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EXPERIMENTAL AND THEORETICAL STUDIES OF HULL-DECKHOUSE INTERACTION - 2-LEVEL DECKHOUSE

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by

Johannes Buhler
Lawrence J. Levy

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*
University of California
College of Engineering
Berkeley, California

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE
Experimental and Theoretical Studies of Hull-Deckhouse Interaction - 2-Level Deckhouse

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
Technical Report

5. AUTHOR(S) *(First name, middle initial, last name)*
Johannes Buhler
Lawrence J. Levy

6. REPORT DATE
August 1971

7a. TOTAL NO. OF PAGES
72 + iv

7b. NO. OF REFS
10

8a. CONTRACT OR GRANT NO.
N00024-67-C-5362 and
N00014-67-A-0114-0006

b. PROJECT NO.
SR-011-0101, Task 0401

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)
College of Engineering
Report NA-71-4

9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

10. DISTRIBUTION STATEMENT
This document has been approved for public release and sale; its distribution is unlimited.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

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Deflections of hull and deckhouse were measured. Stress distributions along three transverse sections and along the deck to deckhouse joint were calculated from measured strains.

Three bending moment distributions and two deck support arrangements were used in the test program. The experimental results are compared with results from finite element analysis and two other theoretical methods of analysis of hull-deckhouse interaction.

DD FORM 1 NOV 65 1473 (PAGE 1)

S/N 0101-807-6801

Unclassified
Security Classification

Unclassified
Security Classification

14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Ship Structures						
Theoretical Analysis						
Structural Experiments						

DD FORM 1 NOV 65 1473 (BACK)
(PAGE 2)

Unclassified
Security Classification

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TABLE OF CONTENTS

		Page No.
	Abstract	
	Table of Contents	i
	List of Figures	ii
	List of Tables	iv
I.	Introduction	1
II.	Experimental Equipment and Methods	2
III.	Experimental Results	7
IV.	Finite Element Analysis	9
V.	Other Theoretical Methods	10
VI.	Discussion	12
	Figures	15-40
	Acknowledgements	41
	References	42
	Appendix A - Deflection Data	43
	Appendix B - Computer Programs	45
	Appendix C - Stresses and Strains	48
	Appendix D - Fourier Coefficients	60
	Appendix E - Computations for Comparison of Kammerer's and Schade's Methods of Deckhouse Analysis with Experimental Data	61

LIST OF FIGURES

		Page No.
1	Midship Section of Structural Model	15
2	Interior View of Hull Model	16
3	Deckhouse Construction Plan	17
4	Strain Gage Location Map - Deckhouse	18
5	Strain Gage Location Map - Hull Girder	19
6	Location of Dial Gages	20
7	Deckhouse Deflection Instrumentation	21
8	Force Monitoring and Pressure Control	22
9	Electronic Data Acquisition System	23
10	Finite-Element Step Designation	24
11	Deflections and Longitudinal Stresses, Test 8AH	25
12	Deflections and Longitudinal Stresses, Test 9AH	26
13	Deflections and Longitudinal Stresses, Test 8BH	27
14	Deflections and Longitudinal Stresses, Test 9BH	28
15	Deflections and Longitudinal Stresses, Test 8CH	29
16	Deflections and Longitudinal Stresses, Test 9CH	30
17	Longitudinal Stress Distribution Amidships - Stanchions Loose	31
18	Longitudinal Stress Distribution Amidships - Stanchions Fixed	31
19	Shear and Vertical Stresses at Bond, Tests 8A & 9A	32
20	Shear and Vertical Stresses at Bond, Tests 8B & 9B	32
21	Shear and Vertical Stresses at Bond, Tests 8C & 9C	33
22	Shear and Vertical Stresses at Deckhouse End, Tests 8AH & 8AS	34
23	Shear and Vertical Stresses at Deckhouse End, Tests 9AH & 9AS	34
24	Shear and Vertical Stresses at Deckhouse End, Tests 8BH & 8BS	35

LIST OF FIGURES (cont.)

		Page No.
25	Shear and Vertical Stresses at Deckhouse End, Tests 9BH & 9BS	35
26	Shear and Vertical Stresses at Deckhouse End, Tests 8CH & 8CS	36
27	Shear and Vertical Stresses at Deckhouse End, Tests 9CH & 9CS	36
28	Comparison of Kammerer's and Schade's Analysis for a Two-Level Deckhouse Under Bending Moment B	37
29	Comparison of Tests 9AH-S and Theory at Midships	37
30	Comparison of Tests 9AH-S and Theory at Midships	38
31	Comparison of Tests 8BH-S and Theory at Midships	38
32	Comparison of Tests 9BH-S and Theory at Midships	39
33	Comparison of Tests 8CH-S and Theory at Midships	39
34	Comparison of Tests 9CH-S and Theory at Midships	40

LIST OF TABLES

		Page No.
1	Designation and Condition of Test	6
2	Pressure Distribution in Tests	6
3	Deflection Data, Appendix A	43
4	Corrected Deflection Data, Appendix A	44
5	Stresses and Strains - Tests 8AH & 8AS, Appendix C	48
6	Stresses and Strains - Tests 9AH & 9AS, Appendix C	50
7	Stresses and Strains - Tests 8BH & 8BS, Appendix C	52
8	Stresses and Strains - Tests 9BH & 9BS, Appendix C	54
9	Stresses and Strains - Tests 8CH & 8CS, Appendix C	56
10	Stresses and Strains - Tests 9CH & 9CS, Appendix C	58
11	Fourier Coefficients for Experimental Bending Moment Expansion	60

I. INTRODUCTION

This report presents the results of a series of twelve structural tests performed to study hull-deckhouse interaction. The model, testing apparatus, instrumentation, and testing method are detailed in Section II. The previous series of tests (Ref. [4]) were performed using a single deckhouse, whereas this series of tests was conducted using a two level deckhouse.

The presentation of the experimental data and the computation of the stresses are outlined in Section III.

The finite element analysis is outlined in Section IV.

Two other theoretical methods of stress analysis are described in Section V.

In Section VI, the experimental results are discussed. Also, the different theoretical methods of analysis are evaluated in this section.

II. EXPERIMENTAL EQUIPMENT AND METHODS

1. Structural Model

A detailed description of the ship structural model is given in Ref.[4]. It is a longitudinally framed box girder, 42 feet long, 8 feet wide and 56 inches deep, with an attached 22-foot long deckhouse. For these tests the model was modified by adding a second level to the deckhouse.

A transverse section in way of the deckhouse is shown in Figure 1. A photograph of the interior of the hull model is shown in Figure 2. The model has no conventional transverse bulkheads. The restraint to vertical deformation of the main deck provided by such bulkheads is simulated by a number of stanchions attached to the deck, along the bond between deckhouse side and deck, and extending to the bilge of the model. When it is desired to make a stanchion effective, a spacer is inserted between the overlapping portion of the flanges of the upper and lower parts of the stanchion and the two are firmly bolted together.

The model deckhouse construction plan is shown as Figure 3. The two decks of the two-level deckhouse are bolted to the sides and ends of the deckhouse with 1/4-inch bolts on 3-inch centers. All other structural joints are welded. The diaphragm plate, shown in Figure 3, was installed on one end only. At the other end, the deckhouse was welded directly to the upper deck of the hull girder.

2. Load Application

The test model was subjected to static loads on the Ship Structures Static Testing Machine which is located at the University of California Richmond Field Station and described in Ref.[2]. The model rests on seven bags of equal size which cover its entire bottom area. Each bag has its individual control

valve and can be subjected to air pressures ranging from +12 to -12 psig; this feature allows application of positive and negative loads to each of seven transverse sections of the test model under investigation. When not under tests, the model is suspended at its four corners by means of turnbuckles. During the entire test the pressure in two of the seven bags is adjusted to carry the weight of the model, so that the forces in the turnbuckles decrease to zero. This is continuously checked by recording the forces on a 4-track Sanborn, Model 154, strip chart recorder (Figure 8).

3. Strain Gage Instrumentation

A strain gage map showing the location of the 524 gages applied to the model is shown in Figures 4 and 5. Figure 4 is an expanded view of the deckhouse and the first level deck of the deckhouse. Figure 5 is an expanded view of the hull girder. Gages are distributed along three transverse sections of the hull and deckhouse, and along the joint of the deckhouse sides and ends to the main deck.

Gages are generally applied to both sides of the plate in order to obtain the "heart-of-plate" strain. All gages are of etched foil type, with a resistance of 120 Ω. Three different sizes of these gages have been selected to suit the requirements at different locations. Those used for all 3-gage rosettes were 1/4" x 1/8". In positions 713 to 721, ready-made rosettes with 1/8" x 1/16" gages were installed. In all other locations, 1/2" x 1/4" gages were used. The strain gages were connected to bridge completion boxes (Figure 7). Each box has thirty-six terminals. Thirty-five terminals were used for active gages, the remaining terminal was connected to a dummy gage (resistor). The strains were measured automatically in an electronic data acquisition system (Figure 9) and recorded on magnetic tape. A description of the electronic system is given in Ref.[1].

4. Deflection Instrumentation

A total of seventeen dial gages were used to measure the relative deflection of hull and deckhouse. The distribution of these gages is shown in Figure 6. All gages were attached to two trusses running along the outer edges of the main deck and supported only near the ends of the hull. Gages lettered A to K were used to measure the deflection of the hull along the deck edge. Gages numbered 1 to 6 gave the deflection of the deckhouse as measured at the edge of the deckhouse deck. Gages 5, 6, F, I and J were installed to check the symmetry of the deflections about both axes of the model. Some of the gages can be seen in Figure 7, which is an end view of the deckhouse, looking aft.

The lowest resolution reading of the deflection gages was 0.001 inch.

5. Test Conditions

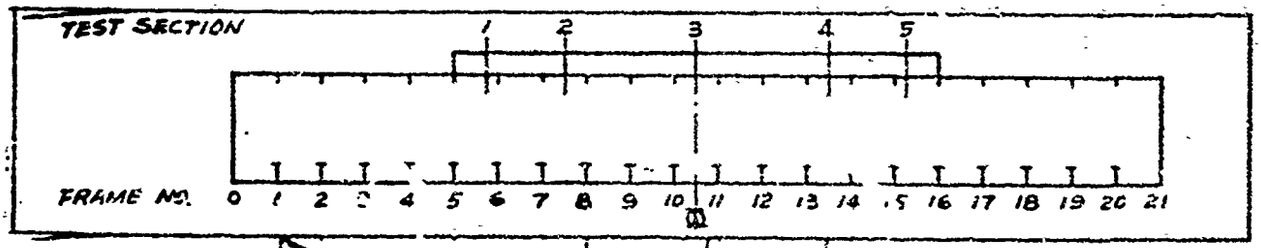
Load and stanchion support conditions of the twelve tests discussed in this report are summarized in Table 1. The last letter in the designation given to each test (S or H) represents sagging or hogging. Net pressures applied by each of the bags are listed in Table 2. The odd values of pressure result from setting the pressure regulators in units of cm. of Hg rather than psi.

6. Test Methods

Each experiment consisted of reading strains and deflections at each of three load conditions. The first and third load conditions, designated initial and final, have the model afloat on bags 3 and 5. The second, or test step, has the model under pressures corresponding to those listed in Table 2. Bags 3 and 5 have an additional pressure sufficient to float the loaded model. In general the pressure in bags 3 and 5 is approximately the sum of the pressure in either the initial and final step and the nominal

test pressure. Any deviation is due to pull on the model periphery by the strap sealing the vacuum surrounding the pressure bags. A detailed description of the test procedure is given in Ref.[1].

TABLE I DESIGNATION AND CONDITION OF TEST



STANCHIONS AT FRAME NOS. / LOAD DISTRIBUTION	NONE	ALL
	8AS	9AS
	8AH	9AH
	8BS	9BS
	8BH	9BH
	8CS	9CS
	8CH	9CH

TABLE 2 Pressure Distribution in Tests

Pressure in Bag No. (psig)							Test No.
1	2	3	4	5	6	7	
7.73	0	-7.73	0	-7.73	0	7.73	8&9 AS
-7.73	0	7.73	0	7.73	0	-7.73	8&9 AH
7.73	0	-3.865	-7.73	-3.865	0	7.73	8&9 BS
-7.73	0	3.865	7.73	3.865	0	-7.73	8&9 BH
0	5.03	-10.06	10.06	-10.06	5.03	0	8&9 CS
0	-5.03	10.06	-10.06	10.06	-5.03	0	8&9 CH

III. EXPERIMENTAL RESULTS

1. Presentation of Deflection Data

As shown in Figure 6, dial gages were distributed port and starboard on both the main deck edge and the deckhouse edge. The gages on the starboard side were installed to check the symmetry of the deflections about the longitudinal axis of the model. The maximum difference between port and starboard readings was $4 \cdot 10^{-3}$ in. The maximum difference between deflection readings for hogging and sagging was $3 \cdot 10^{-3}$ in. For these reasons, only port deflections in hogging were plotted.

Deflection readings are shown in Appendix A. A correction had to be made on the deflection readings because the trusses were supported at 18" from the ends of the main deck and not at its ends. The correction was obtained by extrapolation of the deflection curve to the end of the deck (see Ref.[1]). Corrected values are listed in Table 4 and plotted in Figures 11-16.

2. Computation of Strains and Stresses

The strain data are stored on magnetic tape in binary coded decimal form. During one test of three runs, 1572 values are obtained from 524 strain gages. Each value, called a sample, consists of 6 digits representing a number from 0 to 12000 and a sign. Two computer programs, reproduced in Appendix B, are used to process the strain readings.

A program DATDUMP serves to read the data from tape and to punch them on cards in a convenient form. Each card contains the initial, test, and final readings (runs) for two strain gages. Simultaneously, a printout of the data is made.

A second program, called STRESS serves to read and process the data obtained with DATDUMP. Bad data with non-interpretable

digits are changed to zero and listed for identification. The readings are then converted into strain values by multiplication with a calibration factor (Statement 3010). "I" is an index assigned to each strain gage consistent with the chronological order in which the gages are scanned. The strain readings X(I) are then assembled for each position (Statements 14 through 742). Note that the position numbers are identical with the statement numbers. The designations A_1 through A_6 refer to the direction and location of the gages according to the comment cards following statement 2400. For a definition of longitudinal, transverse and diagonal directions, see Appendix B. The values of A1 to A6 are printed in the last six columns of Tables 5 to 10.

Stresses are computed for each position number in Statements 2501 to 2505, assuming the following values for the material constants:

$E = 3 \times 10^5$ lbs/in^2	Modulus of elasticity
$G = 11 \times 10^6$ lbs/in^2	Shear modulus
$\nu = 0.3$	Poisson's constant

The stress values are printed out in the first 5 columns of Tables 5 to 10. Some values are plotted in Figures 11 to 27.

IV. FINITE ELEMENT ANALYSIS

The finite element analysis is based on procedures in which the real continuous structure is approximated by an assemblage of simple structural elements. Conditions of equilibrium of forces and compatibility of displacements are required to be satisfied at discrete locations throughout the approximating structure. This results in the reduction of the problem to the solving of sets of simultaneous equations relating these forces and displacements.

The degree of approximation involved varies, depending on the size of the mesh used in subdividing the structure into elements, but satisfactory convergence to the exact solution is generally obtained if the mesh size is made sufficiently small. One should see Ref.[7] for a more complete description of this type of analysis.

It is necessary to use a very fine mesh when examining regions of high stress concentration, such as the connection of a deckhouse end structure to the hull, resulting in excessive demands on computer capacity. A procedure is outlined in Ref.[7] whereby one may examine closely, by a succession of refinements, small regions of interest in a large structure.

In the analysis used here, one-quarter of the deckhouse (cut along centerline & midships) was used in step one. These results were plotted against the experimental data at the three cross sections, Figures 11-18. In the vicinity of the deckhouse end, two refinements were made in the size of the segment examined, and the results of step three were plotted against the experimental data, Figures 22-27.

The boundaries used in the different steps are shown in Figure 10.

V. OTHER THEORETICAL METHODS

Two other more simplified methods of analysis were used to analyze the stresses at the midship section. The first one was proposed by Kammerer, Ref.[6], and the second one was proposed by Schade, Ref.[10].

Kammerer's method for calculating the stress distribution across hull and deckhouse utilizes semi-empirical results of fullscale experiments to evaluate the effect of differential deflections between deckhouses and their hull girders. These data have been incorporated into an analytical treatment of the problem based on plane stress theory. Shear lag is taken into account in figuring the "equivalent area" of the deckhouses, but is not considered in the hull girder analysis. The design charts given in Kammerer's paper are plotted using full ship dimensions, and it was therefore necessary to extrapolate model scantlings to full-scale. Calculations for one case are shown in Appendix E.

Schade's method for calculating the stress distribution across hull and deckhouse is also based on plane stress theory, but differs from Kammerer's in that shear displacement is accounted for in the sides of the hull and deckhouse and shear lag in the hull girder is included. The last item allows the stress at the deckhouse-hull connection to be different from the stress at the hull side. This method does not depend on empirical data, but instead upon the evaluation of a deck flexibility factor "K". The values of "K" were determined experimentally in Ref.[3] to be 650 psi for the all stanchions loose condition and 34,000 psi for the all stanchions fixed condition.

Fourier coefficients for the expansion of the three bending moments used in the experiments are listed in Appendix D.

The nomenclature for Schade's method is reproduced in Appendix E, along with calculations for one case.

Both of these methods were based on the simplifying assumption that the bending moment could be expanded into one constant term and one sinusoidal term. This is a good assumption in most cases, but will not hold in the case of bending moment "C", a "saddle form" bending moment. It was therefore necessary to return to the basic formulation of the equations and rederive them based on "n" sinusoidal terms. This was done for Schade's methods using Reference [9]. The new equations are shown at the end of Appendix E.

First a new equation for "r" was developed and is shown as Eq. E-8A. Next, using the new assumption for bending moment (Eq. E-9A), a new equation for "p_f" was obtained and is shown as Eq. E-10A. The first four terms of Eq. E-10A are from the homogeneous solution and the last two terms are from the particular solution of the differential equation. The first four terms have coefficients which must be evaluated using the boundary conditions. All six terms must be evaluated for each term of the moment expansion. Because "ρ" will be different for each term of the moment expansion, all of the "effective" geometric properties, and coefficients calculated from these, have to be recalculated for each term also. Figures 33 and 34 were obtained using a three term expansion.

VI. DISCUSSION

As stated, this report is a continuation of a previous report (Ref.[4]). The main reason for conducting this series of tests was to find what effect the addition of a two-level deckhouse would have on the previous experimental results. Another reason was to further check the various theoretical methods of predicting stress. Only the two extreme stanchion support conditions were used (no stanchions, and all stanchions fixed). Three bending moment distributions were used, instead of five as in the previous work, since the previous variation in moment distribution gave no significant variation in longitudinal direct stress distribution (except for "saddle-form" bending moment "C").

The experimental results followed the same basic form as shown in Part I (Ref.[4]), the only major difference being the reversal of stress in the deckhouse in the "no stanchion" condition. Where, in the one-level deckhouse experiments, the stress would decrease as one moves from the hull girder to the deckhouse top, now the stress decreases and reverses sign below the deckhouse top. This could have been expected from extrapolation of the previous results, but goes against intuition.

In Figures 11-16, the experimental longitudinal stresses and deflections are plotted along with the theoretical finite element values. The two agree very well, although the finite element deflections and stresses are generally slightly less than experimental values for moment distributions "A" and "B", and slightly greater than experimental values for moment distribution "C".

In Figures 17 and 18, the experimental longitudinal stress distributions amidships are compared. They are basically the same as shown in Part I (Ref.[4]), except that the second level of the deckhouse has lessened the effect of moment distribution on deckhouse stresses. The plots were obtained by multiplying the

computed stresses for each moment distribution by the ratio of the midship value of bending moment "C" to the midship value of their respective bending moments.

Figures 19-21 are again similar to those of Part I. These figures show the shear and vertical stresses at the deckhouse-hull bond. They show, as expected, highest vertical stresses at the deckhouse end and over the midship stanchions and frames (higher values when stanchions are in place). They show high shear stress at the deckhouse end, continuously decreasing to zero at amidships.

Figures 22-27 compare the experimental values of vertical and shear stress with the theoretical values of the third step finite element analysis. There is generally good agreement between the two values, especially for the vertical stress. These figures again show the difficulty of obtaining accurate values at the corners, due to the finite size of the strain gages. Because of the very steep stress gradient. it is impossible to measure the maximum stresses involved.

Figure 28 shows a comparison of the values obtained by Kammerer's and Schade's methods for a typical bending moment. This shows that Kammerer's method will give results between the two extreme values of Schade's method, but that it gives results much closer to the rigid deck extreme than to the flexible extreme. This should be expected since most naval and passenger ships upon which the empirical data are based have fairly rigid main deck support. For this reason, in Figures 29-34, Kammerer's method is only compared with experiment for the "all stanchions fixed" condition.

In Figures 29-34, the experimental results at amidships are plotted along with Kammerer's and Schade's methods. The comparison is generally good. As stated in Section V, it was necessary to extend Schade's method in order to obtain reasonable correlation

between experimental and theoretical results for bending moment "C".

Kammerer's method will give a reasonably good approximation of stress when very little information is available on the ship's structure. It is by far the simplest method to apply, but requires that the bending moment be of simple sinusoidal shape.

Schade's method also gives a good approximation of stress, but requires the finding of a deck flexibility factor (which makes it more versatile). It is fairly simple to apply, unless more than one sinusoidal term is required to approximate the bending moment distribution, which complicates the problem somewhat.

The finite element method can, of course, be the most accurate, but also requires the greatest amount of work to solve a problem.

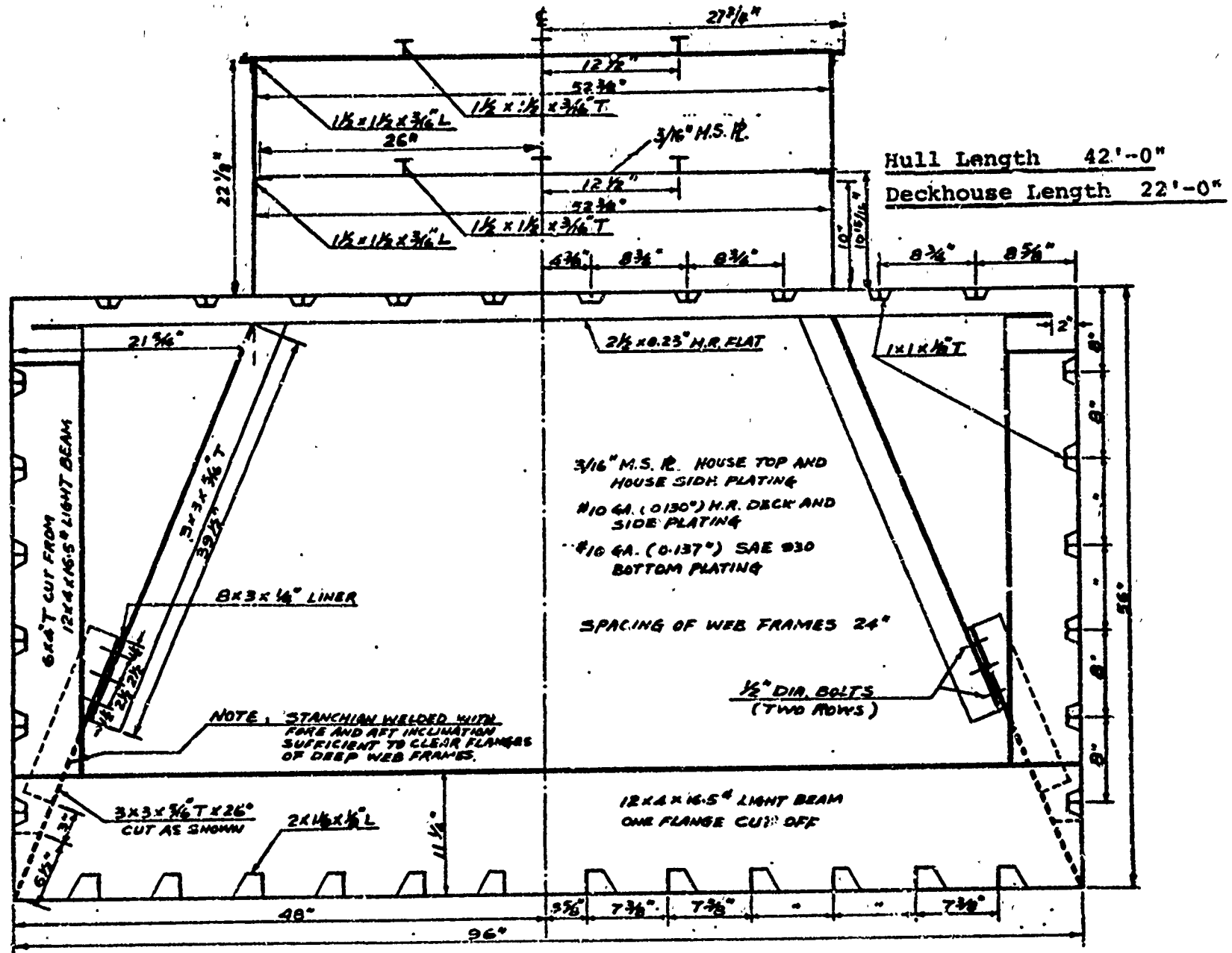


FIGURE 1. MIDSHIP SECTION OF STRUCTURAL MODEL

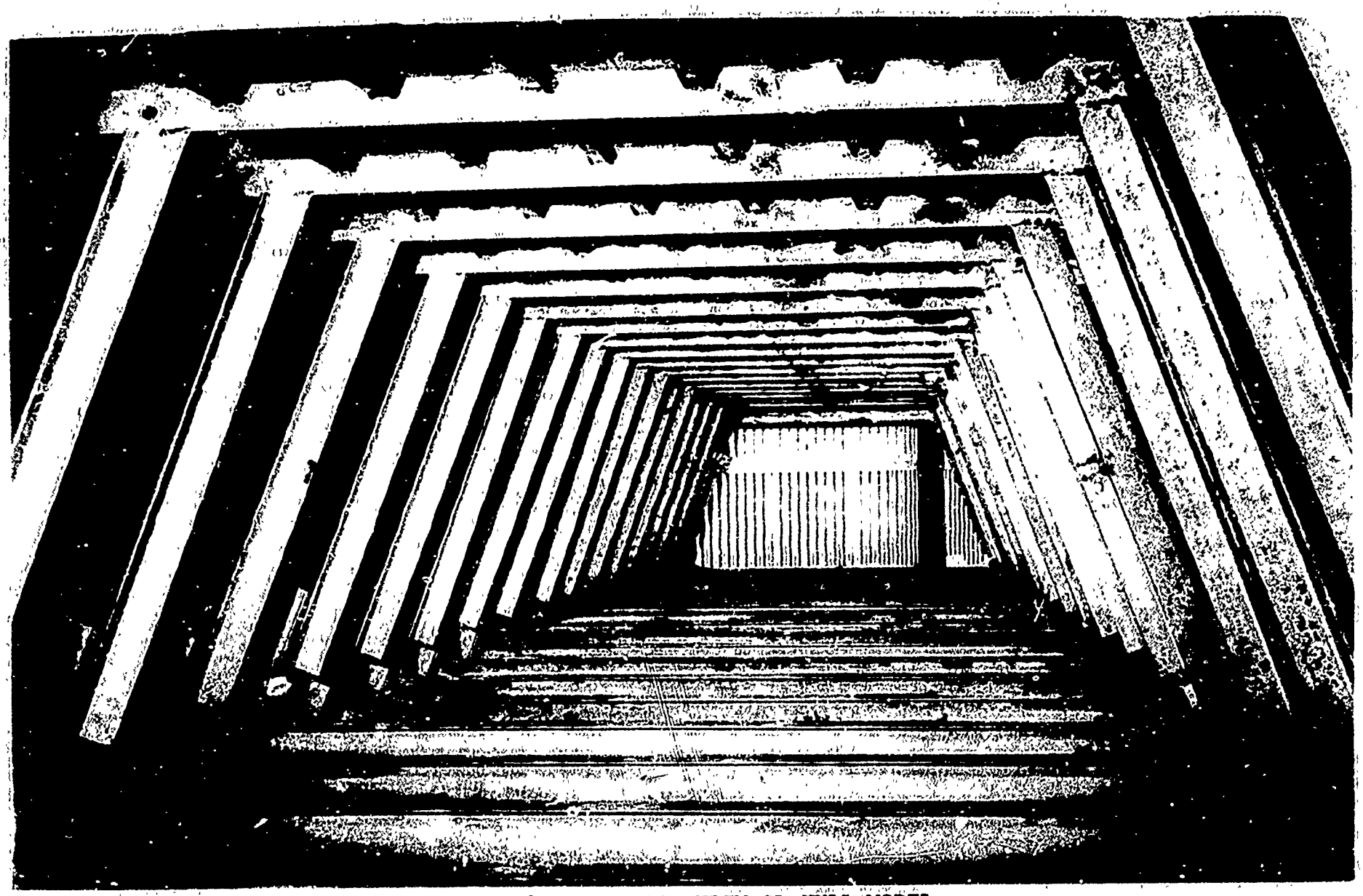


FIGURE 2. INTERIOR VIEW OF HULL MODEL

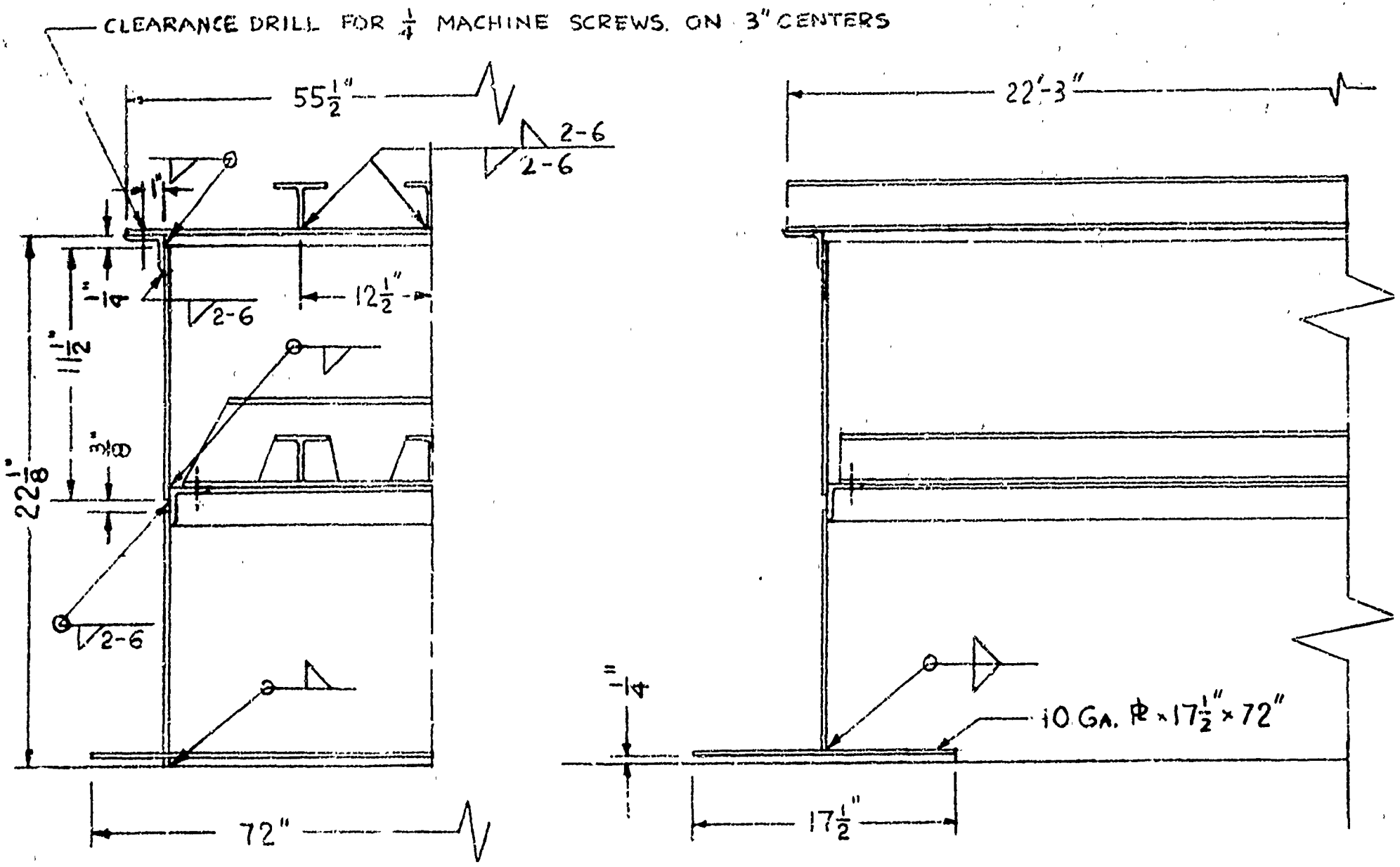


FIGURE 3. DECKHOUSE CONSTRUCTION PLAN

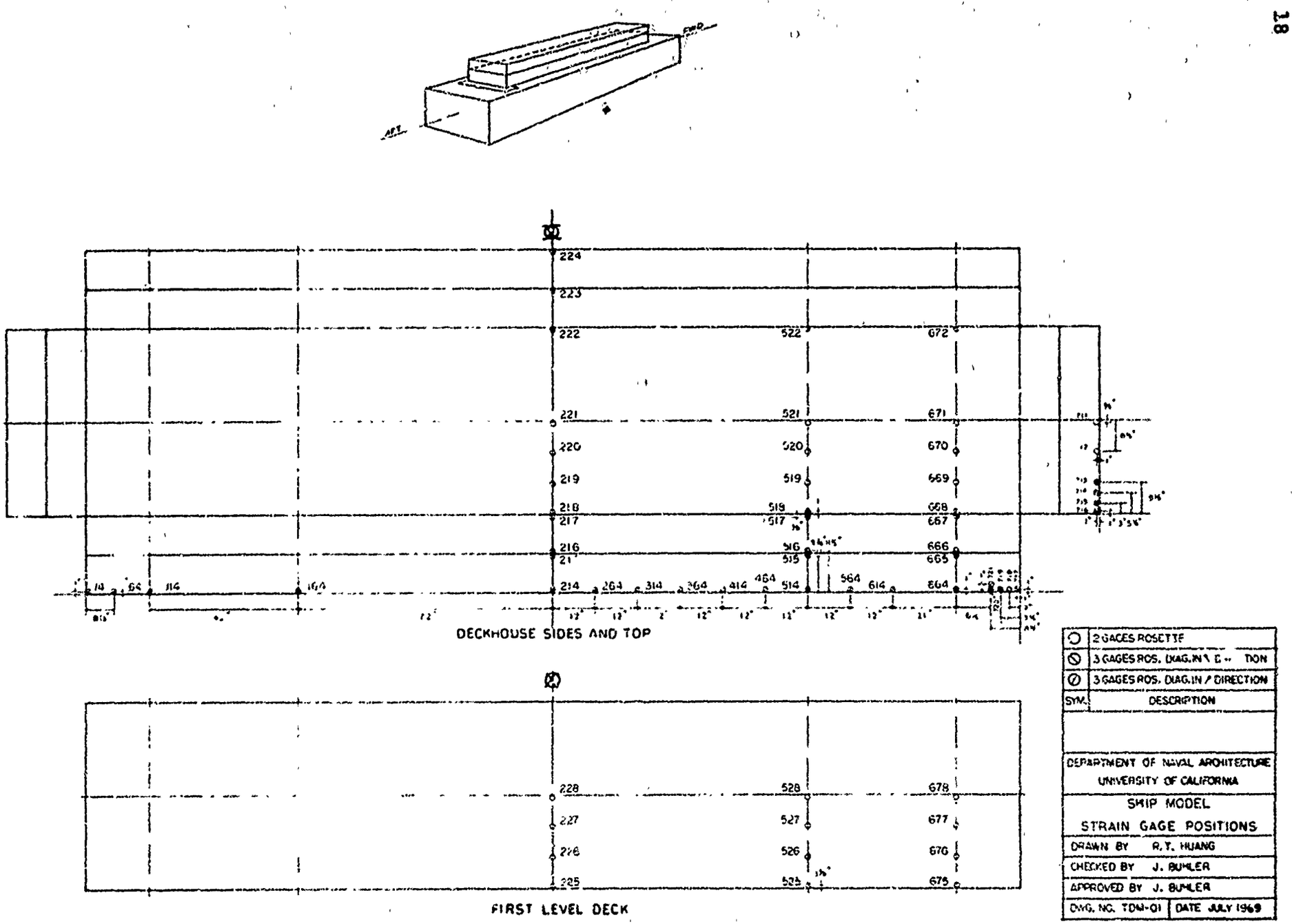


FIGURE 4. STRAIN GAGE LOCATION MAP - DECKHOUSE

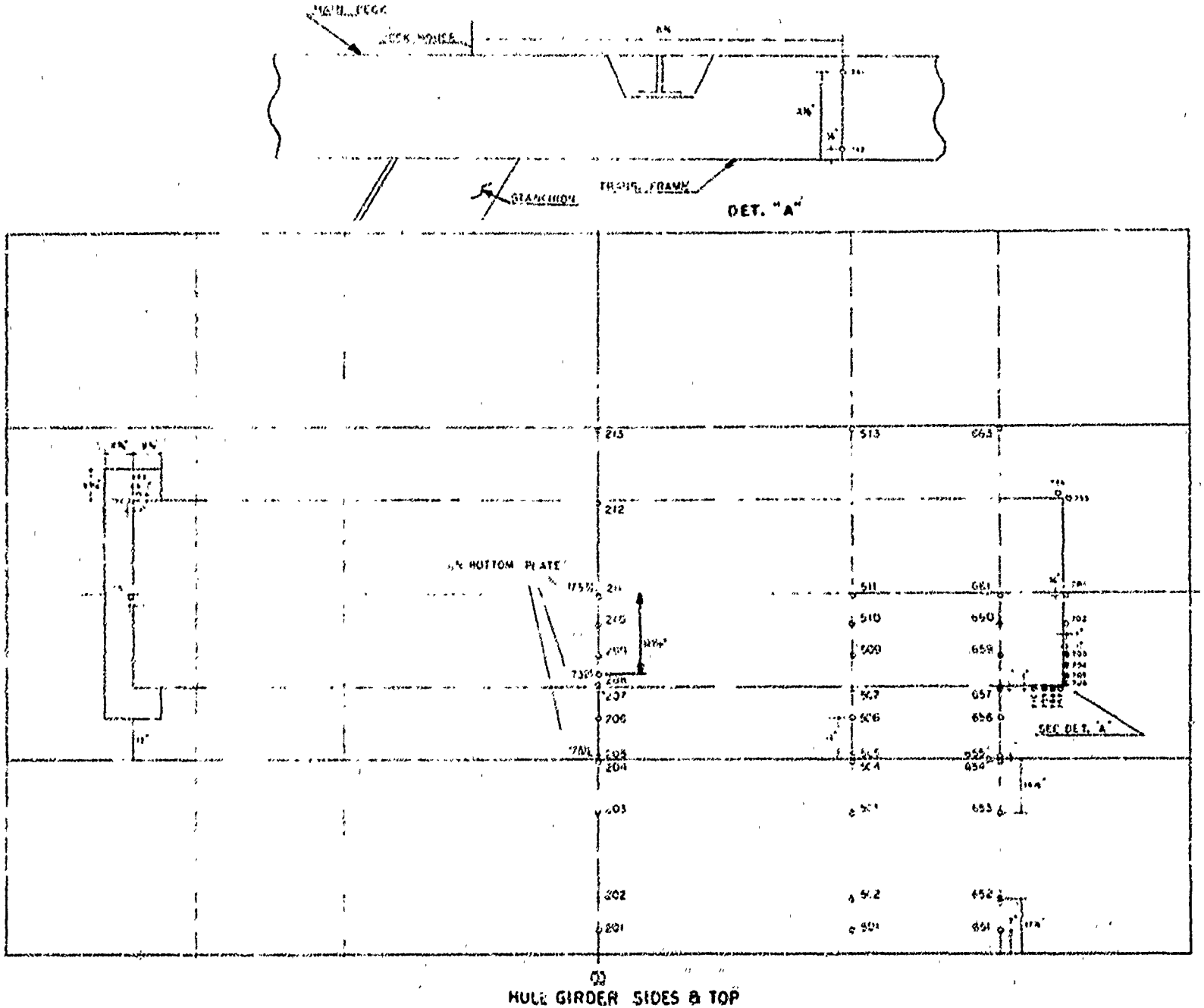


FIGURE 5. STRAIN GAGE LOCATION MAP - HULL GIRDER

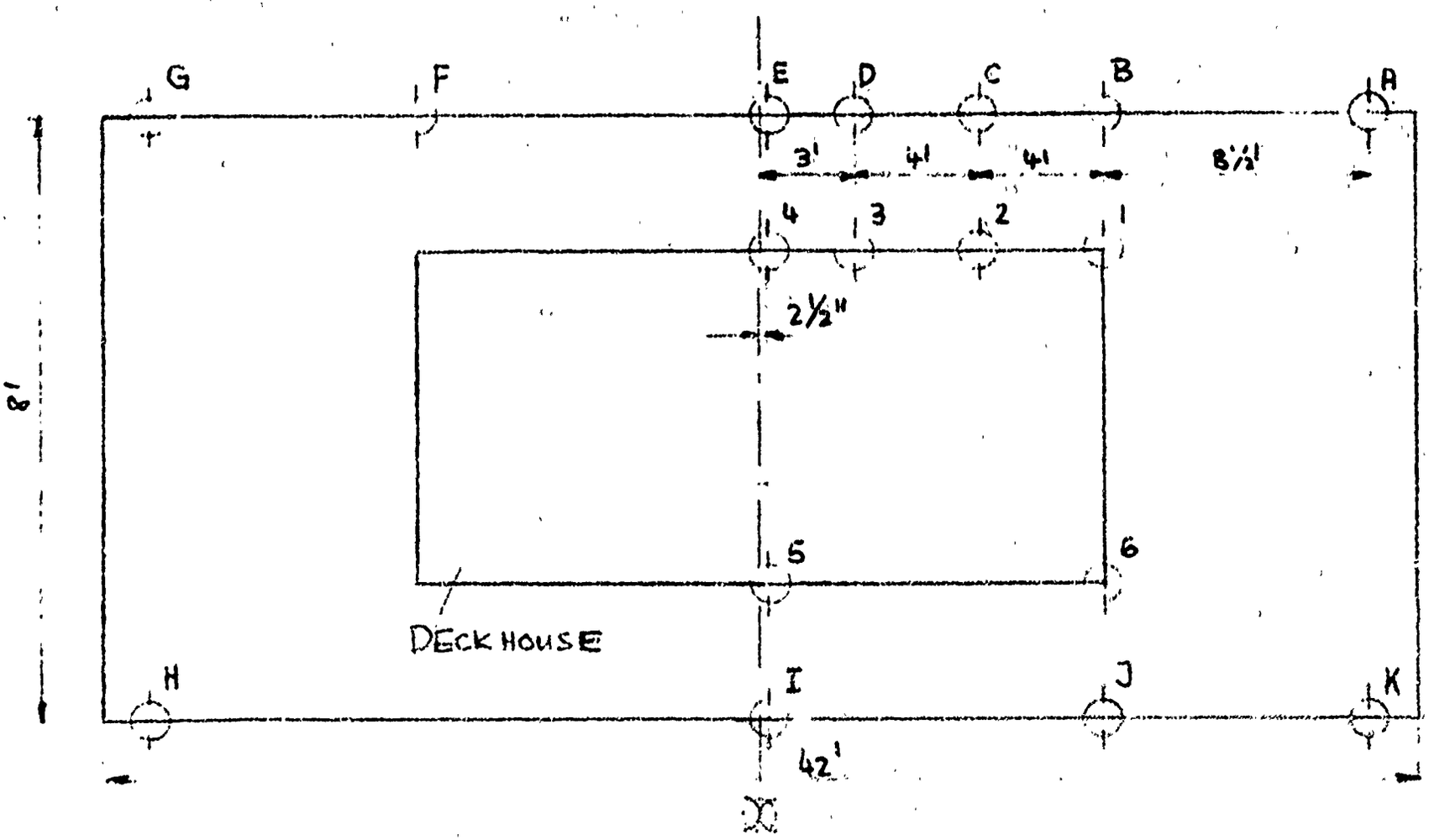


FIGURE 6. LOCATION OF DIAL GAGES

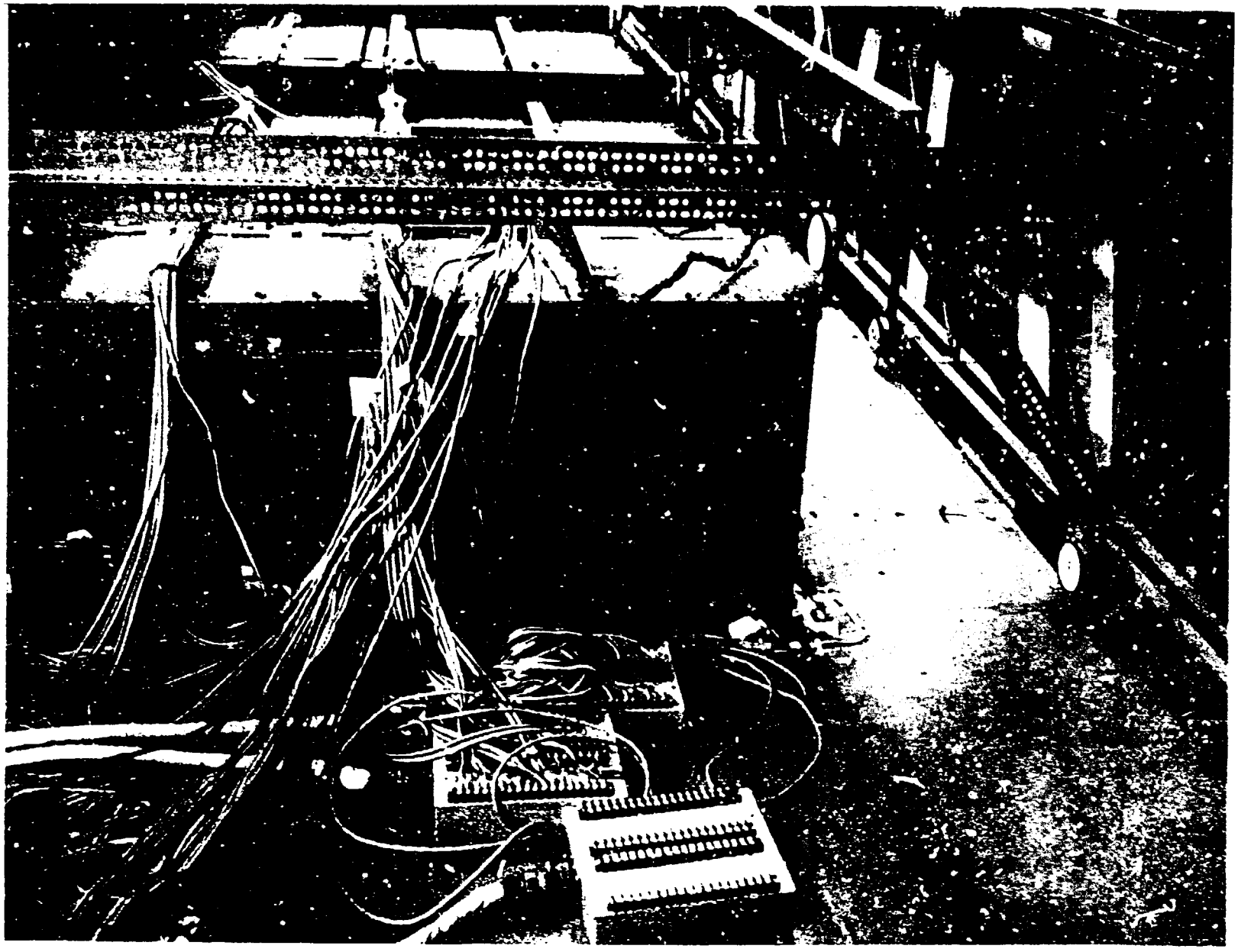


FIGURE 7. DECKHOUSE DEFLECTION INSTRUMENTATION

FIGURE 8 FORCE MONITORING AND PRESSURE CONTROL

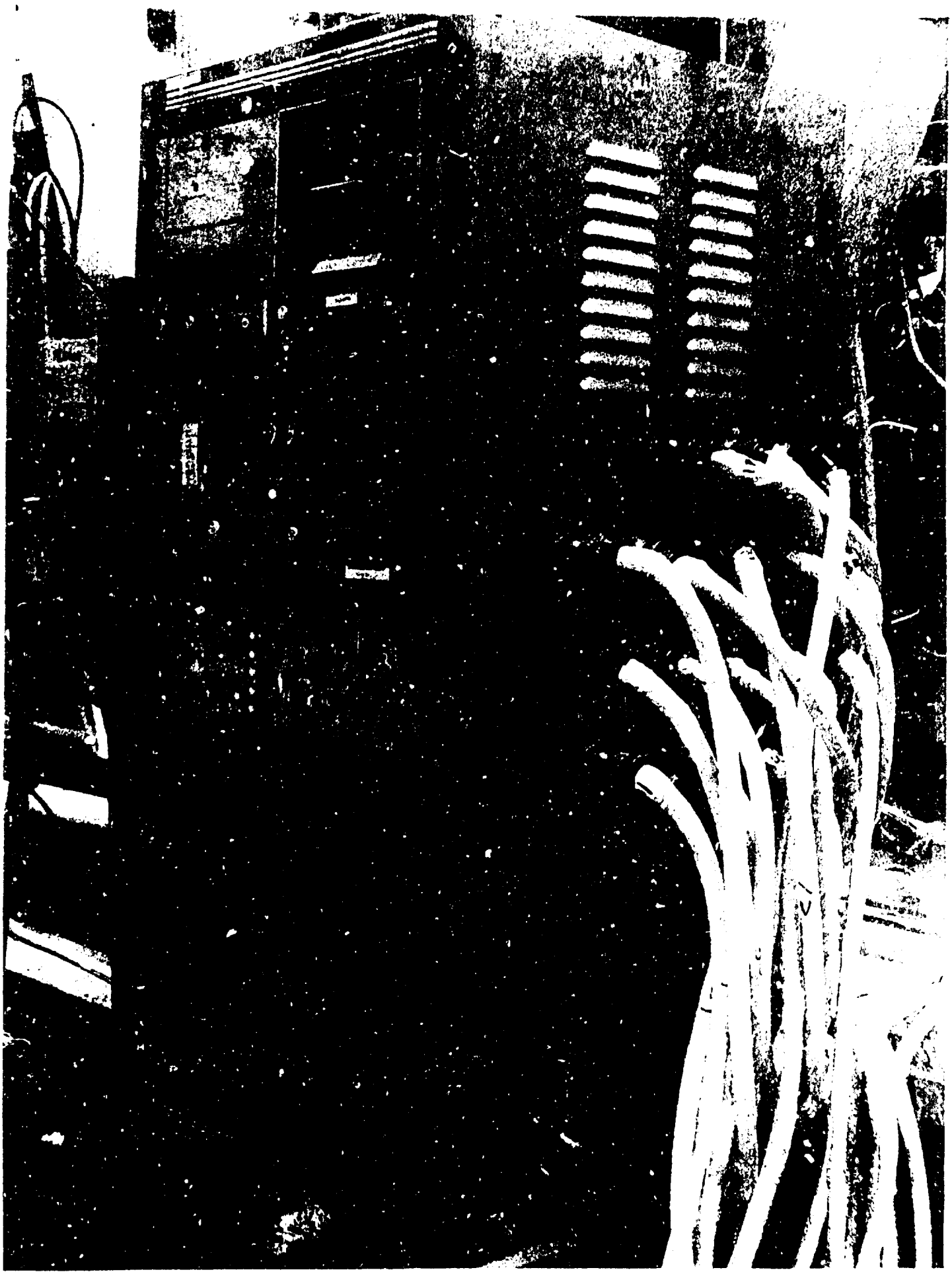


FIGURE 9 ELECTRONIC DATA ACQUISITION SYSTEM

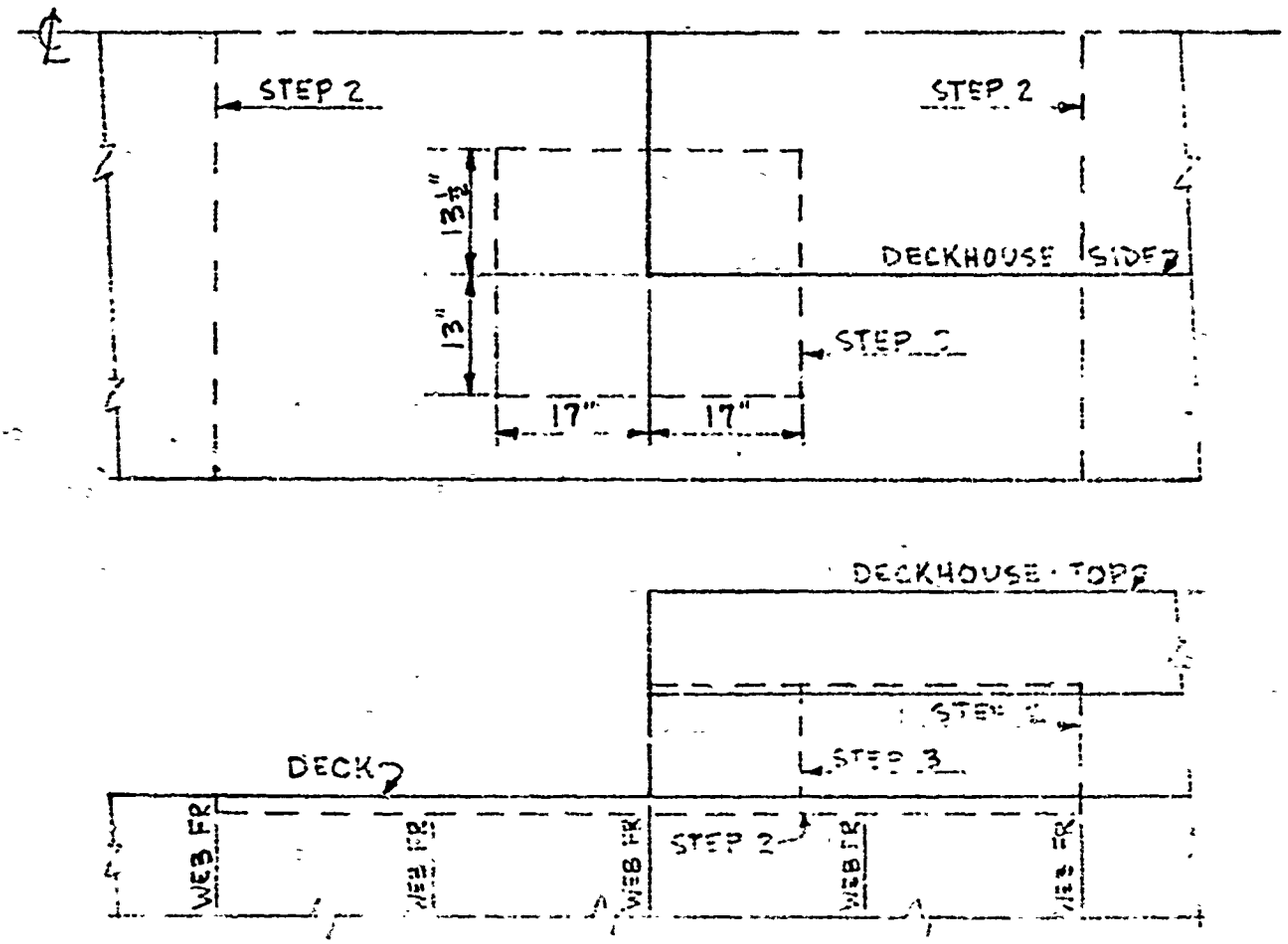


FIGURE 10. FINITE-ELEMENT STEP DESIGNATION

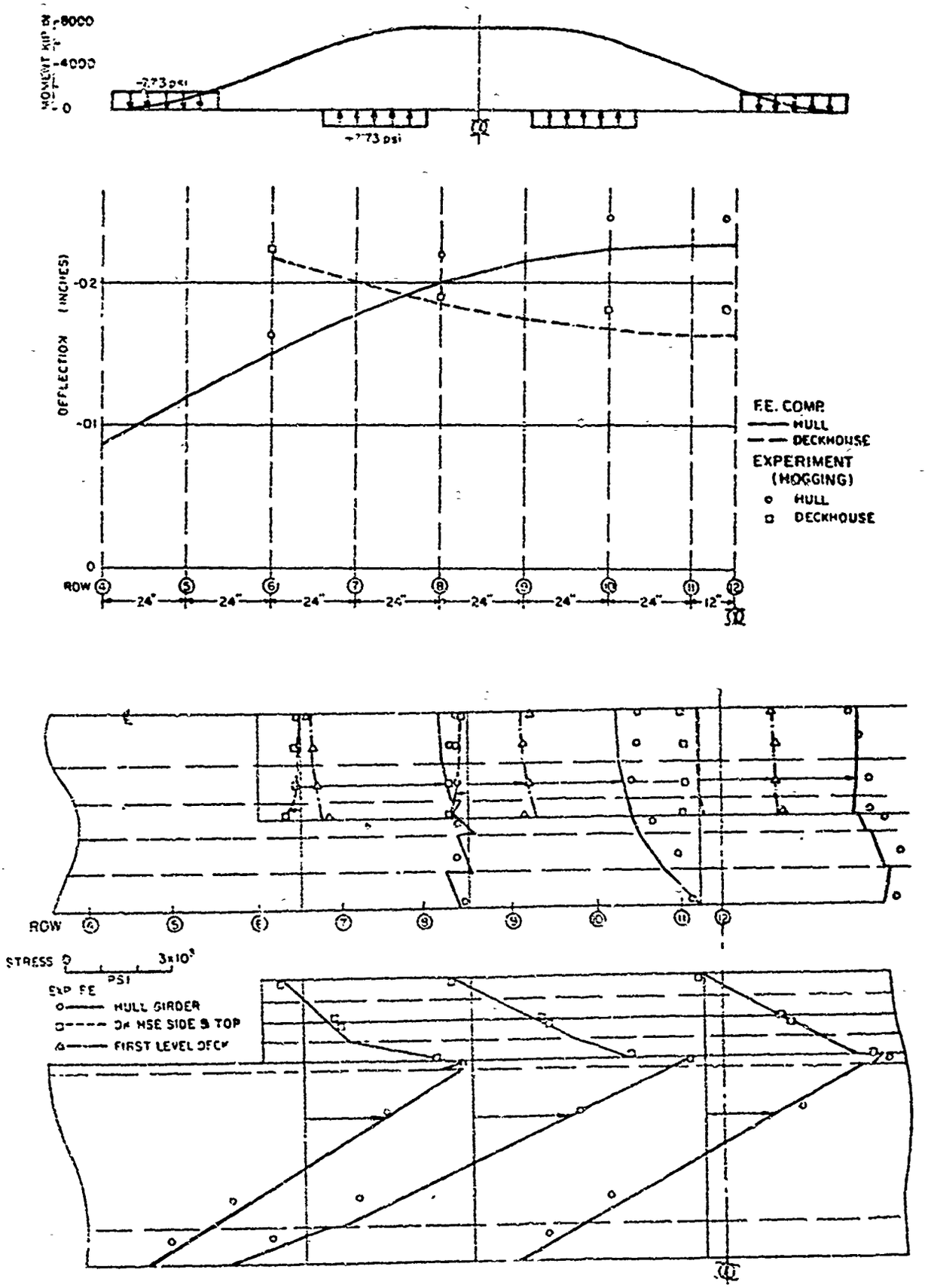


FIGURE 11. DEFLECTIONS AND LONGITUDINAL STRESSES, TEST 8AH

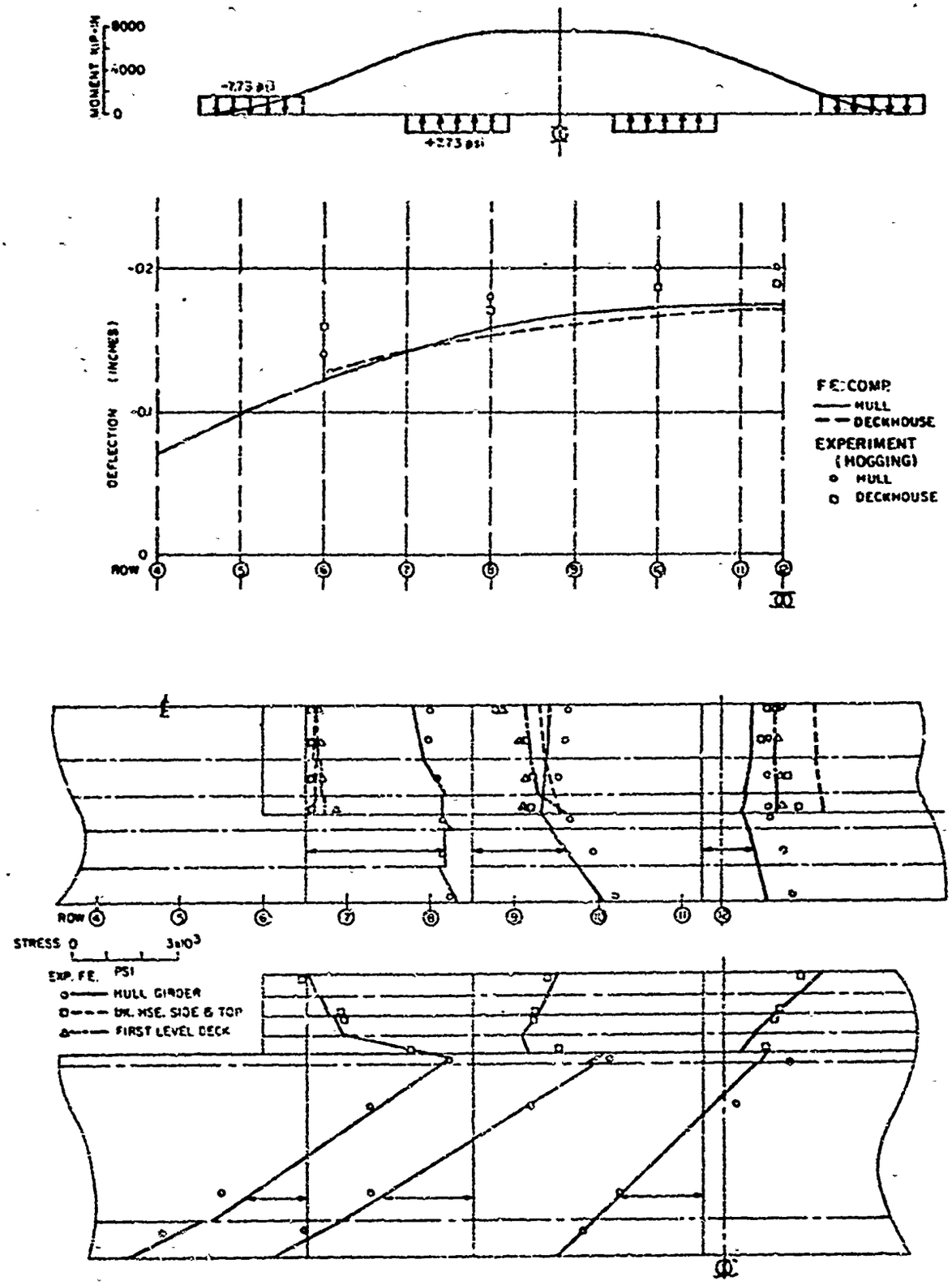


FIGURE 12. DEFLECTIONS AND LONGITUDINAL STRESSES, TEST 9AII

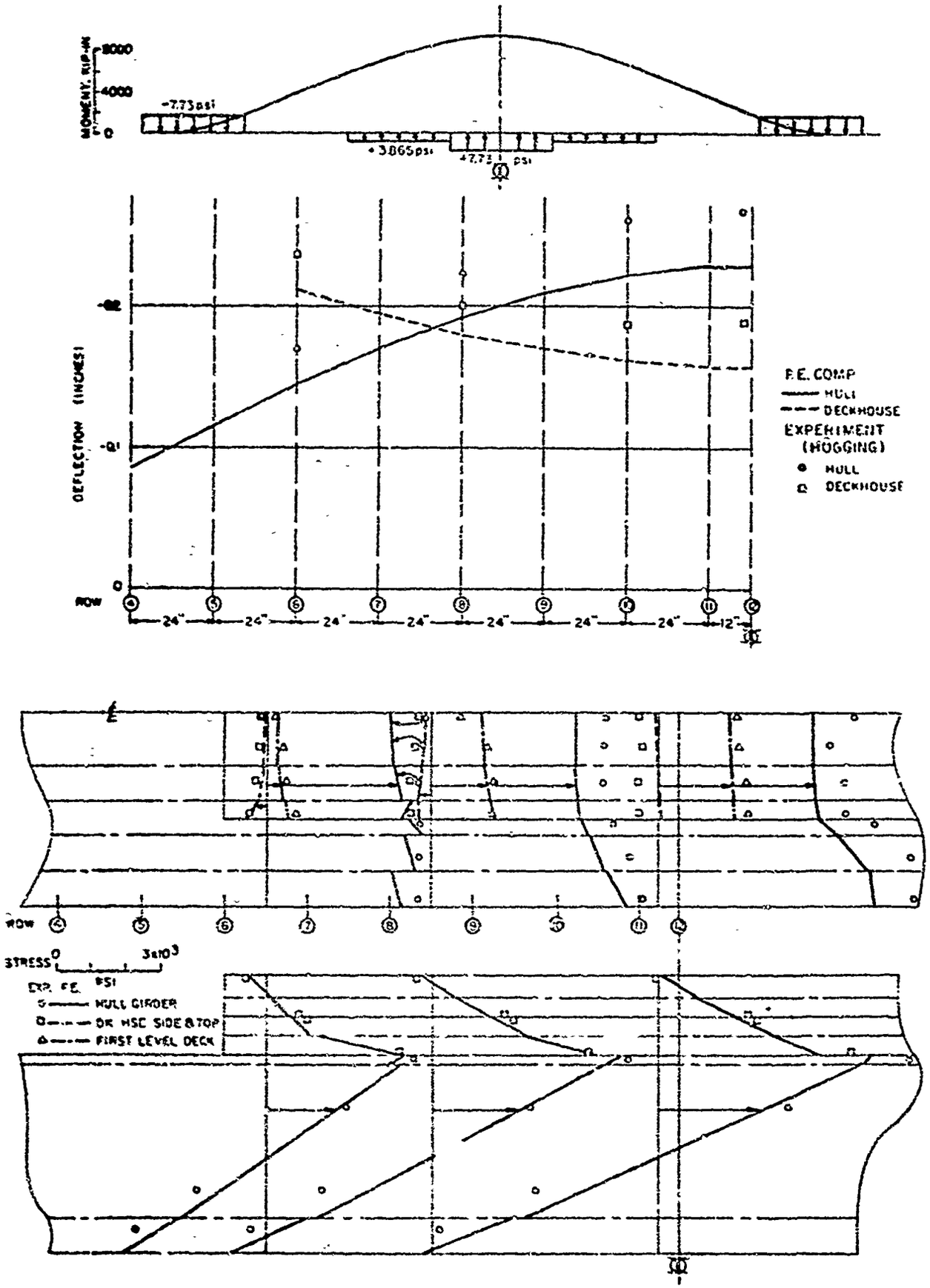


FIGURE 13. DEFLECTIONS AND LONGITUDINAL STRESSES, TEST 8BH

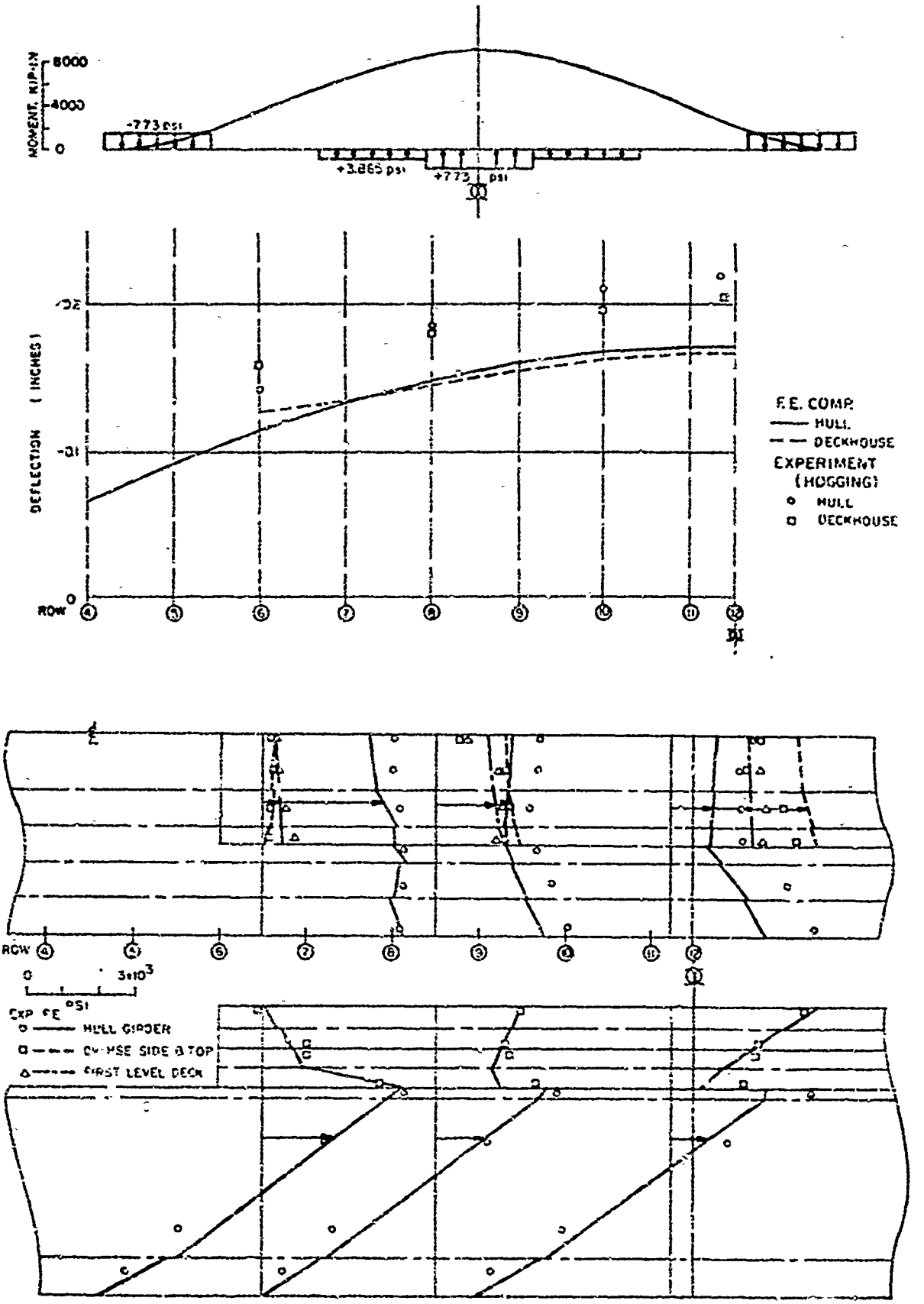


FIGURE 14. DEFLECTIONS AND LONGITUDINAL STRESSES, TEST 9BH

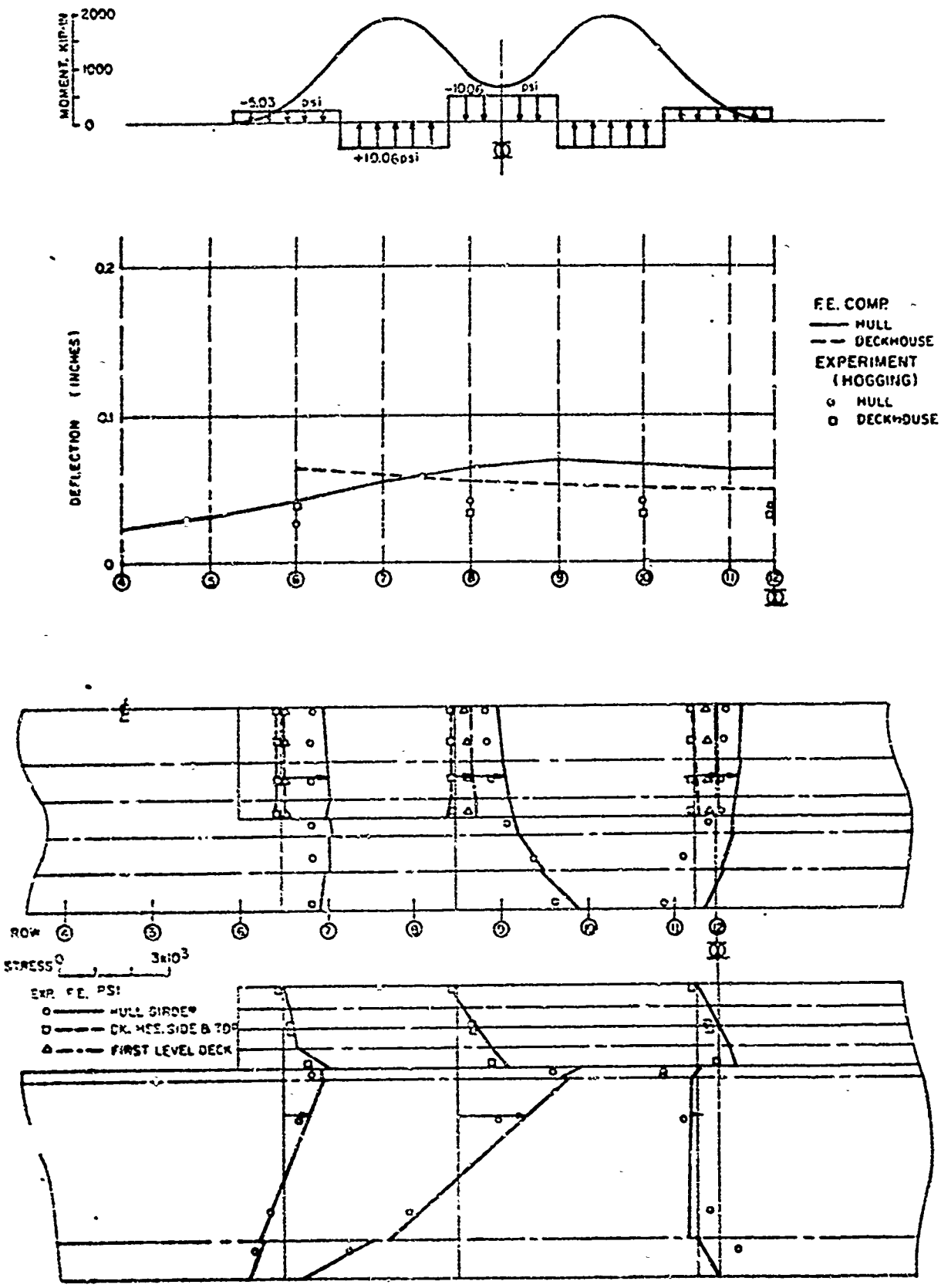


FIGURE 15. DEFLECTIONS AND LONGITUDINAL STRESSES, TEST 8CH

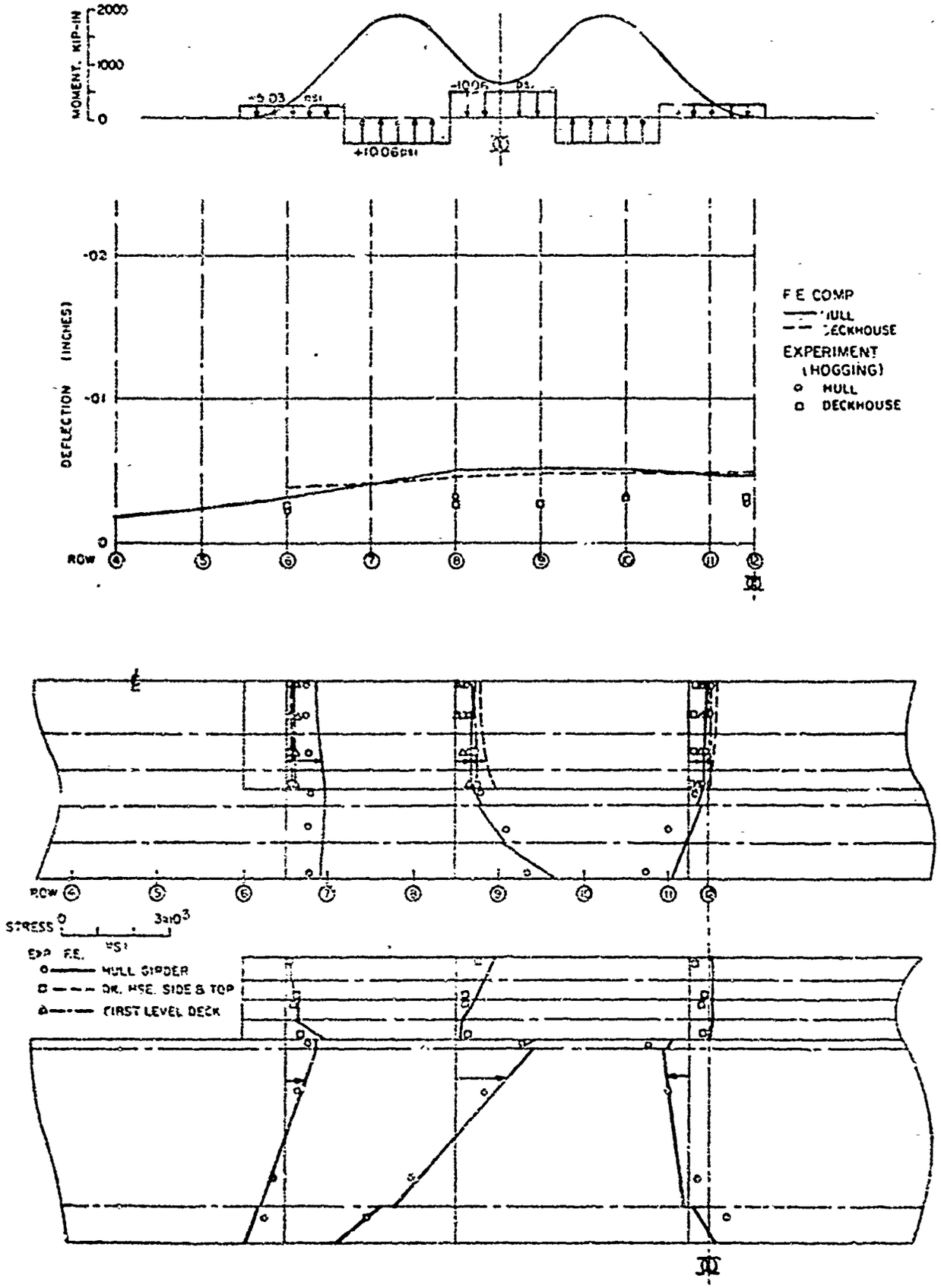


FIGURE 16. DEFLECTIONS AND LONGITUDINAL STRESSES, TEST 9CH

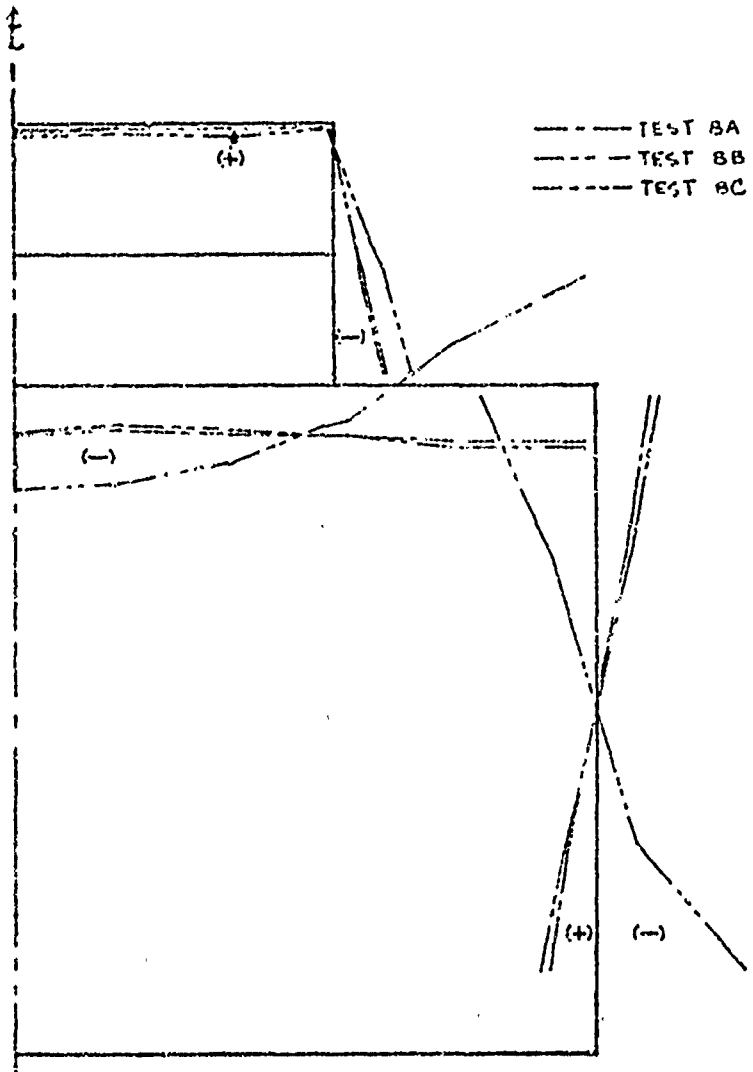


FIGURE 17. STANCHIONS LOOSE

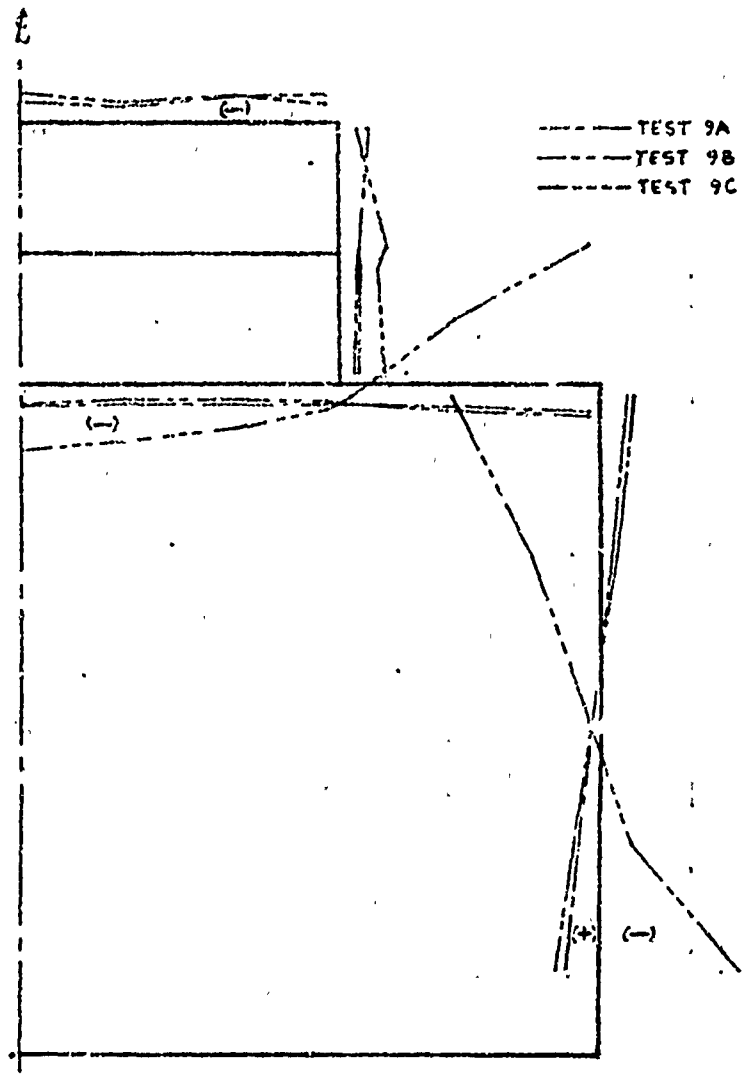


FIGURE 18. STANCHIONS FIXED

LONGITUDINAL STRESS DISTRIBUTION AMIDSHIPS

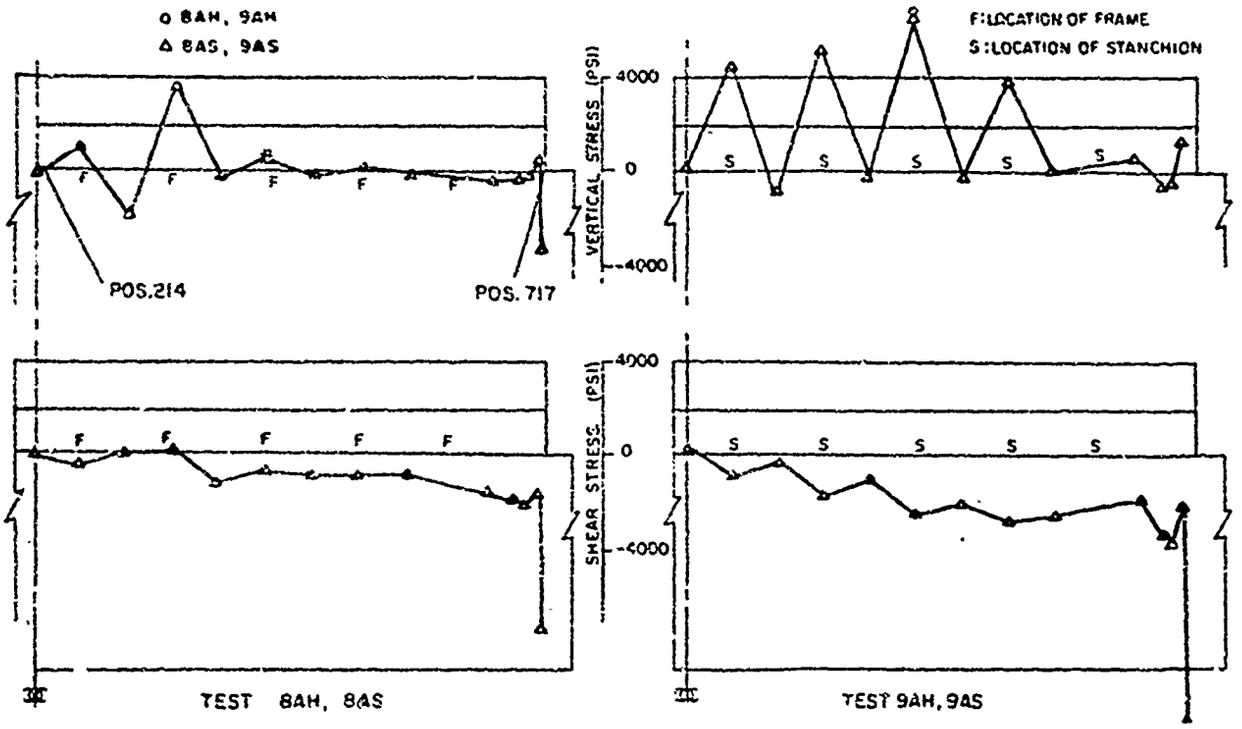


FIGURE 19. SHEAR AND VERTICAL STRESSES AT BOND, TESTS 8A & 9A

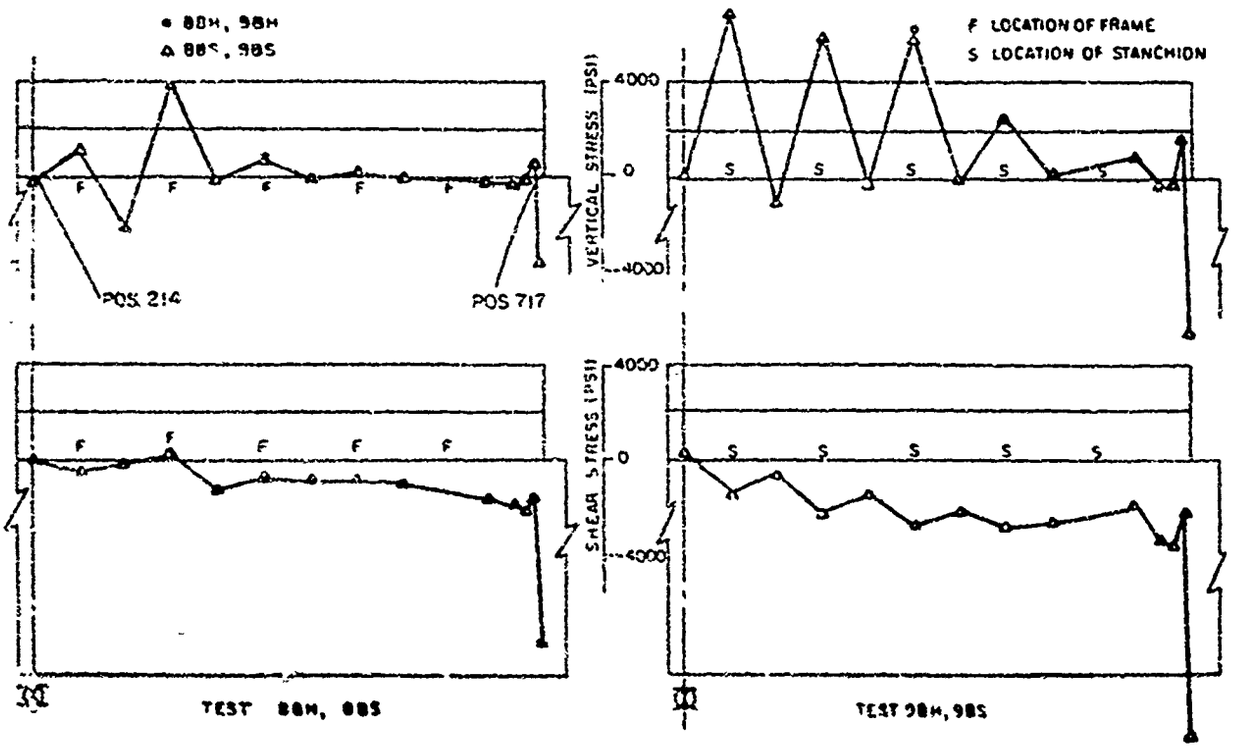


FIGURE 20. SHEAR AND VERTICAL STRESSES AT BOND, TESTS 8B & 9B

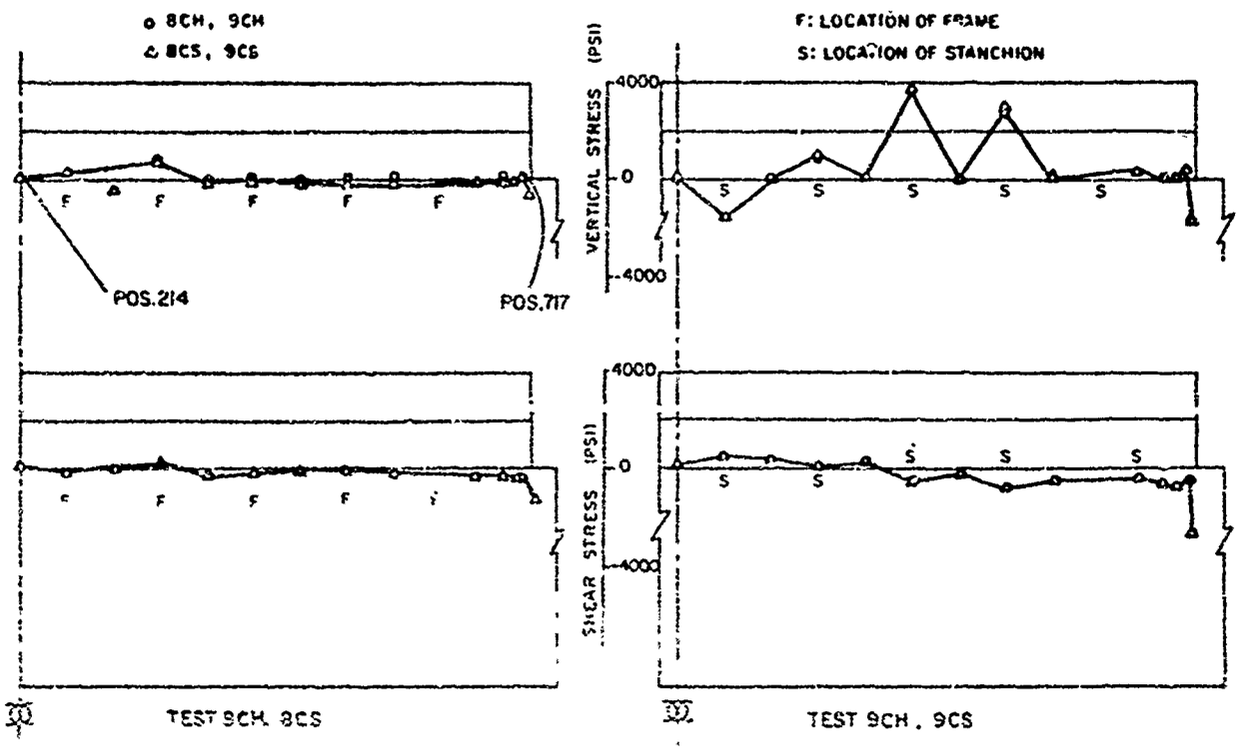


FIGURE 21. SHEAR AND VERTICAL STRESSES AT BOND, TESTS 8C & 9C

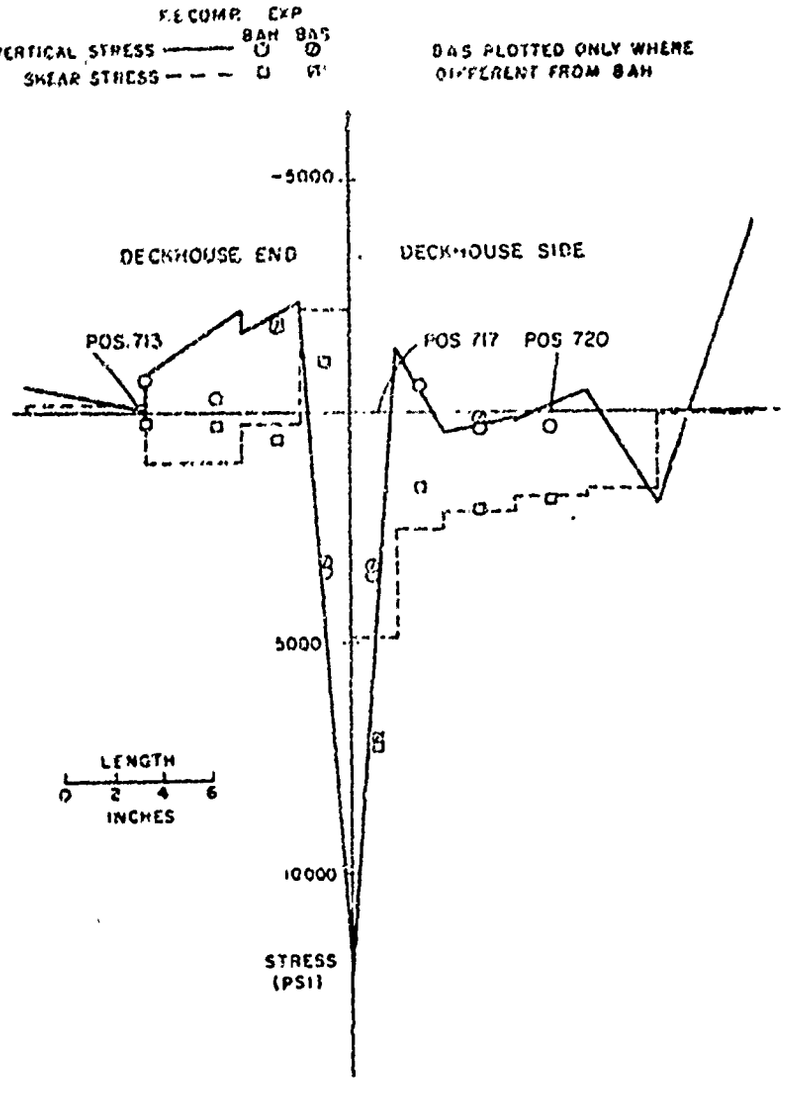


FIGURE 22. TESTS 8AH & 8AS

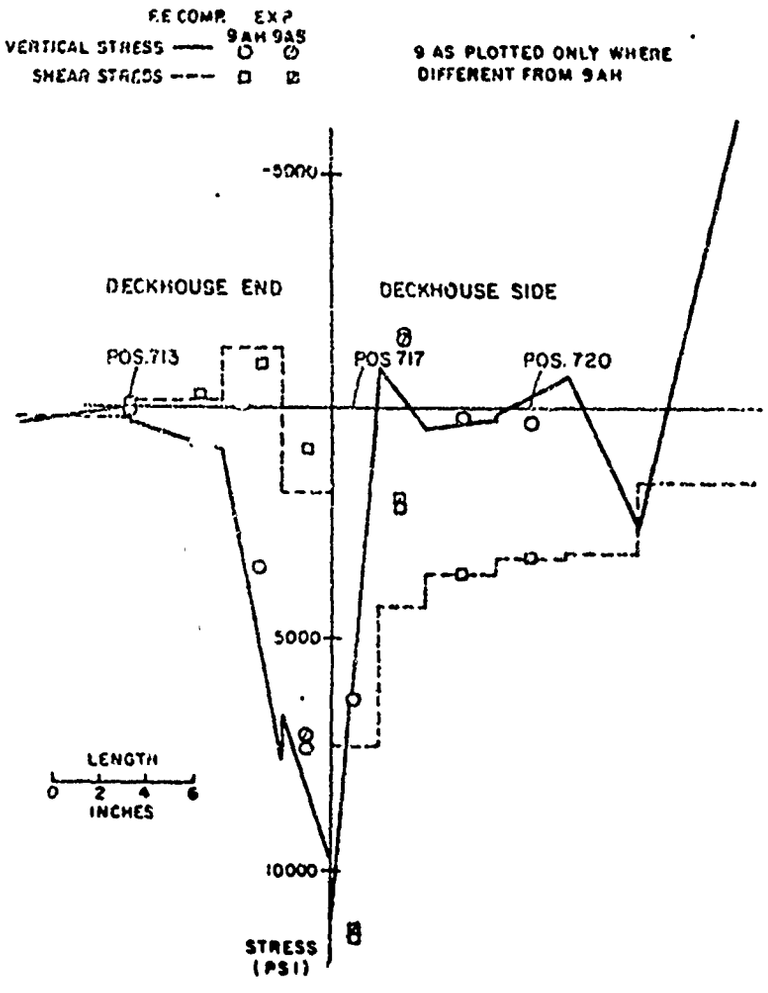


FIGURE 23. TESTS _ & 9AS

SHEAR AND VERTICAL STRESSES AT DECKHOUSE END

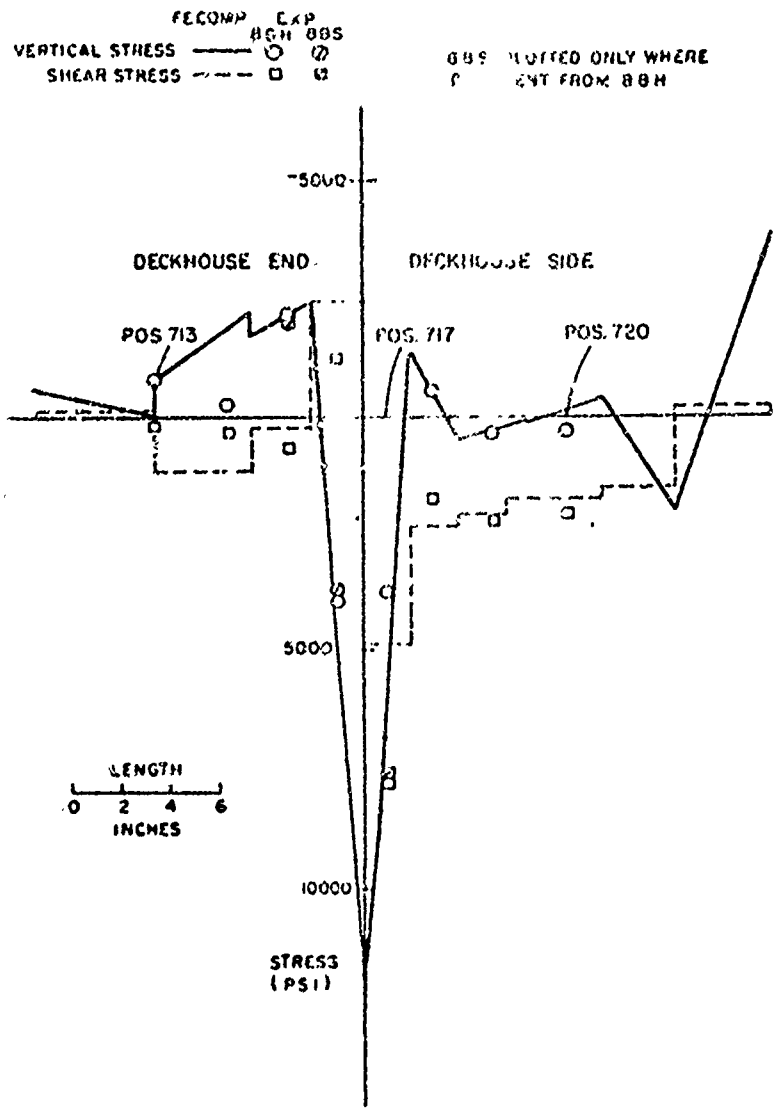


FIGURE 24. TESTS 8BH & 8BS

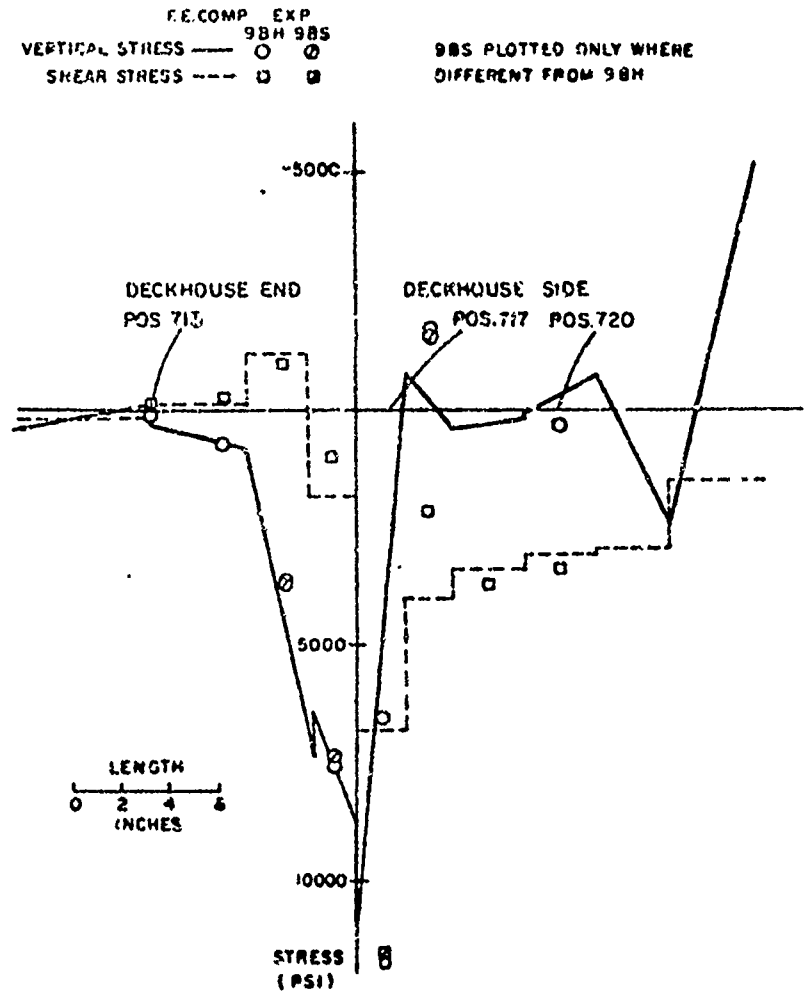


FIGURE 25. TESTS 9BH & 9BS

SHEAR AND VERTICAL STRESSES AT DECKHOUSE END

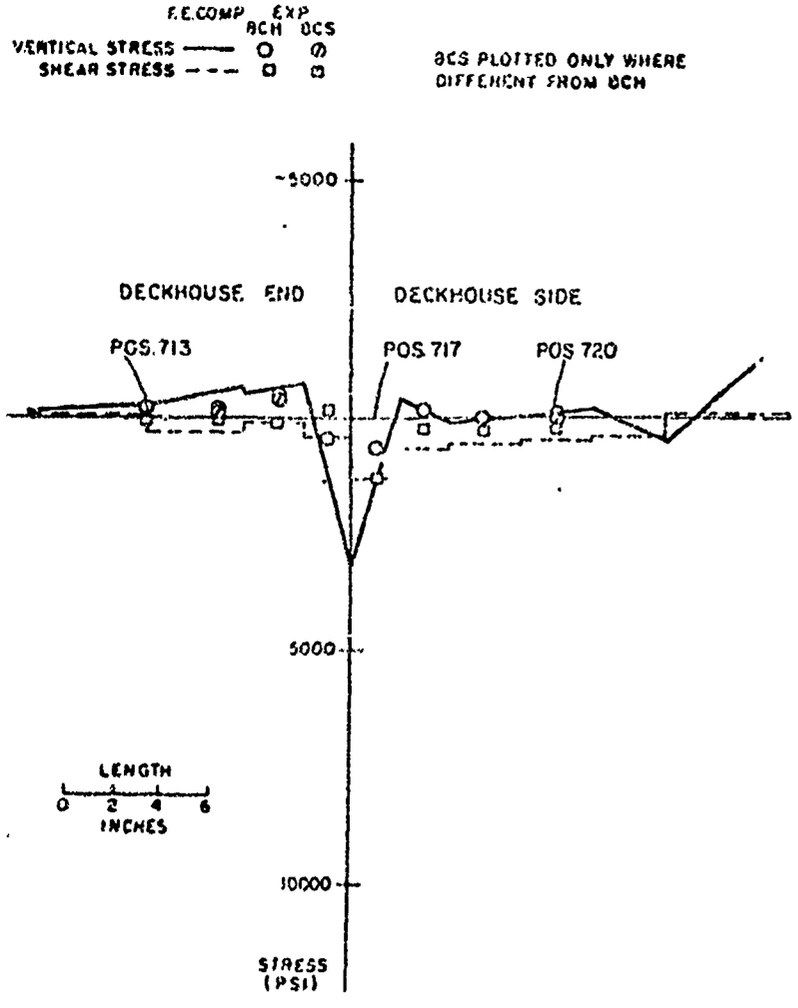


FIGURE 26. TESTS 8CH & 8CS

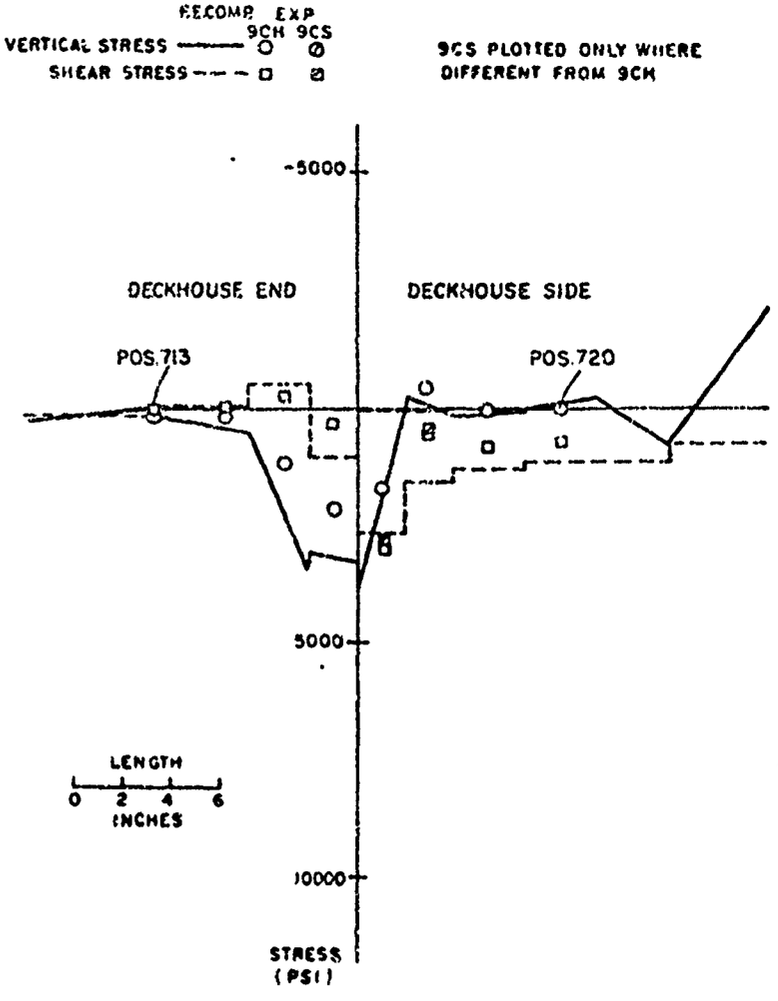


FIGURE 27. TESTS 9CH & 9CS

SHEAR AND VERTICAL STRESSES AT DECKHOUSE END

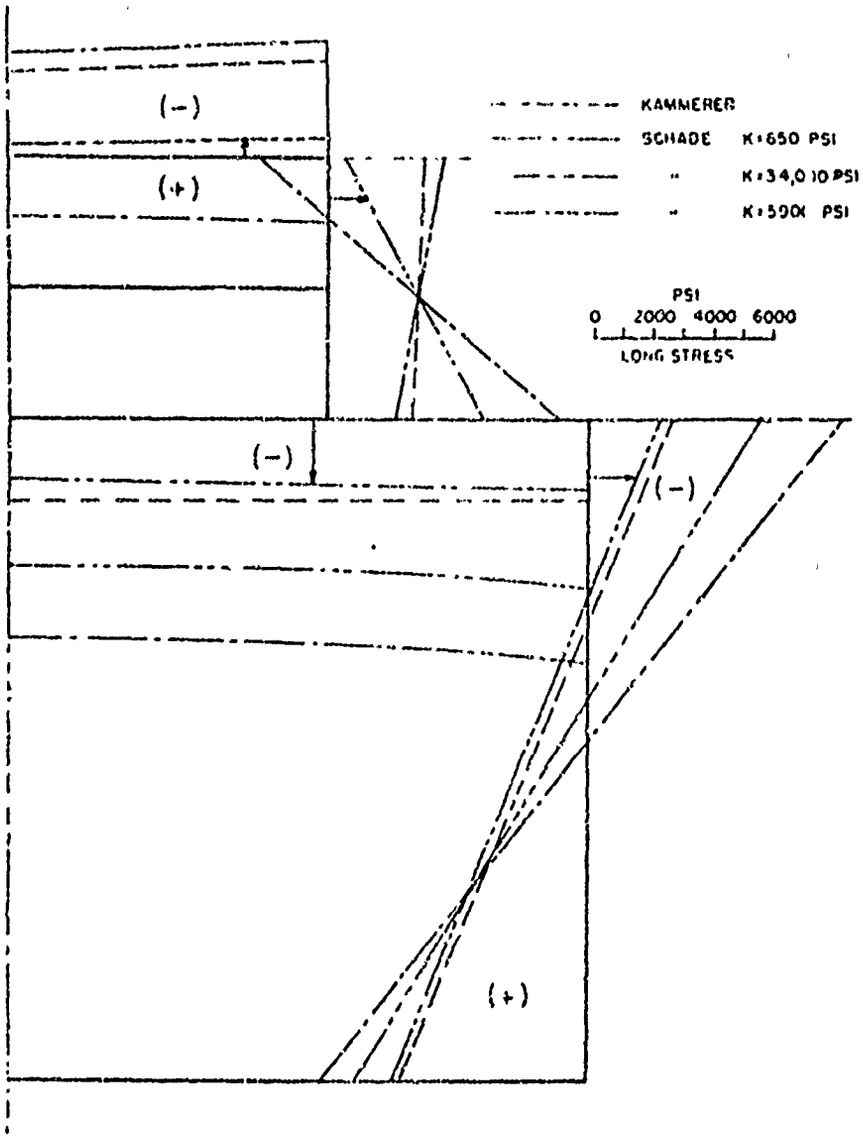


FIGURE 28. COMPARISON OF KAMMERER'S AND SCHADE'S ANALYSIS FOR A TWO-LEVEL DECKHOUSE UNDER BENDING MOMENT B

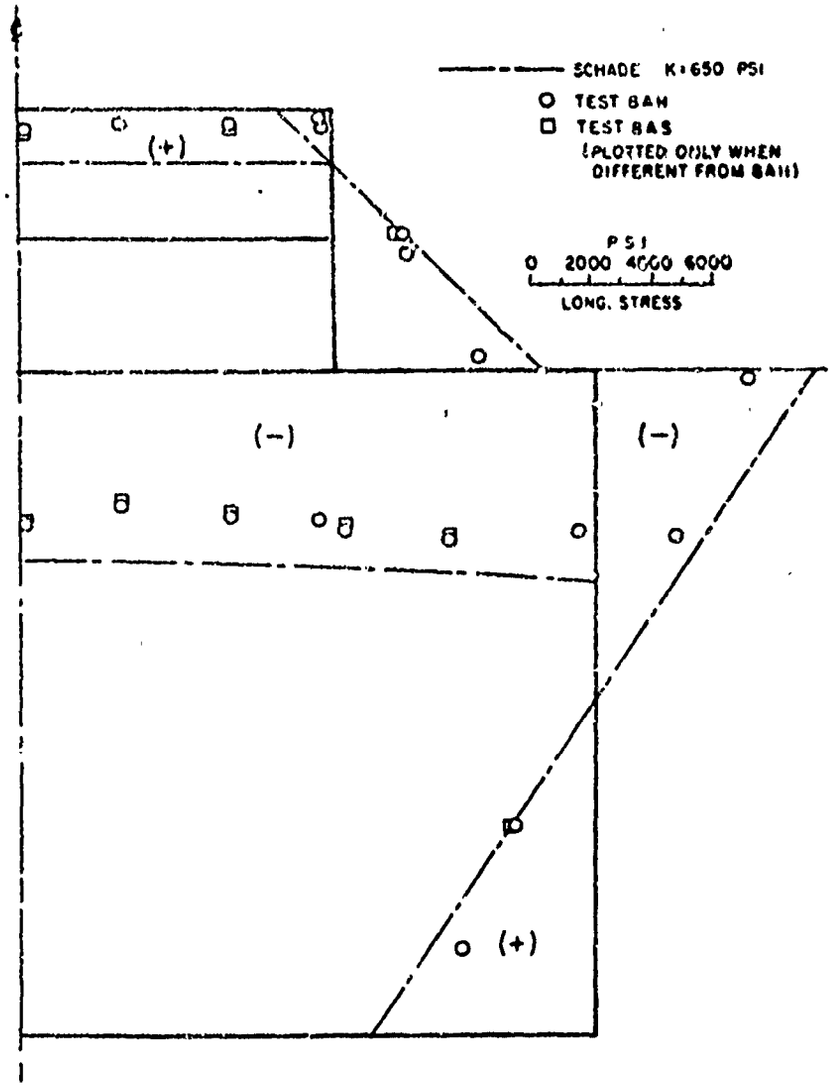


FIGURE 29. COMPARISON OF TESTS 8AH-S AND THEORY AT MIDSHIPS

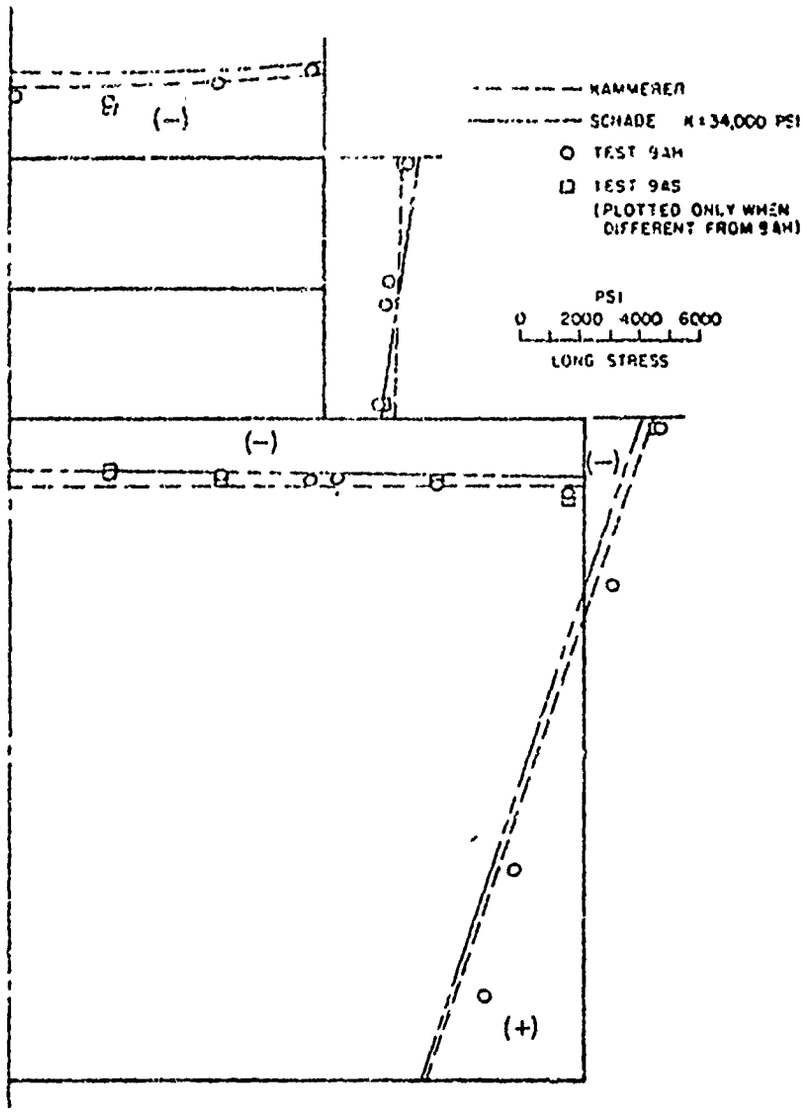


FIGURE 30. COMPARISON OF TESTS 9AH-S AND THEORY AT MIDSHIPS

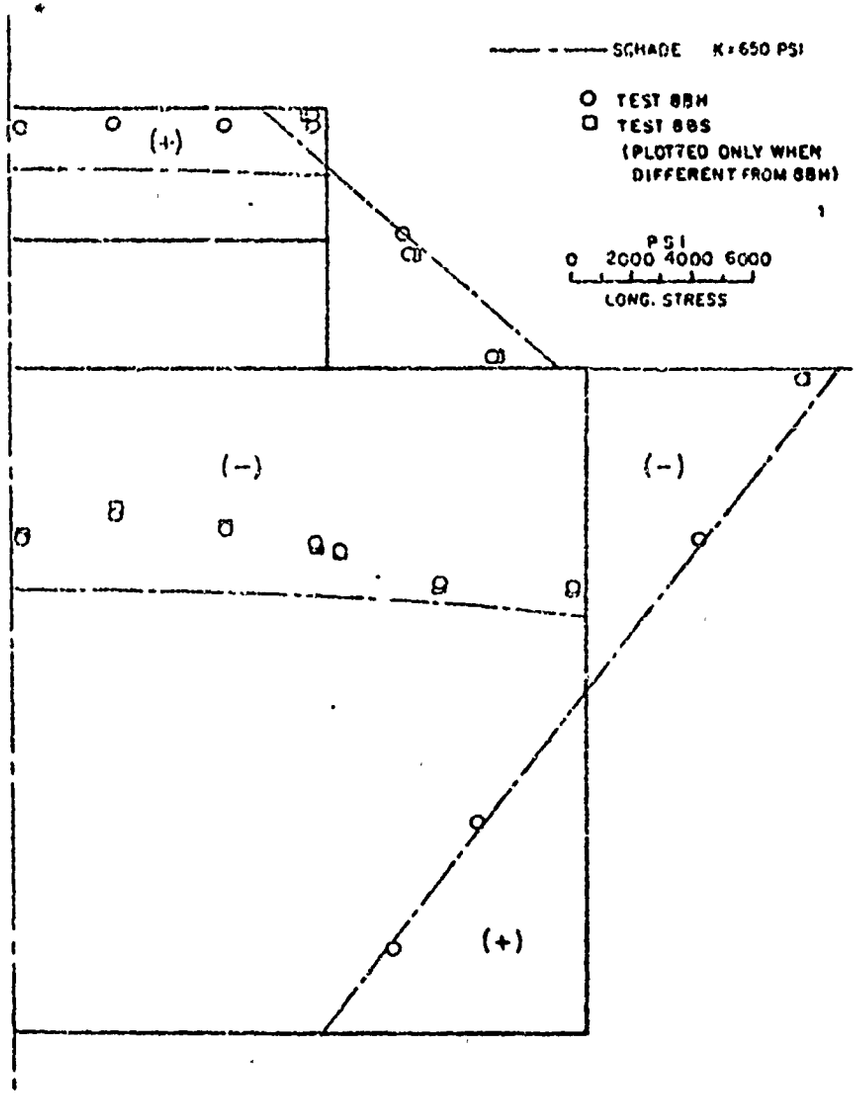


FIGURE 31. COMPARISON OF TESTS 8BH-S AND THEORY AT MIDSHIPS

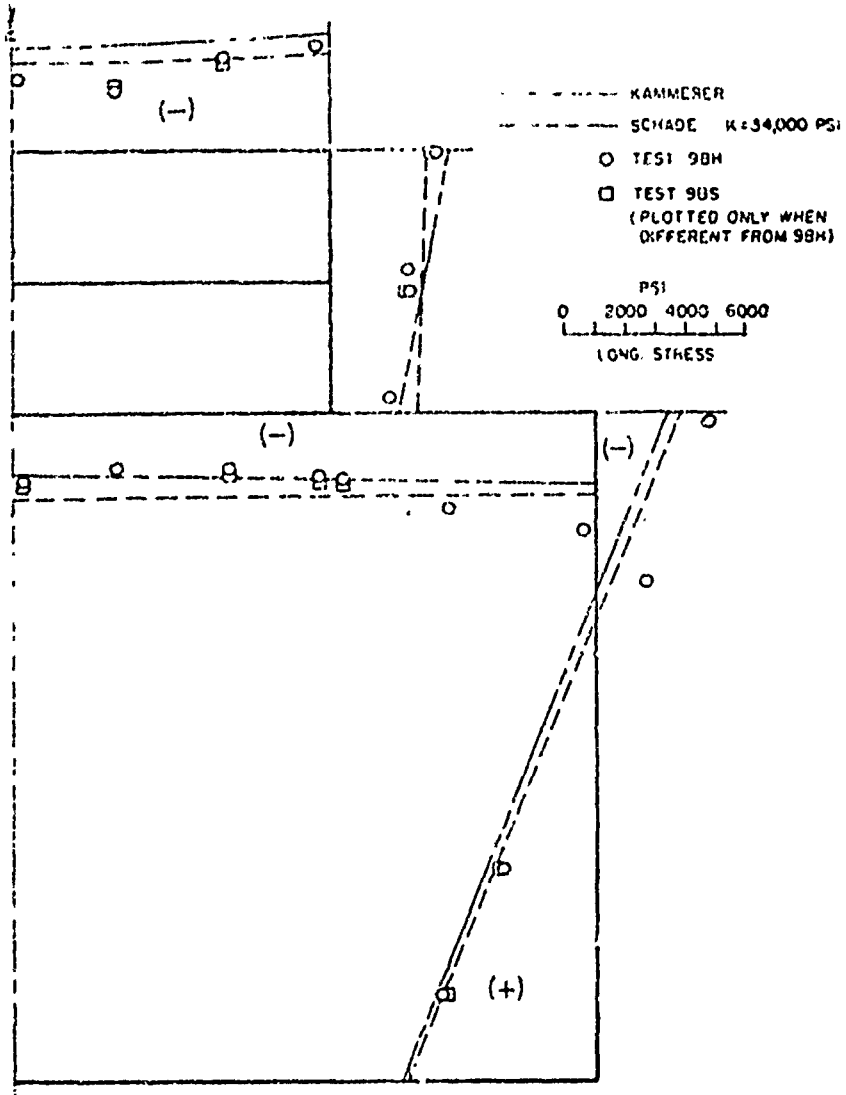


FIGURE 32. COMPARISON OF TESTS 9BH-S AND THEORY AT MIDSHIPS

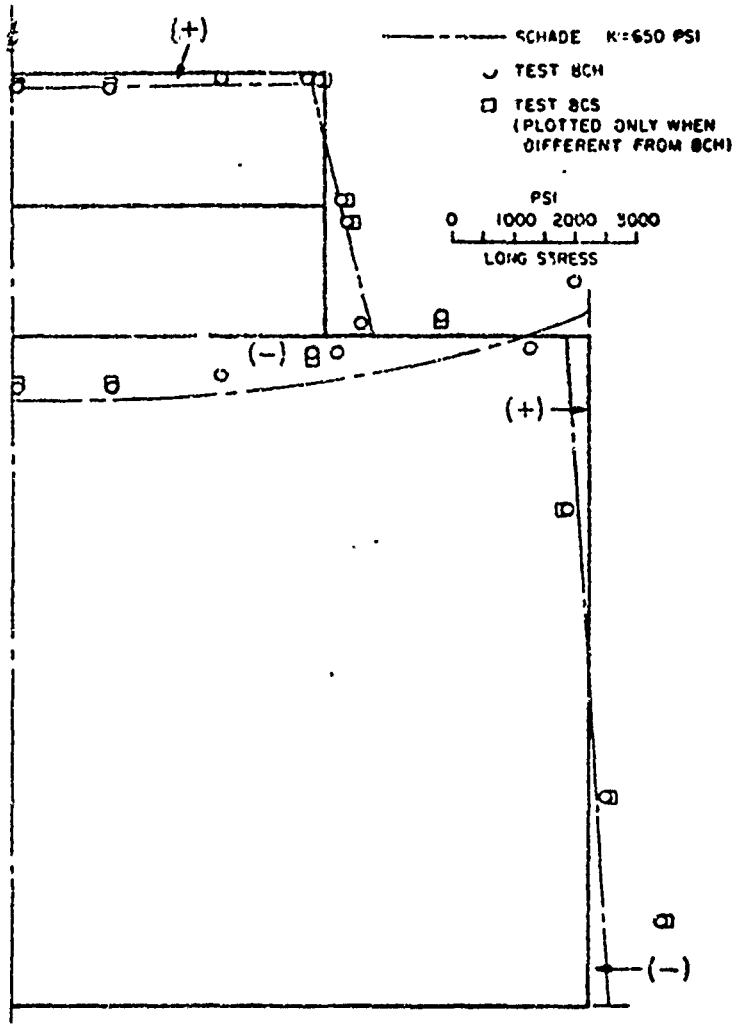


FIGURE 33. COMPARISON OF TESTS 8CH-S AND THEORY AT MIDSHIPS

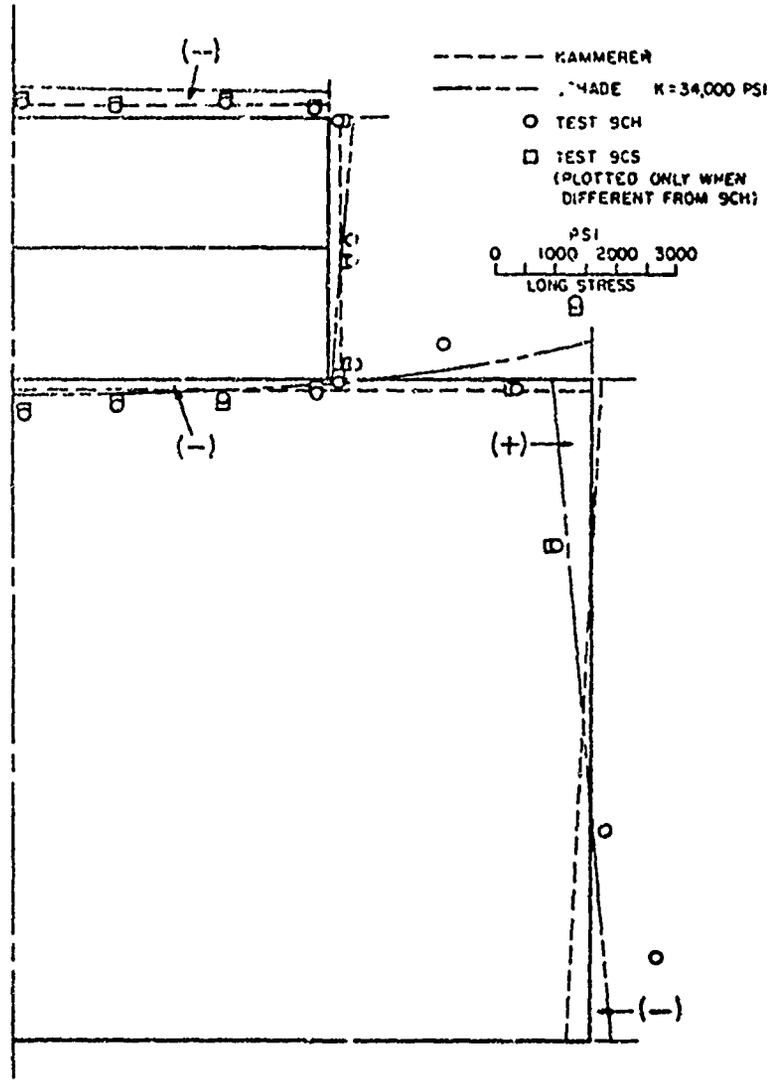


FIGURE 34. COMPARISON OF TESTS 9CH-S AND THEORY AT MIDSHIPS

ACKNOWLEDGEMENTS

The authors are obliged to Professor J. R. Paulling for the guidance and help given throughout the performance of the project. The following students were actively involved in the performance of the tests and the evaluation of the results: Kwang June Bai, Rong Tsao Huang, and Theodore R. Wise. Their assistance is gratefully acknowledged.

The work was made possible by the financial support of the Naval Ship Engineering Center and the Naval Ship Research and Development Center.

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APPENDIX A

TABLE 3

DEFLECTION DATA, in x 10^{-3}

GAGE	TEST											
	8AH	8AS	8BH	8BS	8CH	8CS	9AH	9AS	9BH	9BS	9CH	9CS
A	11	12	10	13	1	1	8	10	8	1	1	1
B	147	150	154	157	23	22	126	126	129	129	19	18
C	201	201	208	211	40	38	166	166	171	170	32	31
D	224	225	244	246	39	36	184	182	196	196	30	30
E	226	226	249	251	35	32	186	185	203	202	27	26
F	149	149	156	156	24	23	130	128	134	132	20	19
G	11	11	12	11	1	1	10	9	10	9	1	1
H	9	9	9	9	1	1	7	6	7	7	1	1
I	227	227	-	251	35	32	185	183	201	199	27	26
J	147	146	153	153	24	22	124	123	127	126	18	18
K	11	12	12	12	2	2	9	9	9	10	1	1
1	204	203	220	218	34	33	146	146	145	150	24	23
2	171	173	185	183	30	28	157	157	165	161	27	26
3	160	160	173	171	28	26	171	170	182	180	29	28
4	162	162	174	174	28	26	177	175	189	187	29	27
5	159	162	72	173	27	26	174	-	187	-	30	28
6	203	203	217	217	37	35	142	142	146	145	23	22

The sign of the deflections is shown reversed for sagging.

TABLE 4

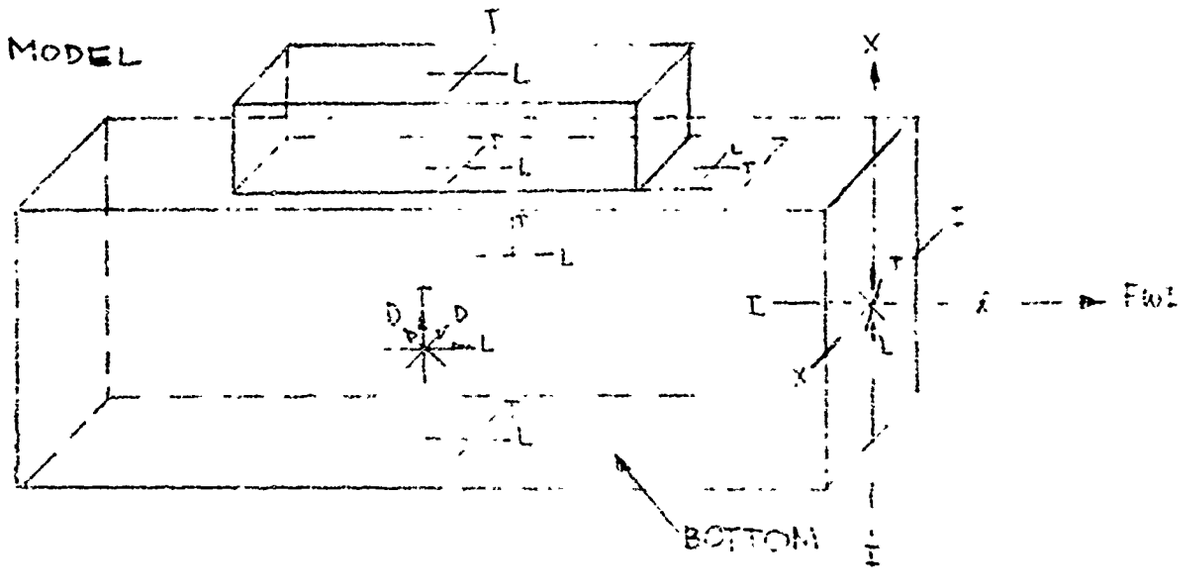
CORRECTED DEFLECTION DATA, in x 10^{-3}

GAGE	TEST											
	8AH	8AS	8BH	8BS	8CH	8CS	9AH	9AS	9BH	9BS	9CH	9CS
A	31	32	25	28	3	3	23	25	23	26	2	2
B	167	170	169	172	25	24	141	141	144	144	20	19
C	221	221	223	226	42	40	181	181	186	185	33	32
D	244	245	259	261	41	38	199	197	211	211	31	31
E	246	246	264	266	37	34	201	200	218	217	28	27
F	169	169	171	171	26	25	145	143	149	147	21	20
G	31	31	27	26	3	3	25	24	25	24	2	2
1	224	223	235	233	36	35	161	161	160	165	25	24
2	191	193	200	198	32	30	172	172	180	179	28	27
3	180	180	188	186	30	28	186	185	197	195	30	29
4	182	182	189	189	30	28	192	190	204	202	30	28
CORRECTION	+20	+20	+15	+15	+2	+2	+15	+15	+15	+15	+1	+1

The sign of the deflections is shown reversed for sagging.

APPENDIX B

CODING AS USED IN THE COMPUTER PROGRAMS AND IN TABLES 5 THROUGH 10



Location of Gage

X: Top, Starboard or Forward Side.

I: Bottom, Port or Aft Side.

Direction of Gage

L: Longitudinal

T: Transversal

D: Diagonal

Abbreviations

STRS: Stress

STR: Strain

D: Direct

B: Bending

Conventions

Stresses are given in units of psi, strains in μ in/in.

Tensile stresses appear with negative sign.

Gages located in marked area have different convention as shown.

B.1. Program DATDUMP

Program

```
      PROGRAM DATDUMP(INPUT,OUTPUT,TAPE9,PUNCH)
      DIMENSION Y(12),X(1200,3)
C YIM) IS THE ALPHANUMERIC SAMPLE RECORDED IN THE MAGNETIC TAPE. THE
C INDEX M IS THE TOTAL NUMBER OF SAMPLES PER RECORD.

C X(I,J) IS A REAL VARIABLE REPRESENTING THE SET OF STRAIN GAGE
C READINGS IN A COMPLETE TEST. INDEX I IDENTIFIES THE STRAIN GAGE.
C MAXI IS THE TOTAL NUMBER OF STRAIN GAGE ON THE MODEL. INDEX J
C INDICATES THE NUMBER OF RUNS IN ONE TEST. MAXJ INCLUDES THE INITIAL
C AND THE FINAL RUN.

C NN IS AN INTEGER VARIABLE REPRESENTING THE TOTAL NUMBER OF
C RECORDS IN THE MAGNETIC TAPE.

      READ 1,NN
    1 FORMAT(I5)
      READ 6,MAXI,MAXJ
    6 FORMAT(2I5)

      I=1
      J=1
      DO 3 II=1,NN
      READ (9,4)Y
    4 FORMAT (12A6)
      IF(EOF,9) 10,300
300   IF(IOCHECK,9) 31,30
C TO PUT TAPE RECORDED SAMPLES INTO ARRAY FOR CALCULATION AND HAVE THEM
C PUNCHED TO BE USED AS DATA CARDS.
   30 DO 7 M=1,12
      X(I,J)=Y(M)
      I=I+1
      IF(I.LE.MAXI) GO TO 9
      J=J+1
      I=1
    9 IF(J.GT.MAXJ) GO TO 10
    7 CONTINUE
    3 CONTINUE

   10 PRINT 11,MAXI,MAXJ
   11 FORMAT(1H1,*NUMBER OF STRAIN GAGES ON MODEL    *,I5/1H0,*TOTAL NUMB
     1ER OF TESTING RUNS       *,I5)
      PRINT 15
   15 FORMAT(1H0,*THE X(I,J) ARRAY*)
      PRINT 20,((X(I,J),J=1,MAXJ),I=1,MAXI)
   20 FORMAT 1//,(6(4X,A6)/))
      PUNCH 21,((X(I,J),J=1,MAXJ),I=1,MAXI)
   21 FORMAT ((6(4X,A6)))
      STOP
   31 PRINT 32,II
   32 FORMAT(* PARITY IN RECORD*,I5)
      GO TO 30
      END
```

Sample Output , guges 1-50

NUMBER OF STRAIN GAGES ON MODEL 50

TOTAL NUMBER OF TESTING RUNS 3

THE X(I,J) ARRAY

GAGE 1	-01501	-01529	-01505	-01093	-01193	-01091	GAGE 2
GAGE 3	-03207	-03264	-03208	-00093	-00091	-00089	
	-00583	-00588	-00606	-00032	-00032	-00051	
	+01359	+01266	+01358	+00061	+00064	+00059	
	-00234	-00325	-00235	-01936	-01981	-01936	GAGE 10
	-00468	-00983	-00664	+00099	+00099	+00098	
	-00864	-00871	-00645	-00302	-00272	-00335	
	-00946	-00934	-00947	-00127	-00100	-00129	
	-02946	-02927	-02947	-02953	-02939	-02954	
	-00361	-00315	-00359	-00146	-00136	-00149	
	-00504	-00532	-00505	+00293	+00300	+00294	
	+00431	+00225	+00432	+08915	+08935	+08920	
	-01544	-01748	-01543	+00601	+00618	+00633	
	+00427	+00439	+00427	-00295	-00335	-00293	
	-00469	-00783	-00672	+00583	+00605	+00590	
	-00631	-00566	-00601	+00385	+00400	+00387	
	-03002	-02925	-03001	-02039	-03065	-02035	
	-01078	-01074	-01078	+00669	+00615	+00669	
	-00776	-00813	-00777	-02455	-02438	-02454	
	-01456	-01472	-01457	-01348	-01334	-01350	
	-00442	-00460	-00463	-02243	-03275	-02243	
	-00897	-00873	-00889	-01758	-01700	-01760	
	-00645	-00637	-00650	-00119	-00151	-00118	
	-00805	-00787	-00807	-01292	-01312	-01294	GAGE 48
	-03012	-02998	-03012	-02873	-03964	-02871	
	RUN 1	RUN 2	RUN 3	RUN 1	RUN 2	RUN 3	

3.2. Program STRESS

```
      PROGRAM STRESS(INPUT,OUTPUT)
      DIMENSION X(1200,5),  XX(1200,3),   Y(6,5),   Z(500)
      DIMENSION LIST(4)
      EQUIVALENCE (KGO,LIST(5))
      DATA LIST /0,0,1,999,0,999/
      ASSIGN 90 TO KGO
      CALL SYSTEM(78,LIST)
      GO TO 95
 90   KOK
      PRINT 91,I,J,X(I,J)
 91   FORMAT(1H,2I10, 5X,F10.0, I10,5X,BAD DATA CHANGED TO ZERO,5X,A30/)
      X(I,J)=0.0
      GO TO 40
 95   CONTINUE
C
C  X(I,J) IS A REAL VARIABLE REPRESENTING THE SET OF STRAIN GAGE
C  READINGS IN A COMPLETE TEST. INDEX I IDENTIFIES THE STRAIN GAGE.
C  MARK IS THE TOTAL NUMBER OF STRAIN GAGE ON THE MODEL. INDEX
C  INDICATES THE RUN NUMBER IN ONE TEST. MARKJ INCLUDES THE INITIAL
C  AND THE FINAL RUN WHICH ARE MADE UNDER IDENTICAL CONDITION, DEFINED
C  AS ZERO LOAD.
C
C  STRAINS ARE COMPUTED FOR EACH LOADING CONDITION (NI) BY TAKING THE
C  DIFFERENCE BETWEEN THE READING FOR THIS CONDITION AND THE AVERAGE OF
C  RUN NO. 1 AND RUN NO. MARKJ (INITIAL AND FINAL). THE FOLLOWING
C  RELATIONS ARE VALID. MARKJ=I AND MARK=MARKJ-2.
C
C  Y(L,1)-Y(L,2)-Y(L,3) ARE USED FOR TEST IDENTIFICATION. Y(L,1) IS
C  PRINTED AS AA-AA-AA (MONTH-DAY-YEAR) AND INDICATES THE DATE ON WHICH
C  TESTS ARE MADE. Y(L,2) IS PRINTED AS A AND INDICATES THE TEST NO. ON
C  THAT DATE. Y(L,3) IS PRINTED AS A OF A AND INDICATES THE NUMBER N OF
C  A SPECIFIC LOADING CONDITION AND THE TOTAL NUMBER OF LOADING
C  CONDITIONS, M OF MANY.
C
C  Z(K) IS A REAL VARIABLE REPRESENTING THE NUMBER OF A POSITION ON THE
C  MODEL AT WHICH STRAIN IS MEASURED AND STRESS IS COMPUTED. SINCE SOME
C  POSITIONS HAVE TO BE PRINTED MORE THAN ONCE IN THE OUTPUT, MAXK OF
C  INDEX K IS LARGER THAN THE TOTAL NUMBER OF POSITION ON THE MODEL.
C
      READ 2015,ELMOD,POISRT,SHMOD,CALFTR
 2015 FORMAT(4F10.0)
C  ELMOD = YOUNGS MODULUS OF ELASTICITY(1,000,000 FOR STEEL)
C  POISRT = POISSONS RATIO
C  SHMOD = SHEAR MODULUS(1,000,000
C  CALFTR = CALIBRATION FACTOR OF STRAIN GAGES
      CONSTN=ELMOD/(1.-POISRT*POISRT)
      READ 2025,MARK,MARKJ,MARK
 2025 FORMAT(3I10)
      MAXI=MARKJ-2
      READ 2035,(Y(L,I),Y(L,2),Y(L,3),L=1,MAXL)
 2035 FORMAT (10A8)
      READ 2055,(Z(K),K=1,MARK)
 2055 FORMAT(10F5.0)
      READ 2045,((X(I,J),J=1,MARKJ),I=1,MARK)
 2045 FORMAT(10A10)
      J=0
 30   J=J+1
      I=0
      IF (J.GT.MARKJ) GO TO 50
 40   I=I+1
      IF (I.GT.MARK) GO TO 30
      DECODE (10,45,XII,J),XII,J)
 45   FORMAT(F10.0)
      GO TO 40
 50   CONTINUE
C
C  CORRECTING STRAIN GAGE READINGS
      DO 3010 I=1,MARK
      DO 3010 J=1,MARKJ
 3010 X(I,J)=X(I,J)*CALFTR
C
C  USE LINEAR INTERPOLATION BETWEEN INITIAL AND FINAL RUNS TO COMPUTE
C  STRAIN VALUES.
      MARKM=MARKJ-1
      DO 3011 I=1,MARK
      DO 3011 J=2,MARKM
      X(I,J)=X(I,1)+(X(I,MARKJ)-X(I,1))*(J-1)/(MARKJ-1)
 3011 CONTINUE
      DO 2600 J=2,MARKJ
      L=J-1
      PRINT 2005,Y(L,1),Y(L,2),Y(L,3)
 2005 FORMAT(1H1,52X,*DATE*,2X,A8,5X,*TEST*,2X,A1,5X,*LOADING CONDITION
     1 *,A6)
      PRINT 2006
 2006 FORMAT(121H0 POS.  D.L.STRS  B.L.STRS  D.T.STRS  B.T.STRS  SH.STRS
     2                 POS. ST.F.L  ST.R.T  ST.R.D  ST.F.T  ST.F.D
     3)
C     D.L.STRS. = DIRECT LONGITUDINAL STRESS
C     B.L.STRS. = BENDING LONGITUDINAL STRESS
C     D.T.STRS. = DIRECT TRANSVERSE STRESS
C     B.T.STRS. = BENDING TRANSVERSE STRESS
C     SH.STRS. = SHEAR STRESS
C  A1 = TOP.STARD OR FWD LONGITUDINAL STRAIN GAGE READING
C  A2 = TOP.STBD OR FWD TRANSVERSE STRAIN GAGE READING
C  A3 = TOP.STBD OR FWD DIAGONAL STRAIN GAGE READING
C  A4 = BOTTOM.PORT OR AFT LONGITUDINAL STRAIN GAGE READING
C  A5 = BOTTOM.PORT OR AFT TRANSVERSE STRAIN GAGE READING
C  A6 = BOTTOM.PORT OR AFT DIAGONAL STRAIN GAGE READING
      DO 2600 K=1,MARK
      GO TO(201,202,203,204,205,206,207,208,209,210,211,212,213,214,215,216,217,218,219,220,221,222,223,224,501,502,503,504,514,
     1515,516,517,531,532,533,534,544,545,546,547,201,206,207,208,209,21
     20,211,212,213,509,510,511,512,513,555,556,557,558,560,561,
     3663,225,226,227,228,229,230,231,232,675,676,677,678,679,214,215,220,22
     41,222,518,519,520,521,522,666,667,668,669,670,671,672,701,702,703,704,705,
     57,68,711,712,713,714,715,716,717,718,719,720,721,722,723,724,725,726,727,
     656,657,658,659,729,730,731,732,733,734,735,736,737,738,739,740,741,742,
     72,713,714,715,716,717,718,719,720,721,722,723,724,725,726,727,728,
     8759,75,759,K
 201  A1=X(I,2,J)
      A2=X(I,3,J)
      A4=X(I,38,J)
      A5=X(I,39,J)
      GO TO 2507
 202  A1=X(I,4,J)
      A2=X(I,5,J)
      A4=X(I,40,J)
      A5=X(I,41,J)
      GO TO 2507
 203  A1=X(I,6,J)
      A2=X(I,7,J)
      A4=X(I,42,J)
      A5=X(I,43,J)
      GO TO 2502
 204  A1=X(I,8,J)
      A2=X(I,9,J)
      A4=X(I,44,J)
      A5=X(I,45,J)
      GO TO 2502
 214  A1=X(I,158,J)
      A2=X(I,159,J)
      A3=X(I,16-,J)
      A4=X(I,194,J)
      A5=X(I,195,J)
      A6=X(I,196,J)
      GO TO 2501
 215  A1=X(I,161,J)
      A2=X(I,162,J)
      A4=X(I,197,J)
      A5=X(I,198,J)
      GO TO 2502
 ***   .        .
 ***   .        .
 ***   .        .
 ***   .        .
 ***   .        .
 741  A1=X(I,522,J)
      A4=X(I,523,J)
      GO TO 2505
 742  A1=X(I,524,J)
      A4=X(I,525,J)
      GO TO 2505
2501  DTSTRS=CONSTN*(.5*(A1+A4)+.5*POISRT*(A2+A5))
      BLSTRS=CONSTN*(.5*(A1-A4)+.5*POISRT*(A2-A5))
      DTSTRS=CONSTN*(.5*(A2+A5)+.5*POISRT*(A1+A4))
      BTSTRS=CONSTN*(.5*(A2-A5)+.5*POISRT*(A1-A4))
      SHSTRS=SHMOD*(.5*(A3+A6)+.5*(A2+A5)-(A3-A6))
      PRINT 2075,Z(K),DLSTRS,BLSTRS,DTSTRS,BTSTRS,SHSTRS,Z(K),A1,A2,A3,A4
     1,A5,A6
      GO TO 2600
2502  DLSTRS=CONSTN*(.5*(A1+A4)+.5*POISRT*(A2+A5))
      BLSTRS=CONSTN*(.5*(A1-A4)+.5*POISRT*(A2-A5))
      DTSTRS=CONSTN*(.5*(A2+A5)+.5*POISRT*(A1+A4))
      BTSTRS=CONSTN*(.5*(A2-A5)+.5*POISRT*(A1-A4))
      PRINT 2085,Z(K),DLSTRS,BLSTRS,DTSTRS,BTSTRS,Z(K),A1,A2,A4,A5
      GO TO 2600
2505  DLSTRS=ELMOD*(A1+A4)/2.
      BLSTRS=ELMOD*(A1-A4)/2.
      PRINT 2205,Z(K),DLSTRS,BLSTRS,Z(K),A1,A4
      GO TO 2600
2600  CONTINUE
2075  FORMAT (1X,F5.0,5F10.0,13X,F5.0,F7.0,5F8.0)
2085  FORMAT (1X,F5.0,4F10.0,23X,F5.0,F7.0,F8.0,8X,2F8.0)
2205  FORMAT(1X,F5.0,2F10.0,43X,F5.0,F7.0,18X,F8.0)
      END
```

APPENDIX C

TABLE 5. STRESSES AND STRAINS

TEST 8AH

POS.	B.L.STRS	B.L.STRS	B.T.STRS	B.T.STRS	SM.STRS	POS.	ST.N.L	ST.N.T	ST.N.D	ST.I.L	ST.I.T	ST.I.D
200.	6391.	-1147.	-1186.	-693.		200.	119.	-98.		178.	-16.	
201.	2021.	-88.	-48.	-5.		201.	85.	-24.		91.	-29.	
202.	-2039.	-1468.	-189.	-127.		202.	-97.	22.		-49.	27.	
203.	-9267.	577.	339.	307.		203.	-1511.	44.		-1276.	51.	
214.	-4095.	60.	-137.	1870.	-20.	214.	-142.	96.	-37.	-142.	-6.	-70.
215.	-2540.	-128.	78.	-397.		215.	-85.	14.		-85.	38.	
216.	-2129.	-270.	-28.	-721.		216.	-70.	1.		-75.	46.	
217.	272.	-24.	69.	-7.		217.	11.	-1.		12.	-1.	
223.	-2203.	-192.	58.	-260.		223.	-73.	14.		-72.	31.	
224.	-4919.	409.	-58.	1671.		224.	-147.	39.		-141.	-6.	
501.	4747.	-144.	70.	258.		501.	145.	-45.		200.	-64.	
502.	3716.	-378.	-115.	-207.		502.	105.	-49.		122.	-43.	
503.	-3121.	-116.	-155.	-99.		503.	-103.	17.		-98.	22.	
504.	-6756.	322.	-111.	716.		504.	-204.	79.		-211.	34.	
514.	-8176.	327.	-174.	831.	-847.	514.	119.	63.	-5.	-193.	19.	-30.
515.	-7594.	11.	70.	-226.		515.	-73.	57.		-78.	31.	
516.	-1938.	-124.	-214.	-244.		516.	-65.	4.		-67.	22.	
517.	937.	-13.	110.	-19.		517.	17.	-2.		18.	-1.	
651.	2769.	-227.	-12.	1007.		651.	108.	-2.		143.	-74.	
652.	2019.	-999.	69.	-143.		652.	50.	-24.		87.	-27.	
653.	-2629.	-970.	-713.	-483.		653.	-92.	9.		-65.	25.	
654.	-4447.	79.	40.	-279.		654.	-159.	45.		-149.	94.	
666.	-3456.	-267.	-161.	-661.	-1651.	666.	-125.	11.	10.	-125.	44.	13.
665.	-1251.	6.	249.	-721.		665.	-37.	13.		-42.	28.	
666.	-904.	30.	-429.	92.		666.	-25.	-4.		-26.	-7.	
667.	938.	17.	47.	14.		667.	19.	-1.		17.	-4.	
205.	3561.	-7.	47.	263.		205.	-139.	67.		-151.	68.	
206.	-5720.	-391.	-385.	-176.		206.	-192.	22.		-142.	67.	
207.	-5277.	516.	37.	1213.		207.	-177.	109.		-171.	-3.	
208.	-3160.	-990.	42.	-1239.		208.	-171.	15.		-171.	90.	
209.	-4470.	-297.	61.	467.		209.	-178.	70.		-146.	37.	
210.	-6599.	-402.	4.	436.		210.	-162.	14.		-145.	18.	
211.	-5213.	263.	129.	-222.		211.	-154.	46.		-136.	67.	
212.	-5117.	-241.	19.	-744.		212.	-169.	20.		-166.	74.	
213.	-3648.	107.	-152.	536.		213.	-147.	59.		-131.	18.	
505.	-6633.	149.	53.	209.		505.	-211.	70.		-214.	41.	
506.	-6560.	-467.	-1279.	-1301.		506.	-194.	-14.		-184.	62.	
507.	-5744.	987.	-427.	1370.		507.	-167.	83.		-170.	-20.	
509.	-4707.	-344.	-799.	-1726.		509.	-143.	-33.		-155.	75.	
510.	-4444.	281.	-878.	-1730.		510.	-143.	17.		-144.	74.	
511.	-4844.	-94.	-915.	-1391.		511.	-134.	11.		-152.	25.	
513.	-4057.	-210.	-214.	-472.		513.	-200.	31.		-199.	73.	
515.	-4614.	14.	12.	837.		515.	-163.	75.		-167.	70.	
516.	-4444.	79.	-740.	927.		516.	-165.	37.		-139.	4.	
517.	-4466.	19.	-740.	427.		517.	-163.	32.		-137.	6.	
519.	-4625.	-409.	-700.	-971.		519.	-150.	-6.		-130.	68.	
520.	-5142.	-215.	-717.	-744.		520.	-172.	6.		-137.	38.	
521.	-4329.	-203.	-761.	39.		521.	-151.	29.		-146.	17.	
523.	-4847.	777.	222.	927.		523.	-146.	76.		-142.	38.	
225.	-2350.	-77.	-41.	-359.		225.	-77.	10.		-79.	32.	
226.	-1117.	-19.	-114.	-114.		226.	-76.	15.		-76.	23.	
227.	-2170.	-13.	-177.	-31.		227.	-72.	17.		-70.	14.	
228.	-2344.	-18.	-40.	-13.		228.	-69.	14.		-68.	19.	
525.	-1478.	-42.	28.	-542.		525.	-48.	14.		-49.	27.	
526.	-1744.	-63.	-121.	-19.		526.	-59.	11.		-55.	13.	
527.	-1560.	-74.	-273.	-80.		527.	-53.	10.		-49.	13.	
528.	-1670.	-4.	-109.	6.		528.	-42.	11.		-49.	11.	
675.	-417.	-204.	-70.	6.		675.	-45.	10.		-14.	2.	
676.	-5100.	47.	-17.	190.		676.	-14.	10.		-18.	-0.	
677.	-1984.	-28.	99.	-47.		677.	-15.	4.		-15.	4.	
678.	-2871.	122.	-102.	-249.		678.	3.	-13.		-12.	6.	
218.	9504.	39.	67.	34.		218.	14.	-2.		17.	-7.	
219.	618.	71.	-194.	185.		219.	85.	-4.		13.	-10.	
220.	3066.	171.	187.	-99.		220.	18.	-4.		5.	6.	
221.	5730.	91.	30.	-21.		221.	19.	-9.		15.	-3.	
222.	499.	21.	98.	-1.		222.	39.	-3.		14.	-2.	

TEST 8AS

POS.	B.L.STRS	B.L.STRS	B.T.STRS	B.T.STRS	SM.STRS	POS.	ST.N.L	ST.N.T	ST.	L	ST.I.L	ST.I.T	ST.I.D
200.	4619.	1064.	-42.	521.		200.	-116.	49.			-177.	35.	
201.	-2727.	-9.	-72.	-80.		201.	-49.	22.			-71.	29.	
202.	2784.	164.	3.	123.		202.	97.	-15.			49.	-10.	
203.	9254.	-450.	-230.	-563.		203.	140.	-30.			190.	-95.	
214.	4459.	-532.	35.	-1199.	8.	214.	142.	-107.	35.		111.	3.	76.
215.	2503.	128.	-53.	197.		215.	96.	-15.			86.	-19.	
216.	2165.	387.	19.	669.		216.	78.	-2.			65.	-19.	
217.	-434.	-21.	-54.	-21.		217.	-14.	2.			-13.	3.	
223.	3222.	112.	13.	319.		223.	79.	-17.			73.	-14.	
224.	5000.	-342.	46.	-1557.		224.	110.	-95.			152.	3.	
501.	-5443.	-14.	-28.	-220.		501.	-138.	41.			-139.	47.	
502.	-3.94.	360.	241.	173.		502.	-99.	42.			117.	34.	
503.	3001.	139.	147.	77.		503.	102.	-24.			95.	-27.	
504.	8035.	-555.	-19.	-1178.		504.	175.	-93.			0.	-27.	
514.	4446.	-430.	106.	-983.	721.	514.	102.	-66.	10.		5.	-15.	14.
515.	2154.	35.	-121.	211.		515.	73.	-13.			75.	-77.	
516.	1910.	157.	141.	221.		516.	66.	-46.			62.	-7.	
517.	-613.	6.	-105.	-6.		517.	-19.	2.			-20.	3.	
651.	-3720.	146.	-136.	-182.		651.	-[illegible]	6.			137.	61.	
652.	-2005.	591.	13.	100.		652.	-51.	19.			-79.	24.	
653.	2629.	510.	155.	454.		653.	97.	-9.			67.	-29.	
654.	4615.	-35.	-144.	97.		654.	133.	-47.			147.	-93.	
666.	3744.	251.	317.	836.	623.	666.	123.	-7.	-10.		122.	-61.	-30.
665.	1075.	-54.	-318.	177.		665.	55.	-19.			45.	-20.	
666.	981.	2.	49.	-43.		666.	28.	5.			23.	9.	
667.	-454.	28.	-5.	44.		667.	-17.	4.			-14.	6.	
205.	5543.	-11.	55.	-276.		205.	147.	-63.			192.	-45.	
206.	5616.	390.	299.	861.		206.	189.	-22.			141.	-71.	
207.	5236.	-437.	-154.	-1400.		207.	171.	-111.			174.	-1.	
208.	5038.	414.	-138.	1346.		208.	172.	-15.			171.	-34.	
209.	4741.	401.	-146.	-640.		209.	180.	-75.			141.	-24.	
210.	4200.	319.	17.	419.		210.	149.	-32.			144.	-43.	
211.	5044.	-365.	-193.	320.		211.	159.	-49.			145.	-55.	
212.	5033.	253.	-113.	772.		212.	170.	-32.			148.	-44.	
213.	5446.	-203.	113.	-619.		213.	190.	-65.			186.	-17.	
505.	6362.	-271.	-157.	-326.		505.	211.	-78.			216.	-40.	
506.	5933.	635.	1069.	1683.		506.	172.	24.			163.	-73.	
507.	5205.	-537.	304.	-1770.		507.	169.	-89.			178.	49.	
509.	4553.	286.	727.	1459.		509.	134.	41.			155.	-44.	
510.	4773.	-605.	146.	-134.		510.	133.	-22.			170.	-23.	
511.	4776.	103.	-23.	229.		511.	152.	-14.			150.	-37.	
513.	5921.	212.	105.	731.		513.	178.	-33.			197.	-14.	
515.	4523.	-237.	-165.	-1146.		515.	156.	-87.			149.	-15.	
516.	4331.	-141.	612.	-634.		516.	140.	-42.			135.	-2.	
517.	4331.	-141.	612.	-634.		517.	140.	-47.			136.	-2.	
519.	5341.	714.	634.	1753.		519.	130.	-14.			122.	-34.	
520.	4147.	244.	676.	618.		520.	134.	-2.			135.	-1.	
521.	4648.	215.	700.	-50.		521.	151.	-24.			134.	-19.	
523.	4696.	-1082.	-400.	-1201.		523.	134.	-89.			142.	-31.	
225.	2299.	76.	41.	395.		225.	75.	-9.			74.	-34.	
226.	2247.	24.	42.	81.		226.	76.	-14.			74.	-23.	
227.	2092.	16.	50.	4.		227.	67.	-19.			68.	-13.	
228.	2043.	-36.	39.	-1.		228.	66.	-19.			64.	-20.	
525.	1640.	359.	-41.	215.		525.	43.	-15.			43.	-22.	
526.	1676.	67.	20.	14.		526.	37.	-10.			34.	-16.	
527.	1547.	119.	155.	86.		527.	35.	-9.			47.	-12.	
528.	1479.	-42.	121.	-10.		528.	47.	-11.			45.	-17.	
675.	741.	244.	7.	13.		675.	34.	-10.			35.	-9.	
676.	926.	-99.	7.	-209.		676.	16.	-11.			19.	1.	
677.	349.	-37.	-10.	-4.		677.	12.	-4.			14.	-5.	
678.	201.	-193.	141.	201.		678.	-3.	11.			13.	-6.	
218.	-943.	-109.	9.	-76.		218.	-21.	4.			-15.	5.	
219.	-974.	-194.	-4.	-191.		219.	-22.	1.			-16.	22.	
220.	-451.	-289.	-164.	43.		220.	-23.	3.			-3.	-5.	
221.	-597.	-136.	-28.	-120.		221.	-23.	2.			-16.	0.	
222.	-810.	-117.	-28.	-78.		222.	-23.	4.			-17.	5.	

TABLE 6. STRESSES AND STRAINS

TEST 9AH

POS.	D.L.STRS	D.T.STRS	D.T.STRS	D.T.STRS	SM.STRS	POS.	ST.X.L	ST.X.T	ST.X.D	ST.Y.L	ST.Y.T	ST.Y.D
201.	3914.	-970.	-94.	-639.		201.	37.	-49.		136.	-26.	
202.	2727.	40.	-44.	53.		202.	19.	-15.		35.	-23.	
203.	-1014.	-129.	-49.	-102.		203.	-34.	9.		-30.	10.	
204.	-2500.	197.	-35.	263.		204.	-79.	24.		-52.	15.	
214.	-1411.	12.	24.	-12.	260.	214.	-41.	14.	-35.	-53.	21.	-79.
215.	-2111.	-114.	-92.	-113.		215.	-70.	13.		-49.	20.	
216.	-2549.	-93.	115.	-502.		216.	-76.	11.		-39.	42.	
217.	-2072.	59.	-90.	94.		217.	-94.	10.		-49.	24.	
223.	-2771.	-49.	238.	-250.		223.	-73.	23.		-39.	34.	
224.	-1976.	-51.	27.	-51.		224.	15.	-22.		-44.	22.	
501.	-1516.	-224.	-211.	556.		501.	1.	-102.		17.	-14.	
502.	2973.	-237.	-274.	-203.		502.	.	-44.		11.	-14.	
503.	-1790.	-12.	-403.	-402.		503.	-57.	3.		-33.	5.	
504.	-4614.	235.	-104.	941.		504.	-141.	34.		-139.	23.	
514.	-2447.	40.	-45.	-1474.	-1295.	514.	-77.	15.	5.	-37.	12.	34.
515.	-1557.	115.	157.	157.		515.	-41.	9.		-24.	11.	
516.	-1743.	-49.	123.	-116.		516.	-40.	14.		-20.	14.	
517.	-2141.	-103.	-138.	-145.		517.	14.	19.		17.	22.	
651.	4931.	-604.	216.	676.		651.	111.	-4.		152.	-47.	
652.	3192.	-529.	19.	-180.		652.	63.	-22.		94.	-23.	
653.	-2005.	-154.	-128.	-180.		653.	-36.	7.		-47.	27.	
654.	-4589.	-62.	95.	-355.		654.	-150.	13.		-143.	57.	
664.	-1043.	231.	348.	634.	-1971.	664.	17.	-24.	22.	-111.	44.	34.
665.	-1537.	240.	614.	-74.		665.	-33.	27.		-53.	37.	
666.	-1127.	35.	-452.	241.		666.	-33.	1.		-37.	-22.	
667.	98.	-63.	108.	-70.		667.	70.	1.		7.	5.	
205.	-2717.	-43.	235.	95.		205.	31.	23.		-47.	15.	
206.	-2639.	-120.	-155.	-240.		206.	5.	8.		-74.	34.	
207.	-2114.	264.	-256.	400.		207.	50.	63.		-44.	11.	
208.	-2119.	200.	-271.	645.		208.	57.	32.		-44.	-14.	
209.	-2359.	-248.	-59.	-270.		209.	-76.	14.		-44.	22.	
210.	-2530.	-251.	-112.	-475.		210.	-63.	9.		-61.	27.	
211.	-2420.	59.	-26.	-233.		211.	73.	14.		-41.	31.	
212.	-2016.	155.	-117.	615.		212.	44.	17.		-44.	43.	
213.	-2744.	45.	-141.	272.		213.	22.	22.		-41.	15.	
503.	-4175.	203.	-110.	244.		503.	-135.	64.		-143.	15.	
504.	-3610.	-119.	-463.	-1114.		504.	145.	-15.		-149.	15.	
507.	-2974.	325.	-493.	1512.		507.	-36.	33.		-97.	-31.	
509.	-3533.	-365.	-155.	-1114.		509.	37.	-40.		-86.	41.	
510.	-2553.	162.	-175.	-1114.		510.	-70.	-7.		-91.	10.	
511.	-2711.	-116.	-360.	-263.		511.	47.	-4.		-44.	13.	
513.	-4444.	-230.	-273.	-342.		513.	-135.	27.		-134.	44.	
655.	-4175.	-17.	12.	591.		655.	-144.	42.		-134.	27.	
656.	-3978.	-124.	-711.	77.		656.	-151.	9.		-121.	17.	
657.	-3414.	-128.	-713.	73.		657.	111.	23.		-121.	12.	
659.	-3816.	-335.	-259.	-695.		659.	170.	20.		-117.	15.	
660.	-3575.	44.	-2914.	-473.		660.	-115.	-14.		-111.	17.	
661.	-3545.	-42.	-704.	-40.		661.	-115.	5.		-108.	4.	
663.	-4402.	113.	204.	645.		663.	-131.	65.		-147.	37.	
225.	-2269.	-40.	14.	-106.		225.	-76.	20.		-74.	25.	
226.	-2439.	37.	-76.	39.		226.	-77.	22.		-77.	20.	
227.	-2131.	-22.	-51.	-50.		227.	-51.	19.		-36.	-11.	
228.	-2049.	-21.	-35.	4.		228.	-73.	20.		-42.	14.	
525.	-1630.	-154.	39.	-73.		525.	-73.	27.		-41.	19.	
526.	-1688.	-165.	-44.	-31.		526.	-59.	17.		-33.	17.	
527.	-1675.	-140.	-46.	-161.		527.	-42.	8.		-44.	14.	
528.	-1630.	-6.	-77.	33.		528.	-47.	19.		-44.	11.	
675.	-1093.	-510.	-10.	-116.		675.	-44.	9.		-10.	6.	
676.	-1049.	29.	-18.	149.		676.	-18.	9.		-15.	-1.	
677.	-1047.	15.	-47.	-4.		677.	17.	1.		-14.	2.	
678.	-1603.	130.	-124.	-253.		678.	-5.	-11.		-15.	9.	
216.	-2636.	-39.	47.	54.		216.	-47.	32.		-93.	24.	
217.	-2520.	-235.	-155.	-349.		217.	-47.	7.		-78.	33.	
218.	-1743.	-303.	-306.	343.		218.	-49.	14.		-74.	-24.	
221.	-2260.	-67.	-196.	-14.		221.	-67.	14.		-65.	14.	
222.	-2590.	-109.	10.	-39.		222.	-47.	35.		-65.	24.	

TEST 9AS

POS.	D.L.STRS	D.T.STRS	D.T.STRS	D.T.STRS	SM.STRS	POS.	ST.X.L	ST.X.T	ST.X.D	ST.Y.L	ST.Y.T	ST.Y.D
201.	-3810.	923.	-2.	984.		201.	-89.	43.		-139.	23.	
202.	-2299.	-98.	80.	-24.		202.	-79.	25.		-76.	26.	
203.	999.	83.	6.	61.		203.	39.	-9.		31.	-11.	
204.	7667.	-317.	-97.	-232.		204.	71.	-22.		97.	-22.	
214.	1907.	-109.	-31.	-147.	-290.	214.	62.	-26.	34.	66.	-15.	31.
215.	2136.	-69.	113.	-64.		215.	88.	-19.		72.	-16.	
216.	2141.	72.	-191.	491.		216.	71.	-13.		75.	-40.	
217.	2821.	-32.	90.	-132.		217.	94.	-31.		93.	-22.	
223.	2259.	17.	-194.	377.		223.	76.	-23.		73.	-35.	
224.	2145.	31.	167.	103.		224.	70.	-13.		70.	-17.	
501.	-4632.	116.	469.	-567.		501.	-150.	63.		-168.	81.	
502.	-2856.	265.	74.	703.		502.	-94.	57.		-110.	49.	
503.	1599.	90.	257.	137.		503.	53.	-4.		49.	-11.	
504.	3849.	-413.	6.	-736.		504.	127.	-58.		134.	-17.	
514.	2501.	-110.	255.	141.	2080.	514.	77.	-13.	-91.	87.	-26.	-61.
515.	1456.	-104.	-59.	-99.		515.	63.	-21.		68.	-20.	
516.	1727.	127.	-106.	160.		516.	61.	-17.		56.	-25.	
517.	2059.	114.	62.	70.		517.	31.	-17.		65.	-20.	
651.	-3029.	216.	-346.	-545.		651.	-114.	6.		-141.	53.	
652.	-2366.	686.	-207.	39.		652.	-61.	14.		-92.	20.	
653.	2519.	229.	147.	356.		653.	73.	-7.		63.	-26.	
654.	3126.	91.	-76.	219.		654.	139.	-75.		139.	-54.	
664.	1060.	-204.	-711.	-589.	1839.	664.	104.	-72.	-13.	110.	-37.	-89.
665.	1248.	-194.	-458.	42.		665.	39.	-24.		53.	-41.	
666.	1258.	121.	700.	-172.		666.	41.	4.		29.	16.	
667.	54.	161.	-13.	249.		667.	5.	4.		-1.	-9.	
205.	1907.	240.	312.	4.		205.	102.	-21.		85.	-16.	
206.	2308.	34.	173.	295.		206.	75.	-4.		76.	-24.	
207.	2107.	-101.	180.	-1002.		207.	64.	-43.		64.	15.	
208.	2124.	-271.	343.	-950.		208.	49.	-42.		66.	14.	
209.	2125.	315.	125.	164.		209.	78.	-15.		61.	-20.	
210.	1971.	220.	142.	375.		210.	67.	-9.		60.	-24.	
211.	2358.	-64.	62.	210.		211.	74.	-14.		82.	-29.	
212.	1891.	-319.	175.	-921.		212.	67.	-43.		69.	17.	
213.	2481.	-54.	104.	-253.		213.	89.	-31.		88.	-15.	
503.	6519.	-260.	-40.	-263.		503.	132.	-44.		140.	-36.	
504.	5418.	-401.	674.	1003.		504.	111.	18.		104.	-41.	
507.	2775.	-407.	517.	-1479.		507.	88.	-94.		87.	33.	
509.	2511.	376.	447.	1533.		509.	74.	45.		80.	-50.	
510.	2907.	-315.	726.	-67.		510.	75.	1.		97.	-9.	
511.	2896.	151.	416.	311.		511.	90.	7.		84.	-11.	
513.	3951.	46.	158.	357.		513.	125.	-72.		120.	-49.	
655.	6030.	-145.	-145.	-780.		655.	137.	-70.		134.	-22.	
656.	3810.	30.	569.	-163.		656.	124.	-29.		119.	-13.	
657.	3810.	30.	469.	-163.		657.	124.	-25.		119.	-13.	
659.	3817.	375.	818.	614.		659.	126.	5.		113.	-24.	
660.	3578.	165.	923.	502.		660.	111.	10.		110.	-20.	
661.	3642.	118.	1034.	-15.		661.	116.	-4.		108.	-9.	
663.	6535.	-960.	-255.	-921.		663.	163.	-73.		148.	-50.	
225.	2361.	56.	64.	139.		225.	78.	-17.		78.	-29.	
226.	2669.	7.	125.	5.		226.	80.	-20.		80.	-21.	
227.	2729.	105.	109.	69.		227.	76.	-18.		70.	-20.	
228.	2159.	17.	139.	-17.		228.	71.	-18.		70.	-16.	
525.	1678.	529.	-79.	48.		525.	79.	-22.		93.	-17.	
526.	1795.	63.	77.	19.		526.	61.	-15.		57.	-15.	
527.	1614.	134.	211.	112.		527.	55.	-7.		40.	-11.	
528.	1544.	-9.	169.	19.		528.	49.	-9.		50.	-11.	
675.	836.	489.	35.	94.		675.	40.	-8.		15.	-8.	
676.	972.	-64.	64.	-141.		676.	18.	-8.		19.	0.	
677.	626.	-5.	27.	-16.		677.	15.	-4.		14.	-5.	
678.	203.	-149.	125.	291.		678.	-2.	13.		15.	-9.	
216.	2798.	-144.	21.	-219.		216.	90.	-23.		96.	-22.	
219.	2490.	137.	179.	214.		219.	81.	-16.		78.	-20.	
220.	1[illegible]3.	467.	651.	-569.		220.	69.	-18.		27.	20.	
221.	1908.	-17.	297.	-177.		221.	63.	-19.		61.	-4.	
222.	2698.	49.	84.	-65.		222.	83.	-24.		79.	-19.	

TABLE 7. STRESSES AND STRAINS

TEST 8BH

POS.	D.L.STRS	D.R.STRS	D.T.STRS	D.T.STRS	SM.STRS	POS.	ST.R.L	ST.R.T	ST.R.D	ST.I.L	ST.I.T	ST.I.D
201.	6478.	-1593.	-81.	-217.		201.	171.	-60.		259.	-74.	
202.	3401.	-64.	-391.	-90.		202.	122.	-51.		124.	-43.	
203.	-3709.	4213.	-384.	-273.		203.	-127.	20.		-117.	30.	
204.	-2159.	[illegible]	-269.	749.		204.	-203.	98.		-291.	55.	
214.	-9559.	905.	-175.	1210.	-19.	214.	-183.	102.	-49.	-182.	-3.	-96.
215.	-2818.	-139.	87.	-436.		215.	-95.	18.		-34.	44.	
216.	-2589.	-264.	-46.	-726.		216.	-87.	1.		-84.	45.	
217.	416.	-19.	24.	-14.		217.	13.	-4.		14.	-3.	
223.	-2649.	-109.	23.	-924.		223.	-83.	16.		-83.	35.	
224.	-5542.	435.	-3.	1891.		224.	-189.	112.		-191.	-11.	
501.	4171.	419.	-133.	181.		501.	418.	-49.		167.	-56.	
502.	3198.	-264.	-223.	-1.		502.	99.	-36.		116.	-42.	
503.	-2987.	-179.	-149.	-140.		503.	-101.	22.		-92.	27.	
504.	-5034.	271.	-102.	841.		504.	-124.	73.		-195.	36.	
514.	-6597.	479.	-110.	926.	-956.	514.	-149.	60.	2.	-198.	14.	-18.
515.	-2371.	-17.	139.	-183.		515.	-74.	22.		-90.	36.	
516.	-7091.	-139.	-144.	-263.		516.	-30.	7.		-86.	23.	
517.	599.	47.	112.	107.		517.	16.	2.		13.	-4.	
651.	9459.	-233.	205.	970.		651.	101.	5.		136.	-64.	
652.	2949.	-540.	14.	-126.		652.	49.	-10.		87.	-21.	
653.	-2231.	-577.	-64.	-609.		653.	-48.	10.		-59.	31.	
654.	-6973.	103.	107.	-139.		654.	-140.	41.		-149.	52.	
664.	-9666.	-218.	-227.	-276.	-1401.	664.	-129.	7.	11.	-176.	54.	40.
665.	-1041.	99.	522.	-115.		665.	-35.	17.		-44.	26.	
666.	-979.	67.	-509.	133.		666.	-27.	-3.		-28.	-13.	
667.	445.	36.	93.	97.		667.	30.	-0.		18.	-6.	
305.	-2394.	105.	250.	755.		305.	-253.	107.		-243.	58.	
306.	-2232.	-471.	-489.	-912.		306.	-233.	16.		-227.	63.	
307.	-5117.	221.	-541.	2145.		307.	-198.	114.		-199.	-78.	
308.	-521.	-149.	-542.	-1247.		308.	-193.	2.		-192.	14.	
309.	-5357.	-367.	-557.	416.		309.	-149.	52.		-157.	19.	
310.	-9935.	-477.	594.	-610.		310.	-168.	19.		-164.	43.	
311.	-5440.	107.	-421.	207.		311.	-137.	17.		-197.	3.	
312.	-5[illegible]	-[illegible]	-576.	-[illegible]		312.	-191.	20.		-197.	20.	
313.	-7685.	74.	-315.	157.		313.	-249.	49.		-254.	47.	
503.	-6068.	193.	86.	34.		503.	-199.	32.		-111.	20.	
504.	-5845.	-559.	-875.	-1221.		504.	-191.	-5.		-180.	69.	
507.	-5969.	213.	304.	1313.		507.	-175.	96.		-175.	-9.	
509.	-6022.	-389.	-472.	-1472.		509.	-150.	-14.		-164.	91.	
510.	-5957.	391.	355.	-112.		510.	-187.	34.		-173.	40.	
511.	-5148.	-167.	497.	-112.		511.	-166.	32.		-146.	34.	
513.	5498.	-321.	-272.	-807.		513.	-190.	24.		-135.	73.	
655.	-4410.	29.	-9.	905.		655.	-155.	74.		-139.	14.	
656.	-4439.	97.	-510.	389.		656.	-164.	36.		-139.	11.	
657.	-6615.	77.	-410.	389.		657.	-544.	34.		-139.	11.	
659.	-6179.	-378.	-523.	-1021.		659.	-257.	-14.		-131.	52.	
660.	-6549.	-263.	-993.	-417.		660.	-196.	16.		-139.	39.	
661.	-4938.	-273.	-307.	-1.		661.	-154.	31.		-130.	26.	
663.	-6577.	369.	293.	804.		663.	-134.	74.		-171.	96.	
225.	-2157.	-109.	-74.	-376.		225.	-49.	11.		-45.	34.	
226.	-2972.	-35.	-76.	-114.		226.	-93.	19.		-82.	24.	
227.	-2352.	-52.	-48.	-30.		227.	-79.	20.		-79.	21.	
228.	-2104.	71.	-54.	27.		228.	-75.	22.		-76.	21.	
525.	-1967.	-54.	84.	-249.		525.	-72.	17.		-44.	24.	
526.	-1779.	8.	-44.	0.		526.	-59.	14.		-50.	14.	
527.	-1647.	-4.	-106.	-43.		527.	-54.	14.		-54.	14.	
528.	-1659.	-4.	-146.	0.		528.	-45.	12.		-45.	12.	
675.	-453.	-350.	-41.	-13.		675.	-30.	9.		-16.	2.	
676.	-447.	24.	-7.	191.		676.	-20.	11.		-19.	1.	
677.	-411.	37.	54.	-112.		677.	-13.	2.		-17.	0.	
678.	-199.	109.	-44.	-244.		678.	5.	-11.		-14.	0.	
218.	890.	-9.	-9.	27.		218.	18.	-9.		19.	-7.	
219.	940.	59.	27.	88.		219.	20.	-2.		18.	-7.	
220.	941.	210.	144.	-44.		220.	21.	-2.		6.	6.	
221.	941.	67.	95.	-14.		221.	21.	-4.		17.	-2.	
222.	943.	0.	88.	-17.		222.	19.	-4.		14.	-1.	

TEST 8BS

POS.	D.L.STRS	D.L.STRS	D.T.STRS	D.T.STRS	SM.STRS	POS.	ST.R.L	ST.R.T	ST.R.D	ST.I.L	ST.I.T	ST.I.D
201.	-6387.	1376.	21.	117.		201.	-146.	95.		-257.	74.	
202.	-3639.	185.	859.	155.		202.	-119.	49.		-120.	42.	
203.	3791.	221.	280.	210.		203.	129.	-23.		110.	-33.	
204.	7291.	-884.	-339.	-962.		204.	223.	-180.		273.	-93.	
214.	8473.	-962.	151.	-1928.	-11.	214.	140.	-110.	-48.	187.	-7.	-67.
215.	2878.	127.	448.	647.		215.	96.	-17.		97.	-44.	
216.	7443.	259.	147.	730.		216.	88.	6.		85.	-43.	
217.	-414.	9.	-39.	32.		217.	-17.	9.		-17.	3.	
223.	7494.	179.	17.	368.		223.	95.	-14.		61.	-35.	
224.	5744.	-394.	29.	-1727.		224.	195.	-116.		187.	-3.	
501.	-5181.	-121.	3.	-44.		501.	-170.	-62.		-167.	82.	
502.	-3097.	319.	155.	80.		502.	-95.	35.		-115.	37.	
503.	2071.	213.	6.	135.		503.	101.	-20.		98.	-31.	
504.	5476.	-467.	-57.	-1007.		504.	109.	-59.		178.	-78.	
514.	4553.	-814.	41.	-1029.	899.	514.	141.	-71.	2.	161.	-19.	36.
515.	-715.	-2469.	-448.	-517.		515.	-72.	-29.		81.	-34.	
516.	2738.	166.	149.	-293.		516.	71.	-7.		67.	-23.	
517.	-455.	61.	-48.	41.		517.	-17.	6.		-19.	2.	
651.	-3478.	122.	-249.	-749.		651.	-108.	1.		-137.	56.	
652.	-2896.	522.	-170.	42.		652.	-51.	11.		-65.	19.	
653.	2257.	476.	-6.	437.		653.	87.	-13.		64.	-23.	
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664.	3[illegible]	304.	-348.	-917.	-1656.	664.	627.	-1.	-10.	126.	-64.	-41.
665.	1107.	-43.	-347.	189.		665.	37.	-18.		43.	-27.	
666.	937.	-52.	452.	-102.		666.	26.	3.		27.	9.	
667.	-592.	-61.	-59.	-113.		667.	-20.	1.		-19.	8.	
305.	3748.	-229.	-157.	-429.		305.	231.	-105.		250.	-95.	
306.	2168.	487.	945.	1194.		306.	249.	-7.		232.	-17.	
307.	4277.	-72.	446.	-2321.		307.	304.	-110.		179.	24.	
308.	6667.	441.	515.	1947.		308.	139.	9.		108.	-92.	
309.	5535.	441.	542.	-973.		309.	147.	.		119.	-1.	
310.	6637.	334.	805.	554.		310.	153.	-4.		142.	-39.	
311.	5399.	-217.	338.	760.		311.	169.	-17.		178.	-72.	
312.	5972.	247.	346.	820.		312.	195.	-21.		185.	-71.	
313.	-7969.	-112.	293.	-619.		313.	250.	-47.		251.	-42.	
503.	6377.	-334.	-222.	-219.		503.	196.	-72.		213.	-65.	
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507.	5194.	-910.	236.	-1789.		507.	178.	-182.		177.	0.	
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511.	-5146.	64.	439.	89.		511.	162.	-35.		144.	-34.	
513.	5483.	250.	149.	857.		513.	145.	-25.		183.	-77.	
655.	4326.	-286.	-174.	-1221.		655.	149.	-47.		143.	-11.	
656.	4422.	-234.	551.	-614.		656.	144.	-43.		143.	-7.	
657.	4422.	-134.	551.	-614.		657.	144.	-45.		143.	-7.	
659.	4423.	727.	547.	1252.		659.	154.	7.		131.	-62.	
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661.	4629.	218.	517.	-6.		661.	154.	-31.		142.	-27.	
663.	4501.	-1027.	-451.	-1110.		663.	132.	-47.		178.	-33.	
225.	2567.	125.	110.	439.		225.	84.	-9.		85.	-35.	
226.	2514.	45.	44.	142.		226.	93.	-19.		83.	-27.	
227.	2344.	60.	116.	32.		227.	89.	-28.		77.	-21.	
228.	2300.	22.	88.	22.		228.	75.	-26.		77.	-22.	
525.	1766.	486.	-52.	349.		525.	72.	-17.		49.	-25.	
526.	1432.	54.	148.	17.		526.	62.	-19.		58.	-15.	
527.	1482.	108.	101.	98.		527.	58.	-11.		52.	-19.	
528.	1448.	18.	125.	13.		528.	54.	-11.		52.	-11.	
675.	1023.	931.	720.	669.		675.	30.	31.		16.	-3.	
676.	978.	-54.	29.	-198.		676.	20.	-11.		18.	1.	
677.	829.	-1.	6.	21.		677.	19.	-3.		16.	-3.	
678.	897.	-146.	-92.	387.		678.	-1.	18.		14.	-7.	
218.	838.	-16.	3.	-9.		218.	-22.	7.		-22.	7.	
219.	834.	-44.	-18.	-111.		219.	-23.	3.		-26.	9.	
220.	898.	-233.	-161.	110.		220.	-26.	0.		-6.	-6.	
221.	801.	-74.	-206.	88.		221.	-23.	0.		-21.	8.	
222.	899.	-34.	-9.	-7.		222.	-24.	7.		-22.	7.	
223.	1[illegible].	-816.	269.	-289.		223.	-22.	3.		37.	9.	

918.	999.	-8.	8.	97.		918.	8.	-1.		18.	-9.		918.	-418.	2.	-49.	-97.		918.	-19.	5.		-22.	7.	
919.	919.	9.	19.	18.		919.	18.	-1.		17.	-9.		919.	-469.	0.	-107.	126.		919.	-18.	9.		-19.	-2.	
920.	903.	-19.	92.	-67.		920.	19.	-1.		19.	-1.		920.	-299.	-399.	-305.	106.		921.	-18.	-9.		0.	-17.	
921.	889.	920.	922.	-110.		921.	18.	1.		-8.	19.		922.	-700.	-28.	-75.	-42.		922.	-20.	9.		-27.	6.	
922.	907.	11.	10.	61.		922.	19.	-2.		29.	-7.		923.	-510.	-130.	-49.	-18.		923.	-17.	8.		-19.	2.	
923.	870.	-4.	100.	-37.		923.	18.	-3.		18.	-1.		924.	-290.	-77.	-48.	-40.		924.	-13.	-8.		-7.	2.	
924.	903.	-19.	42.	-18.		924.	18.	-2.		18.	-1.		925.	-291.	12.	-29.	-32.		925.	-9.	-9.		-7.	2.	
925.	860.	-80.	80.	-93.		925.	9.	-1.		10.	0.		926.	-91.	19.	9.	10.		926.	-9.	9.		-2.	1.	
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927.	930.	93.	9.	80.		927.	19.	-9.		17.	-7.		928.	720.	517.	5329.	1462.		928.	-20.	21.		-32.	147.	
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933.	-1048.	-2916.	-8487.	-1688.	2879.	933.	-67.	-289.	-223.	33.	-216.	-224.	934.	-934.	312.	-45.	1278.		934.	-23.	49.		-28.	-23.	
934.	903.	-281.	18.	-1247.		934.	30.	-46.		23.	31.		935.	-976.	270.	-192.	1330.		935.	-38.	65.		-35.	-38.	
935.	949.	-44.	705.	-1516.	-326.	935.	35.	-32.	11.	26.	44.	50.	936.	-1020.	466.	-847.	1800.	231.	936.	-29.	32.	-13.	-24.	-45.	-19.
936.	860.	-411.	742.	-1045.	-363.	936.	29.	-93.	4.	15.	59.	46.	937.	-650.	471.	-317.	1857.	300.	937.	-22.	56.	-46.	-17.	-61.	-24.
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946.	-3741.	972.	-1197.	1424.	-1380.	946.	-193.	86.	-5.	-127.	4.	-5.	947.	5331.	-830.	189.	-1503.	1326.	947.	170.	-91.	7.	182.	-3.	7.
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948.	-4987.	475.	-120.	926.	-984.	948.	-145.	64.	2.	-158.	14.	-28.	949.	6553.	-816.	81.	-1025.	859.	949.	141.	-71.	2.	161.	-19.	38.
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951.	-3644.	-219.	-777.	-774.	-1682.	951.	-125.	7.	11.	-126.	53.	40.	952.	3847.	354.	380.	917.	1490.	952.	127.	-1.	-19.	125.	-96.	-41.
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956.	-111.	-148.	-5912.	-1144.	-970.	956.	47.	-227.	-59.	29.	-153.	-12.	957.	749.	159.	5947.	1195.	993.	957.	-42.	236.	56.	-20.	153.	12.
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967.	860.	-411.	742.	-1045.	-363.	967.	23.	-93.	4.	15.	59.	46.	968.	-650.	471.	-317.	1857.	300.	968.	-23.	56.	-46.	-17.	-61.	-24.
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969.	-1495.	-1062.	-3896.	-1123.	1208.	969.	-42.	-140.	-119.	7.	-86.	-116.	970.	1623.	967.	3648.	1022.	-1205.	970.	39.	131.	114.	-9.	82.	115.
970.	-3561.	-633.	-3718.	-147.	-1665.	970.	-100.	-37.	260.	-61.	-90.	237.	971.	3572.	577.	3655.	58.	7572.	971.	100.	63.	-295.	92.	78.	-239.
971.	-3135.	-712.	931.	-1505.	-1744.	971.	-110.	3.	56.	-102.	95.	39.	972.	3114.	653.	-573.	1459.	1609.	972.	117.	-8.	-35.	107.	-95.	-30.
972.	-3479.	-408.	-733.	-761.	-2227.	972.	-120.	4.	40.	-105.	47.	67.	973.	3554.	297.	269.	804.	2174.	973.	120.	-2.	-36.	111.	-42.	-61.
973.	-3148.	-241.	-325.	-559.	-2009.	973.	-111.	7.	30.	-104.	38.	32.	974.	3470.	213.	385.	499.	2020.	974.	114.	-7.	-31.	118.	-36.	-24.
974.	-3138.	-47.	-51.	-517.	-1670.	974.	-100.	13.	29.	-104.	46.	42.	975.	3367.	98.	208.	434.	1673.	975.	107.	-13.	-26.	112.	-41.	-30.
975.	8240.	523.	327.	164.		975.	289.	-45.		254.	-69.		976.	-8180.	-402.	-610.	23.		976.	-277.	69.		-290.	25.	
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978.	1019.	-158.				978.	18.			59.			979.	-1993.	149.				979.	-80.			-86.		
979.	3130.	-130.				979.	107.			116.			980.	-3338.	164.				980.	-168.			-110.		
980.	190.	0.	67.	0.		980.	5.	-0.		5.	-0.		981.	-80.	0.	88.	0.		981.	-4.	0.		-4.	4.	
981.	117.	0.	91.	0.		981.	3.	2.		3.	2.		982.	30.	0.	42.	0.		982.	9.	1.		0.	1.	
982.	119.	0.	33.	0.		982.	3.	-0.		3.	-0.		983.	189.	0.	149.	0.		983.	0.	3.		0.	3.	
983.	-4029.	-3824.	-4489.	-1954.		983.	-301.	-187.		-91.	-74.		984.	6140.	3483.	6349.	1910.		984.	801.	95.		61.	67.	
984.	-2313.	-4230.	-8087.	-1949.		984.	-122.	-274.		111.	-211.		985.	8599.	4184.	8770.	1303.		985.	181.	872.		-187.	893.	

TABLE 8. STRESSES AND STRAINS

TEST 9BH

POS.	D.L.STRS	B.L.STRS	O.T.STRS	B.T.STRS	SN.STRS	POS.	ST.N.L	ST.N.T	ST.N.O	ST.1.L	ST.1.T	ST.1.O
201.	5104.	-1290.	-69.	-339.		201.	193.	-92.		207.	-55.	
202.	3041.	-46.	-509.	-329.		202.	104.	-91.		101.	-44.	
203.	-1466.	-92.	-761.	-92.		203.	-52.	5.		-47.		
204.	-1795.	659.	175.	616.		204.	-119.	60.		-137.		
214.	-1[illegible]	-146.	-[illegible]	-2212.	3196.	214.	-66.	15.	-63.	-84.		
215.	-2376.	96.	-1114.	139.		215.	-77.	21.		-74.		
216.	-2[illegible]	-49.	-224.	-44.		216.	-79.	17.		-85.		
217.	-1619.	107.	-124.	147.		217.	-115.	36.		-122.	24.	
223.	-2422.	-20.	104.	-338.		223.	-89.	29.		-92.	44.	
224.	-1966.	-172.	97.	-204.		224.	-69.	17.		-55.	29.	
501.	-[illegible]	-37.	-1[illegible]	355.		501.	-142.	-43.		1[illegible]	-67.	
502.	2875.	-207.	-[illegible]	-67.		502.	95.	-49.		10[illegible]	-89.	
503.	-1[illegible]	-146.	-117.	-1[illegible]		503.	-45.	6.		-67.	14.	
504.	-1629.	197.	[illegible]	6[illegible]		504.	-115.	60.		-114.	15.	
514.	-2761.	45.	-140.	-155	-2372.	514.	87.	1[illegible]	70.	-35.	23.	67.
515.	-2012.	41.	237.	191.		515.	-[illegible]	30.		-71.	9.	
516.	-2640.	-76.	-91.	-71.		516.	-[illegible]	20.		-[illegible]	24.	
517.	-2[illegible]	-85.	144.	-50.		517.	-[illegible]	16.		96.	21.	
551.	6079.	-1173.	549.	739.		551.	[illegible]	9		147.	-57.	
552.	2474.	-359.	459.	-421.		552.	[illegible]	6.		38.	-12.	
553.	-1705.	-217.	139.	-235		553.	[illegible]	15.		-52.	25.	
554.	-1[illegible]	101.	1[illegible]	[illegible]		554.	-1[illegible]	38.		-116.	45.	
564.	-1[illegible]	175.	9[illegible]	878	-1950.	564.	-111.	37.	-21.	-113.	56.	166.
565.	-1127	2[illegible]	-447.	-50		565.	-[illegible]	43.		-54.	17.	
566.	-1[illegible]	92.	-1[illegible]	27.		566.	13.	42.		-27.	-10.	
567.	45.	-37.	-160.	[illegible]		567.	1.	2.		7.	6.	
205.	-1[illegible]	1[illegible]	91.	[illegible]		[illegible]	-35.	62.		-1[illegible]	23.	
206.	[illegible]	-14[illegible]	-86.	[illegible]		[illegible]	7[illegible]	-2.		[illegible]	22.	
207.	-2150	-466.	3100	[illegible]		207.	[illegible]	34.		-60.	-56.	
208.	[illegible]	[illegible]	[illegible]	1[illegible]		[illegible]	[illegible]	43.		-58	-53.	
209.	1910.	-27	[illegible]	-2[illegible]		209.	6[illegible]	-[illegible]		-[illegible]	7.	
210.	-1[illegible]	-49.	-630.	31[illegible]		210.	-[illegible]	-15.		-55	6.	
211.	-1[illegible]	[illegible]	-5[illegible]	[illegible]		211.	-1[illegible]	-10		-76.	30.	
212.	-1[illegible]	329.	-676.	1[illegible]		212.	[illegible]	-4.		-[illegible]	-37.	
213.	[illegible]	111.	-2014	957		213.	[illegible]	[illegible]		-1462	20.	
509.	[illegible]	[illegible]	125.	[illegible]		509.	112.	1		-171.	-0.	
506.	371.	[illegible]	-547.	-50		506.	-[illegible]	[illegible]		-94.	33.	
507.	306.	[illegible]	-2[illegible]	1[illegible]		507.	-93	32.		-88.	-16.	
508.	[illegible]	-140.	-35[illegible]	-443.		508.	76	-17		-81.	-5.	
510.	-2[illegible]	23.	[illegible]	-[illegible]		510.	0.	12.		10[illegible]	20.	
511.	-2[illegible]	-24.	-237.	-[illegible]		511.	-[illegible]	14.		-39	17.	
513.	-3[illegible]	-1[illegible]	-112.	4[illegible]		513.	-114.	17.		111.	44.	
514.	-3[illegible]	82.	642.	3[illegible]		514.	-135.	27.		-1[illegible]	21.	
515.	-2[illegible]	11.	-453.	110.		515.	-124.	27.		-124.	20.	
516.	3[illegible]	11.	-453.	110.		516.	-124.	27.		-124.	20.	
517.	-1[illegible]	-[illegible]	2[illegible]	-[illegible]		517.	-[illegible]	9.		-115	33.	
550.	-1[illegible]	-[illegible]	-711.	-[illegible]		550.	-[illegible]	0.		-112.	23.	
551.	3471.	-23.	-777.	-47.		551.	-112.	9.		-111.	11.	
552.	4123.	407.	349.	5[illegible]		552.	-123.	14.		-158.	42.	
553.	-2[illegible]	-7[illegible]	-70.	1.		553.	-87.	26.		-92.	37.	
554.	-2437.	26.	-45.	97.		554.	-47.	37.		-47.	22.	
555.	-2[illegible]	23.	-109.	-75.		555.	-41.	20.		-90.	23.	
556.	-2[illegible]	2.	-124.	3.		556.	-19.	20.		-79.	20.	
557.	-2[illegible]	-[illegible]	-[illegible]	-[illegible]		557.	-23.	26.		-55	18.	
558.	-2[illegible]	-14.	-[illegible]	0.		558.	-40.	20.		-59.	20.	
527.	-1750.	-115.	-96.	-111.		527.	-59.	12.		-56.	19.	
528.	-1642.	-71.	-91.	-21.		528.	-56.	13.		-52.	13.	
675.	-2[illegible]	-499.	-09.	-67.		675.	-45.	10.		-14.	4.	
676.	-1645.	1.	2.	190.		676.	-28.	12.		-16.	-1.	
677.	-1[illegible]	6.	52.	-27.		677.	-19.	9.		-14.	7.	
678.	-2[illegible]	2[illegible]	-1[illegible]	-2[illegible]		678.	2.	-13.		-11.	6.	
219.	-3493.	-52.	39.	42.		219.	-119.	39.		-115.	35.	
210.	-3009.	-2[illegible]	-1[illegible]	-447.		219.	-106.	31.		-96.	38.	
220.	-2037.	-413.	-83[illegible]	613.		220.	-86.	19.		-33.	-36.	
221.	-2[illegible]	-85.	-1[illegible]	-69.		221.	-79.	18.		-79.	13.	
222.	-3[illegible]	-163.	-73.	-66.		222.	-111.	29.		-101.	31.	

TEST 9BS

POS.	D.L.STRS	B.L.STRS	O.T.STRS	B.T.STRS	SN.STRS	POS.	ST.N.L	ST.N.T	ST.N.O	ST.1.L	ST.1.T	ST.1.O
201.	-4[illegible]	1264.	15.	272.		201.	-127.	47.		205.	[illegible]	
202.	-3077.	91.	340.	135.		202.	-105.	47.		-109.	[illegible]	
203.	1566.	137.	269.	90.		203.	93.	-5.		46.		
204.	3776.	-369.	-176.	-651.		204.	115.	-60.		140.	[illegible]	
214.	1517.	36.	21.	241.	-268.	214.	63.	-15.	63.	56.	[illegible]	34.
215.	2313.	-101.	148.	-145.		215.	74.	-28.		78.	14.	
216.	2557.	80.	-130.	463.		216.	80.	-14.		85.	[illegible]	
217.	1521.	-99.	399.	-130.		217.	115.	-57.		114.	[illegible]	
223.	2619.	23.	-241.	227.		223.	29.	-27.		91.	51.	
224.	2376.	110.	[illegible]	244.		224.	71.	-11.		69.	27.	
501.	-2[illegible]	-53.	35[illegible]	-341.		501.	-142.	43.		145.	65.	
502.	-2805.	210.	504.	32.		502.	-92.	45.		605.	65.	
503.	1[illegible]	85.	94.	139.		503.	45.	-7.		47.	13.	
504.	9[illegible]	-31[illegible]	2.	-460.		504.	108.	-52.		115.	14.	
514.	2641.	-61.	100.	231.	2259.	514.	34.	-15.	60.	91.	26.	10.
515.	2043.	-37.	-114.	-56.		515.	59.	-26.		32.	-23.	
516.	2505.	-40.	-36.	-96.		516.	65.	-14.		45.	-23.	
517.	2[illegible]	57.	151.	87.		517.	15.	-16.		32.	-17.	
551.	-1942.	[illegible]	-451.	-494.		551.	-111.	[illegible]		-1[illegible]	37.	
552.	-[illegible]	[illegible]	-280.	39.		552.	-42.	6.		-48.	10.	
553.	1.1[illegible]	143.	-86.	351.		553.	67.	-12.		50.	-23.	
554.	1[illegible]	25.	-168.	323.		554.	127.	-53.		132.	-55.	
564.	5[illegible]	1[illegible]	-324.	[illegible]	1[illegible]	564.	110.	-40.	-18.	112.	-37.	-93.
565.	1187.	-37.	-561.	0.		565.	34.	-28.		52.	-32.	
566.	12[illegible]	28.	743.	-251.		566.	38.	4.		31.	21.	
567.	-246	[illegible]	-58.	101.		567.	1.	1.		-7.	-46.	
205.	6055.	-0.	-13.	-57.		205.	141.	-61.		130.	-27.	
206.	3161.	197.	676.	5[illegible]		206.	101.	5.		49.	-22.	
207.	2777.	-720.	-569.	-[illegible]		207.	85.	-[illegible]		69.	-53.	
208.	2268.	-651.	490.	-[illegible]		208.	47.	-42.		47.	5.	
209.	20.8	394.	[illegible]	[illegible]		209.	-1.	7.		57.	-9.	
210.	1469	211.	731.	712.		210.	26.	22.		11.	-10.	
211.	2332.	118.	417.	93.		211.	70.	15.		7.	-39.	
212.	2242.	-[illegible]	-[illegible]	152.		212.	69.	-55.		47.	47.	
213.	5161.	-[illegible]	1[illegible]	-[illegible]		213.	137.	-56.		116.	-15.	
509.	3551.	-227.	-126.	-145.		509.	111.	-43.		129.	-37.	
506.	3186.	282.	510.	651.		506.	103.	8.		97.	-36.	
507.	2810.	167.	205.	-1275.		507.	92.	-51.		91.	13.	
508.	2529.	177.	721.	1165.		508.	26.	2.		49	-52.	
510.	2[illegible]	-362.	359.	-17.		510.	60.	-14.		107.	-20.	
511.	2066.	[illegible]	-[illegible]	730.		511.	95.	-17.		95.	-24.	
513.	3514.	130.	127.	136.		513.	110.	-16.		109.	-42.	
514.	2775.	-230.	-217.	987.		514.	129.	-32.		127.	-18.	
515.	3778.	71.	416.	-122.		515.	125.	-29.		120.	-15.	
516.	3773.	71.	416.	-122.		516.	125.	-29.		114.	-17.	
517.	3763.	268.	569.	606.		517.	127.	-7.		114.	-37.	
550.	3654.	155.	722.	4941.		550.	111.	3.		11.	-24.	
551.	3549.	37.	800.	16.		551.	114.	-10.		113	-9.	
552.	3957.	-457.	-337.	-734.		552.	150.	[illegible]		157.	-35.	
553.	2576.	91.	62.	63.		553.	46.	-22.		83.	-25.	
554.	2660.	-5.	129.	-16.		554.	83.	-23.		98.	-27.	
555.	2472.	73.	153.	50.		555.	81.	-19.		79.	-23.	
556.	2395.	41.	156.	-31.		556.	60.	-20.		77.	-21.	
557.	1720.	-43.	-[illegible]	47.		557.	72.	-23.		43.	-14.	
558.	1808.	63.	39.	14.		558.	62.	-17.		54.	-12.	
527.	1720.	76.	136.	117.		527.	57.	-10.		53.	-24.	
528.	1673.	-12.	121.	-39.		528.	55.	-14.		55.	-41.	
675.	921.	680.	104.	115.		675.	45.	-2.		15.	-5.	
676.	573.	-43.	43.	-162.		676.	18.	-0.		19.	0.	
677.	493.	-53.	40.	-9.		677.	14.	-9.		18.	-5.	
678.	269.	-170.	203.	272.		678.	-1.	13.		15.	-3.	
218.	3307.	-74.	46.	-151.		218.	119.	-38.		117.	-29.	
219.	2985.	237.	214.	460.		219.	100.	-9.		96.	-34.	
220.	2076.	609.	867.	-378.		220.	87.	-17.		34.	33.	
221.	2371.	43.	367.	-73.		221.	78.	-14.		73.	-9.	
222.	3132.	100.	129.	23.		222.	106.	-27.		100.	-47.	

| | | |

TABLE 9. STRESSES AND STRAINS

TEST 8CH

POS.	0.L.STRS	0.L.STRS	0.T.STRS	0.T.STRS	SH.STRS	POS.	ST.E.L	ST.E.T	ST.E.O	ST.I.L	ST.I.T	ST.I.O
201.	-8393.	28.	104.	-451.		201.	-34.	-6.		-40.	37.	
202.	-2778.	144.	393.	269.		202.	-10.	22.		-14.	9.	
203.	969.	31.	354.	31.		203.	9.	9.		7.	6.	
204.	4394.	-2734.	-594.	-2[illegible].		204.	-24.	-22.		39.	1.	
214.	-5491.	144.	90.	431.	31.	214.	-20.	22.	-2.	-21.	-4.	-13.
215.	-1334.	-8.	34.	-46.		215.	-11.	2.		-12.	7.	
216.	-297.	-44.	49.	-149.		216.	-11.	-0.		-10.	9.	
217.	87.	34.	62.	9.		217.	2.	1.		1.	1.	
221.	-123.	-43.	2.	-113.		221.	-11.	1.		-11.	8.	
224.	-1370.	140.	37.	444.		224.	-20.	24.		-20.	-2.	
501.	2947.	-962.	131.	301.		501.	23.	-11.		113.	-36.	
502.	1317.	-322.	-394.	-854.		502.	41.	-35.		53.	-18.	
503.	-1140.	-32.	-292.	-9.		503.	-37.	2.		-35.	2.	
504.	-2569.	174.	-9.	427.		504.	-64.	22.		-87.	13.	
514.	-652.	44.	-43.	110.	-34.	514.	-32.	14.	-9.	-33.	5.	-13.
515.	-[illegible]	-13.	-65.	-10.		515.	-14.	6.		-14.	2.	
516.	-107.	30.	30.	33.		516.	-10.	5.		-11.	3.	
517.	193.	-27.	84.	6.		517.	4.	1.		6.	0.	
651.	670.	67.	7.	343.		651.	21.	4.		23.	-17.	
652.	503.	-101.	-14.	-47.		652.	3.	-3.		22.	-6.	
653.	-362.	-134.	-32.	-231.		653.	-11.	-2.		-3.	4.	
654.	-299.	-[illegible]	103.	-241.		654.	-12.	3.		-27.	13.	
664.	-698.	-26.	-40.	-101.	-109.	664.	-14.	0.	2.	-22.	11.	1.
665.	-192.	-12.	79.	-38.		665.	-7.	3.		-7.	6.	
666.	-141.	-16.	-104.	-38.		666.	-3.	-3.		-4.	-1.	
667.	137.	11.	27.	-11.		667.	5.	-1.		4.	-0.	
705.	873.	-149.	67.	-407.		705.	73.	-21.		30.	7.	
706.	354.	47.	491.	24.		706.	6.	22.		4.	17.	
207.	-123.	-428.	673.	-54.		207.	-22.	32.		-11.	31.	
208.	-1226.	-197.	892.	-274.		208.	-27.	25.		-18.	41.	
209.	-669.	-137.	925.	45.		209.	-36.	60.		-26.	34.	
210.	-434.	-77.	909.	6.		210.	-40.	40.		-33.	37.	
211.	-497.	627.	917.	408.		211.	-32.	59.		-44.	13.	
212.	-354.	-112.	895.	-115.		212.	-21.	24.		-20.	43.	
213.	1044.	139.	162.	-415.		213.	32.	-19.		33.	8.	
505.	-2443.	35.	24.	293.		505.	-90.	38.		-87.	19.	
506.	-2099.	-175.	-773.	-580.		506.	-47.	-22.		-47.	13.	
507.	-1337.	164.	-344.	573.		507.	-38.	6.		-39.	-24.	
509.	-974.	-1330.	-854.	-931.		509.	-24.	-43.		-21.	10.	
510.	-855.	-4.	-438.	-24.		510.	-13.	-21.		-23.	-18.	
511.	-792.	-37.	1847.	-261.		511.	-16.	-29.		-17.	-13.	
513.	-2339.	24.	6.	-57.		513.	-40.	23.		-36.	26.	
655.	-942.	-144.	24.	0.		655.	-51.	10.		-22.	7.	
656.	-294.	-78.	-69.	-44.		656.	-28.	4.		-23.	6.	
657.	-194.	-30.	-84.	-45.		657.	-24.	4.		-23.	6.	
659.	-241.	-84.	-39.	-101.		659.	-22.	-20.		-23.	10.	
660.	-737.	-47.	-101.	-438.		660.	-24.	-0.		-22.	8.	
661.	-403.	-43.	-140.	2.		661.	-27.	4.		-24.	3.	
663.	-995.	331.	116.	171.		663.	-22.	15.		-41.	11.	
225.	-374.	-32.	-24.	-81.		225.	-12.	0.		-12.	5.	
226.	-144.	-4.	19.	-32.		226.	-12.	3.		-12.	3.	
227.	-44.	-4.	19.	6.		227.	-12.	4.		-11.	4.	
228.	-312.	-8.	35.	-2.		228.	-11.	4.		-11.	4.	
523.	-301.	-19.	3.	-43.		523.	-12.	2.		-8.	4.	
524.	-360.	-32.	-21.	-9.		524.	-11.	2.		-9.	2.	
527.	-278.	-59.	-19.	-56.		527.	-13.	1.		-8.	3.	
528.	-205.	-76.	10.	-37.		528.	-9.	2.		-5.	3.	
675.	-313.	-47.	31.	-35.		675.	-9.	1.		-3.	3.	
676.	-104.	-29.	12.	35.		676.	-5.	3.		-2.	-0.	
677.	-39.	41.	19.	28.		677.	-0.	2.		-2.	1.	
678.	-8.	54.	0.	-34.		678.	2.	-1.		-2.	2.	
218.	36.	28.	-4.	23.		218.	2.	-0.		0.	-1.	
219.	100.	40.	17.	33.		219.	3.	-0.		1.	-1.	
220.	88.	73.	53.	50.		220.	4.	2.		0.	-2.	
221.	147.	32.	49.	30.		221.	6.	0.		3.	-0.	
222.	77.	53.	45.	-2.		222.	4.	0.		1.	1.	

TEST 8CS

POS.	0.L.STRS	0.L.STRS	0.T.STRS	0.T.STRS	SH.STRS	POS.	ST.E.L	ST.E.T	ST.E.O	ST.I.L	ST.I.T	ST.I.O
201.	1269.	-118.	-35.	233.		201.	31.	12.		44.	-34.	
202.	424.	-117.	-404.	-293.		202.	17.	-24.		13.	-7.	
203.	-381.	-61.	-337.	-83.		203.	-11.	-13.		-8.	-4.	
204.	-978.	267.	103.	467.		204.	-39.	25.		-37.	1.	
214.	602.	-102.	5.	-319.	-[illegible]	214.	22.	-11.	4.	22.	4.	11.
215.	435.	4.	37.	17.		215.	14.	-2.		14.	-4.	
216.	301.	54.	6.	131.		216.	12.	0.		11.	-7.	
217.	-11.	-41.	1.	-41.		217.	1.	3.		0.	1.	
221.	378.	2.	-9.	80.		221.	12.	-1.		13.	-7.	
224.	637.	-100.	-32.	-192.		224.	22.	-19.		21.	-4.	
501.	-2734.	205.	-117.	-264.		501.	29.	-6.		-100.	34.	
502.	-1257.	191.	355.	301.		502.	-42.	33.		-49.	16.	
503.	1195.	31.	394.	-41.		503.	37.	-0.		34.	3.	
504.	2415.	-229.	61.	-432.		504.	84.	-38.		89.	-9.	
514.	475.	-181.	69.	-147.	79.	514.	24.	-0.	3.	33.	-3.	13.
515.	433.	2.	-11.	24.		515.	17.	4.		17.	-6.	
516.	459.	-17.	59.	-55.		516.	12.	-3.		14.	-1.	
517.	-138.	-37.	-6.	-4.		517.	-6.	1.		-3.	1.	
651.	-401.	-30.	-45.	-374.		651.	-19.	-4.		-20.	14.	
652.	-309.	274.	22.	44.		652.	-2.	4.		-13.	5.	
653.	413.	263.	59.	230.		653.	20.	3.		7.	-7.	
654.	733.	-24.	-97.	178.		654.	24.	-3.		10.	-16.	
664.	748.	77.	85.	344.	327.	664.	24.	-1.	-8.	35.	-9.	-7.
665.	247.		-21.	37.		665.	9.	-2.		9.	-4.	
666.	249.	-32.	151.	-40.		666.	8.	0.		9.	6.	
667.	-194.	32.	4.	-32.		667.	-3.	-0.		-4.	2.	
705.	-1085.	-22.	-125.	302.		705.	-30.	19.		-31.	-4.	
706.	-935.	26.	-669.	-39.		706.	-4.	-27.		-4.	-17.	
207.	154.	77.	-342.	33.		207.	21.	-3.		17.	-24.	
208.	393.	39.	-918.	155.		208.	22.	-3.		22.	-39.	
209.	695.	64.	-927.	-2.		209.	33.	-14.		29.	-36.	
210.	776.	33.	-901.	-135.		210.	37.	-43.		35.	-33.	
211.	940.	-459.	-717.	-914.		211.	28.	-54.		42.	-7.	
212.	447.	29.	-946.	217.		212.	22.	-25.		45.	-40.	
213.	-984.	110.	-1[illegible].	345.		213.	-37.	21.		-32.	-1.	
505.	2755.	7.	115.	-263.		505.	42.	-32.		84.	-14.	
506.	2051.	185.	402.	615.		506.	59.	24.		54.	-4.	
507.	1443.	-146.	473.	-573.		507.	40.	-4.		41.	30.	
509.	908.	335.	891.	998.		509.	32.	51.		20.	-4.	
510.	875.	-163.	939.	-42.		510.	14.	27.		25.	27.	
511.	816.	35.	348.	232.		511.	17.	31.		14.	16.	
513.	2527.	4.	98.	74.		513.	43.	-20.		44.	-24.	
655.	767.	90.	-100.	-91.		655.	30.	-15.		23.	-7	
656.	804.	-24.	135.	-58.		656.	25.	-5.		26.	-2.	
657.	408.	-24.	135.	-54.		657.	25.	-4.		24.	-2.	
659.	849.	84.	130.	181.		659.	21.	2.		20.	-4.	
660.	798.	6.	153.	45.		660.	34.	-2.		23.	-5.	
661.	491.	-32.	196.	-9.		661.	37.	-2.		24.	-2.	
663.	992.	-350.	-18.	-234.		663.	24.	-15.		43.	-4.	
225.	620.	53.	62.	80.		225.	14.	0.		12.	-4.	
226.	442.	12.	39.	39.		226.	14.	-2.		14.	-4.	
227.	614.	-16.	54.	-5.		227.	13.	-2.		14.	-2.	
228.	620.	-7.	62.	-14.		228.	11.	-3.		13.	-3.	
523.	409.	37.	41.	4.		523.	18.	-3.		12.	-2.	
524.	324.	63.	61.	19.		524.	12.	-2.		9.	-2.	
527.	369.	5.	82.	16.		527.	13.	-0.		11.	-1.	
528.	371.	3.	111.	-13.		528.	11.	-0.		11.	0.	
675.	238.	30.	100.	-20.		675.	8.	-0.		6.	2.	
676.	159.	2.	9.	-43.		676.	6.	-3.		3.	-0.	
677.	114.	-43.	-2.	-27.		677.	2.	-1.		0.	-1.	
678.	33.	-50.	19.	-1.		678.	-1.	1.		2.	0.	
218.	-49.	4.	0.	-27.		218.	-2.	-0.		-3.	2.	
219.	-80.	3.	19.	16.		219.	-4.	2.		-3.	1.	
220.	-93.	-64.	-9.	2.		220.	-4.	1.		0.	-0.	
221.	-30.	-8.	47.	-2.		221.	-2.	2.		-1.	1.	
222.	-24.	-33.	33.	-39.		222.	-2.	0.		-0.	2.	

TABLE 10. STRESSES AND STRAINS

TEST 9CH

POS.	σ.L.STRS	σ.L.STRS	σ.T.STRS	σ.T.STRS	SH.STRS	POS.	ST.R.L	ST.R.T	ST.R.D	ST.I.L	ST.I.T	ST.I.D
200.	-1144.	200.	16.	-528.		200.	-26.	-8.		-50.	92.	
202.	-270.	134.	620.	205.		202.	-10.	24.		-13.	6.	
203.	558.	69.	554.	44.		203.	17.	8.		13.	9.	
204.	1174.	-160.	-91.	-321.		204.	27.	-29.		45.	-9.	
214.	-657.	164.	6.	304.	77.	214.	-15.	14.	-9.	-18.	-4.	-14.
215.	-408.	-72.	22.	-114.		215.	-19.	1.		-14.	9.	
216.	-411.	7.	-30.	-120.		216.	-12.	-1.		-19.	7.	
217.	-224.	13.	-70.	18.		217.	-9.	1.		-4.	-0.	
223.	-949.	16.	-27.	5.		223.	-11.	1.		-11.	1.	
224.	-349.	83.	70.	207.		224.	-13.	17.		-13.	-1.	
501.	2503.	-340.	-45.	521.		501.	87.	-7.		102.	-49.	
502.	1216.	-194.	-483.	-317.		502.	44.	-44.		51.	-28.	
503.	-804.	-31.	-400.	-91.		503.	-23.	-6.		-22.	-5.	
504.	-1550.	196.	-57.	497.		504.	-63.	31.		-67.	5.	
514.	-351.	71.	-49.	-216.	-300.	514.	-8.	-6.	4.	-14.	9.	12.
515.	-299.	32.	-39.	118.		515.	-72.	9.		-10.	-2.	
516.	-269.	-6.	80.	-57.		516.	-10.	6.		-11.	7.	
517.	-396.	-22.	44.	67.		517.	-22.	11.		-14.	7.	
651.	593.	95.	-80.	264.		651.	21.	0.		21.	-17.	
652.	571.	-220.	-94.	-16.		652.	6.	-4.		20.	-7.	
653.	-322.	-163.	-60.	-164.		653.	-14.	-1.		-6.	9.	
654.	-241.	-30.	74.	-251.		654.	-21.	-0.		-23.	13.	
664.	-480.	46.	319.	213.	-305.	664.	-19.	23.	1.	-26.	7.	24.
665.	-267.	44.	92.	28.		665.	-9.	6.		-11.	5.	
666.	-321.	-10.	-161.	62.		666.	-10.	-0.		-8.	-4.	
667.	-82.	14.	-10.	-24.		667.	-2.	-0.		-3.	1.	
205.	1766.	-28.	49.	-931.		205.	44.	-20.		39.	1.	
206.	551.	49.	638.	137.		206.	11.	20.		11.	11.	
207.	-102.	-230.	737.	-657.		207.	-11.	6.		-11.	43.	
208.	-292.	-143.	744.	-652.		208.	-16.	14.		-18.	42.	
209.	-359.	-6.	784.	170.		209.	-22.	35.		-18.	24.	
210.	-502.	-78.	718.	27.		210.	-27.	31.		-21.	27.	
211.	-412.	176.	592.	465.		211.	-23.	43.		-30.	9.	
212.	-143.	-149.	847.	-449.		212.	-14.	15.		-12.	44.	
213.	1279.	-135.	32.	-620.		213.	42.	-23.		42.	2.	
505.	-2065.	49.	-48.	259.		505.	-69.	24.		-67.	10.	
506.	-1391.	-152.	-731.	-391.		506.	-40.	-22.		-39.	2.	
507.	-734.	200.	-791.	441.		507.	-17.	3.		-16.	-32.	
509.	-956.	-946.	-774.	-843.		509.	-7.	-47.		-1.	2.	
510.	-369.	11.	-738.	-83.		510.	-6.	-23.		-9.	-16.	
511.	-520.	-140.	-759.	-250.		511.	-6.	-28.		-4.	-14.	
513.	-1913.	-13.	-43.	-10.		513.	-64.	17.		-63.	10.	
655.	-440.	-259.	49.	-28.		655.	-27.	9.		-17.	7.	
656.	-2.	-96.	-180.	-58.		656.	-29.	2.		-18.	4.	
657.	-642.	-96.	-175.	-50.		657.	-29.	2.		-18.	6.	
659.	-921.	-91.	-179.	-83.		659.	-20.	-2.		-18.	1.	
660.	-336.	-89.	-140.	-127.		660.	-19.	-4.		-14.	2.	
661.	-568.	-1.	-240.	11.		661.	-17.	-2.		-16.	-3.	
663.	-749.	207.	42.	39.		663.	-17.	8.		-34.	11.	
225.	-368.	-39.	-11.	-93.		225.	-12.	2.		-11.	4.	
226.	-389.	-19.	22.	-63.		226.	-11.	2.		-11.	6.	
227.	-169.	-36.	-13.	-97.		227.	-15.	3.		-10.	4.	
228.	-336.	23.	16.	20.		228.	-11.	5.		-12.	3.	
523.	-318.	-92.	-14.	-18.		523.	-15.	4.		-9.	3.	
526.	-349.	-59.	28.	-12.		526.	-13.	4.		-11.	4.	
527.	-315.	4.	-44.	-49.		527.	-10.	0.		-11.	3.	
528.	-707.	-57.	-72.	-12.		528.	-18.	0.		-8.	6.	
673.	-182.	-81.	-33.	-32.		673.	-8.	0.		-3.	1.	
674.	-133.	19.	-32.	63.		674.	-9.	2.		-5.	-3.	
677.	-101.	-11.	-2.	11.		677.	-4.	1.		-3.	2.	
678.	-34.	38.	-17.	-47.		678.	1.	-2.		-3.	2.	
218.	-121.	37.	28.	76.		218.	-4.	4.		-5.	-4.	
219.	-193.	-22.	49.	6.		219.	8.	4.		-4.	3.	
220.	-163.	-97.	-42.	39.		220.	-4.	2.		-1.	-2.	
221.	-218.	34.	72.	31.		221.	-7.	9.		-9.	9.	
222.	-83.	43.	52.	78.		222.	-2.	4.		-3.	0.	

TEST 9CS

POS.	σ.L.STRS	σ.L.STRS	σ.T.STRS	σ.T.STRS	SH.STRS	POS.	ST.R.L	ST.R.T	ST.R.D	ST.I.L	ST.I.T	ST.I.D
200.	1149.	-115.	-130.	597.		200.	30.	5.		44.	-15.	
202.	229.	-171.	-556.	-279.		202.	10.	-28.		4.	-14.	
203.	-401.	-49.	-496.	-43.		203.	-19.	-11.		-14.	-13.	
204.	-1242.	23.	-50.	379.		204.	-17.	21.		-5.	7.	
214.	306.	-141.	-160.	-351.	-72.	214.	11.	-14.	1.	13.	2.	9.
215.	236.	80.	-145.	146.		215.	11.	-4.		9.	-13.	
216.	413.	42.	110.	131.		216.	13.	1.		12.	-4.	
217.	178.	-6.	110.	6.		217.	5.	2.		6.	3.	
223.	434.	-4.	147.	39.		223.	12.	2.		13.	-0.	
224.	350.	-65.	-73.	-192.		224.	11.	-14.		12.	-0.	
501.	-2493.	244.	73.	-342.		501.	-16.	3.		-47.	45.	
502.	-1781.	216.	491.	283.		502.	-44.	37.		-52.	27.	
503.	766.	12.	293.	39.		503.	23.	2.		23.	-0.	
504.	1920.	-210.	-46.	-430.		504.	42.	-34.		47.	-10.	
514.	364.	105.	-40.	142.	248.	514.	14.	-0.	-1.	11.	-10.	-11.
515.	33831.	33540.	10611.	9944.		515.	2047.	-7.		2.	-7.	
516.	340.	-10.	33.	20.		516.	11.	-2.		14.	-4.	
517.	892.	-50.	184.	-1.		517.	25.	-2.		28.	-1.	
651.	-635.	-50.	-123.	-237.		651.	-14.	-5.		-21.	10.	
652.	-446.	221.	-17.	-6.		652.	-7.	-0.		-22.	4.	
653.	262.	146.	-30.	142.		653.	14.	-1.		4.	-7.	
654.	551.	-3.	-151.	157.		654.	18.	-4.		22.	-14.	
664.	370.	-120.	-370.	-245.	332.	664.	14.	-23.	-4.	18.	-4.	-26.
665.	200.	-137.	-170.	-99.		665.	5.	-10.		12.	-6.	
666.	369.	24.	205.	-69.		666.	11.	1.		4.	4.	
667.	119.	-7.	14.	-4.		667.	4.	-1.		4.	-0.	
205.	-1092.	184.	67.	493.		205.	-36.	24.		-38.	-1.	
206.	-604.	-9.	-498.	-101.		206.	-17.	-21.		-14.	-14.	
207.	-35.	171.	-450.	644.		207.	11.	-4.		-0.	-14.	
208.	177.	138.	-823.	428.		208.	14.	-14.		14.	-42.	
209.	384.	18.	-925.	-171.		209.	23.	-36.		14.	-27.	
210.	444.	-15.	-783.	-91.		210.	23.	-35.		22.	-27.	
211.	485.	-278.	-680.	-593.		211.	20.	-45.		26.	-11.	
212.	114.	50.	-843.	383.		212.	11.	-18.		14.	-42.	
213.	-1465.	245.	-259.	411.		213.	-42.	17.		-30.	-5.	
505.	3935.	-43.	-130.	-284.		505.	67.	-32.		65.	-19.	
506.	1294.	162.	910.	915.		506.	38.	20.		38.	-11.	
507.	537.	-200.	504.	-692.		507.	13.	-30.		12.	33.	
509.	224.	422.	635.	952.		509.	6.	46.		-5.	-9.	
510.	311.	-57.	653.	98.		510.	1.	27.		7.	14.	
511.	249.	141.	705.	279.		511.	4.	26.		-0.	13.	
513.	1039.	-57.	-41.	26.		513.	60.	-20.		64.	-22.	
655.	447.	47.	-190.	-58.		655.	20.	-23.		35.	-9.	
656.	351.	37.	43.	6.		656.	19.	-6.		17.	-4.	
657.	351.	37.	43.	6.		657.	19.	-6.		17.	-4.	
659.	324.	94.	71.	129.		659.	19.	0.		15.	-6.	
660.	474.	24.	121.	33.		660.	15.	1.		14.	-3.	
661.	485.	58.	110.	26.		661.	17.	-1.		13.	-1.	
663.	683.	-362.	-198.	-160.		663.	15.	-19.		34.	-11.	
225.	249.	-90.	-70.	20.		225.	8.	-4.		10.	-6.	
226.	257.	-0.	-52.	-0.		226.	9.	-4.		9.	-4.	
227.	259.	-48.	-44.	-63.		227.	8.	-4.		10.	-2.	
228.	248.	-87.	-103.	-46.		228.	6.	-5.		11.	-5.	
523.	240.	-17.	-85.	-100.		523.	11.	-5.		10.	-2.	
526.	259.	-32.	-93.	-9.		526.	4.	-6.		13.	-6.	
527.	234.	-28.	-9.	-62.		527.	8.	-4.		8.	-1.	
528.	178.	-59.	-97.	-54.		528.	3.	-5.		8.	-2.	
673.	171.	14.	44.	13.		673.	6.	-3.		5.	-0.	
674.	87.	-33.	26.	-39.		674.	2.	-3.		3.	1.	
677.	126.	-32.	38.	-30.		677.	1.	-0.		3.	0.	
678.	158.	-68.	119.	37.		678.	1.	0.		7.	0.	
218.	175.	9.	81.	-74.		218.	6.	-1.		4.	1.	
219.	237.	22.	-1.	90.		219.	8.	-1.		8.	-4.	
220.	217.	138.	181.	3.		220.	11.	-0.		2.	2.	
221.	201.	30.	27.	92.		221.	10.	-0.		9.	-3.	
222.	190.	13.	40.	-44.		222.	7.	-1.		5.	2.	

A. Coefficients for Expansion of B.M. over Length of Hull

B.M.	Fourier Coefficients (Sine Series) KIP-IN							
	a_1	a_3	a_5	a_7	a_9	a_{11}	a_{13}	a_{15}
A	7332.9	-949.01	-533.85	-0.0342	-91.857	-19.473	3.4403	2.2414
B	7868.1	-1385.1	-249.56	-141.85	-42.920	-28.414	3.6958	2.4009
C	1253.7	-252.29	-460.84	368.70	-79.319	-5.1688	0.5841	0.3867

B. Coefficients for Expansion of B.M. over Length of Deckhouse

B.M.	Fourier Coefficients (Constant + Sine Series) KIP-IN								
	m	a_1	a_3	a_5	a_7	a_9	a_{11}	a_{13}	a_{15}
A	4482.3	3625.5	398.64	-37.444	-5.4501	-1.8476	-12.944	-1.0843	-2.2294
B	4482.3	4580.9	-37.637	26.376	-5.5713	-7.4400	-0.0113	-4.3631	-2.2753
C	554.95	939.12	770.88	-137.18	-21.705	-5.8589	-33.633	-3.4325	-8.9022

TABLE 11

APPENDIX E

Computations for Comparison of Kammerer's and Schade's Methods of Deckhouse Analysis with Experimental Data

Basic Nomenclature (Kammerer - Ref. 6)

A_{DE} = equivalent area of deckhouse

A_H = area of hull

B = beam of ship

C_E = distance from the strength deck to the effective neutral axis of hull area and equivalent deckhouse area

C_H = distance from the strength deck to hull neutral axis

D_H = depth of hull

I_E = effective moment of inertia of hull and deckhouse

I_H = moment of inertia of hull

K_3 = shear lag factor

L = length of ship

M = bending moment generated by external forces

M_{DE} = statical moment of the equivalent area of the deckhouse about the effective neutral axis

b = width of deckhouse

h = height of deckhouse

ℓ = length of deckhouse

ℓ_E = effective length of deckhouse

σ_D = longitudinal stress at the strength deck

σ_K = longitudinal stress at the keel

σ_T = longitudinal stress at top of deckhouse

Basic Nomenclature (Schade - Ref. 10)

The external loading is applied to the primary member (the hull) identified by the subscript 1; the "following" member (deckhouse or superstructure) is identified by the subscript f.

σ_1 and σ_f	longitudinal stress in sides (x-direction)
$\bar{\sigma}_1$ and $\bar{\sigma}_f$	longitudinal stress in sides at deck (x-direction)
p_1 and p_f	average longitudinal stress (x-direction)
M_1 and M_f	stress moment
S_1 and S_f	section modulus referred to deck
E_1 and E_f	material modulus - normal
G_1 and G_f	material modulus - shear
A_1 and A_f	effective section area including webs and flanges ($A = A_1 + A_f$)
a_1 and a_f	section area (webs only)
I_1 and I_f	section moment of inertia
q_1 and q_f	vertical load/unit length ($q = q_1 + q_f$)
w_1 and w_f	vertical deflection (+ down)
Q_1 and Q_f	vertical shear force ($Q = Q_1 + Q_f$)
e_1 and e_f	distance from bond to individual N.A. ($e = e_1 + e_f$)
z_1 and z_f	vertical coordinate distance from individual N.A. (+ down)
$2b$	beam of hull
y	transverse coordinate distance from centerline
k	spring constant of hull at bond
$\bar{N}$	longitudinal shear flow in deckhouse at bond
$\textcircled{k}$	shear deflection factor
M	bending moment generated by external forces
m	constant component of bending moment

a	amplitude of sinusoidal component of bending moment
F_x	longitudinal external force on hull
2λ	length of deckhouse
ρ	effectiveness ratio

Parameters Used for Computations

$$B \equiv \frac{A_1 r S_f}{(A_1 + rA_f)S_1 S_f + A_1 A_f (e_f S_1 + e_1 r S_f)}, \text{ in.}^{-3} \qquad \text{[E-1]}$$

$$C \equiv \frac{A_1 (re_1 + e_f)}{(A_1 + rA_f)(I_1 + I_f) + A_1 A_f e (re_1 + e_f)}, \text{ in.}^{-3} \qquad \text{[E-2]}$$

$$\delta \equiv 1 + \frac{\eta}{\omega^2}\left(\frac{\pi}{2\lambda}\right)^2 + \frac{1}{4\omega^4}\left(\frac{\pi}{2\lambda}\right)^4 \qquad \text{[E-3]}$$

$$\theta \equiv 1 + \frac{E}{re_1 + e_f}\left(\frac{I_1 e_f}{a_1 G} + \frac{rI_f e_1}{a_f G}\right)\left(\frac{\pi}{2\lambda}\right)^2 + \frac{E}{re_1 + e_f}\,\frac{rI_f e_1}{k}\left(\frac{\pi}{2\lambda}\right)^4 \qquad \text{[E-4]}$$

$$\omega \equiv \sqrt[4]{\frac{k}{4rI_f}\,\frac{(re_1 + e_f)}{E\,e_1}\,\frac{B}{C}}, \text{ in.}^{-1} \qquad \text{[E-5]}$$

$$\eta = \frac{1}{2G}\left(\frac{1}{a_1} + \frac{1}{a_f}\right)\sqrt{\frac{kErI_f e_1}{(re_1 + e_f)}\,\frac{C}{B}} \qquad \text{[E-6]}$$

$$J^2 = \frac{\omega^2}{\eta} = \frac{1}{\frac{E}{G}\left(\frac{1}{a_1} + \frac{1}{a_f}\right)}\,\frac{(A_1 + A_f r)(I_1 + I_f) + A_1 A_f e (re_1 + e_f)}{(A_1 + A_f r) I_1 I_f + A_1 A_f (I_1 e_f^2 + I_f e_1^2 r)}, \text{in.}^{-2} \qquad \text{[E-7]}$$

$$r = \frac{1}{2}\,\frac{1}{\cosh\frac{\pi b}{2\lambda}}\left(\frac{\pi y}{2\lambda}\sinh\frac{\pi y}{2\lambda} + 2\cosh\frac{\pi y}{2\lambda} - \frac{\pi b}{2\lambda}\tanh\frac{\pi b}{2\lambda}\cosh\frac{\pi y}{2\lambda}\right) \qquad \text{[E-8]}$$

ψ, ϕ Parameters for numerical solution for p_f.

Equations

$$M = m + a \sin \frac{\pi x}{2\lambda} \qquad \text{[E-9]}$$

$$p_f = -C\psi m + [(B\delta - C\theta)\phi - B \sin \frac{\pi x}{2\lambda}]a \qquad \text{[E-10]}$$

$$\bar{\sigma}_1 = -\frac{1}{S_1 - rS_f}[(\frac{A_f}{A_1} S_1 + S_f + A_f e)p_f + M] \qquad \text{[E-11]}$$

$$\bar{\sigma}_f = r\,\bar{\sigma}_1 \qquad \text{[E-12]}$$

$$\sigma_1 = (1 + \frac{z_1}{e_1})p_1 - \frac{z_1}{e_1}\bar{\sigma}_1 \qquad \text{[E-13]}$$

$$\sigma_f = (1 - \frac{z_f}{e_f})p_f + \frac{z_f}{e_f}\bar{\sigma}_f \qquad \text{[E-14]}$$

$$p_1 = -\frac{A_f}{A_1} p_f \qquad \text{[E-15]}$$

DETAILS OF CALCULATION

A. Application of Kammerer's Method to the Model

The hull girder of the model was designed to simulate the midship portion of a Mariner and constructed on a 1:9.5 scale. The corresponding full-scale dimensions are:

$$L = 528'$$
$$B = 76'$$
$$D_H = 44.5'$$

The geometric properties of the hull girder, considered as a simple beam, are:

$$A_H = 50.35 \text{ in}^2$$
$$I_H = 29{,}553 \text{ in}^4$$
$$C_H = 29.49 \text{ in } (C_H = 23.35' \text{ in full-scale})$$

The corresponding full-scale dimensions of the deckhouse are:

$$\ell = \ell_E \simeq 209.15'$$
$$b = 41.76'$$
$$h = 17.76'$$
$$\ell/L = 0.396$$
$$b/\ell = 0.200$$
$$\sigma_T/\sigma_D = 1.33 \text{ for } C_H = 15' \text{ (Kammerer's Fig. 7)}$$
$$\sigma_T/\sigma_D = 1.33 \times 0.842 = 1.13 \text{ for } C_H = 23.35' \text{ (Kammerer's Fig. 8)}$$
$$K_3 = 0.943 \text{ (Kammerer's Fig. 10)}$$

The geometric properties of the deckhouse are:

Item	Actual Area [in^2]	Factors	Equiv. Area [in^2]	Lever [in]	Moment [in^2-in]
2nd Level Dk	10.41	1.13 x 0.943	11.09	22.3	247.3
T-Bars	1.58	1.13 x 0.943	1.68	23.0	38.6
Angles	1.05	1.13	1.19	21.8	25.9
Side Plating	4.31	1.09	4.70	16.1	75.7
1st Level Dk	9.75	1.06 x 0.943	9.75	11.0	107.2
T-Bars	1.58	1.06 x 0.943	1.58	11.7	18.5
Angles	1.05	1.06	1.11	10.5	11.7
Side Plating	3.75	1.03	3.86	5.0	19.3

$A_{DE} = 34.96$

$*C_E = 17.4$ 608.3

$M_{DE} = 1152.5$

$$*C_E = \frac{A_H C_H}{A_H + A_{DE}} = \frac{50.35 \times 29.49}{50.35 + 34.96} = 17.4 \text{ in}$$

$$I_E = I_H + A_H(C_H - C_E)^2 + M_{DE}C_E$$

$$= 29{,}553 + 50.35(29.5 - 17.4)^2 + 1152.5(17.4)$$

$$I_E = 56{,}979 \text{ in}^4$$

For bending moment B, $M = 9.123 \times 10^6$ lbs-in at midship. Therefore:

$$\sigma_D = \frac{-MC_E}{I_E} = \frac{-9.123 \times 10^6 \text{lb-in } (17.4 \text{ in})}{56{,}979 \text{ in}^4} = -2786 \text{ psi}$$

$$\sigma_T = \left(\frac{\sigma_T}{\sigma_D}\right)\sigma_D = 1.13(-2786 \text{ psi}) \qquad = -3148 \text{ psi}$$

$$\sigma_K = \frac{M(D_H - C_E)}{I_E} = \frac{9.123 \times 10^6 \text{lb-in}(56.0 - 17.4)\text{in}}{56{,}979 \text{ in}^4} = +6180 \text{ psi.}$$

Above results are plotted in Figure 28.

B. Application of Schade's Method to the Model

$m = 4.482 \times 10^6$ lbs-in, $a = 4.641 \times 10^6$ lbs-in (moment B)

$k = 6.50 \times 10^2$ psi (all stanchions loose)

$k = 3.40 \times 10^4$ psi (all stanchions fixed)

Effective Geometric Properties:

		For Constant B.M.	For Sinusoidal B.M.
r	[Eq.E-8]	1.00 [Ref.5]	0.81
ρ_1	[Ref. 8]	1.00	0.82
a_1	in^2	17.56	17.56
A_1	in^2	50.35	44.45
e_1	in	29.49	29.39
I_1	in^4	29,553	25,008
S_1	in^3	1002.1	850.9
ρ_f	[Ref. 8]	0.93	0.93
a_f	in^2	10.16	10.16
A_f	in^2	31.85	31.85

Effective Geometric Properties: (cont.)

		For Constant B.M.	For Sinusouidal B.M.
e_f	in	15.34	15.34
I_f	in^4	1221	1221
S_f	in^3	79.6	79.6

Computation Parameters

B	[Eq.E-1]	1.146×10^{-4}		1.106×10^{-4}	
C	[Eq.E-2]	3.923×10^{-4}		4.026×10^{-4}	
J	[Eq E-7]	2.996×10^{-2}		3.021×10^{-2}	
k		6.50×10^2	3.40×10^4	6.50×10^2	3.40×10^4
ω	[Eq.E-5]	6.663×10^{-3}	1.792×10^{-2}	6.691×10^{-3}	1.799×10^{-2}
$2\lambda\omega$		1.76	4.73	1.77	4.75
η	[Eq.E-6]	0.049	0.358	0.049	0.354
δ	[Eq.E-3]			3.657	1.203
θ	[Eq.E-4]			1.921	1.246
ψ	[Fig. 7 Ref.10]	0.112	0.879		
ϕ	[Fig. 8 Ref.10]			0.091	0.751

Therefore the stresses at the midlength of the deckhouse are:

a) for constant B.M. alone:

	$k = 6.50 \times 10^2$ psi	$k = 3.40 \times 10^4$ psi
p_f [$=-C\psi m$]	-197 psi	-1545 psi
p_1 [Eq.E-15]	+125 "	+978 "
$\bar{\sigma}_1$ [Eq.E-11]	-4385 "	-1266 "
$\bar{\sigma}_f$ [Eq.E-12]	-4385 "	-1266 "
σ_1 (keel) [Eq.E-13]	+4179 "	+2995 "
σ_f (top) [Eq.E-14]	+1704 "	-1672 "

b) for sinusoidal B.M. alone:

	$k = 6.50 \times 10^2$ psi	$k = 3.40 \times 10^4$ psi
p_f	-669 psi	-1798 psi
p_1	+480 "	+1288 "
$\bar{\sigma}_1$	-4097 "	-1069 "
$\bar{\sigma}_f$	-3319 "	-866 "
σ_1(keel)	+4621 "	+3421 "
σ_f(top)	+534 "	-2221 "

Superimposing (a) and (b), we obtain the total stresses for the combination bending moment:

$\bar{\sigma}_1$	-8482 psi	-2335 psi
$\bar{\sigma}_f$	-7704 "	-2132 "
σ_1(keel)	+8800 "	+6416 "
σ_f(top)	+2238 "	-3893 "

Above results are plotted in Figure 28.

Equations for Schade's Method Using "n" Terms of Moment Expansion

$$r_n = \frac{1}{2} \frac{1}{\cosh^2 \frac{n\pi b}{2\lambda}} \left[\frac{n\pi y}{2\lambda} \sinh \frac{n\pi y}{2\lambda} + 2 \cosh \frac{n\pi y}{2\lambda} - \frac{n\pi b}{2\lambda} \cosh \frac{n\pi y}{2\lambda} \tanh \frac{n\pi b}{2\lambda} \right] \qquad \text{[E-8A]}$$

$$M = m + \sum a_n \sin \frac{n\pi x}{2\lambda} \qquad \text{[E-9A]}$$

$$p_f = \alpha_1 \cos \gamma x \cosh \beta x + \alpha_2 \cos \gamma x \sinh \beta x + \alpha_3 \sin \gamma x \cosh \beta x$$

$$+ \alpha_4 \sin \gamma x \sinh \beta x - Cm - \sum C_n \frac{\theta n}{\delta_n} a_n \sin \frac{n\pi x}{2\lambda} \qquad \text{[E-10A]}$$

where,

$$\gamma = \omega \sqrt{1 - \eta} \qquad \beta = \omega \sqrt{1 + \eta} \qquad \text{[E-16A]}$$

$$\delta_n \equiv 1 + \frac{\eta}{\omega^2} \left(\frac{n\pi}{2\lambda}\right)^2 + \frac{1}{4\omega^2} \left(\frac{n\pi}{2\lambda}\right)^4 \qquad \text{[E-3A]}$$

and

$$\theta_n \equiv 1 + \frac{E}{r_n e_1 + e_f} \left[\frac{I_1 e_f}{a_1 G} + \frac{r_n I_f e_1}{a_f G} \right] \left(\frac{n\pi}{2\lambda}\right)^2$$

$$+ \frac{E}{r_n e_1 + e_f} \frac{r_n I_f e_1}{k} \left(\frac{n\pi}{2\lambda}\right)^4 \qquad \text{[E-4A]}$$

all other nomenclature, parameters and equations remain unchanged.