View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by NASA Technical Reports Server

N93-29779

VI. SELECTION AND STATIC CALIBRATION OF THE MARSH J1678 PRESSURE GAUGE

Charles R. Oxendine
Graduate Student

Howard W. Smith
Professor
Department of Aerospace Engineering
University of Kansas

March 1986

Partially supported by
NASA Langley Research Center
Grant #NAG 1-345

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

SUMMARY

During the experimental testing of the ultralight, it was determined that a pressure gauge would be required to monitor the simulated flight loads. After analyzing several factors, which are indicated in the discussion section of this report, the Marsh J1678 pressure gauge appeared to be the prominent candidate for the task. However, prior to the final selection the Marsh pressure gauge was calibrated twice, using two different techniques. As a result of the calibration, the Marsh gauge was selected as the appropriate measuring device during the structural testing of the ultralight.

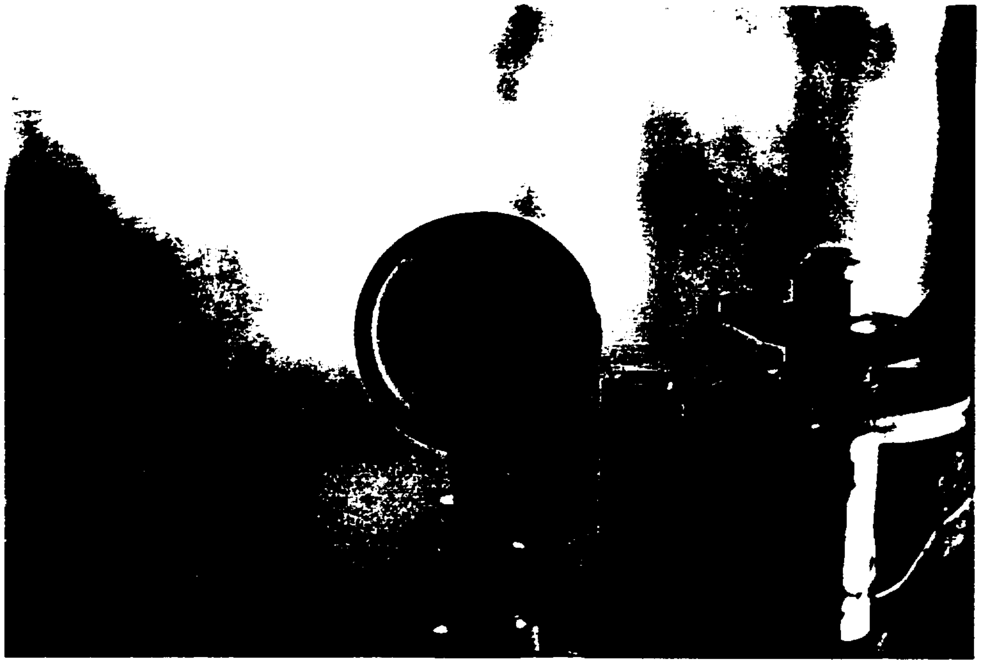
Although, there are commerical pressure gauges available on the market that would have proven to be more efficient and accurate. However in order to obtain these characteristics in a gauge, one has to pay the price on the price tag, and this value is an exponential function of the degree of accuracy efficiency, precision, and many other features that may be designed into the gauge. After analyzing the extent of precision and accuracy that would be required, a more expensive gauge wouldn't have proven to be a financial benefit towards the outcome of the experiment.

INTRODUCTION

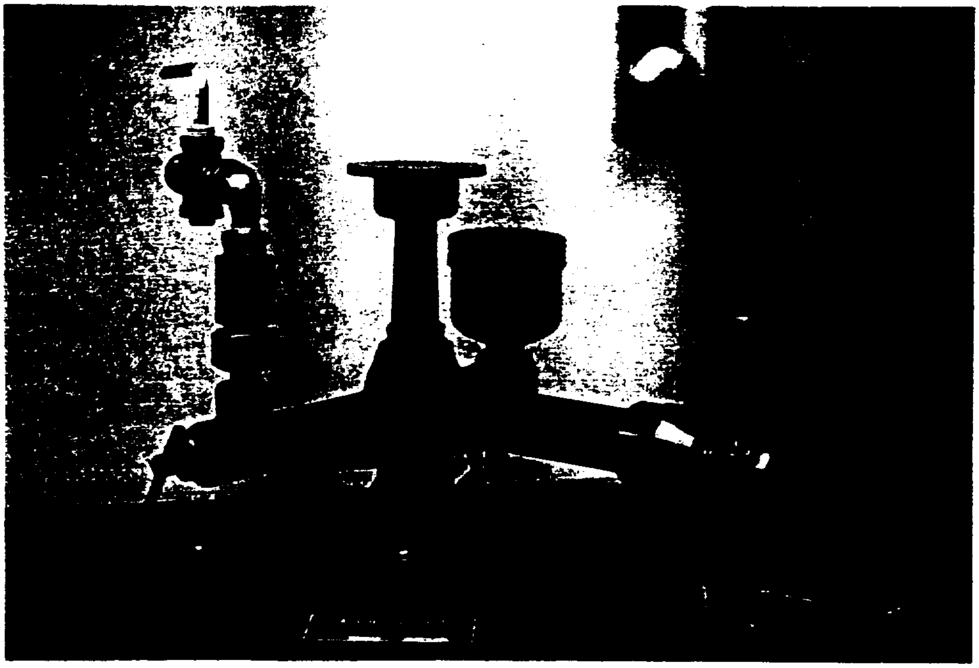
There are several manufactures that design and produce a large variety of measuring devices with specific capabilities that are predetermined for each instrument.

there
The~~ir~~ are two primary objectives of this report. First, it will justify the logical deductions that lead to the selection of the Marsh J1678 pressure gauge as the measuring instrument to monitor the experimental loads that would be exerted on the structure of the ultralight at any given time. Second, it will indicate the two different techniques that were used to calibrate the Marsh pressure gauge, and the margin of error thats associated with each reading as a result of each calibration.

Also, this report was written in partial fulfillment of course requirements in A.E. 592. This report is rated with a worth of 3/4 of a semester hour out of the two hours of A.E. 592.



MARSH PRESSURE GAUGE
Figure 1



ASHCROFT TESTER
Figure 2

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

Calibration Process

There were two calibration tests performed on the Marsh J1678 pressure gauge prior to its acceptance as an experimental measuring device. The first test was completed with an Ashcroft dead weight tester (model no. 1300, and serial no. 1788).

The following procedures were used during the test process and are illustrated in Figure (5) in Appendix (B).

1 - The reservoir was filled with a light mineral oil.

2 - Value B was retracted, so that the compression cylinder could be filled with mineral oil from the resevoir.

3 - The Marsh pressure gauge was connected to the Ashcroft tester at point E.

4 - Value B was closed to prevent the mineral oil from escaping back into the reservoir.

5 - Value D was opened to expose the port of the pressure gauge to the mineral oil contained in the compression cylinder.

6 - Weights of desired increments were added to the platform of piston F.

7 - Value H was screwed until the piston floated freely approximately two inches above cylinder G.

8 - The platform was spun.

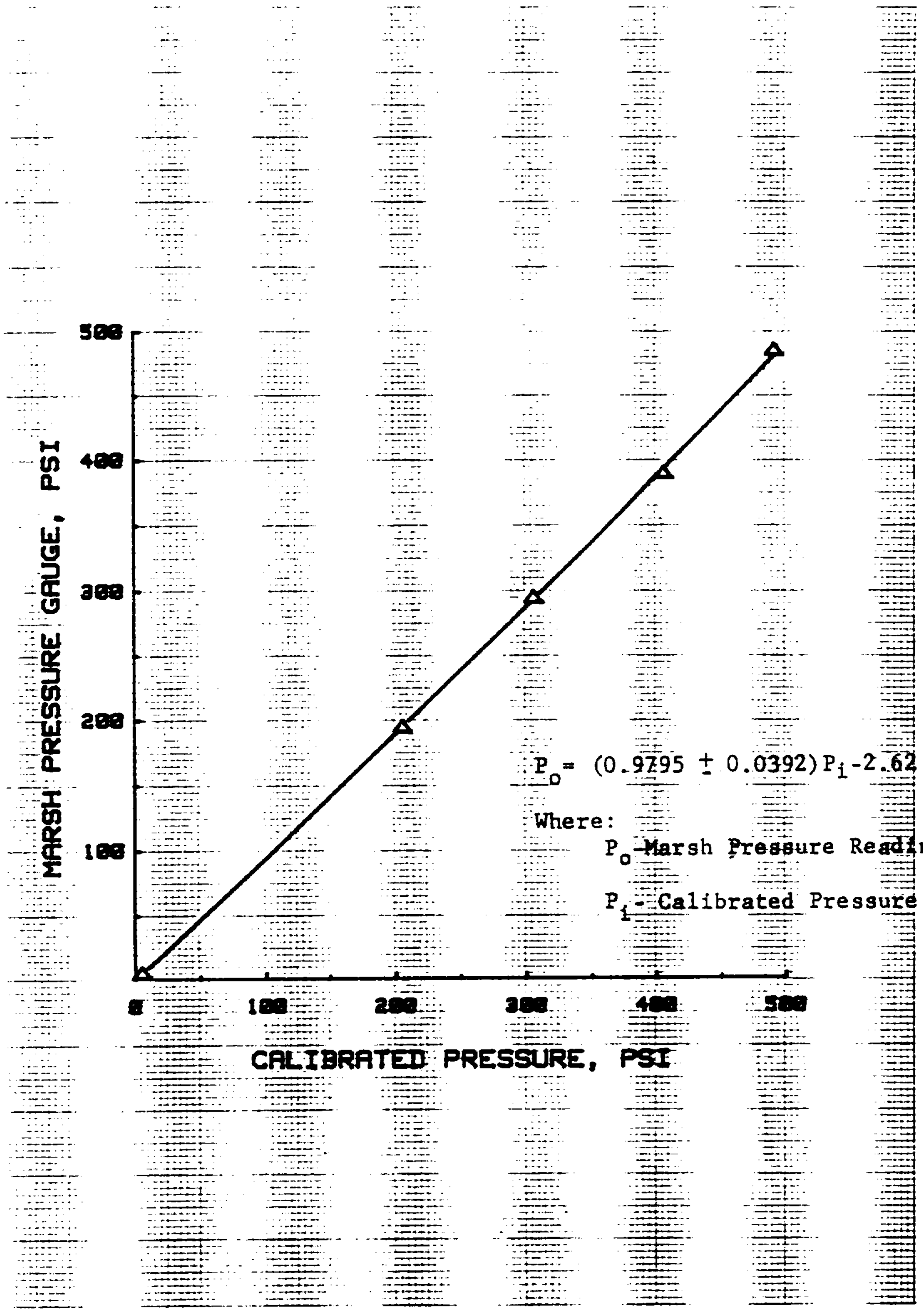
9 - A pressure reading was read from the pressure gauge.

After each incremental weight increase, the steps that followed the addition of weights were compiled. With the Ashcroft dead weight tester, the Marsh pressure gauge was calibrated up to 500 psi. Even though the tester had the capability of calibrating a gauge above 500 psi, the accessories that were required to continue the calibration process were not available. The calibration data can be observed in Table 1 and Figure 3.

ASHCROFT DEAD WEIGHT TEST LAB RESULTS

	CALIBRATED PRESSURE (PSI)	GAUGE READING (PSI)
1.	5	5
2.	205	200
3.	305	290
4.	405	390
5.	490	485

TABLE I



?

$P_o = (0.9795 \pm 0.0392)P_i - 2.62 \pm 12.78$

Where:

P_o - Marsh Pressure Reading

P_i - Calibrated Pressure

$P_o < 500$

CALC	OXENDINE	03/86	REVISED	DATE	ASHCROFT DEAD WEIGHT TESTER CALIBRATION CURVE FOR THE MARSH PRESSURE GAUGE	A.E.592
CHECK						FIGURE 3
APPD						
APPD					UNIVERSITY OF KANSAS	PAGE 6

CALIBRATION PROCESS (CONTINUED)

The second calibration was accomplished by using the facilities at Richards-Gebaur Air Force Base in Missouri.

Initially the test equipment was prepared for testing. The steps that were involved in preparing the test equipment are outlined in appendix B. Once the equipment was ready, the calibration process was completed by using the following steps:

A) Isolate the gauge from the test stand system by closing the associated shut off valve.

B) Using an independent source of pressure connected to a master gauge of known accuracy, connect this pressure source to the test port of the gauge to be calibrated.

C) Remove the ring and glass from the gauge and use a screwdriver and adjust the position of the pointer by turning the self-locking worn adjustment screw

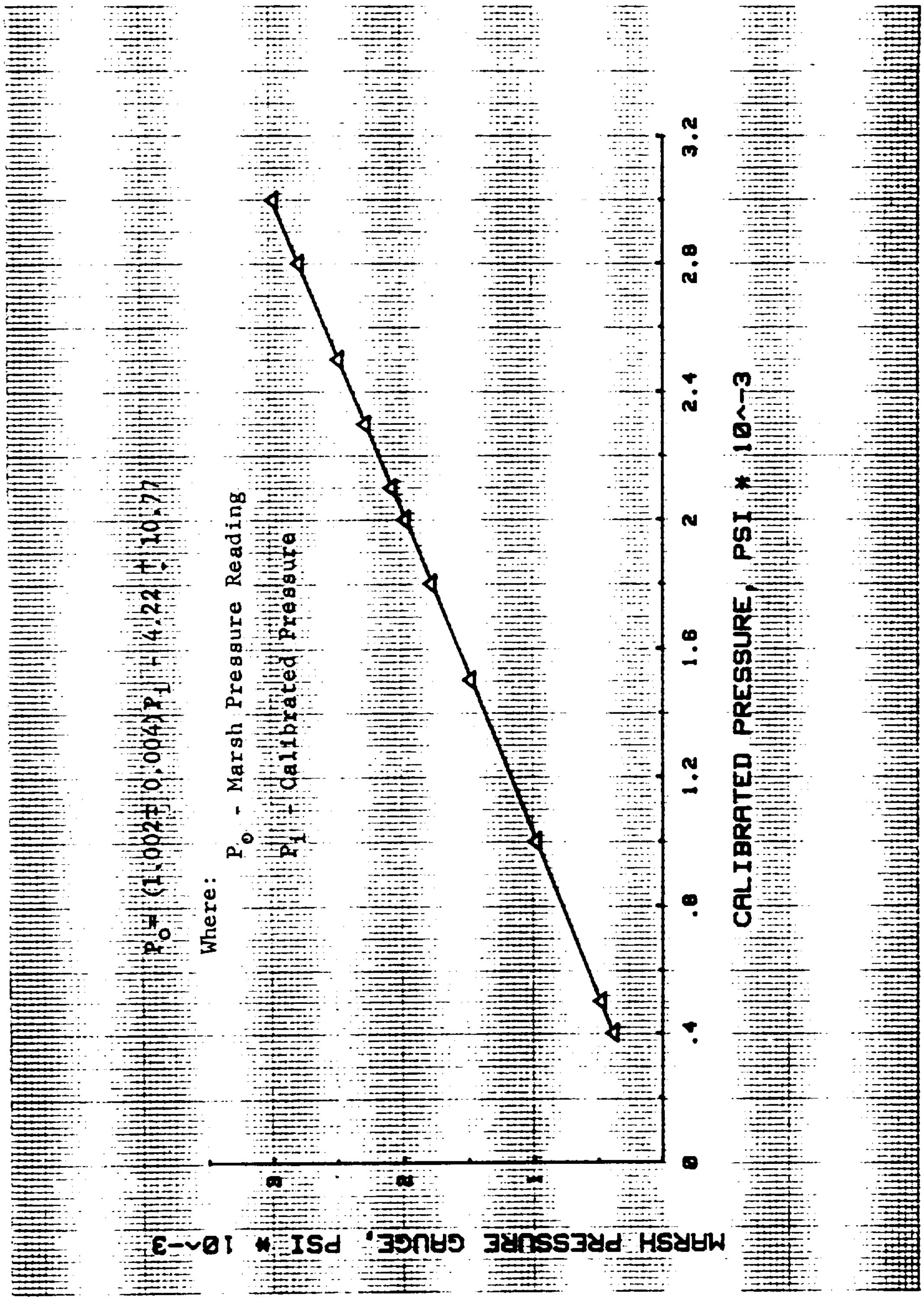
D) Then check the calibration of the pressure gauge at several different pressures, when the adjustment is satisfactory replace the glass and ring

However, when the Marsh pressure gauge was tested, the gauge didn't need to be adjusted, and this fact can be observed from the data that was obtained during the calibration process at Richard Gebaur. This data can be observed in TABLE II, and the calibration curve can be observed in figure 4.

RICHARDS GEBAUR CALIBRATION RESULTS

	CALIBRATED PRESSURE (PSI)	INDICATED GAUGE PRESSURE (PSI)
1.	400	395
2.	500	495
3.	1000	1000
4.	1500	1500
5.	1800	1800
6.	2000	2000
7.	2100	2100
8.	2300	2300
9.	2500	2500
10.	2800	2800
11.	3000	3000

TABLE II



			REVISED	DATE
CALC	VEENDINE	08/21/85		
CHECK				
APPD				
APPD				

CALIBRATION CURVE
FOR
MARSH PRESSURE GUAGE

UNIVERSITY OF KANSAS

A.E. 592

FIGURE 4

DISCUSSION

When a pressure gauge or any other measuring device is being considered for a particular task, several factors have to be analyzed to ensure that the proper gauge has been selected for the job. Because, if the time is not taken to properly analyze these factors, complications as well as inaccuracies can result directly from an improper selection. From the available gauges, the Marsh J1678 pressure gauge was preferred over the other models and brands.

Our decision was based on several factors which included the gauges's operating environment, readability, accuracy, measuring range, recalibration capabilities and versitility for future usages.

Readability During experimental testing the scale on the measuring instrument should be highly visible and relitively easy to comprehend. On the Marsh pressure gauge the scale is marked with slashes in 100 psi increments. The face on the dial gauge has a white enamel background with slashes and numerical values painted in black enamel. The needle is also painted black which enhances the reader's ability to accurately interpret the correct pressure.

Accuracy In experimental testing the degree of accuracy in the laboratory data is an extremely important consideration. Therefore, methods should be developed and practiced in the lab to enhance the accuracy of experimental data, as long as the results of the experiment are more important than the cost. The Marsh company publishes a handbook on standard gauges. This book shows that the Marsh J1678 gauge has a margin of +/- 2% error for the middle half of the scale, and +/- 3% for the remaining half. From Appendix A, it is evident that the margin of error is much less than either 2 or 3 percent, except at pressures below 175 psi.

Measuring Range The measuring range is a factor that can be easily over looked when selecting the proper gauge. However, through a theoretical analysis, it was determined that the ultralight structure could withstand approximately up to four G's, which is equivalent to 600 psi, prior to catastrophic failure. With this information, the range of loads that are of interest can be determined and used in selecting the proper gauge. On the Marsh pressure gauge, the effective range is from approximately 750 psi to 2250 psi, which is the middle half of the gauge.

Recalibration When recalibrating a pressure gauge it is beneficial to have the ability to adjust the location of the pointer so that it can be re-adjusted to rest within the zero band when the pressure applied to the gauge is zero. The Marsh pressure gauge includes a zero band denoting that the pointer may fall anywhere within this band when the gauge is properly calibrated. In addition the gauge is designed in such a way that the needle can be adjusted within a limited range so that a seriously damaged instrument can not be falsely recalibrated.

Vers~~i~~tility When a gauge is selected for vers~~i~~atility a decision has to be made as to whether the gauge will be used for a specific task or for a variety of tasks. If the selection was based on a specific task then, gauge vers~~i~~tility can be limited. However, if the gauge was selected based on a variety of tasks, then the gauge will have to be vers~~i~~tile in order to be used efficiently. When the Marsh pressure gauge was selected, the selection was based mainly on precision and accuracy. Even though vers~~i~~tility was not a deciding factor, the manufacturer designed the gauge with vers~~i~~tility in mind. The universal design features of the Marsh pressure gauge can be observed in Table V. sp

CONCLUSION

From the limited selection of gauges that were readily available the Marsh J1678 pressure gauge was selected as the proper gauge for the task. However, there are gauges on the market that would have proven to be more efficient in accomplishing the same task. Also, it is evident from Figure 1 that accurate scale reading will be difficult to obtain. Although the margin error (inaccuracy) is not suspected to exceed +/- 10 psi. Although even with this error and after analyzing the extent of accuracy that is required during experimental testing, in conjunction with the capabilities of the Marsh pressure gauge, it was concluded that the Marsh gauge would be an acceptable measuring device.

In determining the accuracy and precision of the Marsh instrument, the Gaussian distribution method was used and the calculations are outlined in Appendix A.

The results of the Gaussian distribution for the +/- 3s approach are as follows:

FOR THE DEAD WEIGHT TESTER

$$P_o = (0.9795 \pm 0.0392)P_i - 2.62 \pm 12.78$$

FOR THE HYDRAULIC TESTER

$$P_o = (1.002 \pm 0.004)P_i - 4.22 \pm 10.77$$

Where: P_o - Marsh Pressure Reading (out-put)

P_i - Calibrated Pressure (in-put)

APPENDIX A

(CALIBRATION CALCULATIONS)

CALIBRATION CALCULATIONS

In the calibrating a pressure gauge the relationship between the calibrated input pressure and the output (Gauge Reading) pressure is ideally a straight line. However in reality nothing is perfect. Although the calibration curve is still considered to be a straight line. This line was determined through the least squares method. This method minimizes the sum of the squares of the vertical deviations of the data points from the fitted curve.

USING THE LEAST SQUARES METHOD

$P_O = MP_i + B$

Where:

P_o - Output Quantity

P_i - Input Quantity

M - Sole Of The Line

B - Intercept of the Line On the Vertical Axis

$$M = \frac{N \Sigma P_i P_o - (\Sigma P_i)(\Sigma P_o)}{N \Sigma P_i^2 - (\Sigma P_i)^2}$$

$$B = \frac{(\Sigma P_o)(\Sigma P_i)^2 - (\Sigma P_i P_o)(\Sigma P_i)}{N \Sigma P_i^2 - (\Sigma P_i)^2}$$

Where: N is the total number of data points.

STANDARD DEVIATION

$$S_m^2 = \frac{N\ S_{P_o}^{\ 2}}{N\sum P_i^{\ 2} - (\sum P_i)^2}$$

$$S_b^2 = \frac{S_{P_o} \sum P_i^2}{N \sum P_i^2 - (\sum P_i)^2}$$

The numerical values of the mean and standard deviation were calculated for both calibration processes. The data that was substituted into the above equations were obtained from Table III and IV

Where:

$$S_{P_o}^{\ 2} = \frac{1}{N} (\sum M_{P_i} + B - P_o)^2$$

FOR THE ASHCROFT TEST

MEAN

$$M = \frac{(5)(5.25\text{X}10^5) - (1405)(1365)}{(5)(5.39\text{X}10^5) - (1405)^2}$$

$$= \frac{7.072\text{X}10^5}{7.219\text{X}10^5} = 0.9795$$

$$B = \frac{(1365)(5.39\text{X}10^5) - (5.25\text{X}10^5)(1405)}{7.219\text{X}10^5}$$

$$= \frac{-1.89\text{X}10^6}{7.219\text{X}10^5} = -2.62$$

STANDARD DEVIATION

$$S_m = \left(\frac{(5)(123.66)}{7.219\text{X}10^5}\right)^{1/2} = 1.308\text{X}10^{-2}$$

FOR 3s, $S_m = \pm 3.92\ \text{X}10^{-2}$

$$S_b = \left(\frac{(123.66)^2(5.39X10^5)}{7.219\ X10^5}\right)^{1/2} = 4.26$$

FOR 3s, $S_b = \pm 12.78$

FOR THE RICHARDS GEBAUR HYDRAULIC TEST

MEAN

$$M = \frac{(11)(4.368X10^7)\ -\ (1.989X10^4)(1.991X10^4)}{(11)(4.369\ X10^7)\ -\ (1.991X10^4)^2}$$

$$= \frac{8.474\ X10^7}{8.458\ X10^7} = 1.002$$

$$B = \frac{(1.989\ X10^4)(4.36\ X10^7)\ -\ (4.368\ X10^7)(1.991\ X10^4)}{8.458\ X10^7}$$

$$= \frac{-3.573\ X10^8}{8.458\ X10^7} = -4.22$$

STANDARD DEVIATION

$$S_m = \left(\frac{(11)(161.49)}{8.458\ X10^7}\right)^{1/2} = 1.38\ X10^{-3}$$

For 3s, $S_m = 4.14\ X10^{-3}$

$$S_b = \left(\frac{(161.49)\ (4.369X10^6)}{8.458\ X10^7} \right)^{1/2}$$

$= 3.589$ <u>For 3s,</u> $S_m = 10.77$

CALCULATED DATD OF THE ASHCROFT TSET

	P_i	P_o	P_iP_o	P_i^2	P_o^2
	5	5	25.0	25.0	25.0
	205	200	4.1 X10^{4}	4.2X10^{4}	4.0X10^{4}
	305	290	8.85X10^{4}	9.30X10^{4}	8.41X10^{4}
	405	390	1.58X10^{4}	1.64X10^{4}	1.52X10^{5}
	490	485	2.38X10^{5}	2.41X10^{5}	2.35X10^{5}
Σ	1405	1365	5.25X10^{5}	5.39X10^{5}	5.12X10^{5}

TABLE III

CALCULATED DATA OF RICHARD GEBAUR HYDRAULIC TEST

	P_i	P_o	P_iP_o	P_i^2	P_o^2
	400	395	1.58×10^5	1.61×10^5	1.56×10^5
	500	495	2.48×10^5	2.50×10^5	2.45×10^5
	1000	1000	1.00×10^6	1.00×10^6	1.00×10^6
	1500	1500	2.25×10^6	2.25×10^6	2.25×10^6
	1800	1800	3.24×10^6	3.24×10^6	3.24×10^6
	2000	2000	4.00×10^6	4.00×10^6	4.00×10^6
	2100	2100	4.41×10^6	4.41×10^6	4.41×10^6
	2300	2300	5.29×10^6	5.29×10^6	5.29×10^6
	2500	2500	6.25×10^6	6.25×10^6	6.25×10^6
	2800	2800	7.84×10^6	7.84×10^6	7.84×10^6
	3000	3000	9.00×10^6	9.00×10^6	9.00×10^6
Σ	1.99×10^4	1.989×10^4	4.369×10^7	4.369×10^7	4.368×10^7

TABLE IV

APPENDIX B

(CALIBRATION PROCEDURES)

ASHCROFT DEAD WEIGHT GAUGE TESTER

TYPE 1300

DIRECTIONS FOR USING

FILL RESERVOIR "A" WITH A LIGHT GRADE OF MINERAL OIL (ABOUT S.A.E. 20), OR GLYCERINE. WATER SHOULD ONLY BE USED WHERE IT IS MANDATORY, SUCH AS TESTING OF OXYGEN GAUGES.

TO FILL COMPRESSION CYLINDER "C", CLOSE VALVE "D", OPEN VALVE "B", AND BACK OUT COMPRESSION SCREW "H".

CONNECT GAUGE TO BE TESTED AT "E", CLOSE VALVE "B", AND OPEN VALVE "D". PLACE THE DESIRED WEIGHTS ON WEIGHT PLATFORM OF PISTON "F", AND SCREW IN "H", UNTIL PISTON "F", AND THE WEIGHTS ARE FLOATING FREELY ABOUT 2" ABOVE THE CYLINDER "G".

FOR TESTERS UP TO 500 LBS. CAPACITY THE PISTON AND WEIGHT PLATFORM ALONE PRODUCE THE FIRST 5 LBS. OF PRESSURE; THEREFORE, IF TWO 10 LB. WEIGHTS ARE PLACED ON THE PLATFORM, 25 LBS PRESSURE IS PRODUCED.

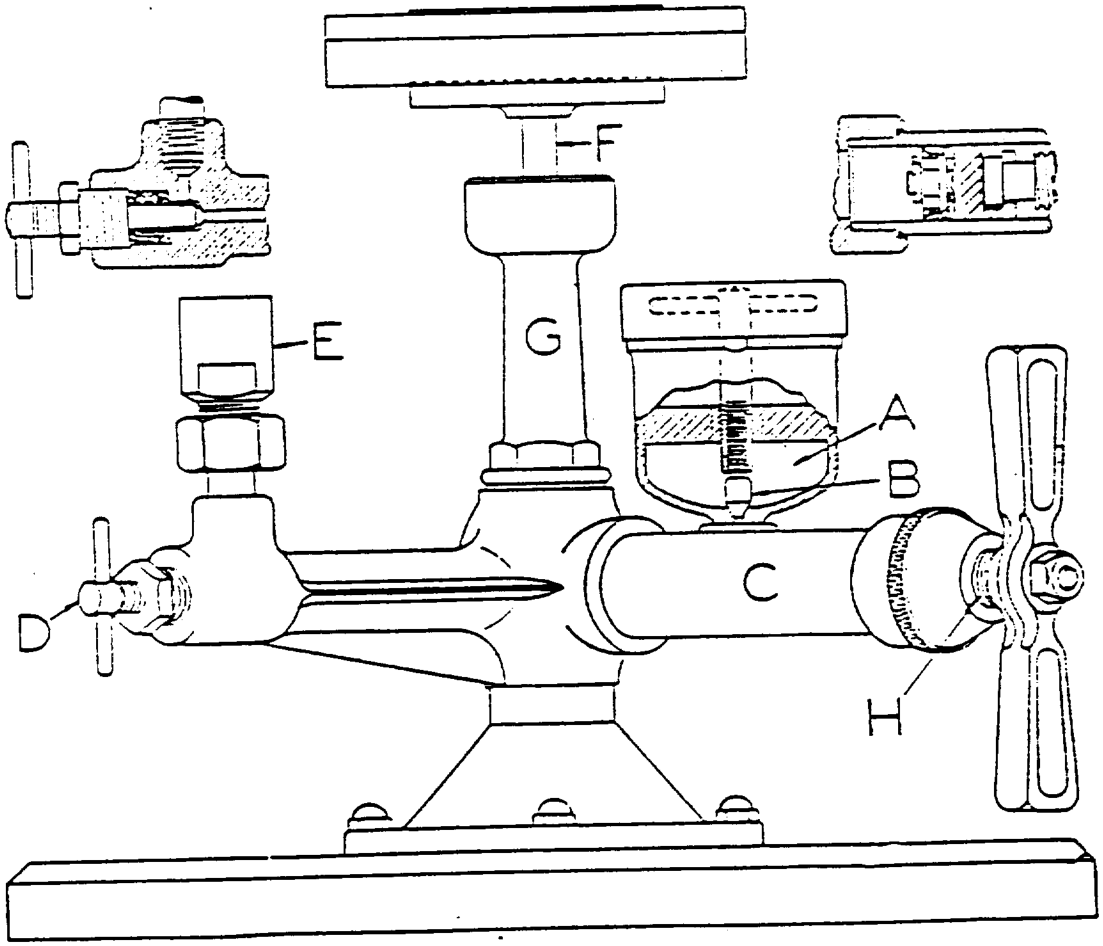
FOR TESTERS ABOVE 500 LBS. CAPACITY, A SMALLER PISTON "F", IS USED, AND THE PISTON AND WEIGHT PLATFORM ALONE PRODUCE THE FIRST 10 LBS. OF PRESSURE.

WEIGHTS AND PISTONS MUST BE KEPT REVOLVING BY HAND DURING TESTS

BEFORE DISCONNECTING THE GAUGE, BACK OUT THE COMPRESSION SCREW "H", THUS RELEASING PRESSURE AND LOWERING WEIGHTS. TO INSURE THAT NO PRESSURE IS REMAINING, VALVE "B" MAY BE OPENED. CLOSE "B" BEFORE MAKING NEW TEST.

VALVE "D" IS ORDINARILY LEFT OPEN AFTER COMPRESSION CYLINDER "C" HAS BEEN ORIGINALLY FILLED. IT IS ONLY CLOSED WHEN RE-PRIMING CYLINDER "C" AND IF GAUGE IS IN PLACE, WILL THUS RETAIN ANY PRELIMINARY PRESSURE WHICH HAS BEEN PRODUCED IN THE GAUGE.

SUITABLE WRENCHES, TOOLS, ETC. ACCOMPANY THE TESTER FOR CONNECTING GAUGE AND MAKING ADJUSTMENTS.



MADE ONLY BY

ASHCROFT GAUGE DIVISION

OF

MANNING, MAXWELL & MOORE INC.

BRIDGEPORT CONNECTICU

Figure V

SECTION VII
CALIBRATION

7-1. GENERAL.

7-2. A calibration check is required every 180 days, however, calibration of the complete test stand as a unit is not considered practical. Refer to paragraph 3-5 for the initial adjustments to be made before operation of the test stand.

7-3. FLUID TEMPERATURE CONTROLLER. (15, figure 4-2.)

7-4. To adjust the fluid temperature controller, proceed as follows:

CAUTION

> The fluid temperature controller requires clean, dry, oil free air at 18 to 20 psi. A piece of hard paper (lint free) placed between the nozzle (10, figure 7-1) and the flapper (9) will show the presence of moisture, oil, or dirt. Add dryers or filters to the air supply line as required to obtain clean dry air before operating or calibrating the temperature controller. Be sure the flapper is lined up with the nozzle and makes a square contact.

a. Turn on air and drain filter (15, figure 4-7) through its drain valve. Adjust pressure regulator (6) to 20 psi supply pressure as shown on supply gage (15, figure 7-1). Set red index pointer (1) at 100°F by turning index setting knob (6).

b. Operate the test stand to pump oil past the sensing element of the temperature controller (refer to paragraph 4-5 and step j of paragraph 3-5 for this operating procedure).

c. Observe the operation of the temperature controller.

Note

> Temperature control processes respond slowly (as compared with pressure). Be sure that the period of observation is of sufficient length for the controller to respond to changes in oil temperature. Also, the position of the sensing element in the hydraulic circuit will cause long delays in adjusting due to load changes.

d. If observation of the temperature controller shows that the controlled temperature cycles too much, proceed as follows:

(1) Turn proportional band adjustment (12, figure 7-1) with a screwdriver to increase (widen) the proportional band in steps until the controller is just stable.

(2) Then increase the setting by half for a margin of stability.

e. If observation of the temperature controller shows that the controlled temperature is sluggish or wandering, proceed as follows:

(1) Turn proportional band adjustment (12) with a screwdriver to decrease the proportional band in steps until measurement is jittery or just cycles a bit.

(2) Increase proportional band until control is stable.

(3) Then increase the setting by half for a margin of stability.

Note

> An attempt to secure a fine operating adjustment which is just stable under the operating conditions of the moment is not advised since slightly changed operating conditions will probably result in instability and cycling.

f. Normal adjustment of the temperature controller should not require excessive adjustment. If the process being controlled is subject to extreme temperature changes or frequent shut-downs and start-ups the temperature controller should be observed through the period of upset to make certain that it remains stable.

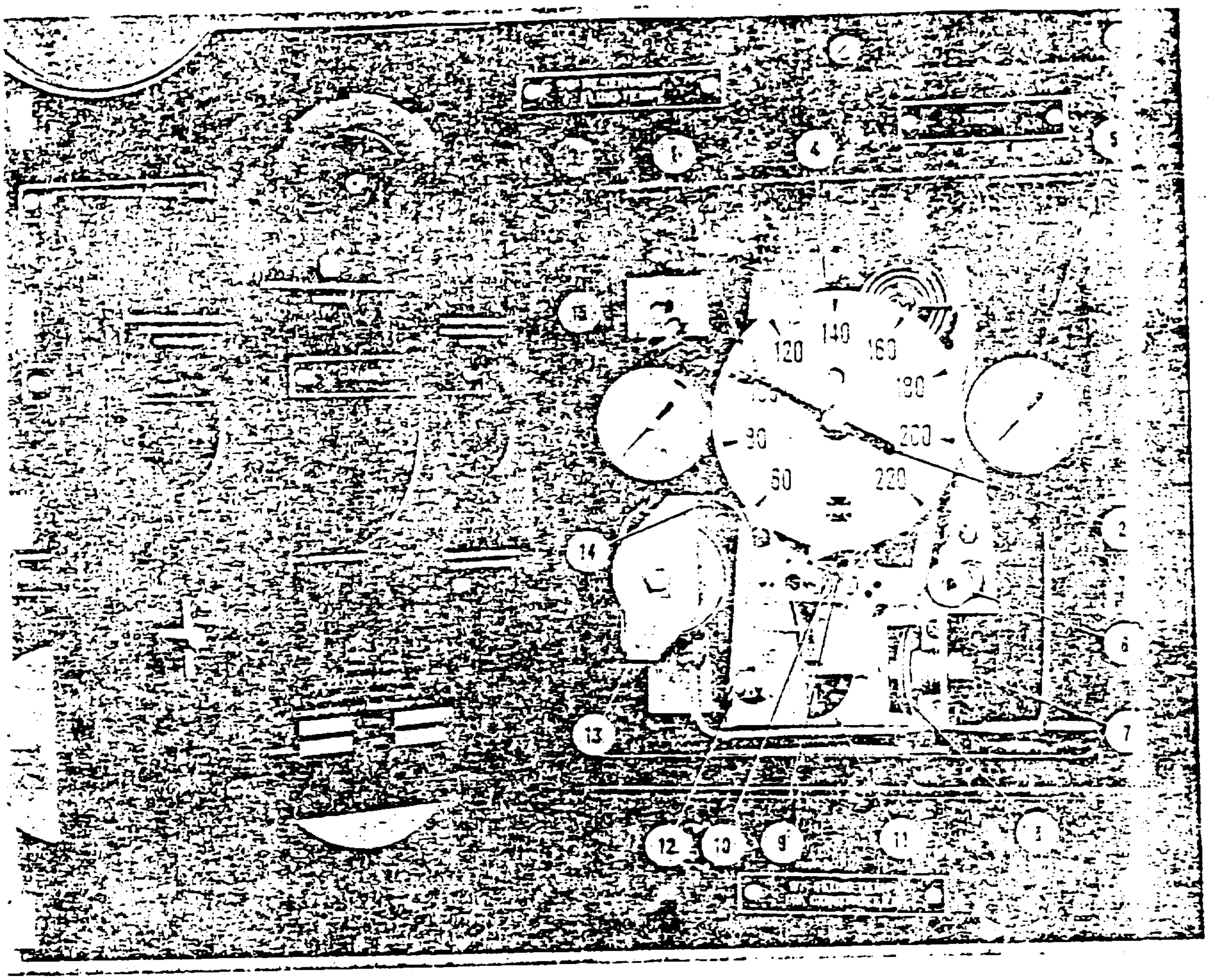
g. If continued adjustment does not bring the process under control, refer to the trouble shooting table in Section VI and check for erratic behavior in the hydraulic system, water system, and temperature controller. To determine if the controller or the process is at fault, operate the controller manually as follows:

(1) Set red index pointer (1) well above black indicating pointer (2) and above the desired temperature of the hydraulic fluid.

(2) Adjust the air supply pressure regulator valve to vary the pressure on the controller diaphragm and thus manually regulate the action of the controller.

(3) When temperature stabilizes at desired value, record the pressure on the output gage (5).

(4) Move the red index pointer (1) back toward the desired temperature until the pressure on the output gage (5) just drops. Restore the air supply pressure to 20 psi. Adjust the red index pointer to be sure the pressure on the output gage is brought to the exact value recorded in step (3) above.



1. Red Index Pointer
2. Black Indicating Pointer
3. Process Connection Block
4. Measuring Head Assembly (mercury actuated)
5. Output Gage
6. Index Setting Knob
7. Synchronizing Nut
8. Feedback Diaphragm Assembly
9. Flapper
10. Nozzle
11. Proportional Dial
12. Proportional Band Adjustment
13. Relay Assembly
14. Orifice Cleaner Button
15. Supply Gage

Figure Fluid Temperature Controller, Door Open

Note

If the process can be controlled manually (steps 1 through 3) but not automatically (step 4) the trouble is in the controller. If the process cannot be controlled manually, the trouble is in the water system or the hydraulic system.

After the controller is in operation, the black in- ating pointer (2) may not be directly over the red dex pointer (1) since factory adjustment is based on psi output as shown on output gage (5). In normal peration the index setting knob can be turned up or own by the amount of the required black pointer change. Be sure to allow measurement to settle at the desired value before proceeding.

i. If output gage pressure is significantly different from 9 psi and the test stand is to be operated at one temperature for a long period, the red pointer may be brought to a matching position with the black pointer by turning synchronizing nut (7).

Note

When the temperatures to be controlled and the hydraulic [illegible] flow in [illegible] to be frequently varied, synchronization with each load change is not necessary; proceed as in step h above.

7-5. HYDRAULIC INDICATORS ZERO ADJUSTMENT. The pressure gages supplied with the test stand have adjustable pointers to permit recalibrating the gages. To recalibrate a gage, proceed as follows:

a. Isolate the gage from the test stand system by closing the associated shut off valve.

b. Use an independent source of pressure (hand pump) connected to a master gage of known accuracy; connect this pressure source to the test port of the gage to be calibrated.

c. Remove the ring and glass from the gage. Use a screwdriver and adjust the position of the pointer by turning the self-locking worm adjustment screw.

d. Check the calibration of the gage at several different pressures. When adjustment is satisfactory, replace the glass and ring.

e. Replace an inaccurate gage that cannot be recalibrated.

7-6. ELECTRICAL INDICATORS ZERO ADJUSTMENT. The voltmeter and ammeter are supplied with an external zero adjustment. Use a screwdriver to adjust pointer to zero with no current flow.

7-7. RESERVOIR AIR RELIEF VALVE ADJUSTMENT. The air relief valve, for the hydraulic reservoir, (93, figure 1-5) must be set to relieve if pressure in the line exceeds 125 psi. By applying regulated air, it can be determined at what psi the relief valve opens. The pressure at which the valve initially opens can be adjusted by increasing or decreasing the spring tension.

7-8. INSPECTION OF RESERVOIR LEVEL FLOAT SWITCH. The switch, S16 figure 1-6, will cut off the electric immersion heaters if the hydraulic fluid level falls below 3/4 full. If the switch does not function properly when inspected replace it. There is no adjustment.

7-9. MANOMETER CALIBRATION. The accuracy of the manometer is confirmed by initial preparation and the before use adjustment requirements contained in paragraph 3-5. 1. Further calibration is not required.

APPENDIX C

(MANUFACTURE'S INFORMATION ON MARSH GAUGES)

Marsh Standard Gauges

A ISI B40.1 Grade B accuracy s ±2% of span in middle half of scale, ±3% of span for rest of scale.

Specifications

Accuracy

Grade B Pressure and Vacuum Gauge specifications as established by ANSI Standard B40.1—1974 states that the permissible error shall not exceed 2% of span at any point between 25% and 75% of span; in the rest of the scale, 3% is permissible.

Sizes and connections

1½", 2", 2½", 3½" and 4½" dial sizes. All connections are male N.P.T. 1½" size has ⅛" bottom or center back outlet. 2" and 2½" sizes have ⅛" or ¼" bottom or center back outlets. 3½" size has ¼" bottom or center back outlet. 4½" size has ¼" bottom outlet.

Bourdon tube assembly

For Vacuum and Pressures to 600 psi Tube, tip and socket are copper alloy.

For High Pressures, 1,000 to 5,000 psi Ni-Span-C Bourdon tube; copper alloy tip and socket.

Movement

Standard movement for all 2", 2½", 3½", and 4½" gauges is the new Acculite™ 2000. It is made of glass-filled thermoplastic polyester, and is available either with or without Recalibrator in some models (see Selection Guide).

1½" Standard Gauges feature a copper alloy movement.

See page 3 for fuller descriptions of both movements.

Dial

New cupped dials are made of steel, with white enamel background and black printed matter. 2" and 2½" only.

Case patterns and construction

Plain Case, Slip Ring—drawn steel, 1½", 3½", 4½".

Plain Case, Twist-lock Ring—drawn steel, 2" and 2½".

Plain Clearfront—drawn steel, 1½".

Stainless Clearfront—drawn stainless steel, 1½" and 2".

Flush Case, Snap Ring—drawn steel, 2", 2½", 3½".

Liquid-filled Plain Case, Nonremovable Ring—phenolic, 2½".

Drawn steel cases and rings are finished in black semi-gloss enamel.

Drawn steel cases in a flush pattern have a clear zinc finish.

Drawn stainless steel cases have a brushed stainless steel finish.

Lens

All Standard Gauges are supplied with flat glass lens except for Clearfront cases, which have a molded acrylic press-fit front. 1½" Plain Case Gauges have a flat plastic crystal.

Phenolic case liquid-filled gauges—special construction features

Neoprene plug seals fill port.

Snap-in, nonremovable polypropylene retaining ring.

Accuracy is ±3% of span in middle half of scale.

300 series stainless steel internal construction is available in bottom connection in selected ranges.

2½" dial size only.

Cupped aluminum dial with black numerals on white background.

Restrictor screw is supplied as standard.

Glycerin filling dampens pulsation and vibration. Suitable for use from −30° to 150°F. Other fills available on special order.

Marsh Standard Gauge Selection Guide

		DIAL SIZE	1½"						2"				
		CASE MATERIAL	Steel				Stainless Steel		Steel				
		CASE PATTERN	Plain		Clearfront		Clearfront		Plain				
		CONNECTION LOCATION	Bottom	Center Back	Bottom	Center Back	Bottom	Center Back	Bottom			Center Back	
		CONNECTION SIZE	¼"	⅛"	⅛"	⅛"	⅛"	¼"	¼"	¼"		⅛"	¼"
		RECALIBRATOR	No	No	No	No	No	No	No	No	Yes	No	No
		RESTRICTOR	None	None	None	None	None	None	Yes	None	None	None	None
COPPER ALLOY BOURDON TUBE	VACUUM	30" Hg/—100 kPa	•	•	•	•	•	•	J1105	J1405	•	J1305	J2005
	COMPOUND	30" Hg x 30 psi/—100 x 210 kPa	•	•	•	•	•	•	J1112	J1412	•	•	J2012
		30" Hg x 60 psi/—100 x 400 kPa	•	•	•	•	•	•	J1114	J1414	•	J1314	•
		30" Hg x 100 psi/—100 x 700 kPa	•	•	•	•	•	•	•	•	•	•	•
		30" Hg x 150 psi/—100 x 1000 kPa	•	•	•	•	•	•	J1118	J1418	•	J1318	•
		30" Hg x 200 psi/—100 x 1400 kPa	•	•	•	•	•	•	•	•	•	•	•
		30" Hg x 300 psi/—100 x 2100 kPa	•	•	•	•	•	•	•	•	•	•	•
		30" Hg x 400 psi/—100 x 2800 kPa	•	•	•	•	•	•	•	•	•	•	•
	PRESSURE	15 psi/100 kPa	•	•	•	•	•	•	•	•	J1640	•	•
		30 psi/210 kPa	J0042	J0242	J0442	J0642	J0842	J1042	J1142	J1442	J1642	J1842	J2042
		60 psi/400 kPa	J0046	J0246	J0446	J0646	J0846	J1046	J1146	J1446	J1646	J1846	J2046
		100 psi/700 kPa	J0048	J0248	J0448	J0648	J0848	J1048	J1148	J1448	J1648	J1848	J2048
		160 psi/1,100 kPa	J0052	J0252	•	J0652	•	•	J1152	J1452	J1652	J1852	J2052
		200 psi/1,400 kPa	J0054	J0254	J0454	J0654	•	•	J1154	J1454	J1654	J1854	J2054
		300 psi/2,100 kPa	•	•	•	•	•	•	J1158	J1458	•	•	J2058
		400 psi/2,800 kPa	•	•	•	•	•	•	J1160	J1460	•	•	J2060
		500 psi/3,500 kPa	•	•	•	•	•	•	•	•	•	•	•
		600 psi/4,000 kPa	•	•	•	•	•	•	•	J1464	•	•	J2064
NI-SPAN-C BOURDON TUBE	HIGH PRESSURE	1,000 psi/7,000 kPa	•	•	•	•	•	•	•	•	J1672'	•	•
		1,500 psi/10,000 kPa	•	•	•	•	•	•	•	•	•	•	•
		2,000 psi/14,000 kPa	•	•	•	•	•	•	•	•	•	•	•
		3,000 psi/21,000 kPa	•	•	•	•	•	•	•	•	J1678'	•	•
		5,000 psi/35,000 kPa	•	•	•	•	•	•	•	•	•	•	•

(') all high-pressure gauges have restrictors as standard equipment

TABLE V

VII. DESIGN OF STATIC REACTION GANTRY FOR AN ULTRALIGHT AIRPLANE DESTRUCTION TEST

AIAA paper #85-4022

Howard W. Smith
Professor
Department of Aerospace Engineering
University of Kansas

October 14, 1985

Partially supported by
NASA Langley Research Center
Grant #NAG 1-345

55-4227

DESIGN OF STATIC REACTION GANTRY FOR AN ULTRALIGHT AIRPLANE DESTRUCTION TEST

Howard W. Smith*
University of Kansas
Lawrence, Kansas

Abstract

The steel gantry superstructure needed to perform an airplane static test is described. Standard civil engineering design practices are used to react the loads generated by an airplane in flight. Reaction columns are mounted on a structural floor to carry the wing airloads and the downward acting fuselage loads are carried directly into the floor. The gantry can accommodate a general aviation airplane or rotorcraft. An immediate use for an ultralight airplane is shown as an example configuration of the four main steel frames.

Introduction

There have been several accidents involving ultralight aircraft. In some of these the integrity of the structure was questioned,[1]**. As a result it was decided that a structural test should be performed.

Discussion

Approach

Since time and funds were limiting factors, it was decided that a structural test to destruction would be performed in the same manner as an FAA static test would be performed for certification of a new general aviation airplane. Testing was abbreviated to include only one flight condition. The "point" to be tested was chosen as point "A" on the V-n diagram.

Airplane Description

The manufacturer called the airplane an "Airmass Sunburst Model 'C'." It is nine feet high, sixteen feet long, and has a wingspan of thirty-six feet. Additional details are shown in Figures 1 and 2, and Table 1.

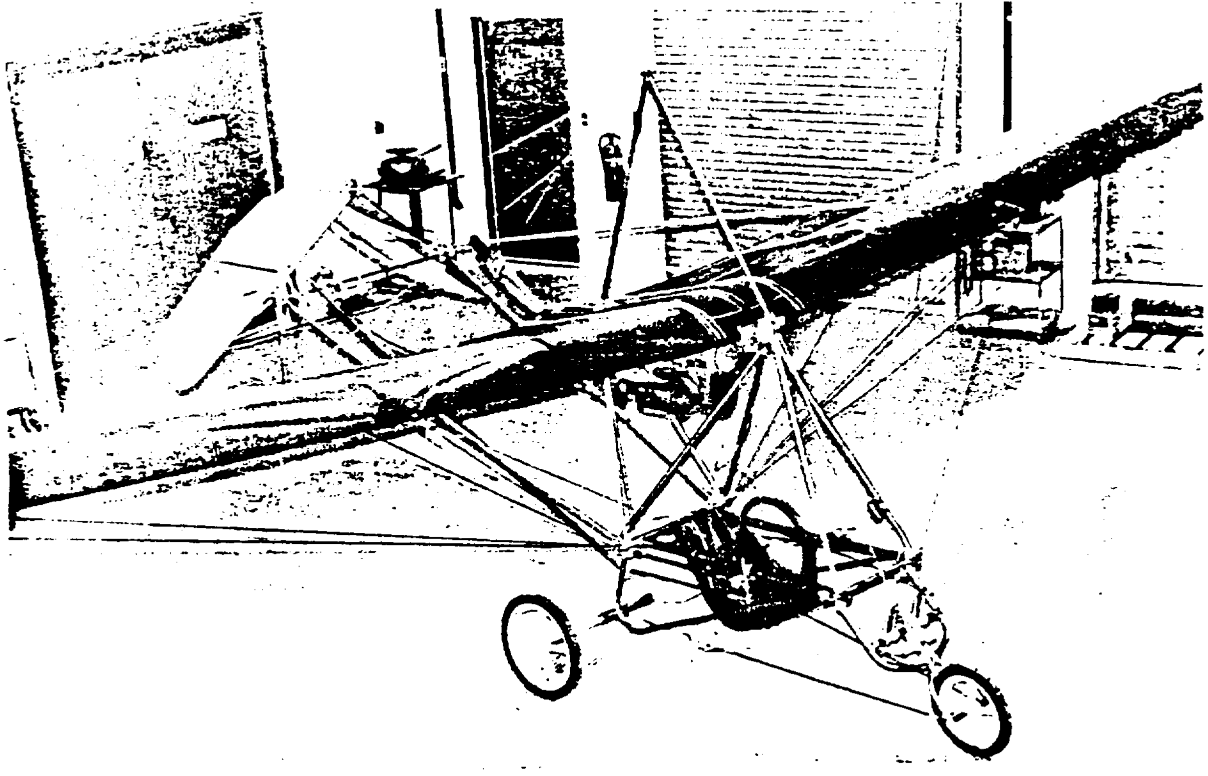


Fig. 1 Airmass Sunburst Model 'C'.

---

*Professor, Aerospace Engineering
Associate Fellow, AIAA

**Numerals in brackets are references.

Hangar Description

A specially designed hangar houses university-owned airplanes. The eastern half also has a structural test floor, which is a scaled version of the structural floor at the Beechcraft Plant in Wichita, Kansas. Figures 3 and 4 show the salient features of the floor. A cruciform test section is fourteen inches of reinforced concrete, with "I-Beams" embedded in floor. These embedded beams provide "up reaction" where needed, and also serve as a foundation for the steel columns of the gantry.

A major shortcoming of the hangar is the lack of an overhead crane. A clearance of twenty-one feet six inches is available for mobile crane operations.

Loads

The empty weight of the airplane is 273.9 pounds, determined by three-point weighing.

Total weight ("Basic Flight Design Weight") is:

Fuel	15.5 #
Pilot	175.0
Airp.	273.9
TOTAL	464.4

Table 1

Airmass Sunburst Ultralight Model 'C'

Geometric Specifications:

•	Length	17.58 ft
•	Height	9.69 ft
•	Wing Span	36.00 ft
	Wing Area	150.93 ft^2
	Aspect Ratio	8.59
	MGC	4.19 ft
	Wing Taper Ratio	0.92
	Incidence Angle	5.50 deg
•	Tail Area	28.04 ft^2
	Tail Span	9.33 ft
	Dihedral Angle	-40.00 deg

Performance Specifications:

•	$C_{L_{max}}$	1.45
•	OWE	277.48 lbs
•	Stall Speed	43.11 ft/sec
	Cruise Speed	50-75 ft/sec
•	Cuyuna 430 cc 30 HP engine.	

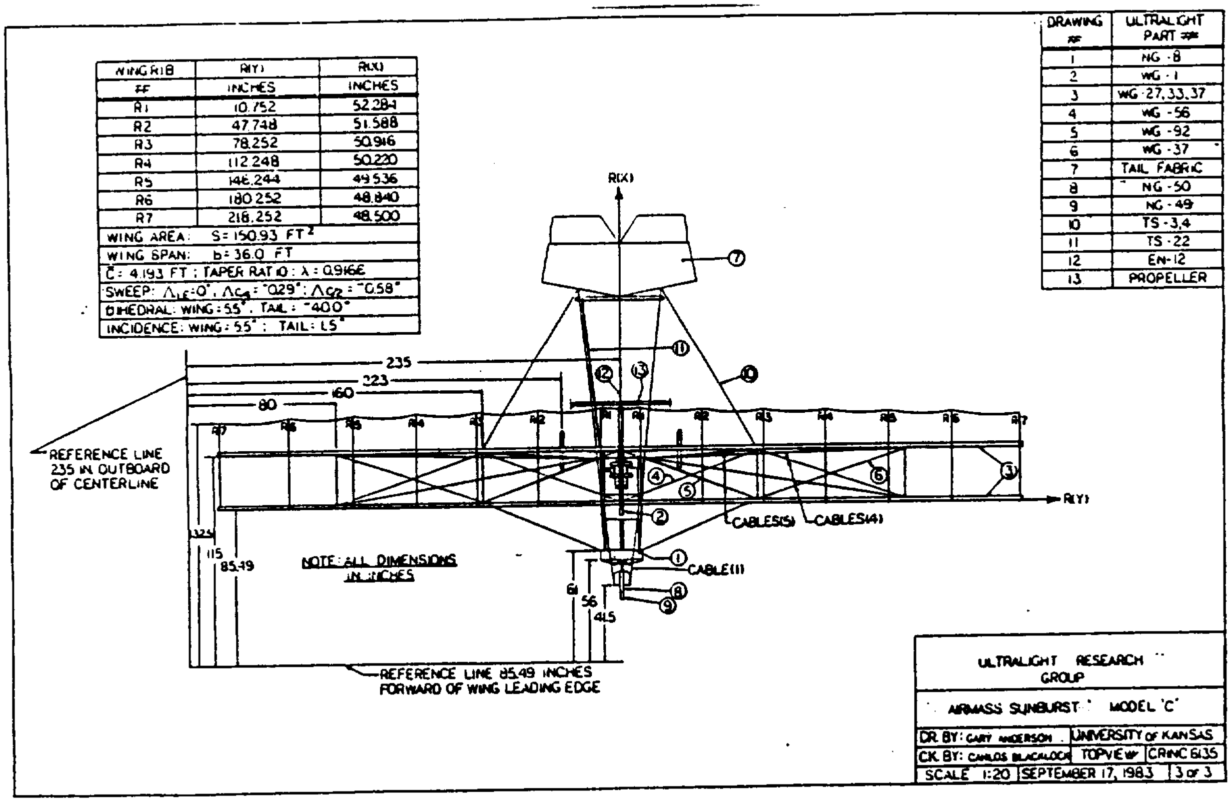


Fig. 2 Planview - "Sunburst".

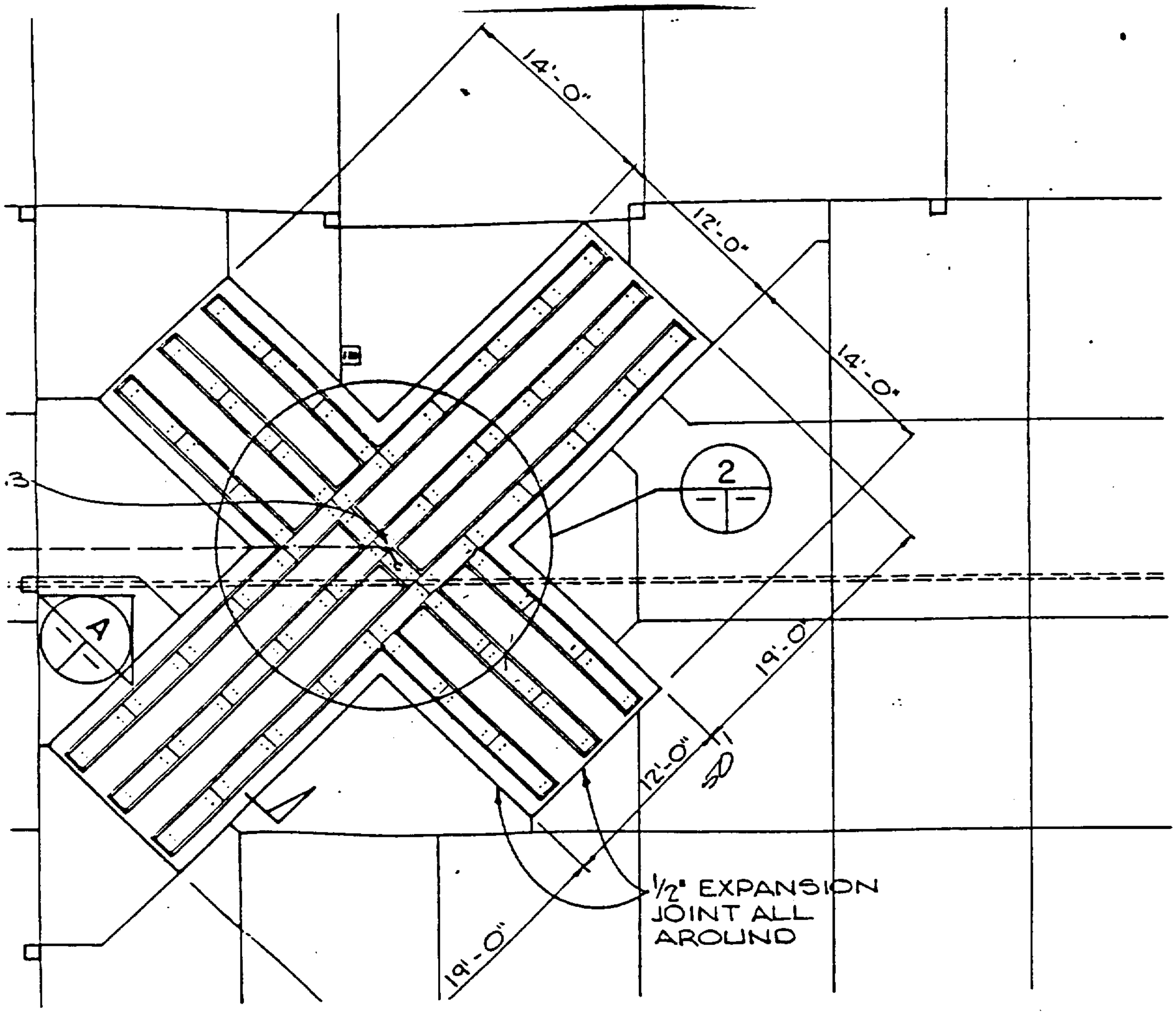


Fig. 3 Cruciform Floor.

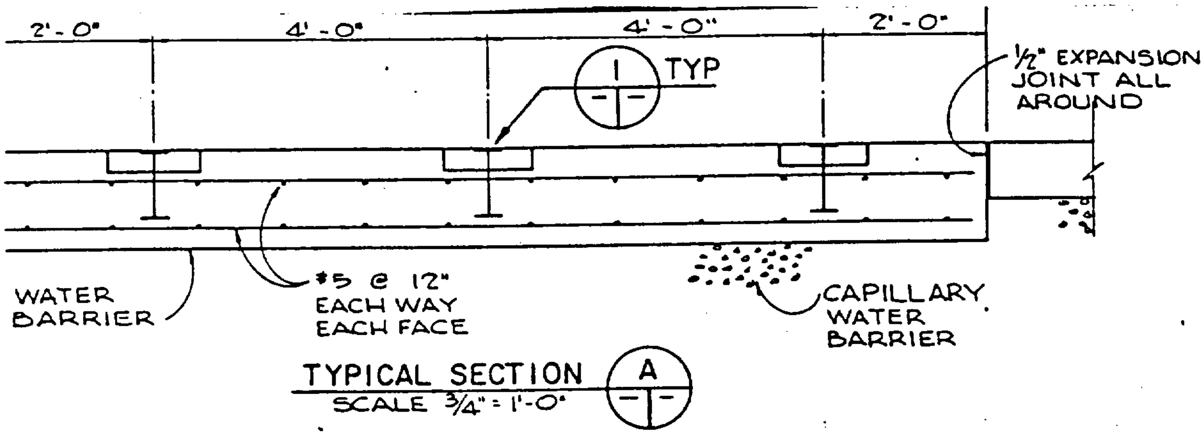


Fig. 4 Embedded Beams.

For structural test purposes, the design limit load factor was assumed to be $n = 4.0$. A factor of safety of 1.5 was assumed,[2].

Using these values, the estimate maximum ultimate load is:

1.5 (4.0) (464.4) = 2786.4 pounds

Rounded, the design ultimate load is 2,800 lbs.

Steel Gantry

Steel used for the superstructure was designed for a general aviation airplane of the "King Air" class. Using the 12,500 lb. limit as prescribed by FAR Part 23, the ultimate load would be 1.5 x 4.0 x 12,500 = 75,000 pounds. This load can be carried by four reaction columns. Round off this number, a column load of 20,000 pounds was used for the steel design. A beam connecting each pair of columns was designed for a 40 kip load. A beam and two columns, called a "portal", was provided for each wing, the aft fuselage, and the forward fuselage. The four portals are connected to each other with beams in the water plane, Fig. 5.

Each column base plate was centered over a floor beam. Each of the three parallel floor beams is on four foot centerlines, and the columns are located on the outer beams. Since the portal height was chosen to be sixteen feet, a portal is twice as high as it is wide. Each of these portals acts as a slender frame, and requires sway bracing normal to the plane of the portal. An external brace is located on every column ten feet from the floor and extending outward and downward at a forty-five degree angle, Fig. 6. The sway brace itself consists of clevises at each end, a turnbuckle and two five-eighth inch diameter rods. Each column is tied to its nearest neighbor with a short sway brace, and the four columns near the wing-body root are diagonally tied with long sway braces, Fig. 7.

All the steel is type A36 and all bolts are type A325 per the AISC Handbook,[3]. A list of the standard steel section chosen is given in Table 2.

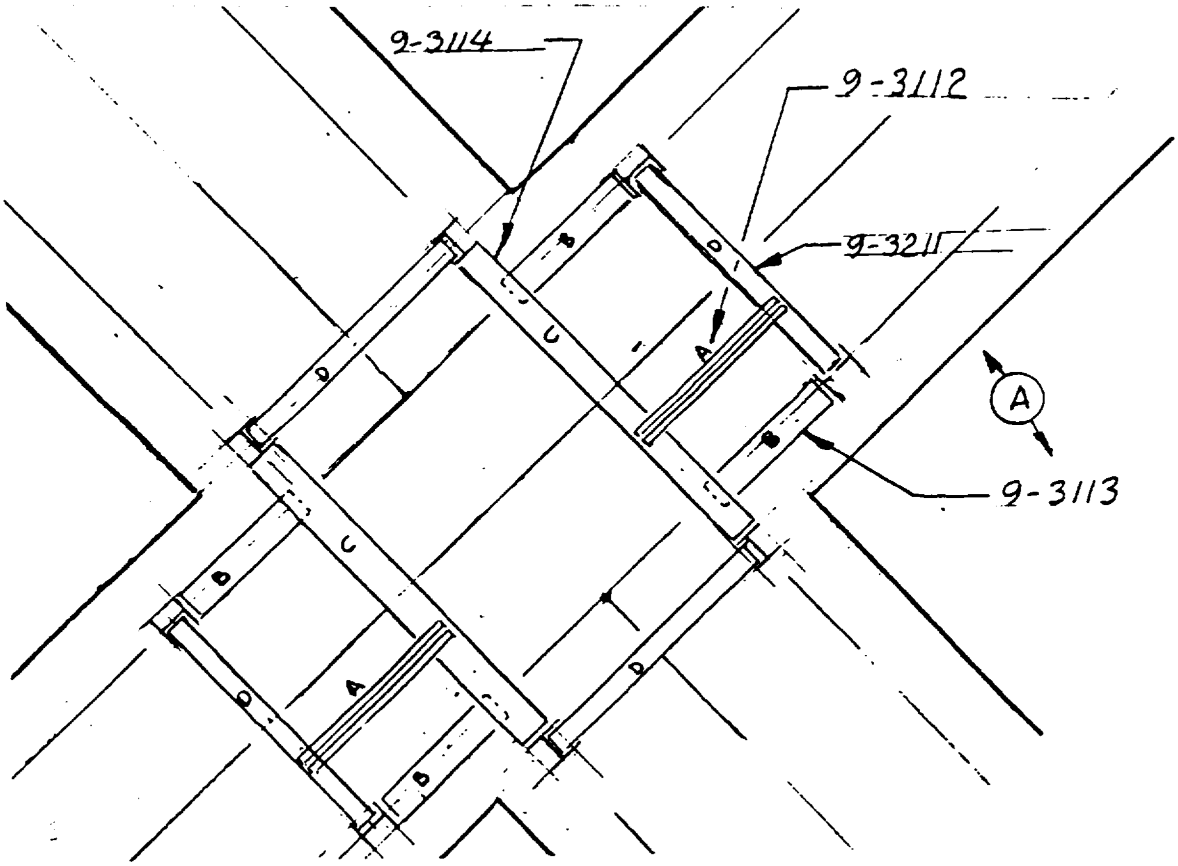


Fig. 5 Overall Steel Installation.

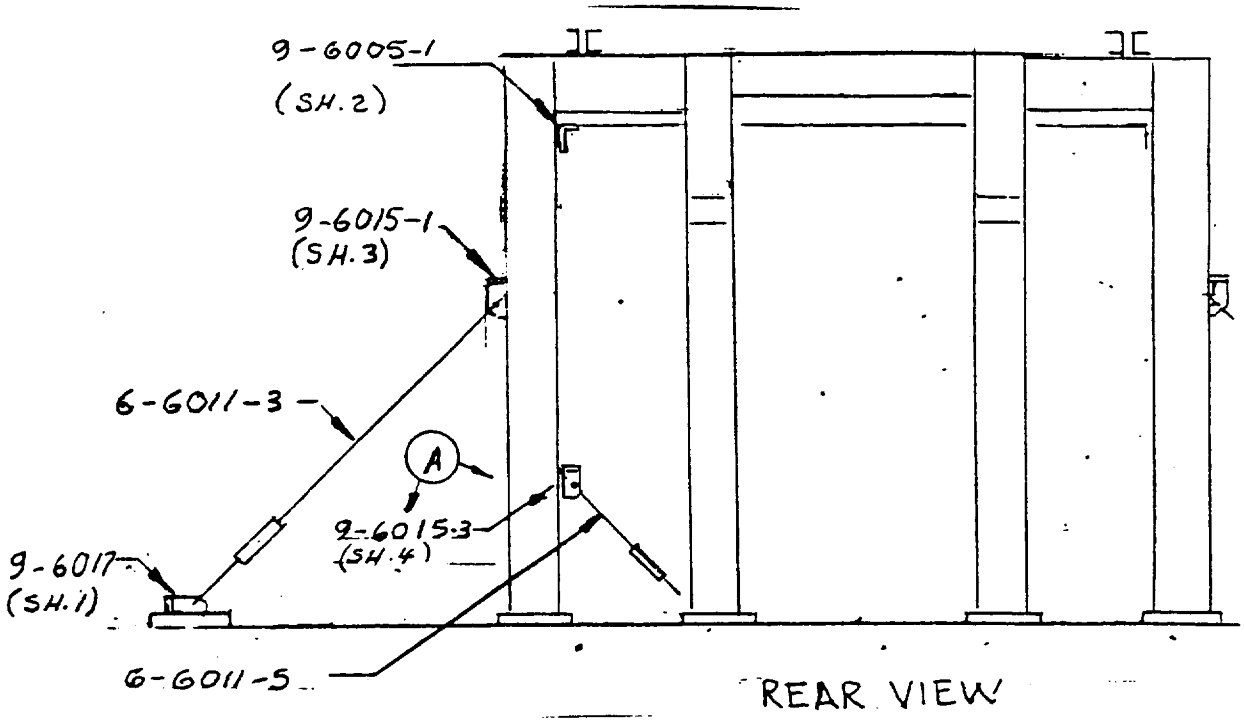


Fig. 6 External Sway Bracing.

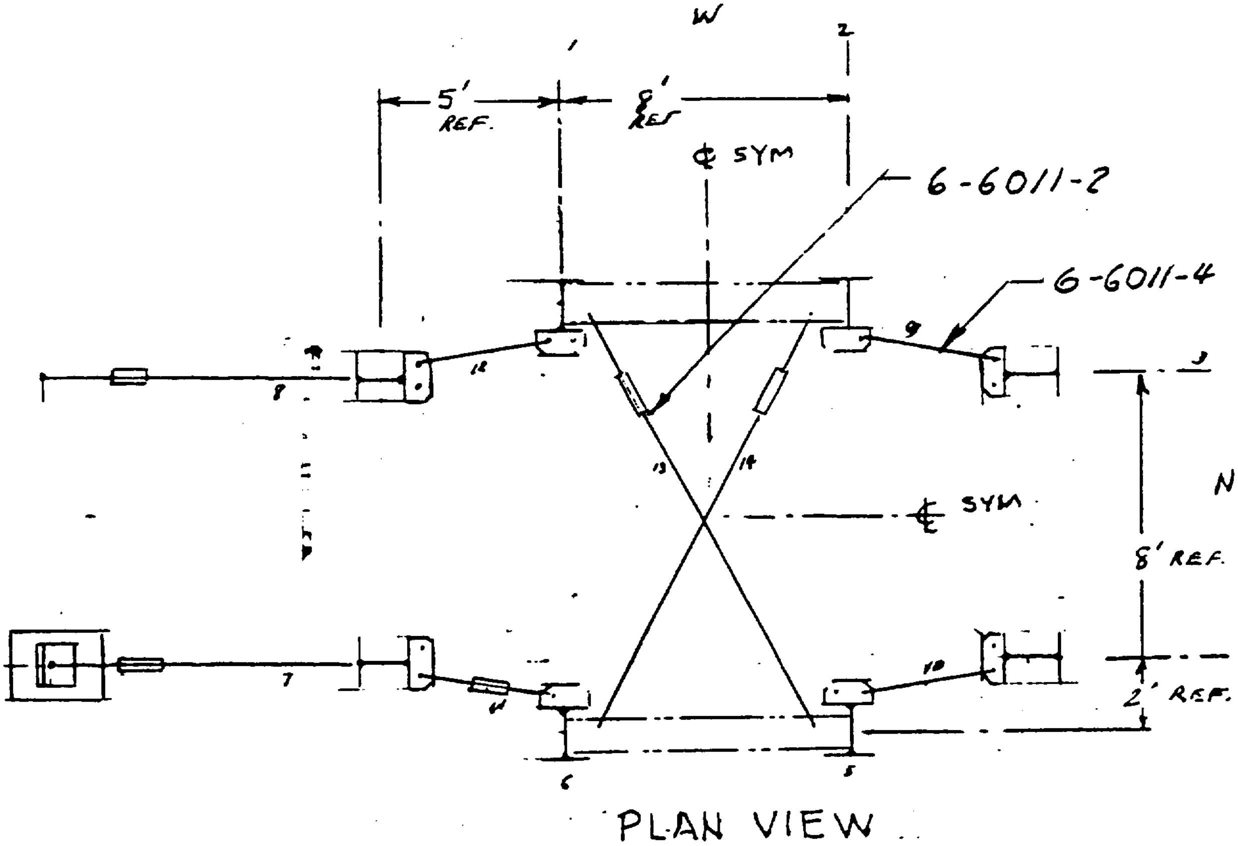


Fig. 7 Internal Sway Bracing.

Table 2. Steel Sections.

8	Columns	W8x24	16'
4	Channels	C12x20.7	5'
4	Beams	W16x40	5'
2	Beams	W18x40	12'
4	Beams	W8x24	8'

All bolts loaded in tension and shear are three-quarter inch diameter. Bolts at column base plate clamps are five-eighth inch diameter. Beam-to-beam connections are made by "good civil engineering practices." A pair of angles is fillet welded to the beam web at each end. The outstanding flange has a hole pattern that matches the repeating pattern in each column flange. Beam "seat" angles are provided for easy construction and disassembly. All assemblies were cleaned and grey primed after welding. All assemblies were painted royal blue before installation.

Acknowledgements

The work described in this paper was performed under NASA Langley Research Center Grant number LRC/NAG 1-345/3-3-83. Six students from the University of Kansas did the drawing of the steel gantry, (in alphabetical order):

Albers, Roger
Bultman, Myron
Clune, Mike
deAlmeida, Sergio
Martin, John
Robertson, Greg

There were many other people, including students, staff, faculty, and townspeople that gave freely of their time. People from Lawrence and Kansas City have given advice and services freely.

References

[1] "Ultralight Vehicle Accidents: Safety Study," NTSB/SS-85-01, Feb. 7, 1985, 405 p.

[2] "Airworthiness Standards for Powered Ultralight Vehicles," Powered Ultralight Manufacturers Association, 7535 Little River Turnpike, Suite 350, Annadale, Virginia 22003, Dec. 9, 1983.

[3] Manual of Steel Construction, AISC, Inc., 400 North Michigan Ave., Chicago, IL 60611, 8th Ed., 1980.