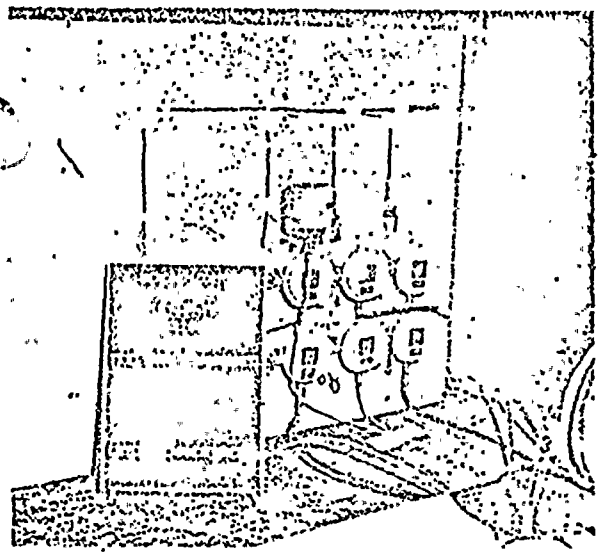
SEISMIC SIMULATION AND RADIATION TEST PROGRAM

ON

SEVEN PRESSURE SWITCHES

FOR

THE MERCOID CORPORATION
4201 BELMONT AVENUE
CHICAGO, ILLINOIS 60641



SEISMIC SIMULATION Test Report

REPORT NO. 44285-1

WYLE JOB NO. 44285

CUSTOMER P.O. NO. 61733

PAGE 1 OF 61 PAGE REPORT

DATE October 26, 1978

SPECIFICATION (S) See References in Section 7.0

1.0 CUSTOMER The Mercoid Corporation

ADDRESS 4201 Belmont Avenue, Chicago, Illinois 60641

2.0 TEST SPECIMEN Seven Pressure Switches (see Paragraph 5.2)

3.0 MANUFACTURER The Mercoid Corporation

4.0 SUMMARY

Seven (7) Pressure Switches, as described in Paragraph 5.2, hereinafter called the specimens, were subjected to a Radiation and Seismic Simulation Test Program as required by The Mercoid Corporation Purchase Order Number 61733, and Wyle Laboratories' Seismic Test Plan 541/6528-5/ES, dated May 19, 1978, Revision A.

The radiation test program consisted of irradiating the non-operative specimens with Cobalt 60.

The seismic test program consisted of resonant search testing and biaxial sine beat testing in each of two test orientations. The specimens were instrumented with accelerometers, electrically powered, pressurized, and monitored for functional operation during the seismic test program.

It was demonstrated that the specimens possessed sufficient integrity to withstand, without compromise of structures or functions, the prescribed simulated seismic environment.

STATE OF ALABAMA
COUNTY OF MADISON } ss

Ala. Professional Eng. License No. 6363

James W. Foreman, being duly sworn, deposes and says. The information contained in this report is the result of complete and carefully conducted tests and is to the best of his knowledge true and correct in all respects.

SEAL James W. Foreman

SUBSCRIBED and sworn to before me this 1st day of January 78

Virginia B. Dent

Notary Public in and for the County of Madison, State of Alabama

Wyle shall have no liability for damages of any kind to person or property, including special or consequential damages, resulting from Wyle's providing the services covered by this report.

PREPARED BY Rod T. Thornburg
R. Thornburg

APPROVED BY H. Jordan for Larry E. Frazier

WYLE Q. A. L. M. Davies
L. M. Davies

WYLE LABORATORIES

4.0 SUMMARY (Continued)

Table I contains a description of the sine beat test runs and the actual input accelerations.

Photograph 1 shows the specimens installed in the side-to-side and vertical orientation for biaxial testing on the Wyle Multiaxis Seismic Simulator Table.

Photographs 2 and 3 show the specimen response accelerometer mounting locations.

Appendix I contains the Certification Letter of the radiation test.

Appendix II contains transmissibility plots of the specimen response accelerometers from the resonant search tests.

Appendix III contains the Instrumentation Log Sheets and the Instrumentation Equipment Sheets.

Appendix IV contains the Wyle Laboratories' Seismic Test Plan 541/6528-5/ES, dated May 19, 1978, Revision A.

The test results for Item 8, as described in the Wyle Test Procedure (Appendix IV), are given in Wyle Laboratories' Test Report Number 44285-2.

5.0 TEST REQUIREMENTS

5.1 Radiation Test

The specimens, as described in Paragraph 5.2, shall be uniformly exposed to 6×10^5 RADS equivalent air dose gamma radiation. The specimens shall be inoperative during the irradiation tests.

5.2 Specimen Mounting and Orientation

The specimens shall be placed on a Wylé-fabricated wall-mount fixture. The mounting hole pattern in each specimen shall be transferred to the test fixture. The holes shall be drilled and the specimens attached using three (3) each Grade 2 Number 10-32 screws. The test fixture shall be welded to the test table in each test orientation. The mounting of the specimens shall simulate the in-service mounting configuration as closely as practical.

Item	Description	Pressure Range	Test Pressure
1	DAW 7023-804B R 8S	10-200 psig	100 psig
2	DAW 7023-804B R 11S	50-1000 psig	500 psig
3	DAW 7023-804B R 12S	100-1500 psig	600 psig
4	DAW 7023-804B R 10S	25-600 psig	300 psig
5	DAW 7023-804B R 6S	5-100 psig	50 psig
6	DAW 7023-804B R 15S	500-5000 psig	1950 psig
7	APWT7041-804 R 33	0-50" H_2O	28" H_2O

The specimens shall be initially oriented in the side-to-side and vertical (SS/V) orientation. For the second test orientation, the specimens shall be rotated 90 degrees in the horizontal plane to the front-to-back and vertical (FB/V) orientation.

5.3 Resonant Search

A low-level (approximately 0.2 g horizontally and vertically) biaxial sine sweep in each test orientation shall be performed from 1.0 Hz to 35 Hz to establish major resonances. The sweep rate shall be one octave per minute. Transmissibility plots of the sine sweeps shall be furnished in the test report.

5.4 Sine Beat Tests

Sine beat tests shall be performed biaxially at one-half octave frequency intervals and at the resonant frequencies detected during the resonant search tests described in Paragraph 5.3 over the frequency range of 1 Hz to 35 Hz. A train of five (5) beats shall be performed with ten oscillations per beat and a two-second pause between beats. The tests shall be performed with the horizontal and vertical inputs in-phase and repeated with the inputs out-of-phase. The excitation input shall be 1.5 g horizontally and 1.0 g vertically, or to the limitations of the test

5.0 TEST REQUIREMENTS (Continued)

5.4 Sine Beat Tests (Continued)

machine. It is anticipated that the required input will be obtained at frequencies above approximately 5 Hz.

5.5 Specimen Response

A total of fourteen (14) specimen-mounted uniaxial piezo-electric accelerometers shall be utilized during the test program. Placement of the accelerometers shall be at the discretion of the Mercoid Technical Representative. Transmissibility plots of the resonant search in each orientation shall be provided in the test report.

5.6 Electrical Powering and Electrical Loading

120 VAC, 60 Hz, single-phase power at approximately 11 amperes resistive load shall be provided for a normally closed (NC) contact on Items 1 through 6. 120 VAC, 60 Hz, single-phase power at approximately 5 amperes resistive load shall be provided for an NC contact on Item 7.

5.7 Electrical Monitoring

Seven (7) electrical monitoring channels (one each specimen) shall be provided to monitor a NC contact of each switch. Each channel shall be recorded on an oscillograph recorder during the Seismic Simulation Test Program. These channels may be used to ascertain electrical continuity, current/voltage levels, spurious operation, contact chatter, etc. before, during and after the seismic excitation.

5.8 Pneumatics

GN_2 pressure sources, as described in Paragraph 5.2, shall be provided for the specimens prior to, during and after the prescribed tests.

5.9 Operational Tests

Pre-seismic and post-seismic operational tests shall be performed by raising and lowering the operating pressure of each switch about its set point.

6.0 PROCEDURES AND RESULTS

6.1 Radiation Test Procedures

The specimens, as described in Paragraph 5.2, were uniformly exposed to 6×10^5 RADS equivalent air dose gamma radiation. The specimens were inoperative during the irradiation tests.

6.1.1 Radiation Test Results

It was demonstrated that the specimens possessed sufficient integrity to withstand, without compromise of structures or functions, the prescribed radiation environment (reference Certification Letter in Appendix I).

6.2 Specimen Mounting and Orientation Procedures

The specimens were placed on a Wyle-fabricated wall-mount fixture. The mounting hole pattern in each specimen was transferred to the test fixture. The holes were drilled and the specimens attached using three (3) each Grade 2 Number 10-32 screws. The test fixture was welded to the test table in each test orientation. The mounting of the specimens simulated the in-service mounting configuration as closely as practical.

The specimens were initially installed on the Seismic Simulator Table in the SS/V test orientations, as shown in Photograph 1. For the second orientation of tests, the specimens were rotated 90 degrees in the horizontal plane to the FB/V test orientation.

6.3 Resonant Search Procedures

A low-level (approximately 0.2 g horizontally and vertically) biaxial sine sweep was performed in the SS/V and the FB/V orientations. The frequency range of the sine sweeps was from 1 Hz to 35 Hz at a sweep rate of one octave per minute.

6.3.1 Resonant Search Results

Table I contains a description of the test runs.

Transmissibility plots of the specimen response accelerometers from the resonant search test in each orientation are contained in Appendix II.

6.0 PROCEDURES AND RESULTS (Continued)

6.4 Sine Beat Test Procedures

The specimens were subjected to biaxial sine beat tests in each test orientation. Sine beat tests were performed at each one-half octave frequency interval over the frequency range of 1 Hz to 35 Hz, since no resonant frequencies were found during the resonant search tests. Each sine beat test consisted of a train of five beats with ten oscillations per beat and with a minimum two-second pause between beats. The minimum excitation input was 1.5 g horizontally and 1.0 g vertically, within the limitations of the test machine. The actual input accelerations are contained in Table I. The sine beat tests were performed with the horizontal and vertical inputs in-phase and repeated with the inputs out-of-phase.

6.4.1 Sine Beat Test Results

It was demonstrated that the specimens possessed sufficient structural integrity to withstand the prescribed biaxial sine beat test environment.

Test run descriptions, including input accelerations, are presented in Table I.

6.5 Specimen Response Procedures

A total of fourteen (14) uniaxial piezo-electric accelerometers were located on the specimens as shown in Photographs 2 and 3. The placement of the accelerometers was at the discretion of the Mercoid Technical Representative. FM tape and oscillograph recorders provided a record of each accelerometer response. The horizontal accelerometers were oriented in the side-to-side direction during the SS/V testing and re-oriented to the front-to-back direction during the FB/V testing.

6.5.1 Specimen Response Results

Transmissibility plots of the specimen response accelerometers from the resonant search test in each orientation are contained in Appendix II.

6.6 Electrical Powering and Electrical Loading Procedures

120 VAC, 60 Hz, single-phase power at approximately 11 amperes resistive load was provided for a normally closed (NC) contact on Items 1 through 6. Also, 120 VAC, 60 Hz, single-phase power at approximately 5 amperes resistive load was provided for an NC contact on Item 7.

6.0 PROCEDURES AND RESULTS (Continued)

6.7 Electrical Monitoring Procedures

Seven (7) electrical monitoring channels (one each specimen) were provided to monitor a NC contact of each switch. Each channel was recorded on an oscillograph recorder during the Seismic Simulation Test Program. The top terminal block of Items 1, 2 and 3; the side terminal block of Items 4, 5 and 6; and the left terminal block of Item 7 were monitored during the test program.

6.7.1 Electrical Monitoring Results

It was demonstrated that the specimens possessed sufficient electrical integrity to withstand the prescribed simulated seismic environment.

No contact chatter or spurious operation was recorded during the simulated seismic testing.

6.8 Pneumatics Procedures

GN_2 pressure sources, as described in Paragraph 5.2, were provided for the specimens prior to, during and after the prescribed tests.

6.9 Operational Test Procedures

Pre-seismic and post-seismic operational tests were performed by raising and lowering the operating pressure of each switch about its set point.

6.9.1 Operational Test Results

It was demonstrated that the specimens possessed sufficient functional integrity to withstand the prescribed test program.

7.0 REFERENCES

7.1 Mercoid Corporation Purchase Order Number 61733.

7.2 Wyle Laboratories' Seismic Test Plan 541/6528-5/ES, dated May 19, 1978, Revision A.

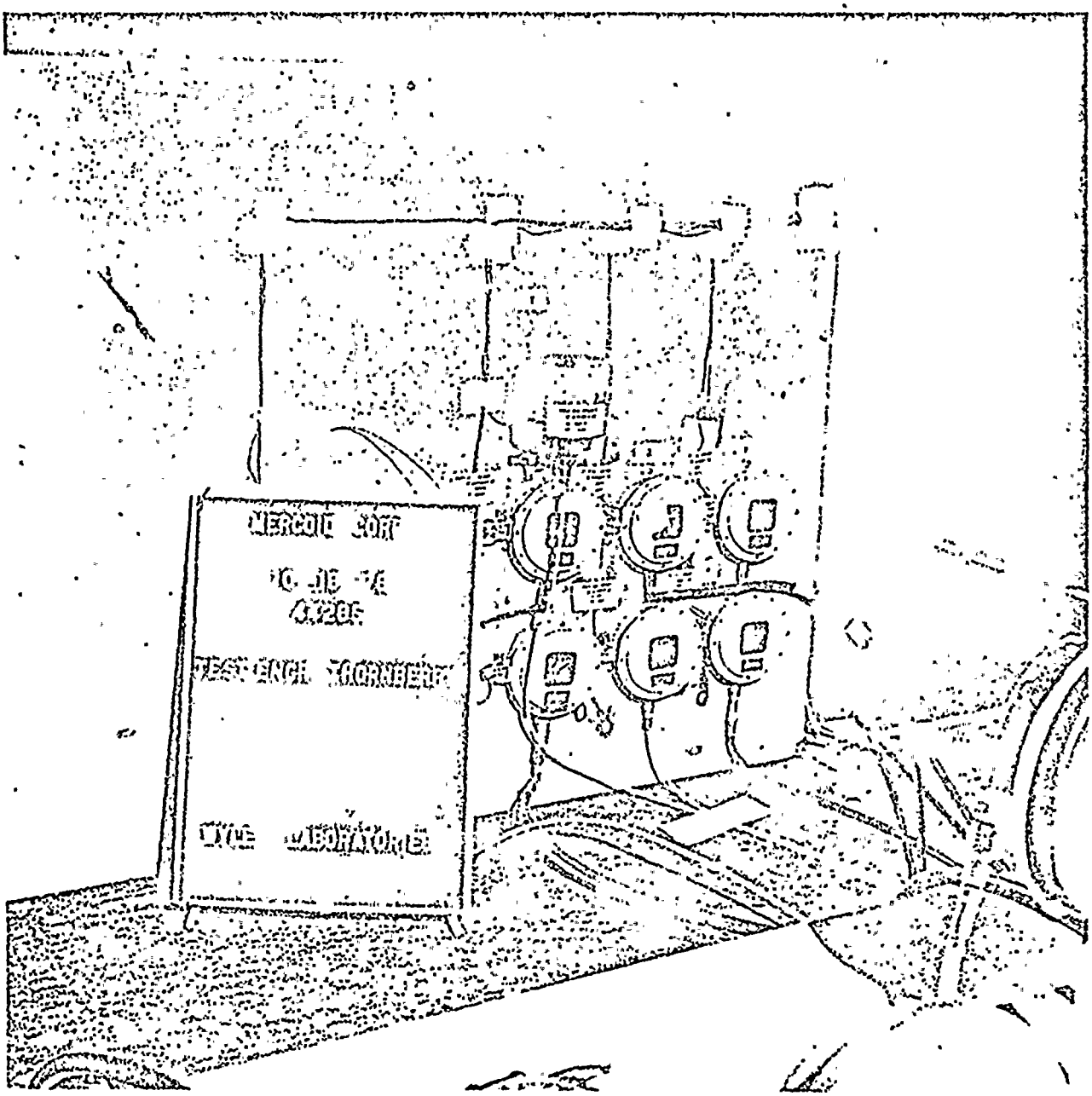
7.3 IEEE Standard 344-1975 Specification entitled "Recommended Practices for Seismic Qualification of Class 1 Electrical Equipment for Nuclear Power Generating Stations".

TABLE I

TEST RUN DESCRIPTION

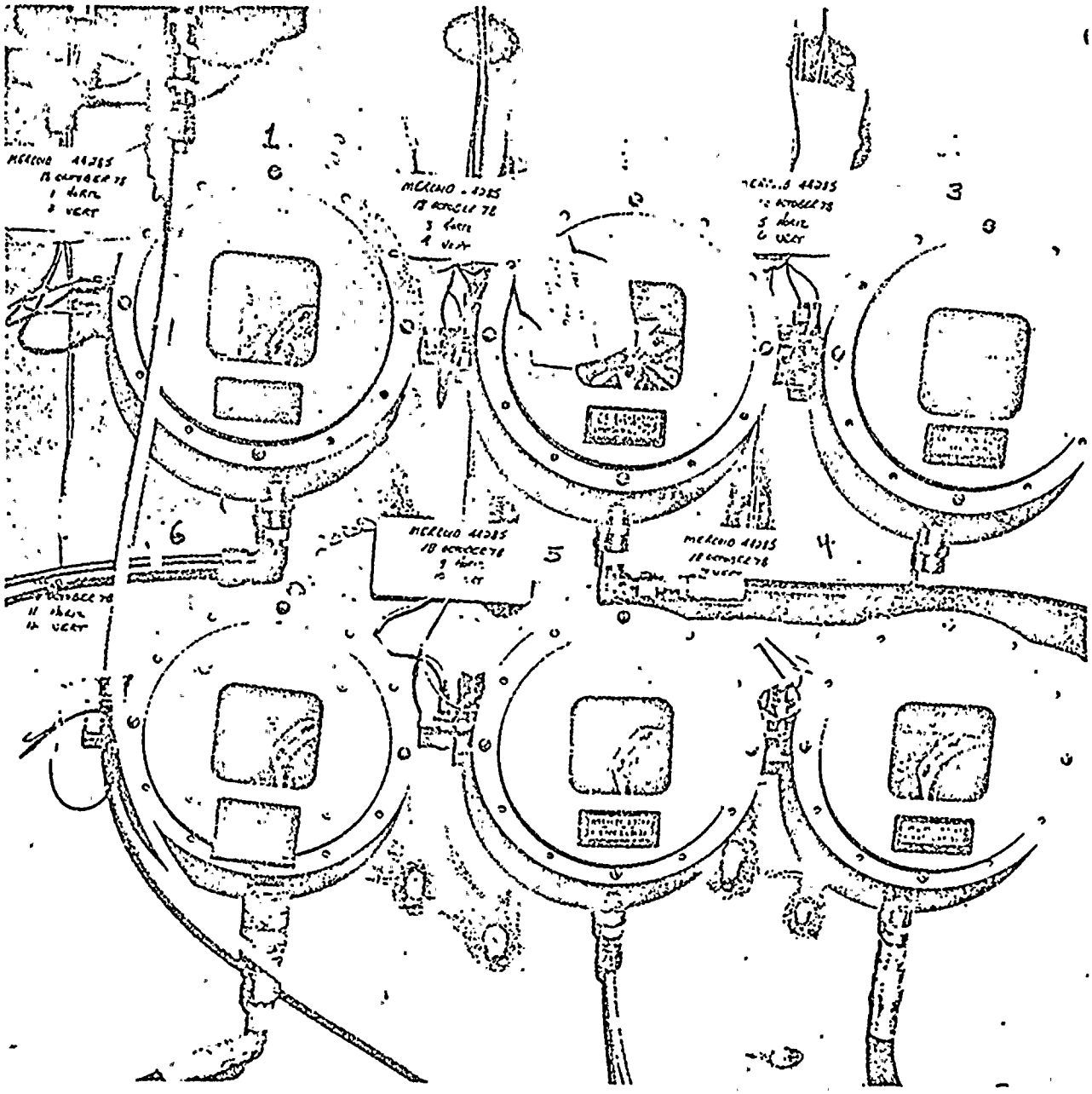
SIDE-TO-SIDE/VERTICAL					FRONT-TO-BACK/VERTICAL AXIS				
RUN NO.	FREQ. (Hz)	PHASE	INPUT ACCELERATION (g) HORIZ.	INPUT ACCELERATION (g) VERT.	RUN No.	FREQ. (Hz)	PHASE	INPUT ACCELERATION (g) HORIZ.	INPUT ACCELERATION (g) VERT.
1	1-35	In	0.2	0.2	26	1-35	In	0.2	0.2
2	1.0	In	0.32	0.32	27	1.0	In	0.32	0.32
3	1.4	In	0.45	0.45	28	1.4	In	0.45	0.45
4	2.0	In	0.65	0.65	29	2.0	In	0.65	0.65
5	2.8	In	0.95	0.95	30	2.8	In	0.95	0.95
6	4.0	In	1.5	1.05	31	4.0	In	1.5	1.05
7	5.6	In	1.5	1.05	32	5.6	In	1.5	1.05
8	8.0	In	1.5	1.2	33	8.0	In	1.6	1.2
9	11.3	In	1.6	1.2	34	11.3	In	1.6	1.1
10	16.0	In	1.6	1.1	35	16.0	In	1.6	1.2
11	22.6	In	1.5	1.2	36	22.6	In	1.6	1.2
12	32.0	In	1.6	1.05	37	32.0	In	1.5	1.05
13	35.0	In	1.6	1.1	38	35.0	In	1.6	1.1
14	35.0	Out	1.6	1.5	39	35.0	Out	1.6	1.2
15	32.0	Out	1.5	1.1	40	32.0	Out	1.5	1.1
16	22.6	Out	1.6	1.2	41	22.6	Out	1.5	1.1
17	16.0	Out	1.5	1.25	42	16.0	Out	1.5	1.1
18	11.3	Out	1.6	1.1	43	11.3	Out	1.5	1.1
19	8.0	Out	1.5	1.2	44	8.0	Out	1.5	1.2
20	5.6	Out	1.5	1.1	45	5.6	Out	1.5	1.05
21	4.0	Out	1.5	1.05	46	4.0	Out	1.5	1.05
22	2.8	Out	0.95	0.95	47	2.8	Out	0.95	0.95
23	2.0	Out	0.65	0.65	48	2.0	Out	0.65	0.65
24	1.4	Out	0.45	0.45	49	1.4	Out	0.45	0.45
25	1.0	Out	0.32	0.32	50	1.0	Out	0.32	0.32

NOTE: Runs No.'s 1 and 26 are sine sweep tests.



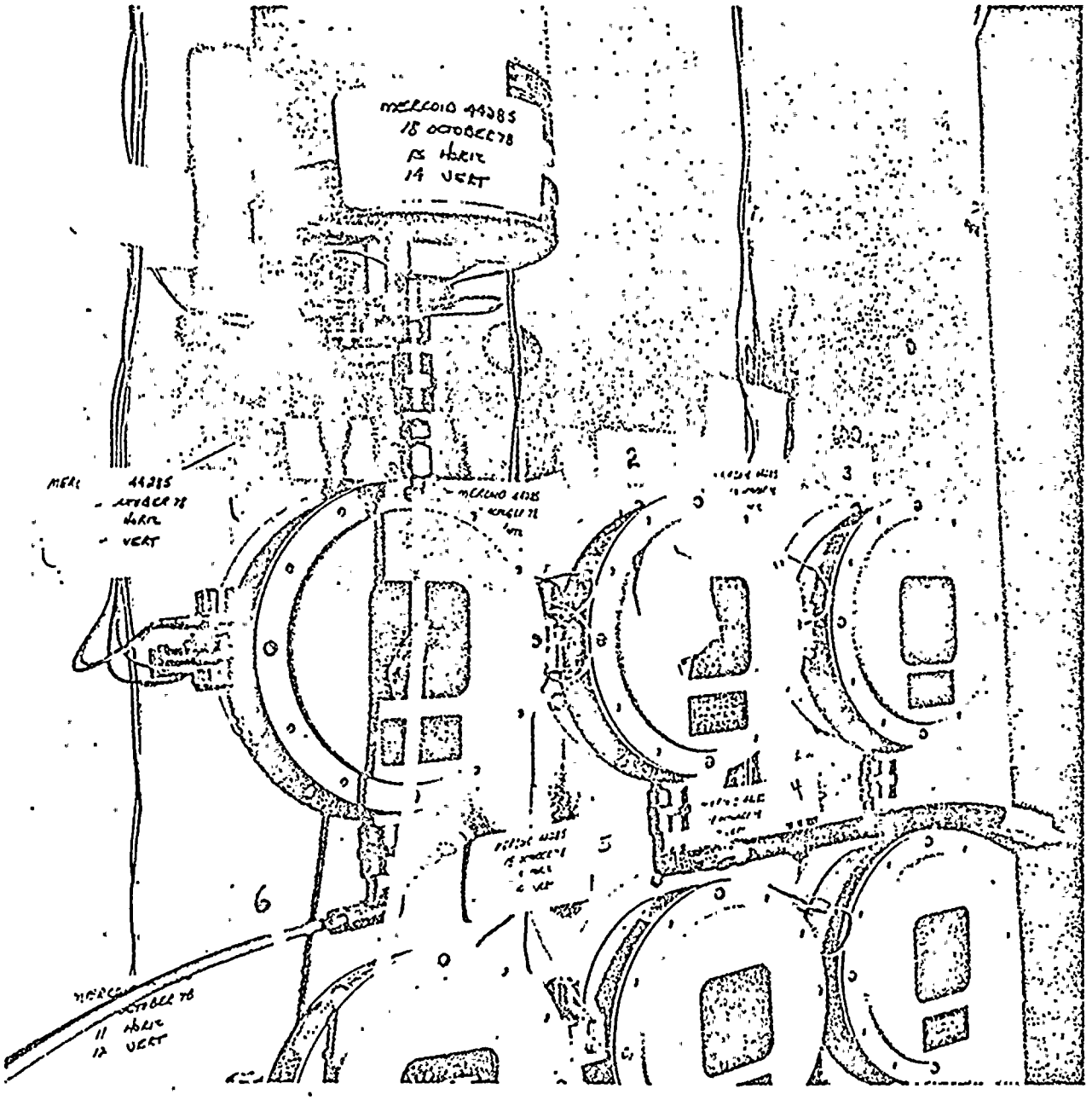
PHOTOGRAPH 1

TEST SETUP
SIDE-TO-SIDE/VERTICAL ORIENTATION



PHOTOGRAPH 2

ACCELEROMETER LOCATIONS
ITEM 1 - 1H, 2V; ITEM 2 - 3H, 4V;
ITEM 3 - 5H, 6V; ITEM 4 - 7V, 8H;
ITEM 5 - 9H, 10V; ITEM 6 - 11H, 12V



PHOTOGRAPH 3

ACCELEROMETER LOCATION
ITEM 7 - 13H, 14V

ATTACHMENT 2
TO
AEP:NRC:0001C

ENVIRONMENTAL TESTING CORPORATION

ACTON

Test Report No. 16013-2

No. of Pages 411

Report of Test

FOR

SEISMIC AND ENVIRONMENTAL TESTING OF MERCOID PRESSURE SWITCHES FOR AMERICAN ELECTRIC POWER SERVICE CORPORATION

DONALD C. COOK NUCLEAR PLANT:
ACCEPTED FOR Q/A BY _____
OF ELECT. GEN. SECT. AEPSC, N.Y.
TRANSMITTAL TO DOCUMENTATION
FILE REQUIRED:

YES	NO
X	

DATE: 07 13 81
E. G. SECT. FILE: ACTON Corp.

Purchase Order No. 05729-820-ON

Prepared by: Philip D. Harizi Date 7-6-81
Phil Harizi

Reviewed & Approved by: Richard S. Gilfoy Jr. Date 7 July 81
Richard S. Gilfoy

PH/sf

TABLE OF CONTENTS

Report No. 16013-2

Administrative Data

1.0 Purpose of Test: Seismic vibration testing of fifteen (15) various Mercoid pressure switches and one (1) Mercoid differential pressure switch and environmental testing of two (2) Mercoid pressure switches.

2.0 Manufacturer: The Mercoid Corporation Chicago, IL

3.0 Manufacturer's Type or Model No: Refer to section 1.0

4.0 Drawing, Specification or Exhibit: AETC Test Procedure 16013
American Electric Power Service Corporation Test Procedure No. EGSP-061280JM, Rev. 4

5.0 Quantity of Items Tested: Fifteen (15) Mercoid pressure switches
One (1) Mercoid differential pressure switch

6.0 Security Classification of Items: Unclassified

7.0 Date Test Completed: June 26, 1981

8.0 Test Conducted By: C. Pilotte, P. Lizotte, M. Bastien

9.0 Disposition of Specimens: Sent to Indiana & Michigan Power Co.
D. C. Cook Nuclear Plant Operation Dept.

10.0 Abstract: Refer to section 4.0

ACTON ENVIRONMENTAL TESTING CORPORATION

1.0 TEST ITEMS

The following items were submitted by American Electric Power Service Corporation for seismic and environmental testing at Acton Environmental Testing Corporation (AETC).

Manufacturer: The Mercoid Corporation Chicago, IL

ITEM NO.	MODEL NO.	RANGE
82075	DAW-7033-153	1
82076	DAW-7033-153	4
82077	DAW-7033-153	5
82078	DAW-7033-153	6
82079	DAW-7033-153	7
82080	DAW-7033-153	9
82081	DAW-7023-153	15S
82082	DAW-7033-153	3A
82083	DAW-7033-804	4
82084	DSW-7233-153	5
82085	DAW-7023-153	6S
82086	DAW-7023-153	13S
82087	DSW-7233-153	1
82088	DSW-7233-153	3A
82089	DSW-7233-153	4
82090	BBE-221-3	25S

1.0 TEST ITEMS (continued)

Items numbers 82075 to 82089 are pressure switches with single-pole/double-throw snap-action switches; one circuit closes as the other circuit opens. The model numbers with the suffix -153 designate units with a single SPDT switch; the model number with the suffix -804 designates a unit with dual SPDT switches, two close, two open.

Those model numbers with the prefix DAW- designate units with double adjustment set points, one high pressure set point and one low pressure set point. The difference between the high and low set points is the operating differential between "on-off" switch operation. Those model numbers with the prefix DSW- designate units with single adjustment set points. The single set point sets the pressure where switch operation occurs; the operating differential is fixed.

Item No. 82090 is a differential pressure switch which received a high and a low pressure input. Switch action is determined by the difference in pressure between the two inputs. This unit was not electrically monitored for switch action during the testing.

All 16 test items were subjected to the seismic vibration testing as specified in section 3.0. Items 82079 and 82084 were

1.0 TEST ITEMS (continued)

also subjected to the environmental test, specified in section 3.0, subsequent to the seismic testing.

2.0 TEST REQUIREMENTS

2.1 RESONANCE SURVEY TEST REQUIREMENTS

The purpose of the resonance survey specified in section 3.3 was to monitor the mechanical response of the test items to determine any resonant frequencies in the seismic bandwidth and to determine each test item's ability to withstand the specified vibration without evidence of mechanical damage or deterioration. The pressure switches were not pressurized during the resonance survey.

2.2 MULTIPLE FREQUENCY TEST REQUIREMENTS

The purpose of the multiple frequency test specified in section 3.4 was to determine the test items' ability to withstand such vibration without evidence of mechanical damage, deterioration, false closure of open contacts for longer than 3 milliseconds, or false opening of closed contacts for longer than 10 milliseconds, or any other interference with proper operation as determined by operational tests performed before and after the multiple frequency vibration.

2.0 TEST REQUIREMENTS (continued)

The multiple frequency test was conducted in such a manner that the Test Response Spectra (TRS) at which the units were qualified would correspond to the SSE level of the Required Response Spectrum (RRS) or, if a failure occurred at that level, to the maximum level at which the unit would fulfill the above acceptance criteria.

Items 82075 to 82089 were pressurized and electrically monitored as specified in section 3.2 during all multiple frequency vibration testing.

Item number 82090 was pressurized as specified in section 3.4 but not electrically monitored during the multiple frequency vibration testing.

2.3 ENVIRONMENTAL TEST REQUIREMENTS

The purpose of the environmental test specified in section 3.6 was to determine the test item's ability to withstand the elevated steam temperature and pressure conditions without any evidence of mechanical damage, deterioration, false opening or closing of contacts, or interference with proper operation as determined by operational tests performed before and after the environ-

2.0 TEST REQUIREMENTS (continued)

mental testing. The test items were pressurized and electrically monitored as specified in section 3.6 during the environmental testing.

3.0 TEST PROCEDURES

3.1 TEST MOUNTING

Each Mercoid pressure switch was mounted on the vertical surface of a steel plate vibration test fixture in the manner shown in Figures 1 and 2. After each Mercoid pressure switch was plumbed and mounted, the test fixture/test item assembly was securely attached to the 45° biaxial table of the AETC seismic test facility. The use of the 45° biaxial table results in equal horizontal and vertical input components.

3.2 TEST MONITORING

During the multiple frequency vibration testing, test items 82075-82089 were electrically monitored to indicate any spurious opens and closures of the single-pole/double-throw switches. Across each of the open and closed contacts of the SPDT switches, a chatter monitoring circuit was connected. The chatter detector was set to monitor the open contacts for false closures longer than 3 milliseconds and to monitor the closed contacts for false openings longer than 10 milliseconds.

The output from the chatter monitor's gate circuitry was connected to an oscillographic recorder to record when

3.0 TEST PROCEDURES (continued)

contact chatter occurred in excess of the above specified times. Each contact set of the SPDT switches was also connected directly to the oscillographic recorder input circuit to record the switch status and to record false opens and closures. The visicorder records are included with this test report.

During the resonance survey, test items 82075-82083, 82085, 82086, 82089 and 82090 were each monitored with one (1) triaxial group of three (3) accelerometers to determine each unit's mechanical response. One triaxial group of three accelerometers was also attached to the test fixture to serve as control accelerometers monitoring the test input. Test items 82084, 82087 and 82088 (tested at an earlier date than the above) were each monitored with one (1) biaxial group of two (2) accelerometers, with one biaxial group also attached to the test fixture to serve as control accelerometers.

During the multiple frequency vibration test, all test items with the exception of item 82084 were monitored with triaxial groups of accelerometers as described above for the resonance survey. Item 82084 (tested at an earlier

3.0 TEST PROCEDURES (continued)

date) was monitored with one biaxial group of two accelerometers.

During each set of tests performed on groups of three Mercoid units, the accelerometers were mounted and numbered as follows:

TRIAXIAL ACCELEROMETER NO.	AXIS ORIENTATION	ITEM ATTACHED TO
1	Front-to-back	82075, 82078,
2	Side-to-side	82081, 82086
3	Vertical	82088*
4	Front-to-back	82076, 82079,
5	Side-to-side	82082, 82083,
6	Vertical	82087*
7	Front-to-back	82077, 82080,
8	Side-to-side	82085, 82089,
9	Vertical	82090
10	Front-to-back	On test
11	Side-to-side	fixture
12	Vertical	(control)

*During multiple frequency test only - see next table.

3.0 TEST PROCEDURES (continued)

BIAXIAL ACCELEROMETER NO.	AXIS ORIENTATION	ITEM ATTACHED TO
1	In-axis horizontal	82084
2	Vertical	
3	In-axis horizontal	82088*
4	Vertical	
5	In-axis horizontal	82087*
6	Vertical	
7	In-axis horizontal	On test fixture (control)
8	Vertical	

*During resonance survey only

During the resonance survey, the output from all accelerometers, through appropriate signal conditioning, was recorded on visicorder recording paper included with this test report. During the multiple frequency test, the output from the triaxial control accelerometers was used for response spectrum control. The output from the control accelerometers, through appropriate signal conditioning, was analyzed by a Spectral Dynamics SD321 Shock Spectrum Analyzer and the X-Y plots of the Test Response Spectra are included as part of this test report.

3.0 TEST PROCEDURES (continued)

During the vibration testing, the Mercoid pressure switches were visually monitored for signs of mechanical damage or deterioration. Item number 82090, the Mercoid differential pressure switch, was monitored visually only, without any additional electrical monitoring.

3.3 RESONANCE SURVEY

The resonance survey consisted of a biaxial sinusoidal input with peak horizontal and vertical acceleration components of 0.2 g at frequencies from 1 to 35 Hz. The resonance survey was performed at a sweep rate of 1 octave/minute. For each group of test items, the input was applied in two (2) horizontally perpendicular biaxial directions of excitation as follows:

Front-to-back and vertical

Right-to-left and vertical

3.4 MULTIPLE FREQUENCY TEST

The multiple frequency test consisted of a biaxial pseudo-random excitation. The shaker table test input was recorded on a 14-channel tape recorder, each track having discrete frequency sine beats recorded at a different

3.0 TEST PROCEDURES (continued)

frequency and delay between beats. All frequencies were recorded at maximum level.

The outputs from the 14 channels were played back and combined in a 14-channel mixer which resulted in the pseudo-random multiple frequency test input. The individual mixer channels have attenuation controls so that the level of each tape channel output passing through the mixer could be controlled. In this manner, the Test Response Spectrum was shaped by controlling the level of the individual frequencies.

The test input was adjusted such that the Test Response Spectrum from the control accelerometer, computed at Q=20, 2 1/2% damping, enveloped the appropriate Required Response Spectrum shown in Figure 10. The test inputs were applied seven (7) times in each of four (4) horizontally perpendicular biaxial directions of excitation. The test duration for each input was thirty (30) seconds.

The levels of the first five (5) inputs in each biaxial direction were such that the TRS from the control accelerometer would envelope the OBE RRS shown in Figure 10. The levels of the sixth and seventh inputs in each biaxial

direction were such that the TRS from the control accelerometer would envelope the SSE RRS shown in Figure 10.

For each group of test items, the inputs were applied in four biaxial directions of excitation as follows:

Right-to-left and vertical

Front-to-back and vertical

Left-to-right and vertical

Back-to-front and vertical

In order to verify that the test items were operating properly, the operational tests specified in section 3.5 were performed prior to the vibration testing of each group of items and before and after test run #7 of the multiple frequency test in each biaxial direction of excitation. During each run of the multiple frequency test, the electrical monitoring of the SPDT switch contacts, as specified in section 3.2, was performed.

For each test item, a pressure input was applied and held constant during each run of the multiple frequency test. During the first six test runs in each biaxial direction of excitation, the pressure input was held constant at the Test Condition #1 level (see below). For the seventh test run, the

3.0 TEST PROCEDURES (continued)

pressure input was changed to the level of Test Condition #2. The pressure settings to which the set points of each test item were adjusted, the level of the pressure input for Test Conditions #1 and #2, and the adjustable operating range of each Mercoid pressure switch were as shown in Table 1.

ITEM NO.	ADJUSTABLE OPERATING RANGE (PSIG)	HIGH PRESSURE SET POINT (PSIG)	LOW PRESSURE SET POINT (PSIG)	TEST CONDITION #1 (PSIG)	TEST CONDITION #2 (PSIG)
82075	1/8 - 15	8	3	12	2
82076	1 - 35	17	10	20	7
82077	2 - 60	30	20	40	15
82078	5 - 100	50	40	60	35
82079	5 - 150	75	55	90	50
82080	10 - 300	150	120	190	100
82081	500 - 5000	2000	1000	2500	800
82082	1/8 - 20	10	5	12	2
82083	1 - 35	17	10	20	7
82084	2 - 60	3.8	NA	40	1
82085	5 - 100	50	35	60	30
82086	300 - 2500	1000	700	1250	500
82087	1/8 - 15	7	NA	10	5
82088	1/8 - 20	7	NA	10	5
82089	1 - 35	15	NA	20	10

TABLE 1 - TEST CONDITIONS

ITEM NO.	ADJUSTABLE OPERATING RANGE (PSIG)	HIGH PRESSURE SET POINT (PSIG)	LOW PRESSURE SET POINT (PSIG)	TEST CONDITION #1 (PSIG)	TEST CONDITION #2 (PSIG)
82075	1/8 - 15	8	3	12	2
82076	1 - 35	17	10	20	7
82077	2 - 60	30	20	40	15
82078	5 - 100	50	40	60	35
82079	5 - 150	75	55	90	50
82080	10 - 300	150	120	190	100
82081	500 - 5000	2000	1000	2500	800
82082	1/8 - 20	10	5	12	2
82083	1 - 35	17	10	20	7
82084	2 - 60	3.8	NA	40	1
82085	5 - 100	50	35	60	30
82086	300 - 2500	1000	700	1250	500
82087	1/8 - 15	7	NA	10	5
82088	1/8 - 20	7	NA	10	5
82089	1 - 35	15	NA	20	10

TABLE 1 - TEST CONDITIONS

3.0 TEST PROCEDURES (continued)

Item number 82090, the Mercoid differential pressure switch, was supplied with a 13 psig pressure input to its high side and a 12.75 psig pressure input to its low side. These pressures were maintained constant during the multiple frequency test runs.

For those test items which failed to fulfill the qualification acceptance criteria during the SSE levels of multiple frequency testing (test runs #6 & #7), additional testing was done at lower vibration input levels until a maximum level was determined at which the unit would qualify. The additional multiple frequency testing was conducted using RRS curves of 3/4 SSE, 1/2 SSE, and 1/4 SSE as shown in Figure 11. The additional test runs were each 30 seconds in duration.

3.5 OPERATIONAL TEST

Operational tests were performed on test items 82075-82089 before and after vibration testing as specified in section 3.4, and before and after environmental testing as specified in section 3.6. The operational status of each Mercoid pressure switch was verified by the following operation test.

3.0 TEST PROCEDURES (continued)

After the set point indicators were adjusted to the values specified in Table 1 of section 3.4, the pressure input was varied above and below the set points and the SPDT switches were electrically monitored to verify that the contacts changed state. The contact monitoring was performed using the oscillographic recorder input circuit to record the switch action. The pressures at which the switching action occurred were observed as the input pressure was varied to below the low set point and above the high set point.

3.6 ENVIRONMENTAL TEST

Following the completion of the multiple frequency vibration test, items 82079 and 82084 were subjected to the following environmental test. The test items, mounted vertically as shown in Figure 1, were placed inside an AETC high pressure test chamber. The pressure switches were plumbed and wired through the chamber wall such that the switches could be pressurized and electrically monitored during the elevated temperature and pressure test.

3.0 TEST PROCEDURES (continued)

The set point indicators on the two test items were set as follows:

ITEM NO.	HIGH SET POINT	LOW SET POINT
82079	75 psig	55 psig
82084	3.8 psig	NA

Operational testing, as specified in section 3.5, was performed on the pressure switches. After the operational testing, the pressure inputs to the switches were set as follows:

ITEM NO.	TEST PRESSURE
82079	90 psig
82084	25 psig

The test chamber was sealed and steam at 15 psig and a minimum of 120°C was applied for a minimum of 10 seconds. The test was considered commenced when the chamber attained a steady-state temperature of a minimum of 120°C and a pressure of 15 psig. The steam temperature and pressure were continuously recorded during the testing.

3.0 TEST PROCEDURES (continued)

The SPDT switches were electrically monitored continuously using a chart recorder input circuit to record the switch status. Following completion of the high temperature and pressure test, the chamber was vented to atmospheric conditions and the operational test was repeated.

The pressure inputs to the switches were then set as follows:

ITEM NO.	TEST PRESSURE
82079	50 psig
82084	1 psig

The high temperature and pressure test was repeated in the same manner as above. After the test, the chamber was again vented to atmospheric conditions and a final operational test was performed.

4.0 TEST RESULTS

4.1 RESONANCE SURVEY TEST RESULTS

There were no structural resonant frequencies detected for any of the Mercoid pressure switches in the 1 to 35 Hz frequency band.

4.2 MULTIPLE FREQUENCY TEST RESULTS

For test items 82075-82083, 82085 and 82086, there was no evidence of mechanical damage, deterioration, false closure of open contacts for longer than 3 milliseconds or false opening of closed contacts for longer than 10 milliseconds, or interference with proper operation detected during or as a result of the multiple frequency test performed at the full SSE shown in Figure 10.

For test items 82084 and 82087-82089, there was no evidence of mechanical damage, deterioration, false closure of open contacts for longer than 3 milliseconds or false opening of closed contacts for longer than 10 milliseconds, or interference with proper operation detected during or as a result of the multiple frequency test performed at the following levels, shown in Figure 11.

4.0 TEST RESULTS (continued)

ITEM NO.	QUALIFICATION LEVELS TEST CONDITION #1	TEST CONDITION #2
82084	SSE	3/8 SSE
82087	3/4 SSE	1/2 SSE
82088	SSE	1/2 SSE
82089	3/4 SSE	3/4 SSE

4.3 ENVIRONMENTAL TEST RESULTS

For test items 82079 and 82084, there was no evidence of mechanical damage, deterioration, false opening or closing of contacts or interference with proper operation detected during or as a result of the environmental test specified in section 3.6.

TEST EQUIPMENT LIST

NAME	MFGR.	MODEL	SER.NO.	RANGE	ACCURACY	INV.#	CAL.FREQ.
Accelerometer	PCB	302A	1772	1 Hz - 5 KHz	±5%	AC415	6 months
Accelerometer	PCB	302A	1773	1 Hz - 5 KHz	±5%	AC416	6 months
Accelerometer	PCB	302A	1774	1 Hz - 5 KHz	±5%	AC417	6 months
Accelerometer	PCB	302A	1775	1 Hz - 5 KHz	±5%	AC418	6 months
Accelerometer	PCB	302A	1777	1 Hz - 5 KHz	±5%	AC420	6 months
Accelerometer	PCB	302A	1779	1 Hz - 5 KHz	±5%	AC422	6 months
Accelerometer	PCB	302A	1780	1 Hz - 5 KHz	±5%	AC423	6 months
Accelerometer	PCB	302A	1781	1 Hz - 5 KHz	±5%	AC424	6 months
Accelerometer	PCB	302A	1805	1 Hz - 5 KHz	±5%	AC425	6 months
Accelerometer	PCB	302A	1807	1 Hz - 5 KHz	±5%	AC426	6 months
Earthquake Simulator-Hydraulic Actuator	MTS	908.34-01 204.63S		24" DA max. DC-200 Hz, 22K force lbs.	±5% ampl.	PE367	6 months
Controller	MTS/Dennison	443.115		DC to 2000 Hz	±1%		
Power Supply		Mod. 63		120 GPM Max. 3K-5K psi max. 250 Hp	NA.		
Power Supply	PCB	483M23	288	12 channel X1 & X5 gain filter frequency 50 Hz	±2%	PE384	6 months
Shock Spectrum Analyzer	SDC	SD321	18	Input: 0.1 Hz to 10 KHz Sensitivity: 31.6 MV to 100 V F.S.	±0.5 db	PE381	6 months
Visicorder	HON	906C	99078	DC to 2 KHz 12 channels 6" paper	±1 db	RE335	6 months
Visicorder	HON	960B	9-8687	DC to 2 KHz 12 channels 6" paper	±1 db	RE301	3 months
Recorder, X-Y	MFE	715E	70154	Input: 1-10-100 MV 1-10V	±0.5%	RE342	6 months
Sweep Oscillator	Ling	CO-100A (701C)	120	0.2 Hz to 5.0 KHz 0.1 to 9.9 octave/minute	±1%	SG321	6 months

TEST EQUIPMENT LIST

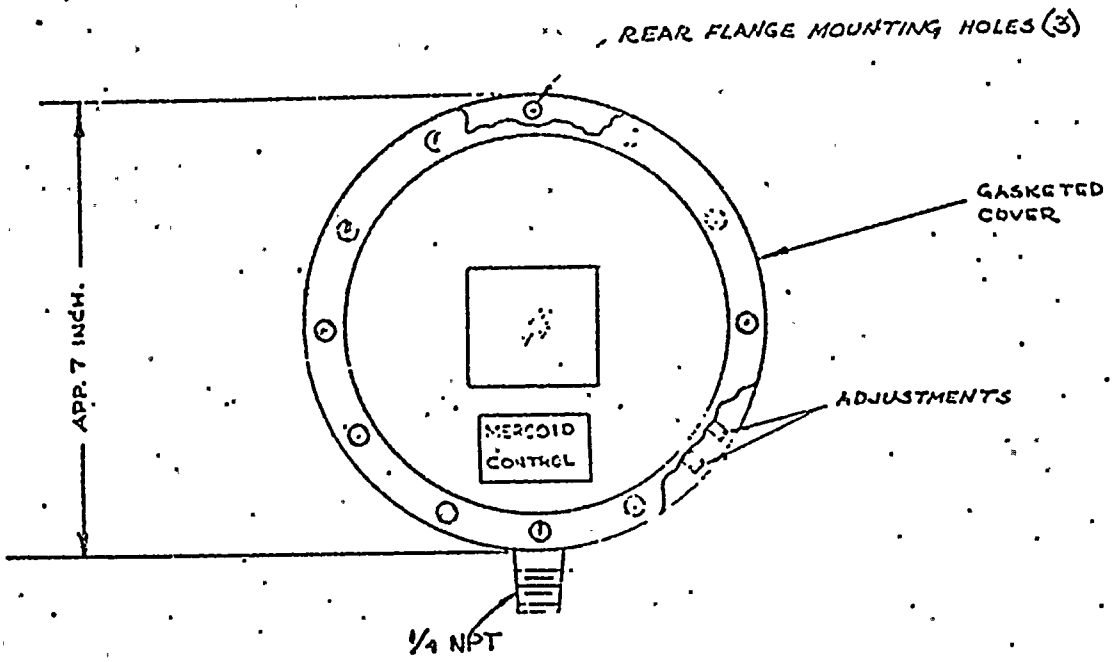
NAME	MFGR.	MODEL	SER.NO.	RANGE	ACCURACY	INV.#	CAL.FREQ.
Scope, Storage	TEK	T912	T912 B015257	DC - 10 MHz Dual Trace	±3%	OS304	6 months
Accelerometer	PCB	302A	2844	1 Hz - 5 KHz	±5%	AC374	6 months
Accelerometer	PCB	302A	666	1 Hz - 5 KHz	±5%	AC375	6 months
Accelerometer	PCB	302A	672	1 Hz - 5 KHz	±5%	AC381	6 months
Accelerometer	PCB	302A	673	1 Hz - 5 KHz	±5%	AC382	6 months
Accelerometer	PCB	302A	2845	1 Hz - 5 KHz	±5%	AC383	6 months
Accelerometer	PCB	302A	2853	1 Hz - 5 KHz	±5%	AC395	6 months
Accelerometer	PCB	302A	1778	1 Hz - 5 KHz	±5%	AC421	6 months
Accelerometer	PCB	302A	1983	1 Hz - 5 KHz	±5%	AC339	6 months
Accelerometer	PCB	302A	4441	1 Hz - 5 KHz	±5%	AC339	6 months
DC Amplifier	HON	117	0225TE74	6 Channel .01/.02/.05/.1/ .2/.5/1/2/5/10	±2%	PE409	6 months
Power Supply	PCB	483A	273	12 channel gain X1	±2%	PE374	6 months
Synthesizer	M/RAD	197S	19710R			PE393	
False Contact Monitor	MTX	202D	310	Detection: 10 & 100 usec	±2%	PE371	6 months
Oscillator Sweep Servo	SDC	SD114A	232	5 Hz - 5 KHz Dynamic Range: 80 db min.	±1% f	PE372	6 months
Amplifier, DC	HON	117-06	1000-54	Gain 0.01/.02/.05/.1/.2/ .5/1/2/5/10	±2 DC	PE394	6 months
Voltage Ref Source	SORE	QR40-2	20	0-40 VDC 0-2 Amp RIPPLE 150 uV	REG. .01%	PD338	6 months
Pressure Indicator	USG	50489	PI336	0 to 200 psi	±0.5 psi	PI336	6 months
Pressure Indicator	HES	NA	H25329	0-500 psi 250 Div.	±1.0 psi	PI305	6 months
Pressure Indicator	USG	1404	PI371	0-100 psi	±1%	PI371	6 months

TEST EQUIPMENT LIST

NAME	MFGR.	MODEL	SER.NO.	RANGE	ACCURACY	INV.#	CAL.FREQ.
Pressure Indicator	HES		25325	0-10,000 psi 1000 Div.	±5psi	PI321	1 year
Amplifier Instrument	BB	3088/16	1003	Volt Gain 1 to 1000 15 Hz to 25 KHz	±1%	AM302	6 months
Filter, Dual	ITH	4302	35207	10 - 1 MHz	±3%	AM346	6 months
Recorder, X-Y	MFE	715#	70142	Input: 1-10-100 MV 1-10V Both Channels	±0.5%	RE343	6 months
Visicorder	HON	1508B	0304A	24 Channel - Inches	±1 db	RE348	6 months
Millivolt Recorder	BRUSH	260	03753	6 Channel	±2%	RE318	3 months
Power Supply	SORE	40-2	101	0-40VDC 0-2Amp RIPPLE 2000V REG.	.005%	PD331	6 months
Power Supply	SORE	40-2	107	0-40VDC 0-2Amp RIPPLE 200 uV REG.	.005%	PD302	6 months
Digital Thermometer	DORIC	DS-520	14954	Type "T" -310 to +750°F	±2°F	TI323	6 months
Digital Voltmeter	FLUKE	8050A	2646175	10 uV to 1000 VDC - 10 mV to 750 VAC True RMS 0-20 Megohms Res. dB voltage	DC±.03%R ±2 digits	ML504	6 months
Pressure Indicator	USG	1404-4 1/4"		0-15 psi	±.25%	PI317	6 months

RENTAL EQUIPMENT:

Honeywell 5600E Recorder #73371
Pressure Transducer 0-200 psia Statham S/N 2702



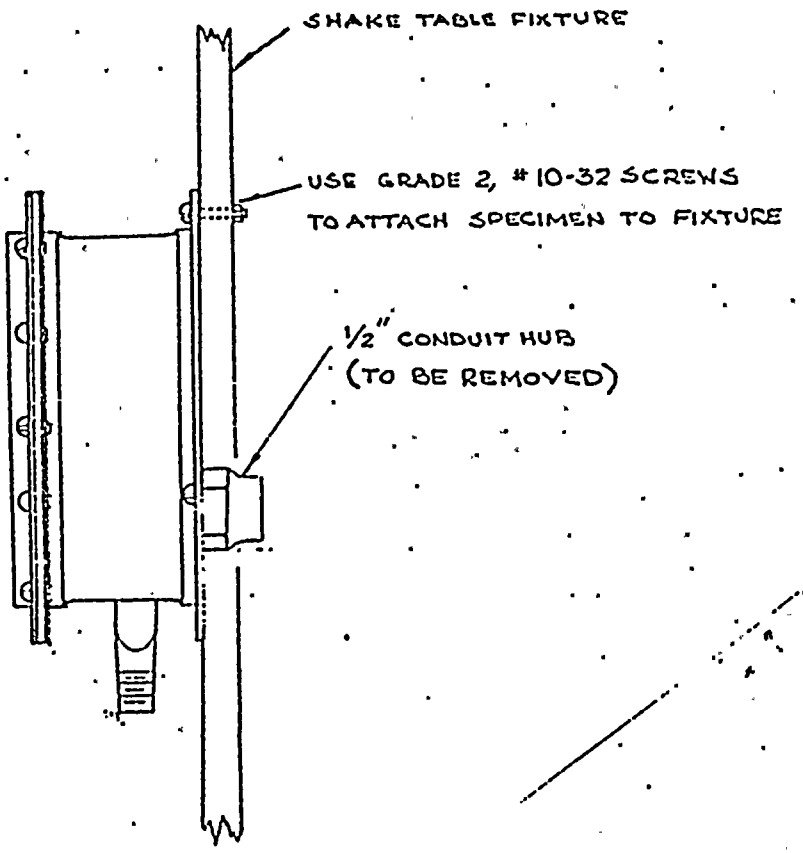


FIGURE 1
TEST MOUNTING

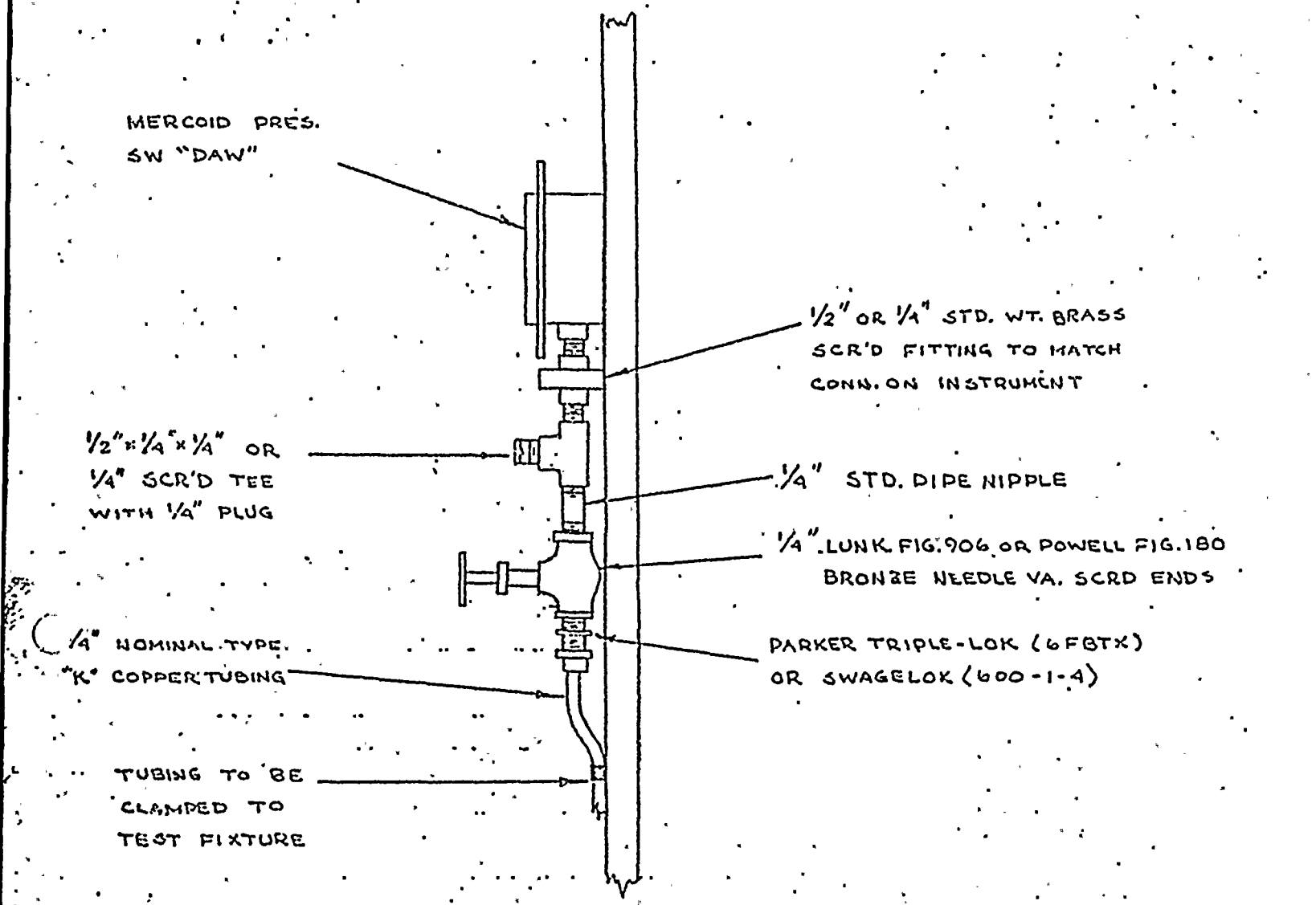


FIGURE 2

TEST MOUNTING

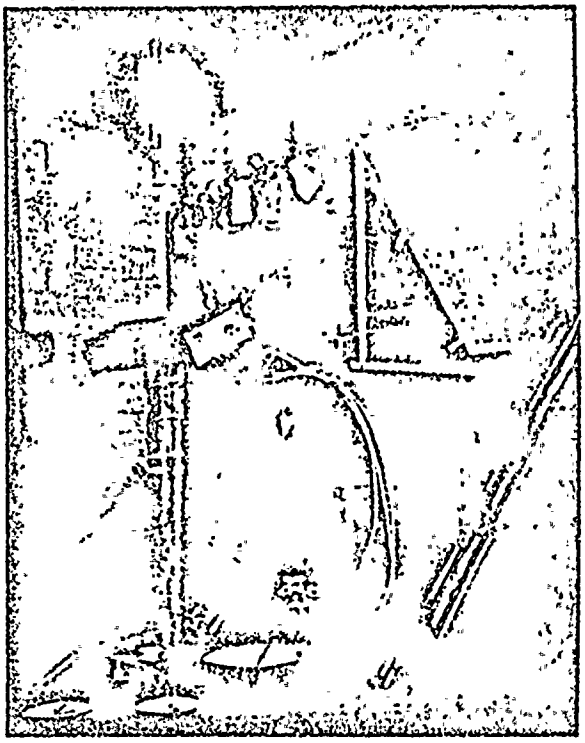


FIGURE 3

VIBRATION TEST SET-UP

FRONT-TO-BACK & VERTICAL
BIAXIAL DIRECTION

Report No. 16013-2

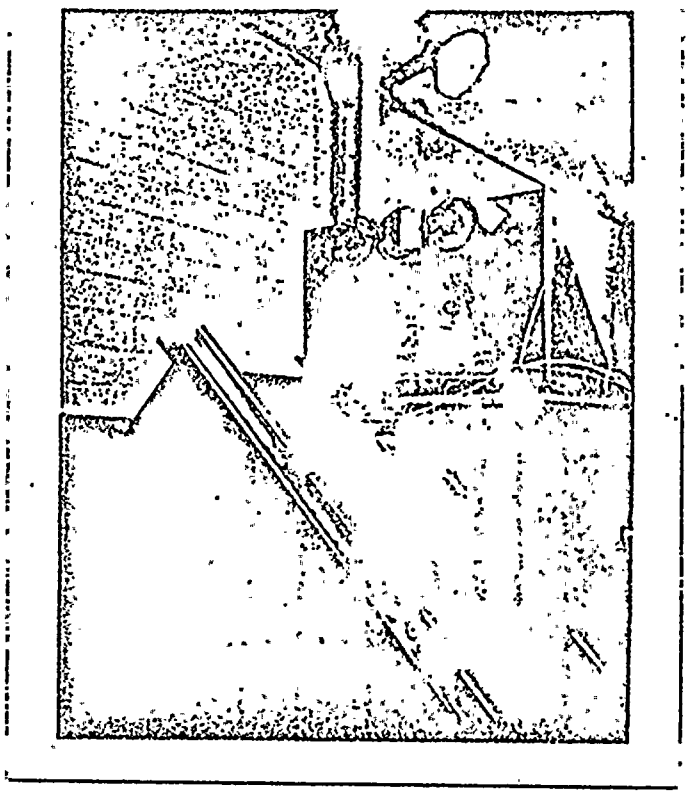


FIGURE 4

VIBRATION TEST SET-UP
RIGHT-TO-LEFT & VERTICAL
BIAXIAL DIRECTION

Report No. 16013-2

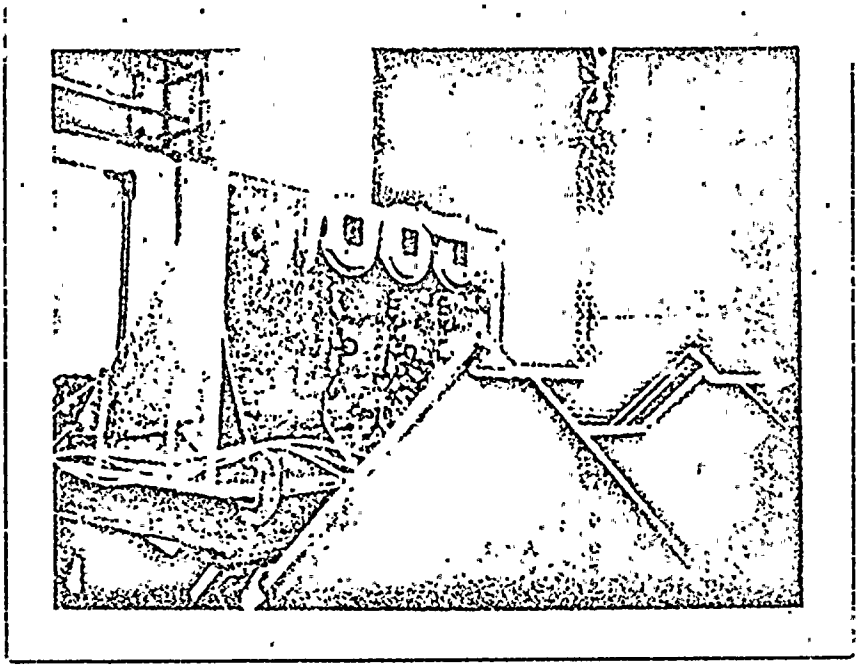


FIGURE 5

VIBRATION TEST SET-UP

BACK-TO-FRONT & VERTICAL
BIAXIAL DIRECTION

Report No. 16013-2

ACTON ENVIRONMENTAL TESTING CORPORATION

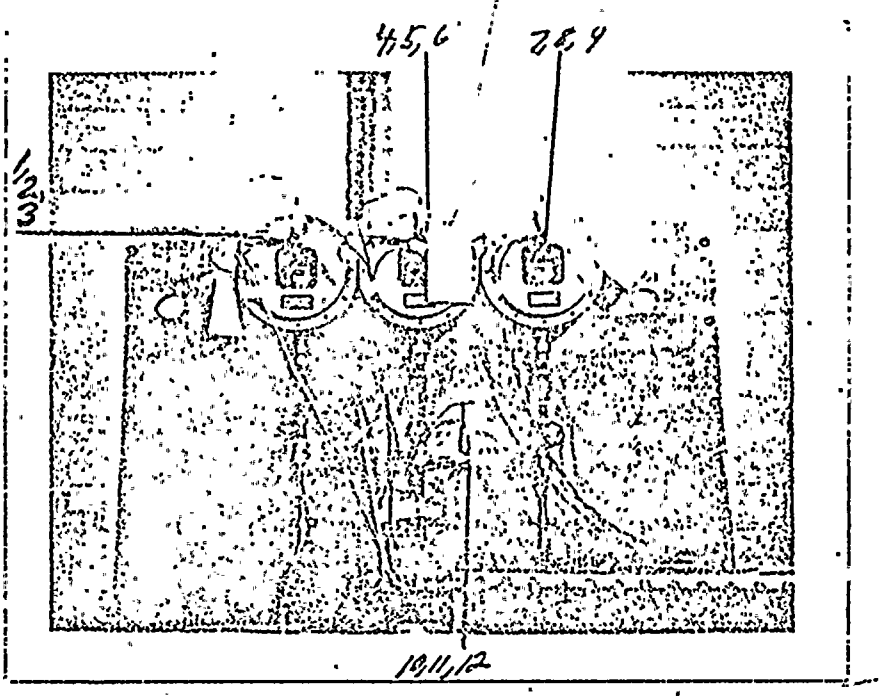


FIGURE 7

ACCELEROMETER LOCATIONS

Report No. 16013-2

ACTON ENVIRONMENTAL TESTING CORPORATION

Page _____

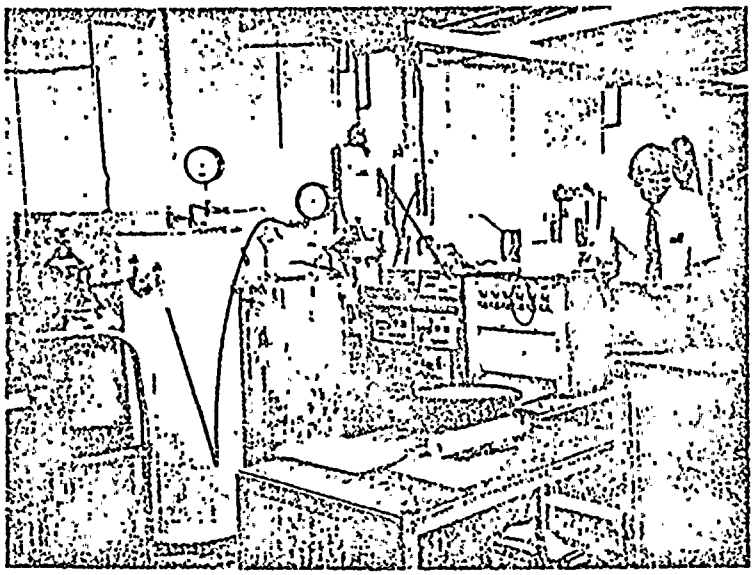


FIGURE 8

ENVIRONMENTAL TEST SET-UP

Report No. 16013-2

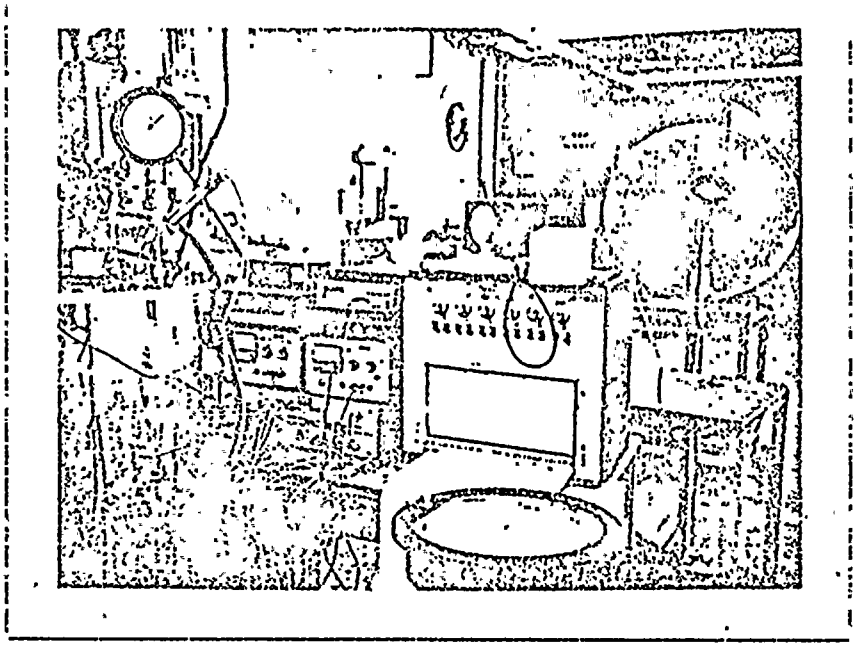


FIGURE 9

ENVIRONMENTAL TEST SET-UP

Report No. 16013-2

Q-20

ENVIRONMENTAL TESTING CORPORATION

REQUIRED RESPONSE SPECTRUM

Q = 20, 2 1/2 % DAMPING

Test No.
Date
Customer
Test Item P/N
Test Item S/N
Type of Test
Spec No.
Para. No.
Conditions
Temperature
Period of Test
Control Axis
Pick-up No.
Pick-up Axis
Operator
Program Co-Ordinator
GRMS

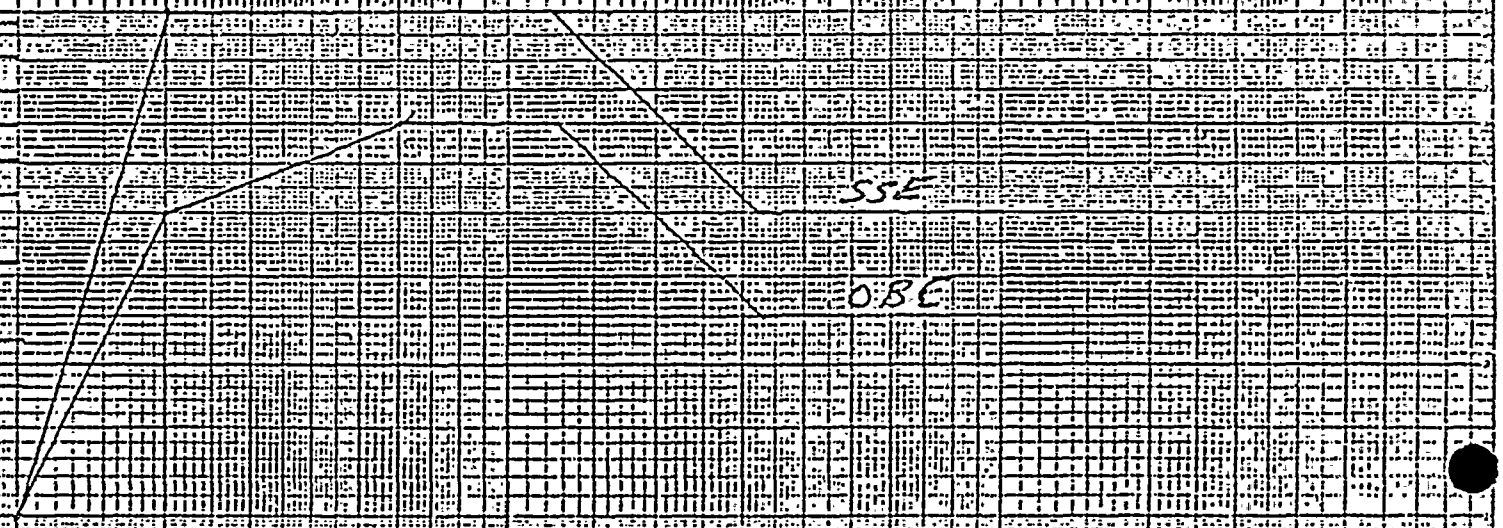


FIGURE 10

ENVIRONMENTAL TESTING CORPORATION

Q = 20

REQUIRED RESPONSE SPECTRUM

Q = 20, 2 1/2 % DAMPING

Test No.
Date
Customer
Test Item P/N
Test Item S/N
Type of Test
Spec No.
Para. No.
Conditions
Temperature
Period of Test
Control Axis
Pick-up No.
Pick-up Axis
Operator
Program Co-Ordinator
CRAIS

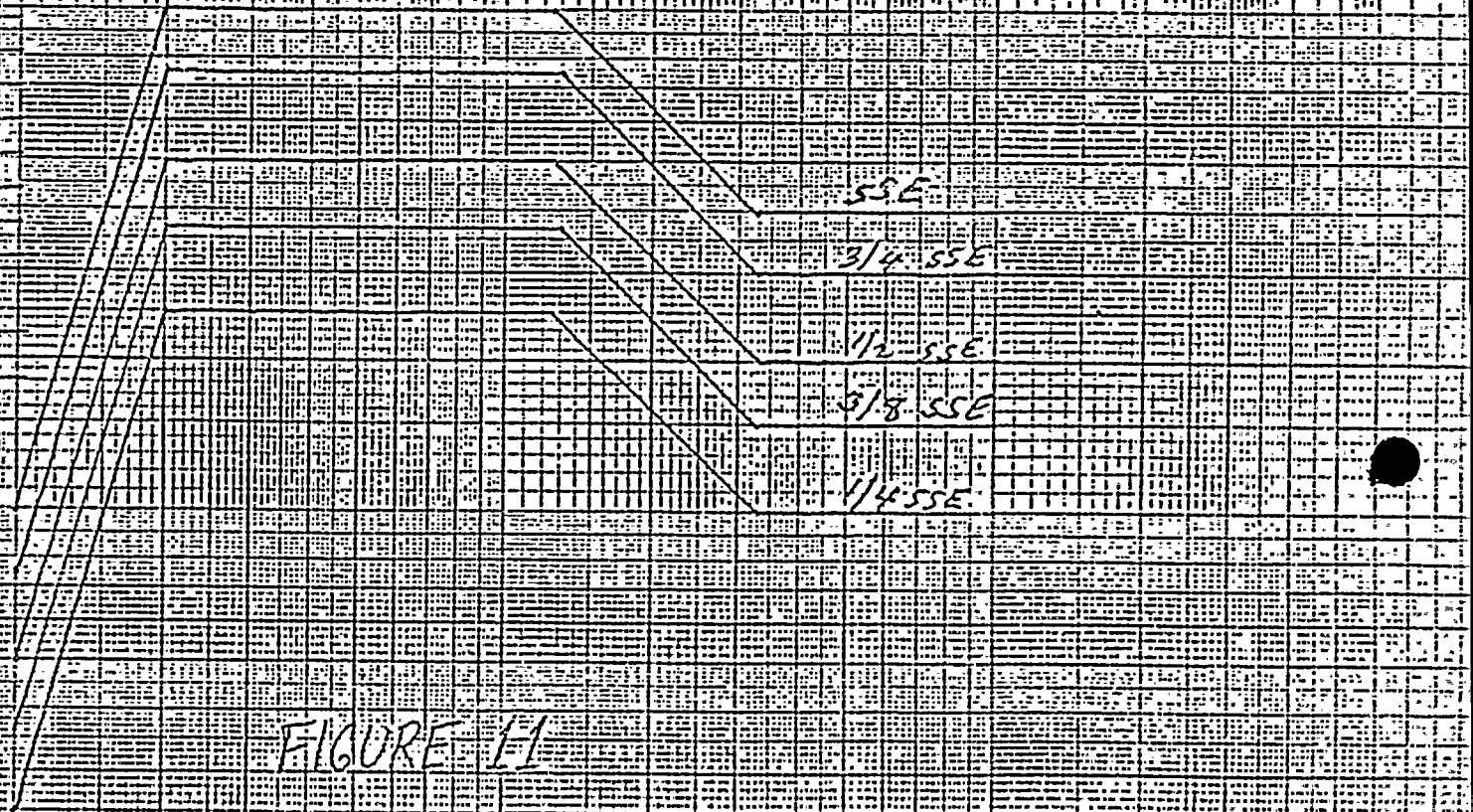


FIGURE 11