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WYLE LABORATORIES

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TECHNICAL MEMORANDUM 68-13

TEST PLAN FOR MARL-EXPERIMENTAL SHROUD TEST PROGRAM

By

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WYLE LABORATORIES
RESEARCH DIVISION, HUNTSVILLE FACILITY

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I. PURPOSE

The purpose of this test will be to acquire acoustic and vibration data for the experimental shroud and the attached payload, so that more accurate specifications can be made to define noise attenuation, transmission loss and vibratory loads on the shroud-payload types of structures.

II. CRITICALITY OF RESULTS AND MANPOWER ESTIMATE

The results of this test are needed to substantiate the theoretical estimates of large payload response to shroud vibration induced acoustically. It is estimated that this program will require approximately 1850 manhours.

III. TEST SPECIMEN

The test specimen consists of a cylindrical shroud and a simulated planetary vehicle and its mounting structure. Figure 1 shows the structural configuration of the test specimen.

The shroud is made of six segments of aluminum foil honeycomb with aluminum face sheets. The average surface density of the aluminum structure is 0.0088 pounds per square inch. The assembled shroud is 25 feet high, 21.66 feet in diameter, and weighs approximately 3337 pounds.

The simulated payload consists of a cylindrical tank with an overall length of 156 inches. This tank will be filled with water to simulate the weight of a planetary vehicle during tests. The weight of the simulated payload is approximately 19450 lbs, and is supported by an eight-point mounting structure as shown in Figure 2.

The experimental shroud is equipped with a top cover which has a hoisting bracket at its center for lifting purposes, and a bottom cover which provides a supporting surface on top of the MARL. These covers are equipped with attachment points for cables which secure the shroud to the ground.

The total weight of the test specimen, including shroud, simulated planetary vehicle, top cover, bottom cover, and mounting fixture, is approximately 30,000 pounds.

IV. TEST SETUP

After the test specimen has been completely assembled, it will be lifted on top of the test fixture (MARL) and fastened properly so that it can be transported to the desired locations for acquiring vibro-acoustic data. During each test, the experimental shroud should be oriented with its 0° reference axis toward the center of firing and be placed in a location where the spectrum of sound pressure levels approximates the spectrum envelope as specified in Figure 3. The specimen must be securely fastened to the ground by cables, as shown in Figure 4, to maintain lateral stability. A check on the leveling of the specimen shall be made prior to each firing. Tires on MARL shall be inflated to a minimum pressure to provide ground vibration isolation.

A minimum of four (4) exposures will be required for this test program.

V. TEST PROCEDURE

Three types of transducers will be used in the data acquisition system, namely:

a) Strain Gage Transducer

b) Accelerometer, and

c) Microphone.

The above transducers shall be connected to the data recording system according to the block diagram as shown in Figure 5. A total of 60 channels is requested. The breakdown on the data channels are as follows:

Strain Gage Transducers	-	12 channels
Accelerometers	-	30 channels
Microphones	-	18 channels

The location of each transducer is identified by the station number in the longitudinal direction and by the angle θ in the circumferential direction and by the radius, R, in the radial direction, (as shown in Figures 1 and 2, respectively).

Strain-gage transducers are used to measure forces and lateral bending stresses acting on support linkages. The axial forces are measured by transducers S1 through S8; the lateral bending stresses are measured by transducers S9 through S12. The requirements for strain gage transducers are specified in Table I, and the locations are identified by Figures 2, 6 and 7. Derivation of output signals of the strain gage transducers is presented in Appendix A.

The accelerometer requirements are specified in Table II. There are five triaxial accelerometers to be mounted on the test structure and are identified by the following accelerometer group:

(A28L, A29R, A30T)
(A31L, A32R, A33T)
(A34L, A35R, A36T)
(A37L, A38R, A39T)
(A40L, A41R, A42T)

where L, R, T, represent, respectively, the directions of the longitudinal, radial and tangential accelerations.

Accelerometers A24, A25, A26L and A27L are to be mounted on the simulated payload. The remainder of the accelerometers are to be mounted in the radial direction on the inner wall of the shroud. Detailed locations of these accelerometers are shown in Figure 8.

The microphone requirements are specified in Table III. These microphones can be classified as:

a) Wall Microphone, and

b) Internal Microphone.

The wall microphones are to be mounted on the shroud with diaphragms set flush to the exterior wall of the shroud. The internal microphones are to be mounted in the approximate locations shown in Figure 10. Final positions of the microphones shall be measured to within ± 0.5 in.

After the instrumentation has been installed, the test specimen must be visually inspected. Any holes in the covers, around the edge of the covers, or in the shroud must be filled with an appropriate compound. Before the test, all instrumentation must be calibrated with standards traceable to the National Bureau of Standards.

During the actual test duration, data must be continuously recorded. After the test, the instrumentation and test specimen must be visually inspected. Any damage must be noted for future reference.

VI. DATA REQUIREMENTS

The oscillograph records and reduced taped data will constitute the date from this test. The oscillograph records will be reviewed to select slice times for digital computer analysis. The following data outputs are requested:

1. Standard RAVAN output for all measurements; and

2. The cross-correlation of data channels of strain gage transducers, accelerometers and microphones, as specified in Tables IV, V and VI, respectively. This should include:

    a) Cross-correlation functions,

    b) Cross-spectral density,

    c) Phase differences, and

    d) Coherence function.

Data reduction for the cross-correlation functions shall be performed in the frequency range of 10 ~ 2000 Hz.

In order to provide valid cross-correlation information for the acquired data, all correlated data channels for the recording system shall be phase-matched.

The maximum phase difference between any two correlated channels shall not exceed ± 5 degrees.

VII. DISPOSITION OF SPECIMEN

The entire test assembly, including top and bottom covers, experimental shroud, simulated payload and supporting structure and MARL, shall be returned to MSFC c/o R-P and VE-SVR.

VIII. REPORT REQUIREMENTS

The test report should include the following: (1) detailed description of the instrumentation used, as well as a description of the calibration procedures; (2) locations of the instrumentation shown by photographs; (3) photographs of the overall test specimen; (4) a detailed description of any damage incurred during the test; and (5) any other items pertinent to the test. The report should be completed within three weeks after the test has been run.

TABLE I

STRAIN-GAGE TRANSDUCER REQUIREMENTS

Meas. No.	Meas. Type	Amplit. μin./in.	Freq. Range (Hz)	Location			Figure No.	Remarks
				Sta.	θ°	R(In.)		
S1	Strain	± 4000	10~2000	N.A.	0	N.A.	2,6	Upper Linkage
S2	"	"	"	"	0	"	"	Lower Linkage
S3	"	"	"	"	0	"	"	Upper Linkage
S4	"	"	"	"	0	"	"	Lower Linkage
S5	"	"	"	"	90	"	"	Upper Linkage
S6	"	"	"	"	90	"	"	Lower Linkage
S7	"	"	"	"	180	"	"	Upper Linkage
S8	"	"	"	"	180	"	"	Lower Linkage
S9	"	"	"	"	0	"	2,7	Center, Upper Link.
S10	"	"	"	"	0	"	"	Center, Lower Link.
S11	"	"	"	"	90	"	"	Center, Upper Link.
S12	"	"	"	"	180	"	"	Center, Lower Link.

N.A. — Not applicable

TABLE II

ACCELEROMETER REQUIREMENTS

Meas. No.	Meas. Type	Amplit. (g)	Freq. Range (Hz)	Location			Figure No.	Remarks
				Sta.	θ°	R(In.)		
A13	Accel-eration	± 75	10~2000	280	0	N.A.	8,9	
A14	"	"	"	280	180	"	"	
A15	"	"	"	215	315	"	"	
A16	"	"	"	215	135	"	"	
A17	"	"	"	150	0	"	"	
A18	"	"	"	150	90	"	"	
A19	"	"	"	150	180	"	"	
A20	"	"	"	85	45	"	"	
A21	"	"	"	85	225	"	"	
A22	"	"	"	20	0	"	"	
A23	"	"	"	20	180	"	"	
A24	"	± 30	"	135	0	"	"	Mounted on Payload
A25	"	"	"	135	90	"	"	"
A26L	"	"	"	135	180	"	"	"
A27L	"	"	"	135	270	"	"	"
A28L	"	± 40	"	150	0	"	"	

TABLE II (Concluded)

ACCELEROMETER REQUIREMENTS

Meas. No.	Meas. Type	Amplit. (g)	Freq. Range (Hz)	Location			Figure No.	Remarks
				Sta.	θ°	R(In.)		
A29R	Accel.	± 40	10~2000	150	0	N.A.	8,9	
A30T	"	"	"	150	0	"	"	
A31L	"	"	"	150	90	"	"	
A32R	"	"	"	150	90	"	"	
A33T	"	"	"	150	90	"	"	
A34L	"	"	"	150	270	"	"	
A35R	"	"	"	150	270	"	"	
A36T	"	"	"	150	270	"	"	
A37L	"	± 30	"	216.5	-	"	"	Mounted on Payload
A38R	"	"	"	216.5	-	"	"	"
A39T	"	"	"	216.5	-	"	"	"
A40L	"	"	"	60.5	-	"	"	"
A41R	"	"	"	60.5	-	"	"	"
A42T	"	"	"	60.5	-	"	"	"

TABLE III

MICROPHONE REQUIREMENTS

Meas. No.	Meas. Type	Amplit. dB	Freq. Range (Hz)	Location			Figure No.	Remarks
				Sta.	θ^o	R(In.)		
M43	SPL	145	10~10,000	290	-	0	10	Internal Microphone
M44	"	"	"	225	90°	30	"	"
M45	"	"	"	140	0	128.5	"	"
M46	"	"	"	140	90	"	"	"
M47	"	"	"	140	180	"	"	"
M48	"	"	"	75	270	80	"	"
M49	"	"	"	75	45	"	"	"
M50	"	"	"	75	135	"	"	"
M51	"	"	"	10	-	0	"	"
M52	"	"	"	185	225	50	"	"
M53	"	"	"	115	315	65	"	"
M54	"	155	"	225	315	130	"	Wall Microphone
M55	"	"	"	225	225	"	"	"
M56	"	"	"	140	0	"	"	"
M57	"	"	"	140	90	"	"	"
M58	"	"	"	140	270	"	"	"
M59	"	"	"	10	180	"	"	"
M60	"	"	"	185	0	"	"	"

TABLE IV

CROSS-CORRELATION DATA REQUIREMENTS FOR STRAIN GAGE SIGNALS

Data Channel	To Be Correlated with
S1	S2
	S3
	S4
	S9
S4	S10
S5	S6
	S11
S8	S7
	S12

TABLE V

CROSS-CORRELATION DATA REQUIREMENTS FOR ACCELEROMETER AND STRAIN GAGE TRANSDUCER SIGNALS

Data Channel	To Be Correlated with
A17	A29R
	A18
	A19
	A13
	A22
	A24
	A26
	S1
	S2
	S9
	S10
A29R	A24
	A26
	A38R
	A41R
A28L	A37L
	A40L

TABLE VI

CROSS-CORRELATION DATA REDUCTION REQUIREMENTS
FOR MICROPHONE, STRAIN GAGE TRANSDUCER AND ACCELEROMETER SIGNALS

Data Channel	To Be Correlated with
M56	M57
	M58
	M60
	M45
	A17
	A29R
	S1
	S9
	S10

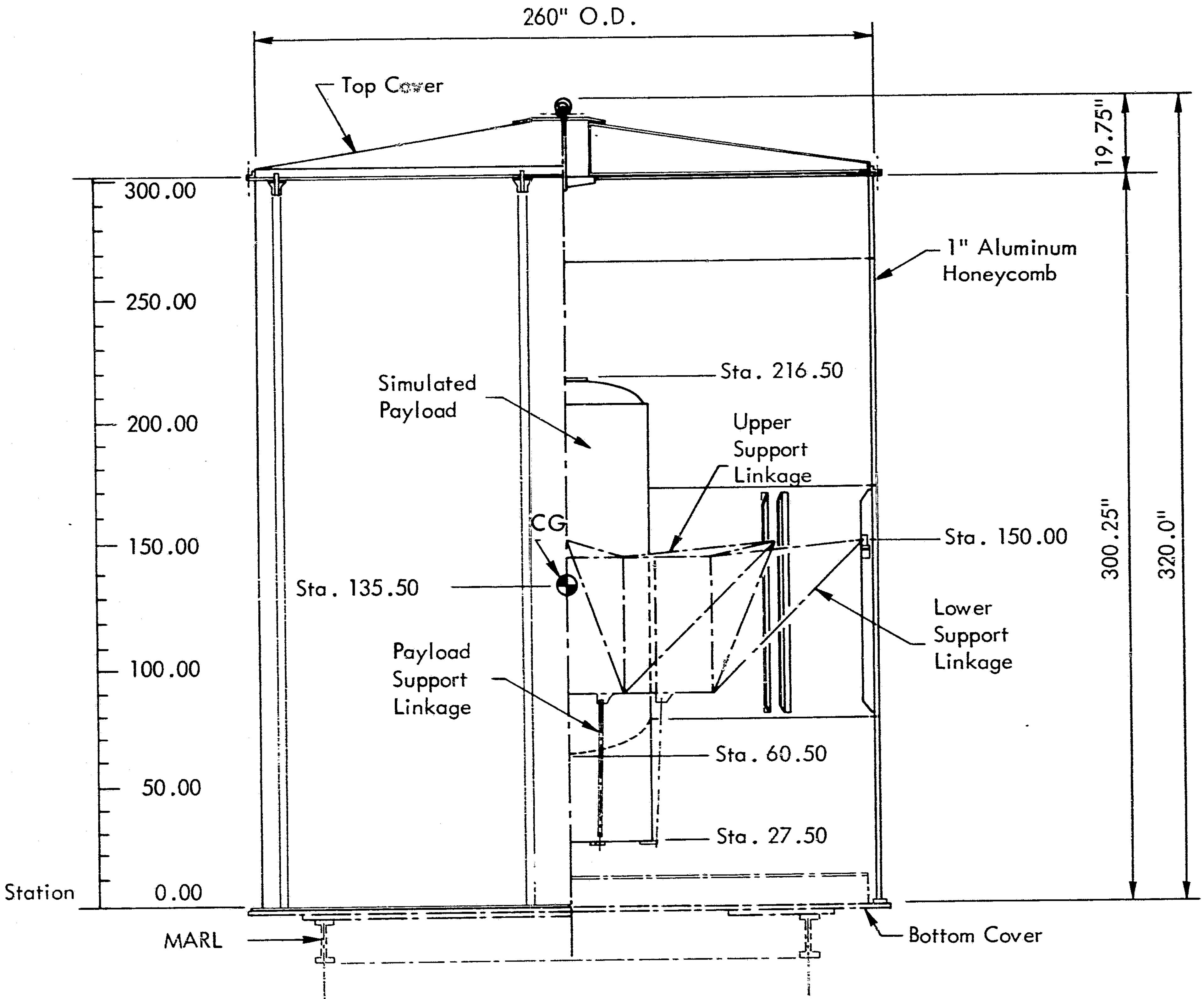


Figure 1. Schematic of the Experimental Shroud

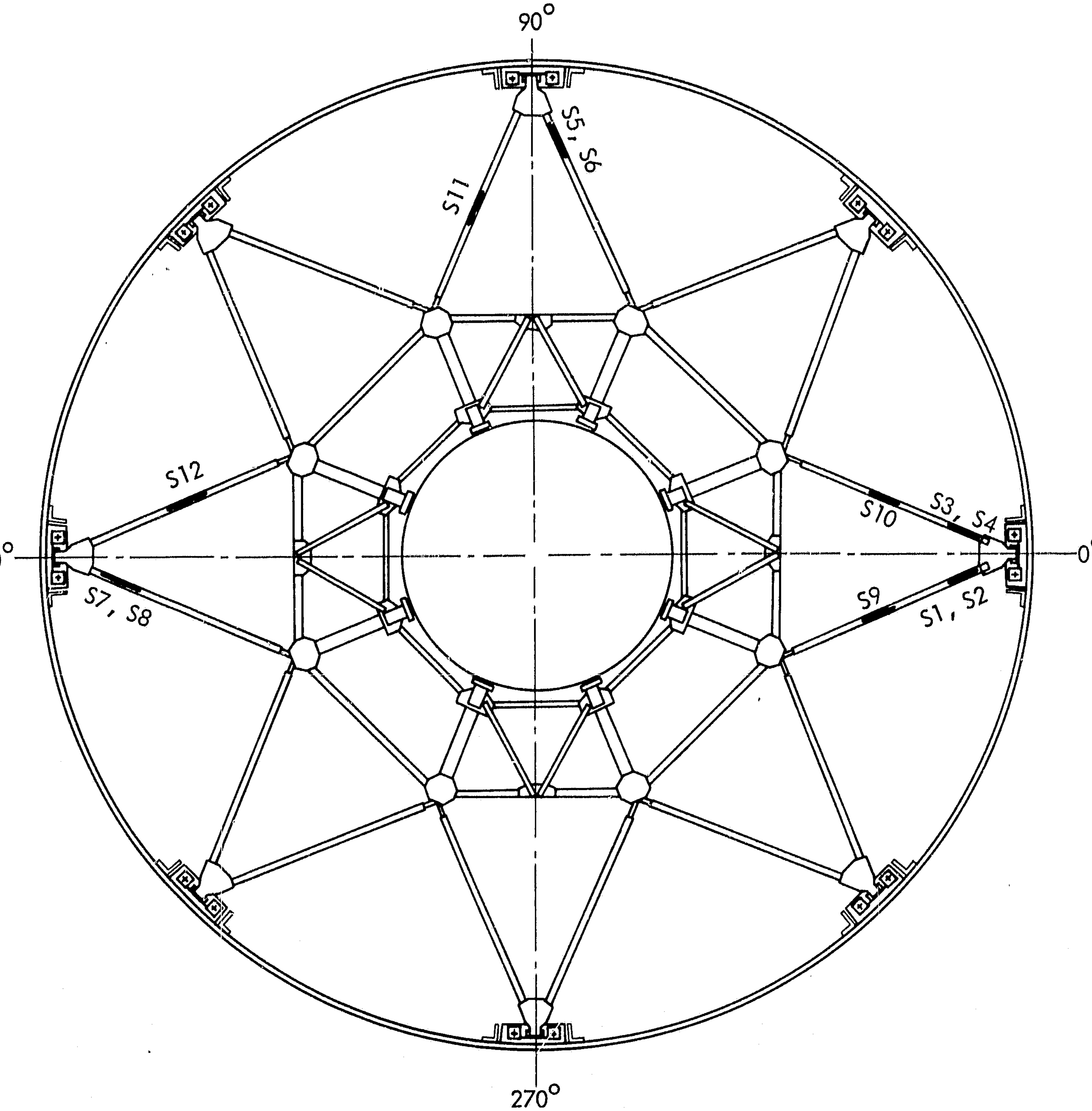


Figure 2. Sectional View of the Experimental Shroud-Payload Structure and Locations of Strain Gage Transducers

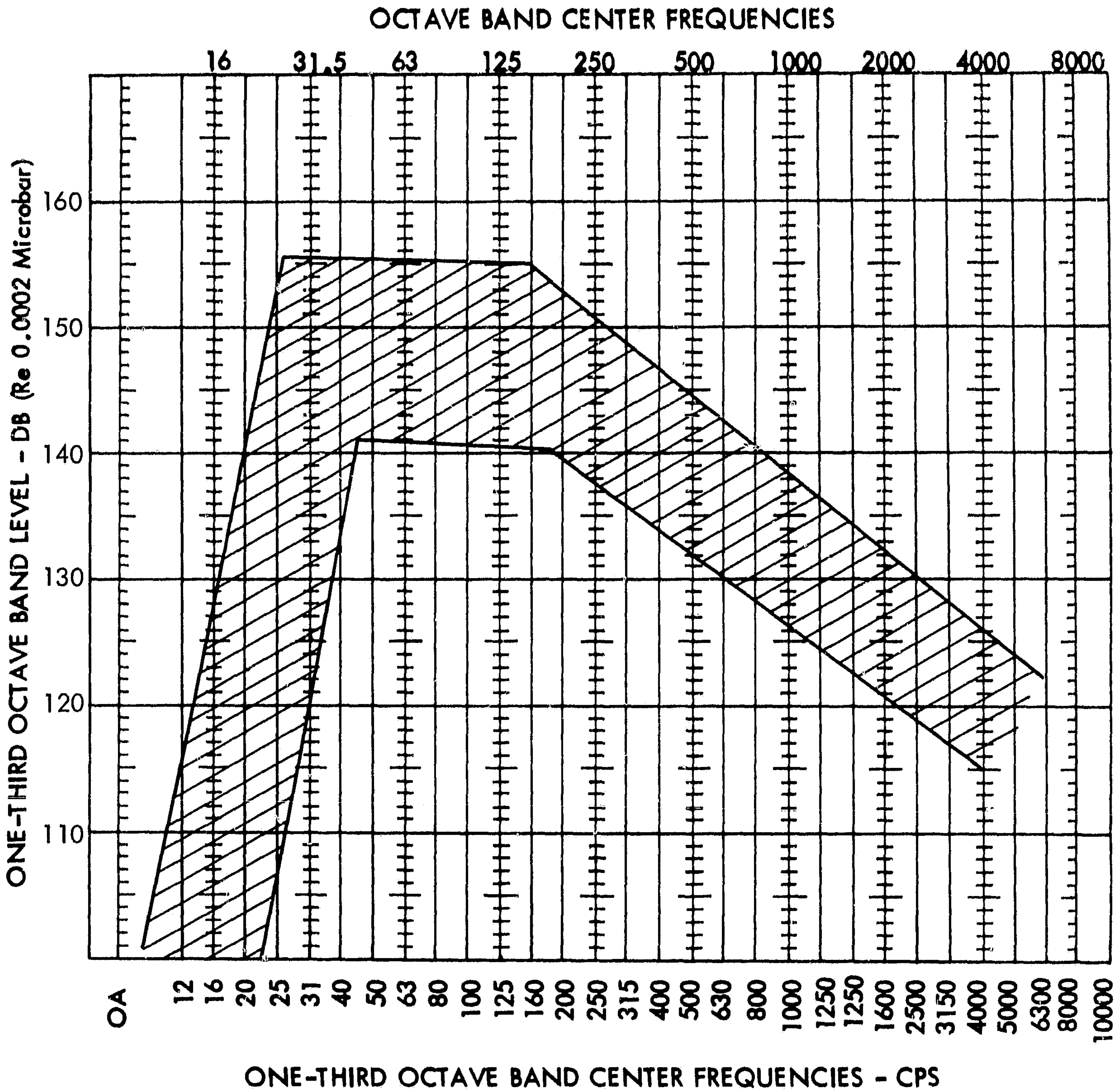


Figure 3. Proposed SPL Spectra Envelope for Experimental Shroud Testing Program

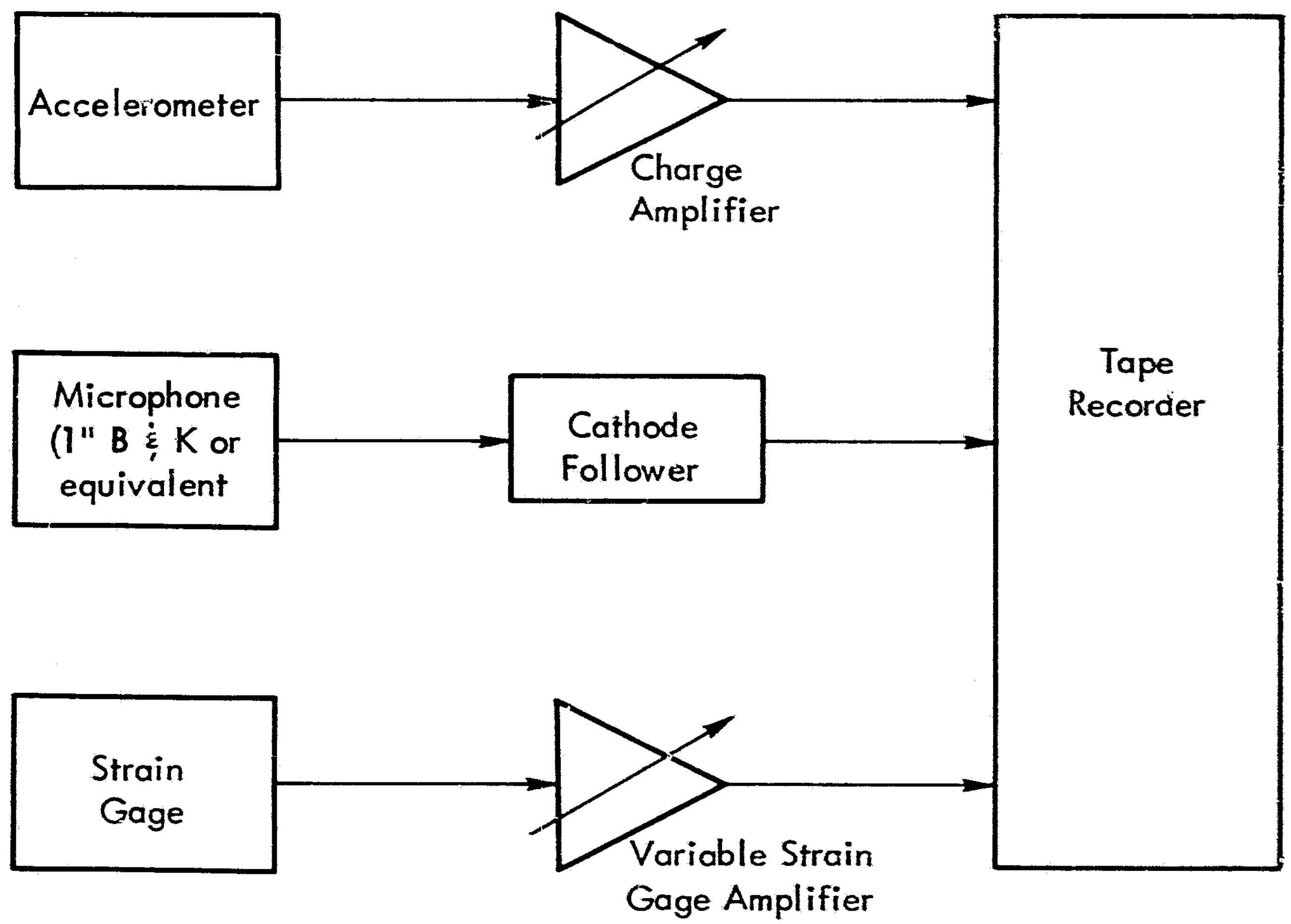


Figure 4. Block Diagram of the Transducer System

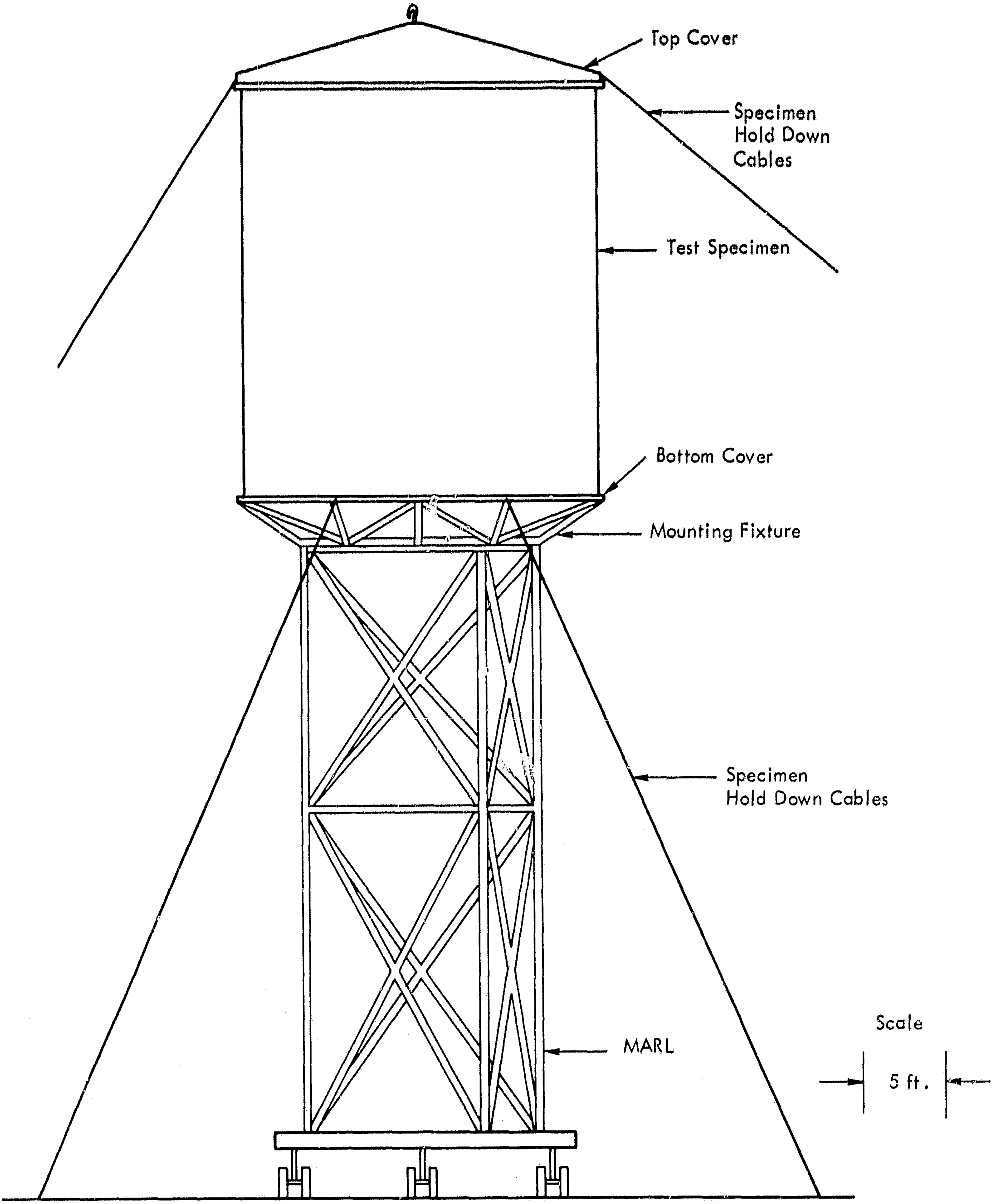
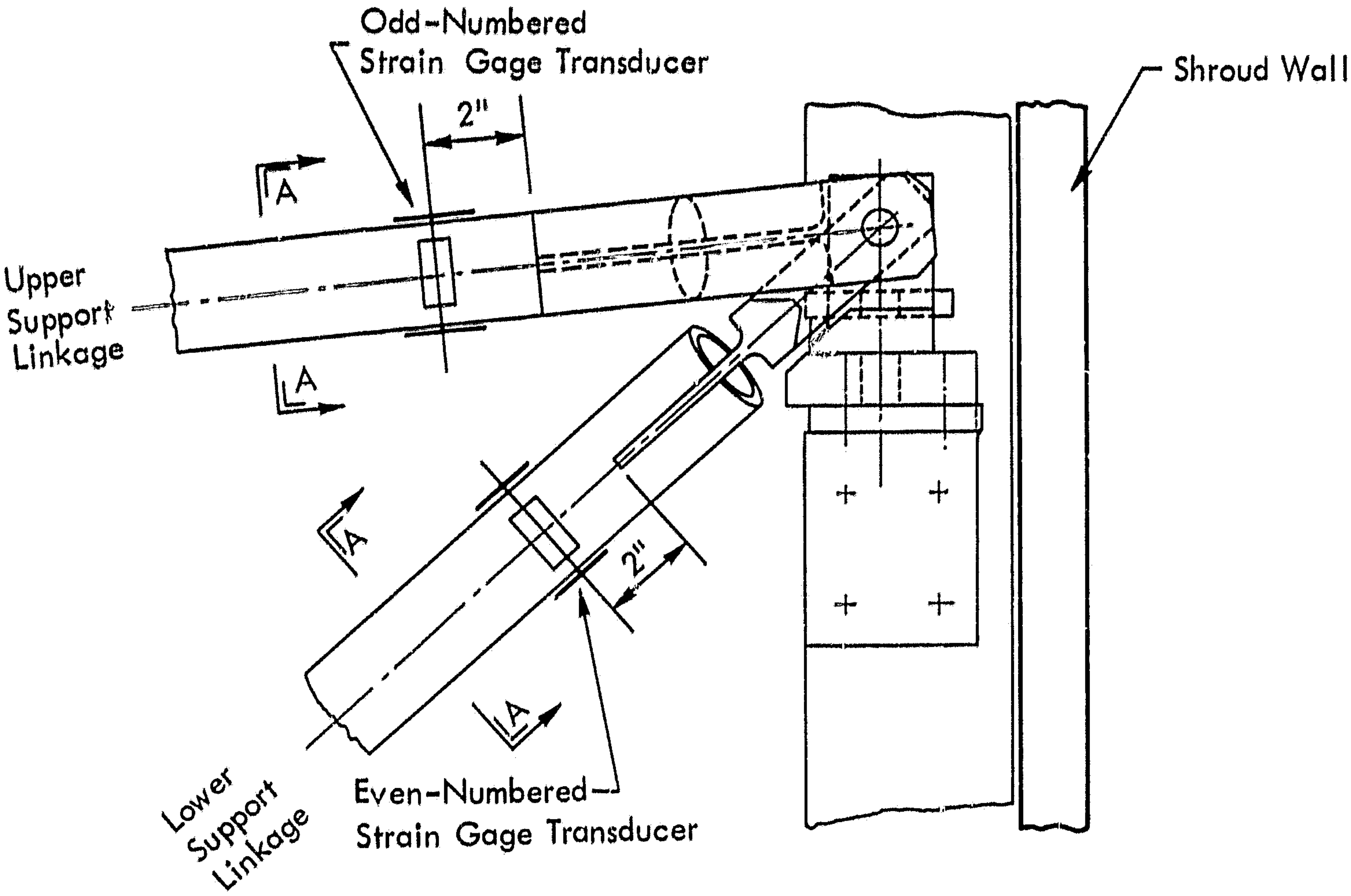
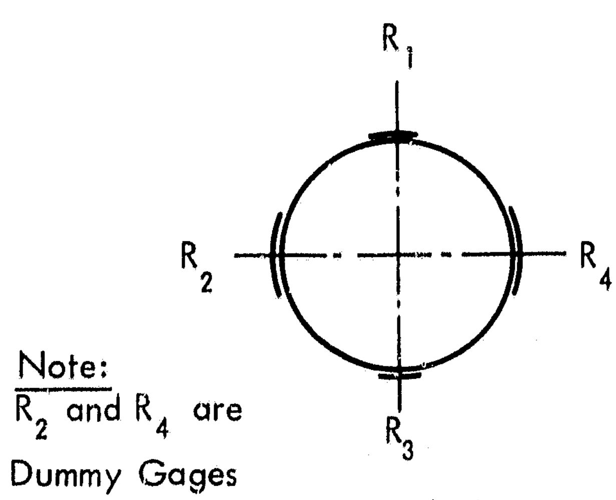


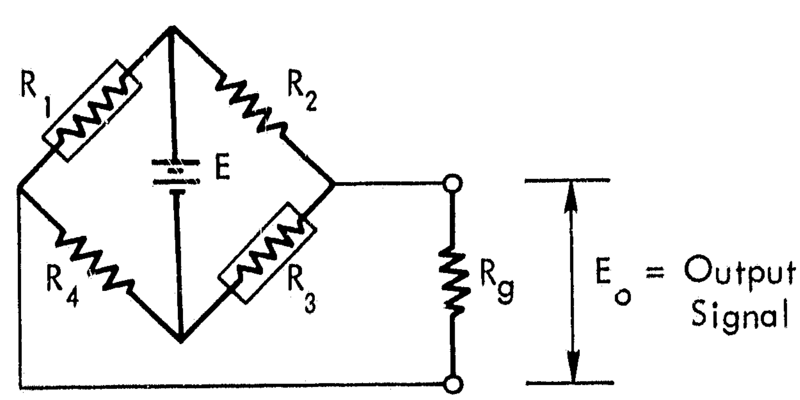
Figure 5 Test Setup



a. Strain Gage Location

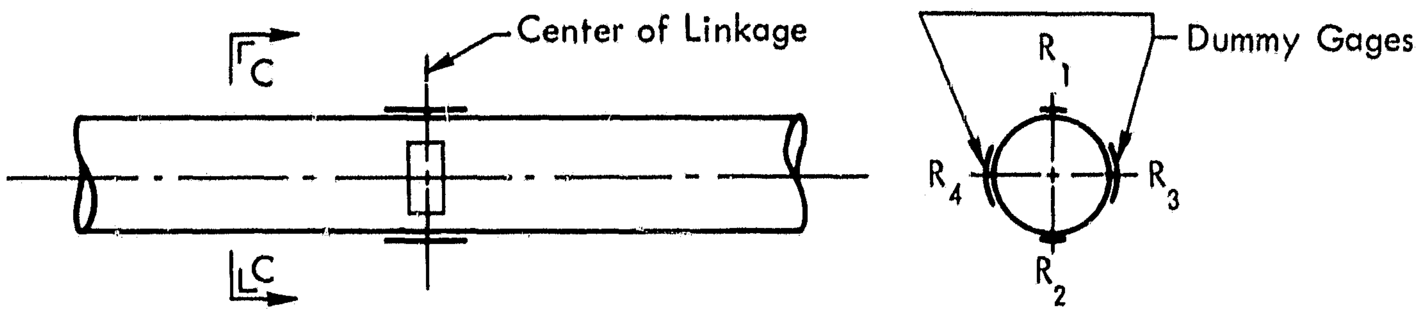


Section A-A



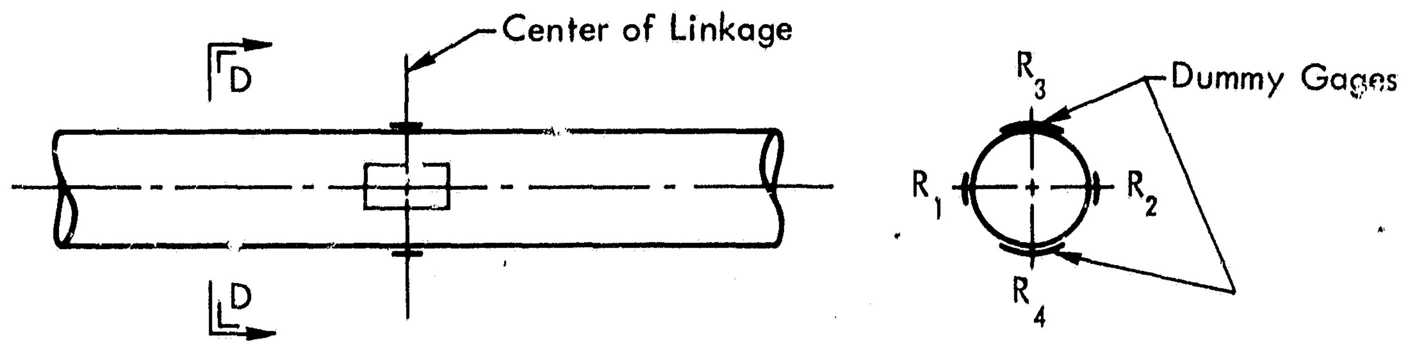
b. Schematic of Transducer Circuit

Figure 6. Locations of Strain Gage Transducers for Measuring Axial Load And Schematic of the Transducer Circuit (S1 through S8 inclusive)



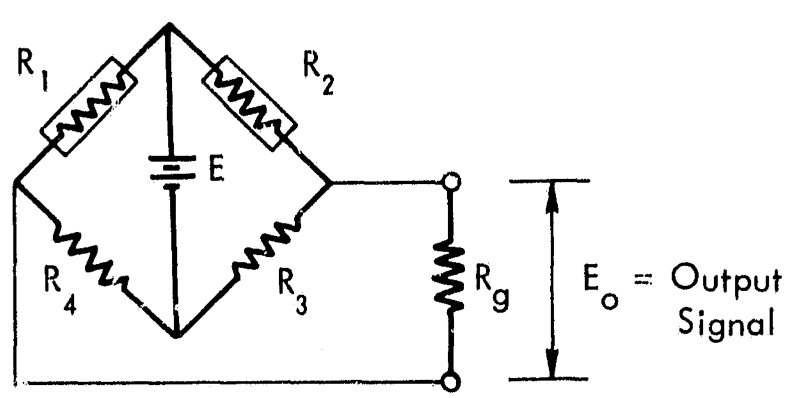
a. Strain Gage Location For S9, and S11

Section C-C



b. Strain Gage Location for S10, and S12

Section D-D



c. Schematic of Transducer Circuit

Figure 7. Arrangement of Strain Gage Transducers for Measuring Lateral Load and Schematic of the Transducer Circuit

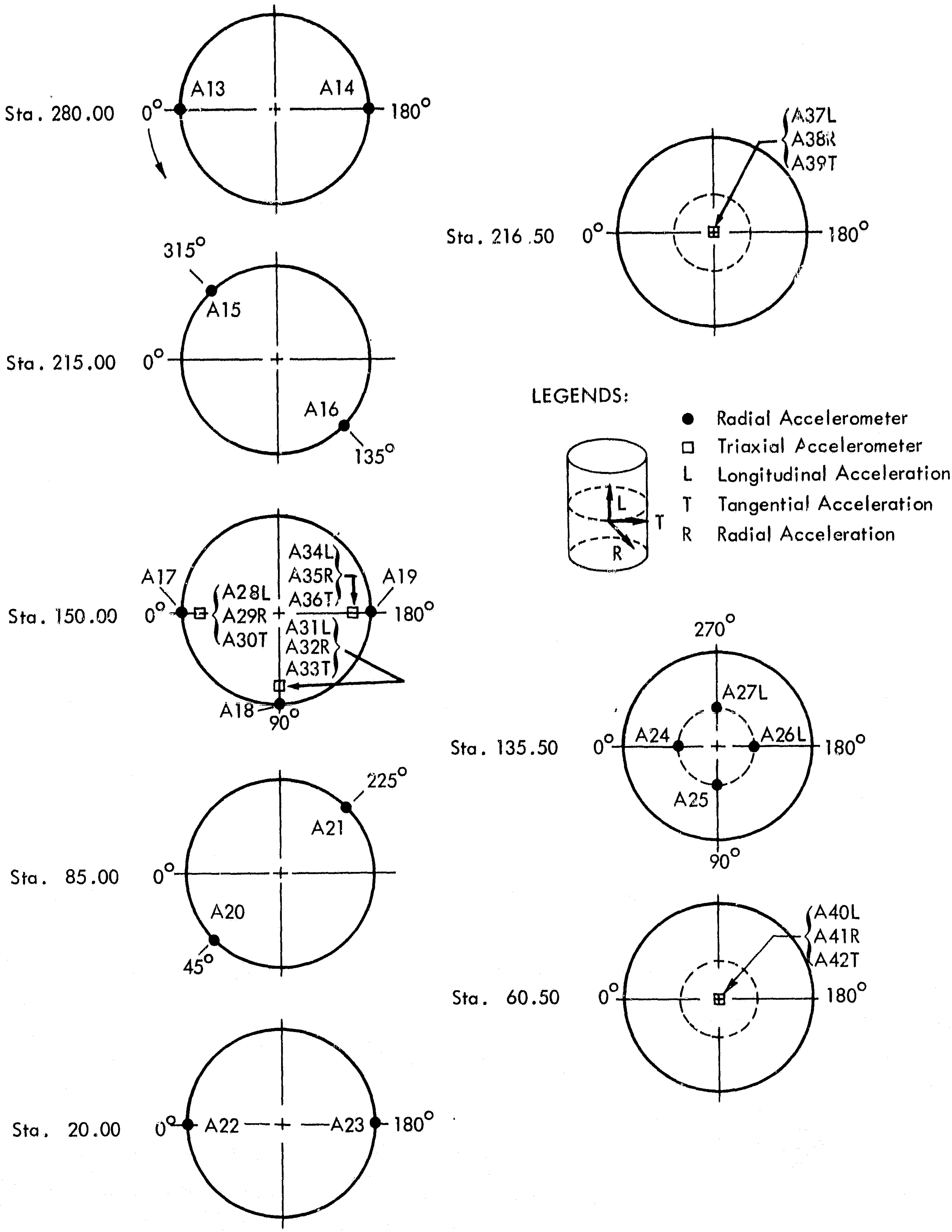


Figure 8. Locations of Accelerometers

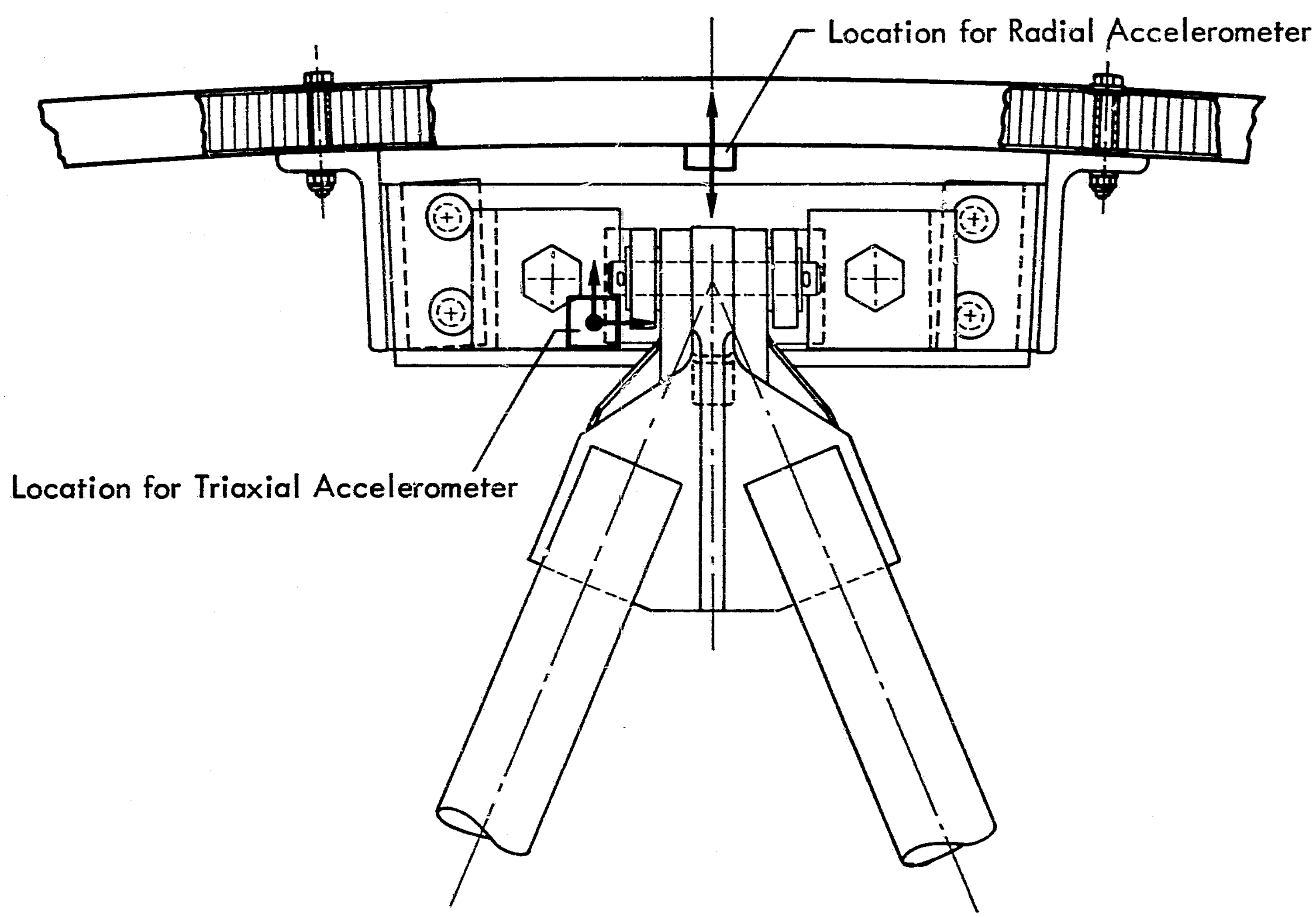


Figure 9. Desired Locations for Triaxial and Radial Accelerometers

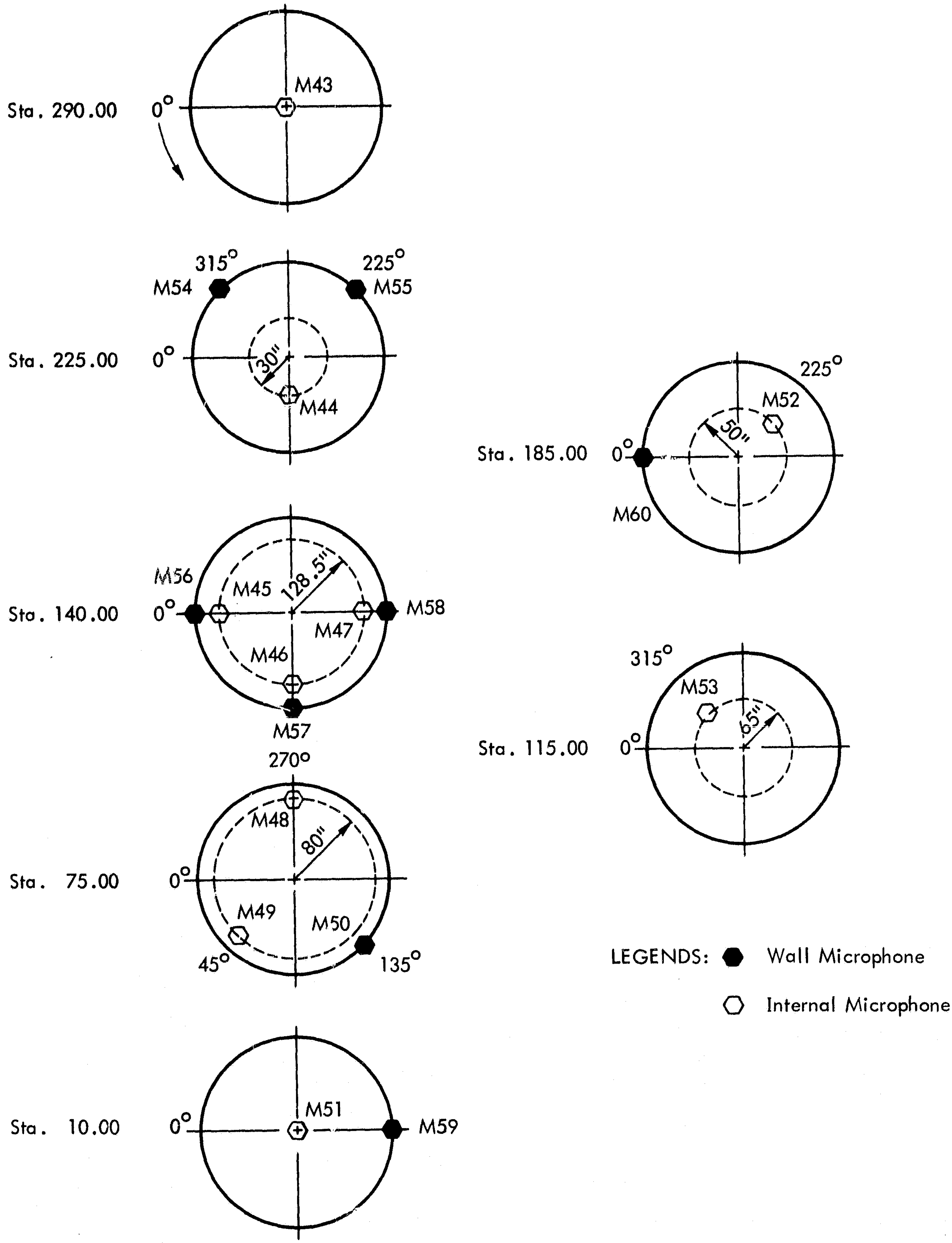


Figure 10. Locations of Microphones

APPENDIX A

DERIVATION OF OUTPUT SIGNALS OF STRAIN-GAGE TRANSDUCERS

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DERIVATION OF OUTPUT SIGNALS OF STRAIN-GAGE TRANSDUCERS

The output signal, E_o, of the strain-gage transducers as shown in Figures 6-a and 7-b can be derived as follows:

Let I_o = Output current

R_g = Output resistance or gage resistance.

Then it can be shown that *

$$I_o = \frac{E(R_2 R_4 - R_1 R_3)}{R_2 (R_1 + R_4)(R_g + R_3 + R_4) + R_1 R_3 R_4 - R_2 R_4^2 + R_g R_3 (R_1 + R_4)} \qquad (1)$$

and the output signal E_o is

$$E_o = I_g R_g \qquad (2)$$

Assume that all gages have the same nominal resistance R and by allowing resistance changes in all four legs of the Weatston bridge, Equation (2) becomes:

$$E_o = \frac{ER_g}{4(R + R_g)} \left(\frac{\Delta R_1}{R_1} - \frac{\Delta R_2}{R_2} + \frac{\Delta R_3}{R_3} - \frac{\Delta R_4}{R_4} \right) . \qquad (3)$$

For the strain-gage transducer as shown in Figure 6-b, the changes in dummy gages R_2 and R_4 will be negligible, therefore we may set

$$\Delta R_2 = \Delta R_4 \approx 0,$$

* Perry, C.C. and Lissner, H.R., "The Strain Gage Primer," McGraw-Hill Book Co. 1955.

hence, the output signal is

$$E_o \simeq \frac{ER_g}{4(R + R_g)} \left(\frac{\Delta R_1}{R_1} + \frac{\Delta R_3}{R_3} \right) \tag{4}$$

It is evident that signals introduced by bending stresses will be automatically eliminated from the strain-gage arrangement, as shown in Figure 6-b, therefore, only the axial force will be sensed.

The transducer, as shown in Figure 7-b, is used to measure vibratory bending stresses. Gages R_3 and R_4 are dummy gages. By neglecting changes in R_3 and R_4, the output signal in this case is:

$$E_o \simeq \frac{ER_g}{4(R + R_g)} \left(\frac{\Delta R_1}{R_1} - \frac{\Delta R_2}{R_2} \right) \quad . \tag{5}$$

Since ΔR_1 and ΔR_2 due to bending will always have opposite signs, Equation 5 will yield directly the vibratory bending stresses.