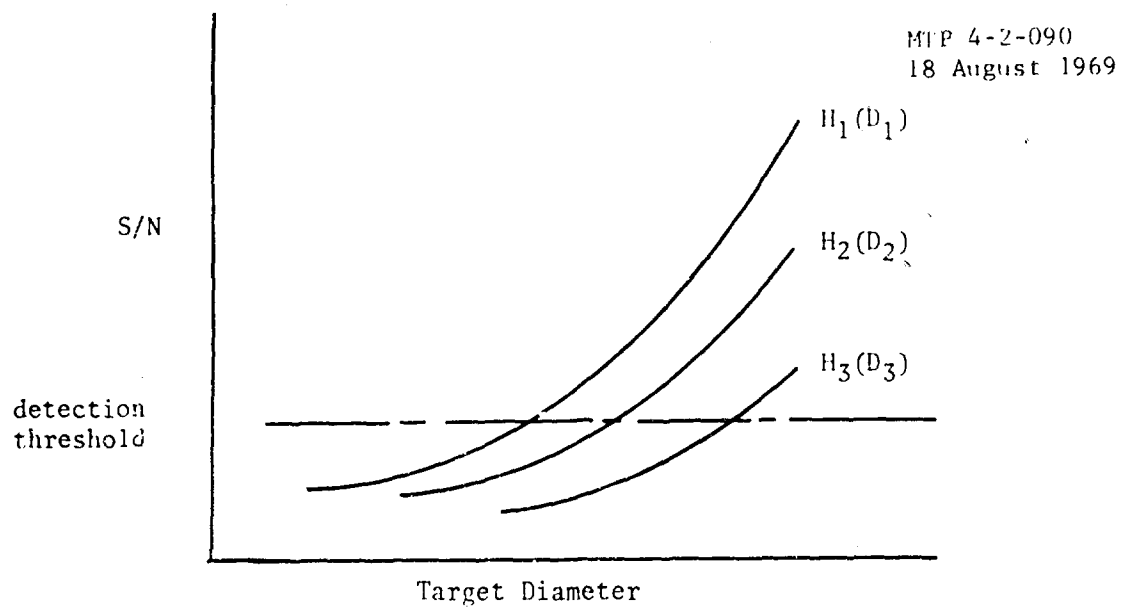


Figure 3. Signal to Noise Ratio as a Function of Target Diameter.

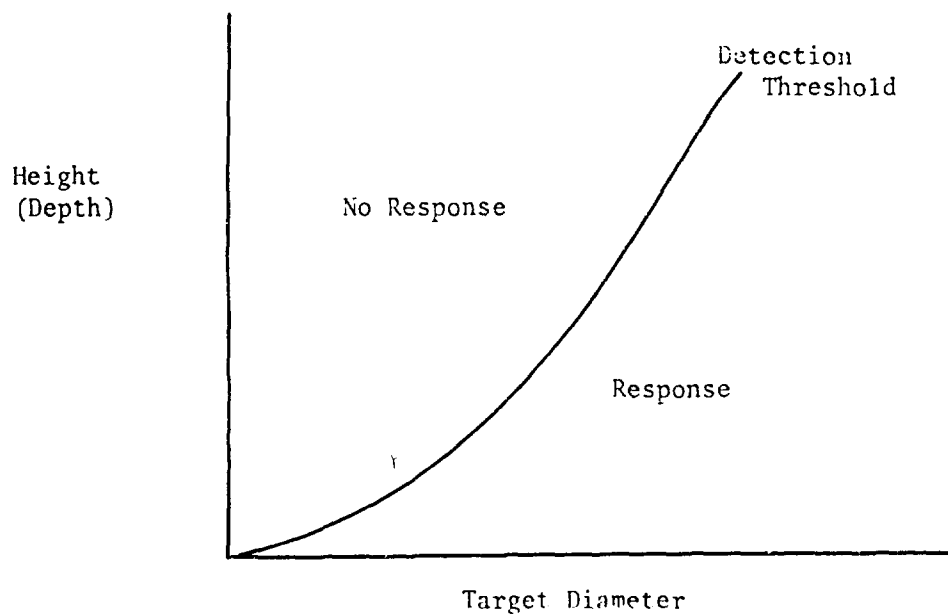


Figure 4. Target Height (Depth) as a Function of Target Diameter.

MTP 4-2-090
18 August 1969

Mutual interference test data shall be presented as:

- a. A polar map of the minimum non-interference area surrounding the test item for each set of test conditions.
- b. The mean minimum non-interference distance for each set of test conditions.

6.4.3 Balance Point Drift

Balance point drift shall be presented in both tabular and graphical form to show change in balance point noise or signal level with respect to time.

6.4.4 Target Acquisition

Target acquisition test data shall be reduced to and presented as:

- a. A listing of optimum conditions for detection of each target in each target environment together with suitably annotated recordings of target signatures.
- b. Relative to each entry in a. above, present in descending order the target signatures and pertinent data achieved under the remaining test conditions to indicate the degradation from optimum signature with target environment, target depth, etc.
- c. For each target signature obtained in the point mode, present the recorded signature, with the time base scale translated into distance and the actual target dimensions superimposed on the presentation.
- d. Analyze the cumulative data obtained in the point mode to derive the distribution of errors between operator estimates of target dimensions and actual target dimensions.
- e. Tabulate data showing balance point noise level as a function of target environment. Indicate test item reaction to magnetic soil environment.
- f. For each target signature obtained in the search mode, present the suitably annotated signature recordings in matrix form to indicate degradation of signature with test conditions. Indicate those conditions in which the signature was degraded to the point where the target was unrecognizable as such.

6.4.5 Environmental

Evaluate the reduced environmental test data and prepare a comprehensive report listing areas of weak design on construction methods that could be improved to reduce any performance degradation caused by environmental conditions.

APPENDIX A

LABORATORY TEST APPARATUS

In order to achieve a controlled laboratory environment for testing mine detectors a mechanical test apparatus of the type indicated in Figure A-1 is recommended. Like mechanism are employed in research institutions to easily, continuously, and linearly traverse a test area and thereby obtain repeatable test results.

A typical traversing mechanism of the type illustrated is driven by a reversible motor with reversing limit switches placed at the end of the cart track. The test item detector head is mounted on the cart's lower cross arms which can be varied in height through a series of attachment holes on the vertical members. The entire assembly is constructed of non-metallic components in order to minimize the degradation of test results. Metallic elements such as the reversible motor may be installed in a remote location. Test instrumentation is connected to the detector head by means of suitable electrical wire or cable.

The track is placed on a test box of soil which contains the curied object to be detected. Nominal dimensions of the test box are 8 feet long, 3 feet wide and 1 foot deep.

MT^o 4-2-090
18 August 1969

TEST	WHITE SECTION	☒
NO	BUFF SECTION	☐
NO	NO	☐
NO	NO	☐
<i>50</i>		
DESCRIPTION, AVAILABILITY CODES		
QST.	AVAIL.	SPECIAL
<i>A</i>		

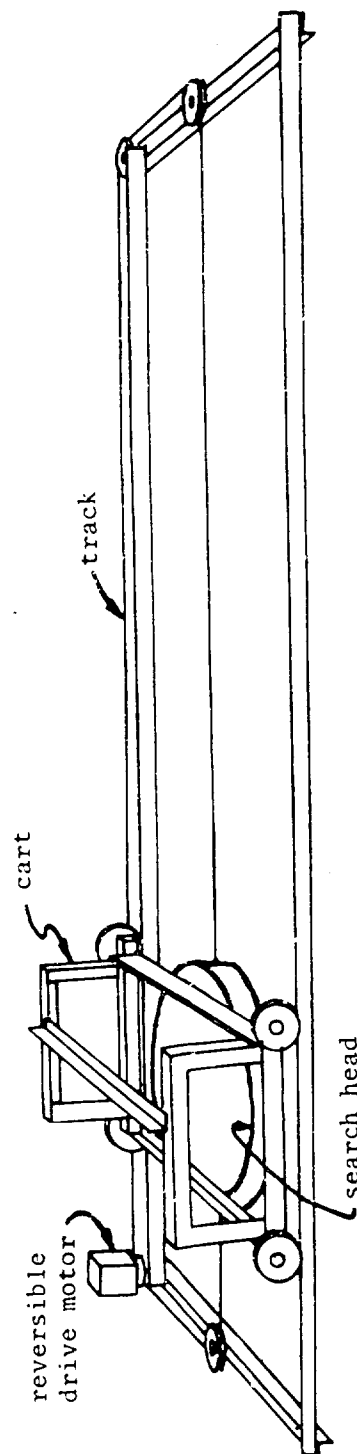


Figure A-1. Laboratory Test Apparatus