NASA CONTRACTOR
REPORT

Report No. 61294

CRYOGENIC STRETCH FORM BOTTLE TEST PROGRAM

By T. R. Alchorn

Lockheed Missiles and Space Company
Sunnyvale, California

March 3, 1969

Final Report

Prepared for

NASA-GEORGE C. MARSHALL SPACE FLIGHT CENTER
Marshall Space Flight Center, Alabama 35812

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16. ABSTRACT

Three stainless steel pressure vessels received from the George C. Marshall Space Flight Center were instrumented for measurement of strain and temperature, subjected to pneumatic and hydraulic pressure cycling at elevated and cryogenic temperatures and, finally, pressurized to rupture at cryogenic temperature. Successful completion of the program and the rupture of the vessels at the anticipated pressure levels indicates suitability of the forming techniques. Detail analysis of strain data recorded during the program will be performed by Marshall Space Flight Center and should result in confirmation of this conclusion.

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FOREWORD

This report was prepared by Lockheed Missiles & Space Company, Santa Cruz Test Base, under Contract No. NAS 8-21482, "Cryogenic Stretch Form Bottle Test Program", for the George C. Marshall Space Flight Center of the National Aeronautics and Space Administration. The work was administered under the joint technical direction of the Astronautics Laboratory and the Manufacturing Engineering Laboratory of the George C. Marshall Space Flight Center.

The reader is referred to NASA CR-84035, Contract No. NAS 8-11977, for the Research and Development work document covering this subject. The reference document is the Final report generated under Contract No. NAS 8-11977, and is entitled RESEARCH AND DEVELOPMENT ON CRYOGENIC STRETCH-FORM HELIUM BOTTLES FOR THE SATURN V, S-1C VEHICLE, by Arde-Portland, Inc. , Paramus, N. J.

TABLE OF CONTENTS

1.0 SCOPE

This report describes the testing performed on three (3) pressure vessels fabricated with cryogenic forming techniques for the purpose of verifying the reliability of the technology to produce bottles having high weld efficiency for use in a cryogenic aerospace application.

Testing included high and low temperature cycling with pressure applied both pneumatically and hydraulically culminating in burst of the vessels at cryogenic temperature.

2.0 SUMMARY

Three stainless steel pressure vessels received from the George C. Marshall Space Flight Center were instrumented for measurement of strain and temperature, subjected to pneumatic and hydraulic pressure cycling at elevated and cryogenic temperatures and, finally, pressurized to rupture at cryogenic temperature. Successful completion of the test program and the rupture of the vessels at the anticipated pressure levels indicates suitability of the forming techniques. Detail analysis of strain data recorded during the program will be performed by Marshall Space Flight Center and should result in confirmation of this conclusion.

3.0 DESCRIPTION OF TEST PROGRAM

3.1 Introduction

Four (4) subscale Saturn V helium gas storage pressure vessels were received at Lockheed Missiles & Space Company's (LMSC) Santa Cruz Test Base (SCTB) for the NASA George C. Marshall Space Flight Center. These vessels were fabricated using cryogenic stretch-forming techniques and were subjected at SCTB to a series of tests for the purpose of verification of the reliability of the manufacturing technology. These tests included pneumatic and hydraulic pressurization cycling at both elevated and cryogenic temperatures culminating in a burst test while filled with and immersed in liquid nitrogen.

Of the four bottles received, one, S/N 4, was designated as a spare unit and, as such, was neither instrumented nor tested. The three other units, S/N 3, US-2 and US-5, were instrumented as shown in Appendix C and were tested in accordance with the test requirements reproduced in Appendix A.

3.2 Test Facility Description

The test program was conducted in Cell 2 of the Component Test Laboratory at the LMSC Santa Cruz Test Base, Santa Cruz, California. The capabilities of this test cell include remote operation and monitoring of pneumatic and hydraulic pressure systems for the handling of propellants, test fluids and pressurizing/purging gases.

Cryogenic storage dewars are directly adjacent to the test building and serve as the source for both the liquid nitrogen used in the low temperature tests and the gaseous nitrogen used for pressurization, purging and pneumatic actuation. Helium supply is provided from an array of ICC shipping cylinders manifolded to the pressurization system.

The cell itself is 4.57 meters (15 feet) square with reinforced concrete walls on three sides. Weather protection is provided by a raised steel roof and roll-up rear doors.

3.2 <u>Test Facility Description</u> (Continued)

Hardline data acquisition systems link the cell with signal conditioning and recording equipment in the blockhouse. End instruments used for this program include the Dymec 2010J Digital Data System and Moseley Dual Channel, 7100B Strip Chart Recorders. Brown Strip Chart Recorders were used for test control.

The Dymec 2010J Digital Data Acquisition System scans the instrumentation signals and simultaneously prints out on a paper tape. Physical calibrations and calibration data based upon LMSC secondary standards traceable to NBS are furnished with the data tapes, when applicable.

System resolution is tabulated below.

Sample Period	Range (Volts)	Full Scale Reading		Max. Over Range Reading	
1 sec.	0.01*	10.0000	(MV)	300.000	(Volts)
	0.1	100.000	(MV)	300.000	(MV)
	1.0	1000.00	(MV)	3000.00	(MV)
	10.0	10.0000	(Volts)	30.0000	(Volts)
	100.0	100.000	(Volts)	300.000	(Volts)
	1000.0	1000.00	(Volts)	---	
.1 sec.	0.01*	010.000	(MV)	0300.00	(Volts)
	0.1	0100.00	(MV)	0300.00	(MV)
	1.0	01.0000	(Volts)	03.0000	(Volts)
	10.0	010.000	(Volts)	030.000	(Volts)
	100.0	0100.00	(Volts)	0300.000	(Volts)
	1000.0	01000.0	(Volts)	---	
.01 sec.	0.01*	0010.00	(MV)	00300.0	(Volts)
	0.1	00100.0	(MV)	00300.0	(MV)
	1.0	001.000	(Volts)	003.000	(Volts)
	10.0	0010.00	(Volts)	0030.00	(Volts)
	100.0	00100.0	(Volts)	00300.0	(Volts)
	1000.0	001000.0	(Volts)	---	

* Amplifier ext sel gain = +10; voltmeter, autorange

3.2 Test Facility Description (Continued)

Tape Format:

12	11	10	9	8	7	6	5	4	3	2	1	Column
I	I	I	S	R	F	D	D	D	D	D	D	Voltmeter
					T		S	S	S	S	S	Clock *

* Enter prior to each scan.

Code I = channel identification

T = Time

S = Elapsed time in seconds

F = function (polarity)

R = range

D = data

Maximum channel scanning rate (.01 second sample) 17 channels/second
System input resistance 10^9 ohms
Overall system accuracy ± 0.01% of reading ± 1 digit

The Moseley Dual Channel 7100B strip chart recorders have a response time of one-half second for full scale. Accuracy is 0.2% of full scale and linearity 0.1% of full scale.

Environmental test conditions were imposed on the bottles by the use of two separate tanks. Elevated temperature testing was conducted in a closed tank capable of pressurization to prevent boiling of the water used as the test fluid at the required upper operating temperature of 394.3°K (250°F). Low temperature testing was performed in an open top tank. Piping systems used to conduct the various phases of the test program are shown schematically in Figures 1 through 6 of test procedure LMSC 73336 which is included as Appendix B of this report.

3.3 Test Methods

3.3.1 Instrumentation of Test Bottles

Instrumentation on each bottle consisted of one pressure measurement, six temperature points and twenty strain gauges. The temperature transducers were copper/constantan thermocouples. Three were installed internal to the test bottle on a central probe and located with one thermocouple near each end and one at the middle of the bottle. The remaining three were bonded with Lefkoweld type 109 adhesive to the outer surface of each bottle at points approximately longitudinally equivalent to the internal locations (Reference: Sketch 1, Statement of Work, Appendix A). Strain gauges were bonded to each of the three test bottles in biaxial pairs at five locations on each side 180° apart for a total of twenty gauges per bottle. The gauges were Baldwin-Lima-Hamilton type FNH temperature compensated units and were bonded to the bottles using Lefkoweld type 109 adhesive. After curing of the adhesive a coating of Dow-Corning DC-4 was applied to waterproof the gauges.

During the course of the elevated temperature testing loss of strain gauges occurred through separation from the bottle surface and through corrosion of gauge leads. Attempts to alleviate this problem by application of mylar film covered by RTV compound were not totally successful. It was therefore agreed to bring all strain gauge installations up to 100% prior to starting the low temperature test series.

3.3.2 Weight and Volume Measurements

Each bottle with only the strain gauge and thermocouple instrumentation components attached was weighed on a calibrated platform scale. Determination of the volume of each test bottle was made by mounting the bottle vertically with a bulkhead fitting in the upper port and a drain valve in the bottom port. Using filtered water and a graduated cylinder the bottle was filled and the quantity required to do so was recorded.

3.3 Test Methods (Continued)

3.3.3 Proof Pressure Tests

With the bottle set up in the hydrostatic test fixture, as shown in photograph D-4, pressure was applied using filtered water and a Sprague booster pump until a level of 4.07 newtons/meter^2 (5900 psig) was reached. This pressure was maintained for 5 minutes and each bottle checked for damage or deformation. This test was performed at ambient temperature each time that it was required by the work statement, Appendix A

3.3.4 Elevated Temperature Tests

Elevated temperature testing was conducted in two phases for each bottle. The first consisted of pressure cycling each bottle from 0 to 1.62 X 10^7 to 0 newtons per meter^2 (0 to 2350 to 0 psig) 5 times, using helium with the bottle immersed in water at a temperature of 247.05°K (165°F). The water was maintained at this temperature by recirculation through an electrically-heated fluid conditioning trailer. The second phase of the elevated temperature testing required hydraulic cycling of each bottle from 0 to 1.62 X 10^7 to 0 newtons per meter^2 (0 to 2350 to 0 psig) 1000 times at a temperature of 394.3°K (250°F). These cycles were performed at a rate which did not exceed 2 per minute. Photograph D-5 shows one of the bottles mounted in the test support frame ready to be placed in the adjacent elevated temperature environment tank.

3.3.5 Low Temperature Pressure Cycle Tests

Since severe loss of operable strain gauges had occurred during the elevated temperature testing, each of the test bottles was re-instrumented to provide 100% strain gauge operation prior to the start of low temperature activities.

3.3.5 Low Temperature Pressure Cycle Tests (Continued)

Tests in this portion of the program again were conducted in two phases. The five cycles of gaseous helium pressurization required by the first phase were performed in an atmospherically-vented liquid nitrogen bath and ranged in pressure from 0 to 3.50 X 10^7 to 0 newtons per meter^2 (0 to 5080 to 0 psig). At the start of the second phase of the low temperature pressure cycle testing each bottle was suspended on a chain hoist above the liquid nitrogen-filled environment tank. The bottle was then heated to 394.3 ± 5.5°K (250 ± 10°F) by flowing heated gaseous nitrogen through the bottle until stabilization of temperature was achieved as indicated by externally applied temperature sensors. The bottle was then lowered rapidly into the liquid nitrogen. Pressure was maintained within the bottle during its immersion to prevent imposition of external collapse pressure on the bottle due to rapid internal cooling. Each bottle was then filled with liquid nitrogen and subjected to 1000 cycles of hydraulic pressurization from 0 to 3.50 X 10^7 to 0 newtons per meter^2 (0 to 5080 to 0 psig) at a rate of less than 2 cycles per minute.

3.3.6 Low Temperature Burst Tests

For this test each bottle was submerged in the liquid nitrogen environment tank, filled with liquid nitrogen and connected to an elevated surge tank partially filled with liquid nitrogen. Through the surge tank upper port a pressure of 5.25 X 10^7 newtons per meter^2 (7610 psig) was applied to the bottle for a minimum of 5 minutes. The pressure was then raised to 6.89 X 10^7 newtons per meter^2 (10,000 psig) for bottle S/N 3 and to 6.41 X 10^7 newtons per meter^2 (9300 psig) for bottles US-2 and US-5. It was held at this level for a minimum of 5 minutes.

Pressure was then slowly increased in the bottle under test until rupture occurred.

3.4 Test Results

All three of the bottles which were subjected to the test conditions specified in the Statement of Work, Appendix A, satisfactorily completed the test program. During the course of testing no damage or distortion was noted in any of the units. The only anomalies related to the test articles were the instrumentation failures which occurred as a result of the environmental conditions. All data recorded from the strain gauges, thermocouples and pressure transducer together with calibration records and recorder setup information were delivered to the George C. Marshall Space Flight Center for reduction and analysis.

The following tabulation lists the weight and volume measurements for each bottle, together with the approximate burst pressure observed from preliminary data:

TEST ARTICLE	WEIGHT		1st VOLUME		2nd VOLUME		BURST PRESSURE	
	Kg	Lbs.	cc	CuFt	cc	CuFt	N/M^2	psig
S/N 3	44.57	98.25	78,025	2.7554	78,535	2.7734	7.3567×10^7	10,670
US-2	57.48	126.75	97,025	3.4264	97,075	3.4282	6.9499×10^7	10,080
US-5	52.04	114.75	87,530	3.0911	87,550	3.0918	7.347×10^7	10,656

Surveillance of test operations to ensure conformance to the requirements of the test procedure was maintained by Santa Cruz Test Base Quality Assurance personnel and periodic audits by the representative of the USAFPRO were conducted to verify compliance with contract conditions.

3.5 Conclusions and Recommendations

Survival of all three specimens through the cycling tests under high and low temperature conditions indicates that the manufacturing technology utilized results in predictable properties and verifies the reliability of the techniques for the proposed application of the test bottles. Inspection of the manner in which rupture of the vessels ultimately occurred indicates that a high percentage of weld efficiency was, in fact, achieved. Rupture of the vessels at pressure levels quite close to those predicted further verify the suitability of the forming methods. It is expected that analysis of the strain data by Marshall Space Flight Center will confirm these conclusions based on gross test results.

Performance of the strain gauge instrumentation during the course of the test program indicates that there is a need for further study and experimentation with respect to the techniques used in bonding such gauges to various materials and in protecting the gauges and their terminations from attack by test fluids.

4.0 APPENDIXES

APPENDIX A - STATEMENT OF WORK

SUPPLEMENTAL AGREEMENT

SUPPLEMENTAL AGREEMENT	EFFECTIVE DATE: OCT 15 1968	PAGE NO. 1	NO. OF PAGES 2
REQUISITION NO./PURCHASE AUTHORITY: PCN 1-8-30-25753 S3 (1F)	CONTRACT (Order) NO. NAS8-21482	MODIFICATION NO.: 2	

TO (Contractor's name and address) 91821
LOCKHEED AIRCRAFT CORPORATION
MISSILES AND SPACE COMPANY
P.O. BOX 504
SUNNYVALE, CALIFORNIA 94088

ISSUED BY:
PURCHASING OFFICE
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MARSHALL SPACE FLIGHT CENTER, ALABAMA 35812
PR-SC-N/ H.R. Greene/Tel. 842-2361/ ag

ACCOUNTING AND APPROPRIATION DATA:

NO CHANGE

THE ABOVE-NUMBERED CONTRACT IS MODIFIED AS FOLLOWS:

The parties hereto desire to clarify the effort to be made herein. Accordingly, the following change in the schedule is agreed to with no change in the period of performance or compensation:

1. PART II of Exhibit "A" as incorporated by ARTICLE I is deleted and the following substituted therefor:

PART II - STATEMENT OF WORK

The Contractor shall perform for George C. Marshall Space Flight Center, Marshall Space Flight Center, Alabama, the "Cryogenic Stretch Form Bottle Test Program" described and detailed in Appendix 1, "Test Requirements for Subscale Cryogenic Stretch Formed Bottle," *which by attachment is made a part hereof, to verify the reliability of the manufacturing technology used for the cryogenic stretch form fabrication of pressure vessels.

*Appendix 1 (Revised 9-12-68) includes, in addition to the appendix, the following attachments:

Table 1 - "Vessel Design Parameters"
Sketch No. 1 - Alternative-Internal Fluid Temperature (1-3-67)
Sketch No. 2 - Strain Gauge Location for Rolled and Welded Pressure Vessel (Rev. 7-17-67)
Sketch No. 3 - Strain Gauge Locations for Integral Head Pressure Vessels S/N US-5 (Rev. 7-17-68)
Sketch No. 4 - Strain Gauge Locations for Integral Head Pressure Vessels S/N US-2 (Rev. 7-17-68)

Except as hereby modified, all terms and conditions of said contract as heretofore modified remain unchanged and in full force and effect. This Supplemental Agreement is entered into pursuant to the authority of Clause 33 Changes of the General Provisions.

LOCKHEED AIRCRAFT CORPORATION
MISSILES AND SPACE COMPANY
(NAME OF CONTRACTOR)

BY ______ 68 Oct 11
(SIGNATURE) (DATE)

W. D. ORR
(TYPED NAME)

ATTORNEY-IN-FACT
(TITLE)

UNITED STATES OF AMERICA

______ OCT 15
(SIGNATURE OF CONTRACTING OFFICER)

LAWRENCE GARRISON
(TYPED NAME OF CONTRACTING OFFICER)

Note - At completion of the test program the Contractor shall dispose of the four Government-furnished pressure vessels furnished for testing as scrap and credit the Government's account with the sale proceeds.

DCN 1-8-30-25753
APPENDIX "1"
(Revised 9-12-68)

TEST REQUIREMENTS FOR SUBSCALE CRYOGENIC STRETCH-FORMED BOTTLES

Number of Bottles to Be Tested

Three bottles as identified below are to be tested according to tests identified below. The fourth bottle is to be used for strain gage calibration, fixture model or spare.

S/N US-2 (Sketch #4) Integral Head - Test
S/N 3 (Sketch #2) Rolled and Welded - Test
S/N 4 (Sketch #2) Rolled and Welded - Spare
S/N US-5 (Sketch #3) Integral Head - Test

Instrumentation

One pressure, six temperature and 10 strain gage (depending on type of bottle) (0 to 5000 in/in) measurements are required. Installation of these measurements is shown on Sketches #1 through #4. Internal fluid temperature may be accomplished by means of probes or other satisfactory methods. Record temperatures, strain gage readings and pressure throughout all tests. Motion picture coverage will be utilized during burst test.

Weight and Volume Measurements

Conduct measurements prior to starting tests and record.

Proof Pressure Test

Proof pressure test using H_2O at room temperature from 0 psig to 5900 psig ± 50 psig in not less than 10 minutes and hold at 5900 psig for a minimum of three minutes. Check for leakage. Purge before conducting next test.

Elevated Temperature Testing

a. While mounted vertically, the bottle shall be heated to +165°F and shall be subjected to five pressurization cycles of 0 to 2350 to 0 psig using helium at a temperature of +165°F. The bottle shall be pressurized and vented through the lower end. The time to pressurize the bottle from 0 to 2350 psig shall be four (plus one, minus zero) minutes.

b. The bottle shall be hydraulically pressurized using hydraulic fluid at +250°F for 1000 cycles from 0 to 2350 to 0 psig. Cycling rate shall not exceed two cycles/minute. At room temperature, hydraulically pressurize to proof pressure and check for leaks. Purge before conducting next test.

Low Temperature Pressure Cycle Test

a. While mounted vertically, the bottle shall be submerged in an atmospherically vented bath of liquid nitrogen. The bottle shall be subjected to five pressurization cycles of 0 to 5080 to 0 psig with gaseous helium. The bottle shall be pressurized and vented through the lower end. Pressurization time from 0 to 5080 to 0 psig shall not be less than eight minutes.

b. The bottle shall be heated to +250°F ± 10°F and, within 10 minutes after temperature stabilization, submerge in liquid nitrogen. The bottle shall be hydraulically pressurized for 1000 cycles from 0 to 5080 to 0 psig (1-cycle) using liquid nitrogen. The cycling rate shall not exceed two cycles/minute. At room temperature, hydraulically pressurize to proof pressure and check for leaks.

Conduct Volume Measurement

Prior to burst test, conduct volume measurement and record.

Low Temperature Burst Test

The bottle shall be internally pressurized to 7610 psig using liquid nitrogen while submerged in liquid nitrogen and this pressure held for five minutes. The time to increase pressure from 5080 psig to 7610 psig shall not be less than two minutes. If an all welded vessel is being tested and no leakage is detected, it shall be pressurized to 10,000 psig and this pressure maintained for five minutes. If an integral head vessel is being tested it shall be pressurized to 9300 psig and this pressure maintained for five minutes. Pressurization time from 7610 to 10,000 psig or from 7610 to 9300 psig shall not be less than ten minutes. If rupture of a welded vessel does not occur after five minutes at 10,000 psig or at 9300 psig in the case of an integral head vessel, the internal pressure shall be slowly increased until rupture occurs.

TABLE I

VESSEL DESIGN PARAMETERS

Size

- o L/D of 3 to 5
- o 10" min. diameter
- o Thickness Ratio: $\frac{\text{Full Scale}}{\text{Subscale}} = 1$

Pressures at -320°F	Full Scale	Subscale
Working	3300 psi	4400 psi
Proof	4500 psi	6600 psi
Burst	6600 psi	9760 psi

FINAL RESULTS

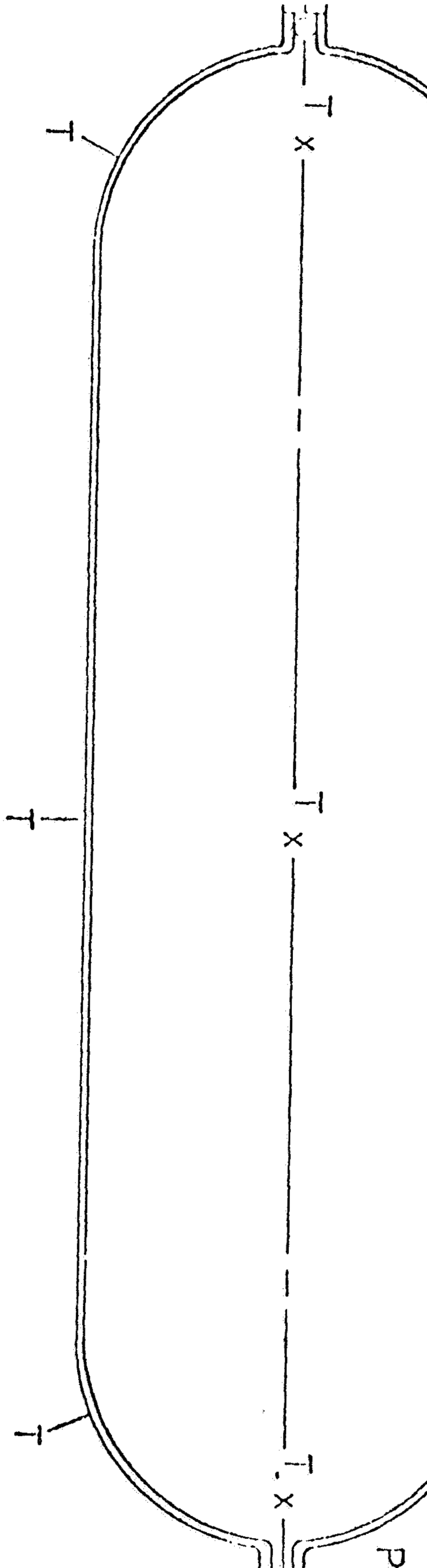
S/N	FORMING PRESSURE	WEIGHT	O.D.	L/D	VOLUME	DISPOSITION
1 (Welded)	10,000 psig	92.4 lbs.	12.5	3.8	-	-320°F burst at 10,850 psig (337 ksi nom. hoop)
3 (Welded)	10,000 psig	92.1 lbs.	12.5	3.8	2.24 cu. ft.	Shipped to MSFC
4 (Welded)	10,000 psig	91.7 lbs.	12.5	3.9	2.27 cu. ft.	Shipped to MSFC
US-2 (Integral)	9,300 psig	112 lbs.	12.4	4.6	3.28 cu. ft.	Shipped to MSFC
US-5 (Integral)	9,350 psig	108 lbs.	12.6	4.2	3.10 cu. ft.	Shipped to MSFC
CF-10	10,175 psig	-	12.6	4.4	-	-320°F burst at 10,300 psig (316.3 ksi nom. hoop

Material Properties

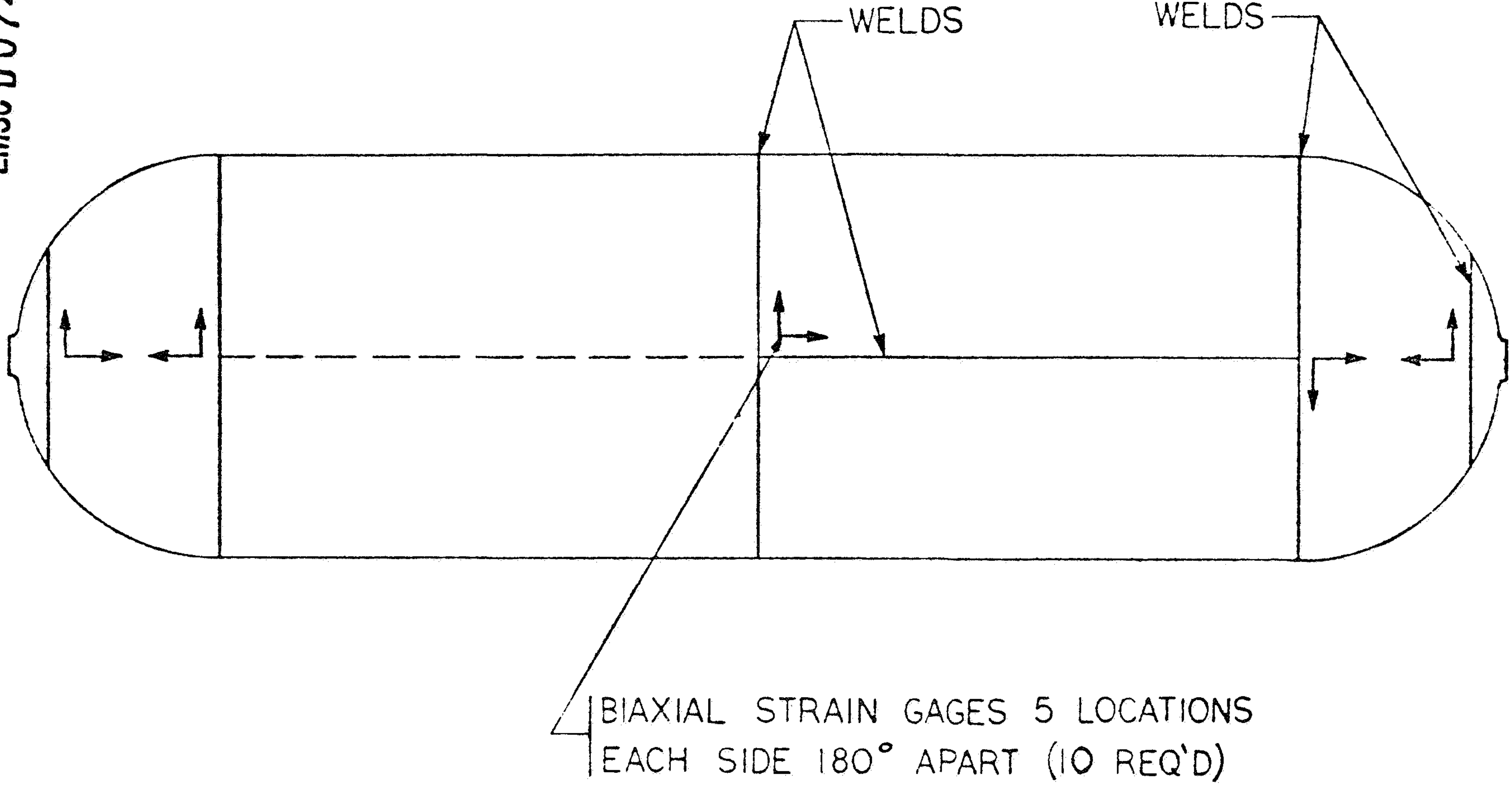
Average K1C of 85 KSI $\sqrt{\text{in.}}$ at -320° F

Average Yield Strength of 300 KSI at -320° F

ALTERNATIVE - INTERNAL FLUID TEMPERATURE

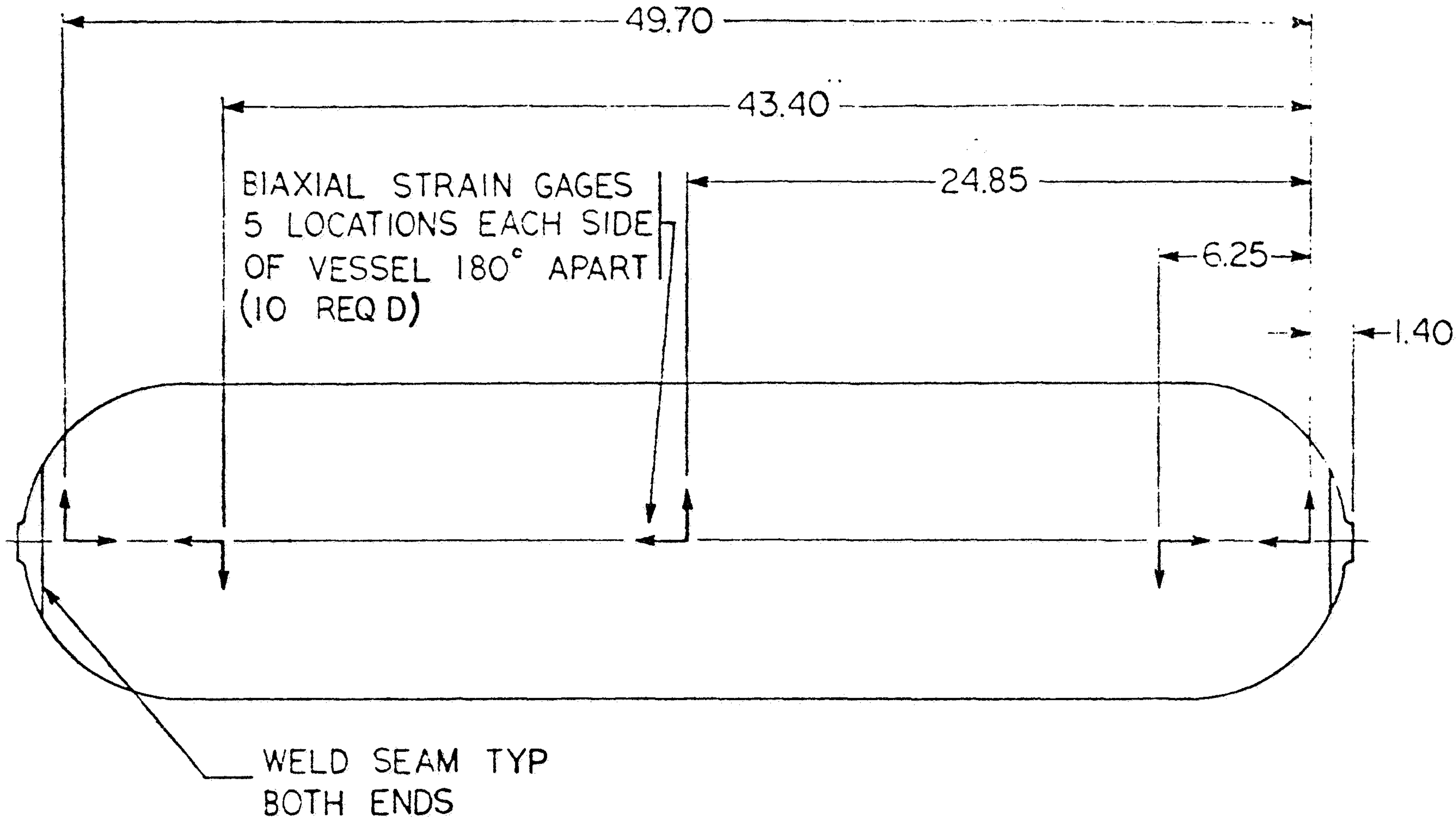


DCN 1-2-30-25753
SKETCH NO 1
1/5/67



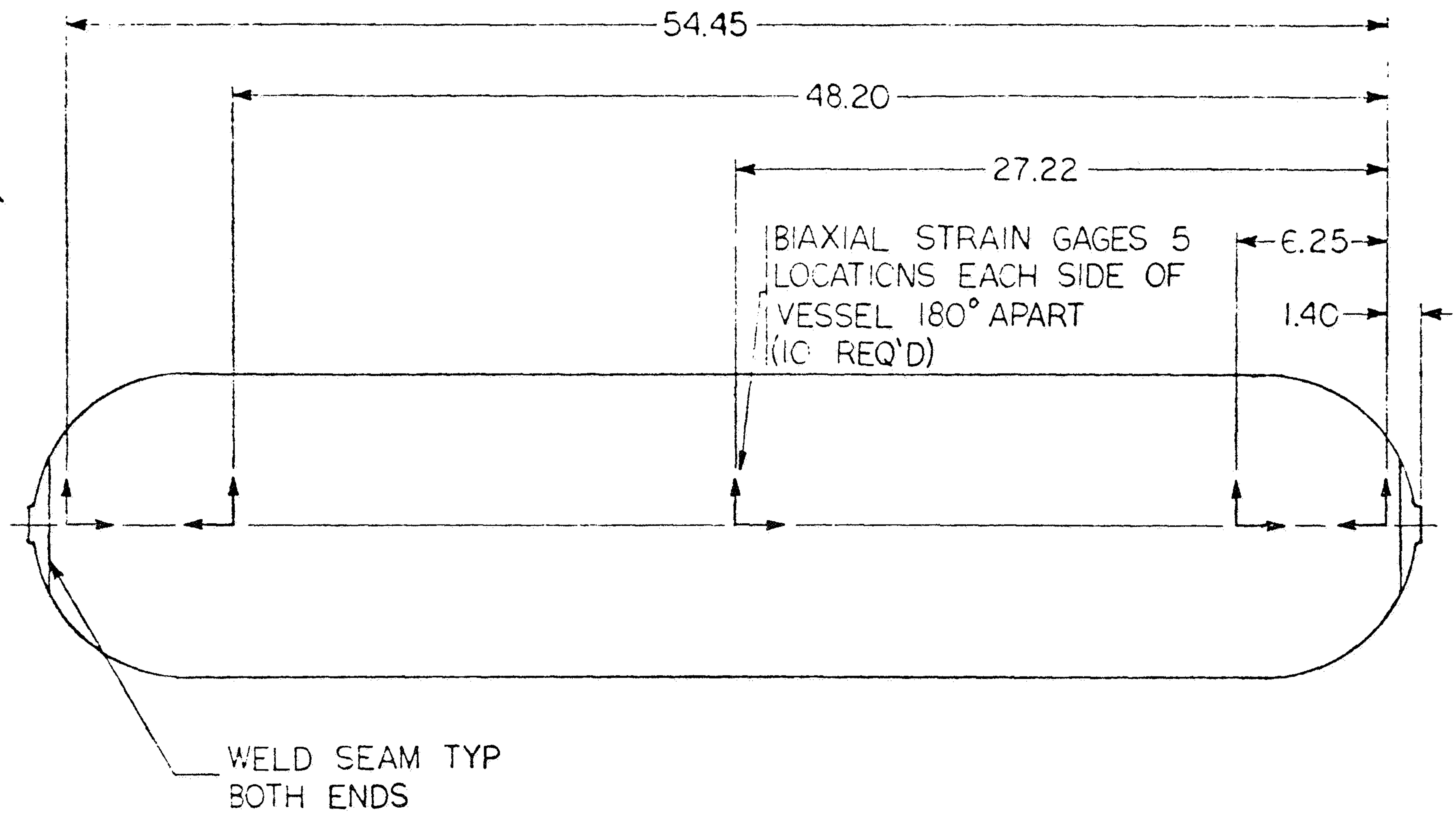
STRAIN GAGE LOCATIONS FOR
ROLLED & WELDED PRESSURE VESSEL
S/N 3 → TEST
S/N 4 → SPARE

DCN 1-8-30-25753
SKETCH NO 2
1-4-67 (REV 7-17-67



STRAIN GAGE LOCATIONS FOR INTEGRAL
HEAD PRESSURE VESSEL S/N US-5

DCN 1-6-30-25753
SKETCH NO. 3
1-4-67 (REV 7-17-68)



STRAIN GAGE LOCATIONS FOR INTEGRAL HEAD PRESSURE VESSEL S/N US-2

DCN 1-8-30-25753
SKETCH NO 4
1-9-67 (REV 7-17-68)

APPENDIX B - TEST PROCEDURE LMSC 73336

REVISIONS

SYM	DESCRIPTION	DATE	APPROVAL

NEXT ASSY	USED ON

APPLICATION

DATE 19 August 1968	**TEST PROCEDURE** (Approval Sheet) STRETCH FORM BOTTLE TEST	LOCKHEED AIRCRAFT CORPORATION MISSILES and SPACE DIVISION SUNNYVALE, CALIFORNIA
DR C.F. Cole		
CHK/SUPV T.R. Alchorn		
ENGRG J.D. Ronda		
ENGRG		
ENGRG	SCALE NONE	LMSC 73336
APPROVED [signature] ENGRG		
ENGRG		CODE SHEET 1 OF 20

FORM LMSD 1008-2

1.0 SCOPE

1.1 The purpose of this procedure is to describe and define the test method used to evaluate the performance of a Cryogenic Stretch Form Bottle.

2.0 Applicable Documents

2.1 Technical proposal LMSC-DO 80238

2.2 Test Schematic CTL 10262

3.0 Requirements

3.1 Equipment

3.1.1 Test Bottle Support Stand

3.1.2 Elevated temperature test fixture

3.1.3 Low temperature test fixture

3.2 Power

3.2.1 28 Volts DC

3.2.2 440 Volts AC

3.2.3 110 Volts AC

3.3 Environment

3.3.1 The requirements of this procedure may be accomplished under normal test area conditions.

3.4 Special Personnel

3.4.1 Authorized assigned personnel only

3.5 Safety

3.5.1 Personnel operating in the test area must be constantly aware of the hazards imposed when operating at the extreme temperatures and pressures required by this test program.

3.6 Controlled Functional Equipment

3.6.1 None

3.0 Requirements (Continued)

3.7 Calibration

3.7.1 Check the calibration decals of the test equipment to verify that the calibration is current.

3.8 Special

3.8.1 The test Bottle is constructed of relatively thin material. All necessary measures shall be taken to avoid dents or scratches in the material as any weakness produced by physical mishandling may cause premature and catastrophic failure.

3.8.2 Extreme care must be taken to avoid damage to the strain gages affixed to external bottle wall. All electrical harnesses must be secured in such manner as to avoid placing a physical load on the Strain Gage Electrical Harness attachment pads.

4.0 Product Assurance Provisions

4.1 PA Inspection/Test personnel shall verify compliance of this Test Procedure and that documentation is accomplished as noted herein.

5.0 Equipment Preparation and System Assembly.

5.1 Bottle weight measurement.

5.1.1 Verify bottle is stripped of all encumbrances except the strain gage and thermocouple components affixed to external area of bottle.

5.1.2 Place bottle on contoured support blocks and transport in enclosed vehicle to Bldg. 649.

5.1.3 Verify scale calibration and zero reading.

5.1.4 Place bottle and associated wiring harness on platform of scales.

5.1.5 Record weight on data sheet and in body of this procedure____________________.

5.1.6 Remove bottle from platform scales and transport to CTL on contoured blocks in enclosed vehicle.

5.0 Equipment Preparation and System Assembly.

5.2 Volumetric measurement.

5.2.1 Suspend bottle in an upright position in bottle support test fixture. (Screw AN 832-8 Bulkhead Fitting into bottle and secure to test fixture by locking firmly in place with AN 924-8 Bulkhead Nut.)

5.2.2 Install Drain Valve at lower port of bottle.

5.2.3 Install small clean funnel and vent line into bulkhead fitting in upper port of bottle.

5.2.4 Using a source of filtered water and a clean calibrated 4000 m/l graduate add ambient temperature water through upper bottle port until bottle is filled to top of bulkhead fitting.

5.2.5 Record total amount of water required to fill bottle in appropriate section of Data Sheet and in body of this procedure.__________________.

5.2.6 Drain water from bottle by removing bleeder plug from lower port of bottle.

5.3 Proof Pressure Test

5.3.1 Install bottle in bottle support fixture in an upright position as described in section 4.2.1.

5.3.2 Plumb a 1/4 inch high pressure tubing line from outlet of Sprague booster pump to lower port of test bottle.

5.3.3 Install a high pressure bleed valve (6000 psig minimum) at upper port of test bottle.

5.3.4 Install a 0-10,000 psig pressure transducer and a 0-10,000 psig dial gage downstream of a high pressure isolation valve in line between Sprague Booster Pump and lower fitting of bottle.

5.3.5 Attach strain gage and thermocouple wiring harness of bottle to facility recording system.

5.3.6 Perform electrical calibration and checkout of pressure transducer, strain gages, and thermocouples as required.

5.3.7 Fill test bottle to overflow with clean filtered water.

5.3 Proof Pressure Test (Continued)

5.3.8 Operate Sprague Booster Pump and bleed all air from pumping system through hand valve at test bottle upper port.

5.3.9 Place Test Cell area in RED.

5.3.10 Notify all personnel to clear the test cell area.

5.3.11 Turn recorders on.

5.3.12 While operating the Sprague Booster Pump from the safety of an adjacent cell slowly bring the pressure of test bottle up to 5900 psig at a rate not to exceed 500 psi per minute.

5.3.13 When test bottle pressure has reached 5900 psi close isolation valve at booster pump outlet and verify that not pressure decay occurs during a three minute hold period. Turn recorders off.

5.3.14 Vent pressure from system by opening the line vent valve at booster pump.

5.3.15 Drain test bottle and purge bottle dry with gaseous nitrogen.

5.4 Elevated Temperature Test "A"

5.4.1 Verify facility piping to environmental tank installed per Figure 2.

5.4.2 Verify functional checkout of water system complete.

5.4.3 Verify functional checkout of pressurization system complete.

5.4.4 Verify leak check of pressurization system complete.

5.4.5 Verify helium high-pressure storage bottle at 6000 psig.

5.4.6 Mount lid of environmental tank on support stand in cell.

5.4.7 Install Test Bottle S/N ______ upper piping to environmental tank lid.

Note: Bottle internal temperature probe must be installed at this time.

5.4.8 Install bottle pressurization line from lower port of bottle to pass through fitting in tank lid.

5.4.9 Install instrumentation pass-through connectors.

5.4.10 Supply a 15 psig source of gaseous nitrogen to test bottle and perform a visual leak check.

5.4.11 Vent pressure to zero and repair leaks.

5.4.12 Clear the cell area of personnel and remotely perform a lock-up leak check of bottle at 500 psig with gaseous nitrogen.

5.4.13 If leakage is detected in Step 5.4.12, vent pressure to zero and repeat Step 5.4.10 through Step 5.4.12.

5.4.14 Vent pressure to zero and remove GN_2 source

5.4.15 Verify all instrumentation connected per Instrumentation and Controls Documentation Sheet.

5.4.16 Verify checkout of instrumentation complete; connectors and strain gages waterproofed.

5.4.17 Verify test bottle bottom guide installed and bottle is free to move vertically without guide placing any restraint on bottle.

5.4.18 Using the overhead hoist and spreader bar, lift bottle and lid assembly from support stand and place carefully in place on gasketed mating flange of the elevated temperature environmental tank.

Note: Environmental tank to be filled with ambient temperature water at this time.

5.4.19 Verify all instrumentation still valid when immersed in water.

5.4.20 Install and tighten environmental tank lid bolts.

5.4.21 Attach external piping to environmental tank lid.

5.4.22 Turn water circulating pump on.

5.4.23 Partially open water reservoir Circulating Valve _____ and bring preheated water at 165° into environmental tank.

5.4.24 Observe water pressure gage on environmental tank and adjust flow to establish an environmental tank pressure of 20 psig.

5.4.25 Close the following hand valves:

V9 Test Tank Vent.

V4 Booster Pump High Pressure Inlet Valve.

V7 Line Vent Valve.

V2 Line Vent Valve.

V3 Booster Pump Low Pressure Inlet Valve.

5.4.26 Open the following hand valves:

V8 Regulator Inlet Valve.

V5 Booster Pump Bypass Valve.

5.4.27 Verify instrumentation people ready for test with all pretest calibrations run.

5.4.28 Verify environmental tank at 165°F by observing temperature probe recorder.

5.4.29 Test conductor make announcement of test.

5.4.30 From the console, operate the following valves·

Open Test Bottle Pressurization Valve ROV 1.

Close Test Bottle Remote Vent Valve ROV 2.

5.4.31 Technician to supply gas pressure to pressure regulator PR1 by opening high-pressure storage bottle isolation Valve V6.

5.4.32 Cell area RED.

5.4.33 Records ON.

5.4.34 Cycle dome loading switch on console to produce a bottle pressurization rate of approximately 600 psi/minute until a pressure of 2370 psig is achieved in test bottle.

Note: Bottle pressurization time to be 4 minutes $^{+1\ \text{min.}}_{-0\ \text{min.}}$

5.4.35 Vent bottle pressure to atmospheric pressure and repeat Step 5.4.34 for a total of five cycles.

Note: It will be necessary to replenish the helium storage bottles to 6000 psig between each test.

5.4.36 At the completion of testing, turn records OFF.

5.4.37 Cell area GREEN.

5.4.38 Secure water and pressurization systems.

5.4.39 Remove test bottle from elevated temperature test fixture and inspect for damage.

5.4.40 When post-test calibrations are complete, disconnect instrumentation and remove test bottle piping. Place test bottle on contoured support blocks in storage building.

5.4.41 Repeat Steps 5.4.1 through 5.4.40 for each test bottle.

5.5 Elevated Temperature Test "B"

5.5.1 Verify facility piping to environmental tank installed per Figure 3.

5.5.2 Verify functional checkout of water system complete.

5.5.3 Verify functional checkout of pressurization system complete.

5.5.4 Verify leak check of pressurization system complete.

5.5.5 Verify CTL GN_2 supply at 3200 psig.

5.5.6 Mount lid of environmental tank on support stand in cell.

5.5.7 Install Test Bottle and associated piping to environmental tank lid pass-through fittings.

Note: Bottle internal temperature probe must be installed at this time.

5.5.8 Install instrumentation pass-through connectors.

5.5.9 Supply a 15 psig source of gaseous nitrogen to test bottle and perform a visual leak check.

5.5.10 Vent pressure to zero and repair leaks.

5.5.11 Clear the cell area of personnel and remotely perform a lock-up leak check of bottle at 500 psig with gaseous nitrogen.

5.5.12 If leakage is detected in Step 5.5.11, vent pressure to zero and repeat Step 5.5.9. through Step 5.5.11.

5.5.13 Vent pressure to zero and remove GN_2 source.

5.5.14 Verify all instrumentation connected per Instrumentation and Controls Documentation Sheet.

5.5.15 Verify checkout of instrumentation complete; connectors and strain gages waterproofed.

5.5.16 Verify test bottle bottom guide installed and bottle is free to move vertically without guide placing any restraint on bottle.

5.5.17 Using the overhead hoist and spreader bar, lift bottle and lid assembly from support stand and place carefully in place on gasketed mating flange of the elevated temperature environmental tank.

Note: Environmental tank to be filled with ambient temperature water at this time.

5.5.18 Verify all instrumentation still valid when immersed in water.

5.5.19 Install and tighten environmental tank lid bolts.

5.5.20 Attach external piping to environmental tank lid.

5.5.21 Verify the following hand valves are in the closed position.

V2 Pressurization Line Bleed Valve
V3 Booster Inlet Valve
V4 Booster bypass Valve
V5 Booster bypass Valve
V6 Accumulator Isolation Valve
V7 Pressurization Line Bleed Valve

V8 Regulator Inlet Valve
V10 Water Reservoir Isolation Valve
V11 Water Pump Recirculating Valve
V12 Environmental Tank Fill Valve
V13 Test Bottle Fill Valve
V14 Water Drain Valve
V15 Water Reservoir Hand Vent Valve

5.5.22 Verify water reservoir heated to 150°F.

5.5.23 Verify instrumentation ready for test with all pretest calibrations run.

5.5.24 Open the following hand valves:

V3 Booster Inlet Valve
V4 Booster Bypass Valve
V5 Booster Bypass Valve
V8 Regulator Inlet Valve
V10 Water Reservoir Isolation Valve
V9 Test Tank Vent Valve
V11 Water Pump Recirculating Valve

5.5.25 Turn water circulating pump ON.

5.5.26 Slowly open environmental tank fill Valve V12 and establish an environmental tank pressure of 15 psig on Gage G5.

Note: If unable to achieve 15 psig on Gage G5, slowly close valve V11 until pressure on Gage G5 reaches 15 psig.

5.5.27 Slowly open Hand Valve V13 to fill test bottle and surge tank with water.

5.5.28 When test bottle and surge tank are filled, close Hand Valve V13.

5.5.29 Increase water reservoir temperature to 210°F.

5.5.30 Close Hand Vent Valve V9.

5.5.31 Close reservoir Remote Vent Valve ROV-4.

5.5.32 Close test bottle Remote Vent Valve ROV-2.

5.5.33 Establish 20 psig on BPR-1.

5.5.34 Adjust water reservoir temperature control to 250°F.

5.5.35 Arm Cell 2 1/2" regulated GN_2 switch at cell box.

5.5.36 Clear all personnel from test and shop area; close gate.

5.5.37 CTL area RED.

5.5.38 Verify environmental tank temperature probe at 250°F.

5.5.39 OPEN Cell 2 1/2" regulated GN_2 supply Valve ROV-3.

5.5.40 Open test bottle pressurization Valve ROV-1.

5.5.41 Records ON.

5.5.42 Verify cell selector on Cell 2.

5.5.43 Verify Cell 2 master switch ON.

5.5.44 Turn bottle test cycling switch to automatic.

5.5.45 Verify that strip chart recorder micro switches allow tank pressure to cycle between 20 psig and 2370 psig at a rate that does not exceed two cycles per minute.

5.5.46 At completion of 1000 cycles, turn automatic cycling switch off.

5.5.47 Records off.

5.5.48 Turn water reservoir heaters off (Switch 9 power panel "A").

5.5.49 Slowly vent pressure from water reservoir to zero psig.

5.5.50 Technician to go to water reservoir area and reduce back pressure regulator to zero psig.

5.5.51 Turn water pump off.

5.5.52 Slowly open test bottle hand vent Valve V-9 to reduce test bottle pressure to zero psig.

5.5.53 Secure CTL GN_2 system.

5.5.54 Drain environmental tank and test bottle of water.

5.5.55 Disconnect piping from environmental tank lid.

5.5.56 Remove environmental tank lid and test bottle assembly from environmental tank; place on support stand.

5.5.57 Inspect bottle for deformation or damage.

5.5.58 Hold bottle and lid assembly on support stand for next test. Do not remove instrumentation.

5.6 Second Proof Pressure Test

Perform Proof Pressure Test of test bottle per Paragraph 5.3.1 through 5.3.15.

5.7 Low Temperature Test "A"

5.7.1 Verify facility piping to low temperature environmental tank installed per Figure 4.

5.7.2 Verify functional checkout of liquid nitrogen system complete.

5.7.3 Verify functional checkout of pressurization system complete.

5.7.4 Support instrumented test bottle from hoist in cell.

5.7.5 Install instrumentation pass-through connectors.

5.7.6 Supply a 15 psig source of gaseous nitrogen to test bottle and perform a visual leak check.

5.7.7 Vent pressure to zero and repair any leaks noted.

5.7.8 Clear the cell area of personnel and remotely perform a lockup leak check of bottle at 500 psig for ten minutes with gaseous nitrogen.

5.7.9 If leakage is detected in Step 5.7.8, vent pressure to zero and repeat steps 5.7.6 through 5.7.8.

5.7.10 Vent pressure to zero and remove gaseous nitrogen source.

5.7.11 Verify all instrumentation connected per instrumentation and controls documentation sheet.

5.7.12 Verify test bottle bottom guide installed permitting bottle to move vertically with guide placing no restraint on test bottle.

5.7.13 Using the overhead hoist, lift test bottle and bottle support assembly and install carefully in place in low temperature environmental tank.

5.7.14 Attach facility piping to test bottle.

5.7.15 Verify the following hand valves are in the closed position:

- V-2 Line Bleed Valve.
- V-3 Booster Pump Inlet Valve.
- V-6 Cell 2 - 6000 psig Supply Valve.
- V-7 Line Bleed Valve.
- V-8 Regulator Inlet Valve.
- V-9 Test Bottle Hand Vent Valve.
- V-16 Low Pressure Accumulator Isolation Valve.
- V-17 Low Pressure Accumulator Discharge Valve.
- V-18 Booster Pump High-Pressure Inlet Valve.

5.7.16 Verify adequate supply of liquid nitrogen available in facility dewar. Record level ___________.

5.7.17 Verify instrumentation personnel ready for test with all calibrations completed.

5.7.18 Open the following hand valves:

- V-3 Booster Pump Inlet Valve.
- V-6 Cell 2 - 6000 psig Supply Valve.
- V-8 Regulator Inlet Valve
- V-18 Booster Pump High-Pressure Inlet Valve.

5.7.19 Open Solenoid Valve SV-4.

5.7.20 Load dome of Regulator PR-1 to 20 psig.

5.7.21 Close ROV-2 Test Bottle Remote Vent Valve.

5.7.22 Open ROV-1 Test Bottle Remote Pressurization Valve and Purge test bottle while venting helium at Pressure Transducer P-3.

5.7.23 Cycle ROV-2 Test Bottle Remote Vent Valve from close to open to close.

5.7.24 After purging for three minutes, reattach tubing to Transducer P-3.

5.7.25 Test area RED; make announcement of test.

5.7.26 Pressurize test bottle to 50 psig.

5.7.27 Open Hand Valve V-21 at liquid nitrogen dewar.

5.7.28 Open ROV-5 Environmental Tank Remote Fill Valve from console.

5.7.29 Fill environmental tank to overflow with liquid nitrogen, then close ROV-5.

5.7.30 When gas temperature at test bottle internal proble has stabilized cycle Remote Valve ROV-2 to vent test bottle to zero psig.

5.7.31 Perform final calibration of instrumentation.

5.7.32 Records ON.

5.7.33 Pressurize test bottle with helium at a rate to achieve a bottle pressure of 5080 psig and return to zero in not less than 8 minutes.

NOTE: Monitor environmental tank temperature Probe T-1 and perform top-off of liquid nitrogen environmental tank as required.

5.7.34 Recover helium and repeat steps 5.7.28 through 5.7.33 for a total of five cycles.

5.7.35 Turn records OFF; secure helium system.

5.7.36 At completion of test, remove test bottle from environmental tank, warm to ambient temperature, and after removing instrumentation place bottle on contoured blocks in storage building.

5.8 Low Temperature Test "B"

5.8.1 Verify facility piping to low temperature environmental tank installed per Figure 5.

5.8.2 Verify functional checkout of liquid nitrogen system complete.

5.8.3 Verify functional checkout of pumping and pressurization system complete.

5.8.4 Verify N_2 high pressure storage bottles at 8000 psig

5.8.5 Support instrumented test bottle and support frame from hoist in cell.

5.8.6 Install instrumentation pass-through connectors.

5.8.7 Supply a 15 psig source of gaseous nitrogen to test bottle and perform a visual leak check.

5.8.8 Vent pressure to zero and repair leaks.

5.8.9 Clear the cell area of personnel and remotely perform a lockup leak check of bottle at 500 psig for ten minutes with gaseous nitrogen.

5.8.10 If leakage is detected in Step 5.8.9, vent pressure to zero and repeat Steps 5.8.7 through 5.8.9.

5.8.11 Vent pressure to zero and remove gaseous nitrogen source.

5.8.12 Verify all instrumentation connected per instrumentation and controls documentation sheet.

5.8.13 Verify test bottle bottom guide installed permitting bottle to move vertically with guide placing no restraint on bottle.

5.8.14 Verify all pretest calibrations are complete. Ambient Temp. cal.

5.8.15 Check facility LN_2 dewar liquid level. Record _________.

5.8.16 Fill environmental tank with LN_2 to overflow by opening the following valves:

Open V-21
Open ROV-7
Open ROV-5

5.8.17 When environmental tank is filled to overflow, close ROV-5.

5.8.18 Provide a 0-50 psig source of gaseous nitrogen to GN_2 heater.

5.8.19 Plumb outlet of GN_2 heater to test bottle lower port piping.

5.8.20 Turn recorders ON.

5.8.21 Turn heaters ON.

5.8.22 Monitor skin temperature of test bottle and turn heaters OFF when skin temperature reaches 260°F. Close V-22 and V-23, and disconnect heater lines.

5.8.23 Provide a 15 psig source of gaseous helium to test bottle at Valve V23 through a 1/4 inch flex line to prevent cryo pumping and instrusion of air into test bottle during the immersion sequence.

5.8.24 Verify instrumentation recording system operating and ready for the immersion of test bottle in LN_2.

5.8.25 Using the overhead hoist, lift test bottle assembly into position over LN_2 environmental tank and lower quickly into LN_2 bath.

NOTE: Environmental tank must be full of LN_2 at start of immersion and additional LN_2 may be required to achieve stabilization of bottle skin temperature.

5.8.26 When stabilization of bottle skin temperature has been achieved, turn records OFF.

5.8.27 Isolate test bottle with 15 psig pressure locked up by closing hand valves V-22 and V-23.

5.8.28 Remove 1/4-inch helium supply flex line from test bottle.

5.8.29 Attach facility piping to test bottle as shown per Figure 5.

5.8.30 Anchor test bottle support frame to environmental tank upper flange and install insulation pads.

5.8.31 Fill test bottle and surge tank with LN_2 by opening the following valves:

Open Test Bottle Isolation Valve V-22.
Open Test Bottle Isolation Valve V-23.
Open Test Bottle LN_2 Fill Valve ROV-6.

5.8.32 Monitor vent and close valve ROV-6 when liquid is observed coming from vent.

5.8.33 Verify position of the following valves:

Close Line Bleed Valve V-2.
Open Booster Pump Inlet Valve V-3.
Open Accumulator Flow Valve V-6.
Close Line Bleed Valve V-7.
Open Regulator Inlet Valve V-8.
Close Tank Vent Valve V-9.
Close Low Pressure Line Valve V-16.
Close Low Pressure Line Valve V-17.

Open LN_2 Line Valve V-21.
Open Test Bottle Isolation Valve V-22.
Open Test Bottle Isolation Valve V-23.

5.8.34 Test conductor make announcement of test: "All personnel clear the test area."

5.8.35 Area RED.

5.8.36 Recorders ON.

5.8.37 Open Test Tank Remote Pressurization Valve ROV-1.

5.8.38 Open GN_2 Supply Valve ROV-3.

5.8.39 Actuate auto sequence ON.

5.8.40 Actuate pump ON.

5.8.41 Continue pressurization of bottle to 5080 to 0 psig (1 cycle) hydraulically at a rate not to exceed two cycles per minute.

5.8.42 Repeat cycles for a total of 1000 cycles.

NOTE: It will be necessary to replenish the liquid level in the surge tank at periodic intervals to avoid excessive use of high pressure gas due to increased ullage. BE SURE BOTTLE IS VENTED TO ATMOSPHERE BEFORE OPENING LN_2 REFILL VALVE ROV-6.

5.8.43 At completion of testing turn records OFF. Area GREEN.

5.8.44 Secure the LN_2 system and allow the LN_2 in test bottle and environmental tank to boil off.

5.8.45 Remove test bottle assembly from environmental tank and examine for distortion or other damage.

5.8.46 Perform proof pressure test of bottle per Paragraph 5.3 and log.

5.8.47 Perform volumetric measurement of test bottle per Paragraph 5.2 and log.

5.9 Low Temperature Burst Test

5.9.1 Verify facility piping to low temperature environmental tank installed per Figure 6.

5.9.2 Verify functional checkout of liquid nitrogen system complete.

5.9.3 Verify functional checkout of pressurization system complete.

5.9.4 Support instrumented test bottle from hoist in cell.

5.9.5 Install instrumentation pass-through connectors.

5.9.6 Supply a 15 psig source of gaseous nitrogen to test bottle and perform a visual leak check.

5.9.7 Vent pressure to zero and repair leaks if necessary.

5.9.8 Clear the cell area of personnel and remotely perform a lockup leak check of bottle at 500 psig for 10 minutes with gaseous nitrogen.

5.9.9 If leakage is detected in step 5.9.8 repeat steps 5.9.7 and 5.9.8.

5.9.10 Vent pressure to zero and remove gaseous nitrogen source.

5.9.11 Verify all instrumentation connected per instrumentation and controls documentation sheet.

5.9.12 Verify test bottle bottom guide installed permitting bottle to move vertically with guide placing no restraint on bottle.

5.9.13 Verify all pretest calibrations are complete.

5.9.14 Using the overhead hoist, lift test bottle and bottle support assembly and install carefully in place in low temperature environmental tank.

5.9.15 Attach facility piping to test bottle per Figure 5.

5.9.16 Verify the following hand valves are in the closed position:

- V-6 Cell 2 - High Pressure Supply Valve
- V-15 High Pressure Accumulator Isolation Valve
- V-16 Low Pressure Accumulator Isolation Valve
- V-17 Low Pressure Accumulator Discharge Valve
- V-30 Cell 3 - High Pressure Supply Valve

5.9.17 Check facility LN_2 dewar liquid level. Record ____________.

5.9.18* Fill environmental tank with LN_2 to overflow by opening the following valves:

Open V-21 LN_2 Line Valve
Open ROV-7
Open ROV-5

* Simultaneously accomplish step 5.9.20.

5.9.19 When environmental tank is filled to overflow as indicated on liquid cover sensor, close ROV-5.

5.9.20 Fill test bottle and surge tank with LN_2 by opening the following valves:

Open V-9 Test bottle hand vent valve
Open V-22 Test bottle isolation valve
Open V-23 Test bottle isolation valve
Open ROV-6 Test bottle LN_2 fill valve

5.9.21 Monitor temperature probe T-3 and close valve ROV-6 when probe T-3 temperature stabilizes at approximately -320°F. Calibrate strain gages at cold condition and record.

5.9.22 Close valve ROV-7 and open valve ROV-4.

5.9.23 Verify that test bottle remote vent valve PRV-1 is open.

5.9.24 Close test bottle hand vent valve V-9.

5.9.25 Open accumulator flow valve V-30.

5.9.26 Test conductor make announcement of test: "All personnel clear the test area".

5.9.27 Establish area condition "RED".

5.9.28 Close test bottle remote vent valve PRV-1.

5.9.29 Open test bottle remote pressurization valve ROV-7.

5.9.30 Start Corblin compressor with upper limit set to 15,000 psig.

5.9.31 Pressurize test bottle to 7610 psig and hold for 5 minutes.

NOTE: Time to pressurize from 5080 psig to 7610 psig shall not be less than 2 minutes.

5.9.32 Increase pressure from 7610 psig to 10,000 psig for bottle S/N 3 or 9300 psig for bottles US-2 and US-5. Hold this pressure for 5 minutes.

NOTE: Time to pressurize from 7610 psig to 9300 or 10,000 shall not be less than 10 minutes.

5.9.33 If rupture has not occurred after holding for the required 5 minutes slowly increase pressure until rupture does take place.

5.9.34 Immediately upon rupture of the test bottle close valve ROV-7 and stop Corblin compressor.

5.9.35 Secure cell systems.

5.9.36 Obtain photo documentation.

5.9.37 Record burst pressure in log.

DATA SHEET FOR STRETCH FORM TEST

BOTTLE SERIAL NO.________

Weight Measurement

Date ____________________

Bottle Weight ____________________

Comment ____________________

____

____

Volumetric Measurement

Date ____________________

Bottle Volume ____________________

Comment ____________________

____

____

Proof Pressure Test

Date ____________________

Pressure Achieved ____________________

Comment ____________________

Elevated Temperature Test A

Date ____________________

No. Cycles-------____________________

Comments ____________________

____

____

____

____

DATA SHEET FOR STRETCH FORM TEST

BOTTLE SERIAL NO._______

Elevated Temperature Test B

Date ____

No. Cycles ______________________________________

Comment _______________________________________

Second Proof Pressure Test

Date ____

Pressure Achieved ________________________________

Comment _______________________________________

Low Temperature Test A

Date ____

No. Cycles ______________________________________

Comment _______________________________________

Low Temperature Test B

Date ____

No Cycles _______________________________________

Comment _______________________________________

DATA SHEET FOR STRETCH FORM TEST

BOTTLE SERIAL NO.________

Third Proof Pressure Test

Date ____________________

Pressure Achieved ____________________

Comment ____________________

Second Volumetric Measurement

Date ____________________

Bottle Volume ____________________

Comment ____________________

____

____

Low Temperature Burst Test

Date ____________________

Pressure Achieved ____________________

Comment ____________________

____

____

Disposition of Bottle

Date ____________________

Comment ____________________

____

____

	NAME	DATE	LOCKHEED MISSILES & SPACE COMPANY A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION	Page	TEMP	PERM
Prepared	COLE	9-6-68	TITLE			
Checked			STRETCH BOTTLE HYDROTEST	Model		
Approved				LMSC 73336 Report No.		

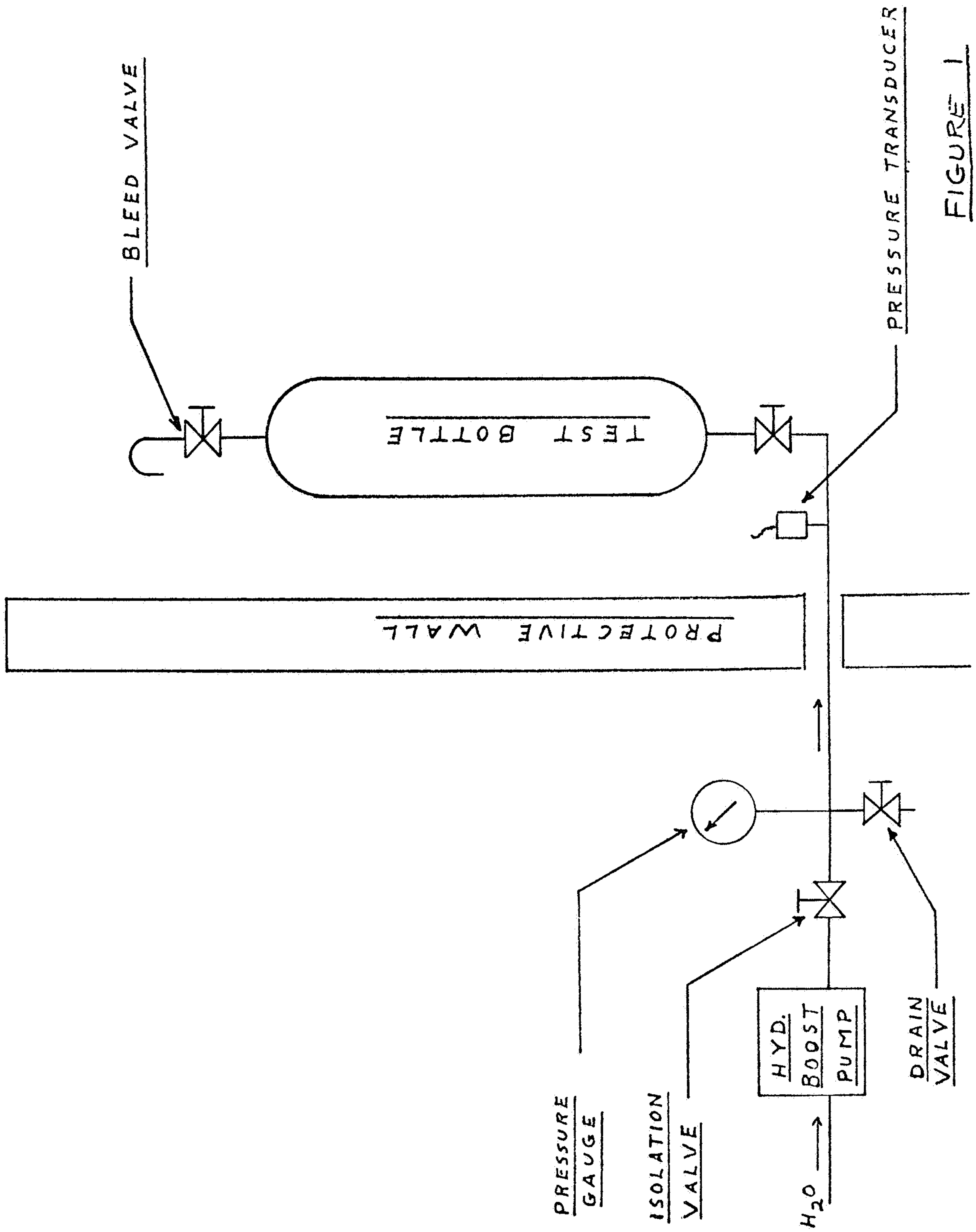


FIGURE 1

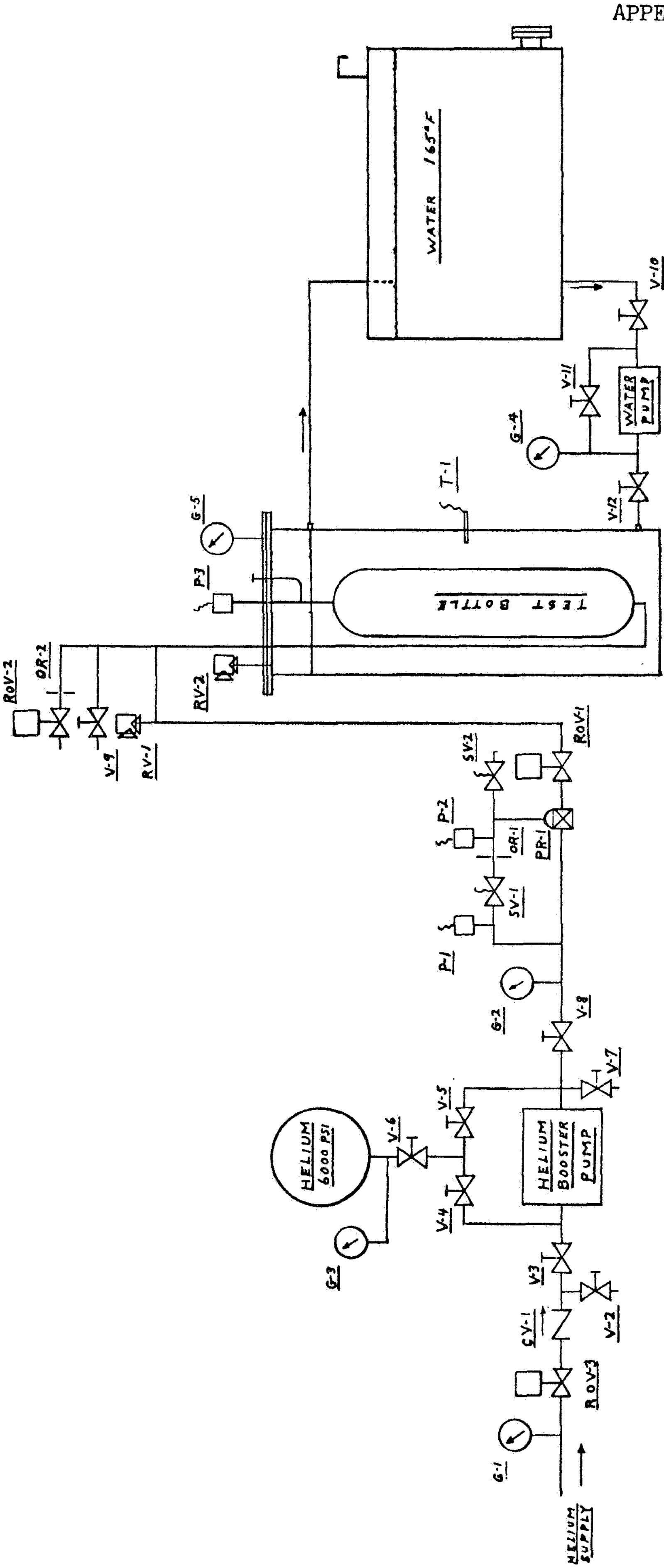

HELIUM SUPPLY
G-1
ROV-3
CV-1
V-2
V-3
G-3
HELIUM 6000 PSI
V-4
V-6
V-5
HELIUM BOOSTER PUMP
V-7
V-8
G-2
P-1
SV-1
OR-1
PR-1
P-2
SV-2
ROV-1
RV-1
V-9
ROV-2
OR-2
RV-2
P-3
G-5
TEST BOTTLE
T-1
V-12
G-4
V-11
WATER PUMP
V-10
WATER 165°F

FIGURE 2

LMSC 73336

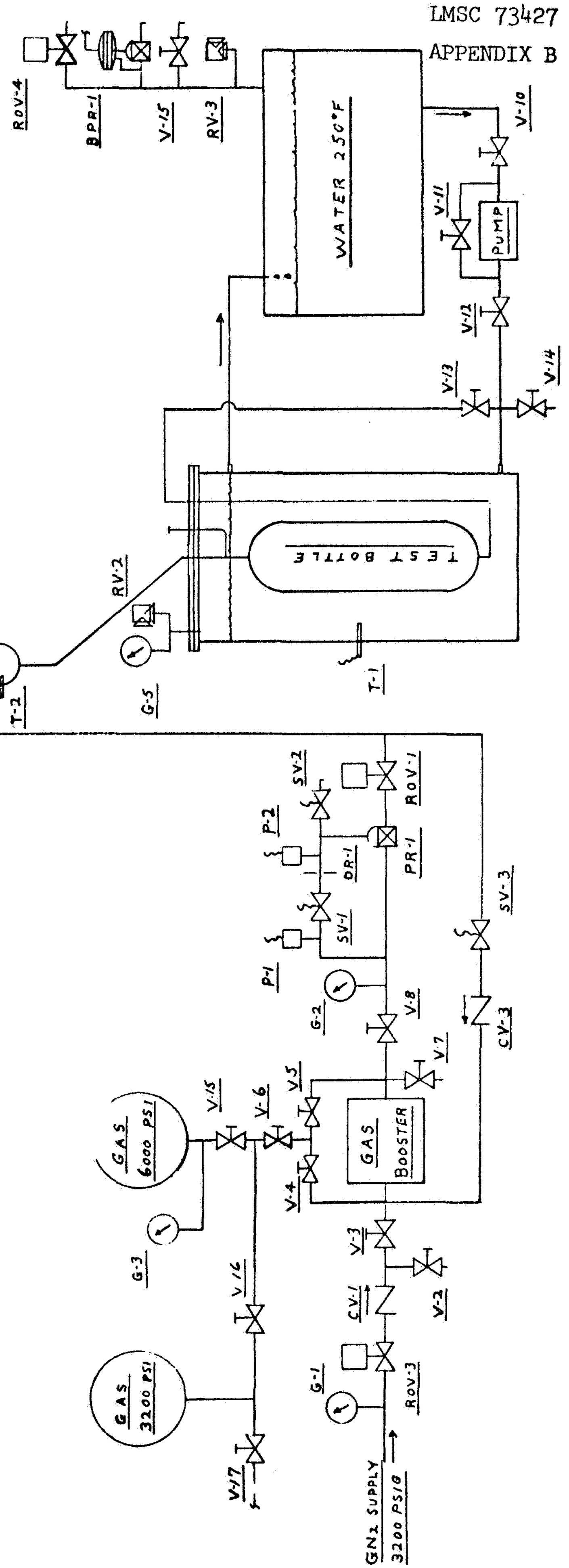
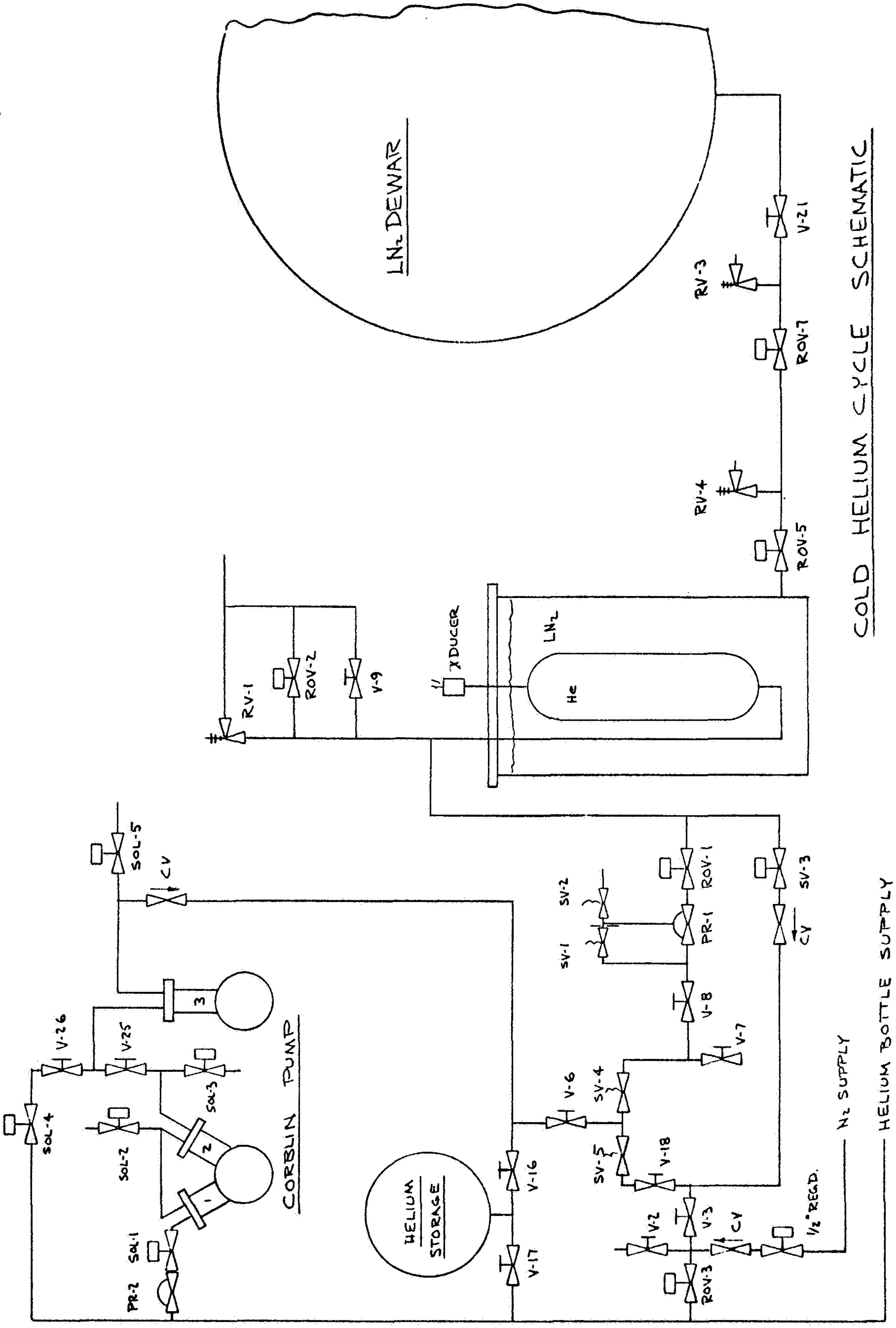


FIGURE 3

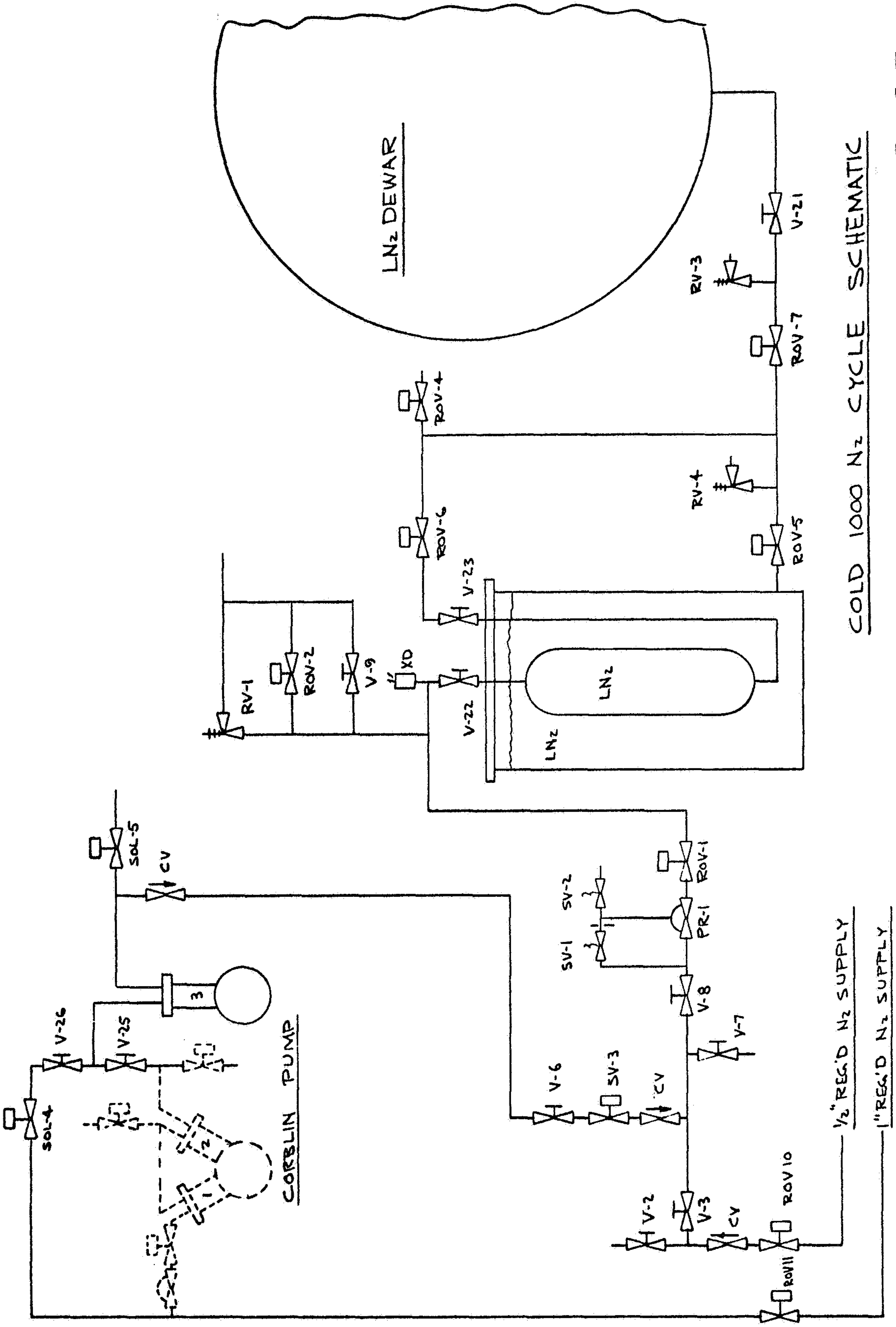
LMSC 73336



COLD HELIUM CYCLE SCHEMATIC

FIGURE 4

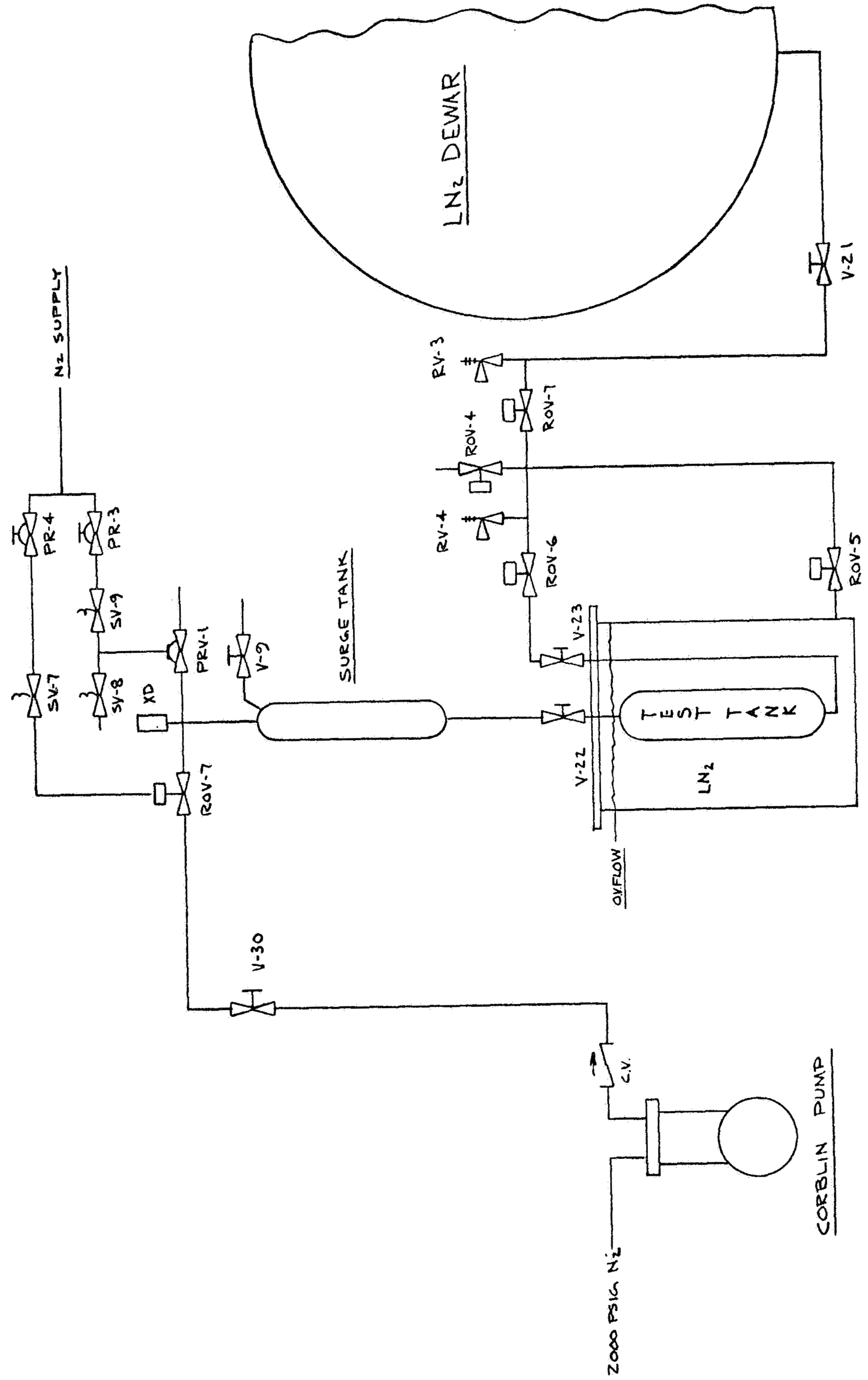
LMSC 73336



COLD 1000 N_2 CYCLE SCHEMATIC

FIGURE 5

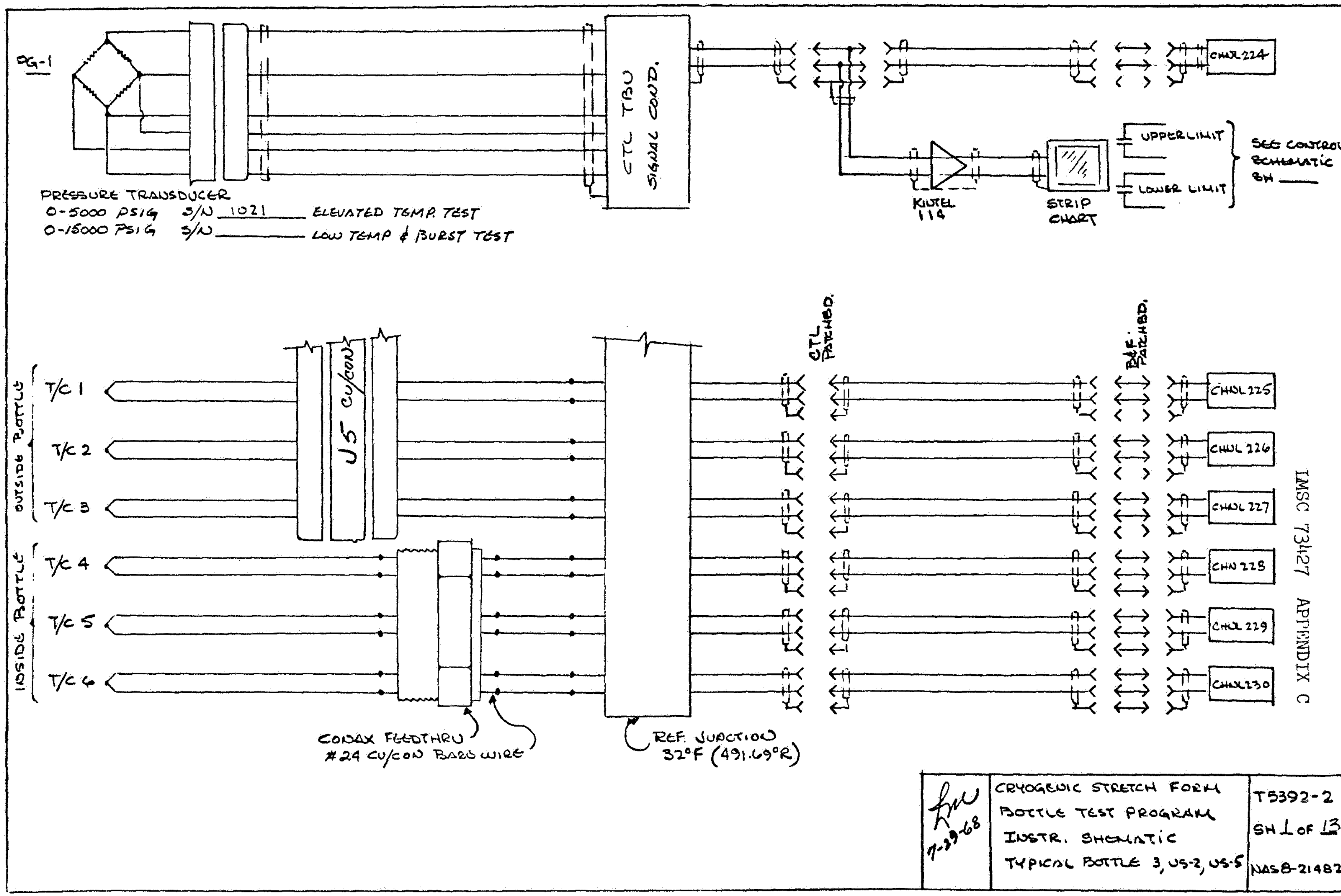
LMSC 73336

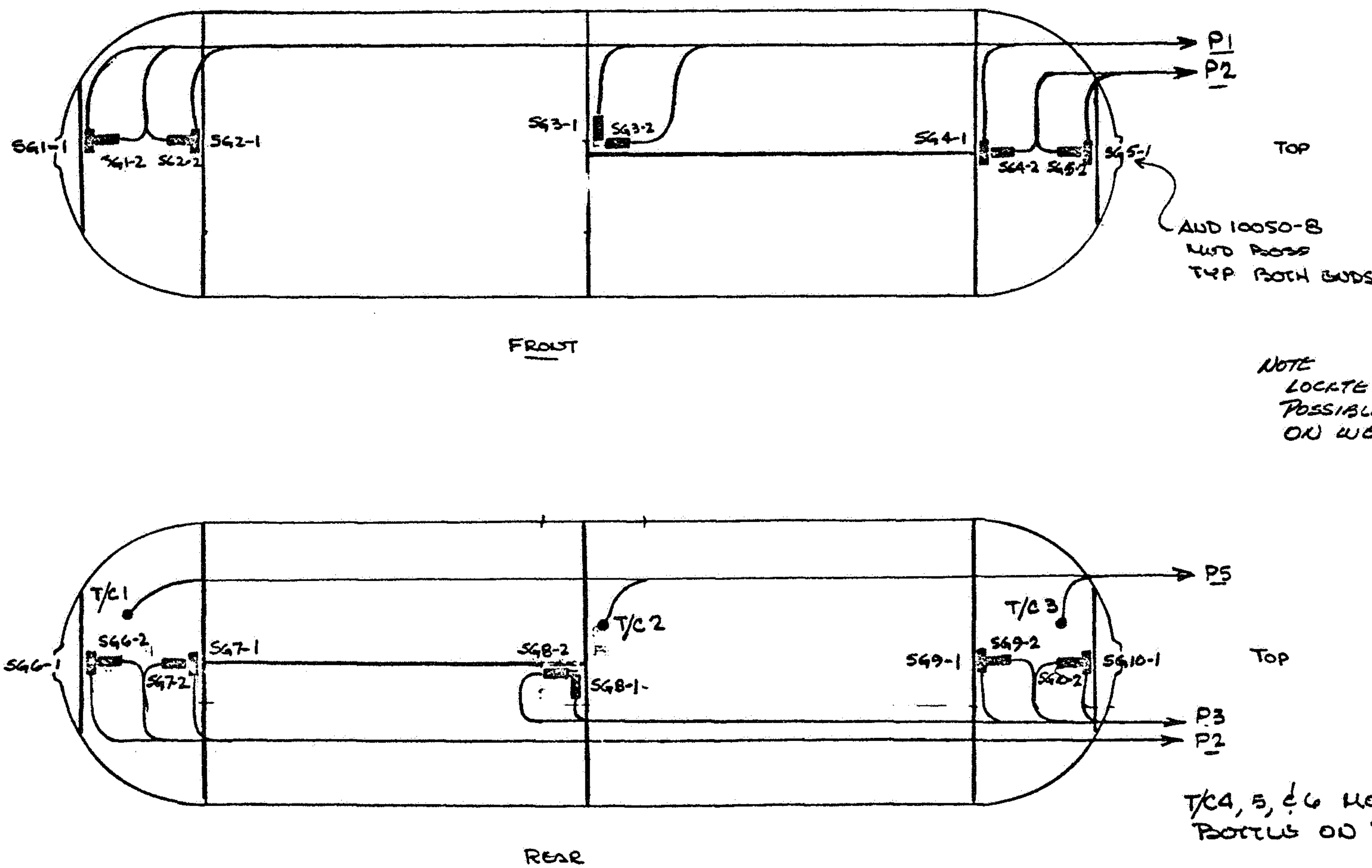


BURST TEST SCHEMATIC

FIGURE 6

APPENDIX C - INSTRUMENTATION INFORMATION

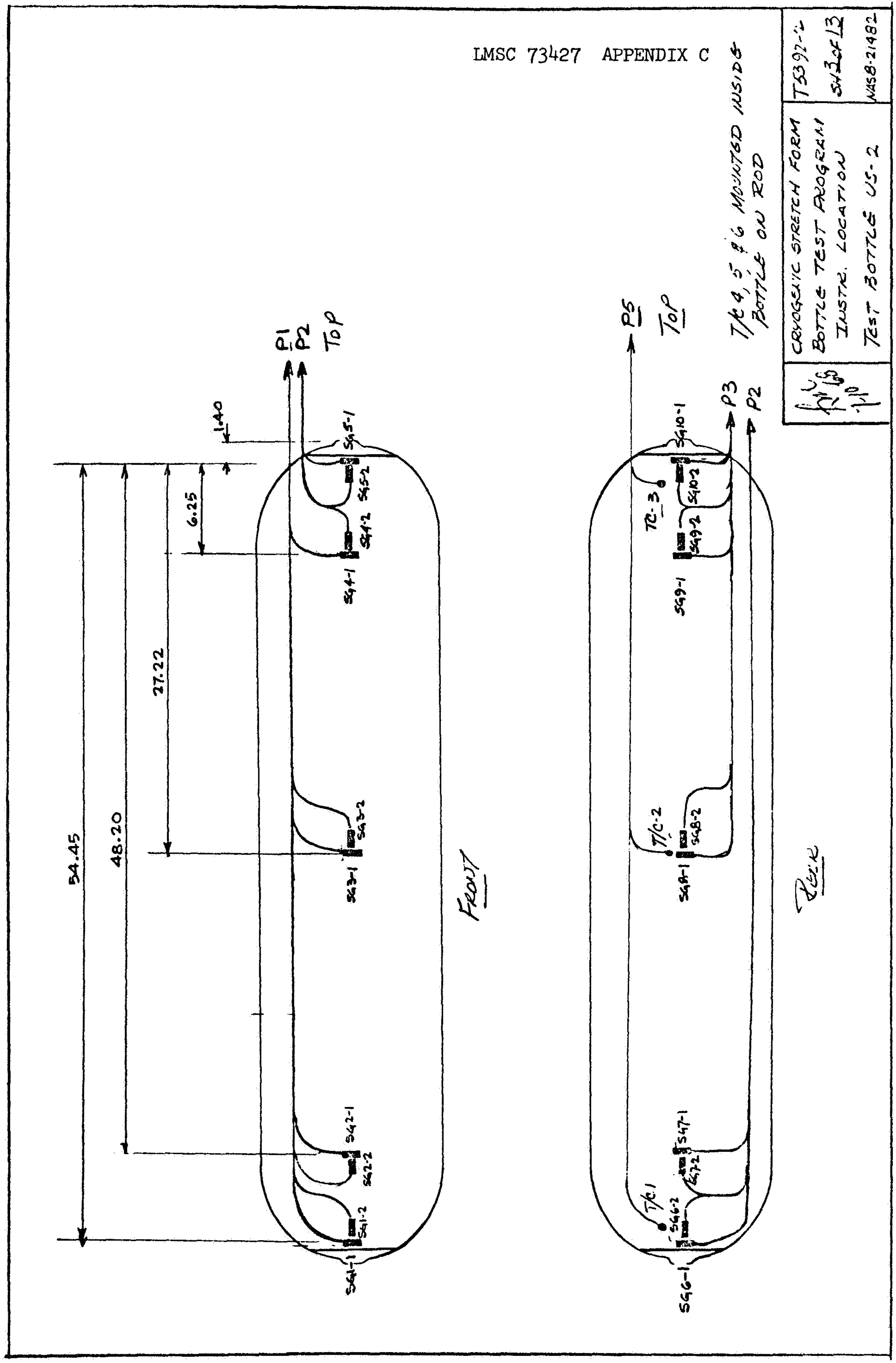

PG-1
PRESSURE TRANSDUCER
0-5000 PSIG S/N 1021 ELEVATED TEMP. TEST
0-15000 PSIG S/N LOW TEMP & BURST TEST
CTL TBU
SIGNAL COND.
CHNL 224
KINTEL
114
STRIP
CHART
UPPER LIMIT
LOWER LIMIT
SEE CONTROL
SCHEMATIC
SH
OUTSIDE BOTTLE
T/C 1
T/C 2
T/C 3
INSIDE BOTTLE
T/C 4
T/C 5
T/C 6
US CU/CON
CTL PATCHBD.
B&F PATCHBD.
CHNL 225
CHNL 226
CHNL 227
CHN 228
CHNL 229
CHNL 230
CONAX FEEDTHRU
#24 CU/CON BARE WIRE
REF. JUNCTION
32°F (491.69°R)
7-29-68
CRYOGENIC STRETCH FORM
BOTTLE TEST PROGRAM
INSTR. SHEMATIC
TYPICAL BOTTLE 3, US-2, US-5
T5392-2
SH 1 OF 13
NAS8-21482

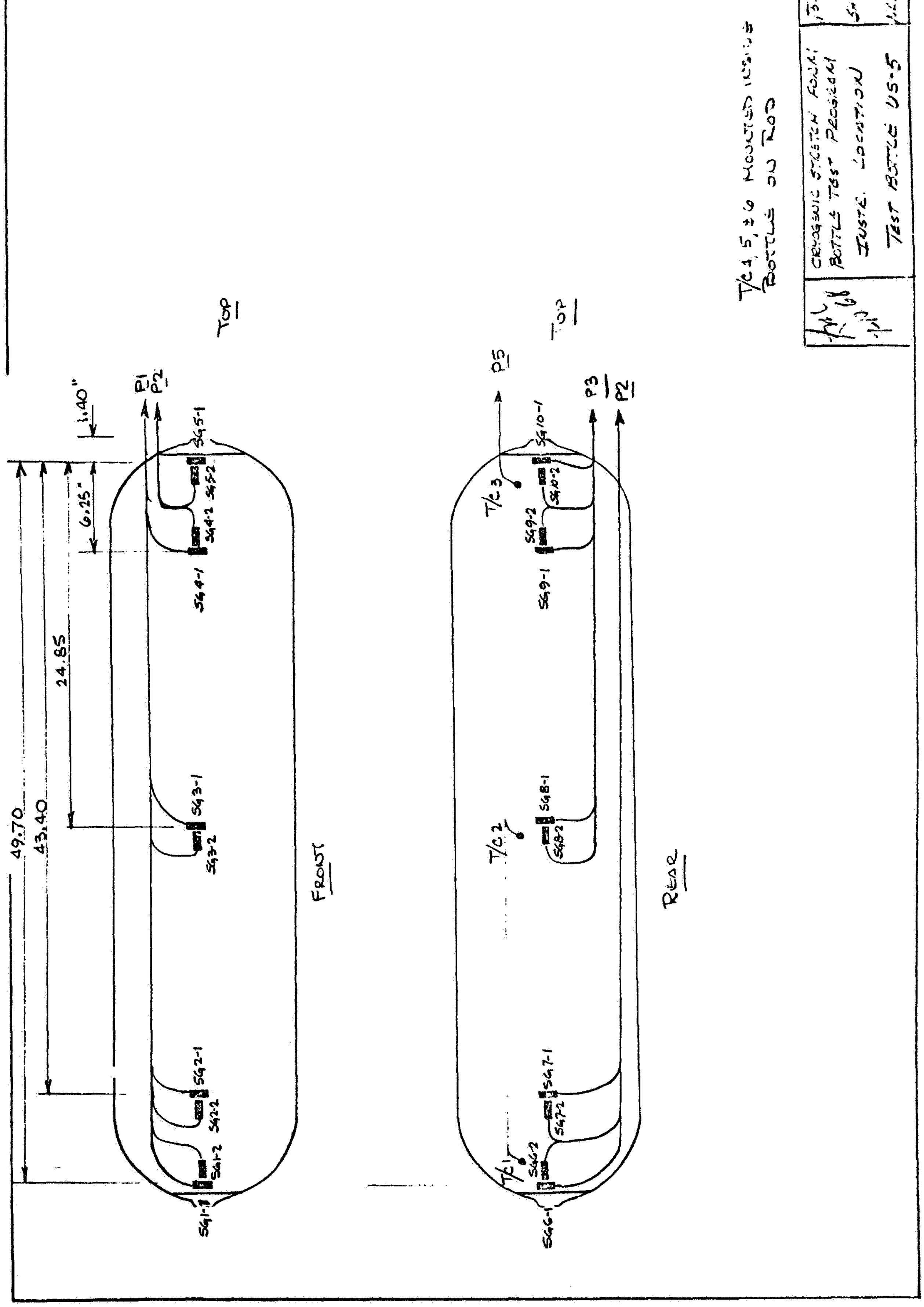


NOTE
LOCATE GAGES AS CLOSE AS POSSIBLE TO WELD BUT NOT ON WELD.

T/C4, 5, & 6 MOUNTED INSIDE BOTTLE ON ROD

1-10-68	CRYOGENIC STRETCH FORM BOTTLE TEST PROGRAM INSTR. LOCATION TEST BOTTLE No 3 & 4	T5392-2 SH 2 of 13 NAS8-21482


T/C 4, 5 & 6 MOUNTED INSIDE BOTTLE ON ROD
CRYOGENIC STRETCH FORM
BOTTLE TEST PROGRAM
INSTR. LOCATION
TEST BOTTLE US-2
T5392-2
SH 3 of 13
NAS8-21482
FRONT
REAR
TOP
P1
P2
P3
P5
54.45
48.20
27.22
6.25
1.40
SG1-1
SG1-2
SG2-1
SG2-2
SG3-1
SG3-2
SG4-1
SG4-2
SG5-1
SG5-2
SG6-1
SG6-2
SG7-1
SG7-2
SG8-1
SG8-2
SG9-1
SG9-2
SG10-1
SG10-2
T/C-1
T/C-2
TC-3


T/C 4, 5, & 6 MOUNTED INSIDE BOTTLE ON ROD
CRYOGENIC STRETCH FORM BOTTLE TEST PROGRAM
INSTR. LOCATION
TEST BOTTLE US-5
TOP
FRONT
TOP
REAR
49.70
43.40
24.85
6.25"
1.40"
P1
P2
P5
P3
P2
SG1-1
SG1-2
SG2-1
SG2-2
SG3-1
SG3-2
SG4-1
SG4-2
SG5-1
SG5-2
SG6-1
SG6-2
SG7-1
SG7-2
SG8-1
SG8-2
SG9-1
SG9-2
SG10-1
SG10-2
T/C 1
T/C 2
T/C 3

Lockheed Missiles & Space Company
Santa Cruz Test Base

DATA FOR STRETCH-FORM BOTTLE TEST

Bottle S/N 3

Elevated Temperature Test "A"

Helium Pressure -2350 psig

Water Bath

5 Cycles

Digital Tape Format

Dymec Channel	Item
203	SG 1-1
204	SG 1-2
205	SG 2-1
206	SG 2-2
207	SG 3-1
208	SG 3-2
209	SG 4-1
210	SG 4-2
211	SG 5-1
212	SG 5-2
213	SG 6-1
214	SG 6-2
215	SG 7-1
216	SG 7-2
217	SG 8-1
218	SG 8-2
219	SG 9-1
220	SG 9-2
221	SG 10-1
222	SG 10-2
224	Test Bottle Pressure
225	TC-1
226	TC-2
227	TC-3
228	TC-4
229	TC-5
230	TC-6

TC-1 through TC-6: Copper/Constantan with 32°F reference

Lockheed Missiles & Space Company

Santa Cruz Test Base

DATA FOR STRETCH-FORM BOTTLE

Bottle S/N 3

Elevated Temperature Test "B"

Water Inside Test Vessel - 2350 psig

Water Bath

1000 Cycles

Digital Tape Format

Dymec Channel	Item
203	SG 1-1
204	SG 1-2
205	SG 2-1
206	SG 2-2
207	SG 3-1
208	SG 3-2
209	SG 4-1
210	SG 4-2
211	SG 5-1
212	SG 5-2
213	SG 6-1
214	SG 6-2
215	SG 7-1
216	SG 7-2
217	SG 8-1
218	SG 8-2
219	SG 9-1
220	SG 9-2
221	SG 10-1
222	SG 10-2
224	Test Bottle Pressure
225	TC-1
226	TC-2
227	TC-3
228	TC-4
229	TC-5
230	TC-6

TC-1 through TC-6: Copper/Constantan with 32°F reference

LOCKHEED MISSILES & SPACE COMPANY

SANTA CRUZ TEST BASE

Data for Stretch-Form Bottle Test

Bottle S/N 3
Low Temperature Test "A"
Helium Pressure - 5080 psig
LN_2 Bath
5 Cycles
Tests Completed 12-11-68

Digital Tape Format

Dymec Channel	Item	
201	Test Bottle Pressure	
202	Blank	
203	SG 1-1	
204	SG 1-2	
205	SG 4-1	
206	SG 5-1	
207	SG 5-2	
208	SG 6-1	
209	SG 6-2	
210	Blank	
211	Test Bottle Pressure	
212	TC-1	Copper/Constantan with 32°F Reference
213	TC-2	
214	TC-3	
215	TC-4	
216	TC-5	
217	TC-6	
218	Environmental Tank Temperature	C/A 32°F Ref.

Strip Charts Channel

Strip Charts Channel	Item
1-1	SG 1-1
1-2	Test Tank Pressure
2-1	SG 2-1
2-2	Test Tank Pressure

LOCKHEED MISSILES & SPACE COMPANY

SANTA CRUZ TEST BASE

Data for Stretch-Form Bottle Test

Bottle S/N 3
Low Temperature Test "B" - 1000 cycles
LN_2 Bath
LN_2 Inside Test Vessel
Tests Completed 1-8-69

Digital Tape Format

Dymec Channel	Item	
201	Test Bottle Pressure	
202	Blank	
203	SG 1-1	
204	SG 1-2	
205	SG 4-1	
206	SG 5-1	
207	SG 5-2	
208	SG 6-1	
209	SG 6-2	
210	Blank	
211	Test Bottle Pressure	
212	TC-1	Copper/Constantan with 32°F Reference
213	TC-2	Copper/Constantan with 32°F Reference
214	TC-3	Copper/Constantan with 32°F Reference
215	TC-4	Copper/Constantan with 32°F Reference
216	TC-5	Copper/Constantan with 32°F Reference
217	TC-6	Copper/Constantan with 32°F Reference
218	Environmental Tank Temperature	C/A 32°F Ref.

Strip Chart Channel	Item
1-1	SG 1-1
1-2	Test Bottle Pressure
2-1	SG 1-2
2-2	Test Bottle Pressure

Lockheed Missiles & Space Company

Santa Cruz Test Base

DATA FOR STRETCH-FORM BOTTLE TEST

Bottle S/N 3

Low Temperature Burst Test

LN_2 Bath

LN_2 Inside Test Vessel

Tests Completed 1-10-69

Digital Tape Format

Dymec Channel	Item
207	Test Bottle Pressure
208	SG 1-1
209	SG 5-1
210	SG 5-2
211	Test Bottle Pressure
212	TC-1 (Copper/Constantan with 32°F reference)
213	TC-2 (Copper/Constantan with 32°F reference)
214	TC-3 (Copper/Constantan with 32°F reference)

Strip Chart Channel	Item
1-1	SG 1-1 (Solid Trace)
1-2	Test Bottle Pressure (Broken Trace)

Lockheed Missiles & Space Company

Santa Cruz Test Base

DATA FOR STRETCH-FORM BOTTLE

Bottle US-2

Elevated Temperature Test "A"

Helium Pressure - 2350 psig

Water Bath

5 Cycles

Digital Tape Format

Dymec Channel	Item
203	SG 1-1
204	SG 1-2
205	SG 2-1
206	SG 2-2
207	SG 3-1
208	SG 3-2
209	SG 4-1
210	SG 4-2
211	SG 5-1
212	SG 5-2
213	SG 6-1
214	SG 6-2
215	SG 7-1
216	SG 7-2
217	SG 8-1
218	SG 8-2
219	SG 9-1
220	SG 9-2
221	SG 10-1
222	SG 10-2
224	Test Bottle Pressure
225	TC-1
226	TC-2
227	TC-3
228	TC-4
229	TC-5
230	TC-6

TC-1 through TC-6: Copper/Constantan with 32°F reference

Lockheed Missiles & Space Company

Santa Cruz Test Base

DATA FOR STRETCH-FORM BOTTLE

Bottle US-2

Elevated Temperature Test "B"

Water Inside Test Vessel - 2350 psig

Water Bath

1000 Cycles

Digital Tape Format

Dymec Channel	Item
203	SG 1-1
204	SG 1-2
205	SG 2-1
206	SG 2-2
207	SG 3-1
208	SG 3-2
209	SG 4-1
210	SG 4-2
211	SG 5-1
212	SG 5-2
213	SG 6-1
214	SG 6-2
215	SG 7-1
216	SG 7-2
217	SG 8-1
218	SG 8-2
219	SG 9-1
220	SG 9-2
221	SG 10-1
222	SG 10-2
224	Test Bottle Pressure
225	TC-1
226	TC-2
227	TC-3
228	TC-4
229	TC-5
230	TC-6

TC-1 through TC-6: Copper/Constantan with 32°F reference

Lockheed Missiles & Space Company

Santa Cruz Test Base

DATA FOR STRETCH-FORM BOTTLE TEST

Bottle US-2

Low Temperature Test "A"

Helium Pressure - 5080 psig

LN_2 Bath

5 Cycles

Tests Completed 29 January 1969

Dymec Channel	Item
204	Test Bottle Pressure
205	SG 1-2
206	SG 2-1
207	SG 2-2
208	SG 3-1
209	SG 3-2
210	SG 4-1
211	SG 4-2
212	SG 5-1
213	SG 5-2
214	Test Bottle Pressure
215	SG 6-1
216	SG 6-2
217	SG 7-1
218	SG 7-2
219	SG 8-1
220	SG 8-2
221	SG 9-1
222	SG 9-2
223	SG 10-1
224	SG 10-2
225	TC-1 } Copper/Constantan with 32°F reference
226	TC-2 } Copper/Constantan with 32°F reference
227	TC-3 } Copper/Constantan with 32°F reference

Strip Chart Channels	Item
1-1	Test Bottle Pressure
1-2	SG 2-2

Lockheed Missiles & Space Company
Santa Cruz Test Base

DATA FOR STRETCH-FORM BOTTLE TEST

Bottle US-2

Low Temperature Test 'B'

LN_2 Inside Vessel

LN_2 Bath

1000 Cycles

Test Completed 20 February 1969

Digital Tape Format

Dymec Channel	Item
203	Test Bottle Pressure
204	Void (SG 1-2 non-functional)
205	SG 2-2
206	SG 3-1
207	SG 6-2
208	SG 7-2
209	SG 9-2
210	Test Bottle Pressure
211	TC-1 } Copper/Constantan with 32°F reference
212	TC-2 } Copper/Constantan with 32°F reference

Strip Chart Channels	Item
1-1	Test Bottle Pressure
1-2	SG 2-2

Lockheed Missiles & Space Company
Santa Cruz Test Base

DATA FOR STRETCH-FORM BOTTLE TEST

Bottle US-2

Low Temperature Burst Test

LN_2 Inside Vessel

LN_2 Bath

Test Completed 24 February 1969

Digital Tape Format

Dymec Channel	Item
203	Test Bottle Pressure
206	SG 3-1
208	SG 7-2
209	SG 9-2
210	Test Bottle Pressure
211	TC-1 } Copper/Constantan with 32°F reference
212	TC-2 } Copper/Constantan with 32°F reference

Lockheed Missiles & Space Company

Santa Cruz Test Base

DATA FOR STRETCH-FORM BOTTLE

Bottle US-5

Elevated Temperature Test "A"

Helium Pressure - 2350 psig

Water Bath

5 cycles

Digital Tape Format

Dymec Channel	Item
203	SG 1-1
204	SG 1-2
205	SG 2-1
206	SG 2-2
207	SG 3-1
208	SG 3-2
209	SG 4-1
210	SG 4-2
211	SG 5-1
212	SG 5-2
213	SG 6-1
214	SG 6-2
215	SG 7-1
216	SG 7-2
217	SG 8-1
218	SG 8-2
219	SG 9-1
220	SG 9-2
221	SG 10-1
222	SG 10-2
224	Test Bottle Pressure
225	TC-1
226	TC-2
227	TC-3
228	TC-4
229	TC-5
230	TC-6

TC-1 through TC-6: Copper/Constantan with 32°F reference

Lockheed Missiles & Space Company

Santa Cruz Test Base

DATA FOR STRETCH-FORM BOTTLE

Bottle US-5

Elevated Temperature Test "B"

Water Inside Test Vessel - 2350 psig

Water Bath

1000 Cycles

Digital Tape Format

Dymec Channel	Item
203	SG 1-1
204	SG 1-2
205	SG 2-1
206	SG 2-2
207	SG 3-1
208	SG 3-2
209	SG 4-1
210	SG 4-2
211	SG 5-1
212	SG 5-2
213	SG 6-1
214	SG 6-2
215	SG 7-1
216	SG 7-2
217	SG 8-1
218	SG 8-2
219	SG 9-1
220	SG 9-2
221	SG 10-1
222	SG 10-2
224	Test Bottle Pressure
225	TC-1
226	TC-2
227	TC-3
228	TC-4
229	TC-5
230	TC-6

TC-1 through TC-6: Copper/Constantan with 32°F reference

Lockheed Missiles & Space Company

Santa Cruz Test Base

DATA FOR STRETCH-FORM BOTTLE TEST

Bottle US-5

Low Temperature Test "A"

Helium Pressure - 5080 psig

LN_2 Bath

5 Cycles

Tests Completed 31 January 1969

Dymec Channel	Item
203	Test Bottle Pressure
204	SG 1-1
205	SG 1-2
206	SG 2-1
207	SG 2-2
208	SG 3-1
209	SG 3-2
210	SG 4-1
211	SG 4-2
212	SG 5-1
213	Void (5-2 non-functional)
214	Test Bottle Pressure
215	SG 6-1
216	SG 6-2
217	SG 7-1
218	SG 7-2
219	SG 8-1
220	SG 8-2
221	SG 9-1
222	SG 9-2
223	SG 10-1
224	SG 10-2
225	TC-1 } Copper/Constantan
226	TC-2 } with 32°F reference

Strip Chart Channels	Item
1-1	Test Bottle Pressure
1-2	SG 2-2

Lockheed Missiles & Space Company
Santa Cruz Test Base

DATA FOR STRETCH-FORM BOTTLE TEST

Bottle US-5
Low Temperature Test "B"
LN_2 Inside Vessel
LN_2 Bath
1000 Cycles
Tests Completed 7 February 1969

Digital Tape Format

Dymec Channel	Item
203	Test Bottle Pressure
204	SG 1-2
205	SG 2-2
206	Test Bottle Pressure
207	TC-1 } Copper/Constantan
208	TC-2 } with 32°F reference

Strip Chart Channels	Item
1-1	Test Bottle Pressure
1-2	SG 2-2

Lockheed Missiles & Space Company
Santa Cruz Test Base

DATA FOR STRETCH-FORM BOTTLE TEST

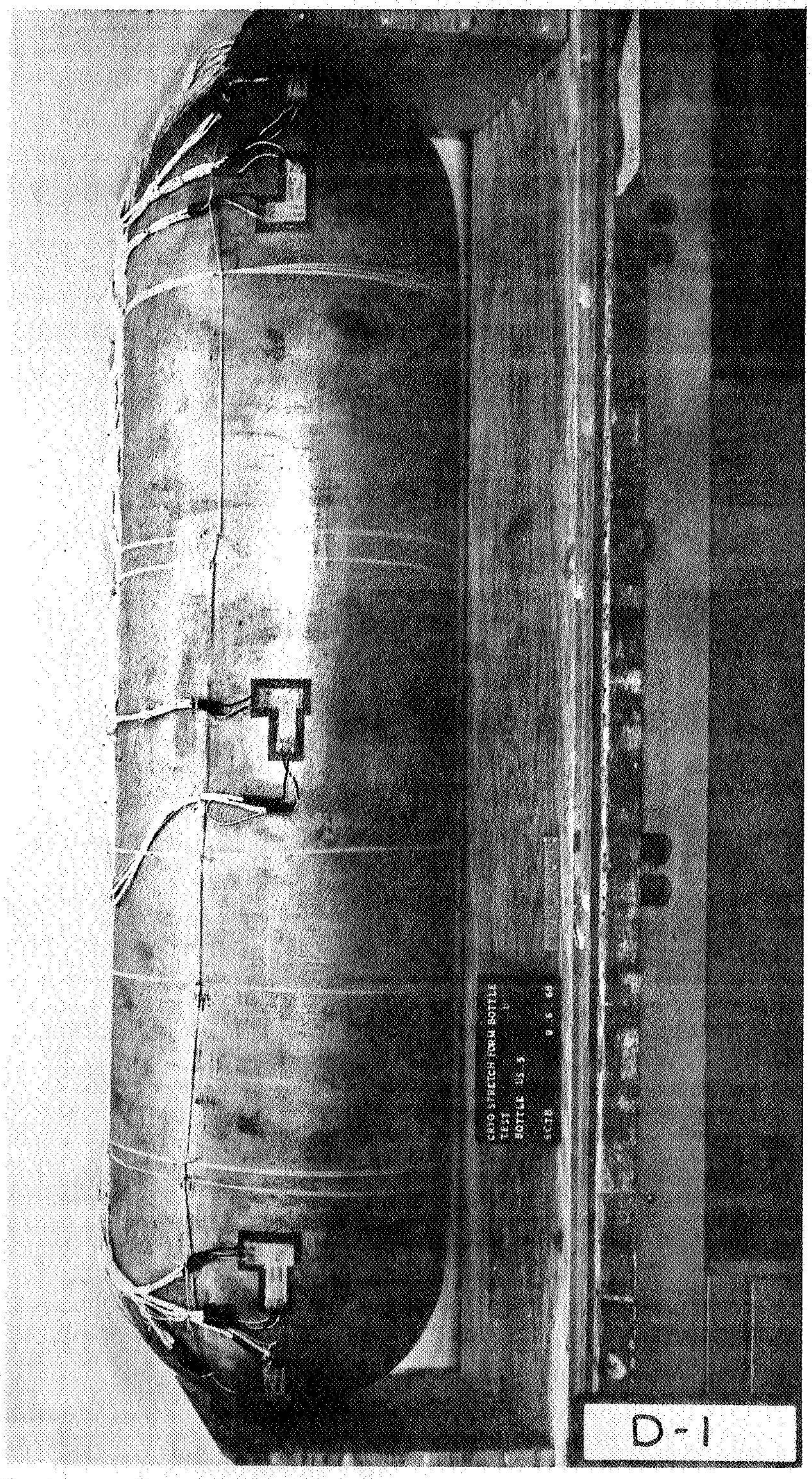
Bottle US-5
Low Temperature Burst Test
LN_2 Inside Vessel
LN_2 Bath
Test Completed 28 February 1969

Digital Tape Format

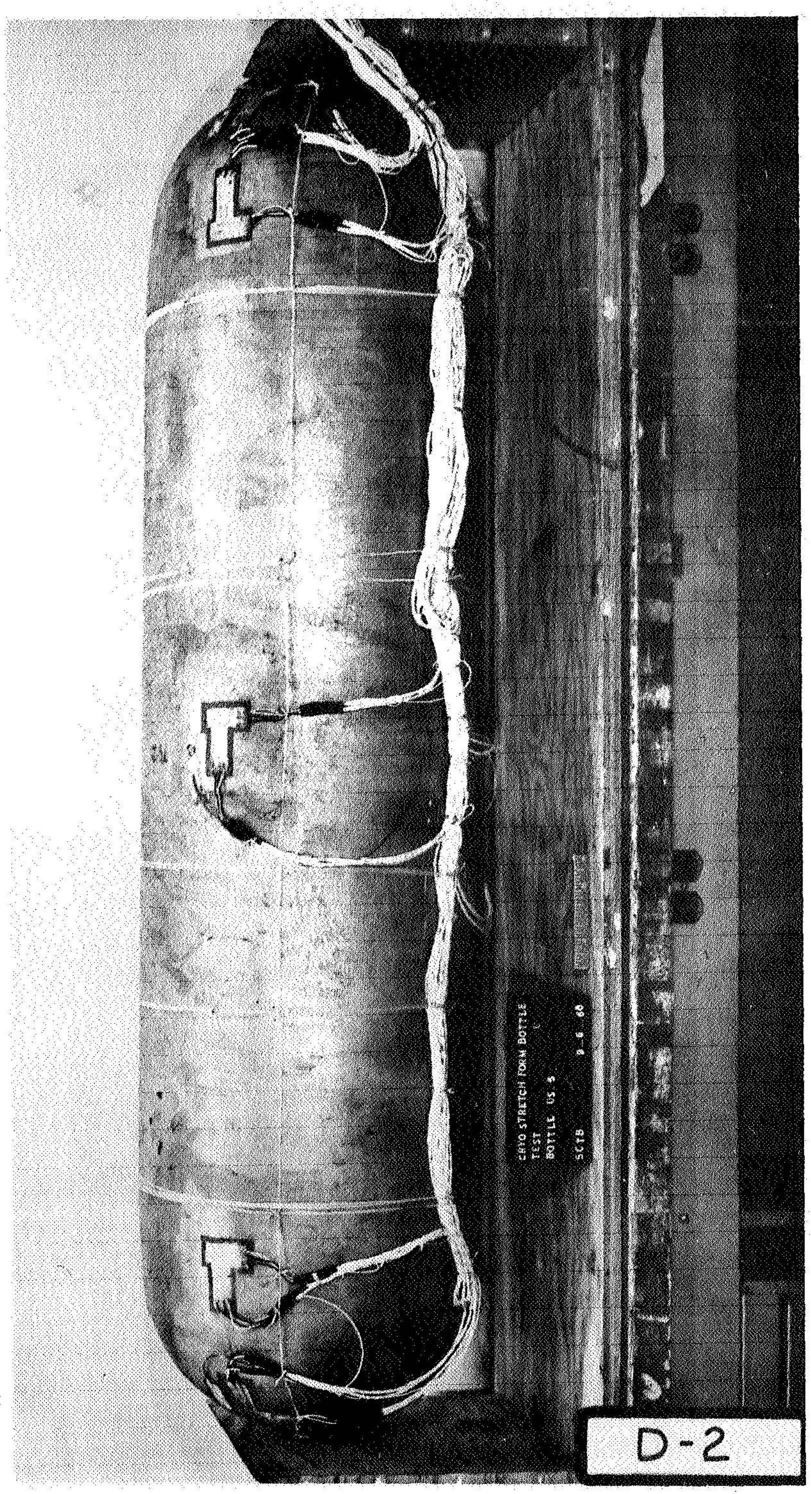
Dymec Channel	Item
203	Test Bottle Pressure
204	TC-1 } Copper/Constantan with 32°F reference
205	TC-2 } Copper/Constantan with 32°F reference
206	Test Bottle Pressure

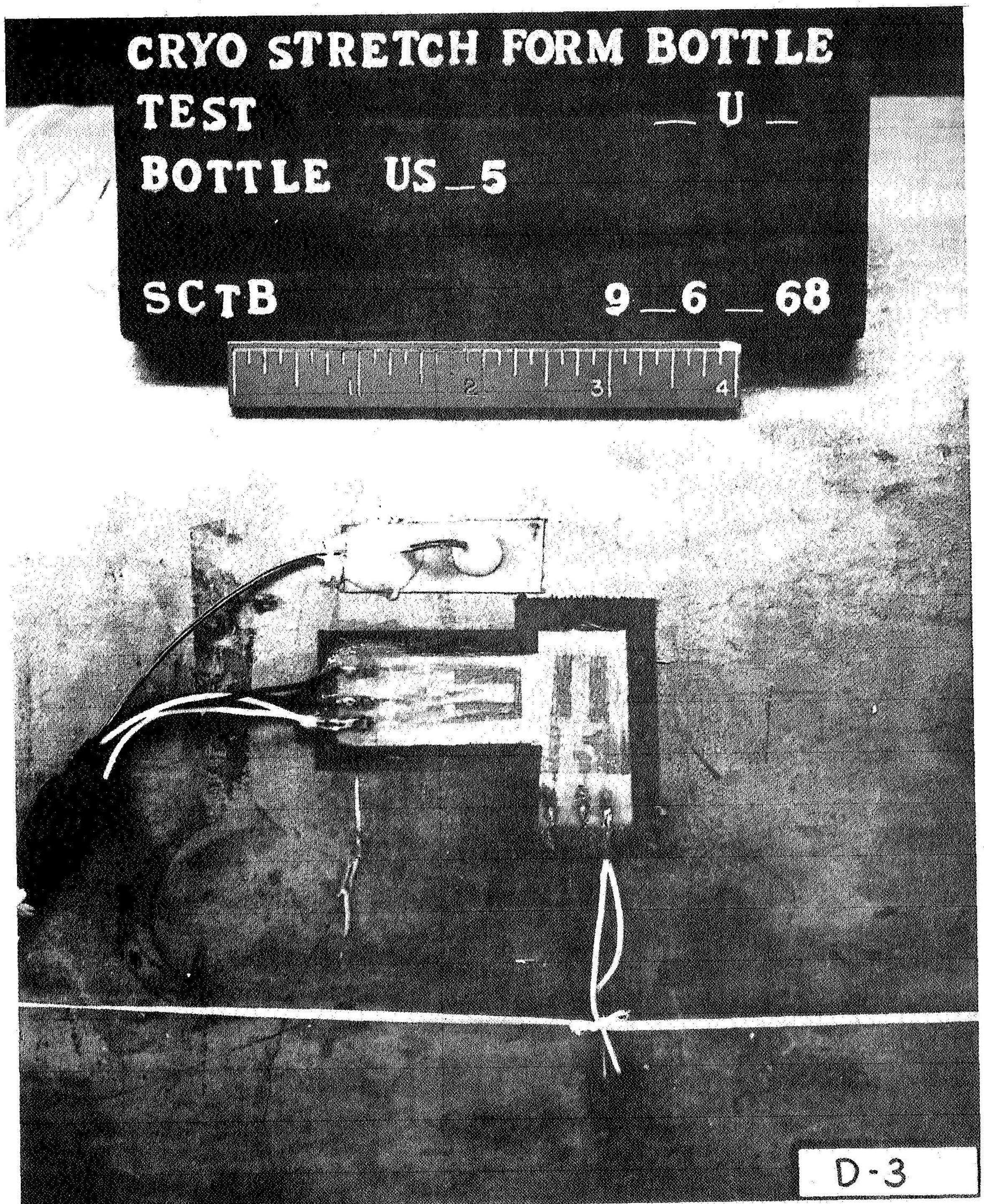
APPENDIX D - PHOTOGRAPHS

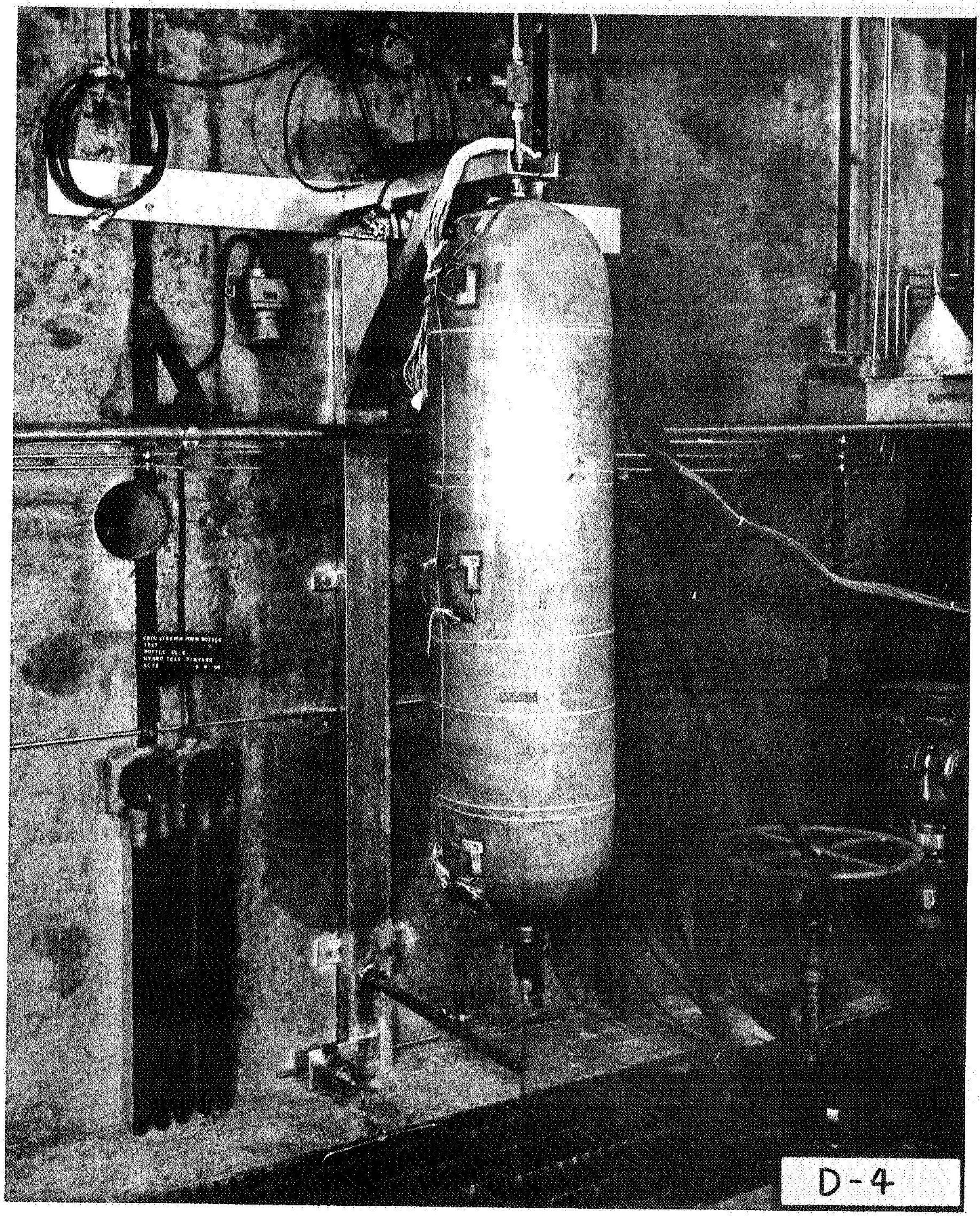
LIST OF PHOTOGRAPHS



D-1


CRYO STRETCH FORM BOTTLE
TEST
BOTTLE US-5
SCTB


CRYO STRETCH FORM BOTTLE
TEST U
BOTTLE US 5
SCTB 9 6 68
1 2 3 4
D-3



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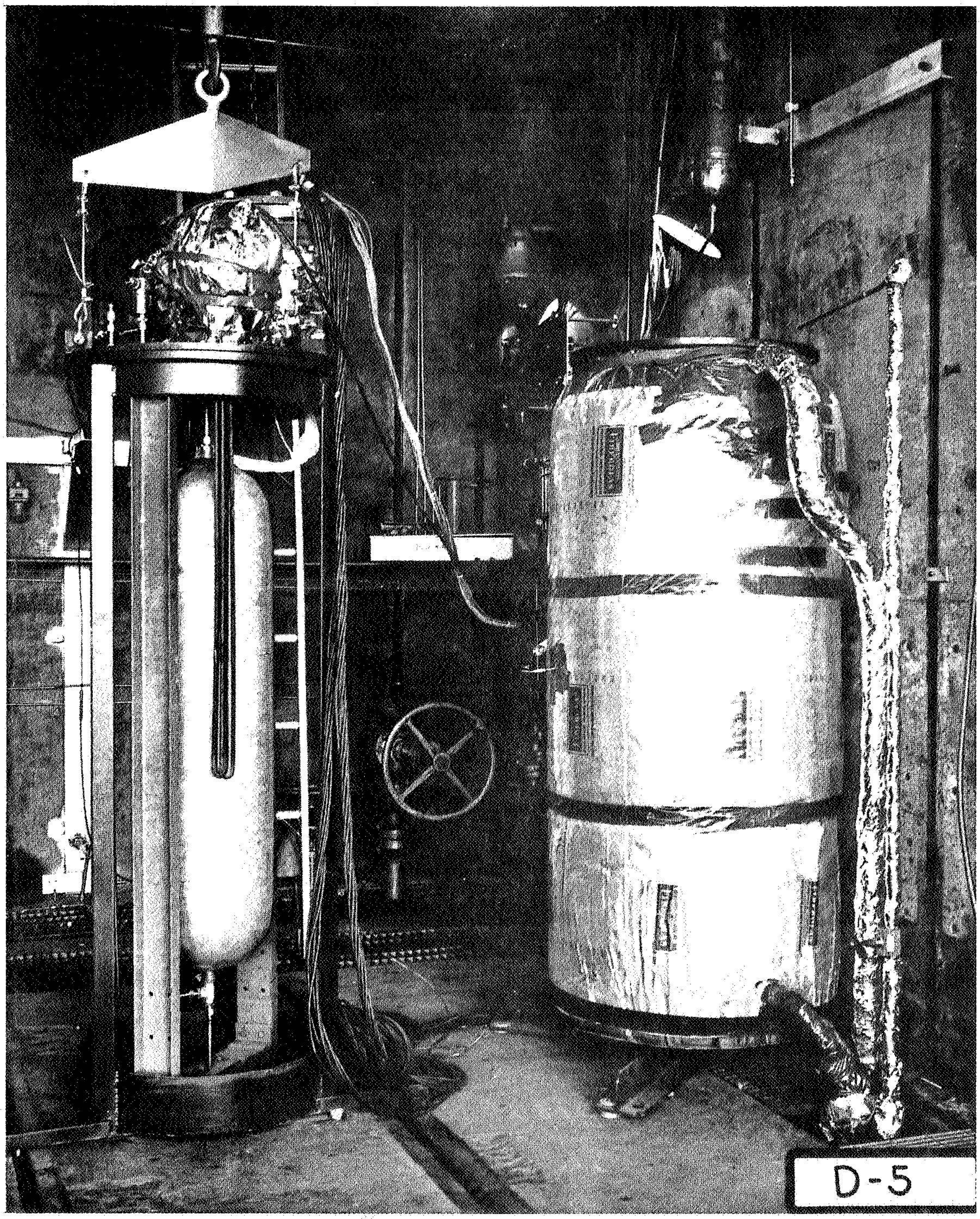
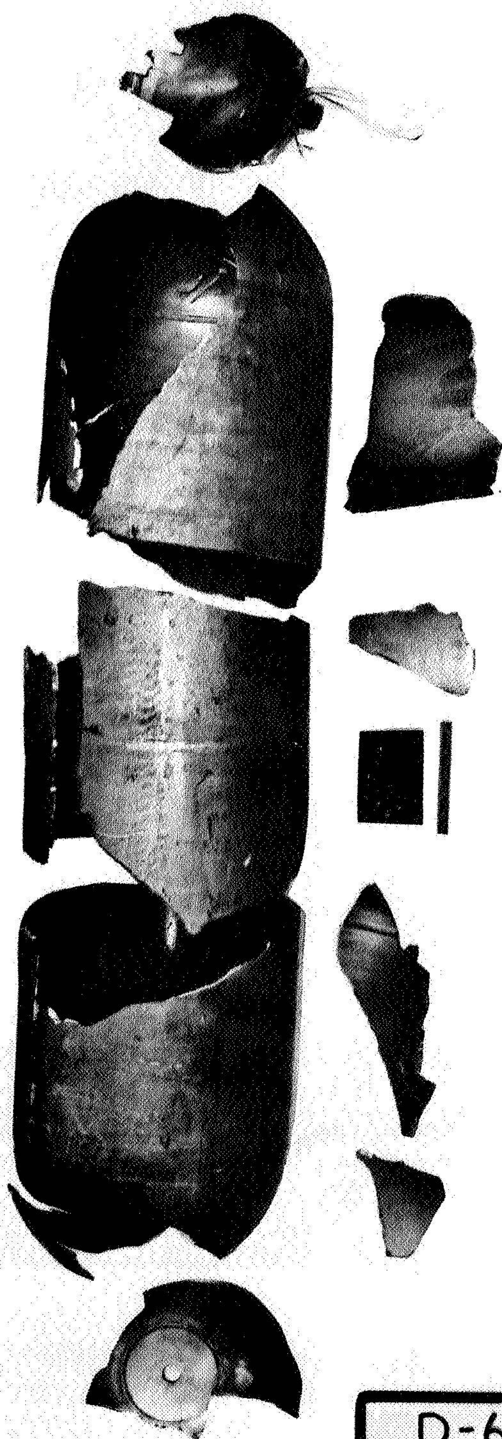
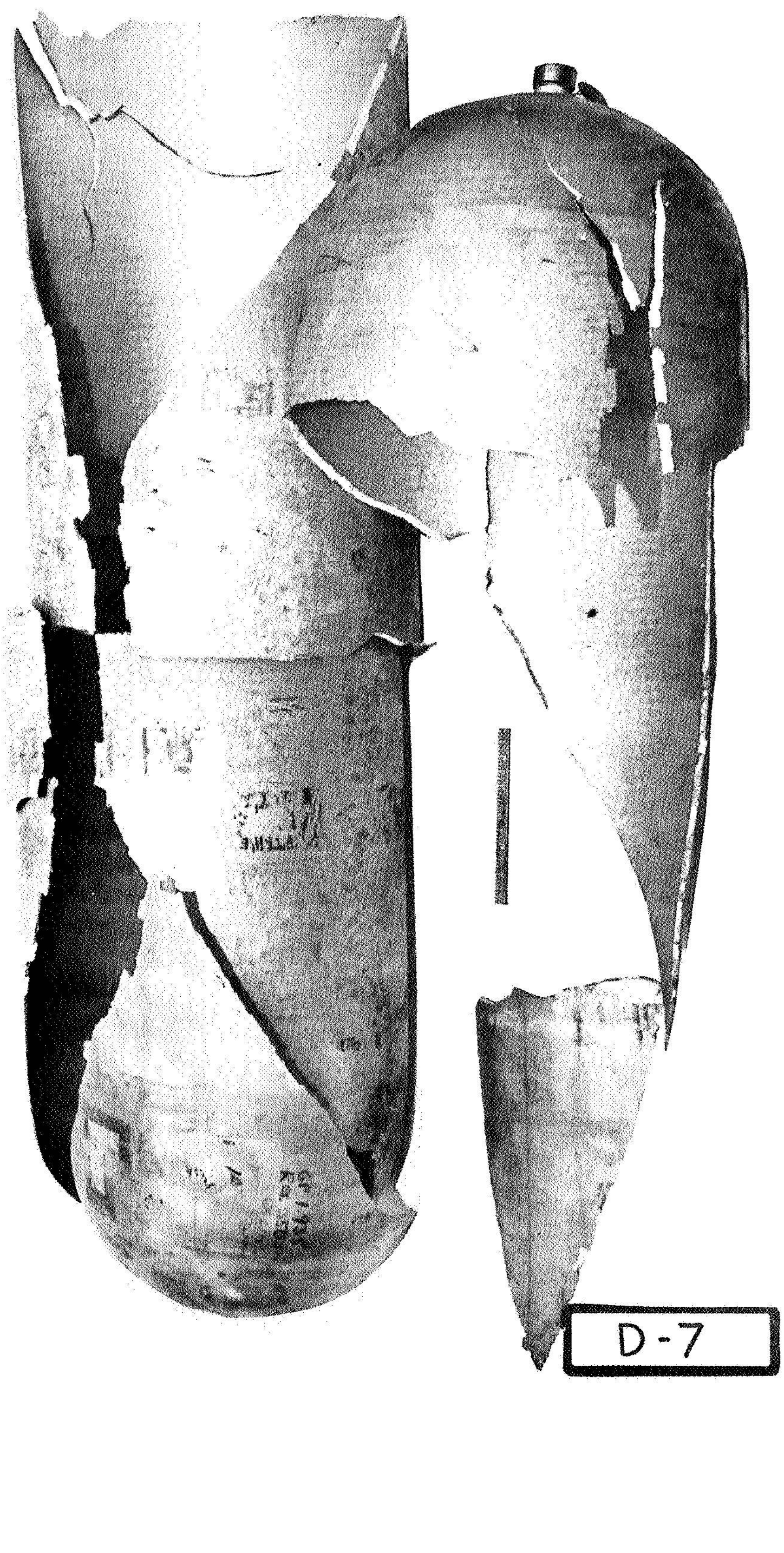
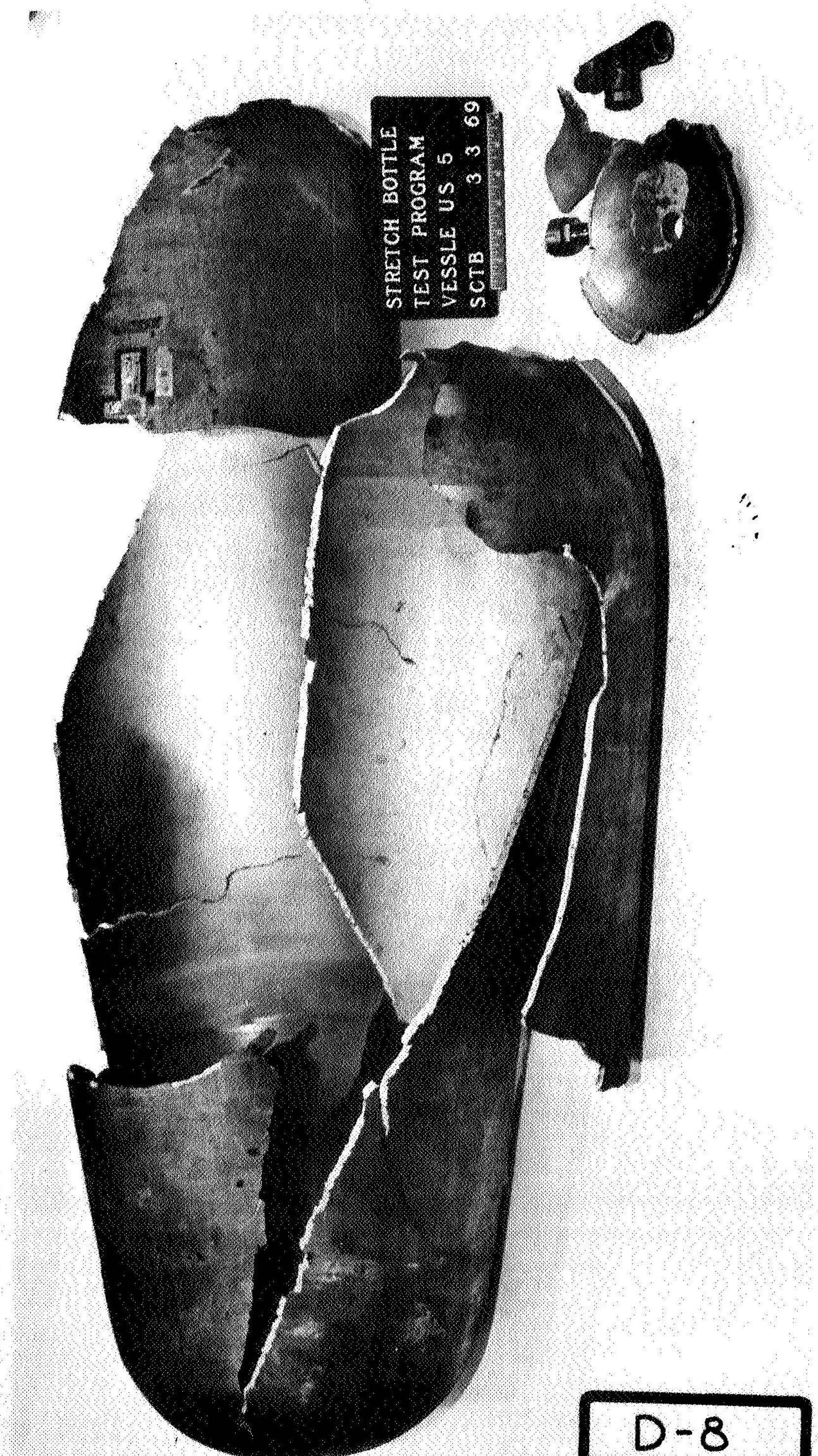


D-5







D-8

APPENDIX E - PROGRESS REPORTS

COPY NO.
Appendix E LMSC 73427

REPORT NO. LMSC 73326

DATED 31 July 1968

REVISED

LOCKHEED MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

SUNNYVALE, CALIFORNIA

TITLE

CRYOGENIC STRETCH FORM BOTTLE
TEST PROGRAM

SUBMITTED UNDER

CONTRACT NAS 8-21482

EFFECTIVE UNDER

41-055F-5392

MODEL C3X REFERENCE ORD 5051

PREPARED BY L. C. Mellema GROUP Space Vehicle & Development Test

L. C. Mellema
Sr. Research Engineer

CHECKED BY R. M. Horner

R. M. Horner
Group Leader

APPROVED BY for C. F. Merlet, Manager

C. F. Merlet, Manager
Propulsion Systems Test

REVISIONS

DATE	REV. BY	PAGES AFFECTED	REMARKS

FORM LMSC 402-2

The activity on the Cryogenic Stretch Form Bottle Test Program, NASA Contract NAS 8-21482, for the period of 28 June through 28 July, consisted primarily of material procurement, preliminary plumbing, facility setup, and test bottle preparation for the installation of strain gages.

All material required for the test setup has been purchased and received, with the exception of liquid nitrogen. Telephone conversations with Mr. Ron Green at NASA-Marshall indicate a contract change order will be issued to authorize LMSC to buy commercial liquid nitrogen for this test. This change is required because storage dewars available at the test site are leased under contract to Union Carbide and, therefore, all liquids placed in the dewars must be supplied by that contractor.

Facility Setup

The test tank for the elevated temperature test, and the associated hot water transfer lines and the hot water source have been installed.

The high-pressure surge tank, which will be used to provide the hydraulic test pressures, is in the final stages of fabrication and should be completed on 30 July 1968.

Facility data acquisition systems have been modified to accept the strain gage and temperature data from the test location. Final checkout will be completed during the strain gage calibration and will occur during the next report period.

Four test bottles have been received from NASA-Marshall and are in the process of being instrumented.

Problem Areas

1. Government-furnished liquid nitrogen can be accepted at the test site providing the supplier is Union Carbide (Linde Co.). If this cannot be accomplished, government-supplied helium could be furnished as an alternate and the nitrogen purchased by LMSC. The second alternate would be to provide a contract change order to increase the scope of the program to allow LMSC to purchase the liquid nitrogen commercially as discussed earlier in this progress report.

2. Telephone conversations with Mr. Irvine and Mr. Veitch dictate changes in strain gage locations and test pressures. We are proceeding per these verbal instructions. However, corrected contract drawings, Sketches 2, 3, and 4 are required as soon as possible to avoid any misinterpretation of telephone conversations.

3. Information from Arde, Inc. indicates the possibility of stress corrosion of 301 material by certain epoxies. The LMSC Chemistry Lab has advised that stress corrosion is mainly due to high alkaline content in epoxy accelerators. LMSC intends using Lefkoweld adhesive which does not exhibit a high alkaline content and, therefore, should not affect the test material.

The Eastman 910 recommended by Arde, Inc. is not acceptable for use at liquid nitrogen temperatures and, therefore, would require additional contract cost to reinstall the strain gages for liquid nitrogen tests.

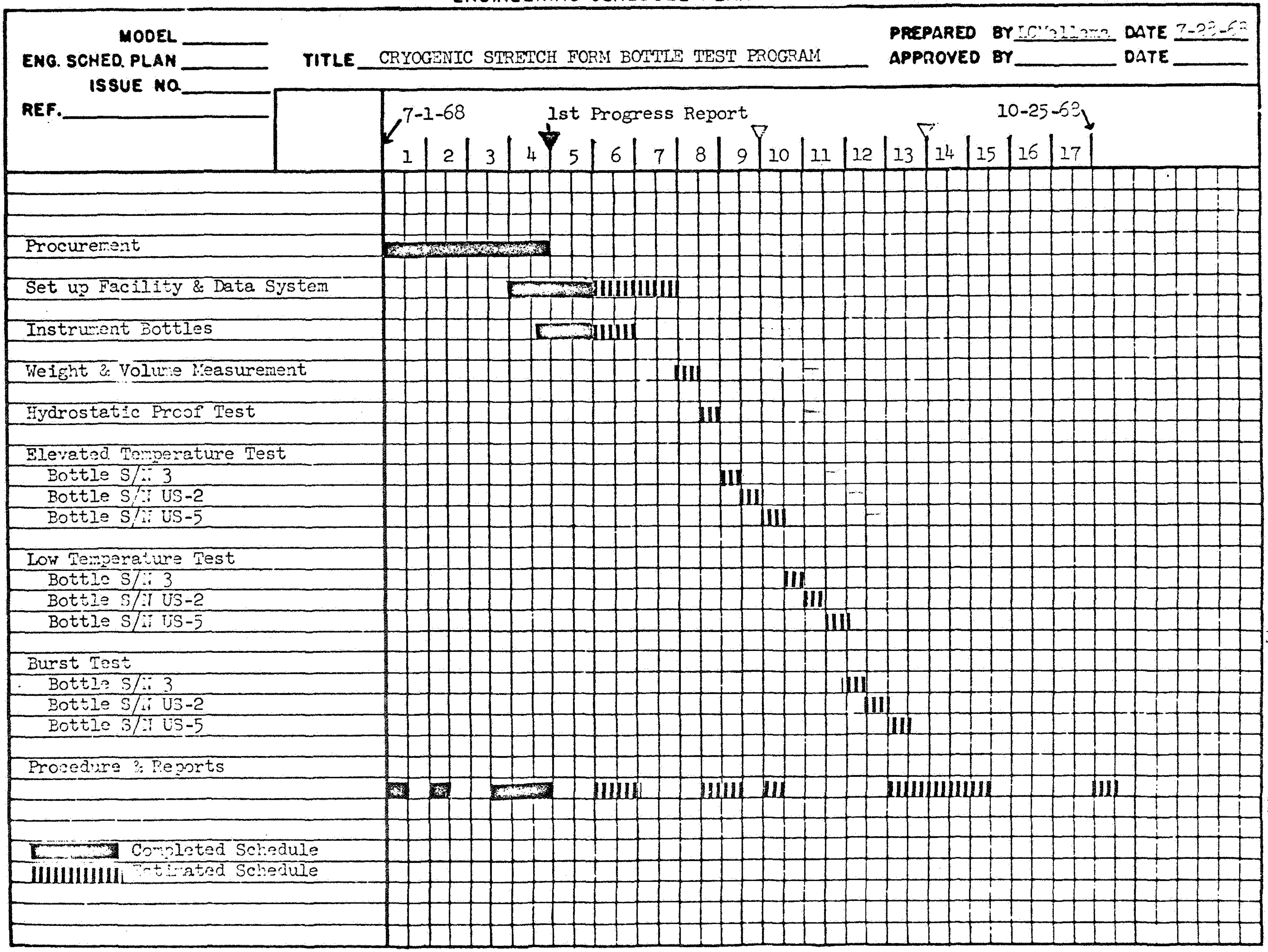
Confirming verbal instructions from Mr. Irvine, LMSC is proceeding as planned with Lefkoweld. LMSC should be contacted immediately if there is any change in these instructions.

Planned Activity for Next Report Period

The facility setup is estimated to be completed by 16 August. Weight and volume measurements of the bottles will be taken 19 August followed by the initial phases of the elevated temperature test during that week. The attached test schedule is up to date and no changes are contemplated at this time.

Attached are preliminary copies of the test plumbing and instrumentation for your review. Still photographs will be taken of the completed test setup and instrumented test bottles, and will be forwarded with the progress report for the period 28 July to 28 August.

ENGINEERING SCHEDULE PLAN



COPY NO.
Appendix E LMSC 73427

REPORT NO. LMSC 73345

DATED 3 September 1968

REVISED

LOCKHEED MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

SANTA CRUZ TEST BASE, SANTA CRUZ, CALIFORNIA 95060

TITLE

CRYOGENIC STRETCH FORM BOTTLE TEST PROGRAM

SUBMITTED UNDER

CONTRACT NAS 8-21482

EFFECTIVE UNDER

41-055F-5392

MODEL C3X REFERENCE ORD 5051

PREPARED BY [signature] T. R. Alchorn GROUP Space Vehicle & Development Test

CHECKED BY ______ APPROVED BY [signature]
C. F. Merlet, Manager
Propulsion Systems Test

REVISIONS

DATE	REV. BY	PAGES AFFECTED	REMARKS

FORM LMSC 402-2

This report was prepared by Lockheed Missiles & Space Company, Santa Cruz Test Base, under Contract No. NAS 8-21482, "Cryogenic Stretch Form Bottle Test Program," for the George C. Marshall Space Flight Center of the National Aeronautics and Space Administration. The work was administered under the technical direction of the Manufacturing Engineering Laboratory, of the George C. Marshall Space Flight Center.

During the period from 29 July 1968 through 28 August 1968 activity on this contract continued to consist principally of setup of the facility and installation of instrumentation on the three bottles to be tested.

Strain gages necessary to complete the preparation of the third test bottle were received from the vendor and installed on the unit. Wire harness and connector installation on two units is complete except for waterproofing and installation is proceeding on the third unit with completion expected by 6 September 1968. Problem areas 2 and 3 of the previous progress report (LMSC 73326) have been resolved satisfactorily with receipt of revised drawings showing strain gage locations and a change letter deleting the requirement for use of Eastman 910 adhesive.

Volumetric measurements have been made of the test bottles and results are as follows:

S/N 3	78,025 cc H_2O @ 54°F
S/N US-2	97,025 cc H_2O @ 62°F
S/N US-5	87,530 cc H_2O @ 54°F

Weight measurements will be made on completion of electrical harness work.

Facility Setup

Fabrication and cleaning of the high-pressure surge tank was completed and the tank was hydrostatically proof-pressure tested to 12,000 psi.

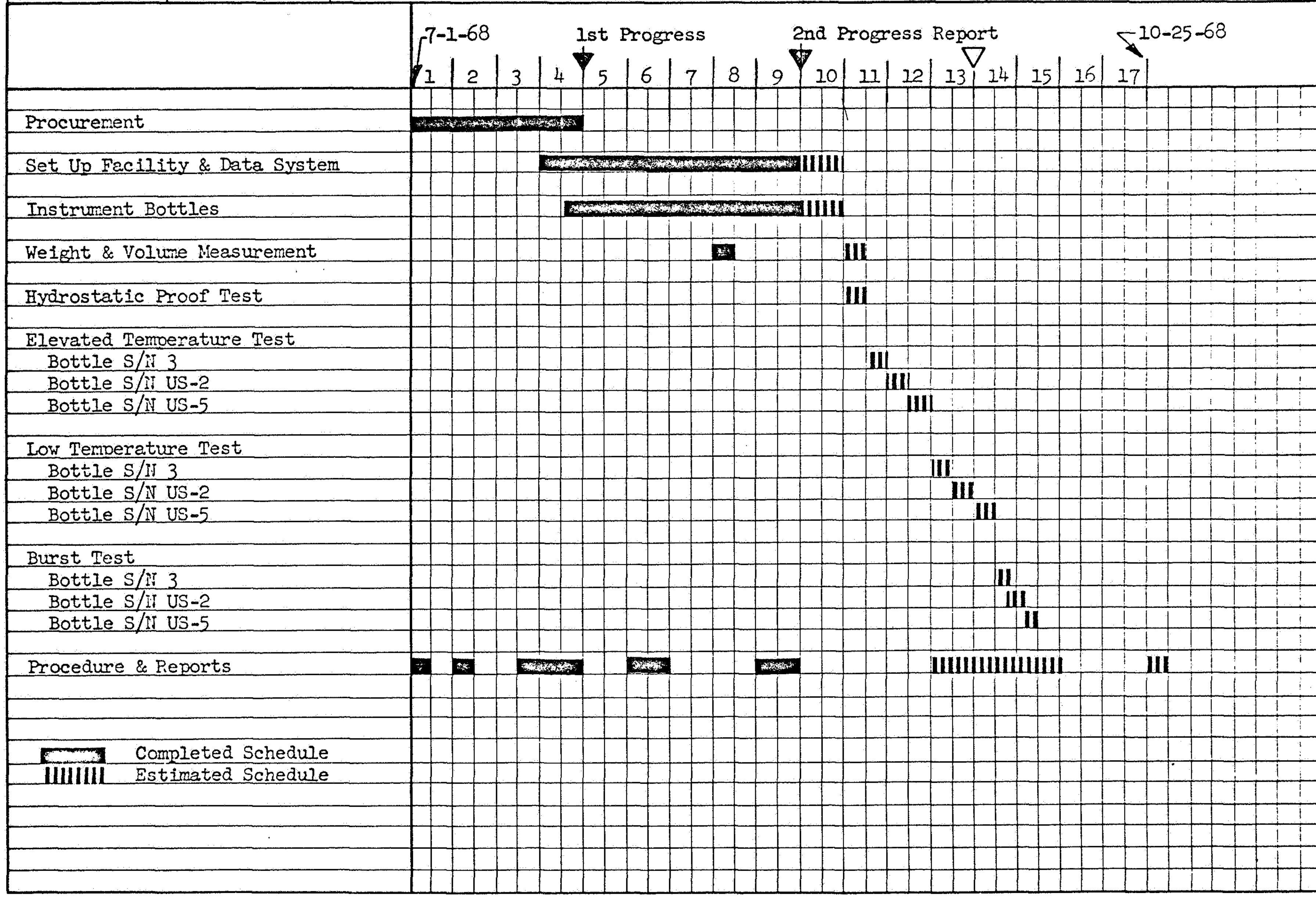
The system for hydrostatic proof-pressure testing of the instrumented bottles has been completed. Facility setup for data acquisition is complete and the elevated temperature test facility is scheduled for completion on 6 September.

Planned Activity for Next Report Period

Delay in delivery of strain gages from the vendor has resulted in a delay in completion of bottle instrumentation. A schedule impact of two and one-half weeks as shown on the attached chart has resulted as a consequence. Effort will be expended to accelerate testing activities to recoup this loss and the final report will be prepared concurrent to the final phases of testing in order to adhere to the committed report delivery date. It is expected that weight measurements and hydrostatic proof testing of the bottles will be conducted during the week of 9 September followed, in the same week, by the start of the elevated temperature test.

SCHEDULE PLAN

MODEL	PLAN	TITLE	PREPARED BY:	DATE
		CRYOGENIC STRETCH FORM BOTTLE TEST PROGRAM	T. R. Alchorn	9-3-68
ISSUE NO.	REFERENCE		APPROVED BY:	DATE
II	ORD 5051			



COPY NO.
Appendix E LMSC 73427

REPORT NO. LMSC 73371

DATED 9 October 1968

REVISED

LOCKHEED MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

SANTA CRUZ TEST BASE, SANTA CRUZ, CALIFORNIA 95060

TITLE

CRYOGENIC STRETCH FORM BOTTLE TEST PROGRAM

SUBMITTED UNDER
CONTRACT NAS 8-21482

EFFECTIVE UNDER
41-055F-5392

MODEL C3X REFERENCE ORD 5051

PREPARED BY T. R. Alchorn GROUP Space Vehicle & Development Test

CHECKED BY R. M. Horner, Group Leader

APPROVED BY C. F. Merlet, Manager, Propulsion Systems Test

REVISIONS

DATE	REV. BY	PAGES AFFECTED	REMARKS

FORM LMSC 402-2

This report was prepared by Lockheed Missiles & Space Company, Santa Cruz Test Base, under Contract No. NAS 8-21482, "Cryogenic Stretch Form Bottle Test Program," for the George C. Marshall Space Flight Center of the National Aeronautics and Space Administration. The work was administered under the technical direction of the Manufacturing Engineering Laboratory, of the George C. Marshall Space Flight Center.

Test Progress

During the period from 29 August 1968 through 9 October 1968, several facility problems occurred and were resolved. Details of the various aspects of these problems are discussed later in this report.

The elevated temperature test phase was begun. Test Bottle S/N US-5 has satisfactorily completed the elevated temperature A phase, 5 cycles; the elevated temperature B phase, 1000 cycles; and the subsequent proof pressure test. Test Bottles S/N's US-2 and US-3 are progressing through the elevated temperature A phase, 5 cycles. The test data are being tabulated as generated at the conclusion of each test phase.

During the A phase, 1000-cycle test on Bottle S/N US-5, progressive loss of strain gage data occurred and at the conclusion of the test ten strain gages were defective. Post-test inspection revealed that the immersion of the bottle in the 250°F hot water was removing the DC-4 protective compound. Although the compound is presumably good to 400°F, it apparently softened enough to flow sufficiently to allow water to contact the exposed electrical leads. The strain gages will be repaired prior to the low temperature test phase.

In order to ensure compatibility of the strain gages on Test Bottles S/N's US-2 and US-3, a Mylar film has been applied over the DC-4. The Mylar film is held in place with RTV silicone rubber. This will protect the gages during the elevated temperature tests. The Mylar film prevents the RTV silicone rubber from adhering to the strain gage.

Facility Setup

The liquid nitrogen bath is 90% complete and the facility plumbing is being routed to accommodate the cold temperature test conditions. A second nitrogen and/or helium compressor and receivers have been obtained and these items will be installed at the Components Test Laboratory to provide a redundant system for the Stretch Bottle Burst Tests.

Revised Program Schedule

As indicated in the previous activity report (LMSC 73345, dated 3 September 1968), a schedule impact had occurred as a result of late delivery of strain gages for use on the tanks. Since that time, each of two separate facility equipment failures produced further significant delays sequentially.

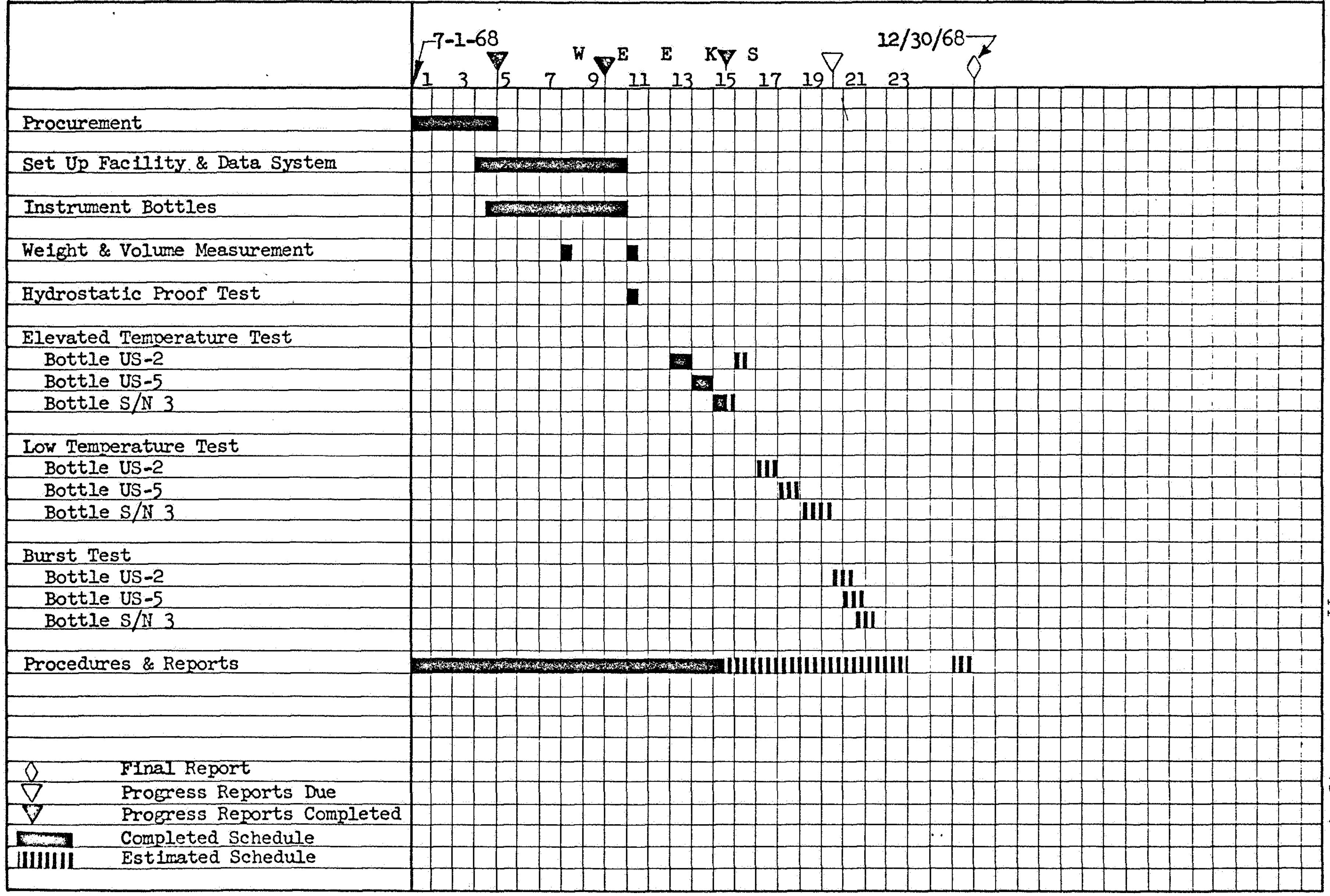
The first facility problem was encountered with the high-pressure helium system. Initially, excessive leakage prevented the attainment of the required pressure. After leak repairs, the booster pump used in achieving the high pressure (6000 psig) failed. This required securing replacement parts from the supplier and testing was necessarily halted until these parts were received, installed, and operationally checked out. In addition, a back-up high-pressure compressor and supply system is being transferred from the LMSC Sunnyvale plant to the Santa Cruz Test Base to ensure that no further delays of this kind occur.

The second facility failure occurred when the water pump motor burned out while an elevated temperature test was being attempted. In the test setup, water is used to provide the controlled temperature environment. A replacement motor has been secured and installed causing a further delay. Experience with the reworked system indicates that the time required to properly temperature condition the test bottle and environmental tank has increased, particularly for the 250°F temperature tests. This has increased the total elapsed time to perform these tests.

The cumulative effect of these various factors is a total delay of eight weeks in completion of the program. The revised schedule is attached.

SCHEDULE PLAN

MODEL	PLAN	TITLE	PREPARED BY:	DATE
ISSUE NO. III	REFERENCE Ord 5051	CRYOGENIC STRETCH FORM BOTTLE TEST PROGRAM	T. R. Alchorn	10-9-68
			APPROVED BY:	DATE



FORM LMSC 481-1 | All-Purpose Bond – Diazo Reproducible

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COPY NO.
Appendix E LMSC 73427

REPORT NO. LMSC 73390

DATED 8 November 1968

REVISED

LOCKHEED MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

SANTA CRUZ TEST BASE, SANTA CRUZ, CALIFORNIA 95060

TITLE

CRYOGENIC STRETCH FORM BOTTLE
TEST PROGRAM

SUBMITTED UNDER

CONTRACT NAS 8-21482

EFFECTIVE UNDER

41-055F-5392

MODEL C3X REFERENCE ORD 5051

PREPARED BY T. R. Alchorn GROUP Space Vehicle & Development Test

CHECKED BY R. M. Horner, Group Leader

APPROVED BY C. F. Merlet, Manager, Propulsion Systems Test

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FORM LMSC 402-2

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Test Progress

During the period from 9 October 1968 through 31 October the elevated temperature test phase for all three bottles was completed satisfactorily. No evidence of damage or deformation was noted as a result of either the elevated temperature testing or the subsequent proof pressure tests.

As a result of immersion in the hot water used to generate the environment for the elevated temperature test phase, some failures of the strain gages were observed on all three bottles.

Test Bottle US-2 was found to have eleven gages inoperative following its proof test; however, three of these recovered after being dried out leaving a net of eight gages failed. Similarly, Bottle US-5 had seven gages inoperative, one recovery, and a net failure of six gages; SN-3 had 3 inoperative, one recovery, and a net failure of four gages.

Discussions between C. F. Merlet, LMSC Program Manager, and NASA personnel at the Marshall Space Flight Center have resulted in the agreement that the failed gages will be replaced in order that 100% instrumentation will be available on each bottle at the start of the low temperature test phase. It was further agreed that gage failures subsequent to the start of low temperature testing would not constitute cause for stoppage of testing or replacement of gages.

Facility Setup

All facility equipment and plumbing required for the low temperature test environment is complete. Work continues on the installation of a second high-pressure gas compressor and receiver bank capable of 15,000 psig output to provide a back-up system for the burst tests.

Program Schedule

The agreement to replace the failed strain gages on the test bottles will have a substantial impact on the remaining test schedule. The required gages are not a stock item. At this writing, preliminary contacts with the supplier resulted in a delivery of four to six weeks (dependent on their production scheduling) being quoted. Subsequent to gage delivery approximately one week will be required for installation and checkout. As a result this could cause an additional delay beyond the 15 January 1969 completion date which presently has been agreed to. A more realistic estimate can be made when delivery is accomplished. Every possible effort will be expended to expedite re-instrumentation activities and to lessen the schedule impairment.

COPY NO.
Appendix E LMSC 73427

REPORT NO. LMSC 73406

DATED 6 December 1968

REVISED ______

LOCKHEED MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

SUNNYVALE, CALIFORNIA

SANTA CRUZ TEST BASE, SANTA CRUZ, CALIFORNIA 95060

TITLE

CRYOGENIC STRETCH FORM BOTTLE TEST PROGRAM

SUBMITTED UNDER
CONTRACT NAS 8-21482

EFFECTIVE UNDER
41-055F-5392

MODEL C3X REFERENCE ORD 5051

PREPARED BY T. R. Alchorn GROUP Space Vehicle & Development Test

CHECKED BY R. M. Horner, Group Leader APPROVED BY V. L. Smith, Manager, Ordnance & Test Operations

REVISIONS

DATE	REV. BY	PAGES AFFECTED	REMARKS

FORM LMSC 402-2

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Test Progress

During the present reporting period, 1 November 1968 through 30 November 1968, the replacements for the failed strain gages were obtained and installed. Bottle S/N 3 was installed in the fixture and the low temperature test series was attempted but had to be discontinued because of failure of the helium booster pump.

Delivery of replacement strain gages was quoted at four weeks by the vendor; however, a partial shipment was made which arrived on 15 November 1968, thus enabling installation to be begun on 18 November 1968.

Instrumentation on Bottle S/N 3 was completely repaired and the unit was installed in the test fixture. On 25 November 1968 the low temperature test was initiated. In the course of the first of the five required pressurization cycles the helium booster pump developed excessive leakage and the test was suspended while repairs were made. The test was resumed and the first cycle was successfully completed. At this point the pump failed again. Efforts at further repair were unsuccessful and the test was terminated for the Thanksgiving holiday.

In the course of this first test cycle at liquid nitrogen temperature, considerable instrumentation loss was experienced. Fourteen of the twenty strain gages on the bottle either failed electrically or did not maintain adherence to the bottles surface. Of the six good gages, four comprise two bi-axial pairs with the remaining two being unrelated single gages.

Facility Setup

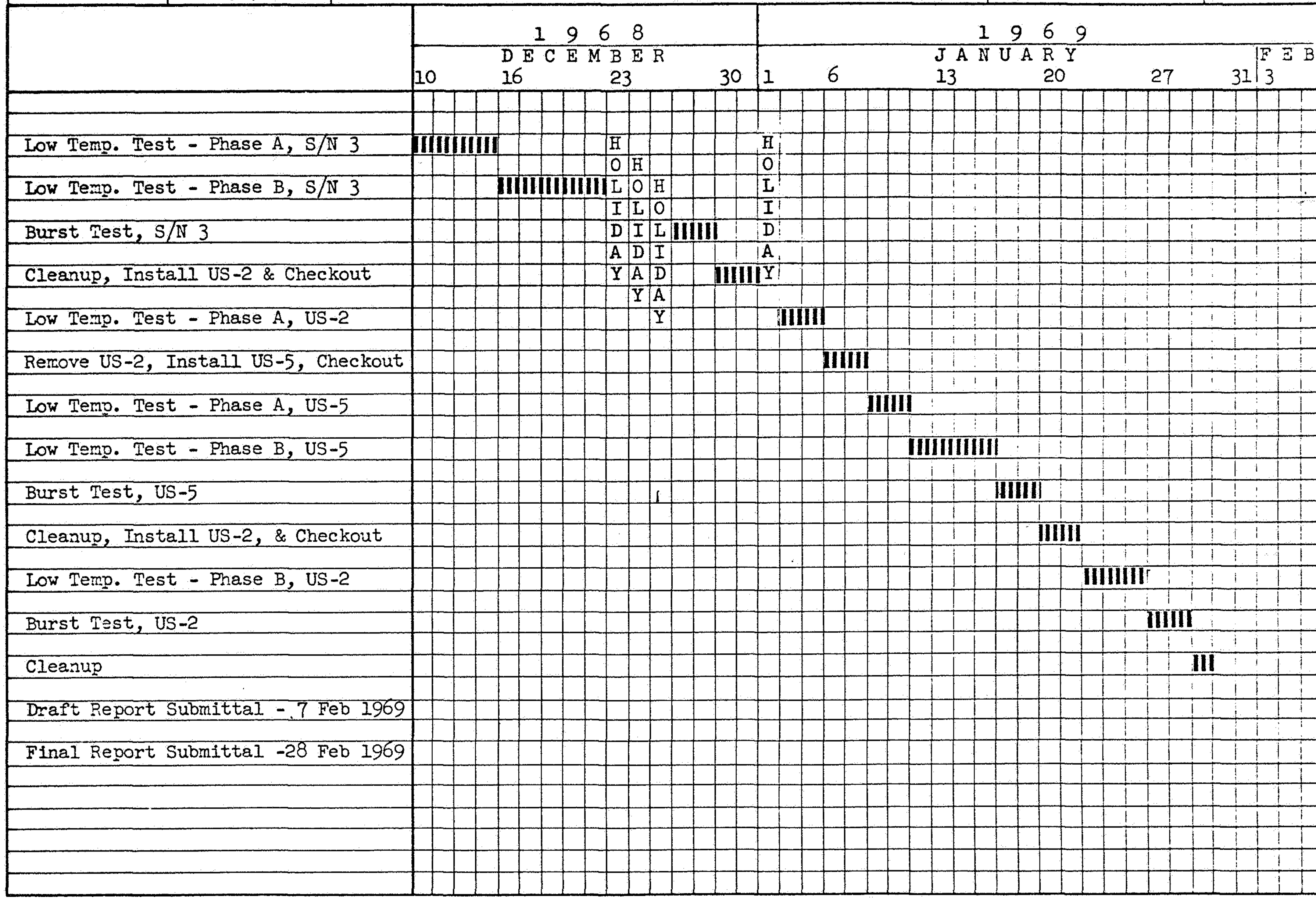
Continued trouble with the helium booster pump has made evident the immediate need for the availability for use of the 15,000 psi gas compressor and receiver bank which is in the process of installation. Completion of this work will be accelerated to enable use of this unit on the test program.

Program Schedule

Upon completion of the installation and checkout of the new compressor, testing of Bottle S/N 3 will be resumed. It is intended to proceed with both phases of the low temperature test and the burst test of this unit in consecutive order prior to any further testing of the remaining bottles. Updating of the subsequent schedule plan for the program is in work and will be heavily dependent on the performance demonstrated by the new pumping unit which is expected to be on-line next week.

SCHEDULE PLAN

MODEL	PLAN	TITLE	PREPARED BY:	DATE
		CRYOGENIC STRETCH FORM BOTTLE TEST PROGRAM	T. R. Alchorn	12-9-68
ISSUE NO.	REFERENCE		APPROVED BY:	DATE
IV	ORD 5051			



FORM LMSC 481-1 *All-Purpose Bond – Diazo Reproducible*

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COPY NO.
Appendix E LMSC 73427

REPORT NO. LMSC 73411

DATED 3 January 1969

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LOCKHEED MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

SUNNYVALE, CALIFORNIA

SANTA CRUZ TEST BASE, SANTA CRUZ, CALIFORNIA 95060

TITLE

CRYOGENIC STRETCH FORM BOTTLE
TEST PROGRAM

SUBMITTED UNDER

CONTRACT NAS 8-21482

EFFECTIVE UNDER

41-055F-5392

MODEL C3X REFERENCE ORD 5051

PREPARED BY T. R. Alchorn GROUP Space Vehicle & Development Test

CHECKED BY R. M. Horner, Group Leader

APPROVED BY V. L. Smith, Manager, Ordnance & Test Operations

REVISIONS

DATE	REV. BY	PAGES AFFECTED	REMARKS

FORM LMSC 402-2

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Test Progress

During the reporting period from 1 December 1968 through 31 December 1968, the low temperature test series on Bottle S/N 3 was in process. Phase A, the helium pressurization cycling, was completed satisfactorily. Phase B was begun with the heating of the bottle to 250°F and subsequent immersion in liquid nitrogen causing no apparent discrepancies. At the end of the reporting period a total of 335 cycles of hydraulic pressurization in liquid nitrogen have been satisfactorily completed. Three strain gages remain in operable condition.

Facility Setup

Installation of the new high-pressure gas pumping unit was completed and the unit was put "on-line." Its performance thus far is quite satisfactory. In an attempt to maintain schedule position, consideration is being given to simultaneous hydraulic cycling of Bottles US-2 and US-5. If feasible this will require some relatively minor rework of the low temperature test fixture.

Program Schedule

A revised schedule indicating a report submittal date of 28 February 1969 was previously forwarded separately. Hydraulic cycling in the low temperature test has proven more time consuming than was expected; however, it is anticipated that simultaneous cycling of Bottles US-2 and US-5 will enable the stated report date to be met.

COPY NO.
Appendix E LMSC 73427

REPORT NO. LMSC 73421

DATED 3 February 1969

REVISED

LOCKHEED MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

SANTA CRUZ TEST BASE, SANTA CRUZ, CALIFORNIA 95060

TITLE

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EFFECTIVE UNDER
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MODEL C3X REFERENCE ORD 5051

PREPARED BY T. R. Alchorn GROUP Space Vehicle & Development Test

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Test Progress

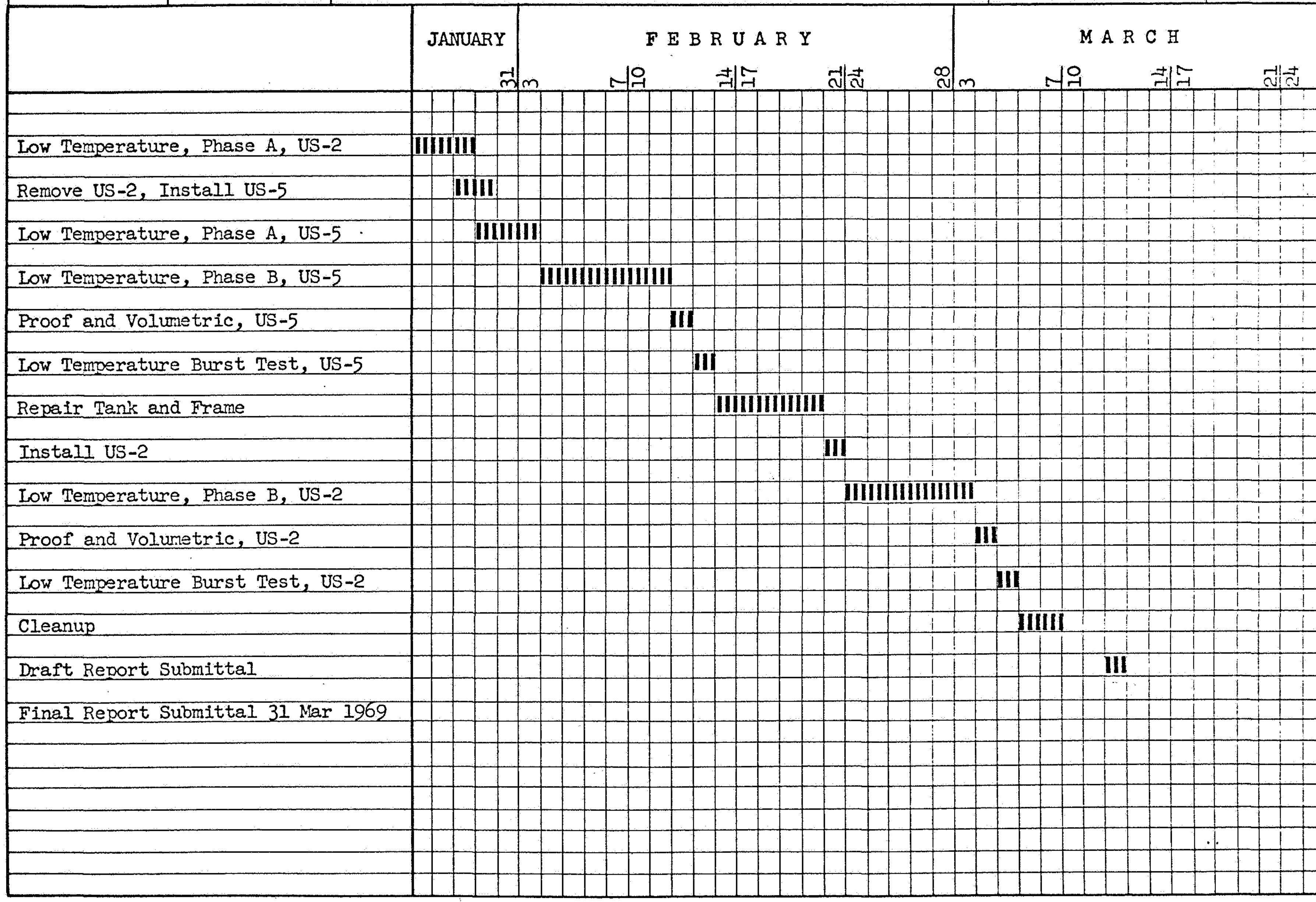
During the period from 1 January 1969 through 31 January 1969, the testing of Bottle S/N 3 was completed. Hydraulic pressurization cycling at low temperature was satisfactorily concluded, a room temperature proof pressure test at 5900 psig was conducted with no evidence of damage or deformation being noted, and volumetric measurements were made. The low temperature burst test of S/N 3 was performed on 10 January 1969. At approximately 7000 psig the three remaining operable strain gages ceased to function. Bottle rupture occurred at approximately 10,670 psig. The environmental tank and bottle support frame incurred damage as a result of the burst. Following completion of repairs Bottle US-2 was installed and subjected to Phase A of the low temperature series, five cycles of helium pressurization. The bottle was then heated to 250°F and rapidly immersed in liquid nitrogen. Bottle US-2 was then removed from the test setup and replaced by Bottle US-5 which at the end of the reporting period had been subjected to five cycles of helium pressurization at low temperature. No damage or distortion has been noted in the case of either bottle.

Program Schedule

As a result of the time required for repair of the test equipment following the bursting of Bottle S/N 3 which is expected to be repeated after bursting of the next unit (US-5), together with the slower than anticipated cycling rate at low temperature, it appears that completion of the test program will follow the newly revised schedule (Issue V) attached herewith.

SCHEDULE PLAN

MODEL	PLAN	TITLE	PREPARED BY:	DATE
		CRYOGENIC STRETCH FORM BOTTLE TEST PROGRAM	T. R. Alchorn	1-31-69
ISSUE NO.	REFERENCE		APPROVED BY:	DATE
V				



MSFC—RSA, Ala

FORM LMSC 481-1 All-Purpose Bond – Diazo Reproducible

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