Report No. UMTA-IT-06-0026 74-8

SOAC

STATE-OF-THE-ART CAR DEVELOPMENT PROGRAM FINAL TEST REPORT

VOLUME 1: COMPONENT TESTING

Boeing Vertol Company
(A division of The Boeing Company)
Surface Transportation Systems Branch
Philadelphia, Pa. 19142

AUGUST 1974
FINAL REPORT

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Prepared for
URBAN MASS TRANSPORTATION ADMINISTRATION
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This document, Volume I of SOAC Final Test Report D174-10024, presents the test results for the component testing of the State-of-the-Art Car. The SOAC has been developed under UMTA's Urban Rapid Rail Vehicle and Systems program which has the objective of enhancing the attractiveness of rapid rail transportation to the urban traveler by providing him with transit vehicles that are as comfortable, reliable, safe and economical as possible. The SOAC is one phase of this program.

The purpose of these tests was to show compliance with the SOAC Detail Specification IT-06-0026-73-2. All component tests were conducted by the supplier of the applicable subsystem. All components tested met the requirements of the Detail Specification except as noted in Section 2.5.

This document, Volume I plus the following additional volumes comprise Boeing Vertol Report D174-10024, State-of-the-Art Car Final Test Report as specified in Section 17.1.4.2 of the SOAC Detail Specification.

- Volume II - Subsystem Functional Testing
- Volume III - Acceptance Testing
- Volume IV - Simulated Demonstration Test
- Volume V - Post Repair Testing

The SOAC detail specification is available from the National Technical Information Services (NTIS).

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VOLUME I - COMPONENT TESTING

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MODEL SOAC CONTRACT DOT-UT-10007

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FORM 46280 (3/67)

SHEET 2

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SOAC FINAL TEST REPORT

VOLUME I - COMPONENT TESTING

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I. INTRODUCTION

The U.S. Department of Transportation, Urban Mass Transportation Administration (UMTA), under Contract DOT-UT-10007, has engaged the Boeing Vertol Company to act as Systems Manager of the Urban Rapid Rail Vehicle and Systems Program. This program is an integrated development program directed toward improving high speed, frequent-stop urban rail systems. The overall objective is to enhance the attractiveness of rail transportation to the urban traveler by providing service that is as comfortable, reliable, safe and economical as possible.

The objective of the State-of-the-Art Car (SOAC) is to demonstrate the best state-of-the-art in rapid rail car design, with two new improved cars using existing proven technology. Primary goals for the cars are passenger convenience and operating efficiency.

The SOAC Test Program Plan and Procedures are described in Boeing Vertol Report D174-10007-1 and is available from the National Technical Information Services (NTIS). The component testing was conducted in accordance with these procedures by system subcontractors to the car manufacturer, St. Louis Car Division, General Steel Industries, Inc. Major subcontractors conducting component testing are The AiResearch Manufacturing Company, a division of the Garrett Corporation - propulsion system; General Steel Industries, Inc., Castings Division - trucks and suspension systems; American Seating Company - seats; and Swedlow, Inc. - windshield.

This document, Volume I - Component Testing, plus the following additional volumes comprise Boeing Vertol Report D174-10024, State-of-the-Art Car Final Test Report as specified in Section 17.1.4.2 of the SOAC Detail Specification.

- Volume II - Subsystem Functional Testing
- Volume III - Acceptance Testing
- Volume IV - Simulated Demonstration Test
- Volume V - Post Repair Testing

2. TEST PROCEDURES AND RESULTS

2.1 Propulsion, Dynamic Braking and Auxiliary Power Equipment

The components comprising the propulsion, dynamic braking and auxiliary power systems were tested by AiResearch Manufacturing Company at Torrance, California. The AiResearch test report No. 73-9363 is included as Appendix I.

2.2 Truck Frame and Bolster

Truck frames and bolsters were statically tested by General Steel Industries at the GSI Test Lab. GSI Reports T34701-1 and T34702-1 are included as Appendix II.

2.3 Windshield

Qualification testing of the SOAC windshield was not conducted since the basic design is similar to the windshield used on the BART Car. The BART test results were reviewed and results extrapolated to the SOAC geometry. (Reference Swedlow Engineering Department Reports No. 724, April 7, 1971 and No. 755, February 2, 1972.)

The windshields are designed to the following criteria:

a. Shall be capable of resisting, without penetration, and the windshield retention, without separation, loads imposed by the equivalent of:

   (1) 175 mph at S/L Pressure (78 lbs. per square foot)

   (2) Impact of 1.0 lb. Stone at 80 mph or 5 lbs. at 50 mph.

b. Light transmission to be at least 85 percent (BART transmission 70% with solar coating).

The BART windshield was tested by Swedlow and Wyle Laboratories in July/August 1970. Swedlow Test Report No. ETR-010, December 17, 1970 is included as Appendix III.

2.4 Seat Strength

The seats for the SOAC were manufactured by the American Seating Company and are similar in design to the seats manufactured for the BART Car; therefore, no additional testing was performed for the SOAC. The American Seating Company strength and test data report on seats representative of the SOAC configuration is included as Appendix IV.

2.5 Materials - Fire Resistance

All major interior materials were tested for fire resistance in accordance with Section 2.4.9 of the Detail Specification. The seat upholstery met the requirements of Federal Highway Administration Standard No. 302 "Flamability of Vehicle Interior Materials" as tested by the American Seating Company. Test results are presented in Appendix V. The remaining items were tested by the Boeing Vertol Quality Assurance Laboratory to a more stringent specification, Federal Standard No. 191. The results of these tests are also presented in Appendix V.

The three items that failed to meet F.S. 191 were not considered to be a fire-potential problem because of their limited usage (Mylar side signs and window glazing rubber) or method of installation, i.e. leaded vinyl sheathing (combustible) sandwiched between the floor panels and the carpeting neither of which supported combustion.

3. CONCLUSIONS

A. SOAC Component Tests were conducted by the subsystem suppliers. All items met the requirements of the Detail Specification except as noted in C. below.

B. The windshield and seats were qualified by similarity to BART designs. BART test results were reviewed and accepted for these items.

C. Interior materials were tested for fire resistance to a more stringent specification than required by the Detail Specification. Three items which failed to meet this specification were accepted because of their limited usage or protective method of installation.

APPENDIX I

PROPULSION, DYNAMIC BRAKING AND AUXILIARY POWER EQUIPMENT TESTS

SHEET 12

GARRETT

AIRESEARCH MANUFACTURING COMPANY
Torrance, California

COMPONENT AND SYSTEM
DEVELOPMENT TESTS
FOR
PROPULSION, DYNAMIC BRAKING AND
AUXILIARY POWER EQUIPMENT

73-9363 (SOAC)

Number of pages 148

Original date 6/14/73

Prepared by W. Curran

Edited by

Approved by

Revision	Date	Pages Affected (Revised, Added, Eliminated)

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STATE OF THE ART CAR

Component and System Development Tests

The test data, graphs and other information included in this document have been extracted from test records and engineering notes. This data was collected during the course of component study and system testing which was carried out in the development phase of the Propulsion and Auxiliary Power subsystem for SOAC. The system testing was done on a laboratory assembly of the vehicle components with motors driving equivalent inertial loads but excluded the gearboxes. The gearbox tests were run in a separate test stand.

The assembly of the test data follows the same general format as the A-2 section of Boeing Vertol document D174-10007-1 SOAC TEST PROGRAM (Rev. 6/12/72).

Paragraphs extracted from D174-10007-1 precede each group of data presented. The groups do not necessarily follow the exact order of the above test program and vary somewhat in content from the original plan.

2. PROPULSION AND DYNAMIC BRAKING, AND AUXILIARY POWER SYSTEMS

a. TRACTION MOTORS (P/N 200732-1)

Production Testing

Each traction motor is subjected to the following production acceptance tests:

1. Resistance of windings and polarity checks
2. Seating of brush faces
3. No load tests
4. Overspeed
5. Dielectric
6. Commutation tests (selected)
7. Black band tests (1st 2 units only)
8. Inspect all critical dimensions

Development Testing

Two traction motors will be utilized to perform the following development testing:

(1) No Load Saturation

Purpose

The purpose of this test is to confirm the capability of the motor magnetic circuit.

Configuration

Two motors are connected together with a flexible coupling. Each of the motors are provided with a constant cooling air flow of 900 cfm and are run in turn with the opposite motor acting as an open circuit generator. The no load saturation of the generating element is then determined as follows:

Procedure

Apply 312 volts motor input voltage. Adjust field current as required throughout the test to provide motor speed of 1560 RPM (base speed).

Change field current of the motor acting as a generator 0-60-0 amperes in 5 amp steps. Record output voltage, field current and speed of the motor acting as a generator.

(2) Efficiency

a. TRACTION MOTORS (Contd.)

Purpose

Determine the overall motor efficiency

Configuration

Two motors are connected with a flexible coupling and are each provided with a constant cooling air flow of 900 cfm. The motors are electrically connected in parallel and the field currents are adjusted such that one is acting as a driving element and the other is acting as a generating (loading) element. The efficiency of the traction motor is then determined as follows:

Procedure

Apply an input voltage equal to 312 - 600 (R armature + R stator) - 2. (The armature and stator resistances are determined in the production acceptance tests). Load the motor and generator system at a rated speed of 1560 RPM such that the sum of the motor and generator armature currents equals 1200 amperes.

Calculate the efficiency of the motor in the following manner:

$$\eta m = \frac{2(E_{input}\ I_{arm}) - E_{input}\ I_{line}}{2\ E_{input}\ I_{arm}} \times 100$$

Repeat the above procedure except at 4300 RPM and 1800 amperes. Regulate input voltage to 600 + 900 $(R_{arm} + R_{stator}) + 2$.

Calculate the efficiency of the motor as a braking generator in the following manner:

$$\eta g = \frac{2(E_{input}\ I_{arm})}{2\ E_{input}\ I_{am} + E_{input}\ I_{line}} \times 100$$

As design goals, the efficiency of the motor, acting as a motor is 90.3% and the efficiency of the motor acting as a braking generator is 91.0%, with 110°C winding temperatures.

(3) Commutation Tests

Purpose

Verify that the commutating characteristics of the machine are acceptable by observation of arcing, tracing or flaring for the following configurations:

a. TRACTION MOTORS (Contd.)

Configuration

As a motor observe commutation at the following test conditions:

a. 175 Volt, 785 Amps, 780 RPM
b. 312 Volt, 750 Amps, 1560 RPM
c. 312 Volt, 750 Amps, 2400 RPM
d. 312 Volt, 750 Amps, 4300 RPM
e. 470 Volt, 565 Amps, 2400 RPM

As a generator, observe commutation at the following test conditions:

a. 125 Volt, 925 Amps, 780 RPM
b. 175 Volt, 925 Amps, 1560 RPM
c. 400 Volt, 925 Amps, 2160 RPM
d. 540 Volt, 710 Amps, 2900 RPM
e. 600 Volt, 740 Amps, 4300 RPM

4. Heat Run

Purpose

Verify that the motor thermal design is adequate for the purpose intended.

Configuration

Connect two motors in the same manner as in the efficiency tests (Item 2)

Procedure

Determine the mean armature temperature rise at each of the listed test conditions in the following manner.

Record the temperature of the thermocouples located in the stator every five minutes while at the test conditions. Stop the test when the temperature rise is not more than 2°F between readings on any of the thermocuples. Stop the cooling air flow when the test is stopped. Measure the rotor temperatures on the armature iron, end turns, risers and commutator surface as rapidly as possible. Measure the armature resistance. Calculate the final armature mean temperature using the following formula:

$$t_f = \frac{R_f - R_i}{R_i} (234.5 + t_i) + t_i$$

a. TRACTION MOTORS (Contd.)

t_f = final temperature

t_i = initial temperature

R_f = final armature resistance

R_i = initial armature resistance

Test Conditions

a. Continuous Rating at Base Speed 175 HP, 312 volts 460 amperes, 1560 RPM

b. One hour rating at Base Speed 230 HP, 312 volts 600 amperes, 1560 RPM (Same procedure as above except stop test at end of one hour)

c. Overload Test 156 volts, 900 amperes, 1560 RPM (Start test with armature temperature, computed as above, at 100 ± 10°C. Stop test when armature reaches 180 ± 10°C)

In the above tests the armature temperature shall not exceed 200°C, and the field winding 180°C.

5. Overspeed

Purpose

Prove the mechanical integrity of the rotor and commutator.

Configuration

Connect two motors in the same manner as in the efficiency tests (Item 2)

Procedure

With an armature temperature of 180 ± 10°C, run the motor at 5160 RPM (120% of top rated speed) for 120 seconds.

No permanent deformation of the rotor and commutator shall have resulted.

6. Dielectric

Purpose

Prove the dielectric capability of the insulation system.

a. TRACTION MOTORS (Contd.)

Configuration

Test the motor in a static condition.

Procedure

Test the motor windings immediately after the overspeed test above with a dielectric voltage of 2700 V 60 Hz between each coil and the motor frame. Apply the voltage gradually, hold at the test voltage for 60 seconds, and reduce the voltage gradually. Each winding not being tested will be connected to the motor frame.

7. Commutation Limit Test

Purpose

Establish the momentary overload limit of the motor to determine the safety margin above the rated load.

Configuration

Connect two motors together through a flexible coupling such that one is being electrically driven as a motor element and the other is electrically connected through an electrical contactor to a resistive load and acting as a generator element.

Procedure

With the generator element unloaded (electrical load contactor open) adjust the resistive load in decending values starting at 1.0 ohm. At each resistive load, with the breaker open, run the motor at 1560 RPM and adjust the generator field current to provide a terminal voltage of 312 volts. Increase the motor speed to 4730 RPM (110% rated speed). The generator voltage shall be approximately 950 volts. Disconnect the motor from the input voltage and allow the system to coast down in speed to 4300 RPM, and close the generator load contactor. Repeat this procedure at gradually decending load resistances until the generator flashes over.

8. Vibration

Purpose

Prove the mechanical integrity of the motor and gearbox to vibratory input loading.

a. TRACTION MOTORS (Contd.)

Configuration

A vibration fixture which independently simulates the axle input to the gearbox and the motor-truck frame mounting will be utilized for this test.

Procedure

With the motor truck frame mounting fixture in a static rigid condition, drive the axle input fixture and scan for resonances in the 20 to 35 Hz region. Resonances in the 80 to 150 Hz region have been given special attention in the design and will not require evaluation.

A fatigue test will be run at any resonance determined or at 35 Hz if no resonance is determined. The desireable test life of the system is as follows: ±5 gs lateral, 10^6 cycles.

Due to the length of the testing at the low frequencies associated with this type of equipment, an accelerated simulated life at a higher g input and a reduce cycle length may be utilized.

9. Noise

Purpose

Determine the audible noise characteristics of the motor-gearbox combination.

Configuration

Connect a motor and gearbox in a manner simulating the installation on the car truck.

Procedure

Record audible noise levels on a broadband noise level meter "C" scale. Recordings will be taken at a distance of 15 feet in each of the four longitudinal and lateral directions, and at various gearbox loadings and motor speeds.

As a design goal, a noise level of 85 db maximum (reference 0.0 2 microbar) will be recorded.

a. TRACTION MOTORS (Contd.)

10. Black Band

Purpose

Determine the proper adjustments for the interpole turns and air gap.

Configuration

Two motors are connected together with a flexible coupling. The motors are electrically connected in parallel and the field currents are adjusted such that one is acting as a driving element and the other is acting as a generating (loading) element.

Procedure

NOTE: A buck-boost circuit will be required for this test.

Apply 312 volts motor input voltage. Adjust field current as required throughout the test to provide motor speed of 1560 RPM (base speed).

Increase the generator field to load the motor.

Increase the motor current to 150 amperes (1/4 load). Energize buck-boost power source and increase boost voltage until visible sparking occurs. Record: output voltage, field current, speed and direction of motor rotation.

Decrease buck voltage until visible sparking occurs and record as before. Change direction of rotation and repeat.

Repeat at 300, 450, 600, 750 and 900 amperes.

Repeat the tests at a speed of 4300 RPM.

Interchange motor and motor that acted as generator and repeat black band tests.

The data obtained from these tests will be utilized to establish an interpole air gap adjustment, and a turns adjustment if necessary, to provide the best compromise over the load and speed range of the motor.

a. Development Testing, Traction Motors

(1) No load saturation data taken on SOAC motor SN3 is shown on Fig. a.1-1.

(2) Motor efficiency data is taken in a test setup with one motor as a driving element coupled shaft to shaft to another motor used as a generator dumping power into a load bank. The data supplied here is for motor SN3 (motor SN7 was used as the generator for the efficiency data, see Fig. a.2-1)

using $$\eta_M \cong \sqrt{\frac{\text{Generator Watts out}}{\text{Motor Watts in}}}$$

The data has a spread of ±4% with a mean value for efficiency of approximately 92%

(3) Data on commutation testing as done on each unit as shown for motor SN-3 in Figures a.3-1 and a.3-2. The ratings for visible commutation shown in the right hand columns of the above figures is defined as follows:

	Rating
No visible sparking	1
Few intermittent fine sparks	1-1/4
Continuous fine sparking over half the brush width	1-1/2
Continuous fine sparking over most of the brush width	2
Continuous fine sparking plus heavy sparking over half of the brush	2-1/2
Continuous heavy sparking	3
Continuous heavy sparking plus blue arcing or streamers	3-1/2
Continuous heavy sparking plus glowing at brush width	4

DATE 6-9-72 CALC. NO. ______ SHEET NO. ______
PART NO. ______ MODEL NO. ______
PREPARED BY Murillo CHECKED BY ______

MOTOR TEST DATA
P.N. 200732-1

SERIAL # 3

1- RESISTANCE MEASUREMENTS

F1 To F2 1.25 OHMS
ROTOR at 90° .012 OHMS

2 INSULATION RESISTANCE

A1 To FRAME 20·10^3 MEGOHMS
F1 To FRAME ≥100·10^3 " "
ARM To FRAME 50·10^3 " "
A1 TO F1 20·10^3 " "

3 ARM. CONCENTRICITY .0003 INCHES

4 MOTOR ROTATION C.W. [✓] PASSED

F1 (+), F2(-), A2(+), A1(-) [ ] FAILED

5. No LOAD SATURATION
C.W. ROTATION AT 1560 R.P.M.

I FIELD AMPS	ARM VOLTS	I FIELD AMPS	ARM VOLTS
0	2.02	60	—
5	68.8	55	331.0
10	132.0	50	325.0
15	191.5	45	318.0
20	230.5	40	309.0
25	254.5	35	291.8
30	271.5	30	279.0
35	286.0	25	261.0
40	298.0	20	236.0
45	315.0	15	194.0
50	325.0	10	128.1
55	331.0	5	56.7
60	332.0	0	2.84

FIG a1-1

DATE ______ CALC. NO. ______ SHEET NO. ______
PART NO. ______ MODEL NO. ______
PREPARED BY ______ CHECKED BY ______

MACHINE SN/3 AS MOTOR						MACHINE SN/7 AS GEN				
1	2	3	4			5	6	7		
SPEED RPM	ARM VOLTS	ARM AMPS	FLD AMPS	ROT	SCALE	ARM VOLTS	ARM AMPS	FLD AMPS	ROT	SCALE
D 780	175	785		CCW					CW	
AC 860	170	760	32	↓	1	133	700	20	↓	1
1560	312	750								
1570	210	780	38		1	187	1000	19		1½
2400	312	750								
2420	275	810	17		1¼	208	890	11		1½
4300	312	750								
4260	340	760	11		3	418	560	13		2½
2400	470	565								
2420	435	580	30.5	↓	1½	225	900	13.5	↓	1½
1	5	6	7			2	3	4		
MACHINE SN/3 AS GEN.						MACHINE SN/3 7 AS MOTOR				
780	125	925		CCW					CW	
850	148	800	50	↓	1	175	900	40	↓	1½
1560	175	925								
1460	175	925	18		1¼	285	740	38		1½
2160	400	925								
1950	380	700	30		1¼	325	960	58		1½
2900	540	710								
2820	470	740	30		1¼	470	720	22		1½
4300	600	740								
3980	600	700	18	↓	2¼	540	800	13	↓	3½

OVERSPEED AT 5160 RPM. S.N 3 ✓ — [✓] PASSED [ ] FAILED

HYPOT AT 2700 V.A.C. S.N. 3

ARM. [✓] PASSED [ ] FAILED

FIELD. [ ] PASSED [ ] FAILED

FIG a2-1

DATE 6-9-? CALC. NO. ______ SHEET NO. ______

PART NO. ______ MODEL NO. ______

PREPARED BY ?? CHECKED BY ______

MOTOR DATA SHEET

SERIAL # 3 AS MOTOR

STATED ACTUAL	SPEED R.P.	ARM. VOLTS	ARM. AMPS	FIELD AMPS	ROTATION	SCALE VOLTS(RPM)
S A	780 860	75 70	785 760	54 32	CCW	1
S A	1560 1500	312 310	750 780	35 38	CCW	1
S A	2400 2400	312 275	750 810	18 17	CCW	1¼
S A	4300 4200	312 340	750 760	9 11	CCW	3
S A	2400 2400	470 435	565 580	34 30.5	CCW	1½

SERIAL # ___ AS A GENERATOR

STATED ACTUAL	SPEED R.P.M.	ARM VOLTS	ARM AMPS	FIELD AMPS	ROTATION	SCALE VOLTS(RPM)
S A	780 800	175 148	785 800	54 50	CCW	1
S A	1500 1400	312 175	750 925	35 18	CCW	1¼
S A	2400 1950	312 380	750 700	18 30	CCW	1¼
S A	4300 3980	312 500	750 700	9 18	CCW	2½
S A	2400 2800	470 420	560 740	34 30	CCW	1¼

OVERSPEED AT 5160 RPM. ☐ PASSED
S.N. ______ ☐ FAILED

HYPOT AT 2700 V.A.C. S.N. ______
ARM. ☐ PASSED ☐ FAILED
FIELD. ☐ PASSED ☐ FAILED

FIG 3-1

DATE 6-9-73
PART NO.
PREPARED BY Murillo

CALC. NO. SHEET NO.
MODEL NO.
CHECKED BY

MOTOR DATA SHEET

SERIAL # 3 AS MOTOR

STATED ACTUAL	SPEED R.P.M.	ARM. VOLTS	ARM. AMPS	FIELD AMPS	ROTATION	SCALE VOLTS(RPM)
S A	780 900	175 170	785 765	54 26.5	CW	1
S A	1560 1580	312 312	750 730	35 38.5	CW	1¼
S A	2400 2390	312 312	750 780	18 17.5	CW	1¼
S A	4300 4250	312 340	750 780	9 10.5	CW	2½
S A	2400 2350	470 130	565 590	34 34	CW	1

SERIAL #__ AS A GENERATOR

STATED ACTUAL	SPEED R.P.M.	ARM VOLTS	ARM AMPS	FIELD AMPS	ROTATION	SCALE VOLTS(RPM)
S A	780 720	175 126	785 620	54 20	CW	1
S A	1560 1500	312 186	750 925	35 20	CW	1
S A	2400 1920	312 380	750 700	18 60	CW	1
S A	4300 3900	312 530	750 740	9 22	CW	2½
S A	2400 2800	470 550	560 720	34 29	CW	1

OVERSPEED AT 5160 RPM. S.N. 3 — [✓] PASSED [ ] FAILED

HYPOT AT 2700 V.A.C. S.N.____

A M. — [✓] PASSED [ ] FAILED

FIELD. — [✓] PASSED [ ] FAILED

FIG 93-2

4. Heat Run

The data included here is for the one hour rating test at 230 HP continuous. Fig a4-1 identifies the temperature sensor locations. Figure a4-2 is a series of 8 pages which are a copy of the strip chart record for a heat run test on Traction Motors SN No. 9 and 11, with No. 9 running as the motor.

The setup for this test is shown in Figure a4-3. The conditions noted on this figure are steady state operating conditions as taken from figure a4-2(7), just before the test was stopped and cooling air was turned off. The lines traced in on these charts are for thermocouple locations 10, 12, 21 and 22. Locations 21 and 22 are air outlet temperatures. Numbers 10 and 12 are winding temperatures near the air outlet which reached the highest values after shut down, see figure a4-2(8).

The airflow rates (approximately 900 CFM per motor) are about 20% lower than that of the forced air cooling system used in the vehicle.

Data from the Overload Heat Run are shown in Fig. a4-4.

Two views of the test set up are shown in the photographs Fig. a4-5 and a4-6.

5. Overspeed

Overspeed tests are run to 5160 RPM (20% above nominal maximum operating speed) on each unit as indicated in figure a2-1.

6. Dielectric

The results of the dielectric test are also shown in figure a2-1, part of the individual motor test data.

7. Commutation Limit Test

This test has not been run

7-16-1970

THERMOCOUPLE LOCATIONS

WERE	NO.	LOCATION
1	A_1	Interpole or COMMUTATING COIL. AIR INLET SIDE
2	A_2	" " OPPOSITE AIR INLET
3	B_1	Compensating POLE FACE WINDING INLET SIDE
4	B_2	" " " OPPOSITE INLET SIDE
5	C_1	SHUNT COIL TOP
6	C_2	SHUNT COIL BOTTOM
7	D_1	BEARING HOUSING
8	E_1	AIR INLET
9	H_1	SAME AS A_1 (DRIVE END)
10	H_2	A_2 " "
11	I_1	B_1 " "
12	I_2	B_2 " "
13	J_1	C_1 " "
14	J_2	C_2 " "
15	K	BEARING HSG DRIVE END
16	L	INTERPOLE (S/N 11 UNIT)
17	M	COMP. WINDING " "
18	N	SHUNT " " "
19		T_2 DUCT 15.375" DIA
20		6 FEET AWAY FROM THE SET OIL AMBIENT THERMOCO
	F_1	EXTERNAL TEMP SENS: Brush holder
	G_1	" " " Brush
21		#11 MOTOR (AIR OUT FROM MOTOR)
22		#9 MOTOR (" " " ")

FIG a4-1

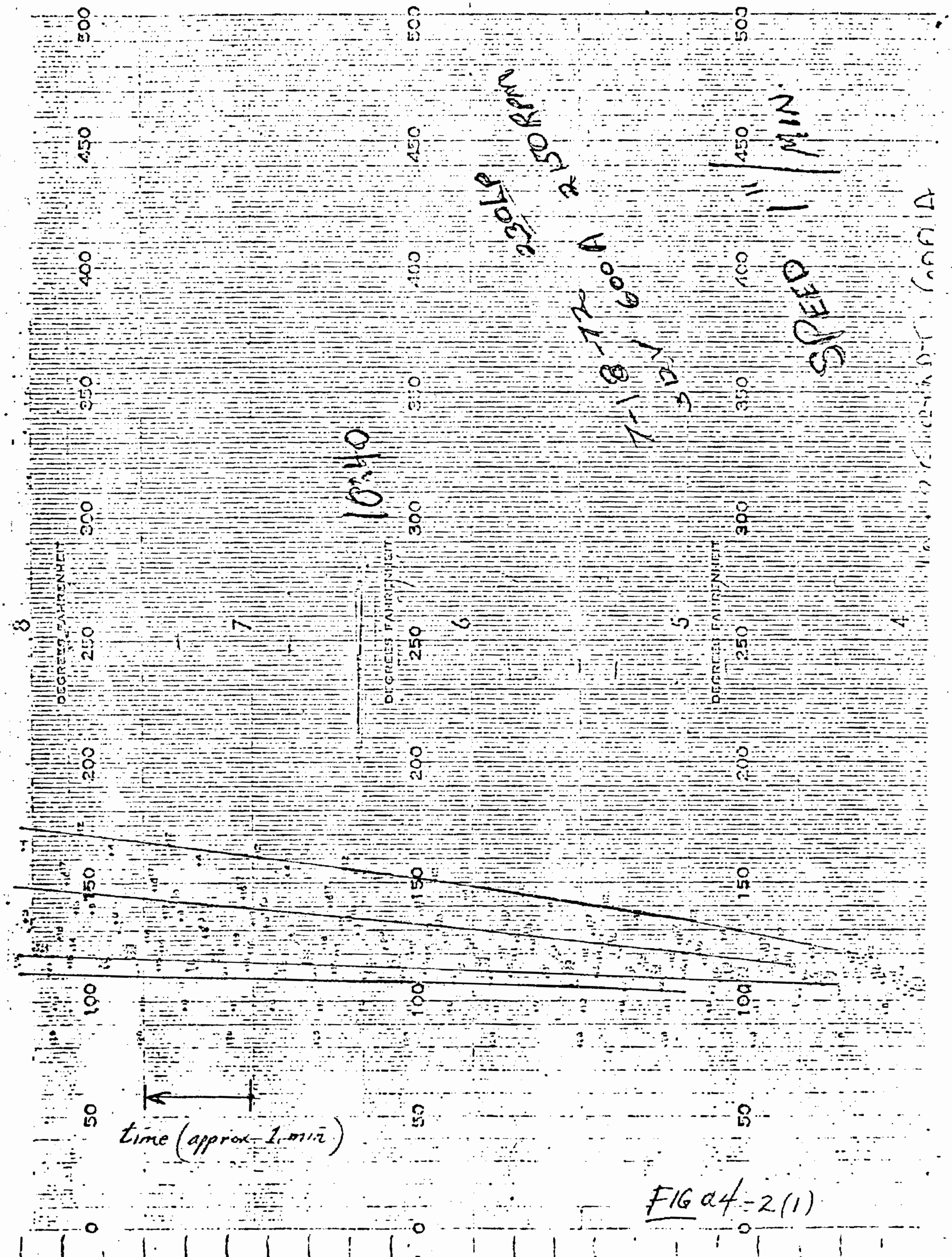

DEGREES FAHRENHEIT
0
50
100
150
200
250
300
350
400
450
500
time (approx 1 min)
10W40
SPEED 1 / MIN

FIG a4-2(1)

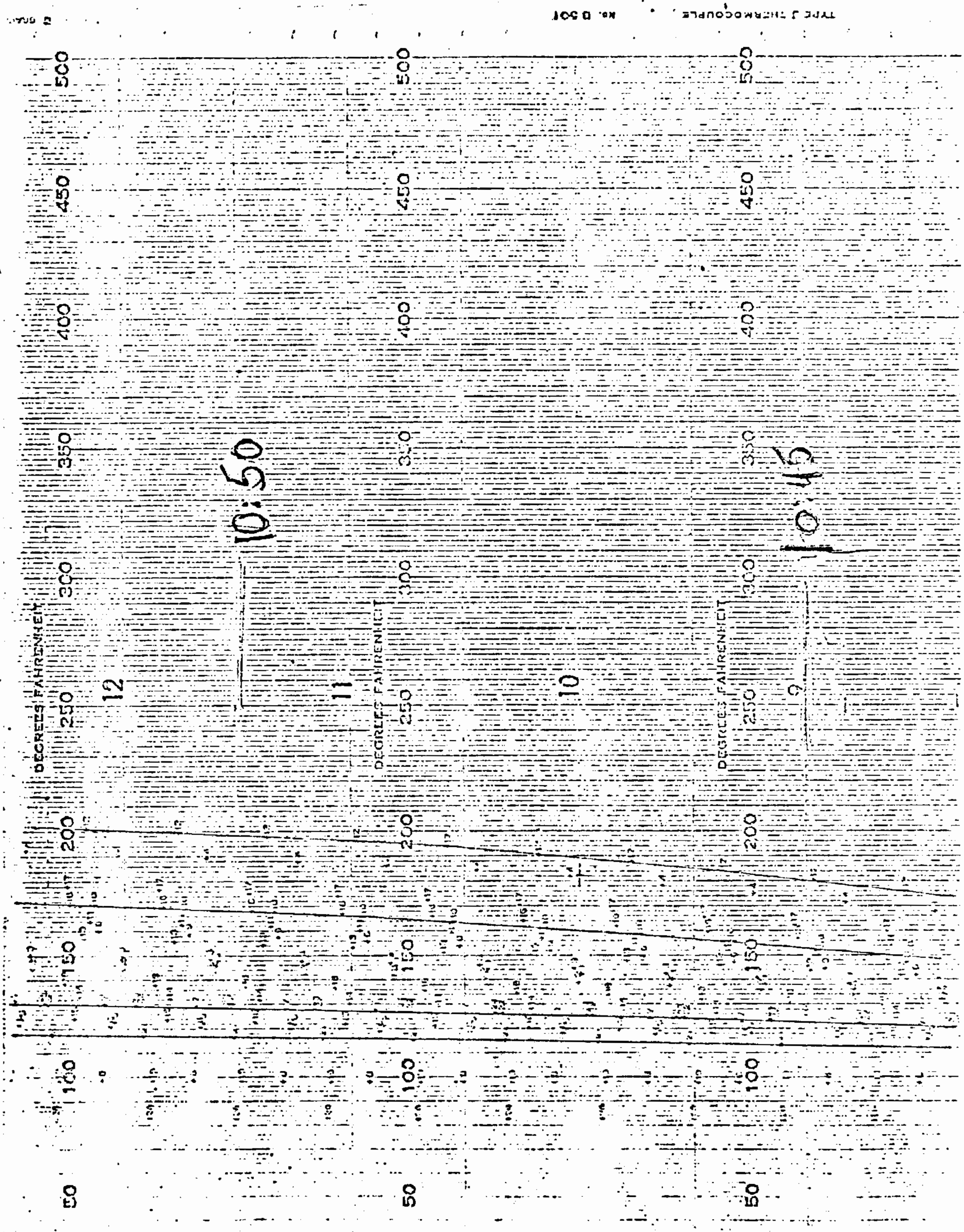

TYPE J THERMOCOUPLE
DEGREES FAHRENHEIT
500
450
400
350
300
250
200
150
100
50
0
10:50
10:45
12
11
10
9

FIG a4-2 (2)

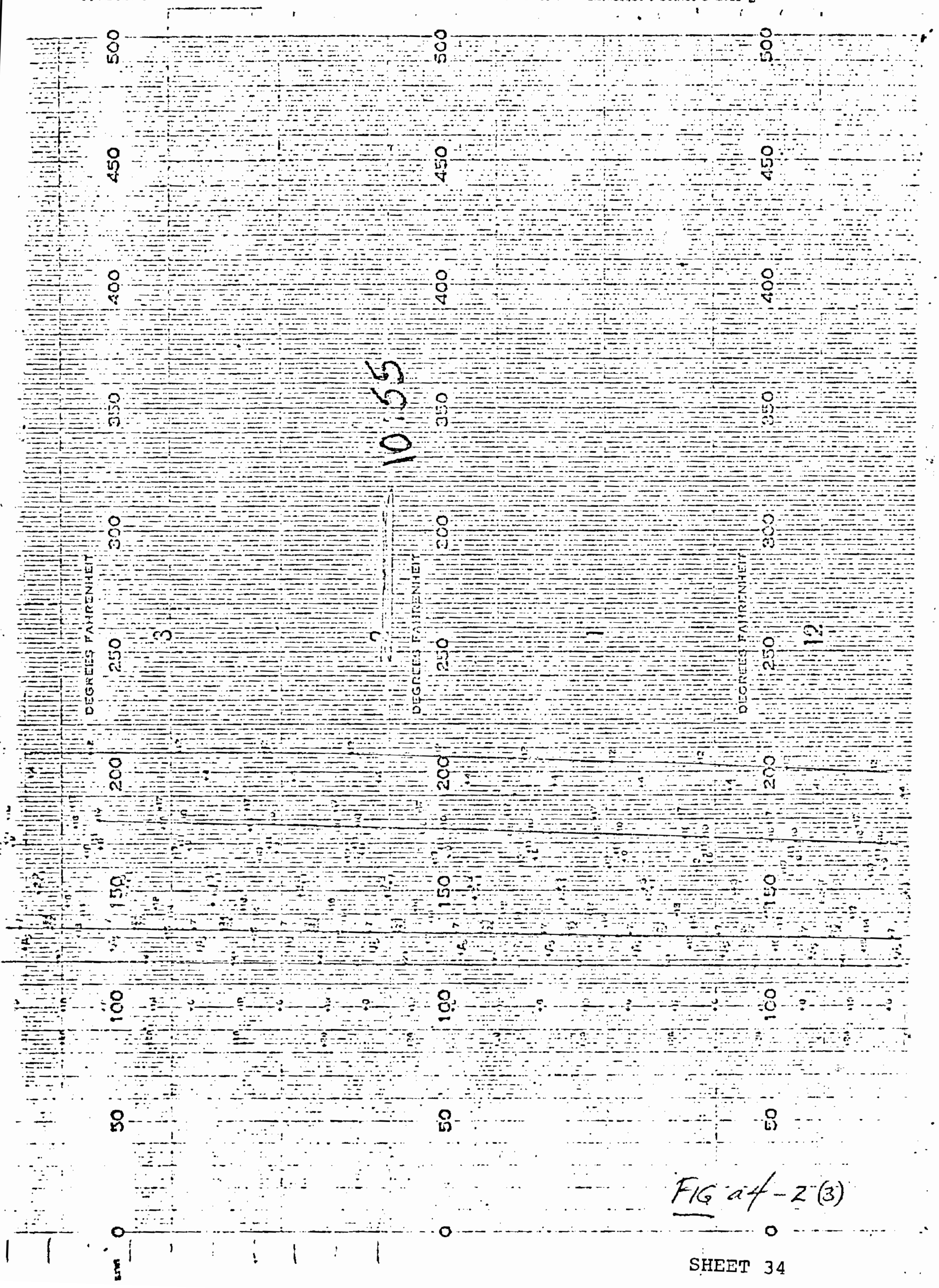

GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
DEGREES FAHRENHEIT
0
50
100
150
200
250
300
350
400
450
500
10:55

FIG a4-Z(3)

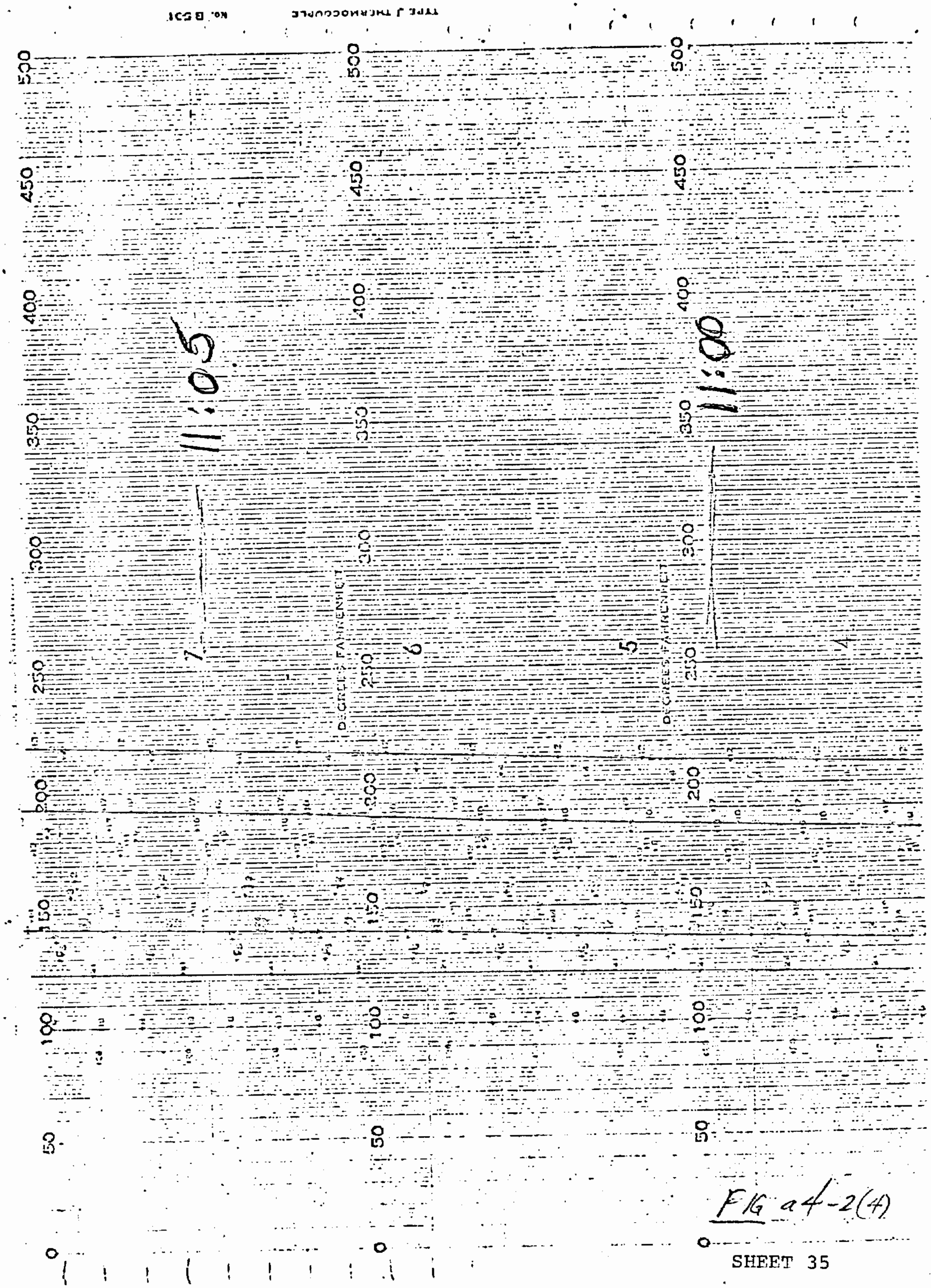

500
450
400
350
300
250
200
150
100
50
0
DEGREES FAHRENHEIT
11:05
11:00
7
6
5
4

FIG a4-2(4)

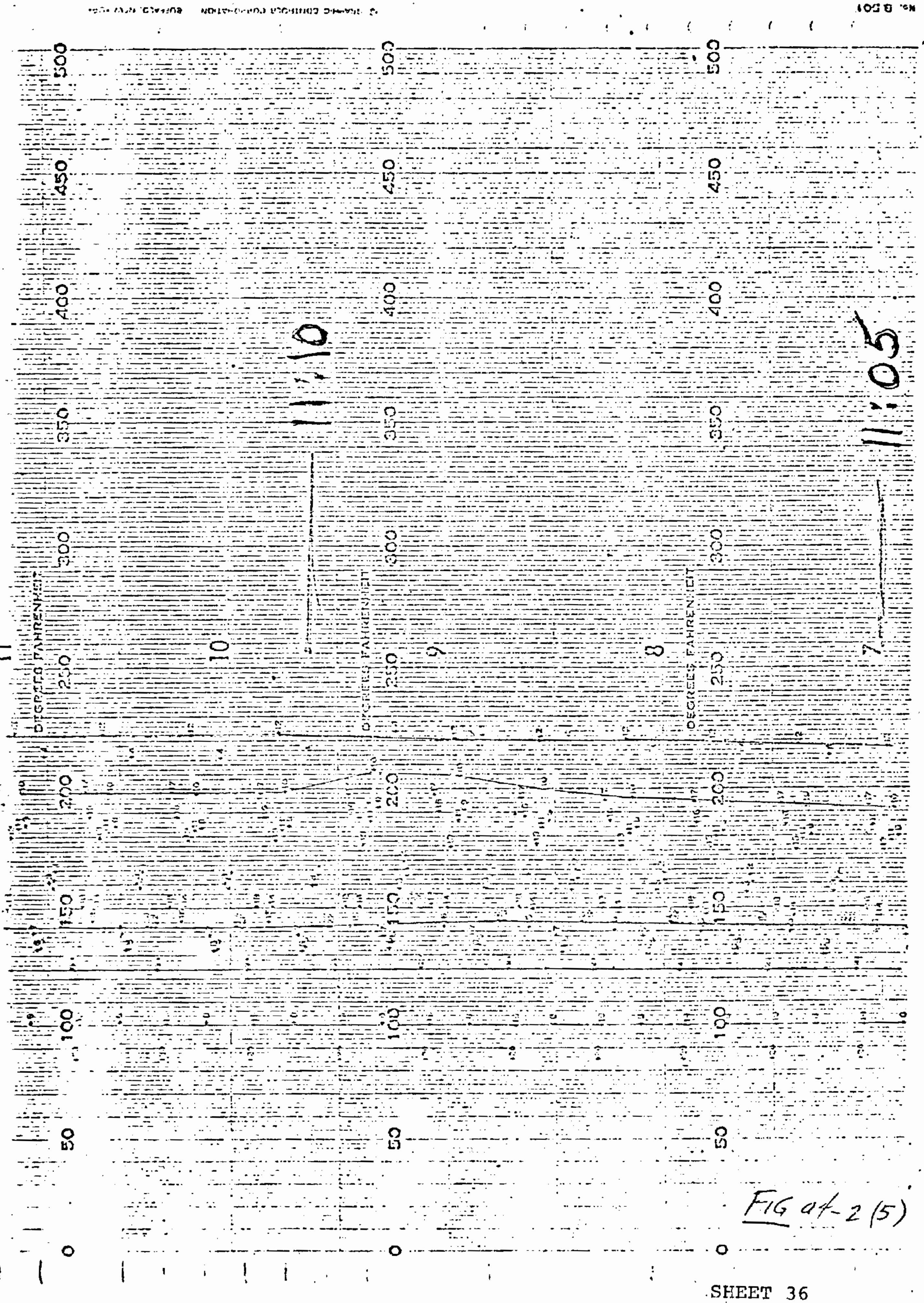

DEGREES FAHRENHEIT
0
50
100
150
200
250
300
350
400
450
500
11:10
11:05
11
10
9
8
7

FIG a4-2 (5)

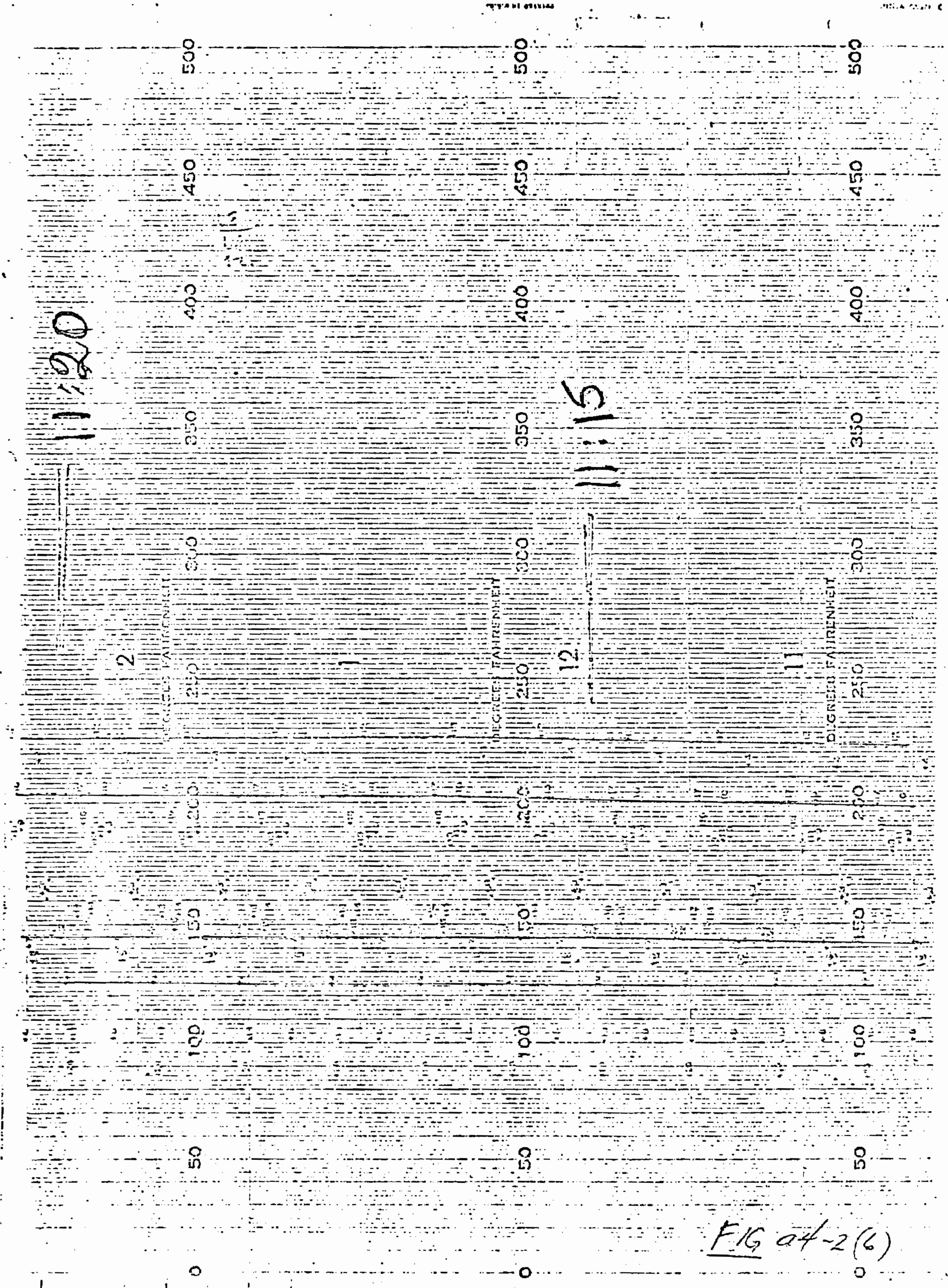

DEGREES FAHRENHEIT
500
450
400
350
300
250
200
150
100
50
0
11/20
11/15

FIG a4-2(6)

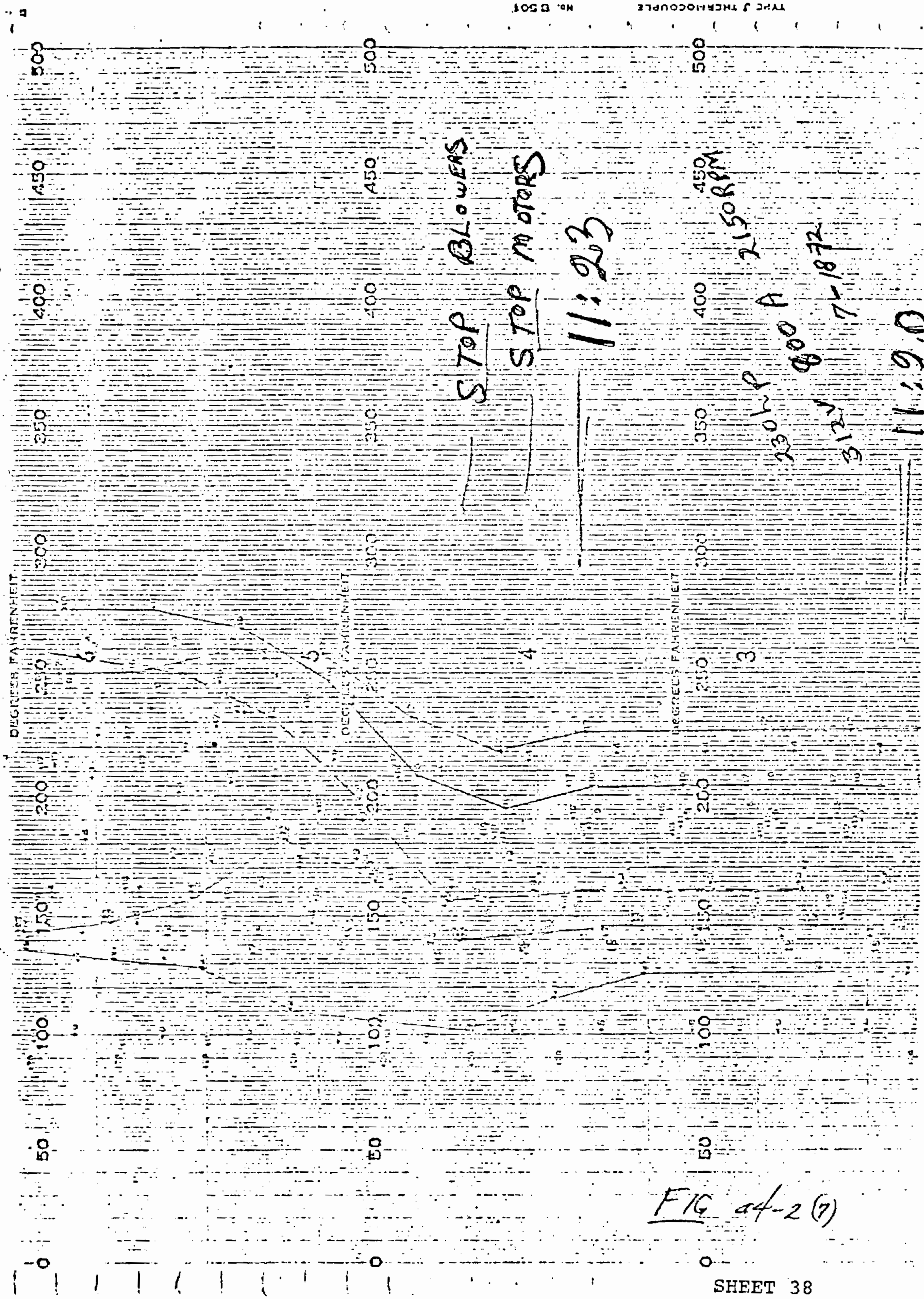

TYPE J THERMOCOUPLE
DEGREES FAHRENHEIT
STOP BLOWERS
STOP MOTORS
11:23
2150 RPM

FIG a4-2 (7)

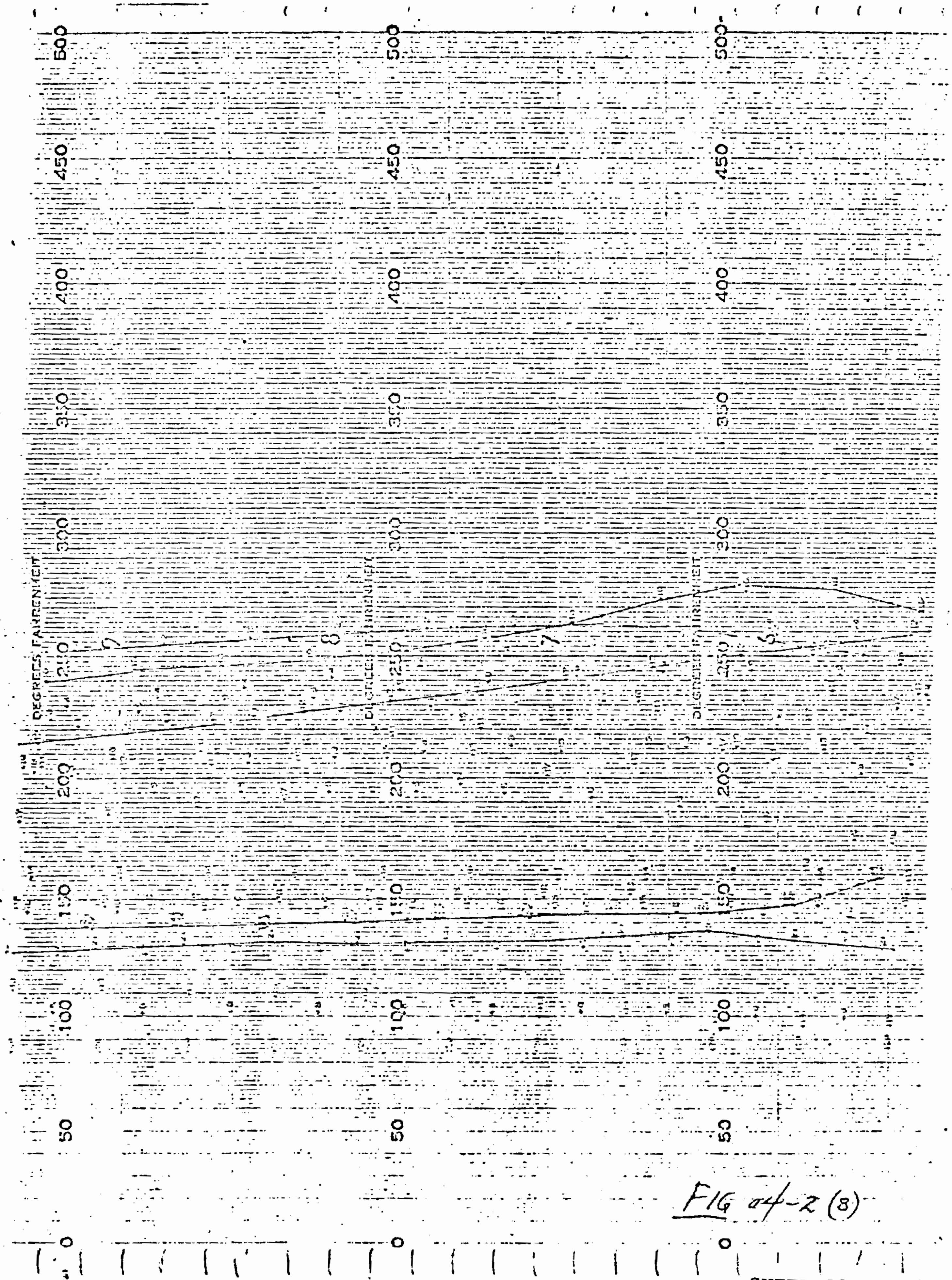


FIG 04-2 (8)

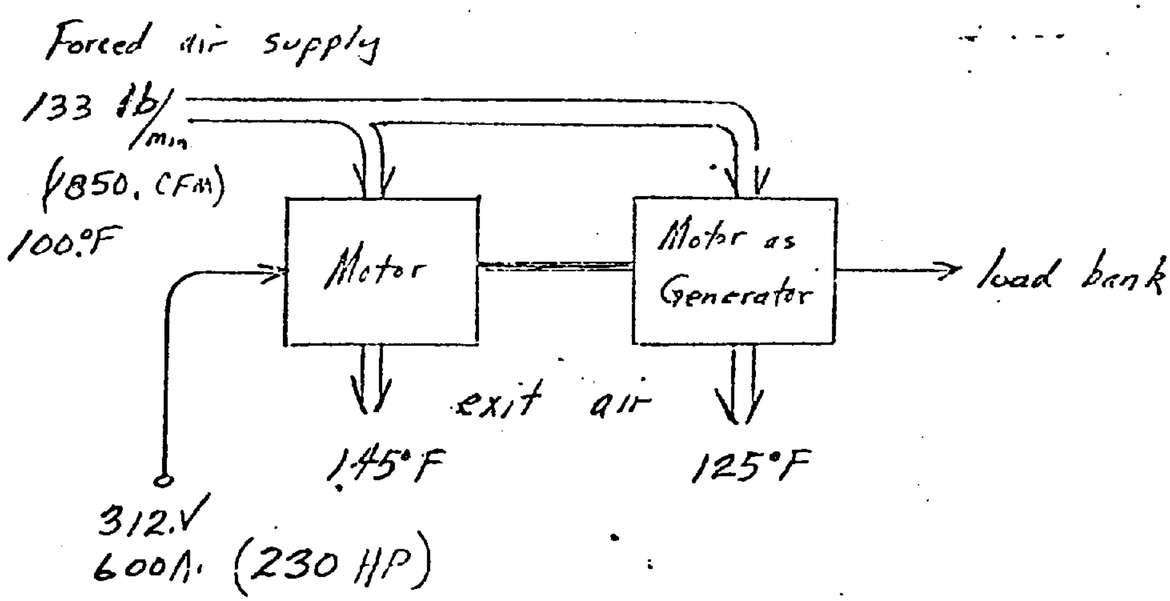
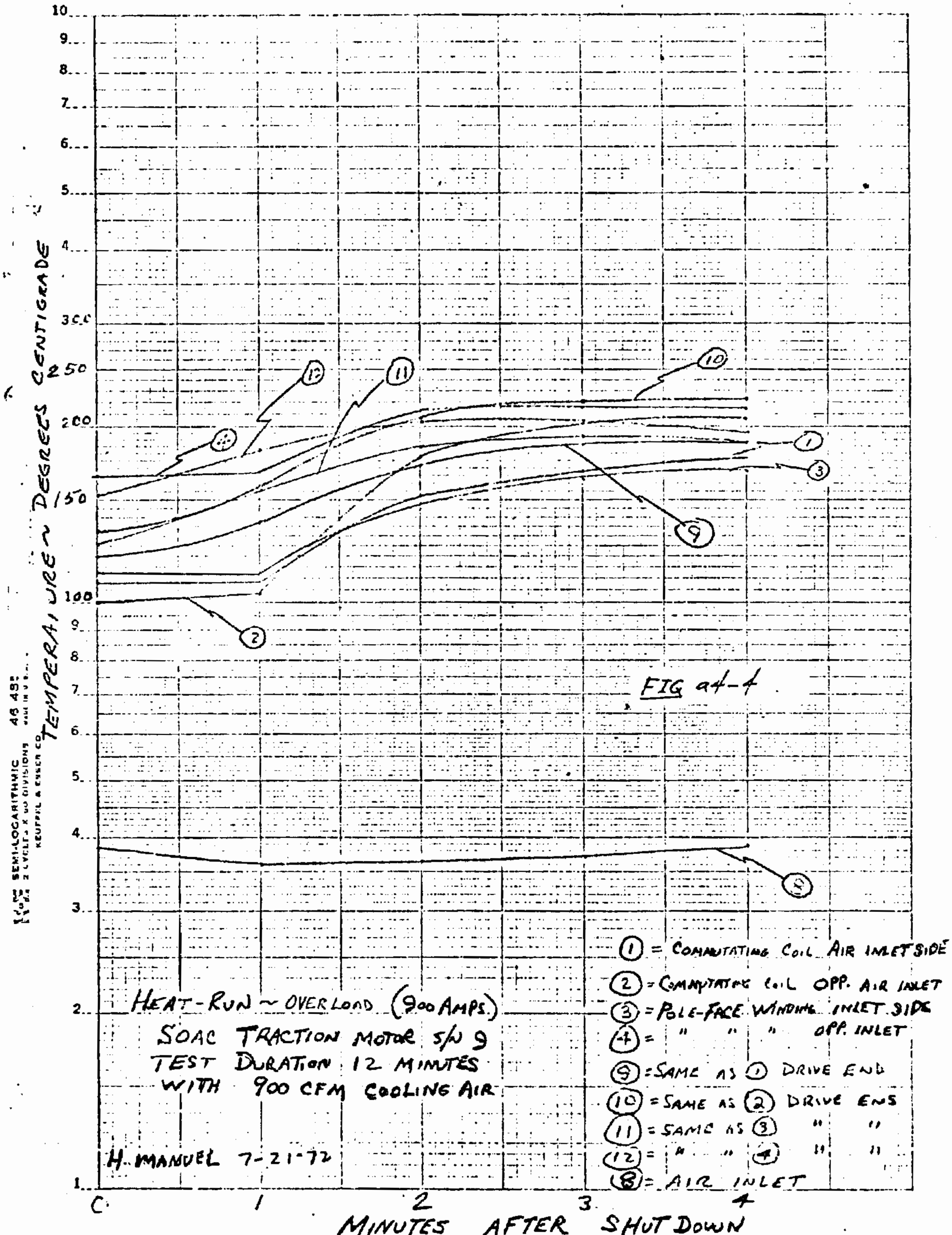


FIG a4-3 80AC Traction Motor Heat Run Test


TEMPERATURE ~ DEGREES CENTIGRADE
MINUTES AFTER SHUT DOWN
FIG a4-4
HEAT-RUN ~ OVERLOAD (900 AMPS)
SOAC TRACTION MOTOR S/N 9
TEST DURATION 12 MINUTES
WITH 900 CFM COOLING AIR
H. MANUEL 7-21-72
(1) = COMMUTATING COIL AIR INLET SIDE
(2) = COMMUTATING COIL OPP. AIR INLET
(3) = POLE-FACE WINDING INLET SIDE
(4) = " " " OPP. INLET
(9) = SAME AS (1) DRIVE END
(10) = SAME AS (2) DRIVE END
(11) = SAME AS (3) " "
(12) = " " (4) " "
(8) = AIR INLET
KEUFFEL & ESSER CO. SEMI-LOGARITHMIC 2 CYCLES X 90 DIVISIONS 46 4952

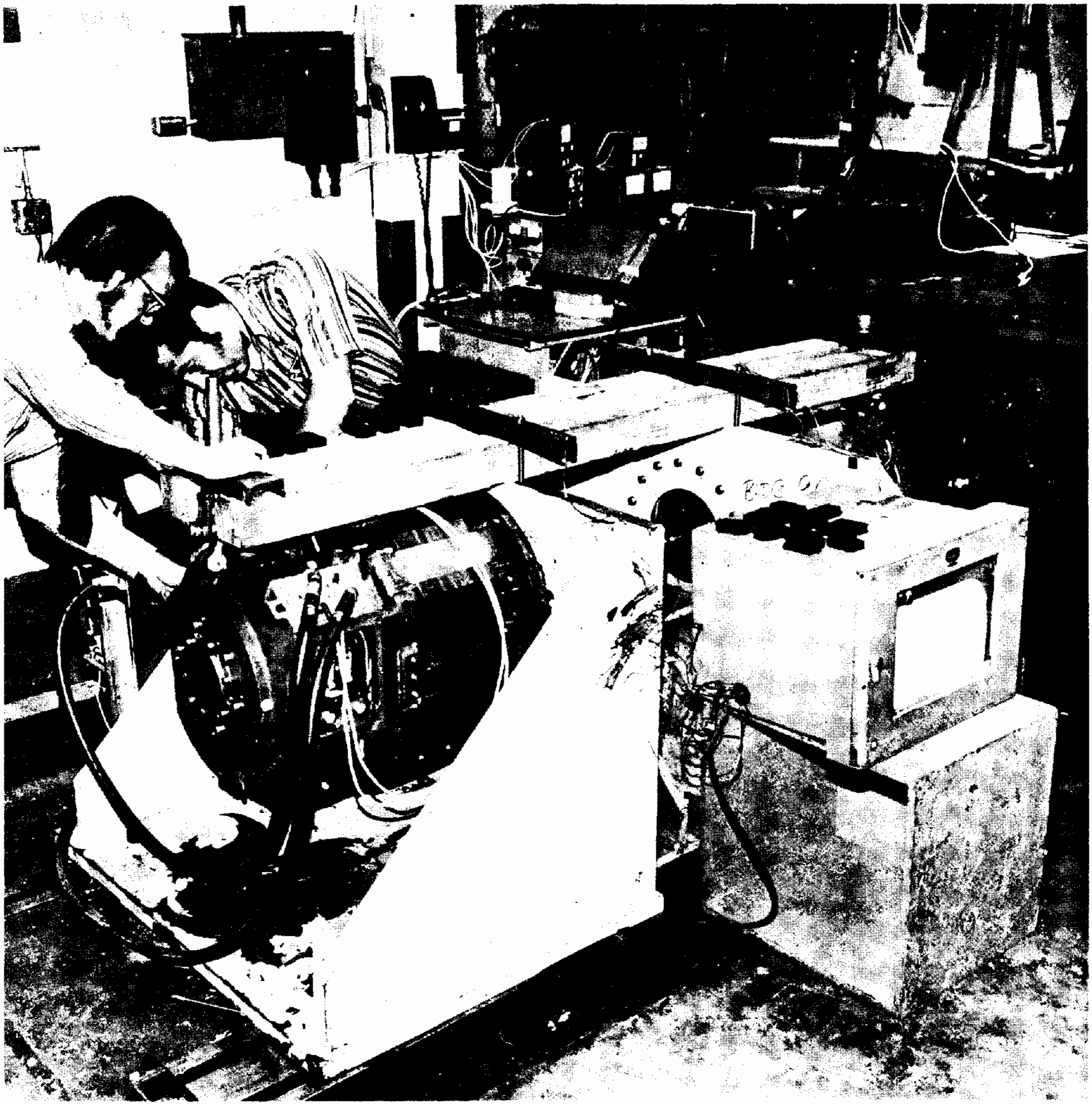


FIG a-4-5

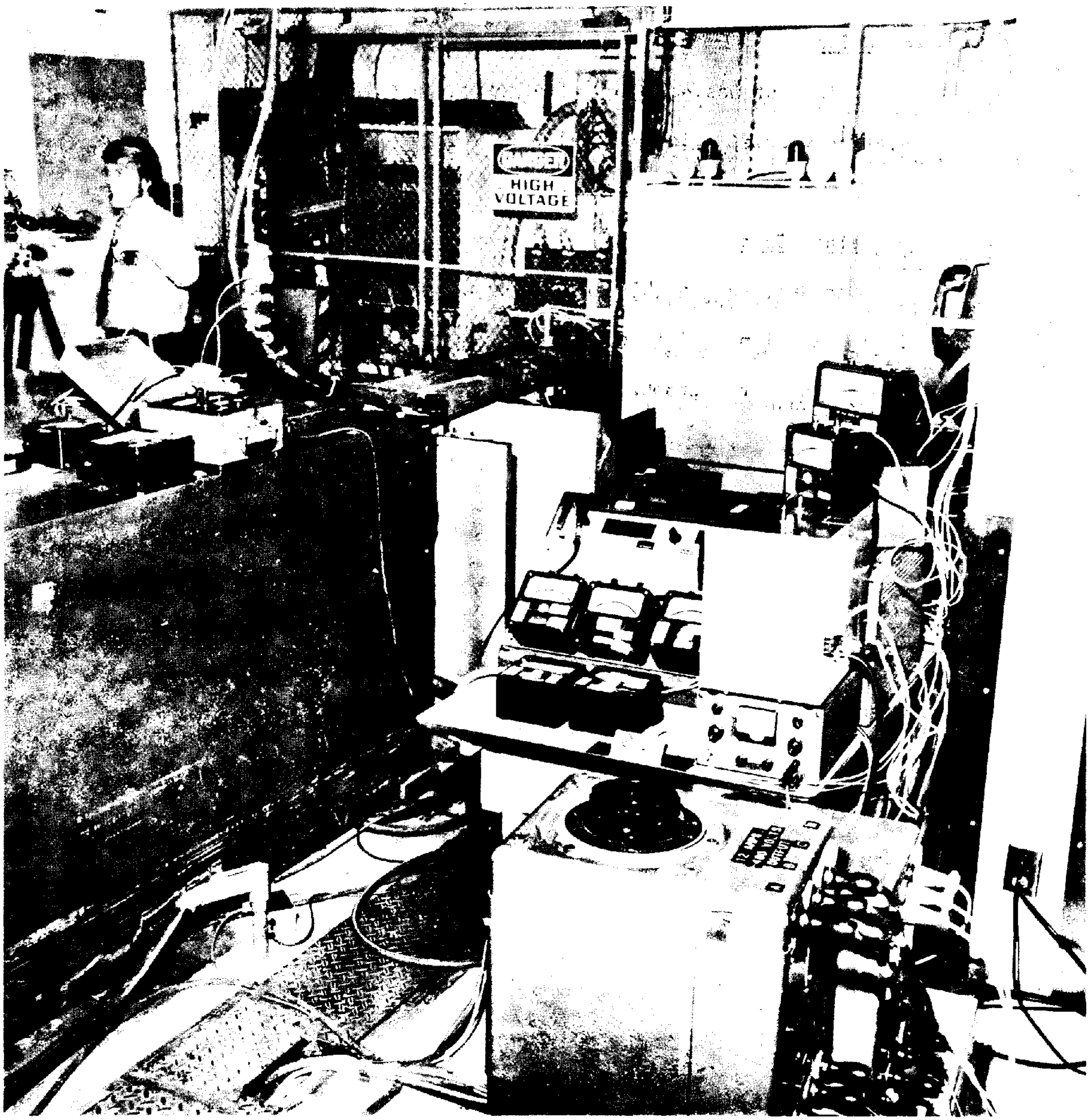


FIG. a4-6

8. Vibration

This test was not run.

9. Noise

This test was not run. The motor is cooled by an external blower and is a relatively quiet unit by itself.

10. Black Band

The data run on this test is shown in reduced form in the graphs on figure a10-1. The lines plotted represent the black band boundary for the conditions stipulated on the graph.

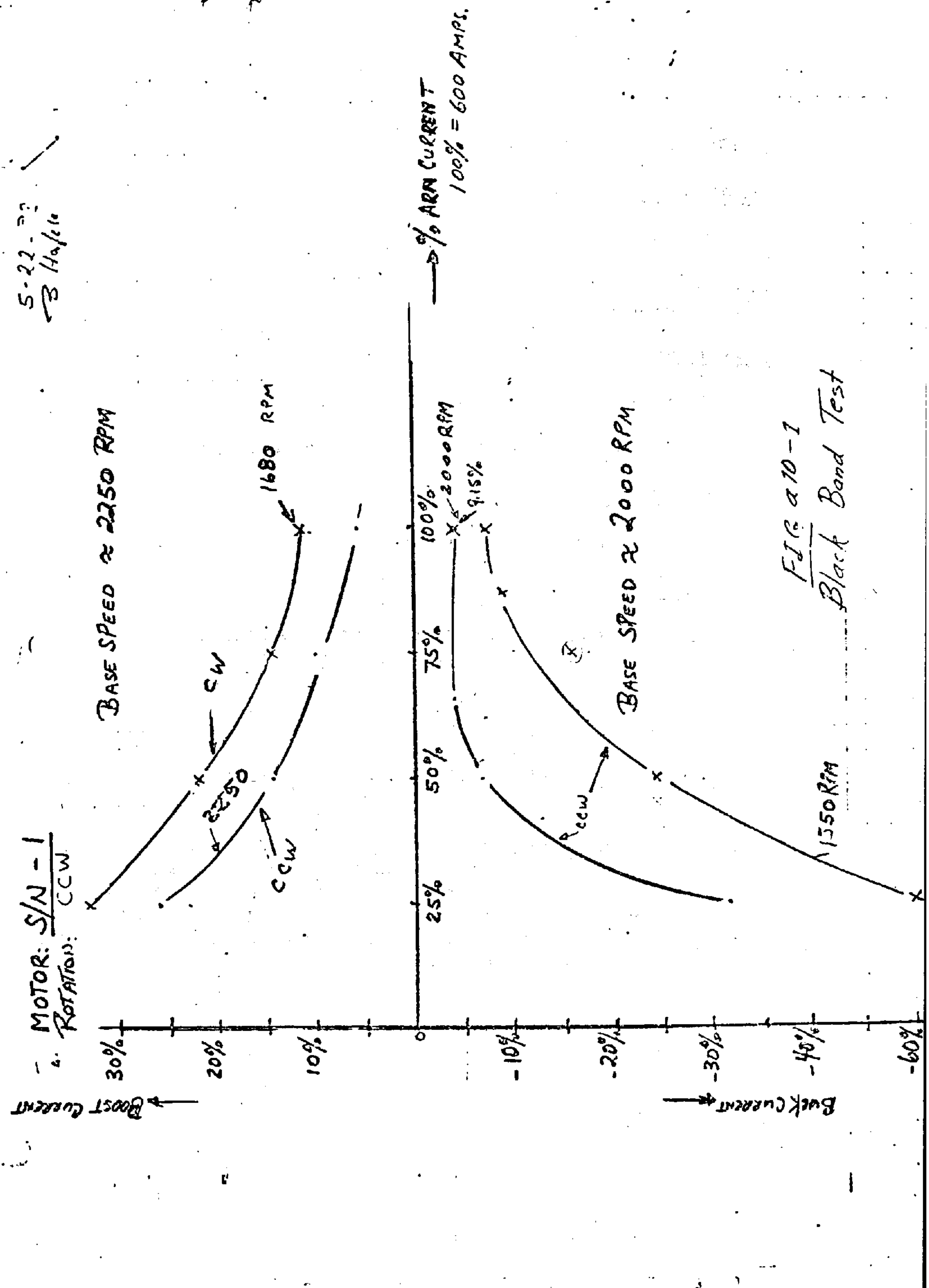


FIG a10-1
Black Band Test

b. INPUT REACTOR (P/N 524054-1)

Production Testing

1. Inductance test
2. Q shall be verified
3. Hi Pot
4. Resistance

Development Testing

Purpose

To insure reactor meets all design specifications.

Configuration

Power source and instrumentation to monitor tests.

Procedure

a. Inductance using incremental inductance bridge (L = 0.30 + 0.03 - 0.0 mhy)

b. Resistance using wheatstone bridge (Rdc = 1.4×10^{-3} ohm ± 10%)

c. Hi Pot: Apply 3000 VAC 60 Hz between inductor terminals and support angles.

d. Thermal tests: Insert four thermocouples on specified surfaces. Connect inductor to a low voltage - high current direct current source. Increase voltage to obtain 1350 amperes through the inductor. Allow temperatures to stabilize. The hot spot temperature rise shall not exceed 100°C.

b. INPUT REACTOR (P/N 524054-1)

Production Testing

Each unit was tested to check compliance with the requirements of specification 422-0500.

Development Testing

No development testing of the component, as such, was made. A heat run was not considered necessary, since its heat load was less than the smoothing reactor.

c. SMOOTHING REACTOR (P/N 524056-1)

Production Testing

1. Inductance tests
2. Q shall be verified
3. Hi.Pot
4. Resistance

Development Testing

Purpose

To insure reactor meets all design specifications.

Configuration

Power source and instrumentation to monitor tests.

Procedure

a. Inductance using incremental inductance bridge
(L = 1.0 + .01 - 0.0 mhy)

b. Resistance using wheatstone bridge
(Rdc = 2.7×10^{-3} ohm ± 10%)

c. Hi Pot: Apply 3000 VAC, 60 Hz between inductor terminals and support angles.

d. Thermal tests: Insert four thermocouples on specified surfaces. Connect inductor to a low voltage - high current direct current source. Increase voltage to obtain 1350 amperes through the inductor. Allow temperatures to stabilize. The hot spot temperature rise shall not exceed 100°C.

c. SMOOTHING REACTOR (P/N 524056-1)

Production Testing

Each unit was tested to check compliance with the requirements of specification 422-0501.

Development Testing

The electrical and mechanical characteristics were verified and a heat run was made to determine the temperature rise of the unit. Details of the heat run follow:

Smoothing Inductor Heat Run

The smoothing inductor was tested for temperature rise by applying D.C. current and monitoring the temperature at selected points. The motion of the train was simulated by blowing air across the inductor.

The air flow across the inductor was not evenly distributed (see chart) but was approximately 2000 ft per minute or 23 miles per hour.

The thermocouples were placed in the air ducts but wedged under the last turn, so that they were not exposed to the air but were essentially covered on both sides by the conductor.

A load bank was utilized to permit the phase delayed rectifier to operate at an advanced firing angle. The voltage was adjusted to deliver 1200 Amp D.C. through the inductor.

A recorder was used to continuously monitor the thermocouple temperatures. Pertinent points are shown plotted on the chart.

Referring to Figure C1-1 it can be seen that the maximum temperature reached was 314°F, but the temperature was still increasing slightly. It did not appear that the final temperature would exceed 320°F. The length of the run was three hours. The ambient temperature was 104°F. The temperature rise was therefore 216°F.

Since the air flow was considered minimal as compared to the actual application, the results of this test were considered acceptable to verify the design of the inductor.

The input reactor had a thermal load of approximately 0.7 watts per sq. inch of surface whereas the smoothing inductor had a heat load of approximately 1.1 watts per sq. inch. It was therefore concluded that a test of the input inductor would not be necessary, since its lower heat load would result in a lower temperature rise.

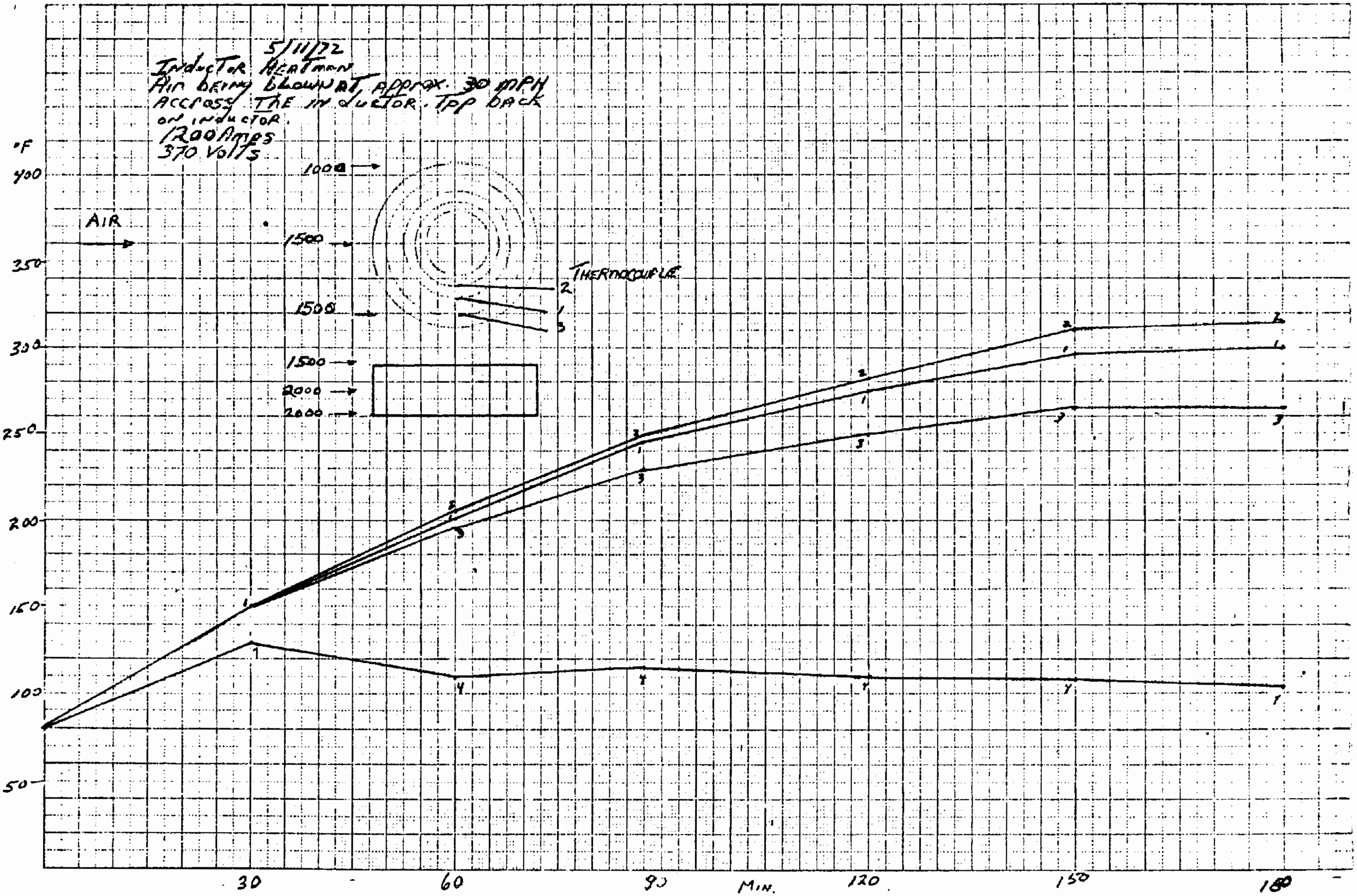

5/11/72
Inductor Heatman
Air being blown at approx. 30 MPH
Accross the inductor. Top back
on inductor.
1200 Amps
370 Volts
AIR
1000
1500
1500
1500
2000
2000
THERMOCOUPLE
2
1
3
°F
400
350
300
250
200
150
100
50
30
60
90
MIN.
120
150
180

FIG. C1-1

d. DC-DC CHOPPER (P/N 524058-1)

Production Testing

1. Thyristors and rectifiers

   a. Blocking life
   b. Dynamic tests

2. Thyristor voltage sharing and snubber operation
3. Logic tests
4. Sensor tests
5. Hi Pot
6. 400 Hz operation to check snubber operation
7. Drive brake transition

Development Testing

Purpose

To insure that components will perform to the required specifications.

Configuration

Power source - loads - high and low temperature ovens - thermocouples - necessary test equipment for monitoring results.

Procedure

a. Thyristor acceptance

   1) Blocking life (72 hrs - 125°C - 960V)
   2) Gate sensitivity (25°C - 3.0V - 150 ma)
   3) Forward voltage drop (25°C - 300A - 1.6-1.9V)
   4) Anode blocking (125°C - 1200V)
   5) Gate sensitivity (125°C - 0.15V)
   6) Turn off time (125°C - 30 μsec max)

b. Rectifier acceptance

   1) Blocking life (72 hrs - 150°C - 1500V)
   2) Anode blocking (200°C - 2000V)
   3) Forward voltage drop (150°C - 300A)

c. Commutating capacitor

   1) Inductance (10.0 + 0.5 - 0.0 mHy)
   2) Hi Pot (2500V - 60 Hz - 1 min)

d. DC-DC CHOPPER (Contd.)

d. Commutating capacitor

1) Capacitance (4 uFd ± 10%)
2) Hi Pot (1000V - 400 Hz - 1 Hr)

Full Load Operational Tests

Purpose

To determine that the DC - DC Chopper functions within all parameters of its design.

Configuration

Equipment required to perform operational tests.

a. Main power source
b. Logic power supply
c. Load bank
d. Capacitor bank
e. Smoothing inductor (or simulated)
f. Motor load (or simulated)
g. Oscilloscopes, ammeters, voltmeters, wattmeters, thermocouples, etc.
h. Cooling fans and ducts

Procedure

a. Chopper test

1) Apply logic power and observe gate drive on all thyristors. Ascertain that main thyristors and commutation thyristors are receiving proper signals.

2) Apply voltage to the capacitor voltage sensor. Increase voltage and observe that main thyristor gate signals are clamped to zero when the voltage exceeds 55 volts and recovers when voltage decreases below 45 volts.

3) Check that frequency is variable from 40 to 400 Hz.

b. Semiconductor tests

With the system connected in the drive mode and the drivers clamped off, apply 100 volts to the main input. Perform start - stop operation and observe DC current. It shall remain nearly zero.

Observe voltage waveforms across all semiconductors and that the following exists:

d. DC-DC CHOPPER (Contd.)

1) Series pairs of the semiconductors share voltages
2) No excessive voltage spikes
3) Main thyristor turn-off time.

Increase the voltage in 100 volt steps to 750 volts and phase the control to full on and return to the chopping mode at each step. Observe the following:

1) Semiconductor voltage sharing
2) Commutator current
3) Current sharing of main thyristors, commutating thyristors and free wheeling rectifiers.

c. Brake mode operation

With the system connected in the braking mode operation, increase the voltage to 1200 volts in 100 volt steps and observe the voltage waveforms across semiconductors, the commutating current and the load current.

d. Heat run at 400 Hz

With the system connected in drive mode and with 2000 CFM cooling air, apply 750 VDC input voltage. Increase the demand signal to obtain 400 Hz at the minimum on time, allow temperature as measured by the thermocouples to stabilize. Record.

Repeat the above procedure at 25%, 50%, 75%, and Full On. Record.

d. DC-DC CHOPPER (P/N 524058-1)

Production Testing

A laboratory test was run on each power semiconductor to insure its suitability in the system. A sample data sheet is shown in Figure d1-1. The operation of the chopper was checked in accordance with an Acceptance Test Procedure. A sample test procedure and data sheet shown in Figure d1-2 and Figure d1-3. The drive brake transition was not included in the component test procedure since it was a system function and not a component function.

Each commutating inductor was checked for compliance with specification 422-0503-9001.

Each commutating capacitor was checked for compliance with specification 195-0500-9001.

Development Testing

The various phases of development testing included:

(1) Commutating capability

(2) Thyristor temperature rise

(3) Heat sink optimization

(4) Thyristor gate drive suitability

(5) Temperature rise of commutating inductor and capacitor

(6) Snubber optimization

(7) Air flow distribution

(8) Thyristor current and voltage sharing

(9) Operation at maximum voltage in drive and brake modes

S/N · 7220

SCR TEST DATA SHEET

Spec/N GE 615°05 0 C

DATE APR 13 1970							
UNITS							
Mechanical Inspection	Lead Pull	Lead Move	Shock (3600G)	Thread	Surface	Markings	
		MV	MV				
X Passed			✓		✓		
Reject							
Anode Blocking 25°C V_R 1200 V	Leakage at Specified Voltage		LIMITS		PASSED	REJECT	
	Forward	Reverse					
X Zero gate volt	[illegible] Ma	0 Ma	≤ 2 Ma	≤ 2 Ma	✓		
Negative gate volt	ND Ma	ND Ma	≤ 2 Ma	≤			
X Gate VP 600 Sensitivity 25°C	Voltage	Current					
	[illegible] V	[illegible] Ma	≤ 3 V	≤ [illegible]	✓		
X VTP VP — TP 25°C	[illegible]		≤	≤	✓		
X VFM 25°C	[illegible] V				✓		
Blocking Life 125°C Open gate	Anode Leakage						
	T=0	T=24 hours					
X VOLTAGE 960 V	Ma	Ma	≤	≤	✓		
Heatsink Temp	°C	°C					
Anode Blocking 125°C V 1200 V	Leakage at Specified Voltage						
	Forward	Reverse					
X Zero Gate V	2 Ma	2 Ma	≤ 2 Ma	≤ 2 Ma	✓		
Negative Gate V	ND Ma	ND Ma	≤	≤			
X Gate VP 600 Sensitivity 125°C	Voltage	Current					
	V	[illegible] Ma	≥ [illegible] V	≥	✓		
X Turn-OFF Time 100°C	us	us	≤	≤	✓		
VP Critical dV/dt	v/us	v/us	≤	≤			
Anode Blocking −40°C VP	Leakage at Specified Voltage						
	Forward	Reverse				—	
Zero Gate V	Ma	Ma	≤	≤			
Negative Gate V	Ma	Ma	≤	≤			
Gate VP Sensitivity −40°C	Voltage	Current					
	V	Ma	≤	≤			

General Comments:

FIG. d1-1

☐ Reject ☒ Passed COMPLETION Test Engineer [illegible] Perm. P

Mfg P/N

ACCEPTANCE TEST DATA

D.C. CHOPPER

Part No. 524058-1

S/N 33-D7

Date: 5-14-73

Tested by: JOE CHUN

D. JACKSON

FIG d1-2 (1)

ACCEPTANCE TEST DATA SHEET

			ACCEPT	REJECT
1.	PRELIMINARY			
1.1	Connections		✓	
1.2	Wiring		✓	
2.	LOGIC			
2.4	Gate voltage	Drawer A-1	✓	
		A-2	✓	
		A-3	✓	
2.4.1	Minimum gate frequency 40 ±2 Hz		✓	
2.5	Gate drive sequence			
	Displacement T_d = 90 ±20 μsec		✓	
2.6.1	Common mode adjustment			
2.6.2	Capacitor ready voltage	E_1 = ~~80~~ 60 ±10V 61V	✓	
		E_2 = ~~70~~ 48 ±10V 46V	✓	
2.6.3	Gate drive clamp		✓	
2.7	Commutator contactor coil		NA	
2.7.1	Auxiliary contacts		NA	
3.	POWER			
3.2.1	Commutator current R_{SH} = .00096	e_c = .17 ± .02v = .630 655A	✓	
		T = 130 ±15μsec	✓	
3.2.4	Snubber resistor voltage	R1	✓	
		R2	✓	
		R3	✓	
		R4	✓	

FIG. d1-2(2)

			ACCEPT	REJECT
3.4	Semiconductor voltages			
	Total main thyristor	e_{pk} = -640, +610	✓	
	Total comtg thyristor	e_{pk} = 720	✓	
	Total free wheel diode	e_{pk} = +1150	✓	
	Single main thyristor	e_{pk} = -360, +300	✓	
	Single comtg thyristor	e_{pk} = 360	✓	
	Single free wheel diode	e_{pk} = 560	✓	

3.5.2 Main thyristor current sharing

HS	Voltage
1	~~.78~~ ✓ 1.30
2	~~.79~~ ✓ 1.30
3	~~.72~~ ✓ 1.26
4	~~.78~~ ✓ 1.38
5	~~.75~~ ✓ 1.30
6	~~.54~~ ✓ 1.35

		ACCEPT	REJECT
	Maximum deviation shall be ±10%	✓	
3.6	Chopper recovery	✓	
3.7.1	Chopper operation at maximum current	✓	

FIG. d1-2(3)

ACCEPTANCE TEST PROCEDURE

D.C. CHOPPER

Part No. 524058-1
S/N 33-D7

FIG. d1-3(1)

1. **PRELIMINARY CHECK**

1.1 All accessible bolted and screw type connections shall be examined and tested for tightness.

1.2 Point-to-point wiring check shall be made using an ohmmeter where a visual check is not sufficient.

1.3 NOTE: A reject at any point must be cleared before proceeding.

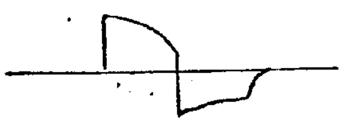
2. **LOGIC CHECK OUT**

2.1 Insert logic cards in their proper spaces.

2.2 Connect logic cable from chopper to propulsion control.

2.3 Apply logic power with $\theta_{command}$ signal at minimum and gates clamped.

2.4 Release gate clamps and observe gate voltage waveforms at terminal boards, on drawers A, A2 and A3. Place scope probe on terminal 1 and reference on terminal 3. The waveform shall be:



2.4.1 The frequency of the gate pulses shall be 40 ±2 Hz.

2.5 Place scope reference on logic common and the probe of channel 1 on A1 Term 1. Place the probe of channel 2 on A3 Term 1. Observe waveform on chopped input.

A1 Term 1

A3 Term 1

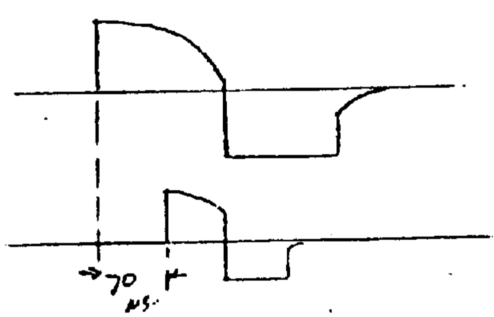


FIG. d1-3(2)

Note displacement of lower waveform (commutation drive) in time from the upper waveform (main drive). Displacement shall be 90 ±20μsec.

T = 70 uSEC.

2.6 Connect a laboratory power supply (0-150V, 1/2 amp) across resistors R517. B+ is connected to the top terminal of the resistor and B- is connected to common. Leave chopper output terminal open.

2.6.1 Place scope reference on logic common and probe on U1 Term. 6. Adjust potentiometer R___ to obtain minimum ac omponent on scope.

2.6.2 Move scope probe to U2 Term. 6. The display, e_o, will be 12 volts dc. Increase the auxiliary supply voltage slowly until e_o falls to zero. Note this voltage E_1 = 60 ±10v 61 V.

Decrease the auxiliary supply voltage until e_o rises to 12v. Note this voltage E_2 = 40 ±10v 46 V

2.6.3 Observe gate voltages at drawers A1 and A3. When e_o is 12 volts, gate signals are present. ✓ yes ___ no

When e_o is 0 volts, gate signals are absent ✓ yes ___ no

2.7 Apply 28 volts to commutator contactor coil. It shall close. NA yes no

2.7.1 Observe auxiliary contact. It shall operate to indicate condition of main contactor. NA

2.8 Remove auxiliary power supply. Turn off logic power.

3 POWER

3.1 Connect smoothing inductor and load bank to the output of the chopper. Close commutator contactor. Connect main power supply to the input

FIG. 21-3 (3)

of the chopper. B+ connects to the input terminal. B- connects to the Common Terminal.

3.2 Apply logic power, but clamp gate drive signals and set θ_{com} signal to zero. Apply main power. Increase the main power voltage to approximately 200 volts. Release gate clamp. Adjust main voltage to 200 volts if necessary.

3.2.1 Observe commutation current waveform as developed across a ~~0.00025~~ ohm coaxial shunt.

I_{pk}

I_{pk} = .630 V x ~~4000~~ 1040 = 655 A

T = 130 μsec

3.2.2 Observe voltages across main thyristors, commutating thyristors, and the free wheeling diodes. Note peak voltages

e_{main} -240 V +205 V

e_{com} +260 V

e_{FW} +365 V.

3.2.3 Observe voltages across each semiconductor. The voltages shall be one-half ±10% of the corresponding voltages of sect. 3.2.2.

3.2.4 Observe voltages across snubber resistors. R___, R___, R___, and R___. Voltage spikes indicate operation of snubber circuits ✓ ✓ ✓ ✓

3:3 Increase main supply voltage to 400 volts. Observe voltage waveforms. The peaks shall not be greater than twice the peaks of sect. 3.2.2. Do not record.

3.4 Increase main supply voltage to 650 volts. Observe voltage waveforms. The peaks shall not be greater than 3.3 times the peaks of sect. 3.2.2 and 3.2.3.

e_{main}	-640	+610
1/2 e_{man}	-360	+300
$e_{comt.}$		720
1/2 $e_{comt.}$		360
e_{FW}		+1150
1/2 e_{FW}		+560

3.5 Turn on air supply to cool thyristors. Reduce main supply voltage to 200v. Advance θ_{com} signal to obtain approximately 50% duty cycle. Measure voltage developed across the current sharing resistors. The voltage is not critical at this point, except as an indication of conduction.

HS	
1	✓
2	✓
3	✓
4	✓
5	✓
6	✓

3.5.1 Advance $\theta_{command}$ signal to maximum to obtain FULL ON condition. Note voltage across sharing resistors.

HEAT SINK	VOLTAGE
1	.270
2	.300
3	.235
4	.130
5	.280
6	.300

The maximum deviation shall be 30%.

3.5.2 Increase the main supply voltage to ~~600v.~~ 592. Note voltages across the sharing resistors.

HEAT SINK	VOLTAGE
1	~~.78~~ 1.30
2	~~.79~~ 1.30
3	~~.72~~ 1.26
4	~~.78~~ 1.38
5	~~.78~~ 1.30
6	~~.84~~ 1.35

The maximum deviation shall be ______ ±10%.

3.6 Retard $\theta_{command}$ signal. Chopper shall chop at maximum duty cycle, decrease in duty cycle and finally decrease in frequency as the $\theta_{command}$ signal is decreased to zero. Note the main supply voltage will have to be adjusted to maintain a constant 600v when the chopper is phased back.

Chopper recovery E_{dc} = 564, R = .368
I = 1600 AMP

3.7 Clamp gate signals. Turn Main Power Supply down to zero and OFF. Short load resistor, leaving the smoothing inductor as the only load.

3.7.1 Turn on main power supply. Increase the voltage to 150v. With $\theta_{command}$ at zero, release the gate drive. Increase the voltage to 600v. Advance $\theta_{command}$ if necessary to obtain 1800 A load current. Chopper shall operate satisfactorily. ___✓___

FIG. d1-3 (6)

The results of some of the various development tests follow:

Full Load Operation Tests

The full load operational tests were conducted as indicated with the exception of the brake mode operation which was done on the prototype and later during system test.

Commutation Temperature Rise

Test Conditions set up for the heat run of the commutation components are as follows:

The air flow distribution was adjusted so that 200 CFM was passed through the Inductor Capacitor compartment and 1200 CFM through the thyristor drawers. Thermocouples were placed in the commutation inductor, commutation capacitor and commutation thyristors. The main thyristors were also monitored. The chopper was operated at 600V, 400 Hz with the duty cycle just off minimum, approximately 5% on time. The reduced data from this part of the heat run is shown in Fig. d1-4.

The commutation inductor did not overheat but it was not stressed to the maximum. The worst case occurs when the system is in brake and all braking current is passing through the free wheel path. This is not a continuous condition, however, and a current rating equivalent to that of the smoothing reactor plus the commutating current is considered adequate. The rms current is

$$i_{rms} = \sqrt{i_{SR}^2 + i_c^2} = 1450.\ A$$

$$\left.\begin{aligned} i_{SR} &= 1360.\ A_{rms} \\ i_c &= 500.\ A_{rms} \end{aligned}\right\} \text{from duty cyle data}$$

A Litz type wire is presently used in order to reduce A.C. resistance. Further testing of the inductor will be accomplished in the prototype.

This test was extended to include various Duty Cycles. After the temperatures

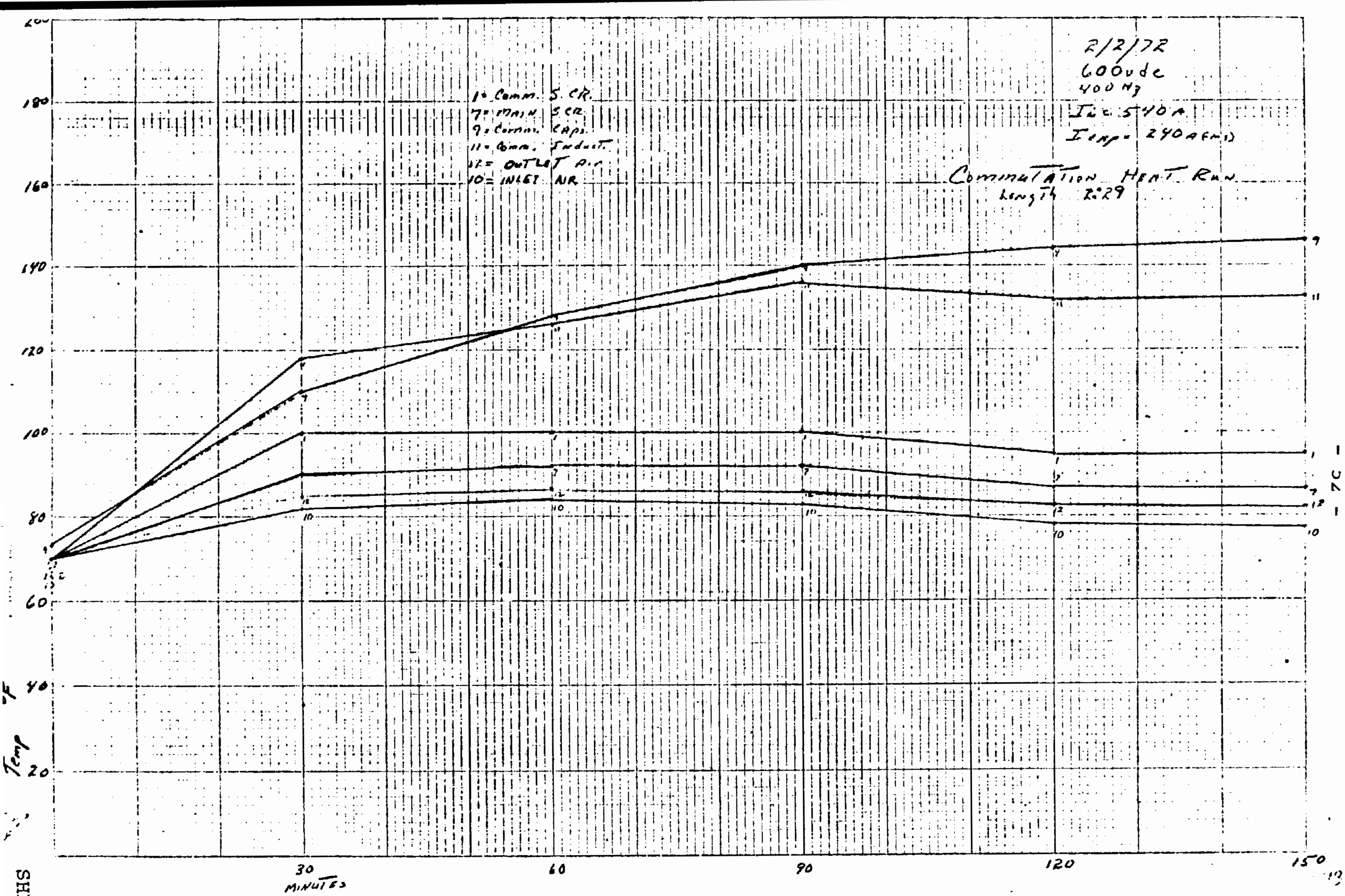

2/2/72
600vdc
400 Hz
I_L = 540A
I_{cap} = 240A(rms)
Commutation Heat Run
Length 2:29
1 = Comm. SCR.
7 = MAIN SCR.
9 = Comm. Caps.
11 = Comm. Induct.
12 = OUTLET Air
10 = INLET AIR
Temp °F
200
180
160
140
120
100
80
60
40
20
30
60
90
120
150
MINUTES

FIG. d1-4

stabilized, the duty cycle was increased and the temperature allowed to stabilize again. This was repeated for steps of 25%, 50%, 75% and Full On. The reduced data is shown in the graphs in fig. d1-5.

Note that the inlet air temperature showed an increase of 12°F over the ambient. It is likely that this increase is due to the heating of the sharing resistors which protrude into the duct area. By placing the sharing resistors on the outlet end of the heat sinks, the temperature of the inlet air could be reduced by approximately 10°F. The extra heat would then be transferred from the main thyristors to the commutators and the rectifiers.

Two views of the chopper test setup for the full load operational tests are shown in the photographs figures d2-1 and d2-2. In figure d2-2 the load banks are in the left and center foreground; the chopper is in the right rear background behind the blower, the calibrated airflow section and lead in ducting.

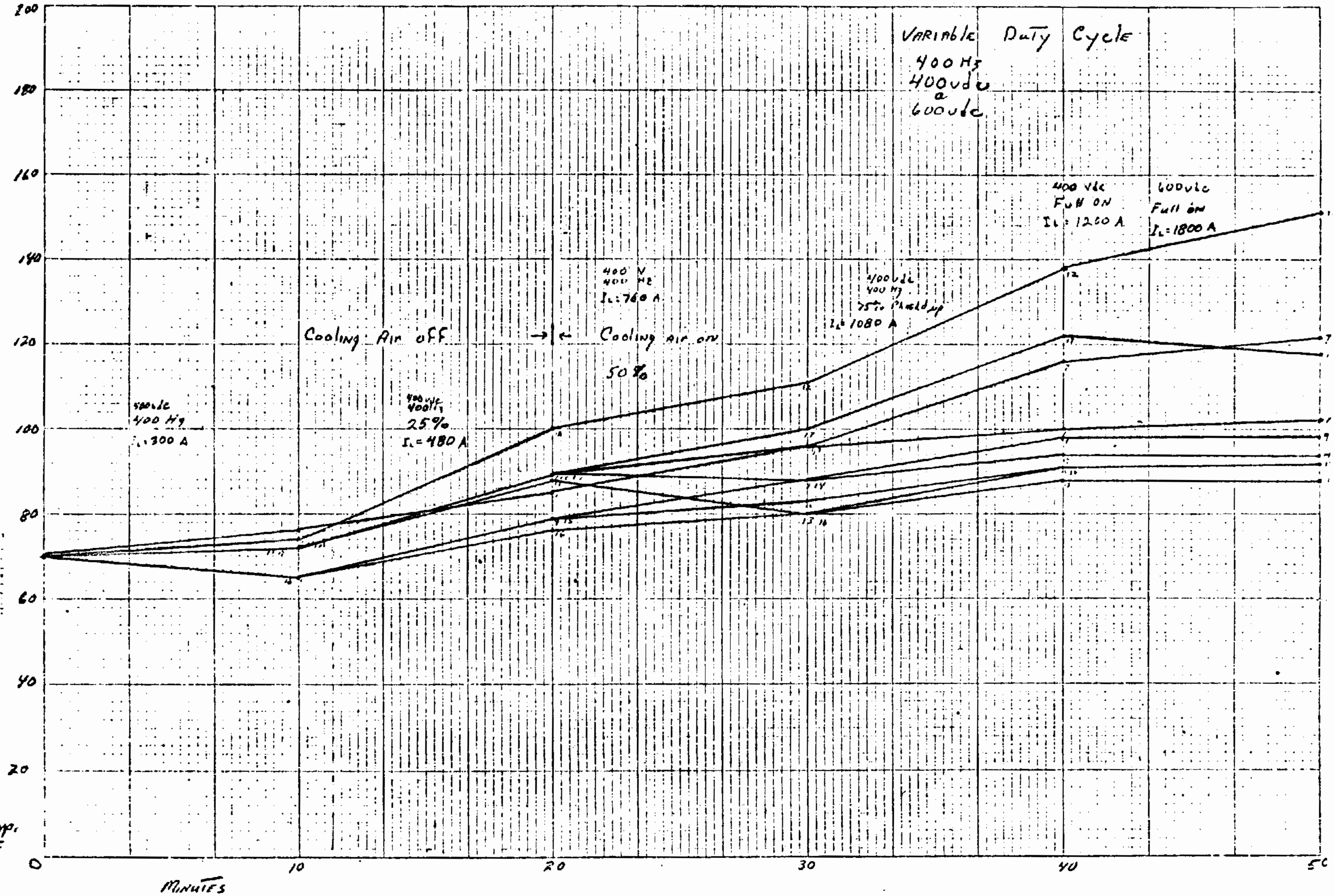

Variable Duty Cycle
400 Hz
400vdc
a
600vdc
Cooling Air off
Cooling air on
50%
25%
I_L = 480 A
400 Hz
I_L 300 A
400 V
400 Hz
I_L:760 A
400vdc
400 Hz
75% Pheld up
I_L 1080 A
400 vdc
Full ON
I_L 1200 A
600vdc
Full on
I_L=1800 A
Temp. °F
Minutes
0
10
20
30
40
50
20
40
60
80
100
120
140
160
180
200

FIG. d1-5

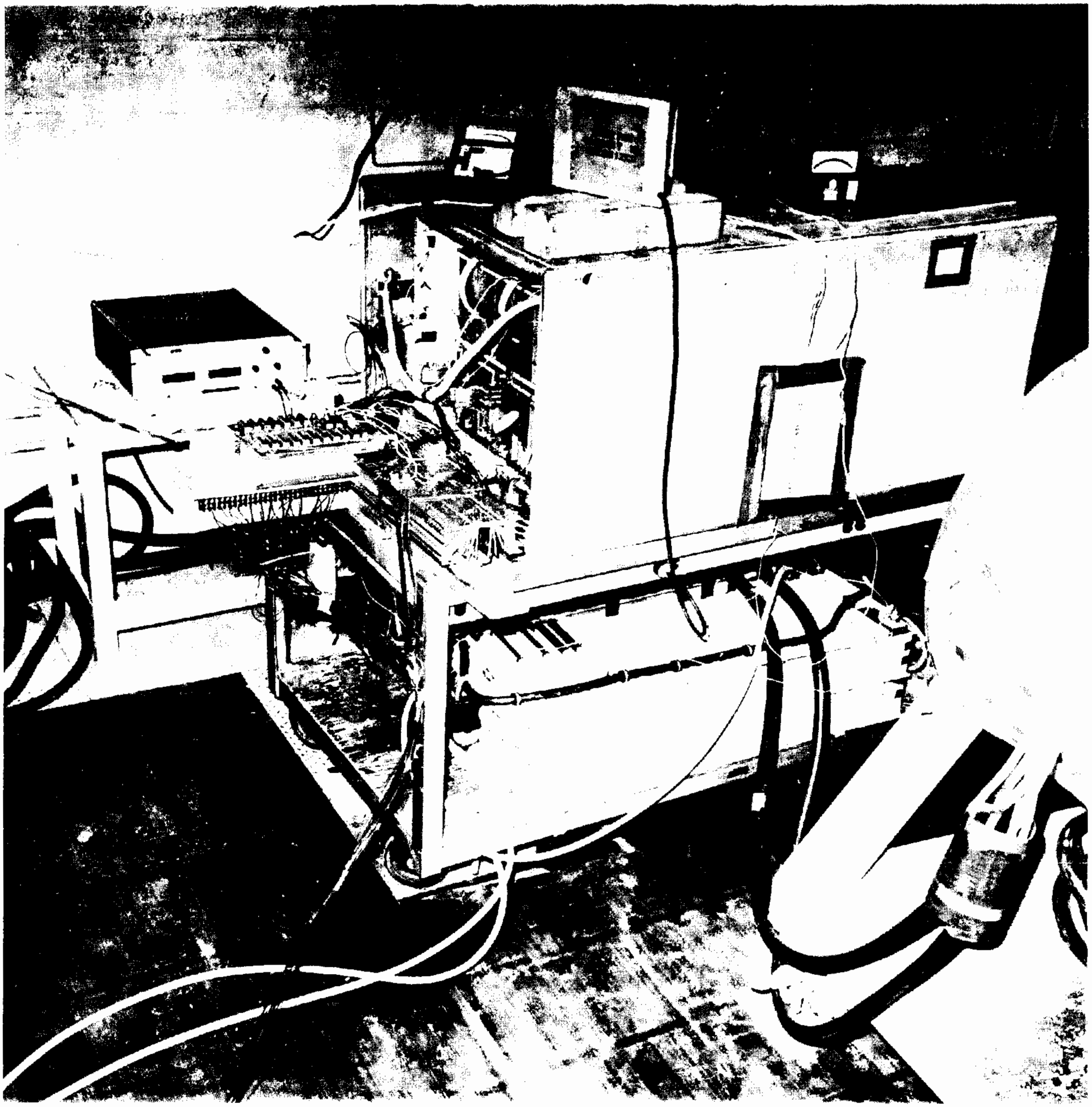


FIGURE d 2-1

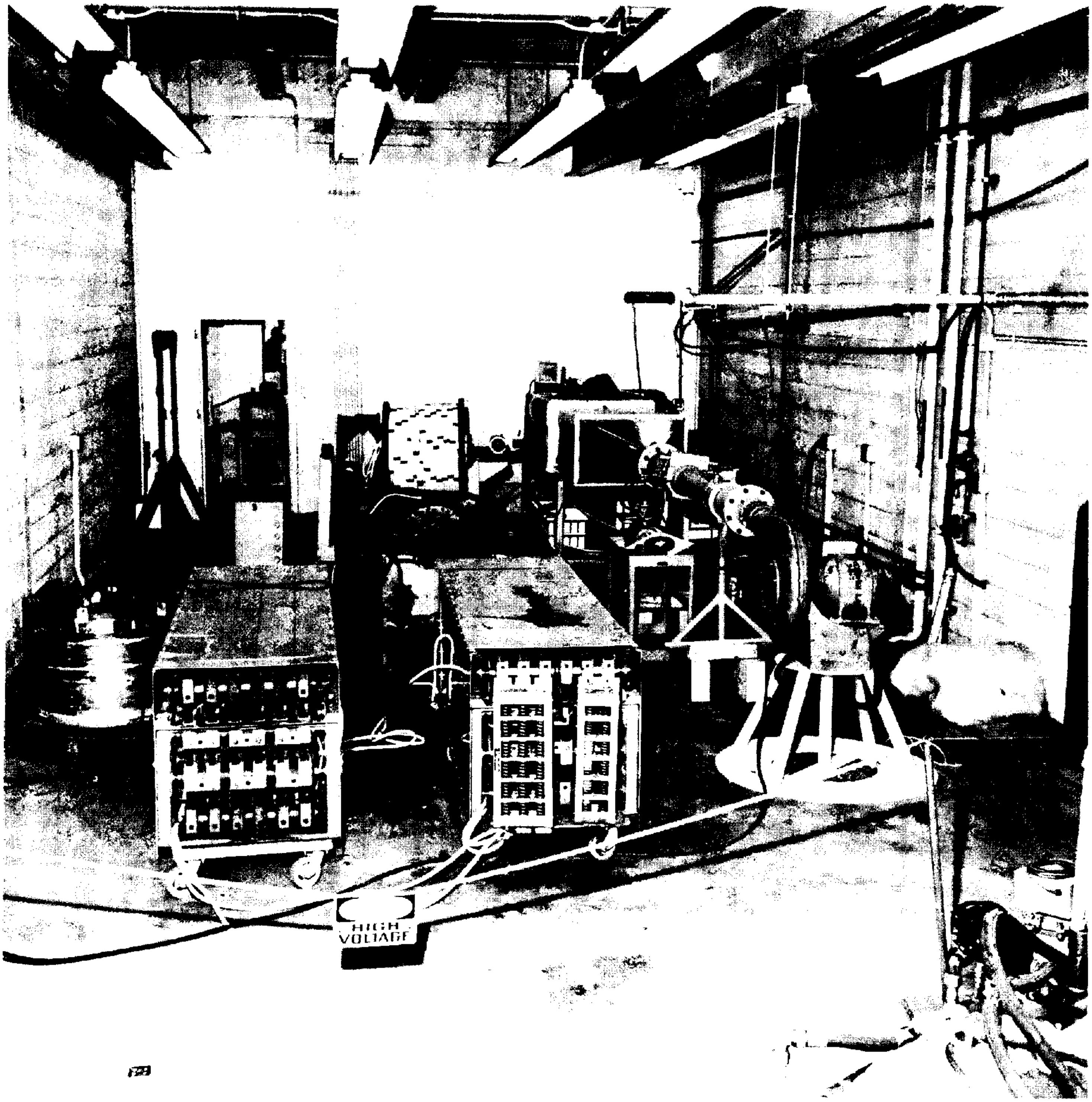


FIGURE d 2-2

e. RESISTOR GRID (P/N 2000428-1)

Production Testing

1. Resistance check
2. Inductance check
3. Meg-ohm check
4. Visual inspection

Development Testing

Purpose

To insure resistor grid meets all design specifications.

Configuration

Power source and instrumentation required to monitor the test results.

Procedure

Subject the grid to a load simulating the maximum duty cycle expected during actual car operation. While at the hot temperature perform the following tests:

a. Resistance measurement using a Wheatstone Bridge (1.520 Oms ± 1.5%)

b. Inductance measurement using incremental inductance bridge (100 x 10^{-6} Henry's)

c. Hipot at 3400 V AC - 60 Hz from the resistor elements to the frame for one min.

f. BLOWER - COOLING (P/N 650932-1)

Production Testing

1. Direction of rotation
2. Rotational speed
3. Current
4. End play
5. Visual inspection for critical dimension

Development Testing

Purpose

To determine the aerodynamic performance.

Configuration

Power source and instrumentation to monitor and record test results.

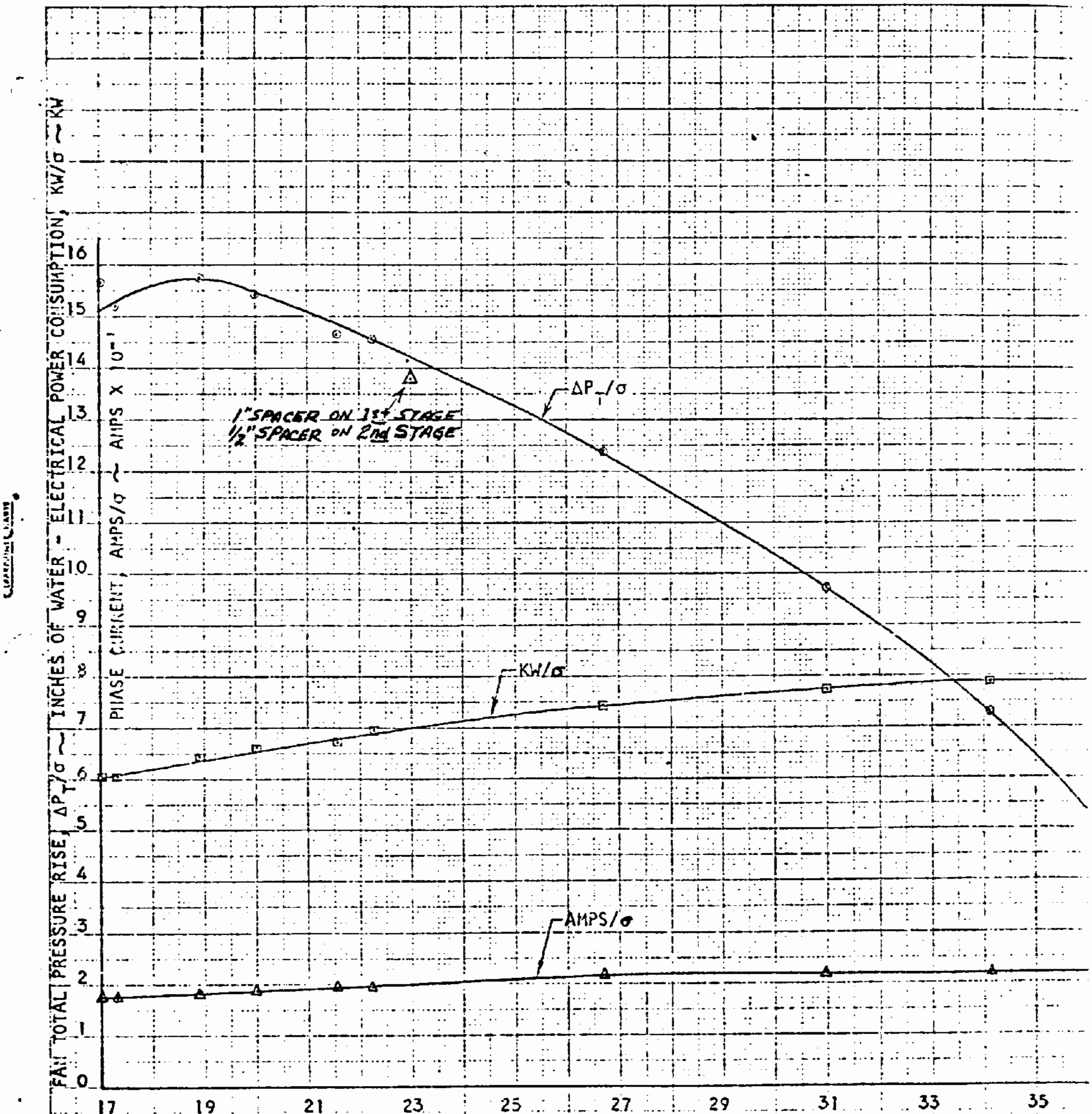
Procedure

Supply 230 V AC - 60 Hz - 3 phase power. The rotation of the fan shall be CCW. The rotational speed shall be 3,450 RPM (min). The input current, per phase, shall be 18.7 AMPS (max). The aerodynamic performance shall be within the limits specified in curve PA 85799.

f. Development Tests, Blower

Test data for the Motor Driven Fan is shown in Figure f1-1. The plotted points are test data and the solid line is predicted performance data for this unit (605932-1). The designation of this curve is PA89900 as opposed to the PA85799 curve which was an earlier performance estimate.

Over the actual operating range of 2300 to 2500 CFM the actual fan performance (as modified with front and back spacers) is very close to the original estimate. Figure f1-1 also shows the predicted and actual values for power consumption and line current. The data sheets for these tests are included and shown in figures f2-1 and f2-2. The line current is approximately 5% above the originally predicted value of 18.7 amps per phase.



FAN VOLUMETRIC FLOW RATE, Q ~ CUBIC FEET PER MIN. X 10^{-2}

CALCULATED BY			PERFORMANCE OF MOTOR DRIVEN FAN P/N 605932-1	FA-89900
TRACED BY				
CHECKED BY				
APPROVED BY			AIRESEARCH MANUFACTURING COMPANY A DIVISION OF THE GARRETT CORPORATION	FIG. f1-1
UNIT NO.				

FORM 01339A
AIRESEARCH MFG. CO.

LAB DATA SHEET

Page 1 of

EWO 3500-171190-30-0401 DATE 5-8-72 TEST PURPOSE AERODYNAMIC CALIBRATION

P/N 605932-1 BAROM 30.00" Hg A.

S/N TEMP 65°F TEST PERS. PETE FAY, ARTHUR KRAMER

NO.	Volts 1	Amps 2	Amps 3	Amps 4	Total Watts 5	Speed 6	7	1st Stage From Brng 8	1st Stage Brng 9	2nd Stage Brng 10	2nd Stage Brng 11	Stator 12	Stator 13	14	15	Time Date REMARKS
1	φ-φ	φA	φB	φC		RPM		°F.	°F.	°F.	°F.	°F.	°F			
2		×10	×10	×10	×40										45 Min	Run 1000 MAY 8-72
3	230	2.1	2.12	2.17	189.	3490		122	108	106	105	139.	181.	No Duct	Connected	- After Stabilization
4																
5				With	Duct +		Orif.	connected			to	Fan				
6	230	2.13	2.14	2.21	199.	3490		106	107	106	104	117.	155			Run 1
7	230	2.18	2.19	2.21	194	3500										Run 2 5-8-72 1020.
8	230	2.14	2.13	2.18	190	3510		115	117	101	100	106	148.			Run 3 With 10" ORIFICE
9	230	2.05	2.01	2.10	183	3500		117	118	99	97	103	142.			Run 4
10	230	1.9	1.86	1.93	165	3520		117	114	100	99	98.	131			Run 5
11	230	1.7	1.67	1.74	149	3535		112	114	98	97	97.				Run 6
12																
13	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~											
14	231	194	1.92	1.98	172	3511		112	114	111	98	99				RUN 7
15	230	1.85	1.84	1.90	153	3520		105	106	102	100	95.				#8 With 7" ORIFICE
16	230	1.81	1.80	1.86	160	3520		105	106	100	99	94				#9
17	230	1.72	1.69	1.76	150	3535		105	107	99	98	95				#10.
18																
19																No [illegible]
20																
21																

FIG. F2-1

FORM #1939A
AIRESEARCH MFG. CO.

LAB DATA SHEET

EWO 3500-171190-30-0401 DATE 5-8-72 TEST PURPOSE AERODYNAMIC CALIBRATION

P/N 605932-1 BAROM 30.00" HgA.

S/N TEMP 65°F TEST PERS. PETE FAY, ARTHUR KRAMER

RUN	ORIFICE ΔP_o ~"H_2O	P_o ~"HgA	T_o ~°F	$\sigma \Delta P$	W #/min	ρ #/FT³	Q FT³/min	FAN ΔP_S ~"H_2O	q	FAN ΔP_T ~"H_2O	FAN $\Delta P_T/\sigma$ ~"H_2O	I_{AVE} ~AMPS	I/σ AMPS	KW ~KILOWATTS	KW/σ	REMARKS
NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	6.0	30.24	74	5.9	278	.0752	3695	3.1	1.0	4.1	4.12	21.8	22.1	7.76	7.88	
2	5.0	30.81	74	5.0	256.5	.0752	3415	6.4	.86	7.26	7.3	21.9	22.2	7.76	7.88	
3	4.1	30.66	75	4.1	233	.0752	3100	9.0	.71	9.71	9.75	21.5	21.8	7.60	7.71	14 X 10 ORIFICE
4	3.05	30.88	76	3.04	201	.0752	2670	11.85	.525	12.37	12.42	20.67	21.95	7.32	7.43	
5	1.95	31.06	76	1.96	162	.0752	2155	14.2	.345	14.54	14.63	18.97	19.2	6.6	6.7	
6	1.25	31.1	77	1.255	130.2	.0752	1730	14.9	.222	15.122	15.2	17.03	17.29	5.96	6.05	
7	11.0	31.04	69	11.2	168	.0754	2225	14.0	.37	14.37	14.58	19.5	19.6	6.88	6.99	
8	8.9	31.1	72	9.0	151	.0756	2000.	14.9	.30	15.2	15.4	18.63	18.8	6.52	6.61	14 X 7 ORIFICE
9	7.9	31.13	72	8.0	142.5	.0754	1890	15.25	.267	15.52	15.78	18.2	18.35	6.4	6.45	
10	6.3	31.13	72	6.38	128.2	.0754	1700	15.25	.215	15.46	15.67	17.23	17.4	6.0	6.05	
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																
21																

FIG. f2-2

SHEET 78

g. HOSTLING CONTROL (P/N 2000502-1)

Production Testing

1. Ohm meter check of circuits per schematic
2. Visual inspection

Development Testing

1. Drop test

Purpose

To insure the design and packaging of the control is adequate to withstand rough handling during normal use.

Configuration

No special equipment required.

Procedure

Unit to be subjected to numerous drops, from various angles, to the simulated car floor from a height of approximately 6 ft.

Cable integrity, switches and internal hardware will show no basic degradation.

h. TRUCK CONNECTOR (P/N 515216-1)

Production Testing

1. Hi Pot
2. Visual inspection

Development Testing

1. Hi Pot

Purpose

To insure insulation between the connectors and the enclosure is adequate.

Configuration

Hi Pot tester

Procedure

Apply 3500 V AC - 60 Hz - between the connectors and the enclosure for 1 min.

i. KNIFE SWITCH (P/N 2000504-1)

Production Testing

1. Visual inspection only

Development Testing

1. None required

j. SPEED INDICATOR (P/N 421-0501-9001)

Production Testing

1. Operational test

Development Testing

1. None required

k. JET PUMP (P/N 2002921-1)

Production Testing

1. Visual and dimensional inspection only

Development Testing *

1. Aerodynamic calibration test

Purpose

To determine the aerodynamic performance requirements, i.e. primary flow and scavenge flow.

Configuration

Place the Jet Pump in a test fixture capable of monitoring fluid temperature, pressure and rates of primary, secondary and total flows.

Procedure

Apply inlet pressure of 10 in. H_2O to primary inlet at established flow rate and record secondary flows and total flows.

* see data under system Airflow Test Pages 106-120

1. POWER CONTROL UNIT (P/N 524060-1)

Production Testing

1. Meg-ohm checks
2. Ohm meter check of wiring per schematic
3. Power checks for pull-in voltage
    a. Main contactor
    b. Chopper contactor
    c. Drive brake switch
4. Sensor calibration tests
5. Overload current sensor tests
6. Differential current sensor tests

Development Testing

1. Heat run - all sections operating

Purpose

To insure that proper thermal conditions exist within the power control unit.

Configuration

Set up the power control unit with dummy electrical loads and appropriate input source voltages and signals, so that all equipment within the unit is exhibiting maximum thermal output. Place thermocouples on all major heat sources within the unit.

Procedure

Run the unit in a steady state, maximum heat output condition and monitor temperatures within the enclosure. After thermal equilibrium is obtained, record temperatures of the major heat source elements by both the thermocouple and delta resistance method.

Temperatures recorded shall not exceed 60°F above the unit ambient temperature.

L. Development Testing. PCU

The tests on this unit consisted of point to point wiring checks and control logic operational checks without 600 VDC power. Further functional tests were conducted on this unit during system checkout.

No heat run was made on the box since, even at full power, the dissipation was much less than 0.1 watts per square inch of surface.

The subsequent modification of adding the two truck isolating diodes (in series with the armature circuits) raised this peak dissipation to something less than 0.2 watts per square inch. The local heating at the diodes could reach a peak of 2 KW but this assembly has integrally mounted forced air blower and there is radiation shielding separating other components in the area.

m. GEAR BOX AND COUPLING

Production Testing

1. Inspect for critical dimensions
2. Back lash measurement
3. No load torque

Development Testing

1. Proof Torque Test

Purpose

Prove the gearbox-coupling system will withstand (with adequate margin) the torque expected to be experienced in the intended usage of the unit.

Configuration

Place the gearbox-coupling in a test fixture, with the output (axle) held stationary. Using an auxiliary high gear ratio gear-box unit, apply torque to the subject gearbox input shaft.

Procedure

Apply a torque of 56,000 inch lbs to the gearbox input shaft. This input torque results in an output gearbox torque of approximately 267,000 inch lbs. Repeat the test in the reverse direction and examine the gearbox-coupling. The unit shall exhibit no permanent deformation.

2. Acceleration and Deceleration Torque Loads

Purpose

Prove the unit capable of operating at the torque levels experienced during acceleration and deceleration.

Configuration

Connect two motor-gearbox combinations through a common axle. Connect the motors electrically so that one acts as a driving element and the other acts as a loading element (generator). Provide an air flow source.

m. GEAR BOX AND COUPLING (Contd.)

Procedure

Vary the load on the gear box by loading the generator element electrically. Vary the field currents of the motor element and the generator element to simulate the load and speed of the system at various points in the acceleration and deceleration of the vehicle. Provide an airflow of a velocity equivalent to the speed of the vehicle at each test point. Run the following test points for a time period of one minute or until an oil temperature of 250°F has been reached:

Motor Torque Ft/Lbs	RPM	Vehicle Velocity MPH	Air Velocity Ft/Sec
1000	900	17	24.7
900	1560	28	40.6
560	2400	44	63.7
320	4300	80	116.0
-960	200	3	4.3

The unit will be disassembled and inspected following these tests. No permanent deformation shall have resulted.

3. High Temperature Test

Purpose

Prove that the lubricant, and method of lubrication is adequate so as not to degrade the performance of the gearbox through the entire operating temperature range.

Configuration

Same as Acceleration and Deceleration Tests (Item 2).

Procedure

Run the gearbox at a speed and load equivalent to the one hour motor rating (230 HP, 1560 RPM). Measure oil sump temperature as in acceleration and deceleration test, except provide no air flow equivalent to the vehicle velocity. Stop testing after a period of one hour, or 250°F oil temperature is reached. If the 250°F oil temperature is reached before one hour, repeat the test with 10, . , 30 and 40 ft/sec air flow across the gearbox.

The unit shall be capable of one hour of operation at the given input with less than 40 ft/sec air flow and less than 250°F oil temperature.

m. GEAR BOX AND COUPLING (Contd.)

4. Audible Noise Tests

Purpose

Determine the audible noise characteristics of the motor-gearbox combination.

Configuration

Connect a motor and gearbox in a manner simulating the installation on the car truck.

Procedure

Record audible noise levels on a broadband noise level meter "C" scale. Recordings will be taken at a distance of 15 feet in each of the four longitudinal and lateral directions, and at various gearbox loadings and motor speeds.

As a design goal, a noise level of 85 db maximum (reference 0.0002 microbar) will be recorded.

5. Oil Consumption and Leakage Test

Purpose

To insure that the case seals are adequate to prevent leakage and the labyrinth seals allow proper but not excessive lubrication.

Configuration and Procedure

Oil consumption and leakage tests will be monitored throughout the test program.

6. Spring Rate of Axle Couplings

Purpose

To confirm that the actual spring rate of the coupling is within the limits calculated for the intended use. (Actual testing to be accomplished by Lord Mfg Co.)

Configuration

Place the unit in a static test fixture capable of measuring displace and load in various directions of force application.

Procedure

Obtain data of load vs deflection of the coupling. The coupling spring rates, as a design goal, shall be as follows:

Note: There is considerable tolerance that can be allowed in the actual spring rates.

m. GEAR BOX AND COUPLING (Contd.)

$$K_{\phi Z} = 50{,}000 \ \frac{\text{in-lb}}{\text{deg}}$$

$$K_{\phi Y} = 50{,}000 \ \frac{\text{in-lb}}{\text{deg}}$$

$$K_{\theta X} = 48{,}000 \ \frac{\text{in-lb}}{\text{deg}}$$

K_Z = 67,500 lb/in

K_Y = 67,500 lb/in

K_X = 170,000 lb/in

K_ϕ = cocking spring rate

K_θ = torsional spring rate

X = axis through axle length

Y = fore and aft axis through center of coupling

Z = vertical axis through center of coupling

7. Gearbox and Coupling Efficiency

Purpose

Prove that the gearbox-coupling efficiency meets the intended requirements.

Configuration

Same as acceleration and decleration torque load tests (Item 2).

Procedure

Utilizing the motor efficiencies determined for the specific motor used in this test, determine the input and output power of the combined series gearboxes. The efficiency of each gearbox is defined as

$$\eta_{GB} = \sqrt{\frac{\text{Power Out}}{\text{Power In}}} \times 100$$

Determine the gearbox efficiency at each of the various tests accomplished during acceleration and deceleration tests (Item 2)

The gearbox efficiency, as a design goal, shall be a minimum of 96%.

m. GEAR BOX AND COUPLING (Contd.)

8. Vibration

Purpose

Prove the mechanical integrity of the motor and gearbox to vibratory input loading.

Configuration

A vibration fixture which independently simulates the axle input to the gearbox and the motor-truck frame mounting will be utilized for this test.

Procedure

With the motor truck frame mounting fixture in a static rigid condition, drive the axle input fixture and scan for resonances in the 20 to 35 Hz region. Resonances in the 80 to 150 Hz region have been given special attention in the design and will not require evaluation.

m. Development Testing, Gear Box and Coupling

1. Proof Torque

This test was not run. The basis for this is the large margin of load vs design stress calculations. The normal maximum operating torque level is 1200 lb ft at the motor end of the gear train. The ultimate stress level in this application for the materials and processing used in the manufacturing of these gears is in excess of 5 times the normal maximum operating level. The infinite cycle fatigue stress level is slightly greater than 2.2 times the normal maximum operating level.

2. Acceleration Deceleration Torque Loads

This test was not run as a separate test. Some data relevant to this item was acquired during testing done in para 3. below

3. High Temperature Test

This test was run at a RPM (2400 at motor) considered to be representative of a continuous severe operating condition. The reduced data is shown in curve form in Fig. m3-1. This test was run without forced air cooling.

4. Audible Noise Test

No data was recorded for this test because the actual noise level was judged to be an order of magnitude less than the test requirement as observed during item 3 above.

5. Oil Consumption Test

This test was not run

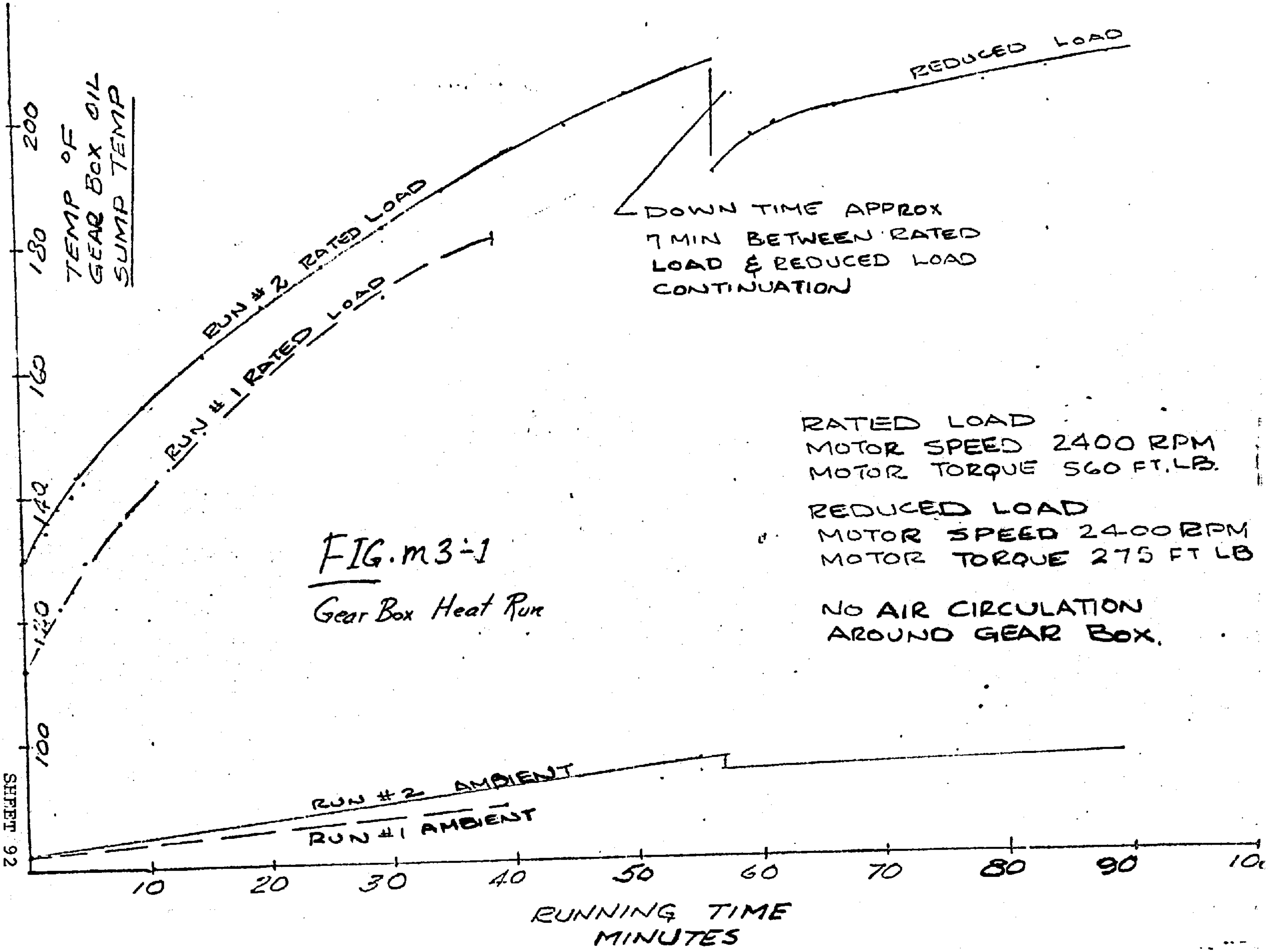


FIG. m3-1
Gear Box Heat Run

6. Coupling Spring Rates

The SOAC coupling spring rates as obtained from Lord Mfg. Co.

Spring Rates	Static*	Dynamic**
K_{tx}, Torsional in. lb/deg.	20,000	37,000
K_x, Axial, lbs/in	170,000	320,000
K_z, Transverse lbs/in.	30,000	56,000
K_{ty}, Cocking, in. lbs/deg.	None	76,000 (estimated from test)

* Test by Lord

** Estimated by Lord

The fatigue life of the coupling was estimated by Lord Mfg. Co. as five years based on a set of combined loads which Lord considered as conservative. In reviewing the fatigue analysis, the most damaging load to the coupling appears to be the transverse (vertical) load due to 8g vibration, which consumes about 40% of the life.

7. Gear Box Efficiency

Two data points were extracted from 8-24-72 laboratory test data shown in Fig. M7-1. The data reduction is illustrated in Fig. m7-2. The motor and generator efficiency data was supplied from other data not part of this test (*).

These calculations show the Gear Box + Coupling combination to be approximately 97% efficient by the definition:

$$\eta_{GB} = \sqrt{\frac{\text{Power Output (Electrical} \times 1/\eta_G}{\text{Power Input (Electrical)} \times \eta_M}} \times 100$$

The test setup is shown in block diagram form in figure m7-2. The actual test fixture is illustrated in figures m7-3 and m7-4 with one of the two drive units mounted.

8. Vibration

This test was not run. A test to determine the assembly natural frequency was run for information purposes and the data and a plot of a point of maximum displacement of the Gear Box/Motor assembly is shown in Fig. m8-1.

LAB DATA SHEET — Page

ENG ____ DATE 7-24 TEST PURPOSE Seao/Ktiv Gear Box

P/N ____ BAROM ____

S/N ____ TEMP ____ TEST PERS. Jackson/Reddick

	MOTOR				GEN											
	FIELD CURRENT	FIELD VOLTS	ARM CURR X 2	ARM VOLTS	FIELD CURR	FIELD VOLTS	ARM CURR X100	ARM VOLTS	RPM AXLE							
NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	REMARKS
1	17	23	435	180	28	39	9.5	180	245							
2	16.5	22	50[illegible]	[illegible]	27.5	40	8.2	218	303							
3																
4																
5	21	30	340	282	24	34	270	280	372	=	340	FTLB	MOTOR		SHAFT	
6	19.5	28	480	245	24	36	395	245	328	=	473	FTLB		"	"	
7	19	27	610	240	24	35	500	238	325	=	595	" "		"	"	
8	17.5	26	800	238	24	37	630	238	330	=	767	"	"	"	"	
9			940	252	?		680	239	344	=	915	"	"	"	"	
10			840	135					200		214	"	"	"	"	
11			450	208					300		412	"	"	"	"	
12			575	292					400		552	"	"	"	"	
13			660	312					500		545	FTLB		MOTOR	Shaft	
14			450	350					600		346	"	"	"	"	
15			420	350					700		277	FTLB		MOTOR	Shaft	
16			350	330					700							
17			220	330					800							
18			190	308					900							
19									700							
20									600							
21									500							

FIG. m7-1

Motor Torque	Power Input Motor Armature Amps	 Volts	Motor Eff(*)	Motor/Gen. RPM	Power Output Generator Armature Amps	 Volts	Gen. Eff(*)	Calculated Eff. Gearbox/Coupling
473	480	245	.930	1569	395	245	.932	.975
762	800	238	.914	1578	630	238	.925	.966

(lb.ft.)

Gear Box
Ratio = 4.78

Test Set-Up

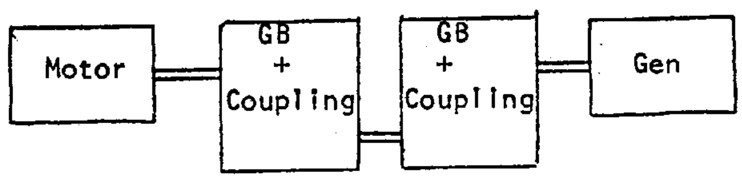


FIG. m7-2 Gear Box - Coupling Efficiency Data

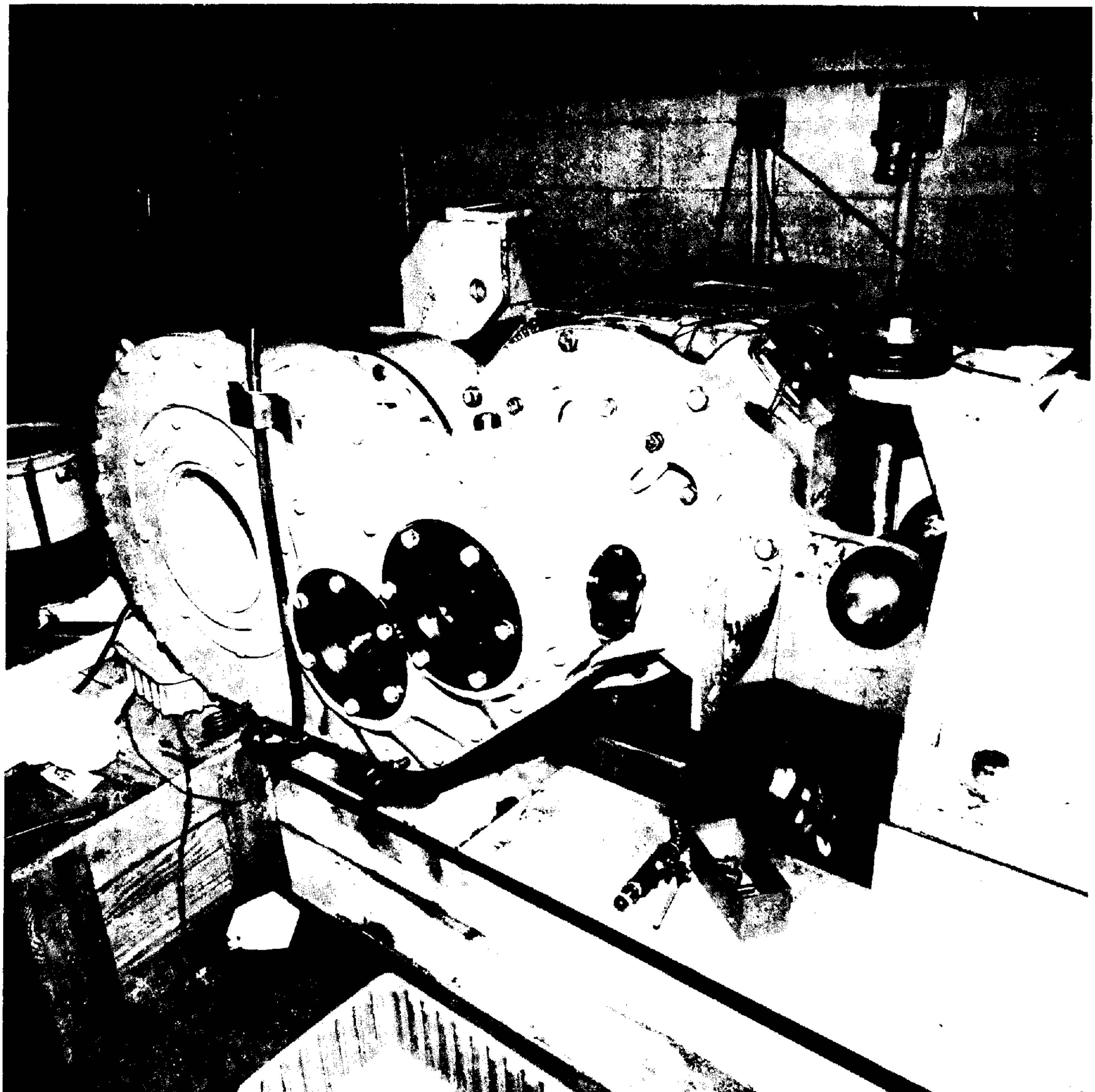


FIGURE m7-3

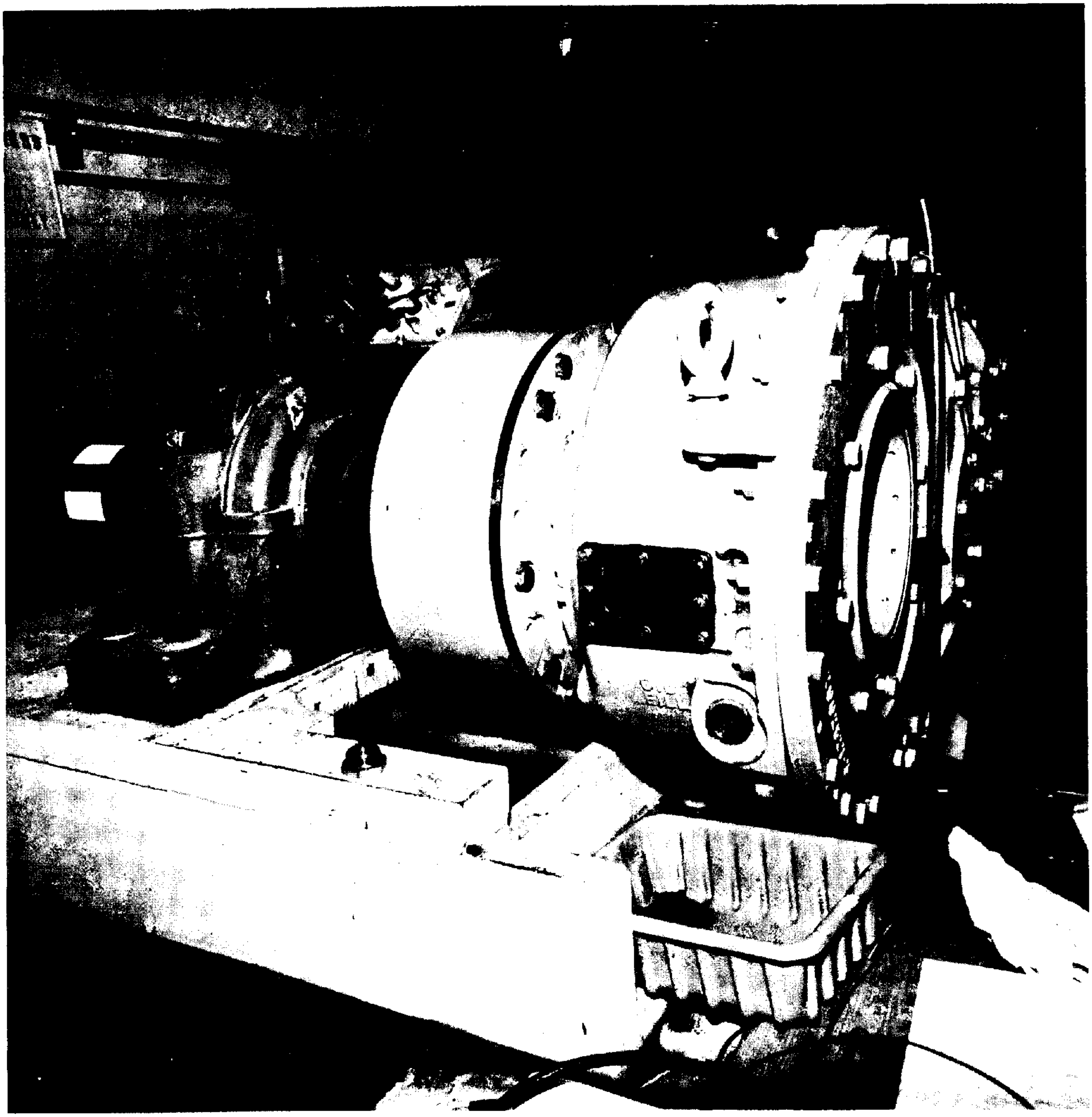


FIGURE m7-4

AIRESEARCH MANUFACTURING COMPANY

Development and Design Engineer's Record

TO | FROM | APPD. | SUBJECT | USE | MODEL | DATE WANTED

№ 222927

MOTOR DISP TOTAL IN.-PEAK TO PEAK	AXEL RPM
0	0
.025	450
.034	600
.040	645
.100	739
.090	805
.027	900
.080	790
.075 ???	700
.120	752
.085	697
.039	580
.034	510
.028	430

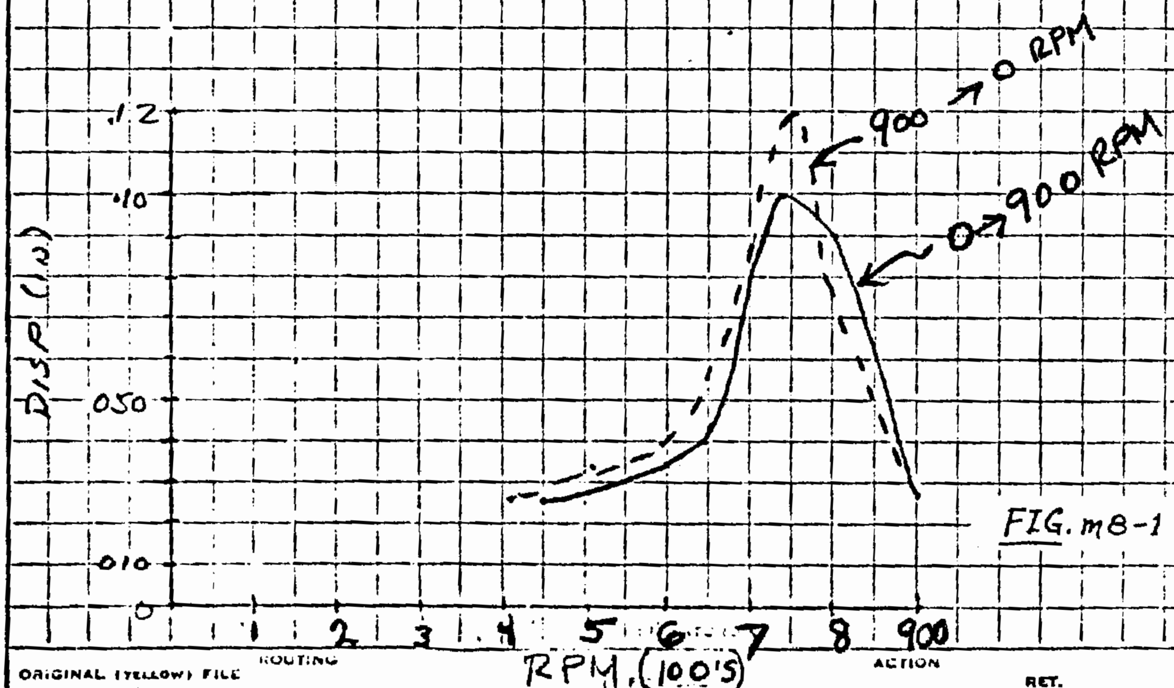


FIG. m8-1

ORIGINAL (YELLOW) FILE
DUP (WHITE)
ROUTING
ACTION
BY RECIPIENT ONLY
RET.
SIGN
DATE

SHEET 90

n. P SIGNAL GENERATOR

Production Testing

1. Continuity checks
2. Operational tests

Development Testing

None required

O. FILTERS AND DUCTS

Production Testing

1. Visual and dimensional inspection only.

Development Testing *

1. Test to establish ΔP in duct section between DC chopper and traction motor (cab end No. 1)

Purpose

To establish the duct size.

Configuration

Test setup simulating fan ducting, DC chopper, ducting (to be tested) and traction motor.

Procedure

Install duct in test setup monitoring inlet pressure, temperature differential pressure (across duct being tested) and outlet pressure and temperature.

* See data under system Airflow Test Pages 106-120

p. MASTER CONTROLLER (P/N 2000503-1)

Production Testing

1. Ohm meter checkout of wiring per schematic
2. Operation of key and handles to check mechanical interlock
3. Visual inspection

Development Testing

1. Operation with P signal generator, and logic electronics

Purpose

To determine that the controller functions properly within its design parameters.

Configuration

Install the controller in a test setup, with the necessary instrumentation to monitor all inputs and test results.

Procedure

Operate master controller through a sequence simulating normal car operation. Determine that the master controller provides the required inputs to P signal generator and logic electronics.

q. PROPULSION CONTROL (P/N 524062-1)

Production Testing

1. Hi Pot (rack, prior to logic card installation)
2. Continuity check of all circuits
3. Functional test all logic cards prior to installation
4. Functional test logic system.

Development Testing

1. Thermal tests

Purpose

To insure the proper thermal conditions exist within the propulsion control unit.

Configuration

Install the propulsion control unit in a test setup using simulated loads, signals and required input voltages. Install thermocouples on all major heat sources within the unit.

Procedure

Test the unit in a steady state, maximum heat output condition. After temperature within the unit has stablized, measure and record the major heat source elements by both the thermocouple and delta resistance methods.

Temperature recorded shall not exceed 60°F above the unit ambient temperature.

q. Development Testing, PPCU

Testing included point to point wiring checks and extensive control logic tests using simulator developed for this purpose. Further functional tests were carried out on this unit during system test.

The card stacks are forced air cooled with internally mounted fans; however, the total dissipation is considerably less than 0.1 watts per square inch of box area and a heat run for this unit was deemed unnecessary.

r. AUX POWER CONTROL (P/N 2000434-1)

Production Testing

1. Continuity checks of all circuits and contactors
2. Hi Pot
3. Functional test all logic cards prior to installation
4. Functional test all components (i.e. field power supply, voltage regulator, etc.) prior to installation
5. Operation and checkout of motor alternator start circuits.

Development Testing

1. Motor alternator start sequence

Purpose

To insure the motor alternator start circuit is functioning properly.

Configuration

Install the aux power control in a test setup with the motor/alternator, associated circuit breakers, contactors, simulated loads and variable high voltage-high current DC source.

Procedure

Apply 600 VDC to M/A start circuit breaker. With no load applied, close circuit breaker, allowing start sequence to occur. After M/A has reached rated speed (1750 RPM) and rated voltage, (230 VAC 60 Hz 3Ø) apply loads.

Reduce voltage to 400 VDC. M/A will shut down shedding all loads.

Increase voltage to 550 VDC, M/A set will restart going through its normal start sequence.

2. Rail Break Operation (June 30)

Purpose

To prove that the start, control, regulation and protection circuits of the Motor Alternator are functioning properly.

Configuration

Install the aux power control in a test setup with the motor alternator, associated circuit breakers, contactors, simulated loads and variable high voltage-high current DC power source.

r. AUXILIARY POWER CONTROL (Contd.)

Procedure

Apply 600 VDC to the M/A circuit breaker. Close circuit breaker. Allow M/A to start and reach rated speed and rated voltage.

Apply 3-phase loads, air conditioners last.

Open contactor (simulating rail break) for 1 sec. and close. Check to insure that all circuits are functioning properly.

3. Heat Run. All sections operating

Purpose

To insure that proper thermal conditions exist within the aux power control unit.

Configuration

Set up the aux power control unit with simulated loads, signals and input voltage, so that all equipment within the unit is exhibiting maximum thermal output. Place thermocouples on major heat sources.

Procedure

Run the unit in a steady state, maximum heat output condition and monitor temperatures within the enclosure. After thermal equilibrium is obtained record temperature of the major heat source elements by both the thermocouple and delta resistance method.

Temperature recorded shall not exceed 60°F above the unit ambient temperature.

r. <u>Development tests. Auxiliary Power Control Unit</u>

Individual component functional tests were made on the Field Phase Delay Rectifiers (PDR's) on the transformer rectifier unit (TR) and the Battery Charger. The PDR's (MA set and two field PDR's) all have integrally mounted forced air blowers. The battery charger is in good thermal contact with the base of the APCU box. No single sub-unit requires to dissipate more than 500 watts peak and the unit as a whole will not exceed 0.2 watts per square inch of surface. No heat run was made on this unit. Observation during system test confirmed that heat dissipation was not a problem even though there was no external forced air flow in that set up.

s. SYSTEM TESTING

Purpose of Test

To functionally test and evaluate the propulsion dynamic braking and auxiliary power system as an integrated transit car system.

To check out each subsystem as it would be arranged in the integrated car system.

To evaluate each subsystem and compare results with predicted values.

To evaluate system protection by failing and/or exceeding prescribed limits.

Procedure

(1) Perform production test on each component to be used in system test or check to see that tests have already been made. Install thermocouples.

(2) Install component in system test facility in correct relative position as in actual car installation. Use system installation Dwg. 2000027-1 as a reference. The traction motors are the exception, and will be mounted outside the test cell wall.

(3) Connect the components per wiring diagrams and wire lists. Check out thermocouples.

s. SYSTEM TESTING (Contd.)

(4) Install circuit breakers in system which are part of cab controls.

(5) Check wiring for grounds.

(6) Test low voltage circuits, using battery voltage to see if contactors, circuit breakers, interlocks, etc., are working properly.

(a) Power Control Unit
Contactor operation, auxiliary contact circuits, overcurrent relay circuits, differential current relay circuit current sensor outputs.

(b) Propulsion Control Unit
Relays which operate drive-brake contactors.
Limit check (response to "P" signal).
Check shutdown circuits from various sensors and switches.

(7) Run cooling fans and measure air flow parameters of fan, chopper, and duct work.

S. SYSTEM TESTING (Contd.)

(8) Air flow to motors on system test will not be ducted as in car. Therefore, adjust air flow to get the desired cubic feet per minute. Measure pressure drop across motor only.

(9) Check start-up, controls, and operation of motor-alternator set.

(a) normal operation

(b) quick shut-down circuits

(c) simulation of rail breaks; short, long, and repetitive gaps

(10) Connect cooling fans to M.A. set.

(a) check starting current of fans when contactor is closed, and voltage transient

(b) steady state load requirement and P.F. of fan motors.

(11) Add traction motor field power supplies to M.A. set output

(a) response to control logic commands

(b) accuracy of field current

(c) steady state loads and Power Factors

(12) Battery charger and battery bus checkout

(a) operation of charger when connected into system

(b) operation of transition to battery and from battery to transformer rectifier as motor/alternator voltage fails

(c) meas. e voltage variation due to transition and see if any transients present that affect logic power supplies.

s. SYSTEM TESTING (Contd.)

(13) Check chopper operation at light loads below base speed. Motoring mode. Observe chopper operation, control logic, waveforms, capacitor bank voltages and currents, temperatures in equipment boxes, chopper turn off time.

(a) variable frequency operation at start

(b) variable angle operation; normal running

(c) stability of closed loops

(14) Check chopper operation at light loads during transition through base speed. Motoring mode.

(15) Check operation of field control and current balance in motors above base speeds.

(16) Check chopper in braking mode, beginning with operation of system above 2900 rpm and using field control. Observe transition into chopping mode.

(a) observe power in brake grids; voltage and/or current

(b) traction motor current balance

(c) voltages on chopper

(d) cushion off

(17) Check operation of speed indicator

(a) accuracy

(b) limit speed buttons

(c) transients; jerk rate

(18) Run full power acceleration performance tests. Strip chart recording of rpm, (or mph) motor current, 3rd rail current and voltage, capacitor bank current. Waveforms of chopper input and output voltage.

S. SYSTEM TESTING (Contd.)

(19) Add dynamic braking at full capability. Observations as in (18).

(20) Run simulated driving schedule, including 30 second station stops. Record temperatures.

(a) repetitive response accuracy

(b) hot spots

(c) component

(d) power consumption and system efficiency

(21) Heat runs at balanced loads; temperature rise

(a) below base speed; various grades

(b) above base speed; various grades

(c) component wear

(d) component noise; electrical and acoustic

(e) power consumption and system efficiency

(22) Full power acceleration with rail breaks under various conditions

(a) M.A. set operation

(b) control logic

(c) air pressure switches

(23) Perform M.A. load shedding tests, with chopper running at various 3rd rail voltages.

(24) Run performance tests at various voltages

(25) System protection tests

(a) overload current relays

(b) differential current relay

s. SYSTEM TESTING (Contd.)

(c) loss of motor field current

(d) loss of air flow

(e) M.A. set malfunctions

Overspeed

Overvoltage

Open-phase

Too long to start

Undervoltage

(f) filter capacitor fuses open

(g) chopper lock up

(h) dead man

(i) brake loss (activation of PKO switch)

(j) loss of logic power

(k) overtemperature sensors

(l) undervoltage 3rd rail

(m) overvoltage 3rd rail

(n) reset trainline

(o) fuse

(26) Slip-slide

5. SOAC System Test

The system test setup was configured to represent the vehicle undercar area. The main frame was of steel "I" beam construction with approximately six feet of ground clearance and all of the components of the Propulsion group excluding the traction motors were mounted in their proper relative positions suspended from the steel frame. With this arrangement it was intended that the local fields due to the large reactors and heavy current carrying conductors would bear some similarity to the vehicle environment. The 600 VDC supply originated from a large transformer/rectifier located remotely in the same building. The cable runs to the traction motors were several times longer than those in the vehicle.

A view looking into the test cell is shown in the photograph, figure s1-1. The suspended components shown at the entrance are the PCU (on the right) and the chopper (on the left). The two motors in the foreground were positioned here temporarily for part of the Air Flow test.

The traction motors used for the system load were located outside the test cell housing the Propulsion Control components for safety reasons. Photographs of this setup are shown in Figures s1-2 and s1-3.

Forced air cooling for the Traction Motors was supplied from an independent blower system. Each motor was directly coupled to an inertial load (flywheel) representing the vehicle. This setup was designed to represent the GTE vehicle and reflected a much higher weight in terms of SOAC wheel size and gear ratio (204,000 lbs) consequently acceleration and deceleration times could not reflect SOAC performance.

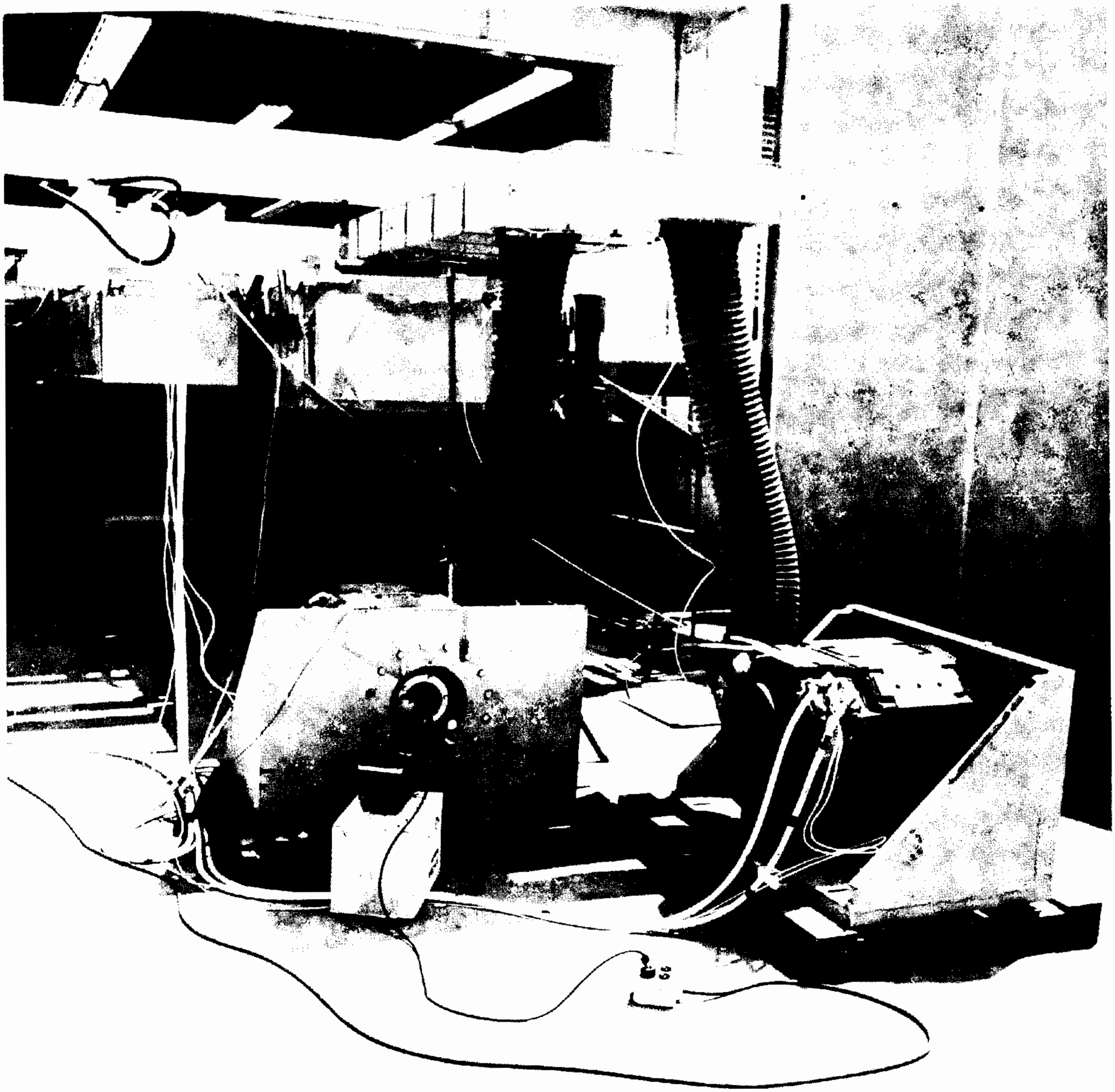


FIGURE s1-1

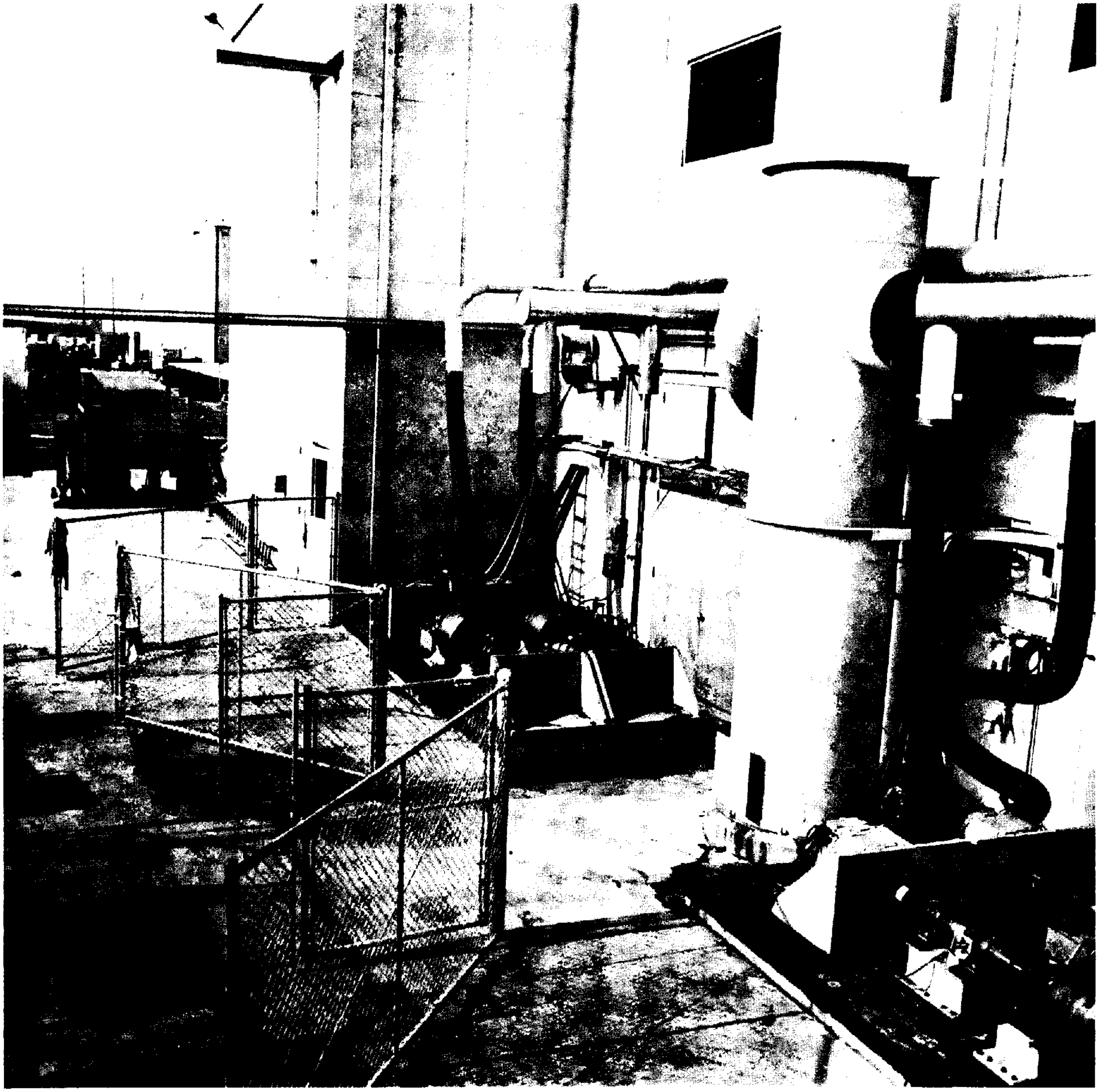


FIGURE s1-2

SHEET 116

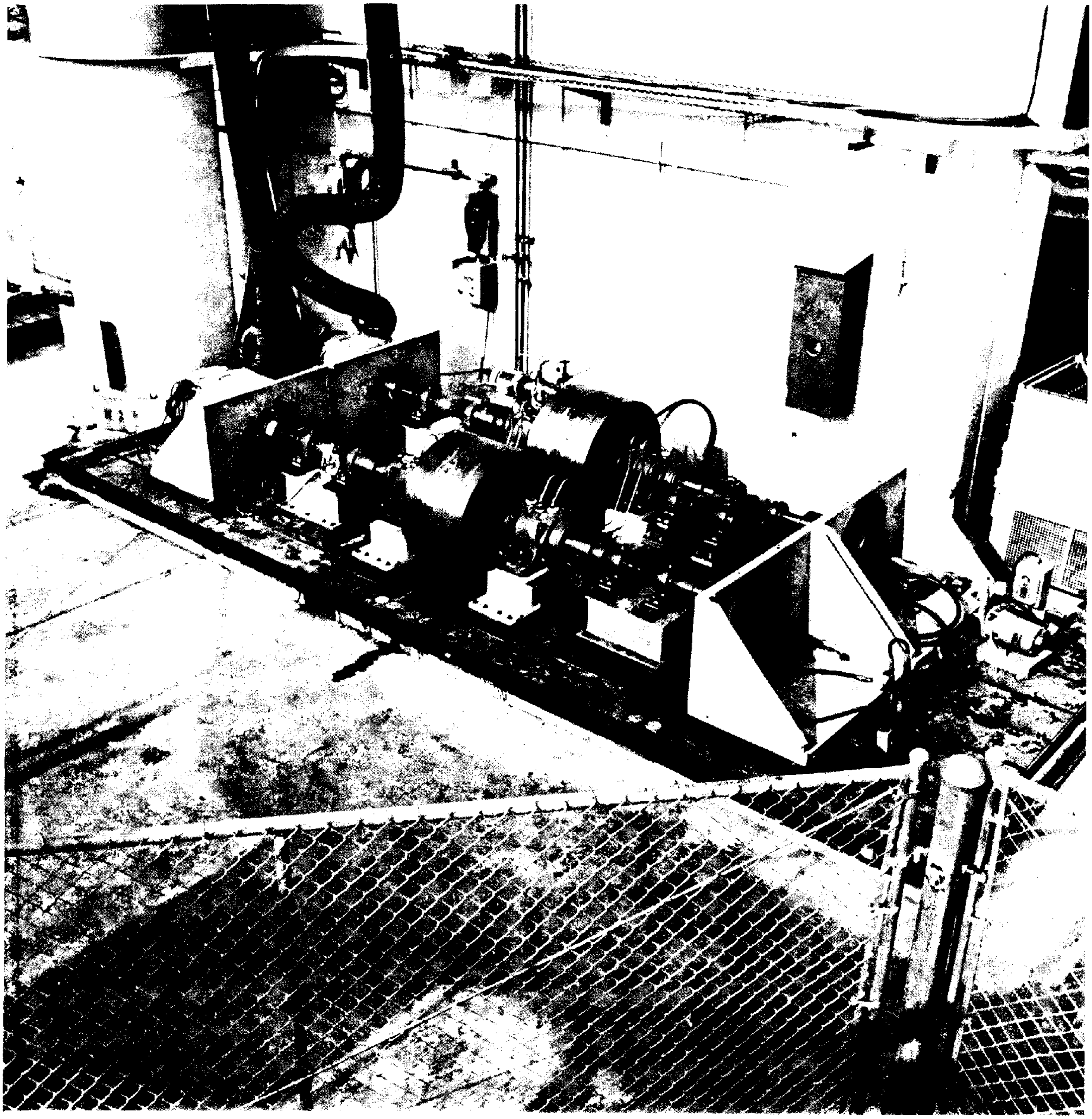


FIGURE s1-3

The SOAC brake grids were also situated external to the test cell and forced air cooling was applied because of the heating (1.8 megawatts peak). Repeated cycles of acceleration and dynamic braking causes these resistors to glow at visible red level. No attempt was made to build up a simulated Air Brake Subsystem.

Air Flow

The first section of this setup to be tested was the Traction Motor Cooling group which consisted of the axial flow fan and filter, the Jet Pump, the Chopper, simulated center sill and flexible ducting to the motors. This setup was fed with a calibrated orifice section used to measure input air flow. The calibrated test section and blower used to compensate for test section pressure drop are shown in figure s2-1. The input section to the filter (ahead of the fan) can be seen in figure s2-2, just behind the small manometer. The Chopper access door is the panel in the upper left of figure s2-2.

The following pages (106 through 120) are reduced data and analysis of the Air Flow Test.

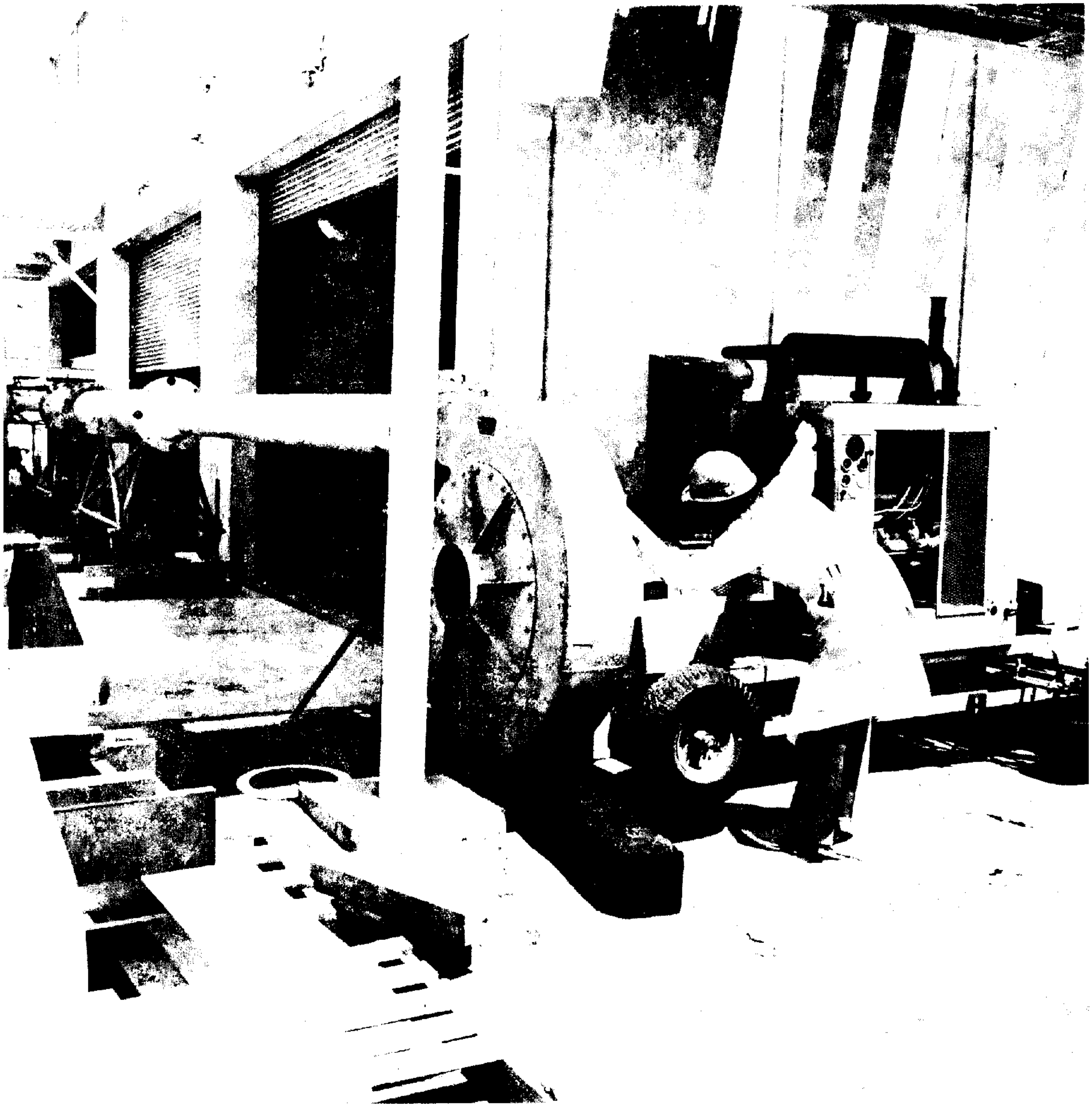


FIGURE s2-1

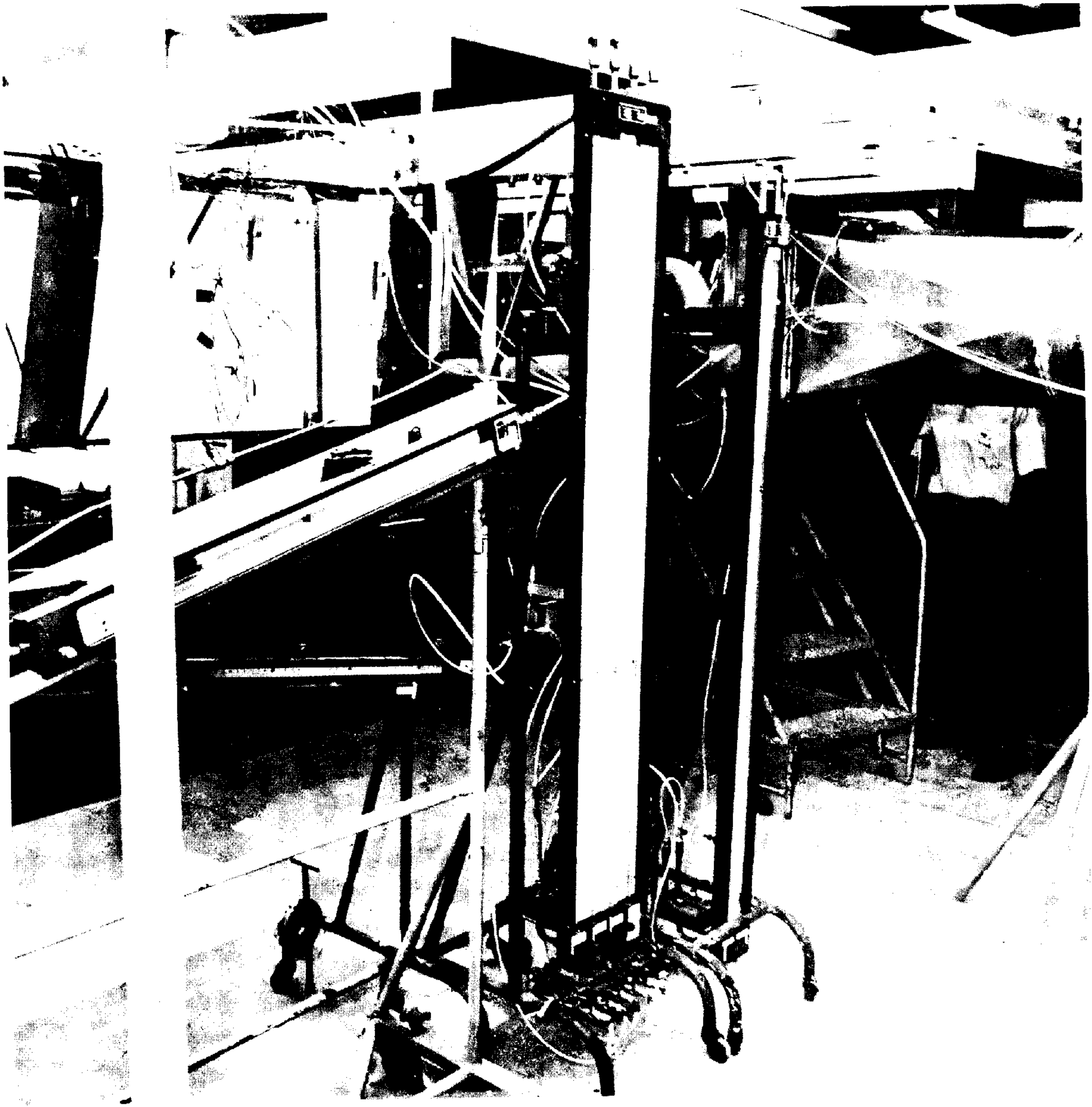


FIGURE s2-2

Air Flow Test (June 28, 29, 1972)

This test was run to assess the performance of the air cooling system for the chopper and traction motors at the No. 1 end (front) of the SOAC car. The cooling system is shown in Figure 52-3. Air is taken in at the filter due to suction at the fan. A small amount of air is bled off to the jet pump ahead of the fan (filter scavenge flow, Q_s) and again downstream of the fan (primary flow, Q_p). The bulk of the airflow goes through the chopper (Q_{CH}) and ducting to the two traction motors. A calibrated orifice was placed at the filter air intake for total flow measurements (Q_T).

The analysis examines the various flows to see if adequate cooling flow is attained for the chopper and the two traction motors. It also determines at what efficiency the "filter/jet pump" is operating. Finally, calculations are made to show what adjustments in flow should be made to attain acceptable overall performance with adequate cooling flow and high filter efficiency.

Examination of the test data (see attached laboratory test log) shows that traction motor rotational speed has little effect on cooling flow. This can be seen from the consistency of the readings in the calibrated orifice data (columns 10 and 11, Page 115) for different motor speeds. Therefore, a nominal speed was selected (3000 rpm, see point no. 7) and the analysis based on this set of data.

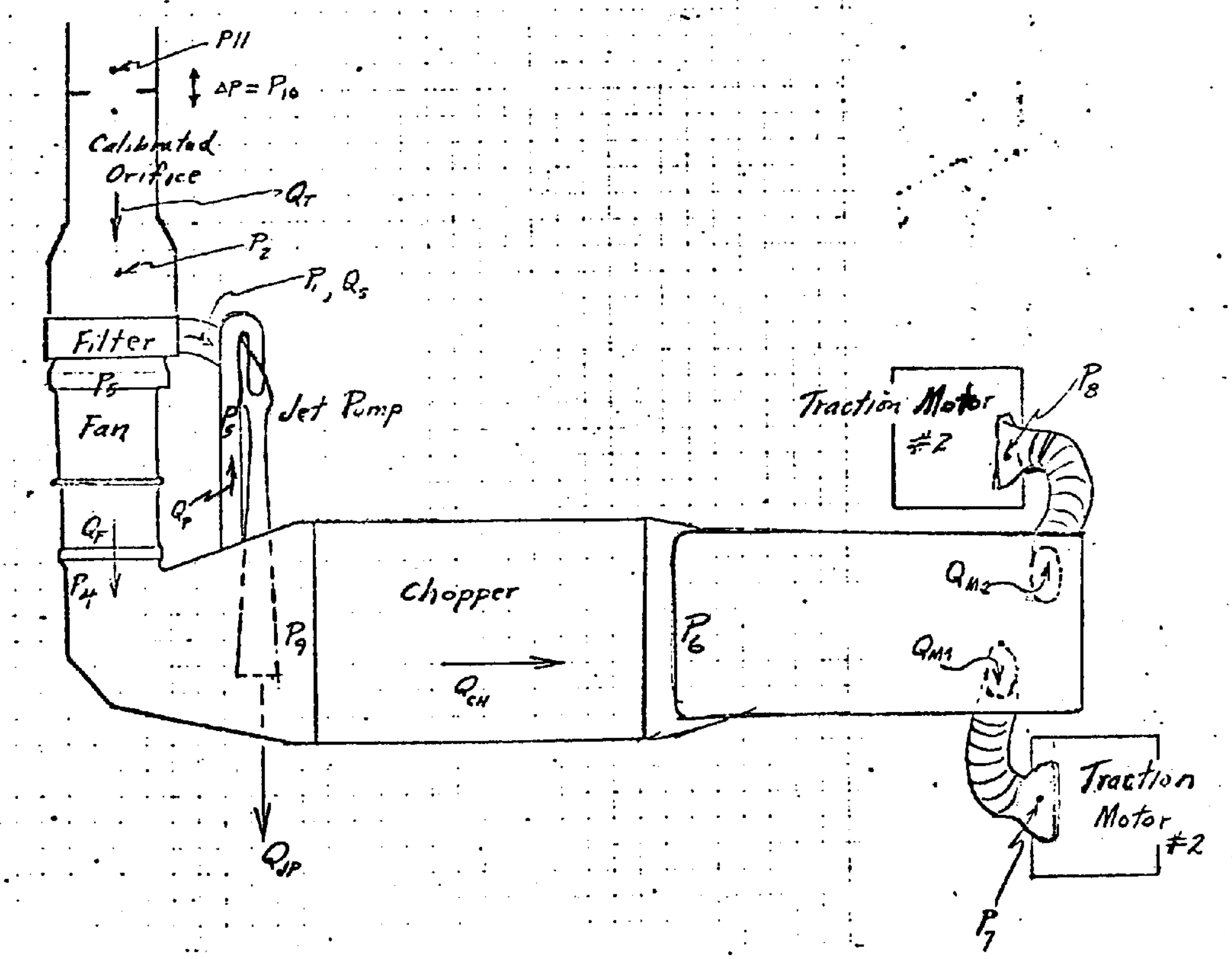


FIG. 52-3 Air flow Test set up.
(North end Cell 29)

Step 1 Calculate mass flow at calibrated orifice from Lab data sheet point 7 - columns 10, 12, 13

Input (gage) pressure = 1.31" Hg (31.23" Hg abs)

Temperature = $88^{o}F$

$\Delta P = 19.15$ "H_2O

$$\sigma = \frac{31.23}{29.92} \times \frac{519}{460 + 88} = 0.99$$

$$\Delta P = .99 \times 19.15 = 18.95 \text{ "}H_2O$$

From orifice curve data (p. 120) the mass flow is determined to be 187 lb/min.

Step 2 Calculate fan volumetric flow rate from data (Page 115) columns 4 and 5

Fan inlet pressure = -2.75 "H_2O gage

Fan outlet pressure = +9.05 "H_2O gage

$\Delta P = 11.8$ "H_2O

$$\sigma_F = \frac{406.8 - 2.75}{406.8} \times \frac{519}{460 + 88} = .945$$

$$\sigma_F \cdot \Delta P_F = 11.2 \text{ "}H_2O$$

(Note: 406.8 "H_2O = 29.92" Hg)

Fan inlet air density = $\sigma_F \times .0765 = .0723$ lb/ft^3

Volumetric flow rate = $\frac{187}{.0723} = Q_F = 2560$ CFM (neglecting scavenge flow)

Step 2 (continued)

Filter scavenge flow design point is 200 CFM

∴ Fan volumetric flow (1st approximation) is 2360 CFM (Q_F)

Step 3 Calculate fan total pressure rise and flow velocity, go to fan performance curve (Page B-1) and enter curve at 2360 CFM

$$\frac{\Delta P_T}{\sigma_F} = 13.9 \text{ "}H_2O$$

$$\Delta P_T = 13.9 \times .945 = 13.1 \text{ "}H_2O$$

Fan cross section area = 1.0 sq ft

$$\therefore \text{ flow speed velocity} = \frac{\text{Volumetric flow rate}}{\text{Area}} = \frac{2360}{1.0} \cdot \frac{1}{60} = 39.3 \text{ ft/sec}$$

Step 4 Calculate fan static pressure rise and duct loss, go to velocity pressure conversion curve (Page 118)

$$\frac{P_V}{\sigma F} = 0.35 \text{ for } 39.3 \text{ ft/sec}$$

$$\therefore \text{ Static pressure rise across fan} = 13.1 - 0.35\,(.945) = 12.8 \text{ "}H_2O$$

Duct entrance loss = $\Delta P_{calc.} - \Delta P_{meas.}$

Step 5 Summarize pressure dops in system ("H_2O)

Filter = $P_2 - P_5$ = - .05 - (-2.75) = 2.7 (See line 17 on data sheet Page 115 and Figure 52-3)

Duct entrance loss = 1.0

Fan pressure rise = 12.7

Duct expansion and turning =
$P_4 - P_9$ = 9.05 - 9.05 ≈ 0.0

Chopper $P_9 - P_6$ = 9.05 - 8.15 = 0.9

Duct to Motor No. 1

Duct to Motor No. 1
$P_9 - P_8$ = 8.15 6.30 = 1.85

Duct to Motor No. 2
$P_6 - P_7$ = 8.15 - 5.70 = 2.45

Motor 1 inlet to Atm
$P_8 - P_0$ = 6.30 - 0 = 6.30

Motor 2 inlet to Atm
$P_7 - P_0$ = 5.70 - 0 = 5.70

Step 6 Determine jet pump operating conditions, go to Page B-3 showing jet pump performance curve (note switch in nomenclature)

Nozzle pressure P_3 (column 3 in data) is 7.55 "H_2O and

ΔP_2 on curve (Page 119) = P_3 - 0.0

Step 6 (continued)

Pressure rise in scavenge path is Aċm - P_1 = 1.96 = ΔP_1

$$\sigma = \frac{460.8 + 1.96}{460.8} \times \frac{519}{460 + 88} = 0.95$$

$\Delta P_1 \sigma$ = 1.86 "H_2O

∴ from curve, volumetric flow = 147 CFM (Scavenge, Q_s)

and the jet nozzle flow = 107 CFM (Q_p)

Step 7 Summarize flows. It will be noted that the approximation made in Step 2 was 200 CFM instead of 147 CMF but this results in less than 2% error in fan pressure rise

Q_T = 2650 CFM

Q_{fan} = 2560 - 147 = 2413 CFM

Q_{JP} = 254

Q_{CH} = 2413 - 107 = 2306 CFM

SUMMARY OF OPERATING FLOW CONDITIONS

	Desired	Test
Flow per motor	1000 CFM	1150 CFM
Jet Pump		
Nozzle	145	107
Scavenge	200	147
Fan	2145	2413

Conclusions

Operating characteristics of the system are quite close to the predict levels. By orificing the motor outlets for higher pressure drop (and bett flow balance) total flow can be brought to the desired level of 1000 CFM f each motor and this will also increase the fan pressure rise so that the je pump will operate nearer its nominal values, resulting in improved filtrati the cooling air flow.

GARRETT AIRESEARCH

FORM 2020 B

LABORATORY TEST LOG

ARTICLE ON TEST ______ S/N ______ DATE ______

E.W.O/CHGE. NO. ______ SUPP. ______ I.D. ______

P/N ______ TECHNICIAN ______ DATA SHEET ______ LOG SHEET ______

PRESS	
P-1	JET PUMP LOW (FILTER SUCTION)
P-2	FILTER INLET
P-3	JET PUMP HIGH
P-4	FAN OUTLET
P-5	FAN INLET
P-6	CHOPPER OUTLET
P-7	TRACTION MOTOR #1
P-8	TRACTION MOTOR #2
P-9	CHOPPER INLET
P-10	ORFACE Δ P
P-11	ORFACE HIGH

PAGE TIME: ______

TOTAL TIME: ______

FIG. 52-4

SHEET 128

FORM [illegible] AiResearch Mfg. Co.

LAB DATA SHEET

Page ____ of ____

EWO ____ DATE 6/28/72 TEST PURPOSE S.O.A.C. AIR FLOW TESTS

P/N ____ BAROM ____ (H_2O) (Hg)

S/N ____ TEMP ____ TEST PERS. ____

NO.	1 JET PUMP LOW (FILTER SWITCH) NEG	2 FILTER INLET NEG	3 JET PUMP HIGH	4 FAN OUTLET	5 FAN INLET NEG	6 CHOPPER OUTLET	7 TRACTION MOTOR #1 EAST	8 TRACTION MOTOR #2 WEST	9 CHOPPER INLET	10 ORIFICE ΔP	11 ORIFICE HIGH	12 MTR RPM	13 ORIFICE [illegible]	14 [illegible]	15	REMARKS
1	1.86	0	6.3	76	3.0	6.8	5.2	4.85	7.6	20.6	1.0	MOTORS NOT ROTATING				[illegible] CFM
2																
3	1.84	.01	6.3	74	2.9	6.7	5.1	4.75	7.45	19.7	1.15	MOTORS CCW		[illegible]		
4																
5	1.85	.03	6.3	74	2.95	6.75	5.1	4.75	7.5	19.7	1.15	MOTORS CCW		820 RPM		
6																
7	1.83	.02	6.3	7.45	2.90	6.75	5.15	4.75	7.55	19.8	1.20	MOTORS CCW		1620 RPM		
8	1.80	.01	6.4	7.55	2.85	6.85	5.30	4.95	7.60	19.7	1.20	CCW		2700 RPM		
9																
10					6-29-72				1105							[illegible]
11												0				[illegible]
12																
13												1000				
14																
15												2000				
16																
17												3000				
18																
19												4300				
20																
21																

FIG. 52-5

FORM 0133A
AiResearch Mfg. Co.

Power Cond. LAB DATA SHEET

EWO 3500-171199-07-0302 DATE 29 June 72 TEST PURPOSE S.O.A.C. Air Flow Test

P/N NA BAROM 29.82 Sawyer, Davis, Goring, Stringer, McCannon, Wong

S/N NA TEMP NA TEST PERS. [illegible]

NO.	1 Filter Inlet Press. "H2O	2 Jet Low Press. "H2O	3 Pump High Press. "H2O	4 FAU Inlet Press "H2O	5 FAU Outlet Press "H2O	6 Orifice Inlet Press. "H2O	7 Orifice Outlet Press. "H2O	8 [illegible] East "H2O	9 [illegible] West "H2O	10 Orifice ΔP "H2O	11 ΔP "H2O	12 Temp. °F	13 Temp. Outlet Temp. °F	14 Fan Temp. °F	15 Fan Speed RPM	Turbine Speed RPM / REMARKS
1	+.07	-1.86	7.25	-2.35	[illegible]	8.90	[illegible]	[illegible]	5.[illegible]	1.30	[illegible]	[illegible]	96.5	93.[illegible]	3500	0
2																
3	-.[illegible]	-1.9[illegible]	[illegible]	-2.8[illegible]	[illegible]	8.90	8.[illegible]	6.[illegible]	5.55	1.30	19.35	88.8	93.[illegible]	95.[illegible]	3500	15[illegible]
4																
5	[illegible]	-1.95	7.55	-2.85	[illegible]	[illegible]	8.10	6.20	5.70	1.31	19.25	88.[illegible]	[illegible]	93.2	3500	[illegible]
6																
7	-.05	-1.96	7.55	-2.75	9.05	9.05	8.15	6.30	5.70	1.31	19.15	88.2	101.5	92.5	3500	3000
8																
9	0	-1.92	[illegible]	[illegible]	[illegible]	9.25	8.2[illegible]	(Run [illegible]								[illegible]
10									[illegible]							[illegible])
11	+.03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.0[illegible]	6.15	[illegible]	[illegible]	[illegible]	[illegible]	96.0	[illegible]	[illegible]	[illegible]
12																
13	-.03	-1.9[illegible]	[illegible]	-2.[illegible]	[illegible]	[illegible]	8.3[illegible]	[illegible]	[illegible]	1.2[illegible]	19.30	79.2	100.5	[illegible]	[illegible]	[illegible]
14																
15	+.0[illegible]	-1.91	[illegible]	[illegible]	[illegible]	9.22	8.[illegible]	[illegible]	[illegible]	1.28	19.10	[illegible]	92.3	[illegible]	[illegible]	[illegible]
16																
17	P_2	P_1	P_3	P_5	P_4	P_9	P_6	P_7	P_8	P_{11}						
18				Note;	[illegible]											
19																
20																
21																

FIG. 52-6

FORM #1339A
AiResearch Mfg. Co.

Power Cond. LAB DATA SHEET

Page 2 of 2

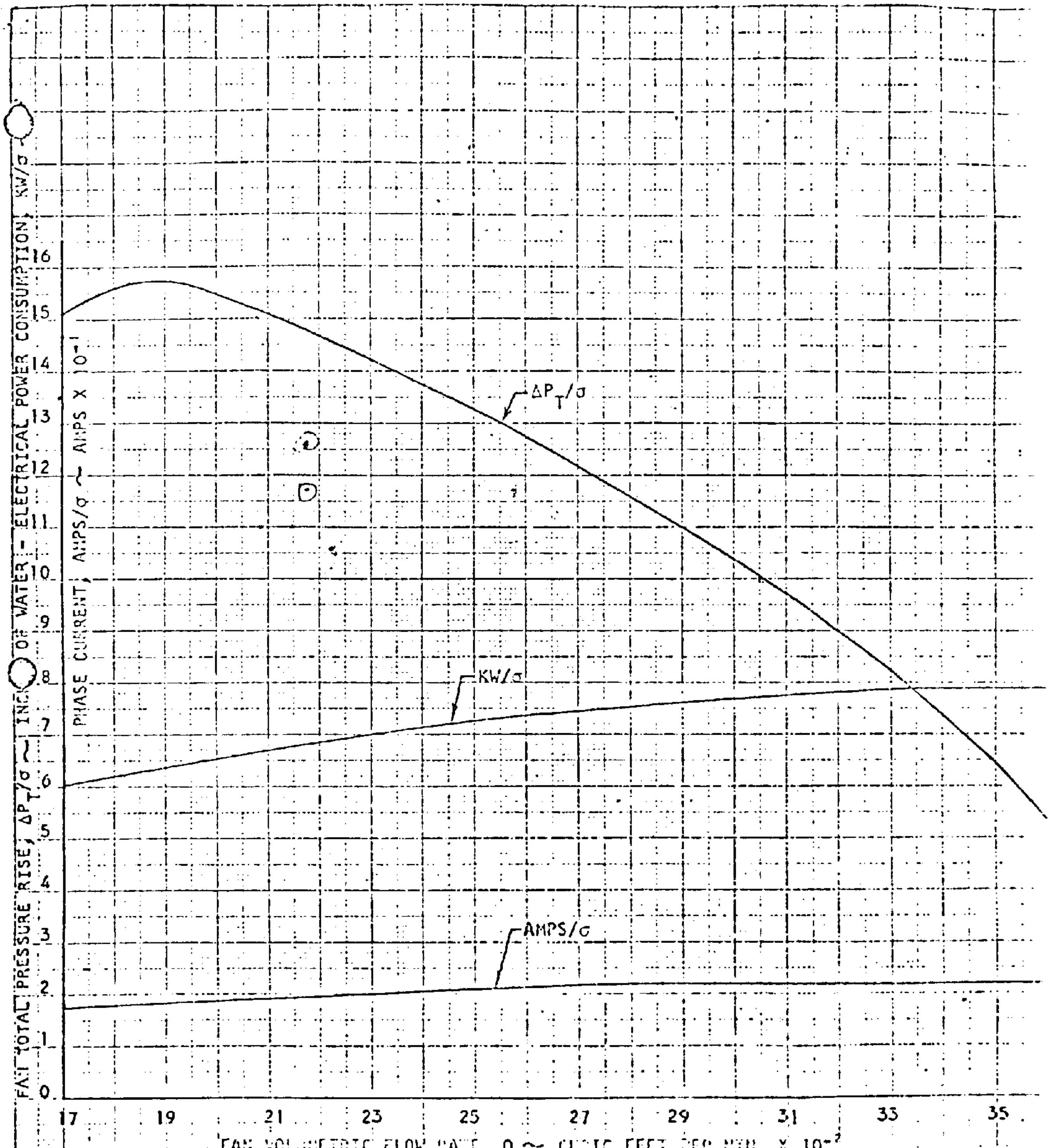
EWO 3520-121193-07-0602 DATE 29 June 72 TEST PURPOSE S.O.A.C. Air Flow Test

P/N NA BAROM NA

S/N NA TEMP NA TEST PERS. See Sheet #1 of 2

				F/D Power Data											
				Aφ Amps	Bφ Amps	Cφ Amps	A-B Volts	A-C Volts	B-C Volts	Aφ KVA	Bφ KVA	Cφ KVA	Total KVA		
NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	REMARKS
1				[illegible]	[illegible]	13.8	227	228	228	4.3[illegible]	4.35	4.30	12.95			[illegible]
2																
3				[illegible]	13.1	12.8	227	226	226	4.30	4.35	4.30	12.95			[illegible]
4																
5				[illegible]	[illegible]	12.8	227	228	228	4.30	4.35	4.30	12.95			[illegible]
6																
7				13.9	13.0	13.6	227	226	228	~~4.30~~	~~4.33~~	~~[illegible]~~	7.43			[illegible]
8							line to line									
9				[illegible]	[illegible]	R[illegible]										[illegible]
10																
11	After [illegible]	[illegible]		13.3	13.5	12.3	227	[illegible]	[illegible]	4.45	4.41	4.41	13.28			[illegible]
12																
13				19.3	19.3	19.1	226	227	227	4.35	4.37	4.33	13.05			[illegible]
14																
15				19.3	19.3	19.1	226	227	227	4.35	4.37	4.33	13.05			[illegible]
16																
17																
18																
19																
20																
21																

FIG. 52-7



CALCULATED BY		5/9/72	PERFORMANCE OF MOTOR DRIVEN FAN P/N 605932-1	PA-89900
TRACED BY				
CHECKED BY				
APPROVED BY			AIRESEARCH MANUFACTURING COMPANY	
UNIT NO.				

FIG. 52-8

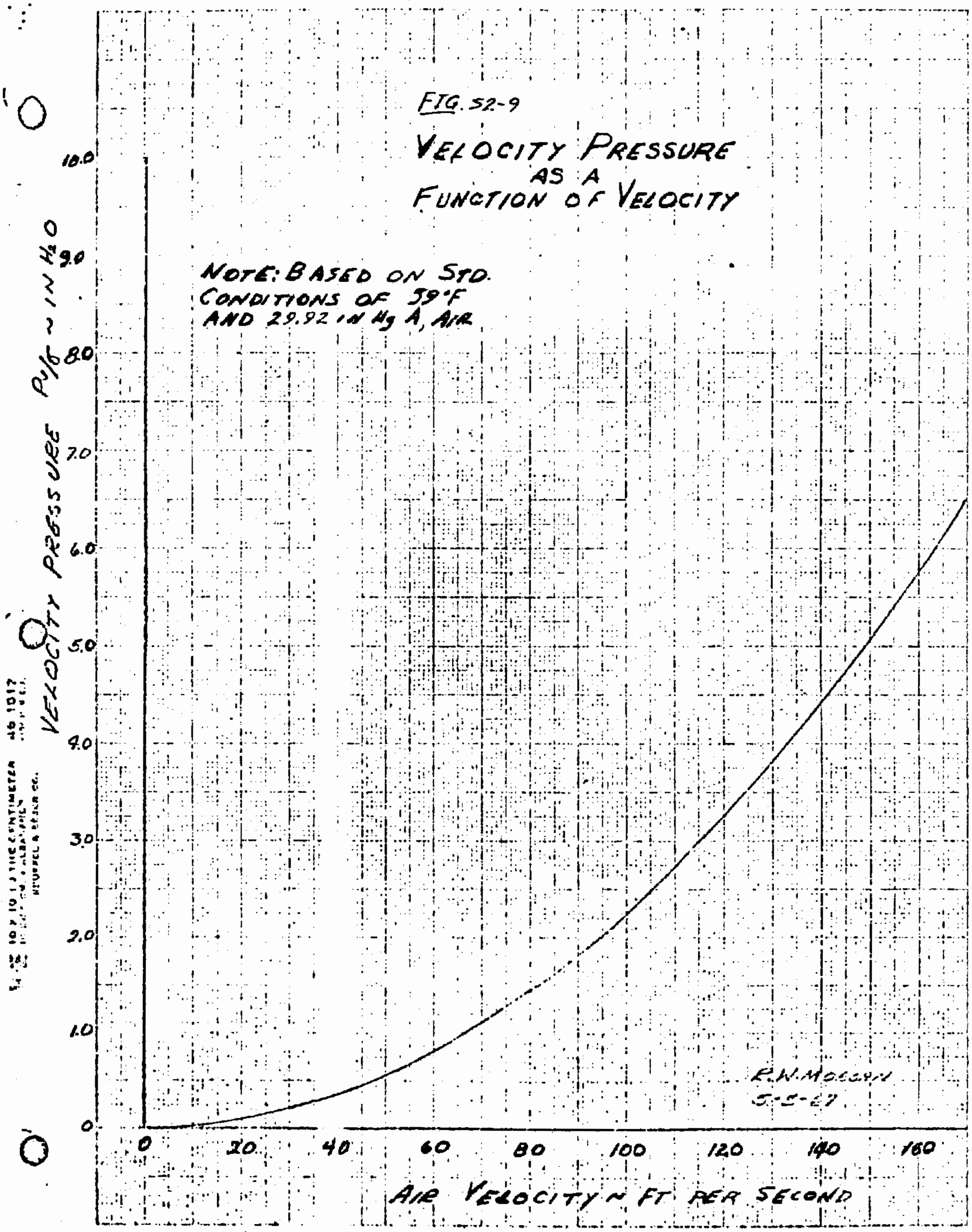


FIG. 52-9
VELOCITY PRESSURE
AS A
FUNCTION OF VELOCITY
NOTE: BASED ON STD.
CONDITIONS OF 39°F
AND 29.92 IN Hg A, AIR
VELOCITY PRESSURE P_v/δ ~ IN H_2O
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
20
40
60
80
100
120
140
160
AIR VELOCITY ~ FT PER SECOND

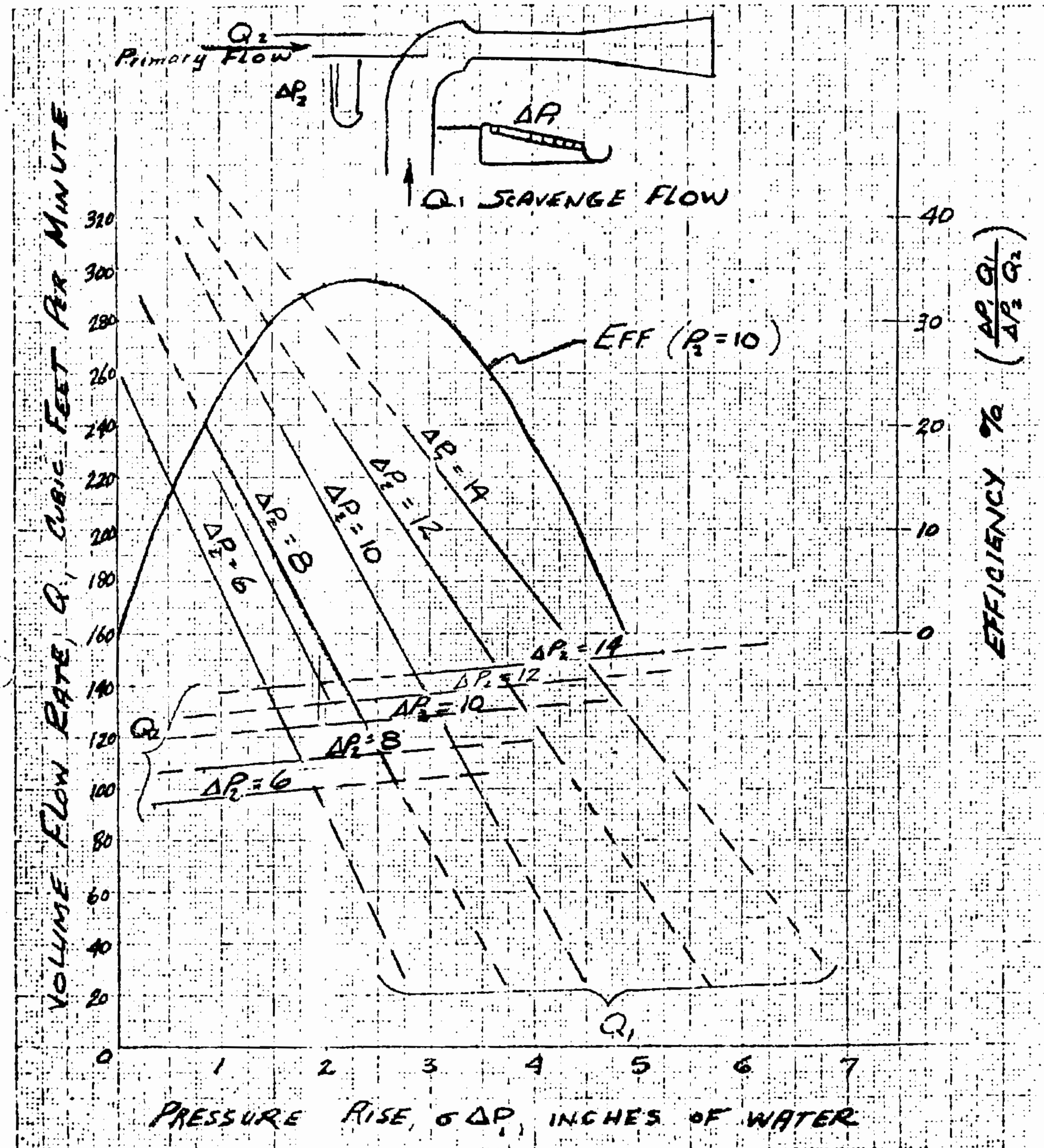


FIG. 52-10	PERFORMANCE FOR JET PUMP OUTLINE No. PA118410	PA118405 PA118406 PA118407
	AIRESEARCH MANUFACTURING COMPANY	

REF. EWO #3200-366250-00-0702

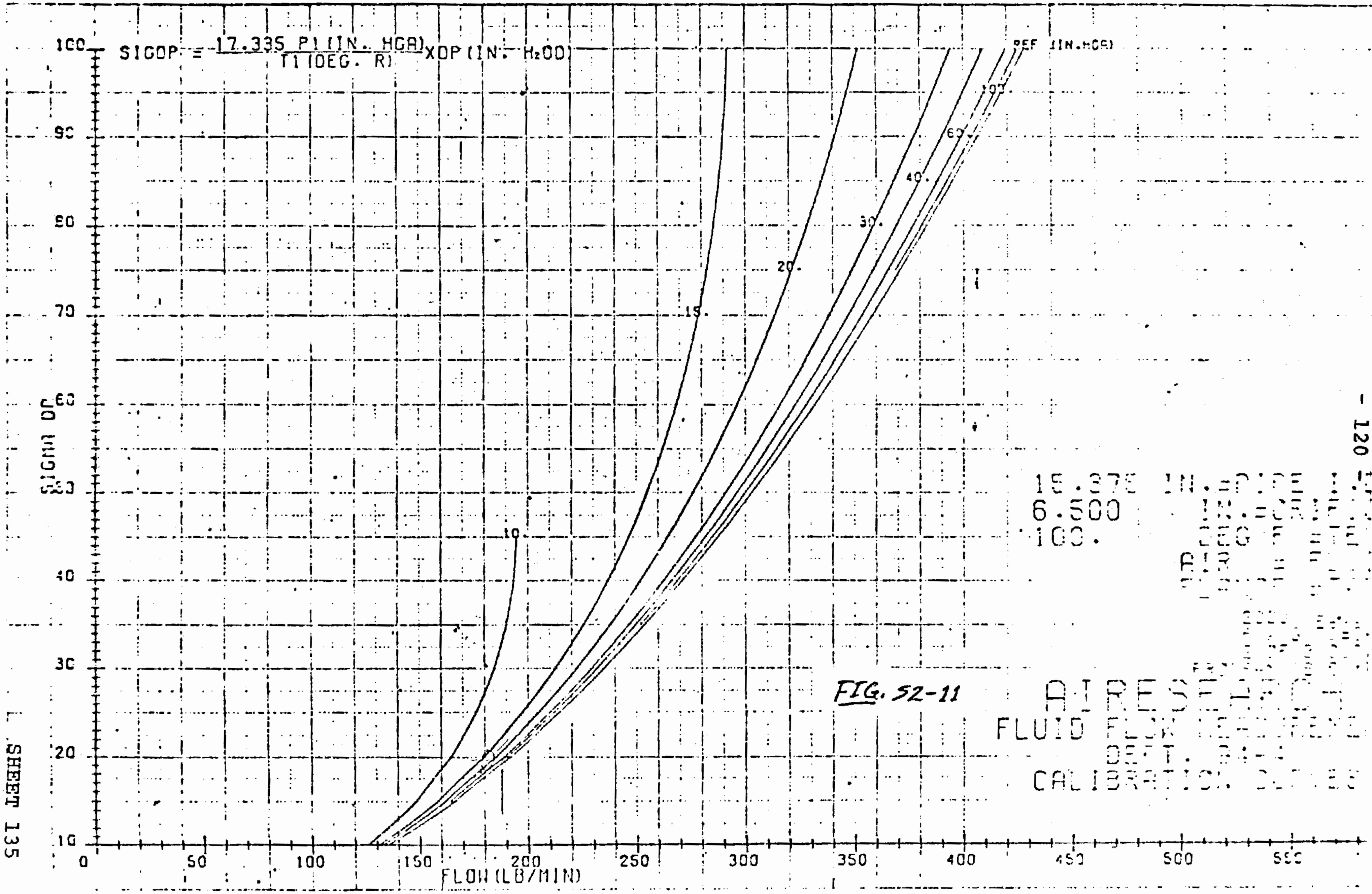

SIGDP = 17.335 P1 (IN. HGA) / T1 (DEG. R) X DP (IN. H2O)
REF (IN.HGA)
100
60
40
30
20
15
10
SIGMA DP
FLOW (LB/MIN)
0
50
100
150
200
250
300
350
400
450
500
550
10
20
30
40
50
60
70
80
90
100
15.375 IN.
6.500
100.
AIRESEARCH
FLUID FLOW
DEPT.
CALIBRATION

FIG. 52-11

Fan Heat Run

The fan motor was run with its normal loading using the same equipment used in the air flow test (see Fig. 52-3 Page 107). After one hour's running, the fan was shut down and electrically disconnected so that one pair of terminals could be monitored for resistance change with respect to time after shutdown. The results of this test are shown in fig. 52-12 in terms of resistance and equivalent temperature rise as compared to ambient conditions prior to the run startup.

Airflow Switch (PN 684-0504-9001)

Static tests with a water manometer were made on four units. The "switch on" under slowly rising pressure occurred over a range of 3.9 to 4.1 inches of water. Starting from 5.0" H_2O and going down slowly the turn off range was 3.0 to 2.5" H_2O. These units were later reworked to provide a smaller up/down hysteresis (approximately 0.5" H_2O in place of the original 1.5" H_2O spread)

FAN RUN FOR 1 HOUR ; 19 AMPS PER PHASE. TESTED 6-29-72

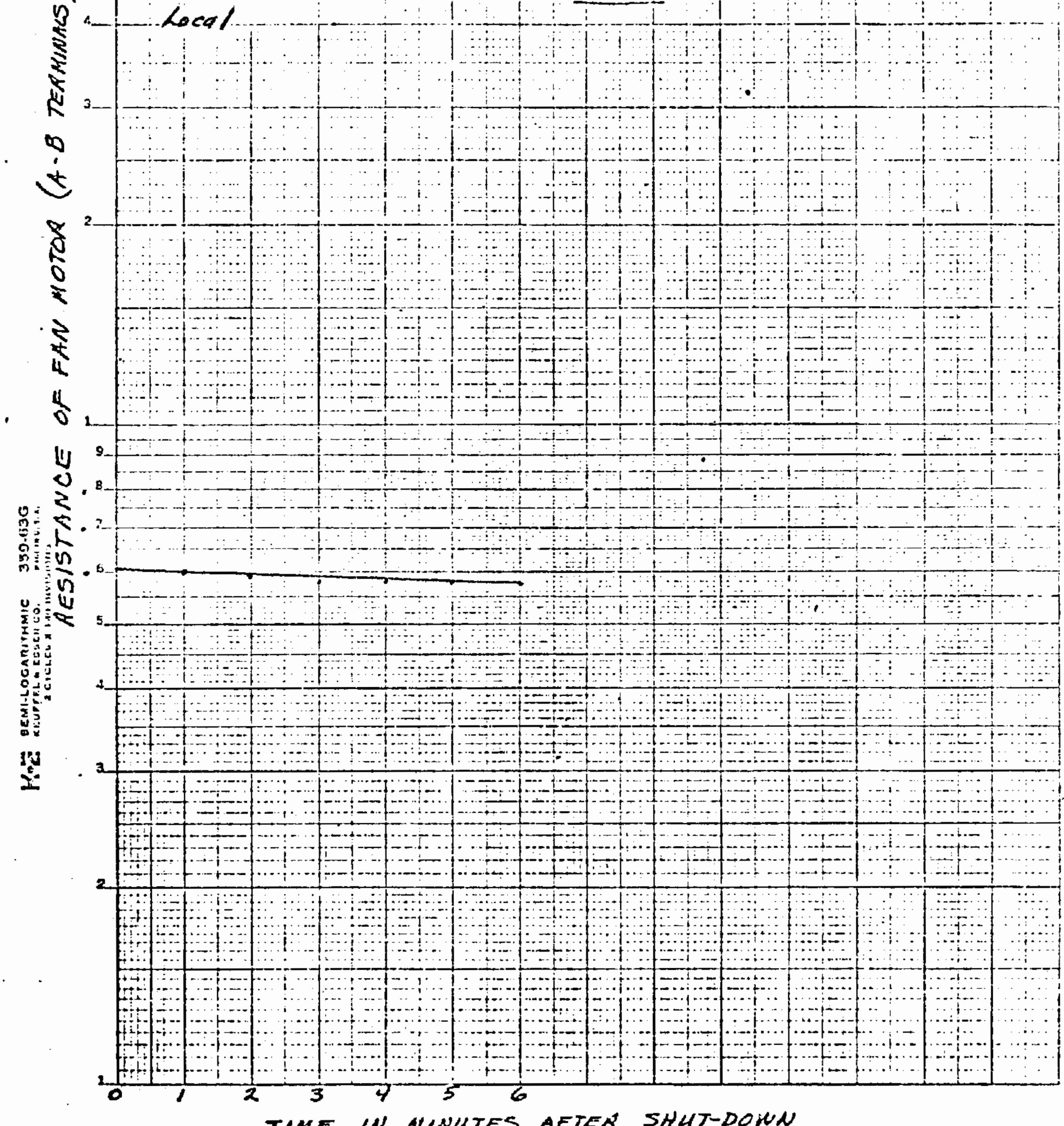
TEMPERATURE RISE —

AMBIENT 69°F = 20.56°C

$$\frac{.61}{.515} = \frac{234.5 + 20.56 + \Delta T}{234.5 + 20.56}$$

ΔT = 47.°C RISE

~~FINAL~~ Local TEMP. = 67.56°C OR 153°F. (VERY CONSERVATIVE)



BERT SAWYER 7-15-72

FIG. 52-12

Traction Motor Cooling

Summarizing the data from the Air Flow Test and from the Traction Motor heat run in Section "a " it is evident that adequate cooling capacity is available.

Figure s2-13 is a block diagram of the elements contained in the SOAC car related to the front truck of the vehicle. This diagram shows the sea level test data for air flow. Motor test data for steady state full power operation is represented in Figure s2-14. It can be seen that the cooling system capacity for pumping air exceeds that used in the motor heat run test by a 30% margin and, consequently, the motors will run cooler in the system than in the test setup.

The hottest temperatures that were recorded were in the compensating pole face winding and the shunt coil at the air outlet side. In steady state 230 HP operation these regions stabilized at approximately 225^{0}F and eventually rose, after shutdown, to 260^{0}F

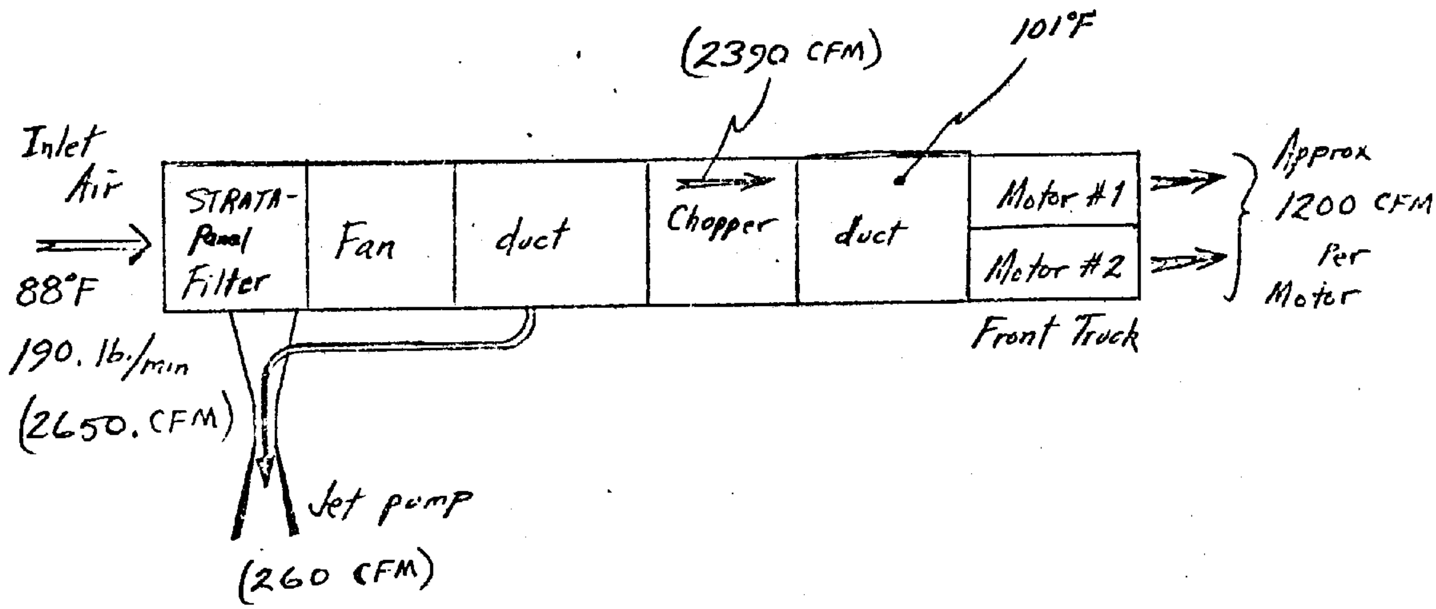


FIG. 52-13 Cooling System SOAC front end

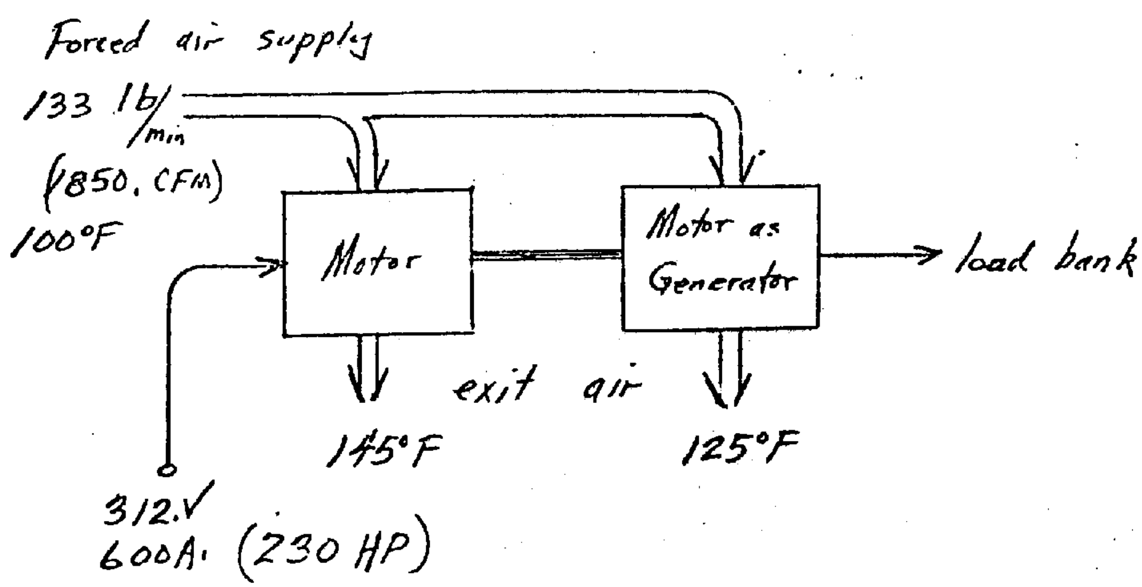


FIG. 52-14 SOAC Traction Motor Heat Run Test

Auxiliary Power

The second phase of the system test was putting the Auxiliary Power Subsystem into operation. This consisted of: (1) checking out the DC supply which includes the transformer/rectifier (T/R), the battery charger and battery B + circuitry; (2) checking out the MA protective and control circuits without 600 VDC being present; (3) start and run the MA with no load using facility 600 VDC and battery only for logic and B +; (4) add T/R load and Battery Charger; (5) with fully operating Auxiliary Power supply check system reaction to added loads.

The above series of checks occurred over a three week period in July 1972. The strip chart record shown in figures s3-1, s3-2, and s3-3 were run in September, after modification and is representative of the subsystem performance in near final form.

Propulsion Control and Dynamic Braking

The main propulsion control components PCU, Chopper and PPCU were individually checked and then coupled together for a preliminary system checkout. At this time no 600 VDC power was applied but a simulator was connected which represented the drive system on the two trucks. The simulator modelled the traction motors in detail so that system responses to conditions of RPM and torque generated demands for corresponding field current and Chopper control of simulated armature current. All of the control logic and the large contactors were exercised in the simulator runs and these activities were critically examined to determine that safe and proper sequencing was occuring.

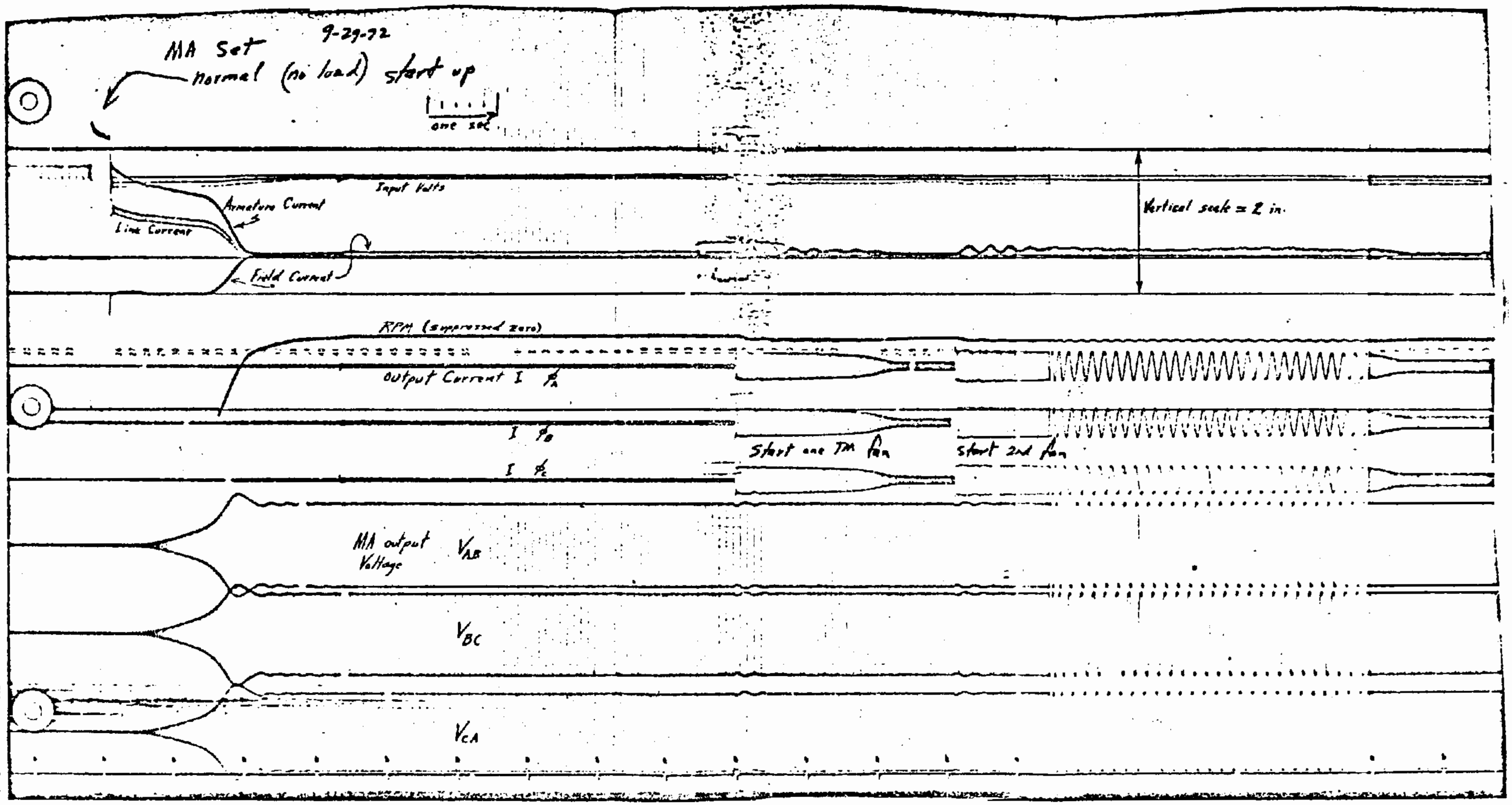


FIG. S3-1 MA Start up

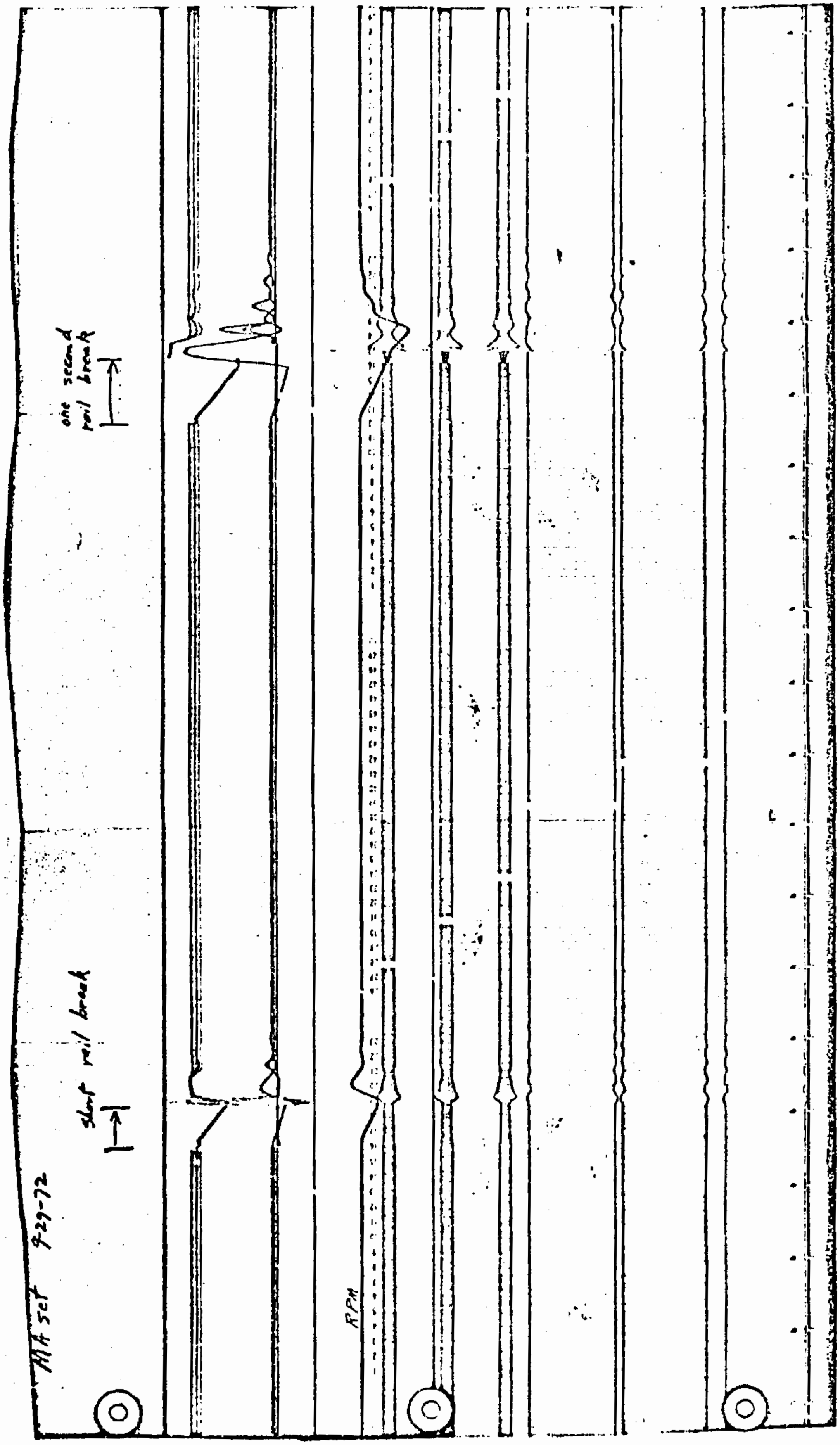


FIG. S3-2 MA Set short rail break, simulated

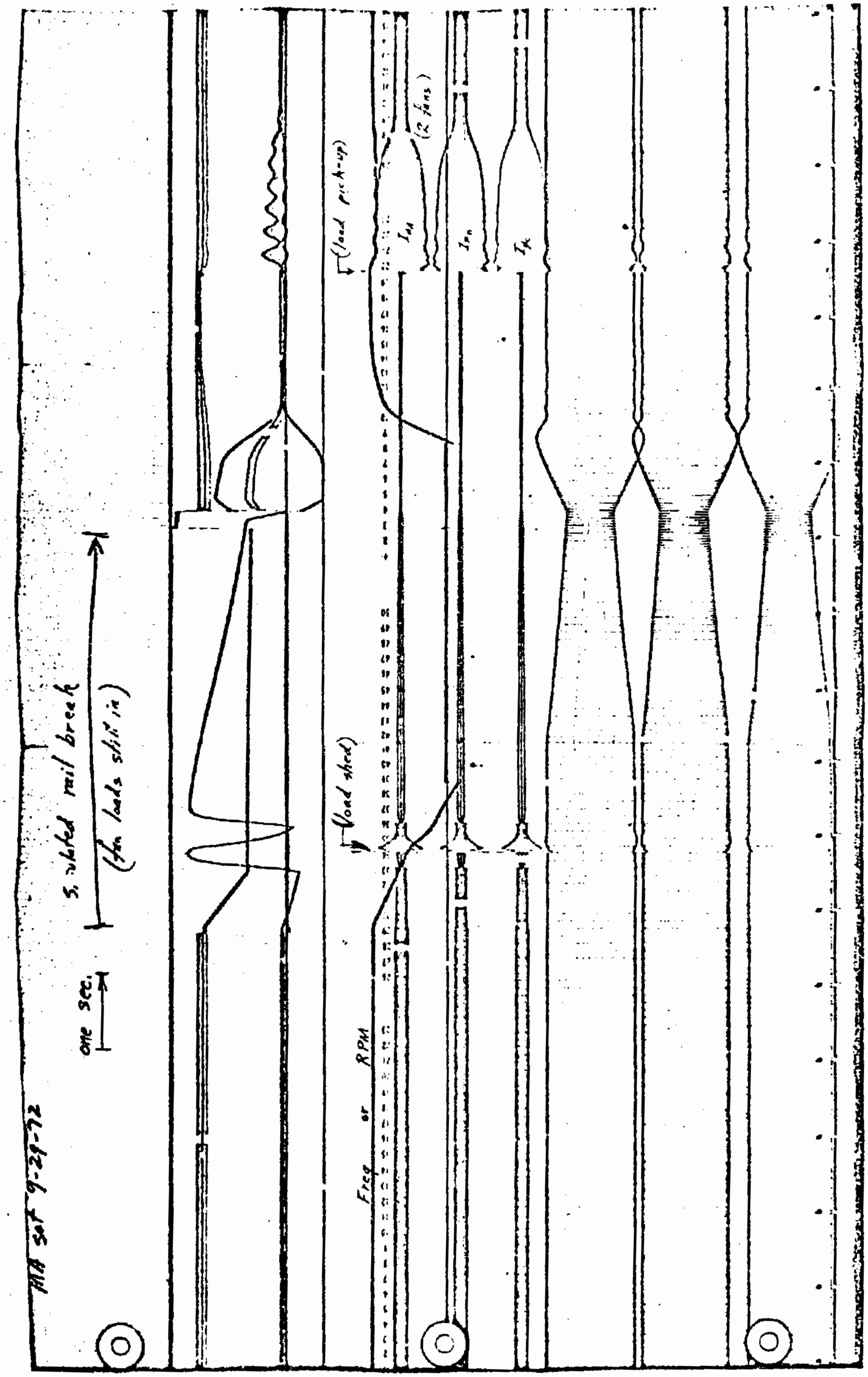


FIG. S3-3 MA Set long rail break, Simulated

After a thorough checkout with the Traction Motor Simulator, the test stand motors were coupled to the system and motor field control tests were made prior to application of 600 VDC power. Then low RPM starts were made with 600V facility power applied. By mid-September 1972, the test stand was fully operative and testing continued through February 1973, concurrent with field testing at Pueblo, Colorado.

Some representative strip chart recordings of actual runs are shown in figures s4-1, s4-2, and s4-3. Figures s5-1 and s5-2 are the instrumentation data sheets which identify the traces and related scaling of date.

Figure s4-1 shows a typical low speed drive/brake transition. Figure s4-2 shows conditions during acceleration as motor passes through base speed (motor field current begins to decrease). Figure s4-3 shows a typical drive brake transition at 73 MPH (approximately 3900 RPM)

Other tests completed during the later part of 1973 included: speedometer calibration, speed limiting, Hostler control checkout, motor stability tests and maximum load cycling. System testing in the test cell was terminated in February 1973.

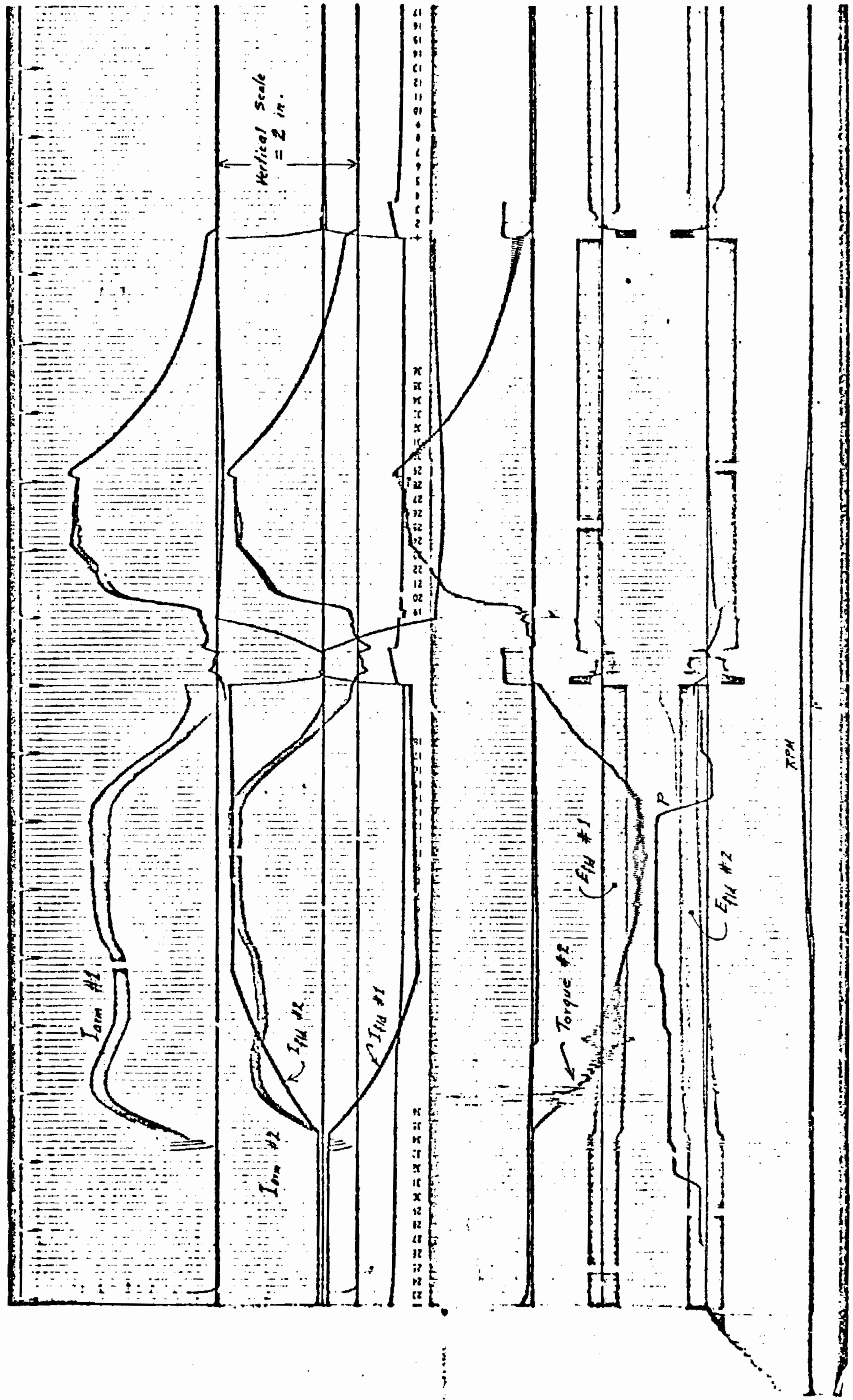


FIG. S4-1 Low speed drive/brake transition

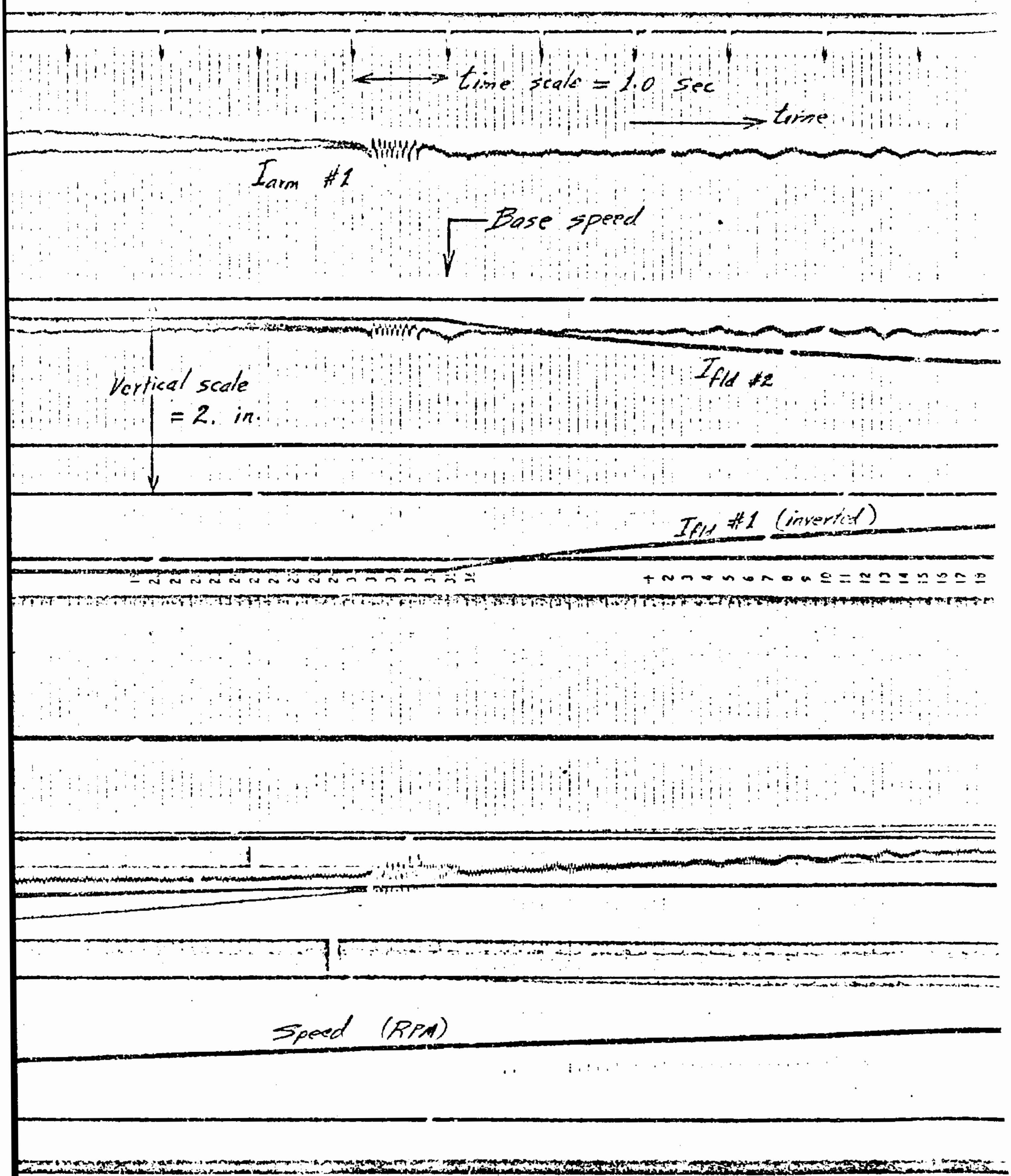


FIG. S4-2 Acceleration through Base Speed

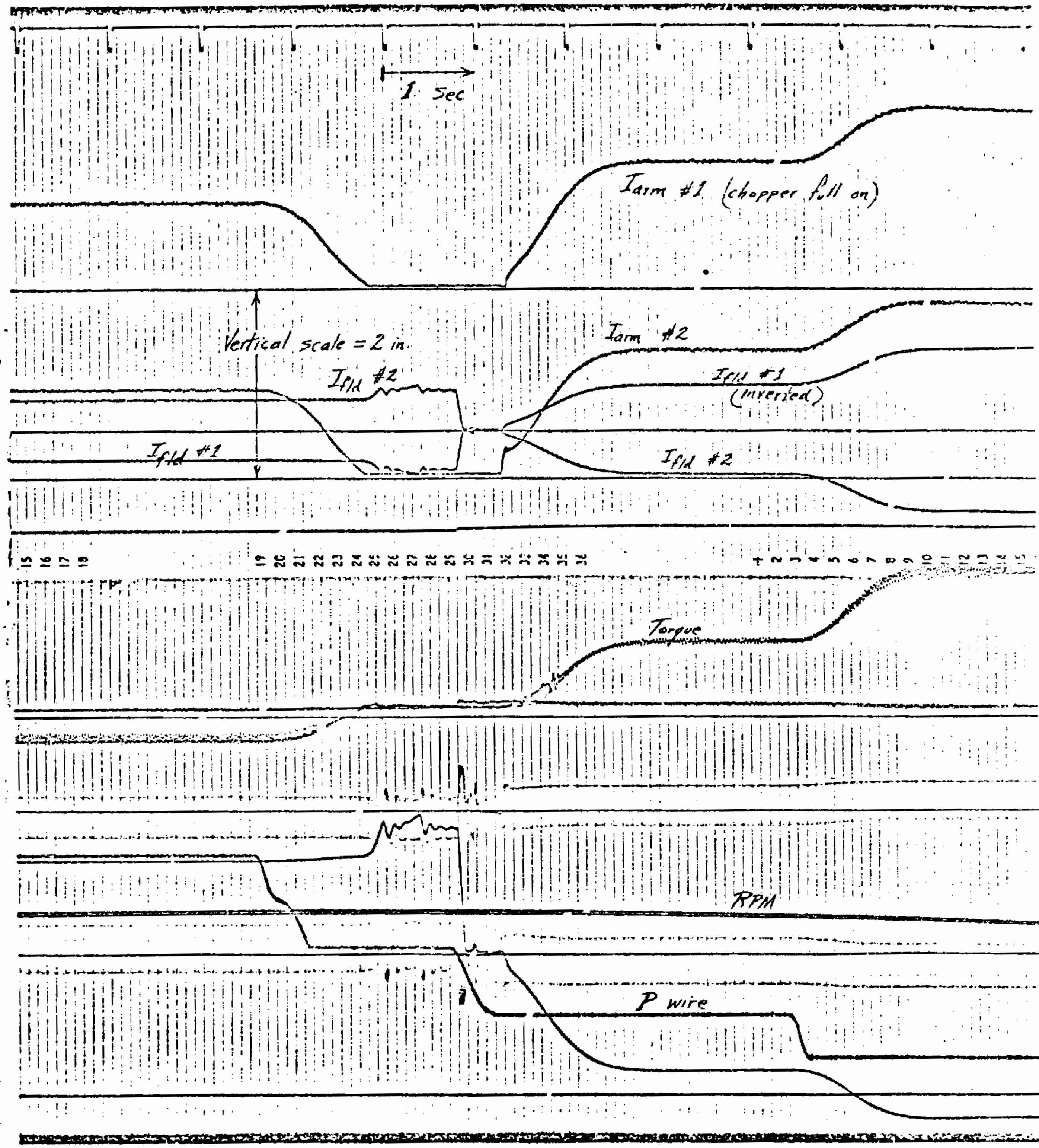


FIG. 54-3 High Speed Drive/Brake Transition

AIRE... ...H MANUFACTURING DIVISION

INSTRUMENT ...CORDING DATA

TRACE SEQUENCE	RECORDED TRACE PARAMETER	TRANSDUCER TYPE	TRANSDUCER CALIB LEVEL	TRANSDUCER RANGE	SIGNAL CONDITIONING DATA ...	SIGNAL CONDITIONING ... CIR. NO.	REQUIRED RANGE	DATA CALIB FACTOR UNITS/IN	RC CALIB RESISTOR OHMS	RC DEFLEC IN	OSCILLOGRAPH BLOCK POSIT. NO.	GALVO TYPE	TRACE REF. LOCATION	REF. TRACE IN DATA UNITS	REMARKS
	ARM I SET 1	SHUNT	50 MVDC	1000 AMP		1		400 AMP			2	364	3.0		
	FIELD I SET 1	HALL	2.0 VDC	50 AMP		3		30 AMP			7	364	4.5		
	FIELD I SET 2	HALL	2.0 VDC	50 AMP		4		30 AMP			8	364	4.5		
	ARM I SET 2	SHUNT	50 MV	1000 AMP		2		400 AMP			10	364	5.0		
	BATT. 'I'		±50 MV	±100 AMP		10		50 AMP			19	364	7.0		
	BATT. 'E'		50 VDC	50 VDC		11		20 VDC			20	319	7.0		
	TORQUE SET 1A		1310 FT LB	1500 FT. LB		12		500 FT LB	60 K-L	2.62	21	319	7.0		
	TORQUE SET 2A		1310 FT LB	1500 FT. LB		14		500 FT LB.	60 K-L	2.62	22	319	7.0		
	FIELD 'E' SET 1		±300 VDC	±300 VDC		6		600 VDC			25	363	8.5		
	FIELD 'E' SET 2		±300 VDC	±300 VDC		7		600 VDC			29	363	10.0		
	TOTAL MOTOR 'E'		1500 VDC	1500 VDC		16		600 VDC			31	364	10.0		
	PWIRE I					15					33	319	11.5		
	MOTOR SPEED #1		10 VDC	4300 RPM		19		2000 RPM			35	341	11.5		
	MOTOR SPEED #2		10 VDC	4300 RPM		20		2000 RPM			36	341	11.5		

PAPER TYPE ______ OSCILLOGRAPH SER. NO. ______ EWO ______ INSTRUMENTATION RECORDING GROUP

PAPER SPEED ______ GALVO LAMP VOLTAGE ______ UNIT ______ TECHNICIAN ______ DATE ______

TIMING LINES ( ) 01 SEC
( ) 01 SEC
( ) 1 0 SEC

ENGR. ______

8-21-72

FIG. 55-1

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SHEET 148

AIRESEARCH MANUFACTURING DIVISION

INSTRUMENT RECORDING DATA

TRACE SEQUENCE	RECORDED TRACE PARAMETER	TRANSDUCER: TYPE	CALIB LEVEL	RANGE	SIGNAL CONDITIONING: DATA DESIGNATION	SYSTEM & CH NO.	REQUIRED RANGE	DATA CALIB FACTOR UNITS/IN	RC: CALIB RESISTOR OHMS	DEFLEC. IN	OSCILLOGRAPH: BLOCK POSIT. NO.	GALVO TYPE	TRACE REF LOCATION	REF TRACE IN DATA UNITS	REMARKS
	EVENT SIG. #1					22		100 VDC			1.	361	0.4		CHOPPER ON AMP.
	2					26		100 VDC			2	361	0.6		TRACT EFFORT AMP
	3					27		100 VDC			3	362	0.8		FLD COMMND. AMP
	4					25		100 VDC			4	362	1.0		Δ COMMND AMP.
	SPARE HI VOLTS #1		1500 VDC	1500 VDC		21		600 VDC			5	361	3.0		CHOPPER COMMUTATED [illegible]
	SPARE HI VOLTS #2		1500 VDC	1500 VDC		23		600 VDC			6	361	3.0		[illegible]
	TOTAL MOTOR I		666 VDC	2000 AMP		5		1000 ADC			7	364	3.0		
	TOTAL SYS. I		.666 VDC	2000 AMP		24		1000 ADC			9	364	4.5		
	MA D.C. INPUT I		50 MV	500 AMP		28		400 ADC			10	364	4.5		
	MA (1+7-N) FIELD I		10 VDC	50 AMP		29		10 ADC			14	364	5.0		
	CAP BANK E		750 VDC	750 VDC		31		400 VDC			15	364	5.0		
	TOTAL SYS. INPUT E		750 VDC	750 VDC		32		400 VDC			16	364	5.0		
	MA OUTPUT FREQ					39		10 HZ			26	341	6.6		
	MA OUTPUT I ØA		50 MVRMS	500 ARMS		33		300A			28	364	6.0		
	MA OUTPUT I ØB		50MV RMS	500 ARMS		34		300A			31	364	6.8		
	MA OUTPUT I ØC		50MV RMS	500 ARMS		35		300A			34	364	7.6		
	MA OUTPUT E ØA-B		250 VRMS	250 VRMS		36		300A			39	364	8.5		
	MA OUTPUT E Ø B-C		250 VRMS	250 VRMS		37		200V			42	364	9.7		
	MA OUTPUT E ØC-A		250 VRMS	250 VRMS		38		200V			45	364	11.1		

PAPER TYPE ______ OSCILLOGRAPH SER. NO. ______ EWO ______

PAPER SPEED ______ GALVO LAMP VOLTAGE ______ UNIT ______

TIMING LINES ( ) .01 SEC ( ) .1 SEC ( ) 1.0 SEC

DEPT 93-3 INSTRUMENTATION RECORDING GROUP

TECHNICIAN ______ DATE ______

ENGR. ______

8-21-72

FIG. 55-2

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SHEET 149

t. MA-SET (P/N 2014606) (DC-Motor and AC-Generator with Exciter)

Production Testing

Each motor alternator set is subjected to the following production acceptance tests.

A. DC-Motor

1. Resistance of windings and polarity check
2. Seating of brush faces
3. No-load tests
4. Overspeed
5. Dielectric
6. Commutation check
7. Black-band tests (1st unit only)
8. Inspect all critical dimensions of set.

B. AC-Generator

1. Resistance of windings
2. -
3. No-load tests
4. Overspeed
5. Dielectric
6. -
7. Load test
8. -

Development Testing

One MA-set will be utilized to perform the following development tests.

A. DC-Motor

1. No-Load Saturation

Purpose

The purpose of this test is to confirm the capability of the motor magnetic circuit.

Configuration

The motor will be driven by the alternator connected to a 220 VAC, 3 phase power supply with a capacity of about 450 amperes. The start-up is made with either a variable power supply (Variac) or a starting transformer to limit the starting inertia current. The exciter field current shall be about 5 amperes at about 12 volts.

Procedure

A voltmeter is measuring the output voltage on the motor leads. A variable DC power supply of 220V, 20 amperes provides the field power.

Change field current of the motor 0-15-0 amperes in 1.5 ampere steps. Field current shall be adjusted increase only up to 15 ampere and decrease only down to zero. Record output voltage and field current.

t. MA-SET (Contd.)

2. Efficiency of MA-Set

Purpose

Determine the overall motor-alternator efficiency

Configuration

The DC-motor will be connected to a variable DC-power supply of 650 volts and about 250 amperes, the AC-generator will be connected to a 3 phase load bank which can absorb about 125 kw at 220 volts. Remove overspeed switch and connect a speed pick-up wheel of the optical or magnetic type to the shaft. Field power for motor and exciter same as for no-load saturation test.

Procedure

Supply full field current to motor, start motor by increasing armature voltage up to 650 volt. Check speed and adjust field current to get 1800 RPM. Energize the exciter field and adjust AC voltage to 230 volts. Close the breaker to the load bank and increase the load gradually to $\frac{125000}{\sqrt{3} \times 230} = 314$ amperes. Adjust motor field at the same time to keep the speed of 1800 RPM constant.

Record: Motor: Armature current: I_m, Armature voltage: E_m

Field current: I_f, Field voltage: E_f

Alternator: Alternator current: I_a, Alternator voltage: E_a

Exciter current: I_e, Exciter voltage: E_e

Set: Speed: RPM

$$\text{Efficiency:} \quad \eta = \frac{\sqrt{3} \times I_a \times E_a \times 100}{I_m \times E_m} \; \% \quad \text{(excluding field power)}$$

$$\text{Overall Efficiency:} \quad \eta = \frac{\sqrt{3} \times I_a \times E_a \times 100}{(I_m \times E_m) + (I_f \times E_f) + (I_e \times E_e)} \; \%$$

As design goal the overall efficiency of the set is 75%.

t. MA-SET (Contd.)

3. Commutation Tests

Purpose

Verify the commutation characteristic of the DC-motor arc within the design limits.

Start and load the DC-motor as above but check commutation at the following load points.

	Volts	Amps	RPM	Load
a.	650	230	1800	Rated
b.	750	200	1800	Rated
c.	750	200	1800	Rated
d.	550	270	1800	Rated
e.	400	270	1800	72° Lo
f.	650	290	1800	125° Lo

4. Heat Run

Purpose

Verify that the motor, alternator and exciter thermal design is adequate for the purpose intended.

Configuration

Same as in Tests 2 and 3. Install thermoindicators in the motor at the mainpole coil, interpole coil and compensating coil, in alternator at the stator coil, on exciter in the stator coil, at the air outlet end use ambient thermometer in oil cup.

Test Conditions

a. Alternate continuous rating of 125 kw, 230 VAC, 1800 RPM with motor voltage at 650 VDC.

b. Same alternator rating with motor voltage at 550 VDC.

Procedure

After set has been at room ambient temperature for at least 8 hours, measure the resistance of the three phases of the alternator, AC-motor resistance at the two diode plates, resistance of the exciter stator winding and resistance of the DC-motor armature between bars about 40 bars apart and marked with permanent markers and record, all resistances and ambient temperatures. Record all temperatures at beginning of test and every five minutes while at test conditions. Stop test when temperature rise between readings

t. MA-SET (Contd.)

is not more than 2°C at any of the test points. Measure the DC-motor temperature on the iron and end turns, risers and commutation surface.

Measure the resistances of all windings specified above and record.

Calculate the final winding temperatures using the following formula:

$$t_f = \frac{R_f - R_i}{R_i} (234.5 + t_i) + t_i \quad ^{\circ}C$$

t_f = Final temperature in °C
t_i = Initial temperature
R_f = Final winding resistance in Ohms
R_i = Initial winding resistance in Ohms

In the above tests the temperature shall not exceed 180°C.

5. Overspeed

Purpose

To prove the mechanical integrity of the rotors and commutator and the speed setting of the overspeed switch.

Configuration

Mount overspeed switch to the MA-set and connect the normally closed switch to a lamp and a 120 VAC power supply. Disconnect the alternator from the load bank to run at no load. Connect one phase to a digital counter. Start up and run motor as before. Reduce motor field slowly and observe when overspeed switch is interrupting the lamp circuit. The circuit shall interrupt at 2,260 RPM (120% of 1890 RPM). The motor shall run for 5 minutes at overspeed and commutation shall be observed to see if sparking occurs from deformation of commutator due to high speed.

6. Dielectric

Purpose

Prove the dielectric capability of the insulation system.

Configuration

Test the motor, alternator and exciter in static condition with windings disconnected.

t. MA-SET (Contd.)

Procedure

Test the power circuit of the motor with a voltage of 2700 VAC, 60 Hz between windings and frame. The shunt field with a voltage of 2000 VAC 60 Hz. The alternator stator winding with 1500 VAC, 60 Hz. The exciter circuits, after short circuiting the diodes with 600 VAC, 60 Hz. All voltages shall be applied gradually, hold the test voltage for 60 seconds and reduce the voltage gradually. Each winding not tested will be connected to the frame.

7. Vibration and Shock

Purpose

Prove the mechanical integrity of the MA-set vibratory and shock input loading.

Configuration

A vibration fixture which simulates the car body input will be utilized in this test.

Procedure

With the MA set on the mounting fixture in a static rigid condition, drive the input fixture and scan for resonances in the 20 hr 150 Hz region. Any resonances in the 80 to 150 Hz region will require special attention and evaluation.

The MA-set will be shock-tested in the axial direction at ±10 g's, 30 ms.

8. Noise

Purpose

Determine the audible noise characteristic of the MA-set.

Configuration

The MA set is running at no-load and at full-load at 1800 RPM.

Procedure

Record audible noise levels on a broadband noise level meter "C" scale. Recordings will be taken at a distance of 15 ft at lateral and longitudinal direction.

As a design goal, a noise level of 85 db maximum (reference 0.0002 microbar) will be recorded.

t. MA-SET (Contd.)

9. Black Band Test (First unit only)

Purpose

To set the right interpole strength by adjusting the interpole air gap.

Configuration

The DC-motor will be loaded by the alternator.

Procedure

Note: A buck-boost circuit at the interpole circuit will be required for this test.

Supply 650 volts motor input voltage. Adjust field current as required throughout the test to provide a set-speed of 1800 RPM and load the motor with the alternator to rated load of 230 amperes.

Energize buck boost source and increase the boost voltage until visible sparking occurs. Record output voltage field current, boost current and speed of motor. Decrease buck voltage until visible sparking occurs and record as before.

Adjust interpole air gap to give signal buck and boost current until sparking occurs.

t. MA Set Development Tests

1. Motor No load Saturation

The data for this test is given for unit SN52-D3 in Figure t1-1(4)

2. Efficiency of the MA Set

The efficiency as defined by $\frac{\text{Watts out (AC)}}{\text{Watts in (DC)}} \times 100$

is given by the expression "$3E_{\phi} \quad I_{\phi} \quad \times 100/(E_{arm} \; I_{arm})$" to an accuracy of approximately +1% at full load since the exciter and the motor field power input is less than a kilowatt.

For SOAC the nominal maximum operating load is about 1/2 the rating of this unit and therefore excitation and field contribute about -2% to the efficiency

$$\eta_{MA} = [3 \times 135. \times 124. \times 100/(650. \times 90.)] - 2. = 83.5\,\%$$

as taken from the fourth line of data in figure t1-1(3)

3. Commutation tests

From the last row of data in figure t1-1(3) there is no sparking throughout the input power range from 6.5 KW to 270 KW.

4. Heat Run

The heat run test data for a nominal maximum power input of 125 KW is shown in figure t4-1. This unit has its own self contained air filter and blower for cooling.

5. Overspeed

The overspeed (+20%) test data is shown on figure t1-1(5).

6. Dielectric

The test data for Hi-Pot is also shown on figure t1-1(5).

ENGINEERING TEST ON SN 52-D3
MA SET P/N [illegible]

DATA SHEET

DATE: 7-18-72
TECH P. Stringer

A. PREPARATION

4. RESISTANCE MEASUREMENT:

I.	SHUNT COIL R_{SH}	7.52	OHMS
II.	STATOR COIL $R_{c,c+Ser}$	0.0437	OHMS
III.	ARMATURE 90° Ra	0.063	OHMS
IV.	ALTERNATOR T_1 to G_1	0.005	OHMS
V.	ALTERNATOR T_2 to G_1	0.005	OHMS
VI.	ALTERNATOR T_3 to G_1	0.005	OHMS
VII.	EXCITER FIELD C to D	2.5	OHMS

5. INSULATION RESISTANCE:

I.	SHUNT COIL to GND.	16×10^4	MΩ
II.	STATOR COILS to GND.	16×10^3	MΩ
III.	ROTOR TO GND.	20×10^3	MΩ
IV.	STATOR Coils TO SHUNT	14×10^4	MΩ

FIG 11-1(1)

SN 52-D3
7-18-72

B. DC MOTOR TEST

1. No Load Test

1.1 Field Resistance Calculation

I. Field Current I_f 17.0 AMPS

II. Field Voltage E_f 134 VOLTS

III. Ambiant Temperature 78 °F.

VI. $R_{SH} = \frac{E_f}{I_f} =$ 7.52 OHMS

1.3 Full speed Test

I. Armature current 7.2 AMPS

II. Armature voltage 650 Volts

III. Field current 11.5 Amps

IV. Field Voltage NOT TAKEN as Required

V. SPEED 1800 RPM.

FIG. t1-1(2)

SN52-D3
7-18-72

MOTOR			ALTERNATOR			LOAD BANK INDICATED LOAD	COMMUTATOR SPARK
ARMATURE VOLTS DC	ARMATURE AMPS DC X6	Field Amps DC	ARMATURE VOLTS OUTPUT	ARMATURE AMPS AC X80	EXCITER AMPS DC		
650	2.0	12	134	0	0	0	BlK
650	6.3	11.2	134	0.66	1.7	20	BlK
650	11.0	11.0	134	1.10	1.8	35	BLK
650	15.0	10.6	135	1.55	1.8	50	BLK
650	20.2	10.3	134	2.15	1.9	70	BLK
650	28.5	9.6	135	3.04	2.1	100	BLK
650	35.8	9.0	134	3.77	2.3	125	BLK
650	42.0	8.4	134	4.40	2.7	145	BLK.

FIG 11-1(3) SHEET 159

SN 52-D3
7-18-72

NO LOAD SATURATION

FIELD AMPS INCREASE	ARMATURE VOLTAGE	FIELD AMPS DECREASE	ARMATURE VOLTAGE
0	6.35	0	6.5
2	122	2	134
4	250	4	260
6	360	6	360
8	490	8	490
10	580	10	580
12	640	12	650
14	687	14	695
16	725	16	730
18	750+	18	750+

FIG t1-1(4)

SN 52-D3
7-18-72

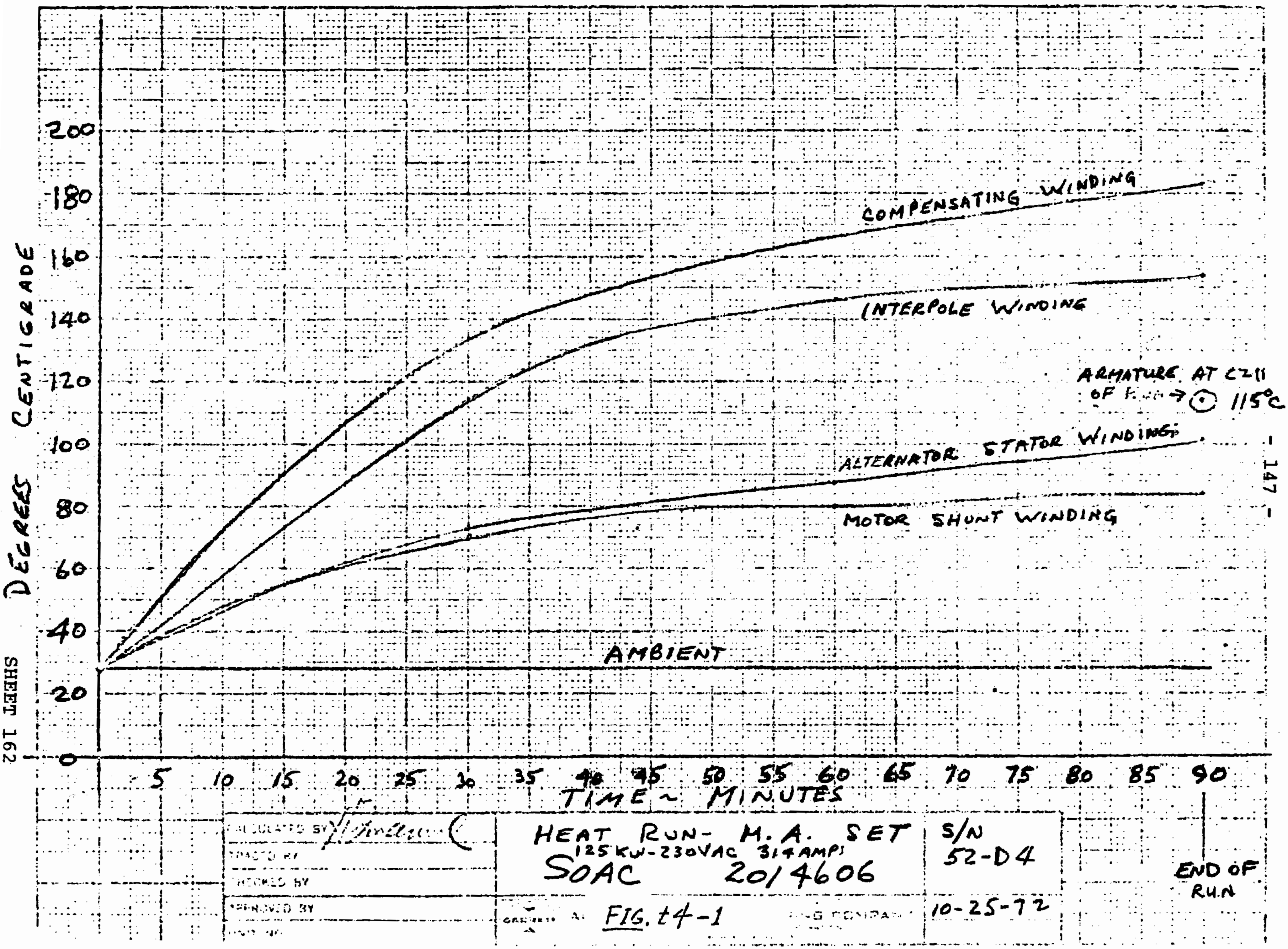
OVERSPEED CONTROL SeT, High 2060 ReseT 1800

OVERSPEED TesT RPM 2160 TIME 2 minutes

Hi PoT A_1 to Ground Volts 2500 TIME 1 MIN.
F_1 To Ground Volts 1500 TIME 1 min.
T_1 To Ground Volts 1500 TIME 1 min.
EXCITER "C" To Ground Volts 1000 TIME 1 min.

SHEET 161

FIG. t1-1 (5)


DEGREES CENTIGRADE
200
180
160
140
120
100
80
60
40
20
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
TIME ~ MINUTES
COMPENSATING WINDING
INTERPOLE WINDING
ARMATURE AT END
OF RUN → ⊙ 115°C
ALTERNATOR STATOR WINDING
MOTOR SHUNT WINDING
AMBIENT
END OF RUN
CALCULATED BY
TRACED BY
CHECKED BY
APPROVED BY
HEAT RUN - M.A. SET
125 KW - 230 VAC 314 AMPS
SOAC 20/4606
S/N
52-D4
10-25-72
FIG. t4-1

MA SET DEVELOPMENT TESTS (continued

7. Vibration and Shock

   These tests were not run

8. Noise

   This test was not run

9. Black Band

   This test was run on the traction motors. Due to the limited speed range and reduced power required in this application, the motor will run entirely in the black.

SHEET 164

APPENDIX II

IIA - <u>TRUCK FRAME STATIC TEST</u>

IIB - <u>TRUCK BOLSTER STATIC TEST</u>

SHEET 166

APPENDIX IIA

TRUCK FRAME

GSI REPORT T34701-1

SHEET 168

STATE OF ART CAR
TRUCK FRAME STATIC TEST
FOUR WHEEL MOTOR TRUCK

Test Report T-34701-1

July 10, 1972

SHEET 170

T A B L E   O F   C O N T E N T S

July 10, 1972

S.O.A.C.
TRUCK FRAME STATIC TEST
FOUR WHEEL MOTOR TRUCK
TEST REPORT T-34701-1

Introduction:

This static test was conducted on the S.O.A.C. truck frame GSI 34701, Serial 1, cast date 3-72, to determine the structural adequacy of the truck frame. The loading forces and loading conditions were those set up in GSI's test procedure as modified in consultation with Boeing-Vertol before the start of the test. During the Stresscoat test a portion of the truck frame wheelpiece adjacent to the side bearing pad was determined to have a marginal stress level.

This section of the truck frame was reinforced on the other side and the test conducted on the pedestal openings on one side of the truck frame and the center portion of the truck frame on the other side.

Also the radius of the side bearer adjacent to the top surface of the truck frame was determined to be too sharp. This radius was chipped and ground to obtain a better blending of the side bearer into the top surface of the casting before conducting the strain gage test.

Object:

The object of this test was to determine the stresses in the truck frame under the above agreed upon loading conditions and to determine the deflection of the chevrons under vertical load.

Conclusions:

The recorded stresses and chevron deflections were satisfactory as agreed upon by Boeing-Vertol and GSI St. Louis Car Division and the Castings Division.

The maximum recorded stresses for the test under the agreed upon loading conditions were:

Loading Condition		Applied Load Lbs.	Max. Recorded Stress 1000 P.S.I. Ten.	Comp.
Vertical Load	With Tie Bars	47,760	+14.1	-16.1
	Loose Tie Bars	47,760	+15.0	-16.1
Lateral Load Applied to Serial Side	With Tie Bars	7,164	+2.7	-1.8
	Loose Tie Bars	7,164	+2.7	-1.8
Lateral Load Applied to Non-serial Side	With Tie Bars	7,164	+2.1	-2.7
	Loose Tie Bars	7,164	+2.1	-2.7
Outward Longitudinal Load	With Tie Bars	24,500	+4.8	0
	Loose Tie Bars	24,500	+9.3	0
Downward Vertical Load on Motor Mount		10,351	+4.8	-15.9
		17,811	+8.4	-27.3
		24,137	+11.3	-37.2
Upward Vertical Load on Motor Mount		10,351	+18.6	-5.4
		17,811	+32.1	-9.6
		24,137	+43.8	-12.9
Lateral Load on Motor Mount Toward Non-Serial Side		6,720	-12.0	+14.7
		11,600	-20.8	+25.5
Lateral Load on Motor Mount Toward Serial Side		6,720	-13.5	+12.3
		11,600	-23.4	+21.3

Personnel:

Present for the Stresscoat test were:

Messrs. R. W. Moore	GSI Castings Division
G. C. Krause	GSI Castings Division
T. M. Herbert	GSI Castings Division

Present for the strain gage test were:

Messrs.	M. Dennis	Boeing-Vertol
	N. Bohm	St. Louis Car (part time)
	E. G. Dunlop	St. Louis Car (part time)
	J. Hrinson	St. Louis Car (part time)
	D. G. K. Wilmot	GSI (part time)
	K. E. Spencer	GSI
	J. D. Burnett	GSI
	G. C. Krause	GSI
	R. W. Moore	GSI
	T. M. Herbert	GSI

Dates of Test:

The test was conducted from 5-19-72 to 6-9-72.

Procedure:

A. Preparation

Prior to applying strain gages, one half of the truck frame was Stresscoated (see Photographs 1 and 2) and loads greater than the agreed upon loading conditions were applied to determine the points of maximum stress. At this time it was decided to reinforce the area of the truck frame between the brake support brackets. This reinforced area of the truck was Stresscoated (see Photograph 3) and the overload conditions repeated.

Stresscoat indications were developed at locations given in Table 1 and shown on Photographs 4 thru 11 and SG 34701.

Strain gages were located on the truck frame at these points and other points to determine the general stress distribution. See SG 34701 for strain gage locations.

B. Instrumentation

Except for strain gages 5, 6, 8, 9, 18, 18S, 37 and 37S which were SR-4 one-half inch gage length type A-5-S6 and rosettes 56, 56S and 57S which were M-M rectangular rosettes type EA-06-125RA-120, all strain gages were SR-4 one-eighth inch gage length type FAP-12-12S6. The strain gages were applied, waterproofed and wired to terminal blocks from which cables were run to a switching unit and read out on a strain indicator.

Loads were applied with hydraulic rams and read out on calibrated hydraulic gages or load cells. See Photographs 12 thru 19 for test setups.

For determining the chevron deflections under vertical load, scale readings were taken between the top of each dummy journal box at the centerline of the box and a prick punch mark on the truck frame directly over the centerline of the dummy journal box.

C. Loading Conditions

The following loading conditions were applied to the truck frame:

Loading Condition	Load for Stress Determination Lbs.	Maximum Load Applied Lbs.
Vertical load applied equally on two side bearers (total). (See Photograph 12 for test setup).	47,760	74,000
Lateral load applied at the centerline of the truck and reacted at each axle. (See Photograph 13 for load application and Photograph 14 for load reaction).	7,164	20,000
Outward longitudinal load applied to each axle (See Photograph 15 for load application and Photograph 16 for load reaction).	24,500	30,000
Vertical downward load applied on each motor mount (See Photograph 17 for test setup).	10,351 17,811 24,137	25,000

Loading Condition	Load for Stress Determination Lbs.	Maximum Load Applied Lbs.
Vertical upward load applied on one motor mount (See Photograph 18 for test setup).	10,351 17,811 24,137	25,000
Lateral load applied in each direction on each motor mount (See Photograph 19 for test setup).	6,722 11,600	12,500

This truck was set up for test using chevrons, dummy axles & dummy boxes. The dummy axles were supported by stands at each end. These stands were located equidistant from the centerline of the journal. Side bearing pads and a dummy bolster were used for vertical load applications to the truck frame. All loads for stress determination are for a car weight of 41,500# on the air springs.

The vertical load of 47,760# due to the load on journal boxes was applied equally to the side bearing pads thru the dummy bolster by communicated hydraulic jacks with a load cell and ball seat. This load was reacted at the supports for the axles. See Photograph 12 for test setup.

For the lateral and longitudinal loading conditions applied to the truck frame a constant vertical load was applied at the center of the dummy bolster by an air spring and reacted near the end of each dummy axle. The reaction was thru ball bearings placed between two hardened steel plates. The vertical load was necessary to maintain the chevrons in place under lateral or longitudinal load. The air spring and ball bearings were used to reduce external resistance to lateral and longitudinal motion to a minimum.

The lateral load of 7,164 lbs. due to 15% of the weight on journals was applied at the centerline of the truck at the centerline of journal height and reacted at the end of each dummy axle. This load was applied to one side of the truck and then reversed to the other side of the truck. See Photograph 13 for load application and Photograph 14 for load reaction.

The longitudinal load of 24,500 lbs. which was applied at the centerline on one axle and reacted at the centerline of the other axle is due to a maximum full service brake shoe force of 10,280 lbs. per wheel plus an adhesion factor of 15% of the weight at rail. See Photograph 15 for load application and Photograph 16 for load reaction.

The motor mount bracket loads were specified by Garrett. (See Comments). The vertical downward motor mount bracket load of 24,137 lbs. was applied thru a rubber pad to each motor mount bracket. The load (48,274 lbs) was applied to the center of a beam supported on each rubber pad. The load was reacted at the supports for the axles. See Photograph 17 for the test setup.

The vertical upward motor mount bracket load of 24,137 lbs. was applied thru a rubber pad to the strain gaged motor mount. This load was reacted at the side bearing pads and the supports for the axles. See Photograph 18 for the test setup.

The lateral motor mount bracket load of 11,600 lbs. was applied thru a rubber pad to each motor mount bracket. The load (23,200 lbs) was applied to the centerline of a beam connected to a plate on top of the rubber by a tension member. The load on the plate placed the rubber pads in compression. The load (23,200 lbs) was reacted at the centerline of the truck. See Photograph 19 for the test setup.

Results of Test:

Tables 1 and 2 contain the stresses for the truck frame.

Sketch A is a plot of the average chevron deflection versus applied vertical load.

Photographs 4 thru 11 show the Stresscoat indications.

Comments:

All truck frames were reinforced per Photograph 3, and had the radius at the side bearers blended before shipment.

For vertical, lateral and longitudinal loading conditions, the tests were conducted in the pedestal areas with the tie bolts with an initial torque of 30 ft.lbs. and at the request of Boeing-Vertol with the tie bolts loose. Spacers were not used for the test.

The following data was supplied by Garrett based on their assumptions:

	Vertical	Lateral	No. Cycles
Condition 11	10,351#	11,600#	10^6
Condition 12	17,811#	6,722#	10^6
Condition 13	17,811#	11,600#	10
Condition 14	24,137#	6,722#	10

Due to the fact that this truck has primary springing, it is very doubtful that the 17,811# vertical force generated by a 15G vertical acceleration or the 11,600# lateral force generated by a 10G lateral acceleration would be obtained. Therefore we feel that the motor test loads are high, the motor bracket was very conservatively tested and recorded stresses are acceptable for the test conditions imposed.

T. M. Herbert

T. M. Herbert
Engineer of Tests

Attachments
TMH:jml

LIST OF ATTACHMENTS

SG 34701	LOCATION AND NUMBERS OF STRAIN GAGES ON THE TRUCK FRAME.
TABLE 1	RECORDED STRESSES IN THE TRUCK FRAME FOR DESIGNATED LOAD CONDITIONS.
TABLE 2	EVALUATION OF ROSETTES ON THE TRUCK FRAME FOR DESIGNATED LOAD CONDITIONS.
SKETCH A	AVERAGE CHEVRON DEFLECTION VS. VERTICAL LOAD.
PHOTOGRAPH 1	STRESSCOAT AREA OF THE TOP SIDE OF THE TRUCK FRAME.
PHOTOGRAPH 2	STRESSCOAT AREA OF THE BOTTOM SIDE OF THE TRUCK FRAME.
PHOTOGRAPH 3	STRESSCOAT AREA OF THE REVISION TO THE TRUCK FRAME IN THE AREA OF THE SIDE BEARER.
PHOTOGRAPH 4	STRESSCOAT INDICATIONS IN THE SIDE WALL OF THE WHEELPIECE UNDER VERTICAL OVER LOAD. ROSETTES 56 AND 56S WERE PLACED AT THESE INDICATIONS.
PHOTOGRAPH 5	STRESSCOAT INDICATIONS IN THE TOP OF THE PEDESTAL OPENING UNDER VERTICAL OVER LOAD WITH LOOSE TIE BARS. STRAIN GAGES 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 45, 46, 19S, 20S, 21S, 22S, 23S, 24S, 25S, 26S, 27S, 28S, 45S AND 46S WERE PLACED AT THESE INDICATIONS.
PHOTOGRAPH 6	STRESSCOAT INDICATIONS IN THE AREA OF THE SIDE BEARER UNDER VERTICAL OVER LOAD. THIS AREA WAS GROUND TO INCREASE THE RADIUS AND STRAIN GAGES 44 AND 44S WERE PLACED AT THESE INDICATIONS.
PHOTOGRAPH 7	STRESSCOAT INDICATIONS IN THE TOP OF THE WHEELPIECE UNDER VERTICAL OVER LOAD INBOARD OF THE BRAKE BRACKET. STRAIN GAGES 39 AND 39S WERE PLACED AT THESE INDICATIONS.
PHOTOGRAPH 8	STRESSCOAT INDICATIONS IN MOTOR MOUNT BRACKET UNDER VERTICAL MOTOR MOUNT LOAD. STRAIN GAGES 16 AND 17 WERE PLACED AT THESE INDICATIONS.
PHOTOGRAPH 9	STRESSCOAT INDICATIONS IN MOTOR MOUNT BRACKET UNDER VERTICAL MOTOR MOUNT LOAD. STRAIN GAGES 11 AND 12 WERE PLACED AT THESE INDICATIONS.

LIST OF ATTACHMENTS (continued)

PHOTOGRAPH 10 STRESSCOAT INDICATIONS IN MOTOR MOUNT BRACKET UNDER VERTICAL MOTOR MOUNT LOAD. STRAIN GAGES 50 AND 51 WERE PLACED AT THESE INDICATIONS.

PHOTOGRAPH 11 STRESSCOAT INDICATIONS IN MOTOR MOUNT BRACKET UNDER LATERAL LOAD. STRAIN GAGES 13, 14, 52 AND 54 WERE PLACED AT THESE INDICATIONS.

PHOTOGRAPH 12 VERTICAL LOAD TEST SETUP. LOAD APPLIED TO DUMMY BOLSTER AND REACTED BY DUMMY AXLES.

PHOTOGRAPH 13 LATERAL LOAD APPLICATION AT THE CENTERLINE OF THE TRUCK AT CENTERLINE OF JOURNAL HEIGHT. SEE PHOTOGRAPH 14 FOR LOAD REACTION. NOTE AIR SPRING TO APPLY VERTICAL LOAD TO RETAIN CHEVRONS IN PLACE. BALL BEARINGS ARE PLACED BETWEEN HARDENED STEEL PLATES UNDER THE AXLES SO THAT THE TRUCK FRAME CAN MOVE LATERALLY FREELY.

PHOTOGRAPH 14 LATERAL LOAD REACTION AT THE ENDS OF THE AXLE. SEE PHOTOGRAPH 13 FOR LOAD APPLICATION.

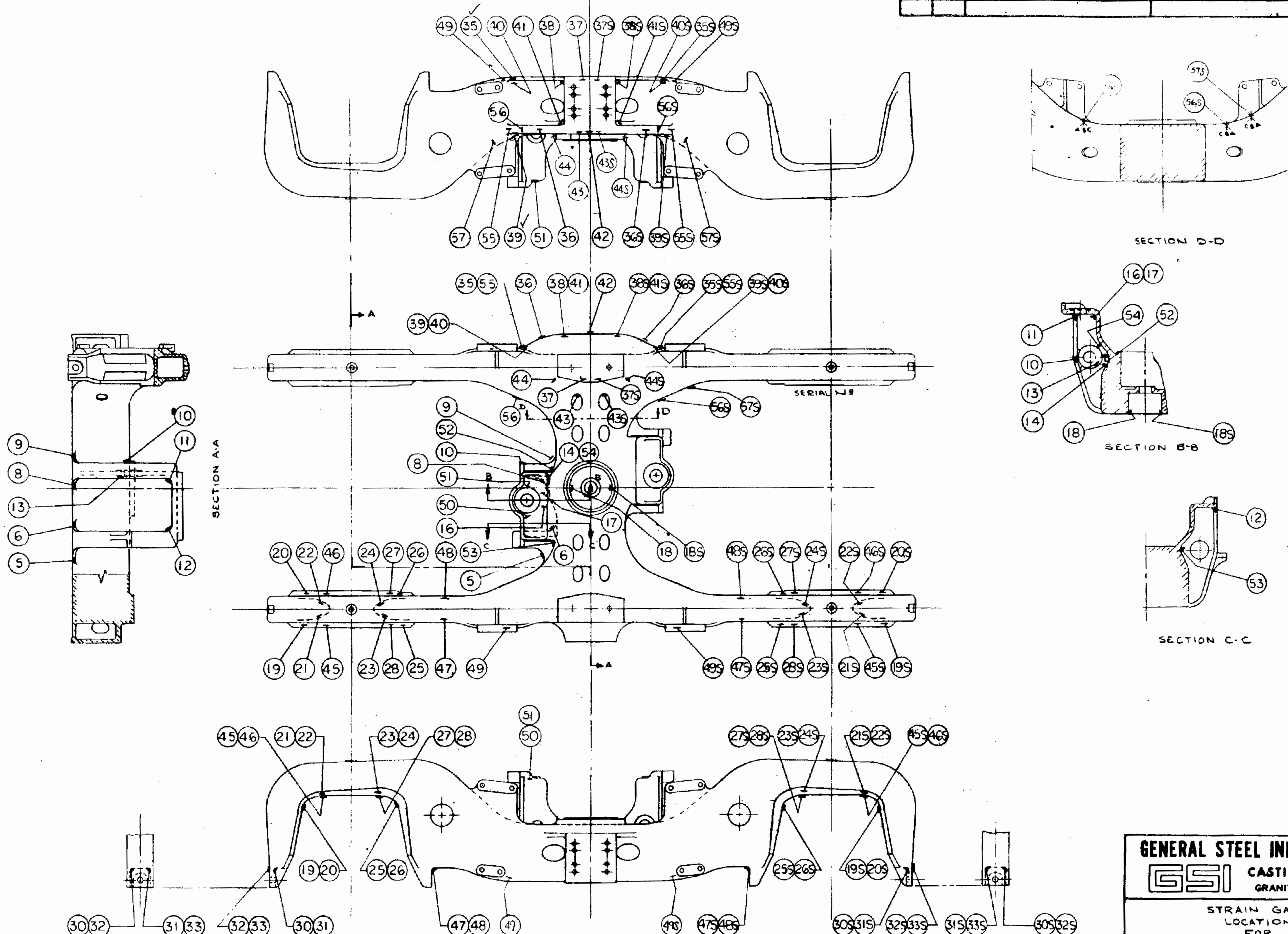
PHOTOGRAPH 15 LONGITUDINAL LOAD APPLICATION AT THE CENTERLINE OF AXLE. THE SAME SETUP FOR VERTICAL LOAD TO RETAIN CHEVRON IN PLACE AS SHOWN IN PHOTOGRAPH 13 WAS USED. SEE PHOTOGRAPH 16 FOR LOAD REACTION.

PHOTOGRAPH 16 LONGITUDINAL LOAD REACTION AT THE CENTERLINE OF AXLE. SEE PHOTOGRAPH 15 FOR LOAD APPLICATION.

PHOTOGRAPH 17 VERTICAL DOWNWARD LOAD MOTOR MOUNT TEST SETUP. BOTH MOTOR MOUNTS WERE LOADED. REACTION TO THESE LOADS IS AT THE AXLES.

PHOTOGRAPH 18 VERTICAL UPWARD MOTOR MOUNT TEST SETUP. ONE MOTOR MOUNT WAS LOADED. REACTION IS AT SIDE BEARERS AND AXLES.

PHOTOGRAPH 19 LATERAL LOAD TEST SETUP. LOAD IS APPLIED TO BOTH MOTOR MOUNTS AND REACTED AT THE CENTERLINE OF THE TRUCK FRAME.



T A B L E I

S.O.A.C. TRUCK FRAME STRESSES UNDER DESIGN LOADING CONDITIONS - PATTERN NO. 34701 SERIAL NO. 1 CAST DATE 3-72

\- DESIGNATES COMPRESSION STRESSES + DESIGNATES TENSION STRESSES STRESS IN 1000 PSI

Gage No.	Stress due to a Vertical Load of 47,760# total applied equally at the side bearers		Stress due to a Lateral Load of 7164# applied to the serial no. side of the truck		Stress due to a Lateral Load of 7164# applied to non-serial no. side of the truck		Stress due to an Outward Longitudinal Load of 24,500# per Axle	
	Tie Bars Torqued to 30 ft. Lb.	Tie Bars Loose	Tie Bars Torqued to 30 ft. Lb.	Tie Bars Loose	Tie Bars Torqued to 30 ft. Lb.	Tie Bars Loose	Tie Bars Torqued to 30 ft. Lb.	Tie Bars Loose
5	-2.4	N.R.	+1.2	+1.2	-1.5	N.R.	0	N.R.
6	0		0	0	0		0	
8	0		0	0	0		0	
9	0		0	0	0		0	
10	0		0	0	0		0	
11 *	0		0	0	0		0	
12 *	0		0	N.R.	0		0	
13 *	0		0		0		0	
14 *	0		0		0		0	
16 *	0		0		0		0	
17 *	0		0	0	0		0	
18	0		0	0	0		0	
18S	0		0	0	0		0	
19 *	0	+7.8	0	0	0	0	0	+5.4
19S*	0	+8.9	0	0	0	0	+1.0	+7.5
20 *	0	+8.1	0	0	0	0	+1.2	+6.0
20S*	0	+6.9	0	0	0	0	+1.2	+6.0
21 *	+3.8	+10.1	+1.2	+1.2	-1.2	-1.2	+1.8	+4.8
21S*	+4.8	+14.4	+1.2	0	0	0	+3.0	+9.3
22 *	+4.4	+9.9	-1.2	-1.2	+1.2	+1.2	+2.2	+5.4
22S*	+6.3	+13.8	-0.9	-1.2	0	+0.9	+2.6	+8.3
23 *	+4.2	+8.1	-1.5	-1.5	+1.5	+1.2	+1.6	+4.5
23S*	+7.8	+15.0	-1.5	-1.8	+1.2	+1.2	+2.1	+7.1
24 *	+6.3	+11.0	+1.5	+1.2	-1.5	-2.4	+1.4	+5.0
24S*	+6.0	+10.8	+1.2	+1.2	-1.4	-1.2	+2.1	+6.0
25 *	+5.6	+11.6	0	0	0	-1.2	+1.0	+3.3
25S*	B.O.	B.O.	B.O.	B.O.	B.O.	B.O.	B.O.	B.O.
26	+7.8	+11.4	-1.2	-1.2	+1.1	+1.2	+0.4	+3.6
26S*	+7.5	+11.6	-1.2	-0.9	0	0	+0.9	+3.8
27 *	+7.2	+12.0	0	0	0	-1.2	+2.4	+5.1
27S*	+7.8	+13.1	0	0	0	0	+2.6	+6.0
28 *	+5.9	+11.4	0	0	0	0	+2.2	+5.1
28S*	+6.6	+12.0	0	0	0	0	+2.1	+5.7
30	0	0	0	0	0	0	0	0
30S	+3.3	0	0	0	0	0	+2.2	0
31	0	0	0	0	0	0	0	0
31S	+2.7	0	0	0	0	0	+1.2	0

Gage No.	Stress due to a Vertical Downward Load applied to Motor Mount Bracket as specified below			Stress due to a Vertical Upward Load applied to the motor mount bracket as specified below			Stress due to a Lateral Load applied to the motor mount bracket as specified below. Lateral Load toward non-serial side of truck		Stress due to a Lateral Load applied to the motor mount bracket as specified below. Lateral load toward serial side of truck	
	10,351#	17,811#	24,137#	10,351#	17,811#	24,137#	6,720#	11,600#	6,720#	11,600#
5	+1.5	+2.7	+3.9	-2.7	-4.5	-6.1	0	0	-0.8	1.2
6	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	-4.6	-8.1	+4.8	+9.3
9	+0.9	+1.5	+1.8	+1.8	+3.0	+4.0	+1.	+1.6	-1.5	-2.6
10	+1.1	+1.5	+2.1	-1.2	-1.8	-2.4	-6..	-10.8	+7.2	+12.3
11 *	-15.9	-27.3	-37.2	+18.6	+32.1	+43.8	-5.0	-8.6	+5.1	+8.7
12 *	-12.0	-20.1	-27.3	+11.6	+20.1	+27.0	0	0	0	0
13 *	+0.9	+1.8	+2.4	-1.2	-2.1	-2.7	+5.4	+9.3	B.O.	B.O.
14 *	+0.6	+1.2	+1.5	0	0	0	-9.6	-16.5	+9.0	+15.6
16 *	-9.2	-15.5	-21.0	+9.0	+15.3	+20.8	0	0	0	0
17 *	-9.2	-15.5	-21.0	+8.9	+15.0	+20.4	+1.5	+2.7	-1.7	-2.9
18	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.

TABLE I (Page 2)

S.O.A.C. TRUCK FRAME STRESSES UNDER DESIGN LOADING CONDITIONS PATTERN NO. 34701 SERIAL NO. 1 CAST DATE 3-72

- DESIGNATES COMPRESSION STRESSES + DESIGNATES TENSION STRESSES STRESS IN 1000 PSI

	Stress due to a Vertical Load of 47,760# total applied equally at the side bearers		Stress due to a Lateral Load of 7164# applied to the serial no. side of the truck		Stress due to a Lateral Load of 7164# applied to non-serial no. side of the truck		Stress due to an Outward Longitudinal Load of 24,500# per Axle		Stress due to a Vertical Downward Load applied to Motor Mount Bracket as specified below			Stress due to a Vertical Upward Load applied to the motor mount bracket as specified below			Stress due to a Lateral Load applied to the motor mount bracket as specified below. Lateral Load toward non-serial side of truck		Stress due to a Lateral Load applied to the motor mount bracket as specified below. Lateral load toward serial side of truck	
Gage No.	Tie Bars Torqued to 30 ft. Lb.	Tie Bars Loose	Tie Bars Torqued to 30 ft. Lb.	Tie Bars Loose	Tie Bars Torqued to 30 ft. Lb.	Tie Bars Loose	Tie Bars Torqued to 30 ft. Lb.	Tie Bars Loose	10,351#	17,811#	24,137#	10,351#	17,811#	24,137#	6,720#	11,600#	6,720#	11,600#
32	+2.4	0	0	0	0	0	+1.2	0	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
32S	+3.0	0	0	0	0	0	+2.1	0										
33	0	0	0	0	0	0	0	0										
33S	0	0	0	0	0	0	0	0										
35	+14.1	N.R.	+1.8	N.R.	-1.2	N.R.	0	N.R.										
35S	+11.9		+1.2	N.R.	-0.9		0											
36	-3.6		+0.9	+0.9	0		0											
36S	-6.9		+1.5	+1.5	-1.4		+1.5											
37	+4.8		0	N.R.	0		0											
37S	+5.1		0	N.R.	0		0											
38	+10.2		0		0		0											
38S	+10.8		0	↓	0		0											
39 *	-15.0		+2.4	+2.4	-2.7		+2.0											
39S*	-15.9		+2.4	+2.4	-2.3		+2.7											
40	+14.1		+2.1	N.R.	-1.2		0											
40S	+8.6		+1.2	N.R.	0		0											
41	-6.0		+2.1	+2.1	-2.6		+1.2											
41S	-6.5		+2.1	N.R.	-1.8		+1.5											
42	-3.9		0	0	-1.2		0											
43	-4.8		-1.5	-1.5	+2.1		+1.8											
43S	-6.3		-1.5	N.R.	+1.5		+1.5											
44 *	-14.6		+1.2	+1.2	0		0											
44S*	-16.1	↓	+1.2	+1.2	0	↓	+0.9	↓										
45 *	+3.3	+9.6	0	0	0	0	+1.8	+5.4										
45S*	+3.6	+10.8	0	0	0	0	+1.8	+7.1										
46 *	+3.5	+10.1	0	0	0	0	+2.1	+5.7										
46S*	+3.9	+12.5	0	0	0	0	+2.6	+7.8										
47	+4.8	-1.8	0	0	0	0	+4.2	N.R.										
47S	+6.3	-2.7	0	0	0	0	+4.8											
48	+7.3	0	0	0	0	0	+4.2											
48S	+8.3	0	0	0	0	0	+4.3											
49	+5.1	N.R.	-1.2	-1.2	+1.2	N.R.	0											
49S	+3.9	↓	-1.2	-1.2	+1.2	↓	0	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓

T A B L E I (Page 3)

S.O.A.C. TRUCK FRAME STRESSES UNDER DESIGN LOADING CONDITIONS PATTERN NO. 34701 SERIAL NO. 1 CAST DATE 3-72

- DESIGNATES COMPRESSION STRESSES + DESIGNATES TENSION STRESSES STRESS IN 1000 PSI

	Stress due to a Vertical Load of 47,760# total applied equally at the side bearers		Stress due to a Lateral Load of 7164# applied to the serial no. side of the truck		Stress due to a Lateral Load of 7164# applied to non-serial no. side of the truck		Stress due to an Outward Longitudinal Load of 24,500# per Axle		Stress due to a Vertical Downward Load applied to Motor Mount Bracket as specified below			Stress due to a Vertical Upward Load applied to the motor mount bracket as specified below			Stress due to a Lateral Load applied to the motor mount bracket as specified below. Lateral Load toward non-serial side of truck		Stress due to a Lateral Load applied to the motor mount bracket as specified below. Lateral load toward serial side of truck	
Gage No.	Tie Bars Torqued to 30 ft. Lb.	Tie Bars Loose	Tie Bars Torqued to 30 ft. Lb.	Tie Bars Loose	Tie Bars Torqued to 30 ft. Lb.	Tie Bars Loose	Tie Bars Torqued to 30 ft. Lb.	Tie Bars Loose	10,351#	17,811#	24,137#	10,351#	17,811#	24,137#	6,720#	11,600#	6,720#	11,600#
50 *	0	N.R.	0	0	0	N.R.	0	N.R.	-6.3	-10.8	-14.7	+6.9	+11.7	+15.9	0	0	0	0
51 *	0	↓	0	0	0	↓	0	↓	-8.3	-14.0	-18.9	+9.3	+16.1	+21.9	0	0	-0.6	-0.9
52 *	0	↓	0	0	0	↓	0	↓	+2.1	+3.6	+4.8	-2.7	-4.5	-6.3	+14.7	+25.5	-13.5	-23.4
53	+3.3	↓	-1.2	-1.2	0	↓	0	↓	-6.3	-10.8	-14.7	+1.2	+2.1	+3.0	-6.0	-10.2	+1.8	+3.3
54 *	0	↓	0	0	0	↓	0	↓	+4.8	+8.4	+11.3	-5.4	-9.6	-12.9	-12.0	-20.8	+12.3	+21.3
55	-6.9	↓	+1.2	+1.2	-1.5	↓	+0.9	↓	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
55S	-12.8	↓	+2.7	N.R.	-2.6	↓	+2.1	↓	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.

Note:

B.O. - Bad Order Strain Gage

N.R. - Not Recorded

* - Stresscoat indications at these strain gage locations

TABLE 2

S.O.A.C. TRUCK FRAME   PATTERN NO. 34701   SERIAL NO. 1   CAST DATE 3-72

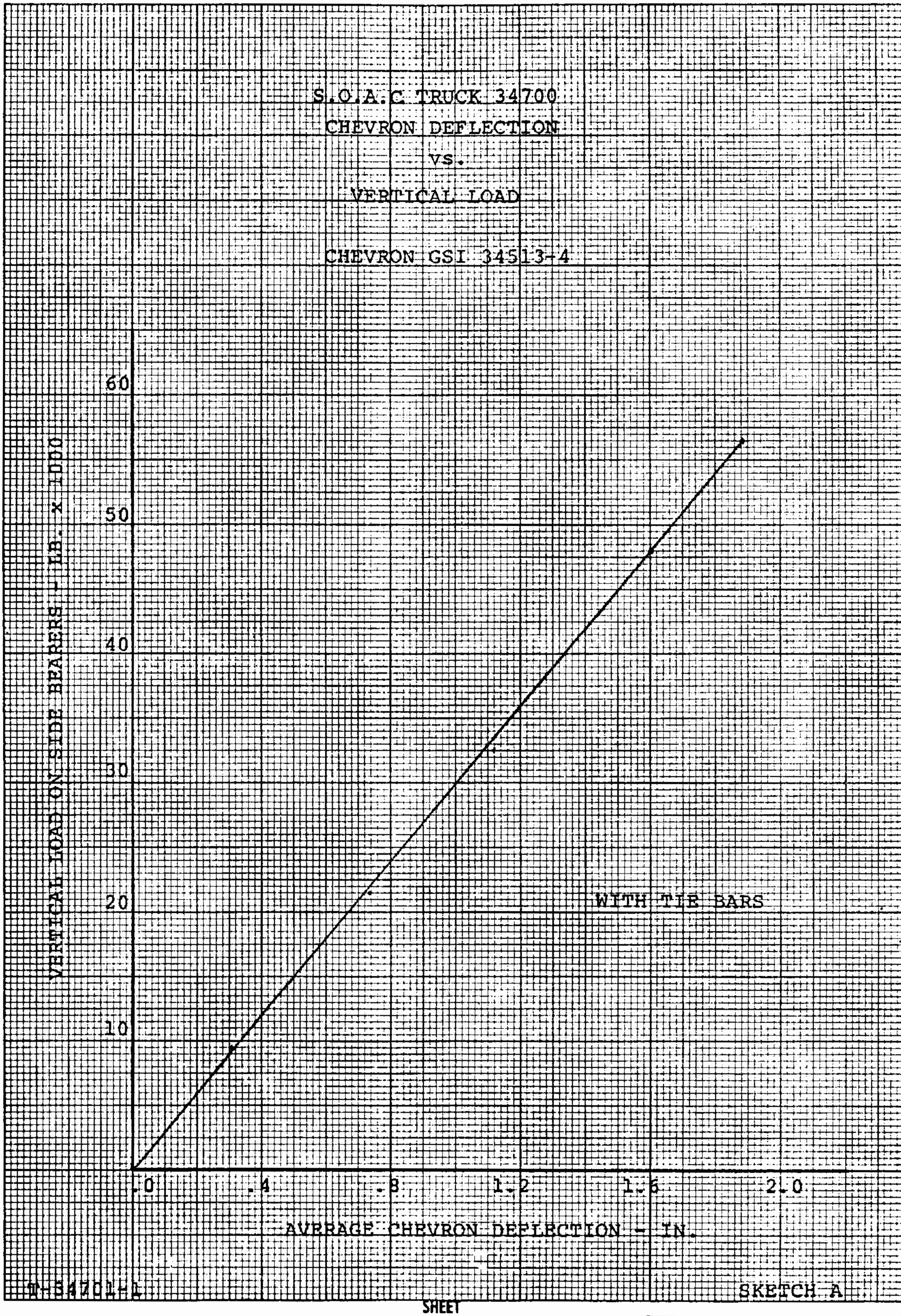
EVALUATION OF ROSETTES UNDER DESIGN LOADING CONDITIONS

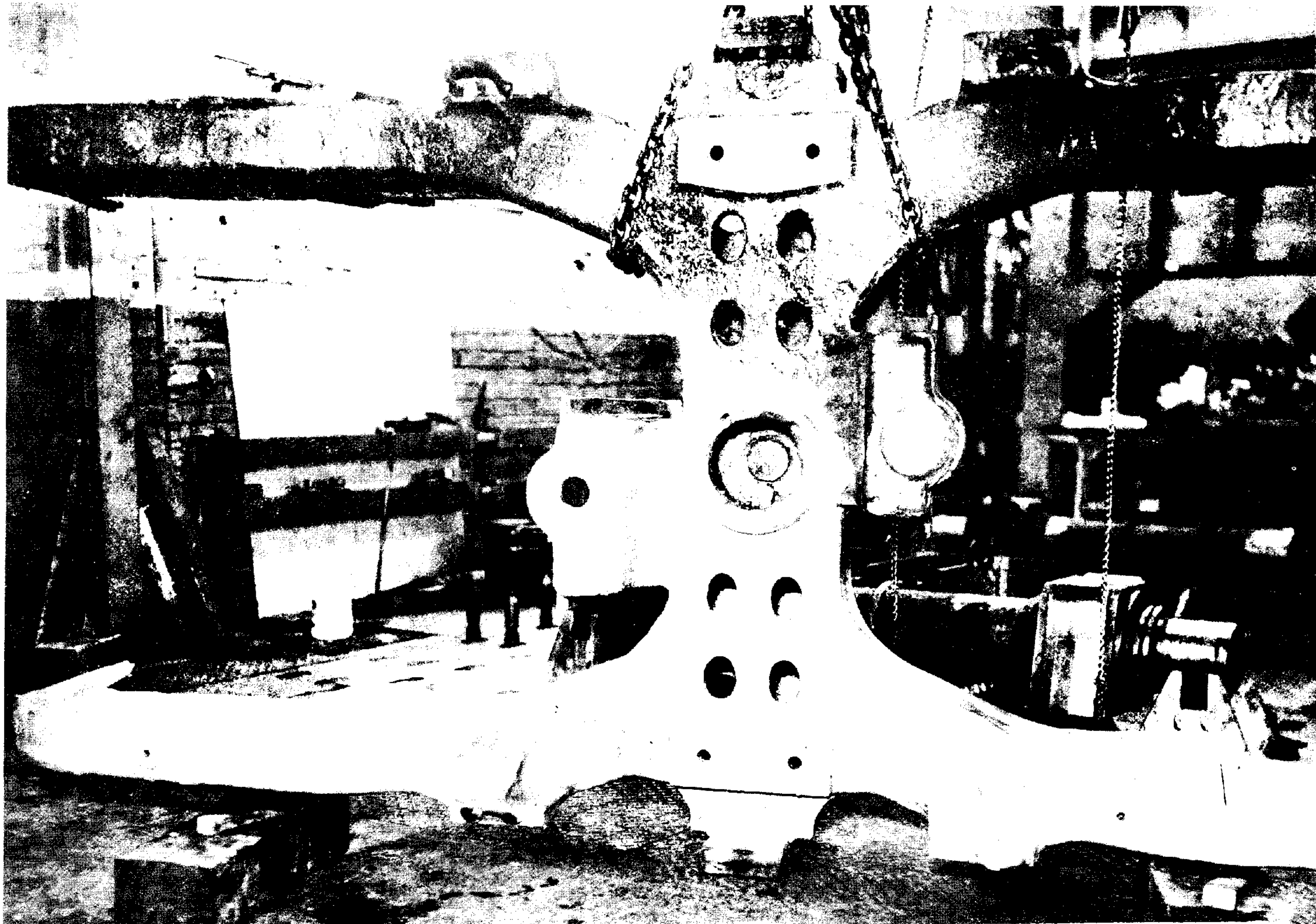
STRESS IN 1000 PSI   + DESIGNATES TENSION   - DESIGNATES COMPRESSION

LOAD CONDITION	RECORDED VALUES in/in x 10^{-6}			MAJOR VALUE	STRESS AXIS	MINOR VALUE	STRESS AXIS
Stress due to a vertical load of 47,750# total applied equally to the side bearers	Gage 56a	Gage 56b	Gage 56c				
	+105	+410	+160	+12.1	2.8°	-0.8	92.8°
	Gage 56Sa	Gage 56Sb	Gage 56Sc				
	0	+250	+150	+ 7.6	168.4°	-1.2	78.4°
	Gage 57Sa	Gage 57Sb	Gage 57Sc				
	+205	+320	-30	+ 9.8	13.4°	-2.2	103.4°
Stress due to an outward longitudinal load of 24,500# per axle	Gage 56a	Gage 56b	Gage 56c				
	0	-50	0	+1.2	90°	-1.2	0°
	Gage 56Sa	Gage 56Sb	Gage 56Sc				
	0	-60	-30	+0.4	80.8°	-1.7	170.8°
	Gage 57Sa	Gage 57Sb	Gage 57Sc				
	-50	-75	0	+0.2	13.2°	-2.4	103.2°
Stress due to a lateral load of 7,164# applied to the non-serial no. side of the truck	Gage 56a	Gage 56b	Gage 56c				
	-60	0	-15	-0.6	-15.4°	-2.6	105.4°
	Gage 56Sa	Gage 56Sb	Gage 56Sc				
	-30	+20	0	0	168.4°	-1.3	78.4°
	Gage 57Sa	Gage 57Sb	Gage 57Sc				
	+15	+20	-40	+0.4	20.1°	-1.5	110.1°
Stress due to lateral load of 7,164# applied to serial no. side of the truck	Gage 56a	Gage 56b	Gage 56c				
	+45	0	+15	+2.0	17.5°	+0.5	107.5°
	Gage 56Sa	Gage 56Sb	Gage 56Sc				
	+40	-15	-15	+1.5	67.5°	-0.4	157.5°
	Gage 57Sa	Gage 57Sb	Gage 57Sc				
	-15	-15	+30	+1.1	17.5°	-0.4	107.5°

NOTE: Angle measured counter-clockwise from Strain Gage B

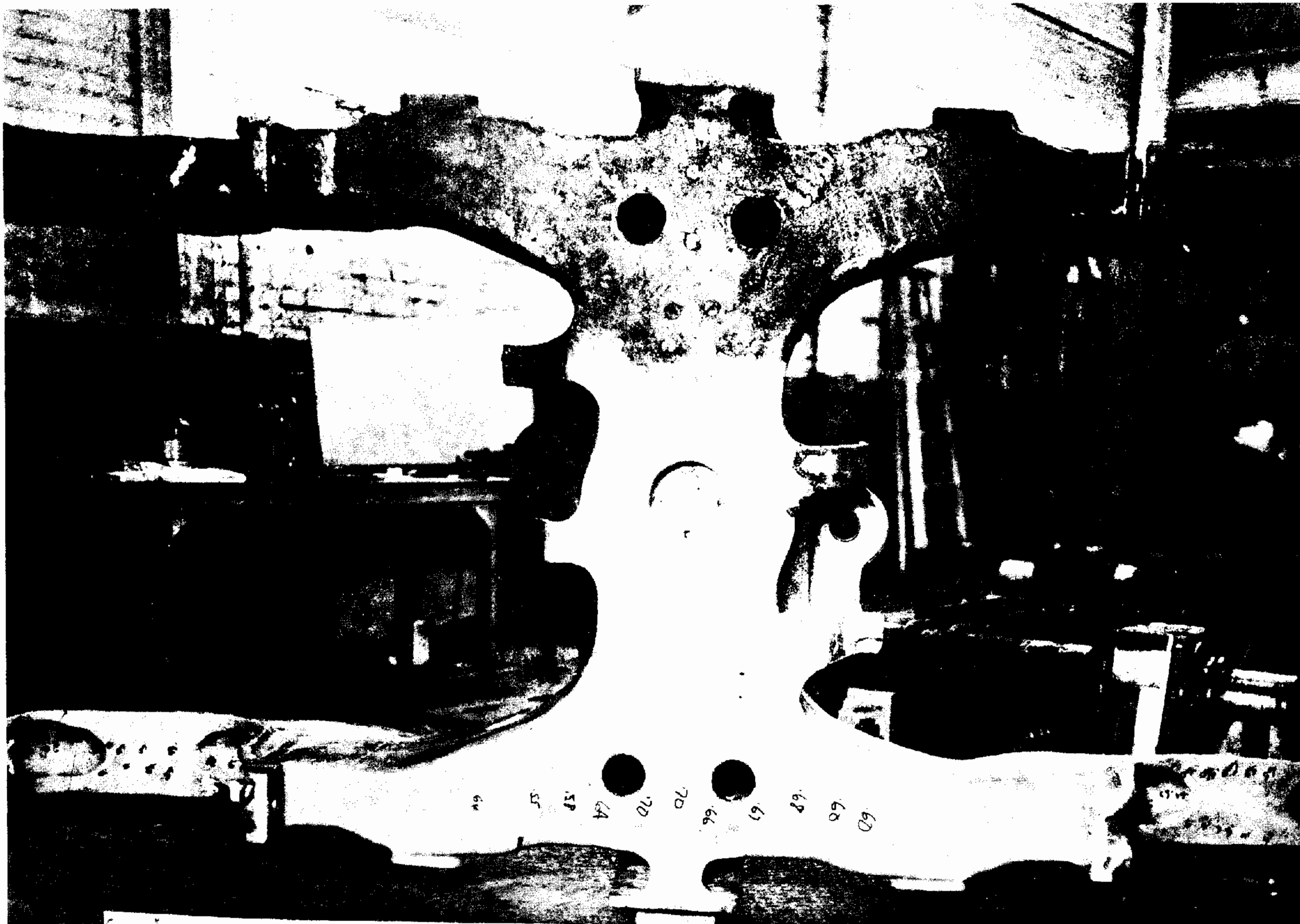
T-34701-1


S.O.A.C TRUCK 34700
CHEVRON DEFLECTION
vs.
VERTICAL LOAD
CHEVRON GSI 34513-4
VERTICAL LOAD ON SIDE BEARERS - LB. x 1000
60
50
40
30
20
10
WITH TIE BARS
.0
.4
.8
1.2
1.6
2.0
AVERAGE CHEVRON DEFLECTION - IN.
T-34701-1
SKETCH A



STRESSCOAT AREA OF THE TOP SIDE OF THE TRUCK FRAME

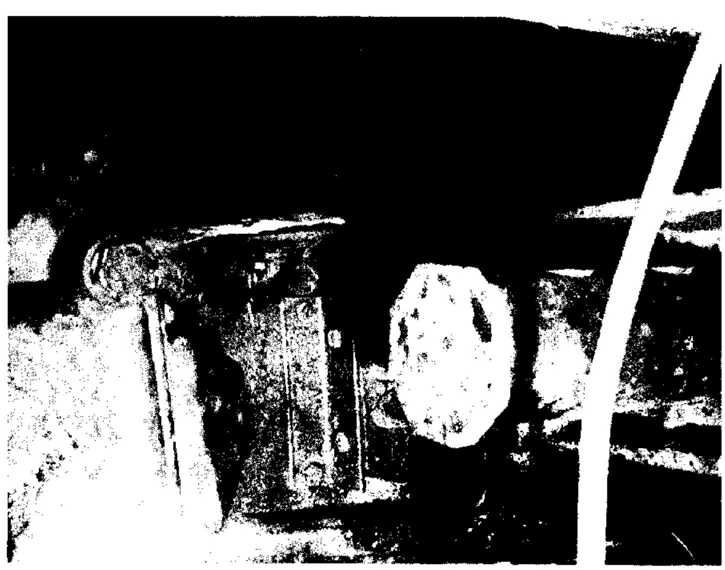
T-34701-1 PHOTOGRAPH 1

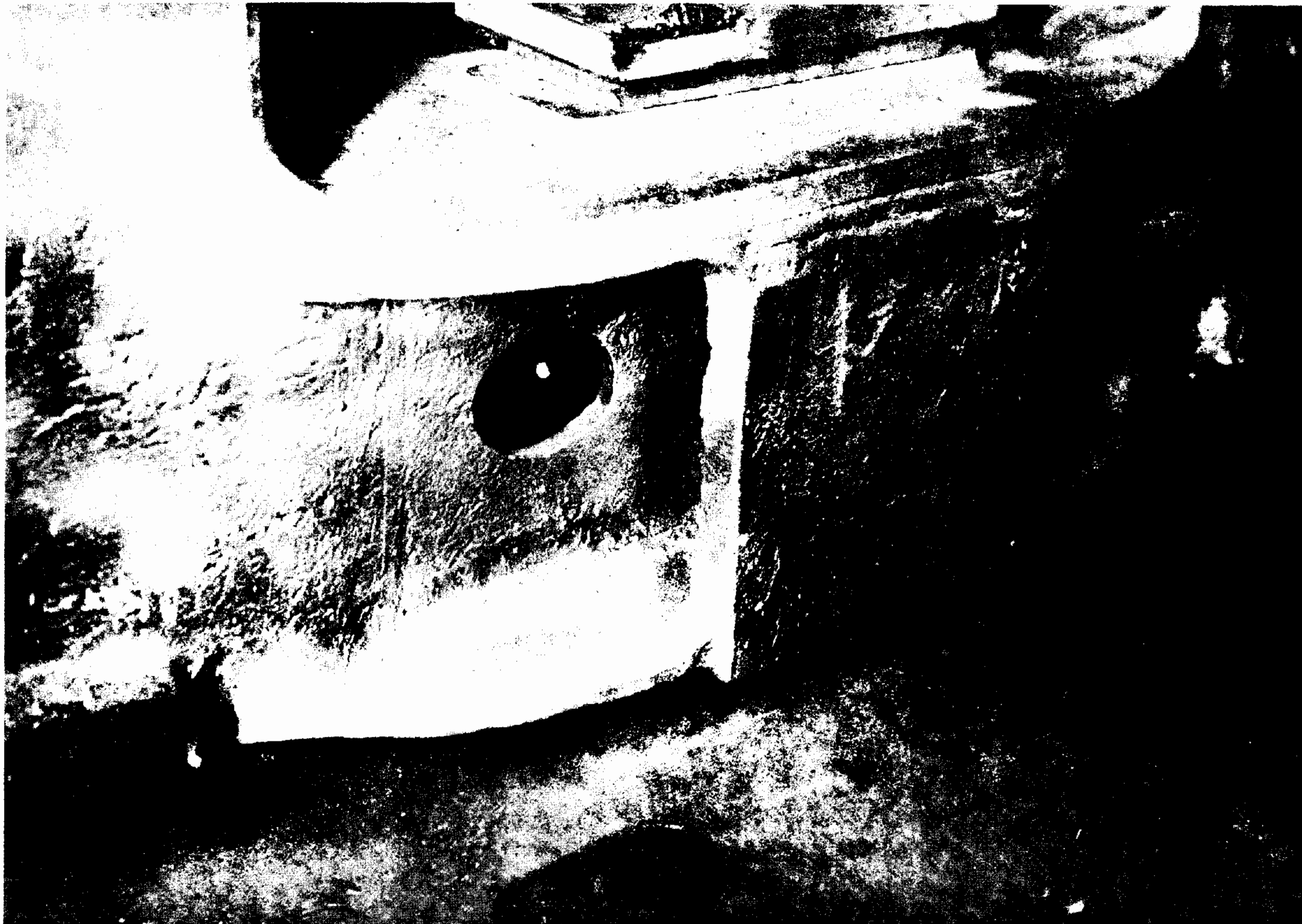


STRESSCOAT AREA OF THE BOTTOM SIDE OF THE TRUCK FRAME

T-34701-1

PHOTOGRAPH 2





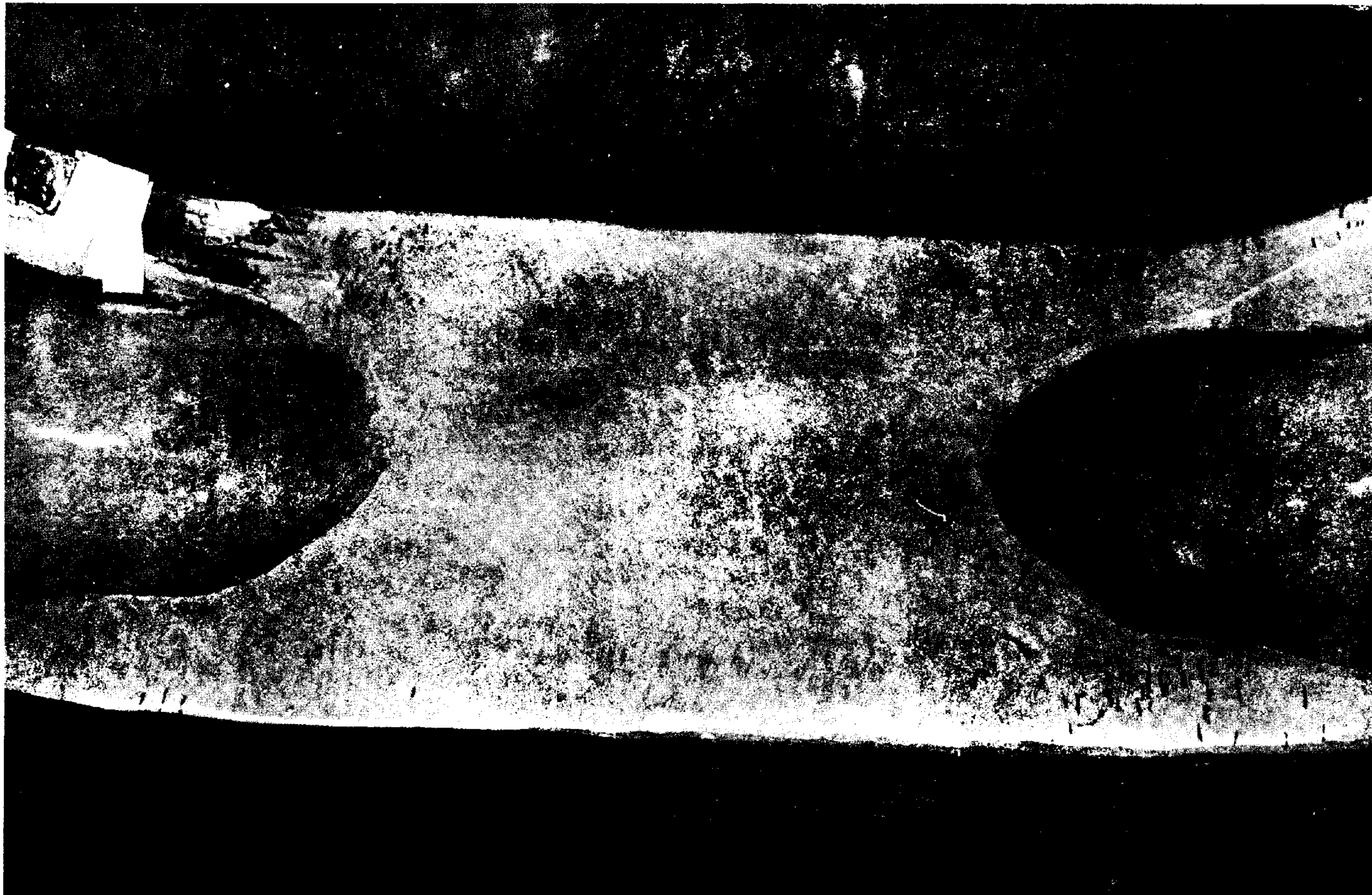
STRESSCOAT AREA OF THE REVISION TO THE TRUCK FRAME IN THE AREA OF THE SIDE BEARER.
T-34701-1

PHOTOGRAPH 3

STRESSCOAT INDICATIONS IN THE SIDE WALL OF THE WHEELPIECE UNDER VERTICAL OVER-LOAD. ROSETTES 56 AND 56S WERE PLACED AT THESE INDICATIONS.

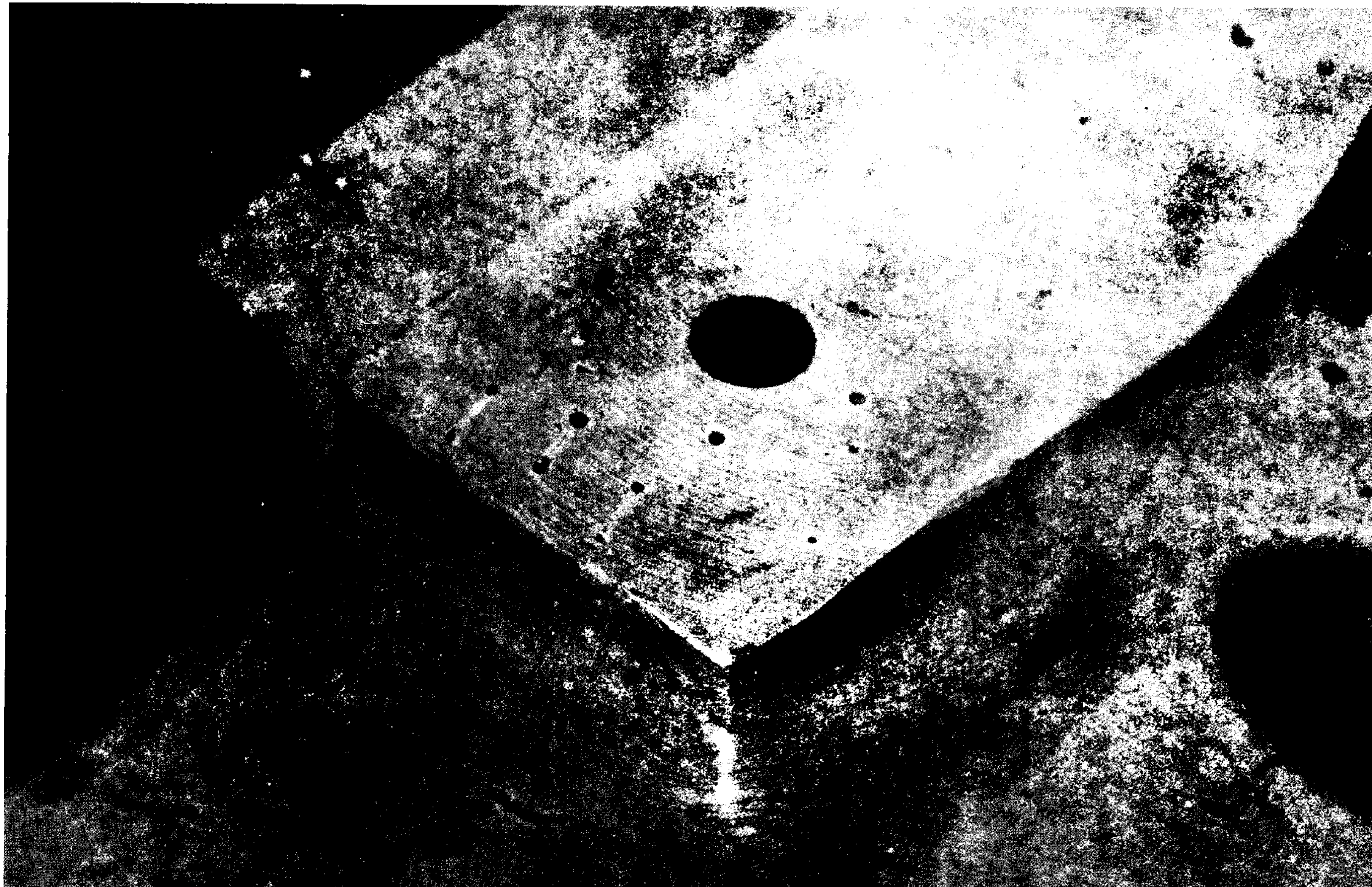
T-34701-1

PHOTOGRAPH 4



STRESSCOAT INDICATIONS IN THE TOP OF THE PEDESTAL OPENING UNDER VERTICAL OVER-LOAD WITH LOOSE TIE BARS. STRAIN GAGES 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 45, 46, 19S, 20S, 21S, 22S, 23S, 24S, 25S, 26S, 27S, 28S, 45S AND 46S WERE PLACED AT THESE INDICATIONS.

T-34701-1 PHOTOGRAPH 5



STRESSCOAT INDICATIONS IN THE AREA OF THE SIDE BEARER UNDER VERTICAL OVER-LOAD. THIS AREA WAS GROUND TO INCREASE THE RADIUS AND STRAIN GAGES 44 AND 44S WERE PLACED AT THESE INDICATIONS.

T-34701-1

PHOTOGRAPH 6

STRESSCOAT INDICATIONS IN THE TOP OF THE WHEELPIECE UNDER VERTICAL OVER-LOAD INBOARD OF THE BRAKE BRACKET. STRAIN GAGES 39 AND 39S WERE PLACED AT THESE INDICATIONS.
T-34701-1

PHOTOGRAPH 7

STRESSCOAT INDICATIONS IN MOTOR MOUNT BRACKET UNDER VERTICAL MOTOR MOUNT LOAD. STRAIN GAGES 16 AND 17 WERE PLACED AT THESE INDICATIONS.

T-34701-1 PHOTOGRAPH 8

STRESSCOAT INDICATIONS IN MOTOR MOUNT BRACKET UNDER VERTICAL MOTOR MOUNT LOAD. STRAIN GAGES 11 AND 12 WERE PLACED AT THESE INDICATIONS.

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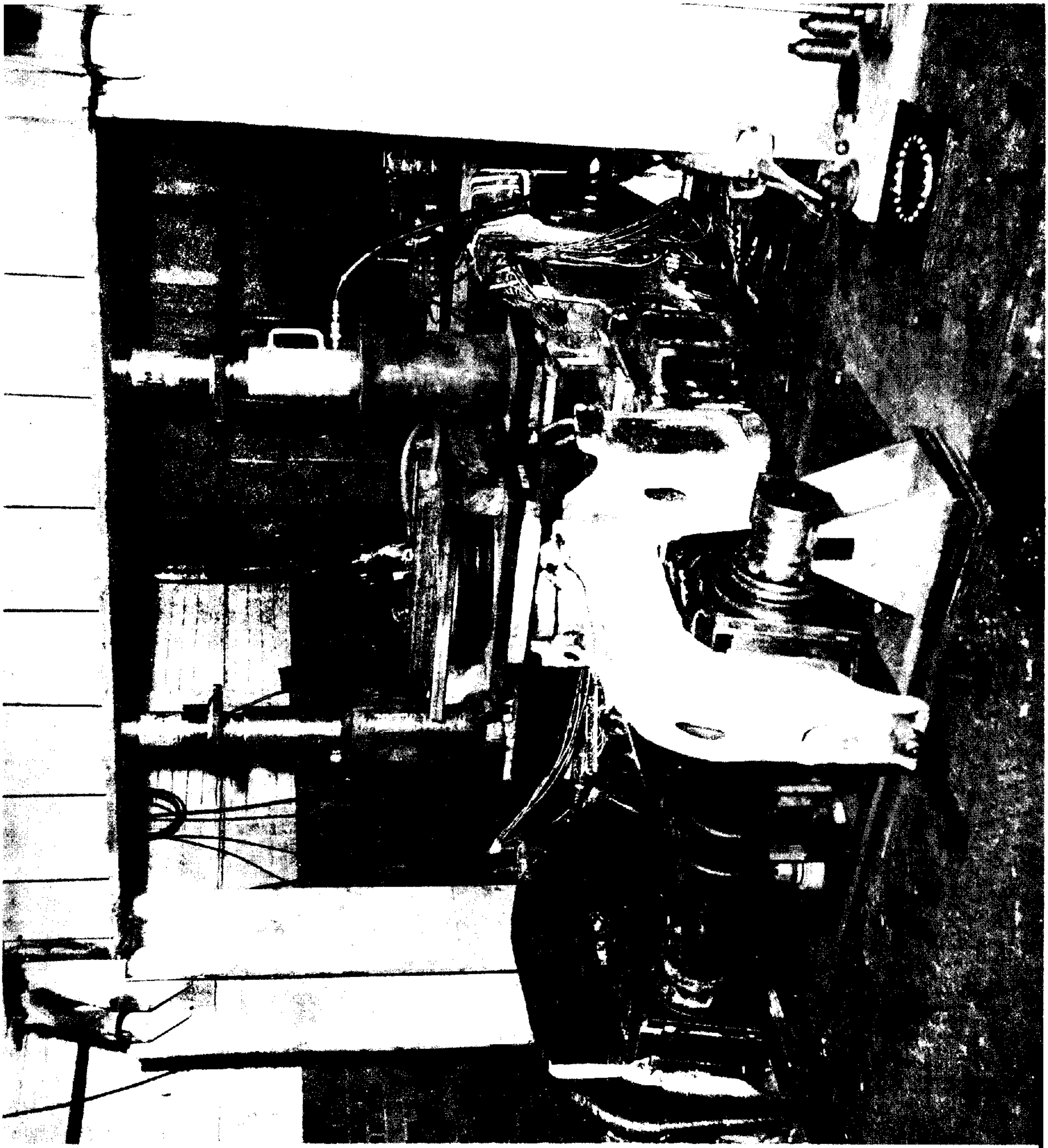
PHOTOGRAPH 9

STRESSCOAT INDICATIONS IN MOTOR MOUNT BRACKET UNDER VERTICAL MOTOR MOUNT LOAD. STRAIN GAGES 50 AND 51 WERE PLACED AT THESE INDICATIONS.

T-34701-1

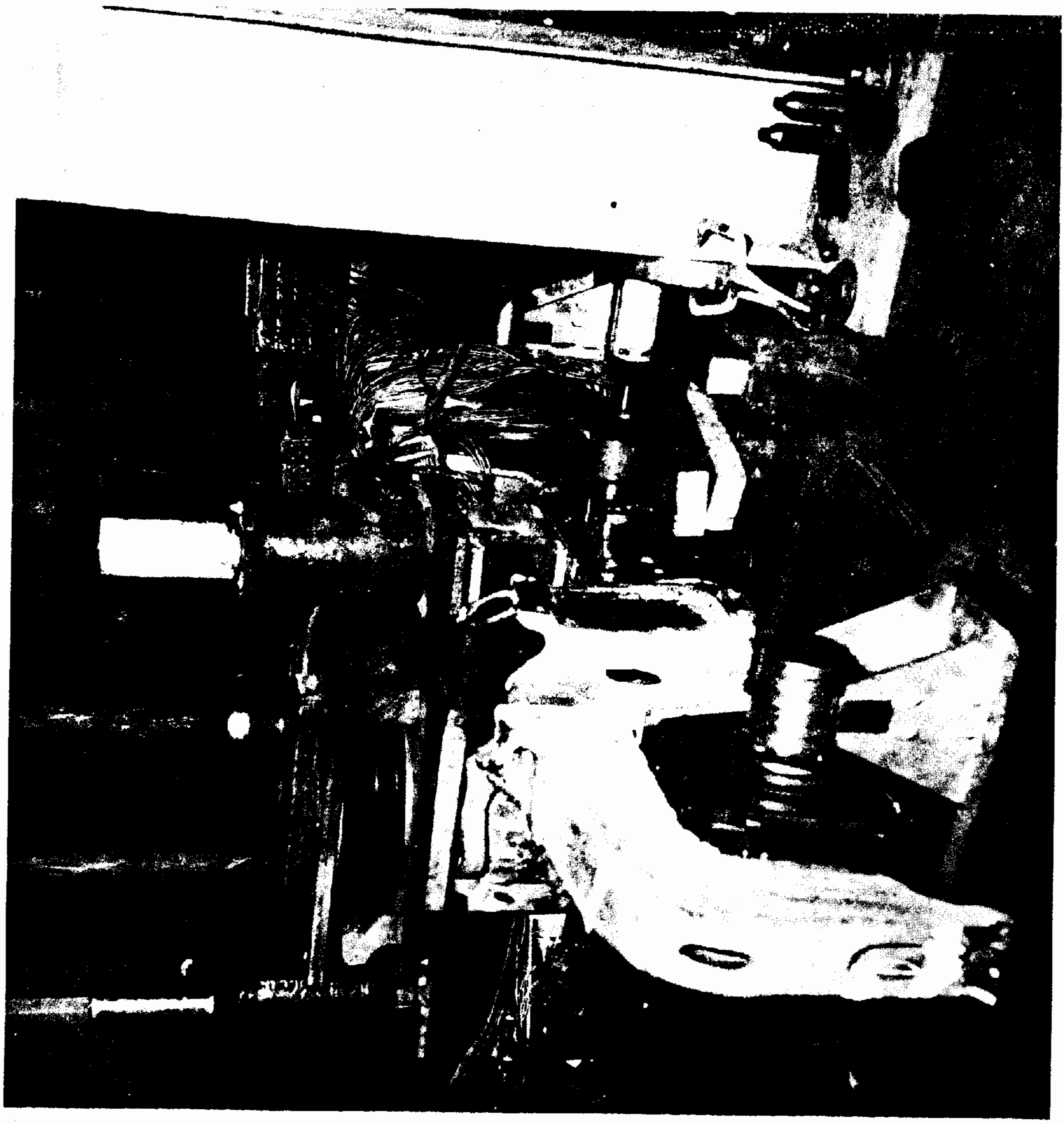
PHOTOGRAPH 10

STRESSCOAT INDICATIONS IN MOTOR MOUNT BRACKET UNDER LATERAL LOAD.
STRAIN GAGES 13, 14, 52 AND 54 WERE PLACED AT THESE INDICATIONS.
T-34701-1 PHOTOGRAPH 11



VERTICAL LOAD TEST SETUP. LOAD APPLIED TO DUMMY BOLSTER AND REACTED BY DUMMY AXLES.
T-34701-1

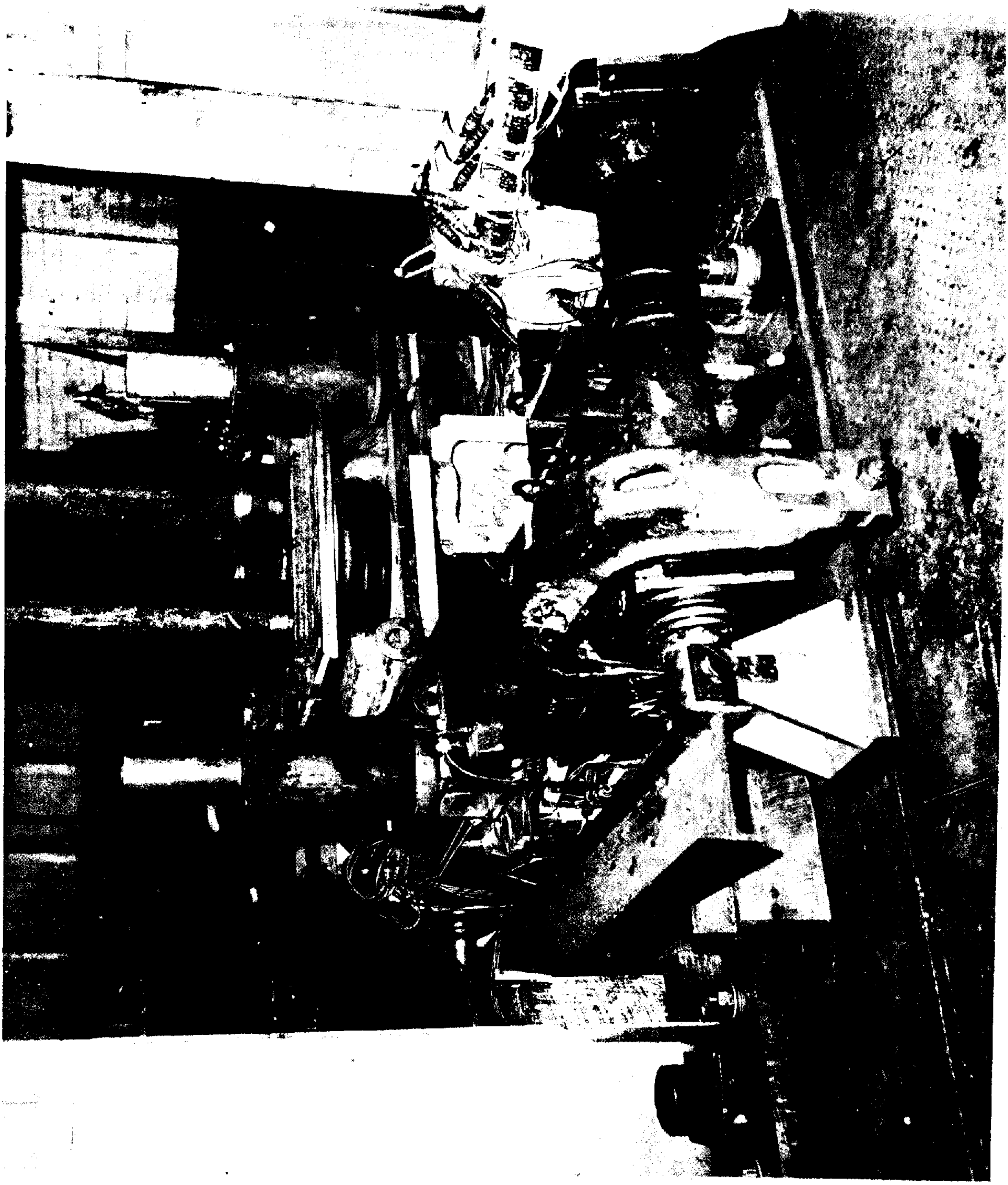
PHOTOGRAPH 12



LATERAL LOAD APPLICATION AT THE CENTER LINE OF THE TRUCK AT CENTER LINE OF JOURNAL HEIGHT. SEE PHOTOGRAPH 14 FOR LOAD REACTION. NOTE AIR SPRING TO APPLY VERTICAL LOAD TO RETAIN CHEVRONS IN PLACE. BALL BEARINGS ARE PLACED BETWEEN HARDENED STEEL PLATES UNDER THE AXLES SO THAT THE TRUCK FRAME CAN MOVE LATERALLY FREELY.

T-34701-1

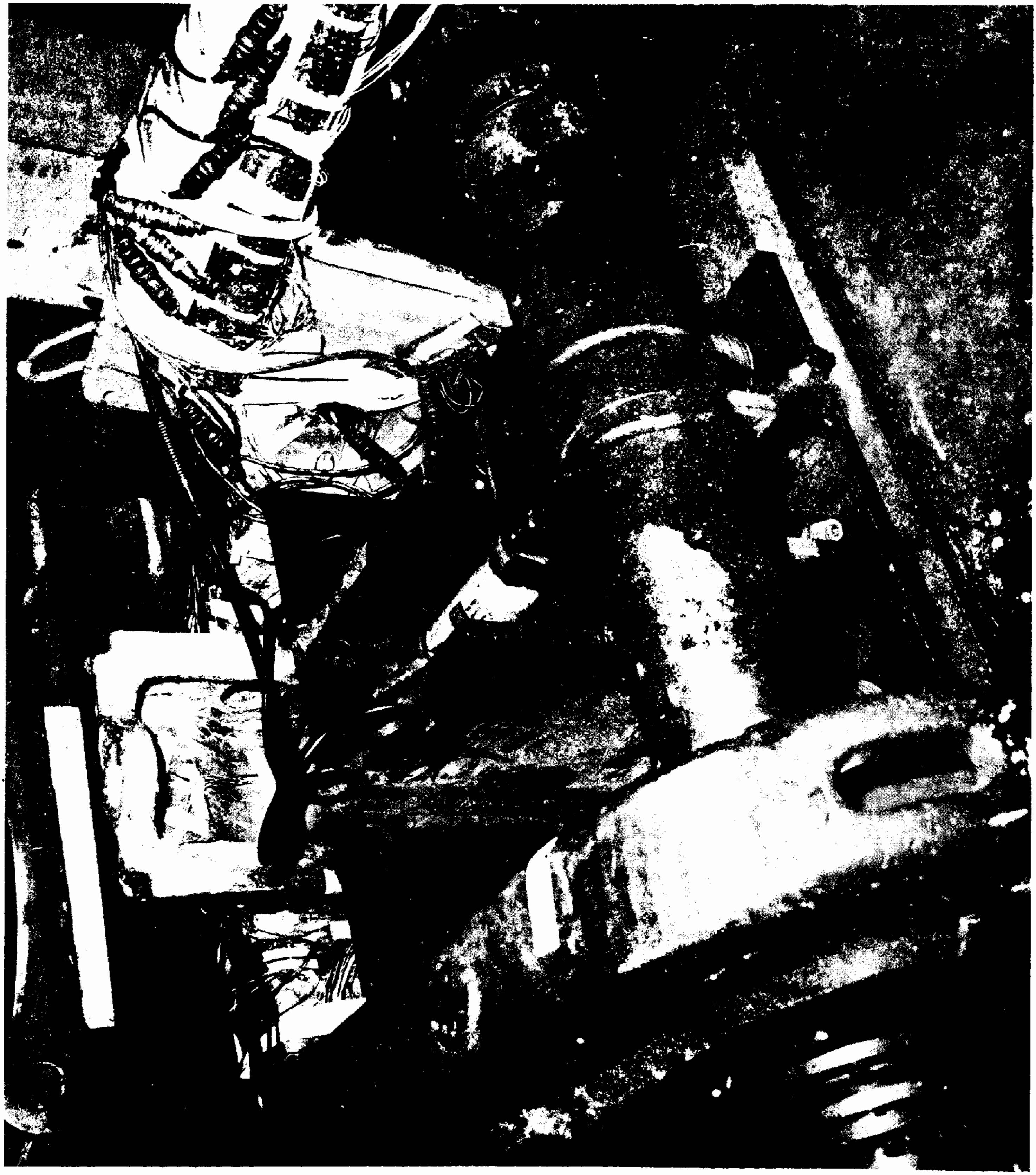
PHOTOGRAPH 13



LATERAL LOAD REACTION AT THE ENDS OF THE AXLE. SEE PHOTOGRAPH 13 FOR LOAD APPLICATION.

T-34701-1

PHOTOGRAPH 14

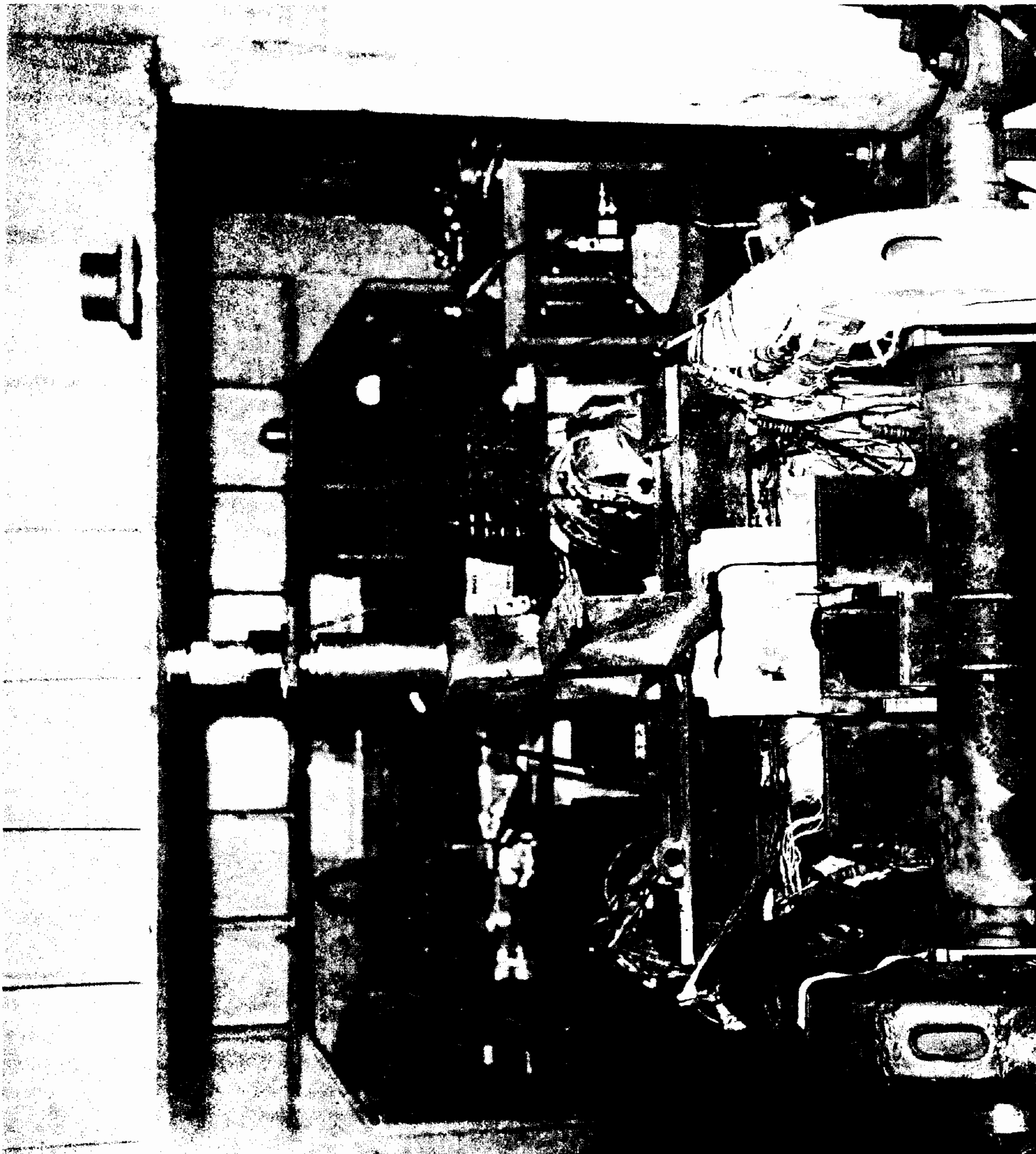


LONGITUDINAL LOAD APPLICATION AT THE CENTER LINE OF AXLE. THE SAME SET-UP FOR VERTICAL LOAD TO RETAIN CHEVRON IN PLACE AS SHOWN IN PHOTOGRAPH 13 WAS USED. SEE PHOTOGRAPH 16 FOR LOAD REACTION.

T-34701-1 PHOTOGRAPH 15

LONGITUDINAL LOAD REACTION AT THE CENTER LINE OF AXLE. SEE PHOTOGRAPH 15 FOR LOAD APPLICATION.
T-34701-1

PHOTOGRAPH 16

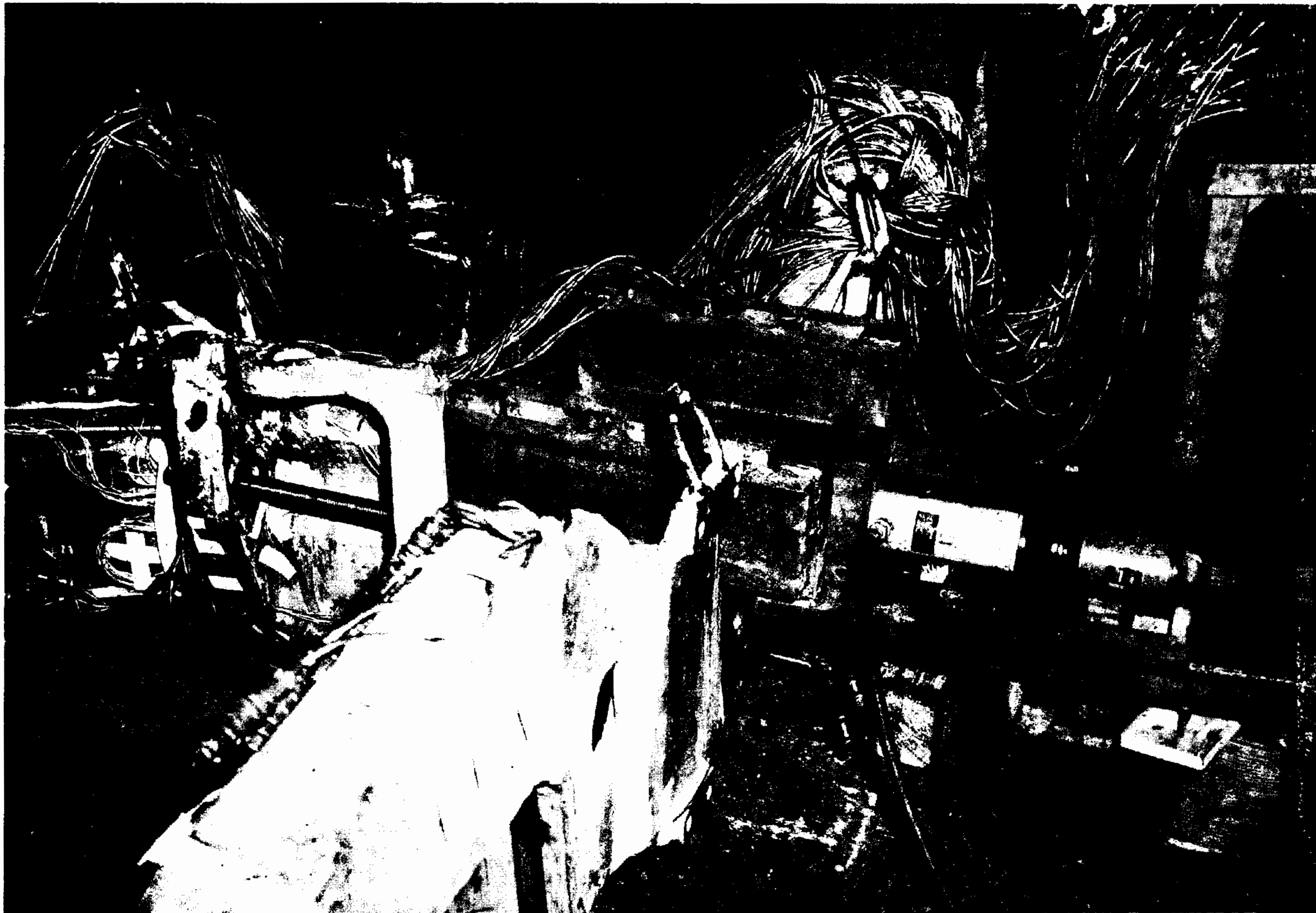


VERTICAL DOWNWARD LOAD MOTOR MOUNT TEST SET-UP. BOTH MOTOR MOUNTS WERE LOADED. REACTION TO THESE LOADS IS AT THE AXLES.
T-34701-1

PHOTOGRAPH 17

VERTICAL UPWARD MOTOR MOUNT TEST SET-UP. ONE MOTOR MOUNT WAS LOADED. REACTION IS AT SIDE BEARERS AND AXLES.
T-34701-1

PHOTOGRAPH 18



LATERAL LOAD TEST SET-UP. LOAD IS APPLIED TO BOTH MOTOR MOUNTS AND REACTED AT THE CENTER LINE OF THE TRUCK FRAME.

T-34701-1

PHOTOGRAPH 19

APPENDIX IIB

TRUCK BOLSTER

GSI REPORT T34702-1

SHEET 214

17

STATE OF ART CAR
BOLSTER STATIC TEST
FOUR WHEEL MOTOR TRUCK

TEST REPORT T-34702-1
August 30, 1972

SHEET 215

TABLE OF CONTENTS

August 30, 1972

S.O.A.C.
BOLSTER STATIC TEST
FOUR WHEEL MOTOR TRUCK
TEST REPORT T-34702-1

Introduction:

This static test was conducted on S.O.A.C. bolster, GSI 34702 serial 2 cast date 4-72, to determine the structural adequacy of the bolster. The loading forces and loading conditions were those set up on GSI's test procedure as modified in consultation with Boeing-Vertol before the start of the test.

Object:

The object of this test was to determine the stresses in the bolster under the above agreed upon loading conditions.

Conclusions:

The recorded stresses were satisfactory.

The maximum recorded stresses for the test under the agreed upon loading conditions were:

Loading Condition	Applied Load lbs.	Maximum Recorded Stress - 1000 p.s.i. Tension	Compression
Vertical Load	42,600	+16.8	-7.2
Lateral Load Normal Car Height	6225	+14.1	-8.1
Lateral Load Shimmed Car Height	6225	± 7.5	-13.5
Longitudinal	6390	+ 4.8	-5.7

Personnel:

Present for the Stresscoat test were:

R. W. Moore	GSI
G. C. Krause	GSI
T. M. Herbert	GSI

Present for the strain gage test were:

J. Hrinson	St. Louis Car (part time)
G. C. Krause	GSI
R. W. Moore	GSI
T. M. Herbert	GSI

Dates of Test:

The test was conducted from 6-15-72 to 6-22-72.

Procedure:

A. Preparation

Prior to applying strain gages, one half of the bolster was Stresscoated (see Photographs 1 and 2) and loads greater than the agreed upon loading conditions were applied to determine the points of maximum stress.

Stresscoat indications were developed at locations given in Tables 1 and 2, and shown on Photographs 3 thru 7 and SG 34702.

Strain gages were located on the bolster at these points and other points to determine the general stress distribution.

B. Instrumentation

Strain gages 3, 4, 22, 23, and 36 thru 41 were SR-4 one-half inch gage length type A-5-S6. Rosettes 42, 43, 44, 47 and 48 were M-M rectangular rosettes type EA-06-125RA-120. All other strain gages were SR-4 one-eighth inch gage length type FAP-12-12S6. The strain gages were applied, water-proofed and wired to terminal blocks from which cables were run to a switching unit and read out on a strain indicator. The lateral and longitudinal loads were applied with hydraulic rams and read out on calibrated hydraulic gages. The vertical load was applied by the air springs and read out on load cells for the strain gage test. For the Stresscoat test the vertical load was applied with hydraulic rams and read out on a load cell. See Photographs 8 thru 11 for test setups.

C. Loading Conditions

The following loading conditions were applied to the bolster:

Loading Condition	Load for Stress Determination Lbs.	Maximum Load Applied Lbs.
Vertical load applied on two air spring seats (total). See Photograph 8 for test setup.	42,600	70,000

Loading Condition	Load for Stress Determination Lbs.	Maximum Load Applied Lbs.
Lateral load applied to two lateral stops (total) for normal car height. See Photograph 9 for test setup.	6,225	16,800
Lateral load applied to two lateral stops (total) for shimmed car height. (Test setup same as for above except lateral load test rigging raised)	6,225	16,800
Longitudinal load applied to two bolster anchor brackets. See Photographs 10 & 11 for test setup.	6,390	14,000

All loads for stress determination are for a car weight of 41,500# on the air springs.

The vertical load of 42,600# due to the load on the side bearing pads was applied to two communicated air springs, one on each air spring seat. The load on the air springs was read out with load cells placed between the air spring and a strongback. During this test the air pressure in the bolster was taken to 100 p.s.i. This vertical load applied to the air spring seats was reacted at the side bearing pads. See Photograph 8 for test setup.

The lateral load of 6,225# (total) is due to 15% of the car body weight on the air springs. This lateral load was applied equally to the two lateral stops on one end of the bolster thru communicated rams and reacted at the two lateral stops on the other end of the bolster. This lateral load was applied both at normal car height and at shimmed car height. See Photograph 9 for test setup.

The longitudinal load of 6,390# (total) is due to 15% of the weight on the side bearing pads. This longitudinal load was applied equally to the two bolster anchor brackets and reacted at the central spigot. See Photographs 10 & 11 for load application and reaction.

Results of Test:

Tables 1 and 2 contain the recorded stresses.

Photographs 3 thru 7 show the Stresscoat indications.

T. M. Herbert

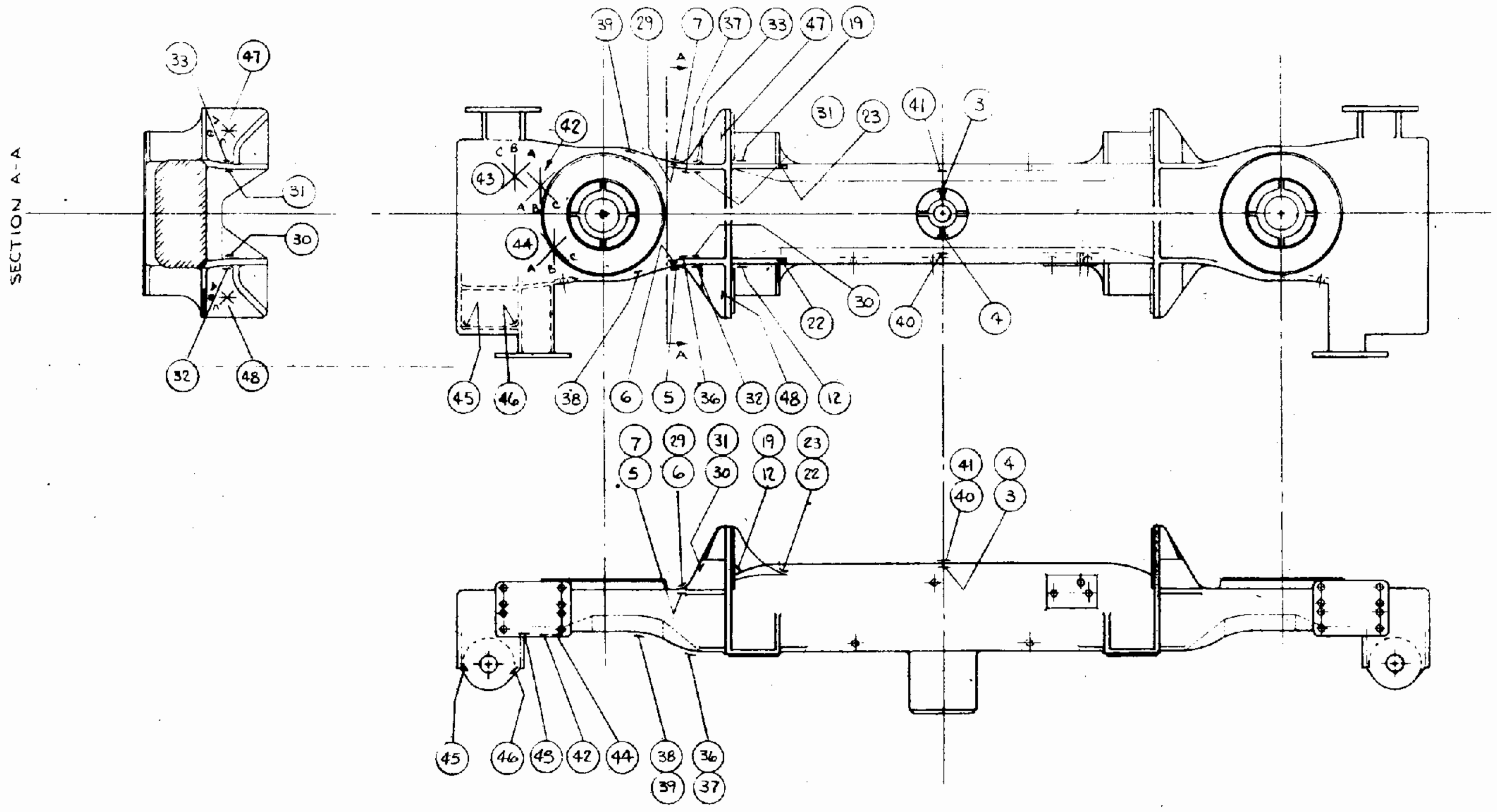
T. M. Herbert
Engineer of Tests

Attach.
TMH:jml

LIST OF ATTACHMENTS

SG 34702	LOCATION AND NUMBERS OF STRAIN GAGES ON THE TRUCK FRAME.
TABLE I	RECORDED STRESSES IN THE TRUCK FRAME.
TABLE 2	ROSETTE ANALYSIS.
PHOTOGRAPH 1	STRESSCOAT AREA OF THE TOP OF THE BOLSTER.
PHOTOGRAPH 2	STRESSCOAT AREA OF THE BOTTOM OF THE BOLSTER.
PHOTOGRAPH 3	STRESSCOAT INDICATIONS IN THE BOTTOM OF THE BOLSTER. ROSETTES 42, 43 AND 44 WERE LOCATED AT THESE INDICATIONS.
PHOTOGRAPH 4	STRESSCOAT INDICATIONS IN THE BOTTOM OF THE BOLSTER AT THE KING PIN OPENING. STRAIN GAGES 3 & 4 WERE LOCATED AT THESE INDICATIONS.
PHOTOGRAPH 5	STRESSCOAT INDICATIONS IN LATERAL BRACKET. ROSETTES 47 & 48 WERE LOCATED AT THESE INDICATIONS. ALSO STRAIN GAGES 32 & 33 WERE LOCATED AT INDICATIONS IN BACKGROUND.
PHOTOGRAPH 6	STRESSCOAT INDICATIONS IN LATERAL BRACKET. STRAIN GAGES 12 & 19 WERE LOCATED AT THESE INDICATIONS.
PHOTOGRAPH 7	STRESSCOAT INDICATIONS IN THE TOP OF THE BOLSTER OUTBOARD OF THE LATERAL BRACKET. STRAIN GAGES 5, 6, 7 AND 29 WERE LOCATED AT THESE INDICATIONS.
PHOTOGRAPH 8	TEST SETUP FOR VERTICAL LOAD APPLIED BY AIR SPRINGS. NOTE LOAD CELLS FOR MONITORING THE LOAD AND REACTIONS AT SIDE BEARERS.
PHOTOGRAPH 9	TEST SETUP FOR APPLYING AND REACTING LATERAL LOAD.
PHOTOGRAPH 10	TEST SETUP FOR APPLYING LONGITUDINAL LOAD. LOAD APPLIED TO OTHER BOLSTER ANCHOR WITH A COMMUNICATED RAM. SEE PHOTOGRAPH 11 FOR REACTION POINT.
PHOTOGRAPH 11	REACTION FOR LONGITUDINAL LOAD AT BOLSTER SPIGOT.

BILL OF MATERIAL				
PART NO	PER	DESCRIPTION	SIZE	MAT'L



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94204	34100
ORDER NO.	NEXT ASS'Y

GENERAL STEEL INDUSTRIES, INC.

GSI CASTINGS DIVISION
GRANITE CITY, ILL. U.S.A.

STRAIN GAUGE LOCATIONS FOR

S.O.A.C.

DR. D.F.W.	CH.	APPROV.
DRAWING NUMBER	SG-34702	DATE 3-23-72 SCALE 1"=1'-0"

SHEET
225/226

TABLE I

S.O.A.C. BOLSTER PATTERN NO. 34702 SER. NO. 2 CAST DATE 4-72

RECORDED STRESSES UNDER DESIGN LOADING CONDITIONS
STRESS IN 1000 PSI + DESIGNATES TENSION - DESIGNATES COMPRESSION

Gage No.	Vertical Load of 42,600# Total load applied by two air springs	Lateral Load of 6225# Total load applied to bolster stops on one end of bolster at normal car height	Lateral Load of 6225# Total load applied to bolster stops on one end of bolster at shimmed car ht.	Longitudinal Load of 6390# Total load applied to bolster anchor brackets
3*	+ 9.9	+0.6	+1.6	-1.5
4*	+14.4	+2.0	+2.4	+2.7
5*	+16.8	0	0	+4.8
6	+ 5.0	0	-0.6	+4.8
7*	+14.6	0	0	-5.1
12*	+ 2.1	+5.0	+7.5	0
19*	+ 2.4	+4.5	+7.5	0
22	+ 5.4	+1.4	+2.0	+1.2
23	+ 5.1	+1.4	+1.8	-0.9
29*	+17.1	+0.6	-0.6	-5.7
30*	+2.1	+3.0	+4.5	0
31*	+2.1	+3.3	+4.8	0
32*	+1.8	-8.1	-13.5	0
33*	+0.9	-6.3	-10.5	0
36	-5.7	0	0	0
37	-4.2	0	0	0
38	-6.9	0	0	0
39	-7.2	0	0	0
40	+6.0	+0.9	+0.9	+2.1
41	+5.4	+0.6	+0.9	-1.5
45	+2.4	0	0	-3.0
46	0	0	0	-4.2
Rosette				
42*	+15.0	0	0	-1.1
43*	+15.2	0	0	-1.3
44*	+15.8	0	0	+1.4
47*	0	+14.1	+7.3	N.R.
48*	0	+12.9	+5.3	N.R.

* Stresscoat indications at these gage locations.

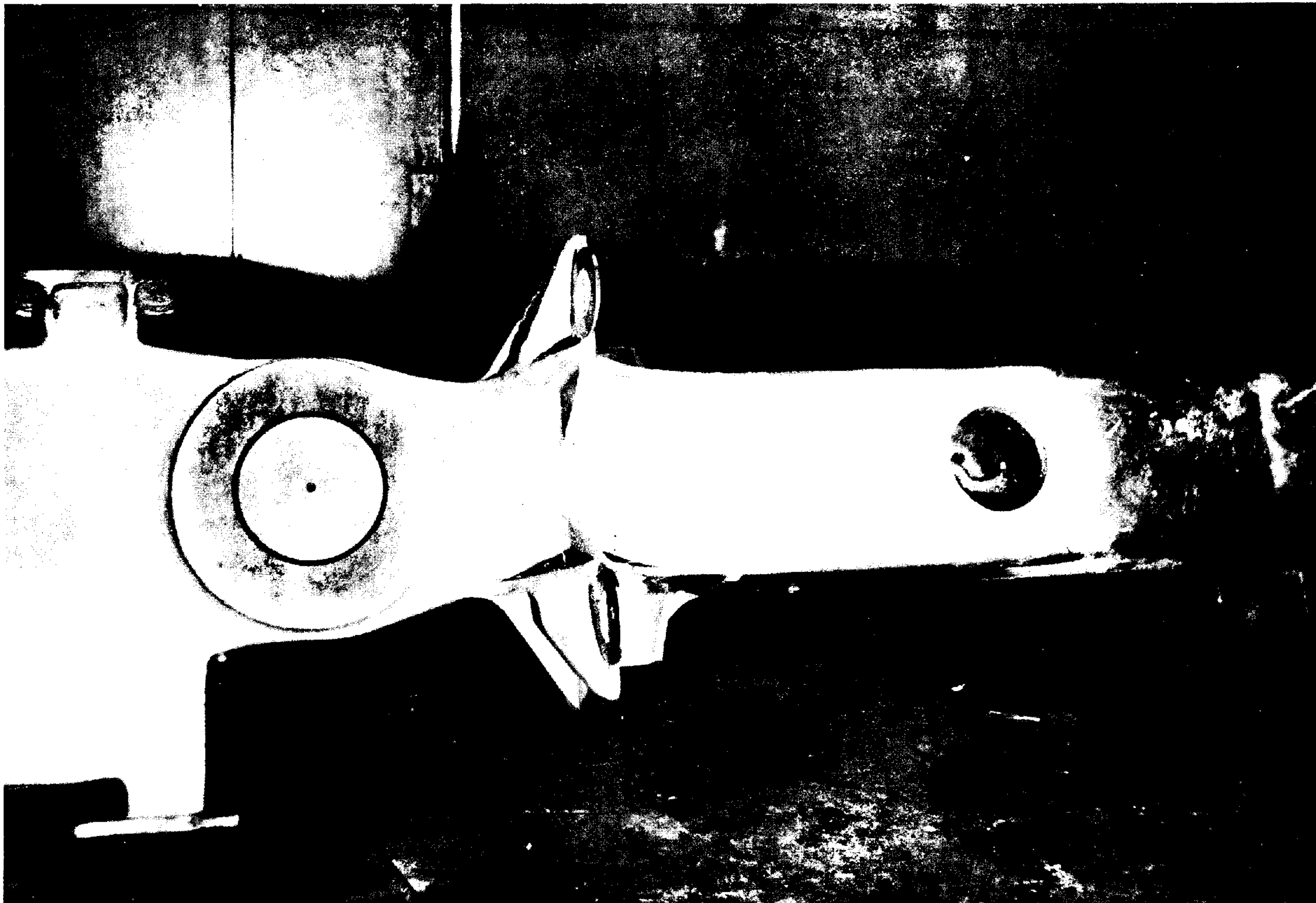
TABLE 2

S.O.A.C. BOLSTER PATTERN NO. 34702 SERIAL NO. 2 CAST DATE 4-72
EVALUATION OF ROSETTES UNDER DESIGN LOADING CONDITIONS

STRESS IN 1000 PSI
+ DESIGNATES TENSION
- DESIGNATES COMPRESSION

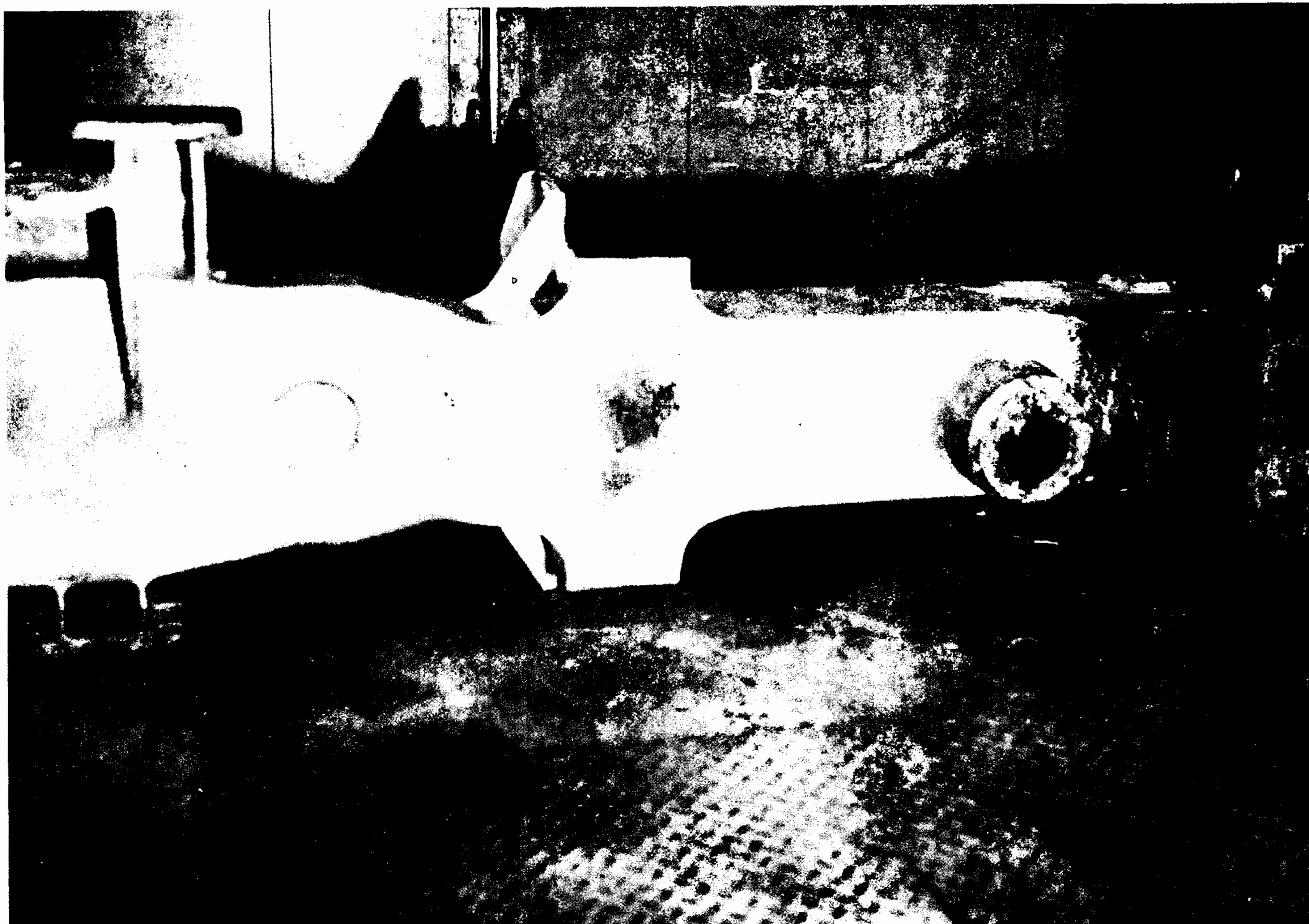
LOAD CONDITION				MAJOR VALUE	STRESS AXIS	MINOR VALUE	STRESS AXIS
Stress due to a vertical load of 42,600# total on the air springs	Gage 42a	Gage 42b	Gage 42c				
	+330	+390	+260	+15.0	169.9°	+10.3	79.9°
	Gage 43a	Gage 43b	Gage 43c				
	+330	+410	+220	+15.2	168.9°	+ 8.4	78.9°
	Gage 44a	Gage 44b	Gage 44c				
	+380	+400	+230	+15.8	160.9°	+10.3	70.9°
Stress due to a longitudinal load of 6390# total applied equally to each bolster anchor bracket	Gage 42a	Gage 42b	Gage 42c				
	-40	-15	+20	+ 0.3	49.7°	- 1.1	139.7°
	Gage 43a	Gage 43b	Gage 43c				
	-40	-15	0	- 0.4	38.0°	- 1.3	128.0°
	Gage 44a	Gage 44b	Gage 44c				
	-25	-15	+45	+ 1.4	62.8°	- 0.6	152.8°
Stress due to a lateral load of 6225#/Bolster at normal car height applied equally to each bracket	Gage 47a	Gage 47b	Gage 47c				
	+350	+350	+170	+14.1	22.5°	+ 8.2	112.5°
	Gage 48a	Gage 48b	Gage 48c				
	+100	+290	+350	+12.9	76.2°	+ 6.4	166.2°
Stress due to a lateral load of 6225#/bolster at shimmed car height applied equally to each bracket	Gage 47a	Gage 47b	Gage 47c				
	+230	+110	-30	+ 7.3	2.2°	+ 1.3	92.2°
	Gage 48a	Gage 48b	Gage 48c				
	-60	0	+170	+ 5.3	102.8°	- 0.6	12.8°

Note: All stress axis measured counter clockwise from Gage A.
Stresscoat indications at all of these Rosette locations.



STRESSCOAT AREA OF THE TOP OF THE BOLSTER
T-34702-1

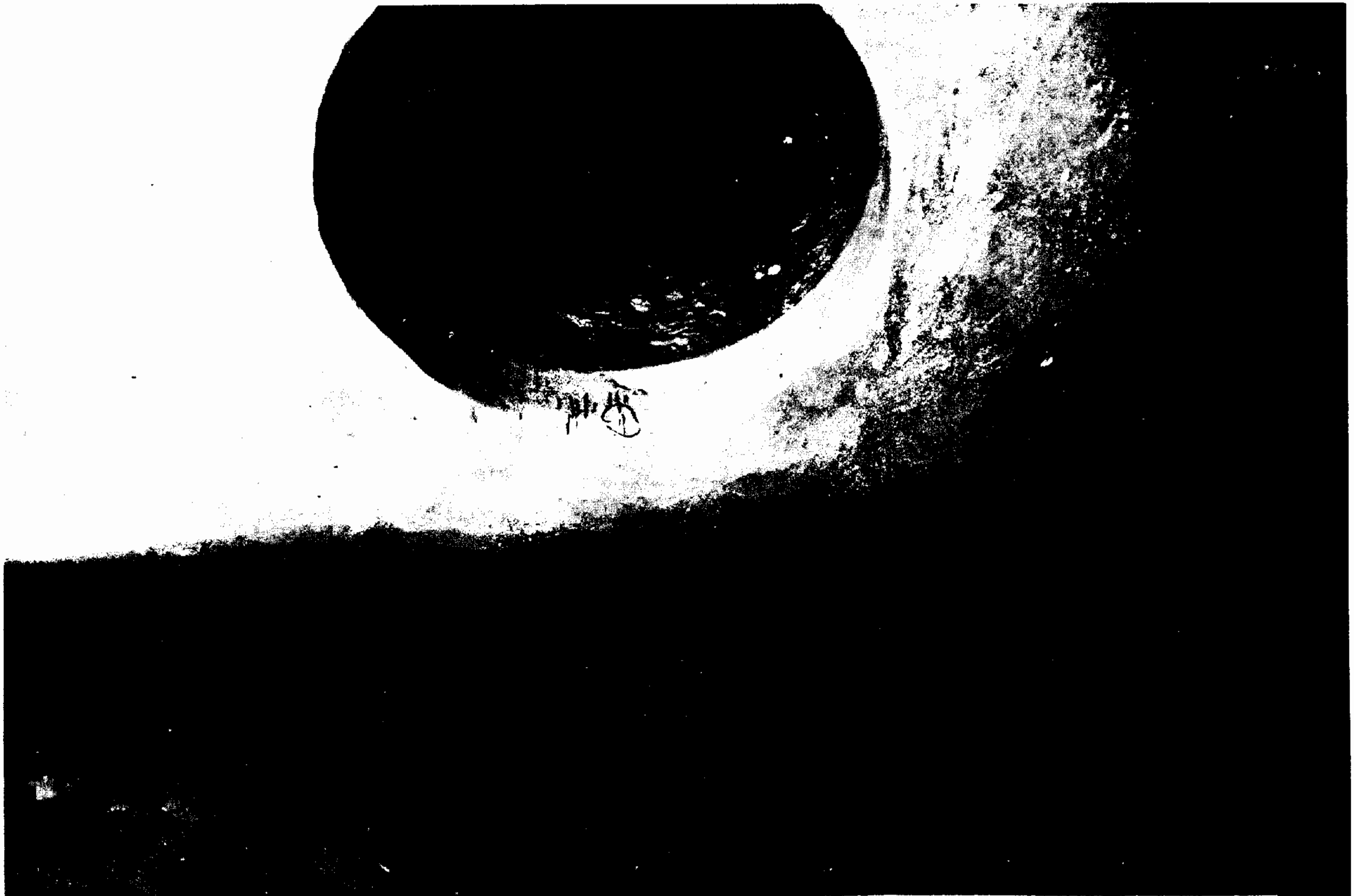
PHOTOGRAPH 1



STRESSCOAT AREA OF THE BOTTOM OF THE BOLSTER.
T-34702-1

PHOTOGRAPH 2

STRESSCOAT INDICATIONS IN THE BOTTOM OF THE BOLSTER.
ROSETTES 42, 43 AND 44 WERE LOCATED AT THESE INDICATIONS.
T-34702-1 PHOTOGRAPH 3

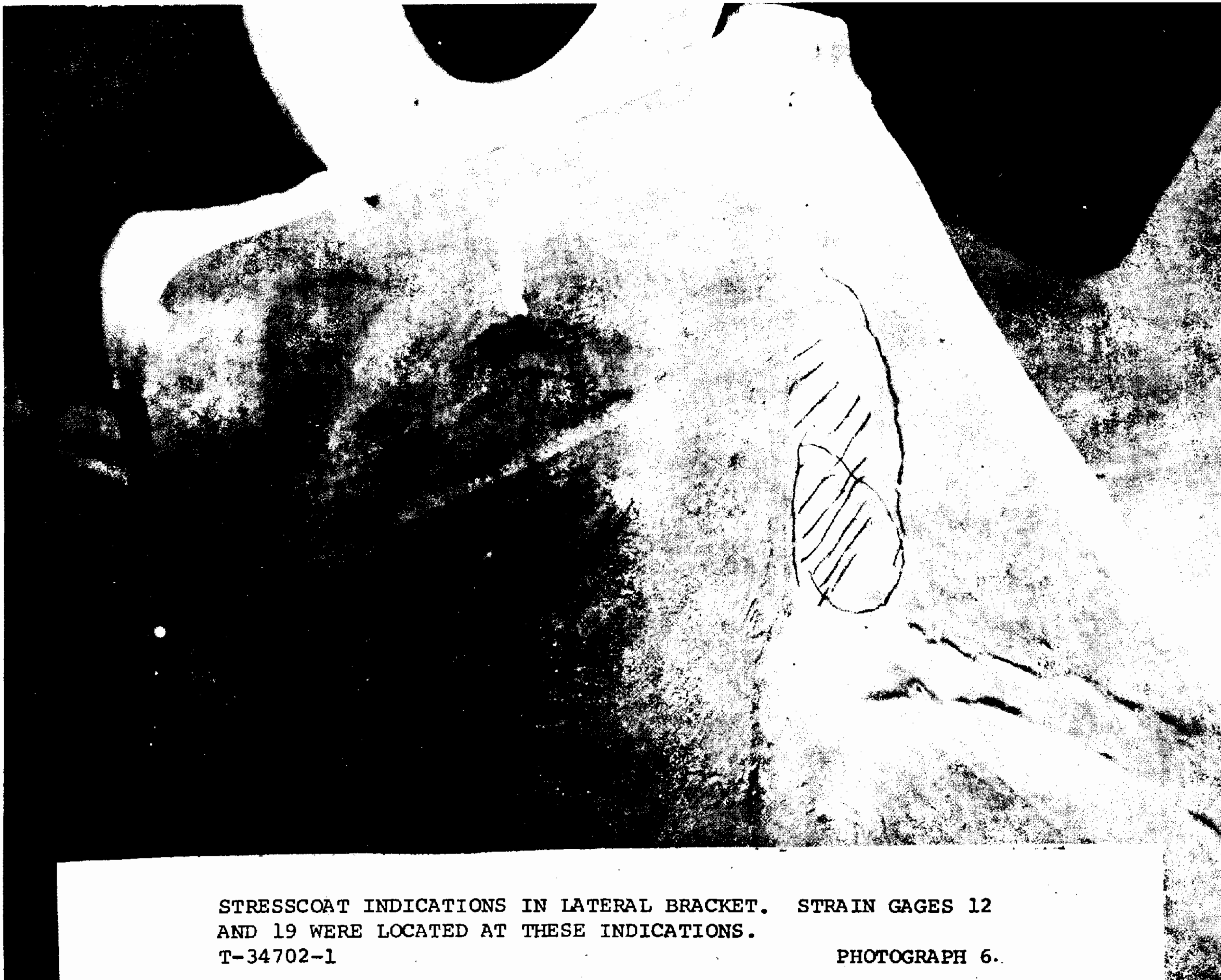


STRESSCOAT INDICATIONS IN THE BOTTOM OF THE BOLSTER AT THE KING PIN OPENING. STRAIN GAGES 3 & 4 WERE LOCATED AT THESE INDICATIONS.

T-34702-1 PHOTOGRAPH 4

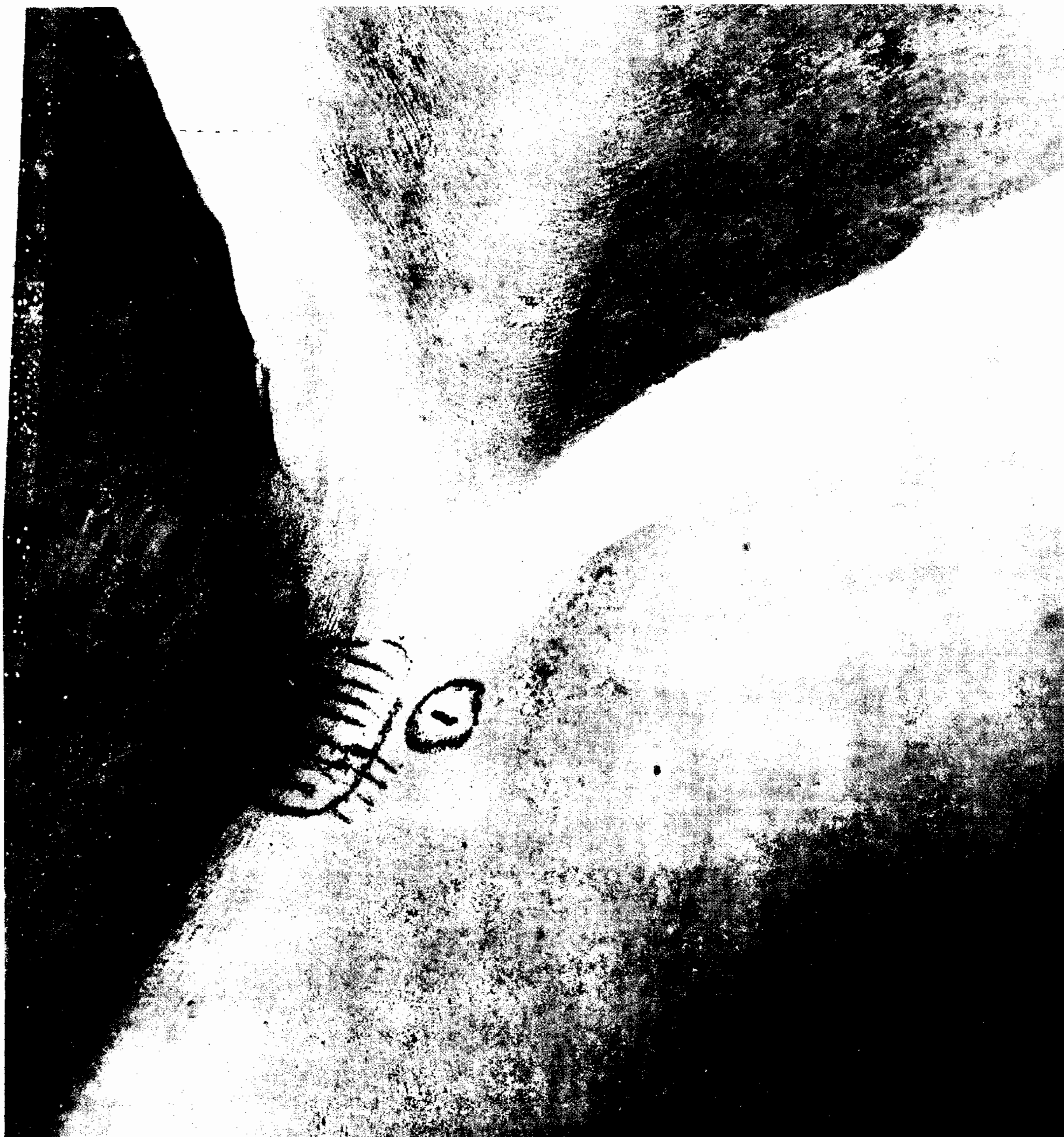
STRESSCOAT INDICATIONS IN LATERAL BRACKET. ROSETTES 47 AND 48 WERE LOCATED AT THESE INDICATIONS. ALSO STRAIN GAGES 32 AND 33 WERE LOCATED AT INDICATIONS IN BACKGROUND.
T-34702-1

PHOTOGRAPH 5



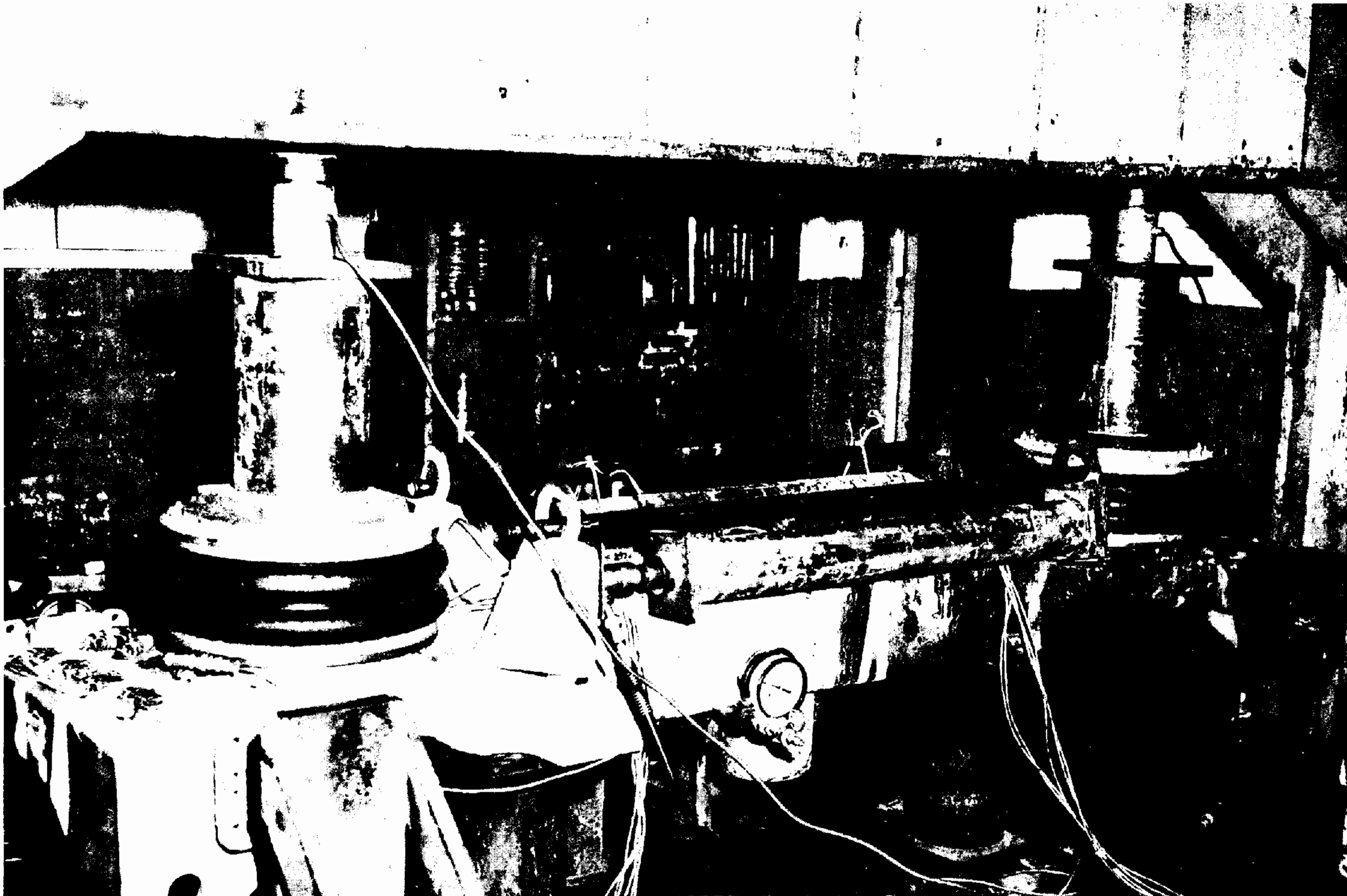
STRESSCOAT INDICATIONS IN LATERAL BRACKET. STRAIN GAGES 12 AND 19 WERE LOCATED AT THESE INDICATIONS.
T-34702-1

PHOTOGRAPH 6.



STRESSCOAT INDICATIONS IN THE TOP OF THE BOLSTER OUTBOARD OF THE LATERAL BRACKET. STRAIN GAGES 5, 6, 7 AND 29 WERE LOCATED AT THESE INDICATIONS.
T-34702-1

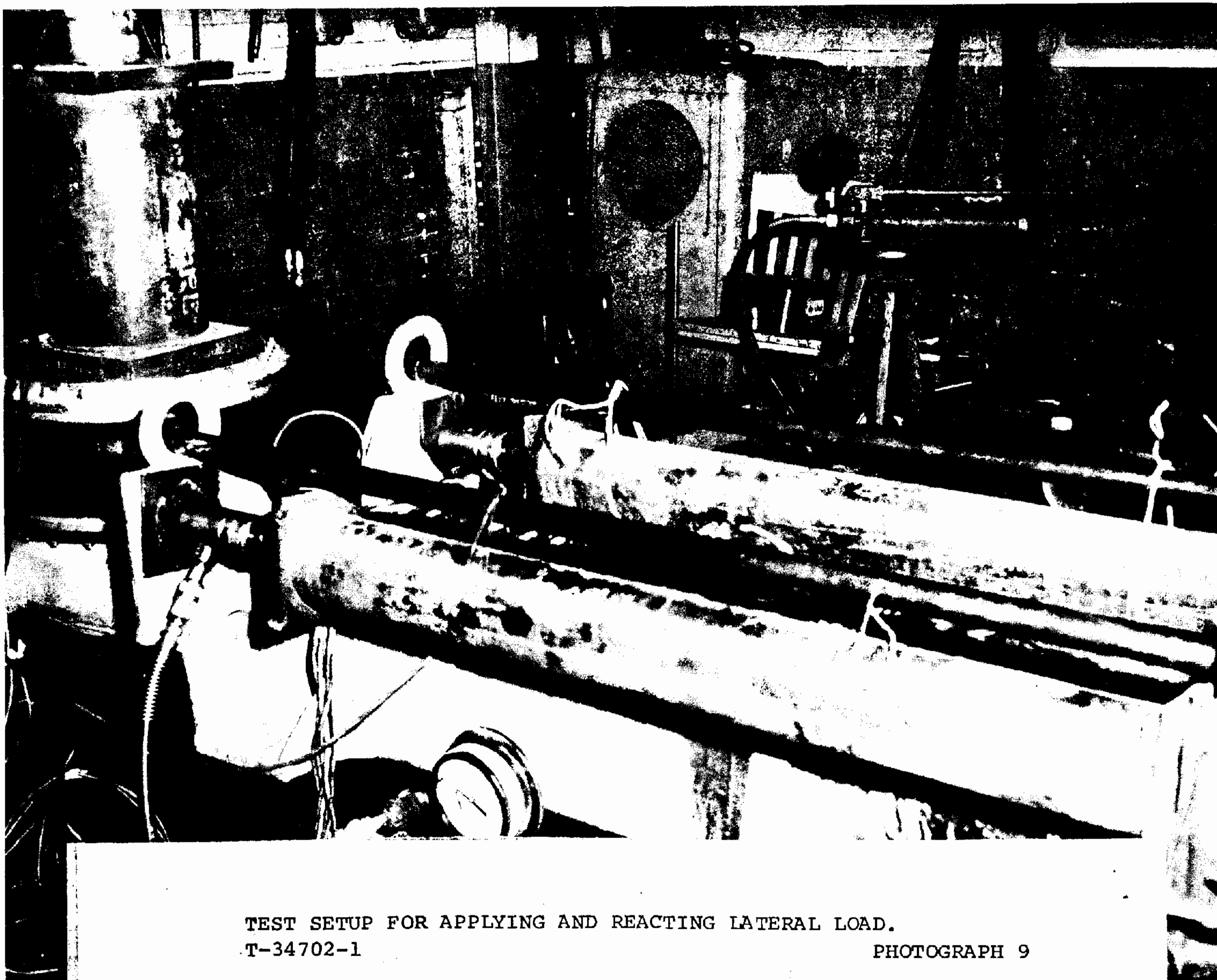
PHOTOGRAPH 7



TEST SETUP FOR VERTICAL LOAD APPLIED BY AIR SPRINGS. NOTE LOAD CELLS FOR MONITORING THE LOAD AND REACTIONS AT SIDE BEARERS.

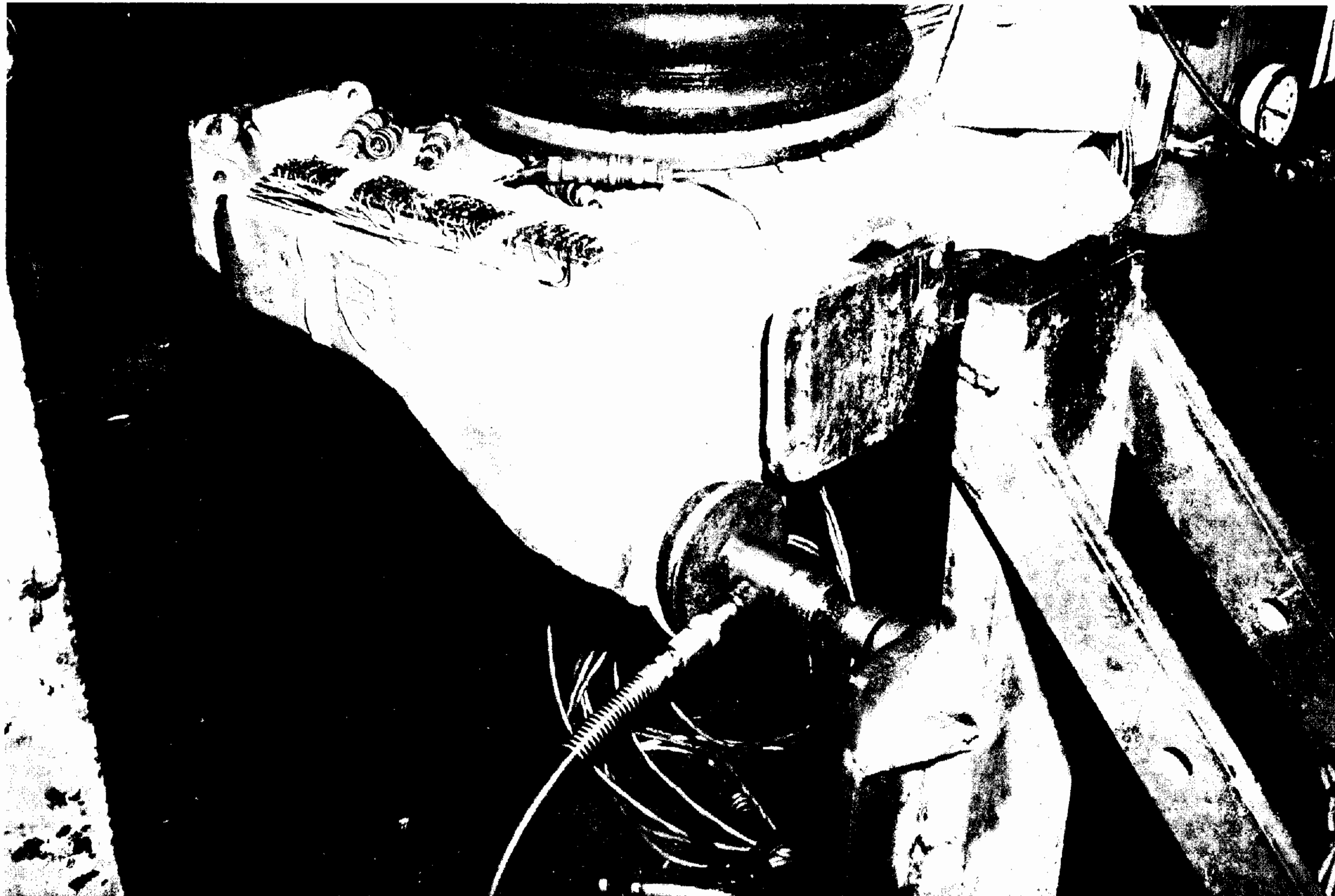
T-34702-1

PHOTOGRAPH 8



TEST SETUP FOR APPLYING AND REACTING LATERAL LOAD.

T-34702-1 PHOTOGRAPH 9



TEST SETUP FOR APPLYING LONGITUDINAL LOAD. LOAD APPLIED TO OTHER BOLSTER ANCHOR WITH A COMMUNICATED RAM. SEE PHOTOGRAPH 11 FOR REACTION POINT.

T-34702-1

PHOTOGRAPH 10

REACTION FOR LONGITUDINAL LOAD AT BOLSTER SPIGOT.
T-34072-1

PHOTOGRAPH 11

SHEET 240

APPENDIX III

WINDSHIELD TESTS

SHEET 242

17 Dec., [illegible]

Swedlow Inc.

PREPARED BY			TYPE
D. Holdridge		QUALIFICATION TEST REPORT	Detailed
REVISION	REVISED BY	SPECIFICATION	CLASSIFICATION
A			Non-Proprietary
B			STAMP IF PROPRIETARY
C			
D			

TITLE

QUALIFICATION TEST REPORT FOR THE WINDSHIELD ASSEMBLY-ATTENDANTS CAB FOR SAN FRANCISCO BAY AREA RAPID TRANSIT VEHICLES

REVISION INFORMATION (DATES, ETC.) LIST AMENDMENTS HERE

SWEDLOW APPROVALS

REVISION	CHECKED BY	APPROVAL	APPROVAL	APPROVAL
	A. Domonzcowicz 12-9-70	J.D. Stansbury 11/25/70	[illegible]	[illegible]
A				
B				
C				
D				

CUSTOMER APPROVALS (IF REQUIRED)

REVISION	CHECKED BY	APPROVAL	APPROVAL	APPROVAL
A				
B				
C				
D				

SHEET 244

TABLE OF CONTENTS

SHEET 246

1.0 INTRODUCTION

This document has been prepared to fulfill the requirements of the Qualification Test Procedure QTP-002 and Rohr Technical Specification S 82125, Paragraph 3.3.5, Windshield Tests.

This document describes those tests required to demonstrate design feasibility and to qualify transparencies manufactured to this design.

2.0 SUMMARY

All of the required tests were performed in accordance with the Qualification Test Procedure (QTP-002) at the Western Avenue Facility of Swedlow, Inc. and were witnessed by the Swedlow, Inc. Quality Control Department, with one exception. The Horizontal Impact Test was performed at Wyle Laboratires, Norco Facility. This test was witnessed by Swedlow, Rohr, PBTB, and Wyle representatives. No failures occurred as the result of testing. Photographs were taken of each test showing the setup and the test specimens after testing. These photographs are presented in Section 9.0 of this report.

3.0 VERTICAL IMPACT TEST

3.1 Place and Date of Test

The vertical impact test was performed on July 21, 1970 at the Western Avenue Facility of Swedlow, Inc. in the Reinforced Plastics Building.

3.2 Test Witnesses

The test was witnessed by J. G. Stansbury and R. Nitta of the Quality Control Department and by D. Holdridge, N. G. Nixon, M. Munoz and A. Domaszewicz from the Engineering Department of Swedlow, Inc.

3.3 Facilities and Equipment Used

A 20-ft. high drop tower, a 12" x 12" x 2 x 4 wooden frame, a wall thermometer, a calibrated gram scale, a 20-ft. scale, and a drop bag per USAS Z26.1 - 1966, were used during this test.

3.4 Test Specimens

Test specimen numbers 3, 7, 8, 9 and 10 per Figure 1 of QTP-002 were used for this test.

3.5 Equipment Calibration

An 0-4500 gram scale built by Pennsylvania Scale Co. was used to weigh the drop bag. This scale was serviced on May 6, 1970 by Western Scale Service and calibrated on July 9, 1970 by the Swedlow Quality Control Department.

3.6 Test Method

The panels were stabilized at 76°F prior to testing. The drop bag was filled with lead shot on a gram scale until the bag, shot, drawstring, and binding cord weighed 11.0 pounds. The bag was then suspended by a cord from the drop tower in order to align the wooden holding fixture. The drop bag was then raised to the 16-ft. mark on the tower and released onto panel number 5. The test was repeated on panel number 5. The panel showed no signs of damage and was photographed. Panels number 2, 7, 8 and 10 were then tested per the test procedure. The maximum temperature during testing was 82°F.

3.7 Results

No glass or acrylic fractures occurred in any of the panels tested. Panels number 7, 8 and 10 delaminated upon impact, but the panels remained completely intact. Photographs are presented in Section 9.0 showing the test facility and each of the test panels immediately after impact.

4.0 HORIZONTAL IMPACT TEST

4.1 Place and Date of Test

The horizontal impact test was performed at the Norco Test Facility of Wyle Laboratories on August 13, 1970.

4.2 Test Witnesses

The test was witnessed by Messrs. Holdridge and Tomko from Swedlow, Inc., Messrs. Hancock and Mann from Rohr Corporation, Messrs. Baeck and Weigle from PBTB, and Messrs. Alterman and Heeseman from Wyle Laboratories.

4.3 Facilities and Equipment Used

A 48-ft. centrifuge, a standard clock, 1.1 lb. ± .1 lb. and 5.1 ± .1 lb. balls, a yardstick, a frame to support the window and a Fastax high speed camera (1000 frames/sec. with 60-cycle timing mark) were used during the tests.

4.4 Test Specimens

Two full-size laminated panels (SWU No.'s 103 and 104) were tested.

4.5 Equipment Calibration

Both of the balls were weighed on a 0 - 4500 gram scale built by Pennsylvania Scale Co., calibrated on July 9, 1970. The centrifuge speed was calibrated using a magnetic pickup, a digital counter, and a Standard clock. A pool ball and a paper target were used during calibration shots to align the frame for mid-panel impact.

4.6 Test Method

The aluminum balls simulating stones were weighed prior to testing. Windshield Number SWU 103 was clamped in the steel frame (Figure 3 of Test Procedure). A 1.1 $\pm$ .1 lb. ball (1.1067 lbs) was fired at the windshield at 80 $\pm$ 3 mph (63.3 rpm @ 212.2 inch radius). The ball was released from the centrifuge by severing the attachment cord with a blasting cap. Impact occurred two inches to the right of center and one inch below center. The second windshield (No. SWU 104) was installed in the frame and a 5.1 $\pm$ .1 (5.0794) pound ball was fired at 50 $\pm$ 3 mph (39.4 rpm at 213.1 inch radius). Impact occurred one-half inch to the left of center and on center vertically. High-speed photographs were taken of both impacts.

4.7 Results

There were no fractures or ejected spalling of the acrylic structural ply. After impact, vision through the windshield was not impaired. The Wyle Certified Data Sheet Report and photographs taken during testing are presented in Section 9.0.

5.0 LIMIT LOAD PRESSURE TEST

5.1 Place and Date of Test

The limit load pressure test was performed at the Western Avenue Facility of Swedlow, Inc., in the Reinforced Plastics Building on July 22, 1970.

5.2 Test Witness

This test was witnessed by R. Nitta of the Quality Control Department, and D. Holdridge, A. Tomko, N. G. Nixon, M. Munoz and A. Domaszewicz of the Engineering Department.

5.3 Facilities and Equipment

A thirty-inch water manometer, three dial micrometers, a pressurized gas bottle, a 0 - 60 psi pressure regulator, and the pressure test fixture (Figure 4 of Test Procedure) were used during this test.

5.4 Test Specimen

A full-size panel assembly (SWU 101) was used as the test specimen.

5.5 Test Method

The test specimen was installed in the test fixture and all the joints sealed. The regulator was then checked to determine the sensitivity of adjustment in controlling the required pressure.

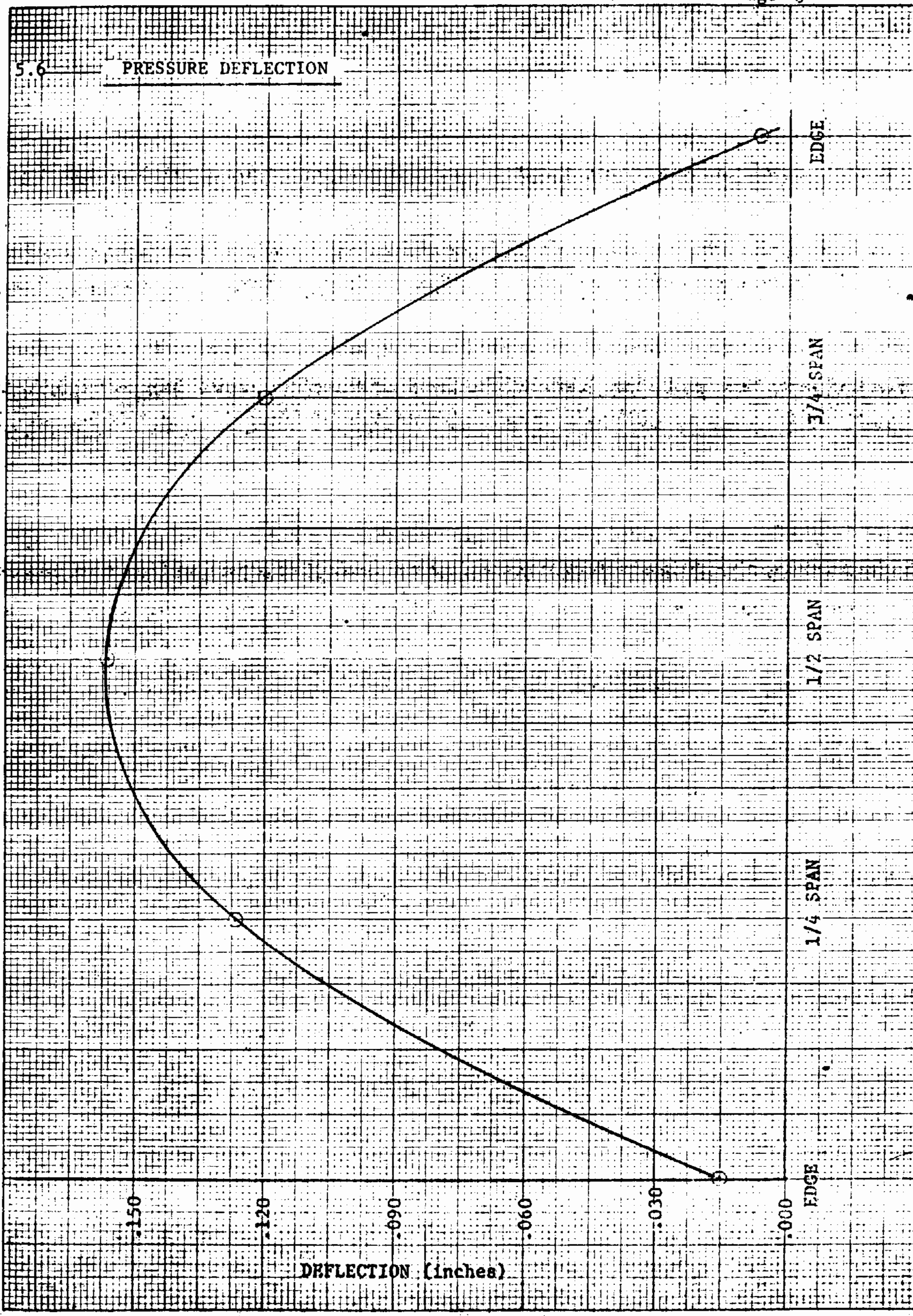
The dial micrometers were then placed along the narrow span of the window at the center, at 1/4 span, and at 3/4 span. The micrometers were all adjusted to read zero deflection with the hands pointing up. The system was pressurized to check out the system. After the system had come back to equilibrium, the first pressure test was performed.

The outer micrometers were then moved to within 1/2-inch of the edge of the frame. A second pressure test was performed. The pressure deflection data is tabulated in Section 5.6 and photographs of the second pressure test are presented in Section 9.0.

5.6 Data Tabulation - Pressure Deflection

TEST NUMBER	TIME (min)	PRESSURE (inch. H_2O)	DEFLECTION (inches)				
			EDGE	1/4 SPAN	1/2 SPAN	3/4 SPAN	EDGE
Checkout	0	0		0	0	0	
	3.0	10.1		.126	.145	.116	
	6.0	0		.006	.007	.005	
First Test	0	0		.002	.003	.001	
	3.0	10.1		.128	.158	.121	
	7.0	10.1		.130	.160	.121	
	10.0	10.1		.130	.160	.121	
	13.0	0		.005	.005	.004	
Second Test	0	0	.001		.002		.001
	3.0	10.1	.015		.157		.008
	10.0	10.1	.015		.158		.0085
	16.0	0	.001		.001		.000

5.6 PRESSURE DEFLECTION



5.7 Results

There were no fractures, delaminations, or permanent deformations of the test specimen as a result of the pressure test. The mid-panel deflection at 10.1 inches of water (52.53 psf) was 0.160 inches, which is well below the 0.257 inch deflection that would constitute a failure.

6.0 LIGHT TRANSMISSION AND REFLECTANCE TESTS

6.1 Place and Site of Test

The light transmission tests were performed at the Western Avenue Facility of Swedlow, Inc., in the Test Laboratory on July 16, 1970.

The reflectance tests were performed at Perkin-Elmer Corporation, Costa Mesa, California on October 2, 1970.

6.2 Test Witnesses

The light transmission test was witnessed by M. Bullinger and R. Nitta of the Quality Control Department and by D. Holdridge of the Engineering Department of Swedlow, Inc.

The reflectance test was witnessed by Dr. R. Bell, Supervisor of the Swedlow Thin Films Department and by Joe Keish of Perkin-Elmer Corporation.

6.3 Facilities and Equipment Used

A Gardner Large Sample Hazometer Model HG1230, Serial No. 102, a Bausch and Lomb Spectronic 505 Spectrophotometer, and a Perkin-Elmer Spectrophotometer were used.

6.4 Test Specimens

Test specimen numbers 1, 2 and 3 per Figure 5 of QTP-002 were tested.

6.5 Test Method

The test specimens were cleaned before testing. The zero and full-scale readings of the test equipment were adjusted. The mid-panel reflectance and light transmission were then recorded.

6.6 Results

The light transmission and haze data for specimens numbered 1 thru 11 are listed in Section 6.8. The reflectance test data is presented in Section 6.7 of this report. The mean IR transmission between .7 and 2.5 microns is determined from the equation

$$T = \frac{\int_{\lambda=.7}^{\lambda=2.5} I_{\lambda s} T_{\lambda}\, d\lambda}{\int_{\lambda=.7}^{\lambda=2.5} I_{\lambda s}\, d\lambda}$$

where $I_{\lambda s}$ is the percent intensity of the sunlight reaching the earth on a clear day at wave lengths between .7 and 2.5 microns. T_{λ} is the percent light transmission of the sample in the same wave length range. The mean transmission is 25.9%.

Light transmission values are marginal based on 70 percent. A request has been made to change the minimum light transmission requirement to 65 percent.

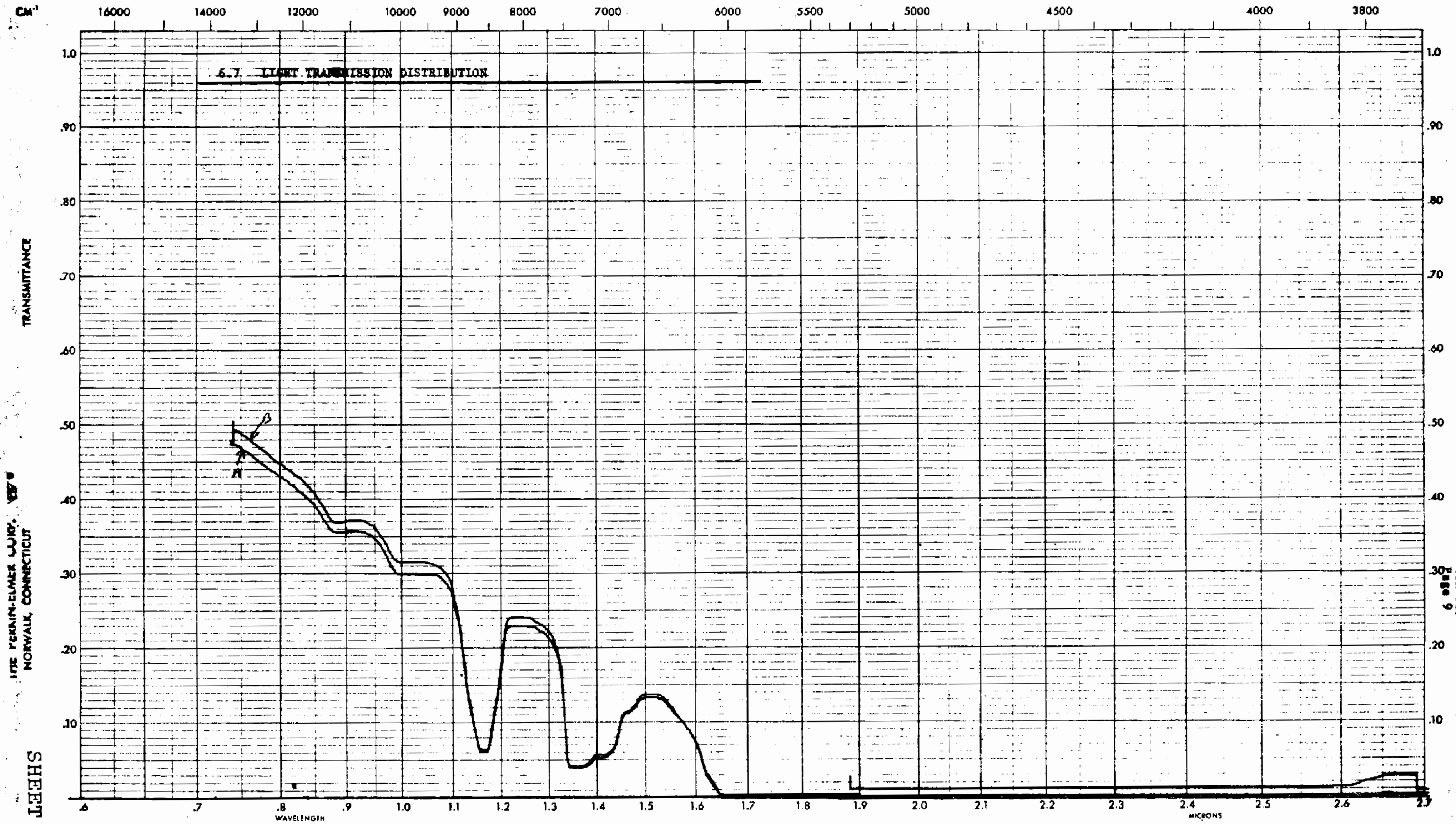
SAMPLE BART WATTLESS PLATES
ORIGIN SWEDLOW
SOLVENT —
CONC. —

CELL PATH — —
REFERENCE AIR
OPERATOR LEA
REMARKS —

SLIT WIDTH 10μ
RESOLUTION 1Å
SCAN SPEED

CURVE NO. 672
ORD. EXP.
PEN RESPONSE —
DATE 10-2-70

NIR



PERKIN-ELMER CORP., NORWALK, CONNECTICUT

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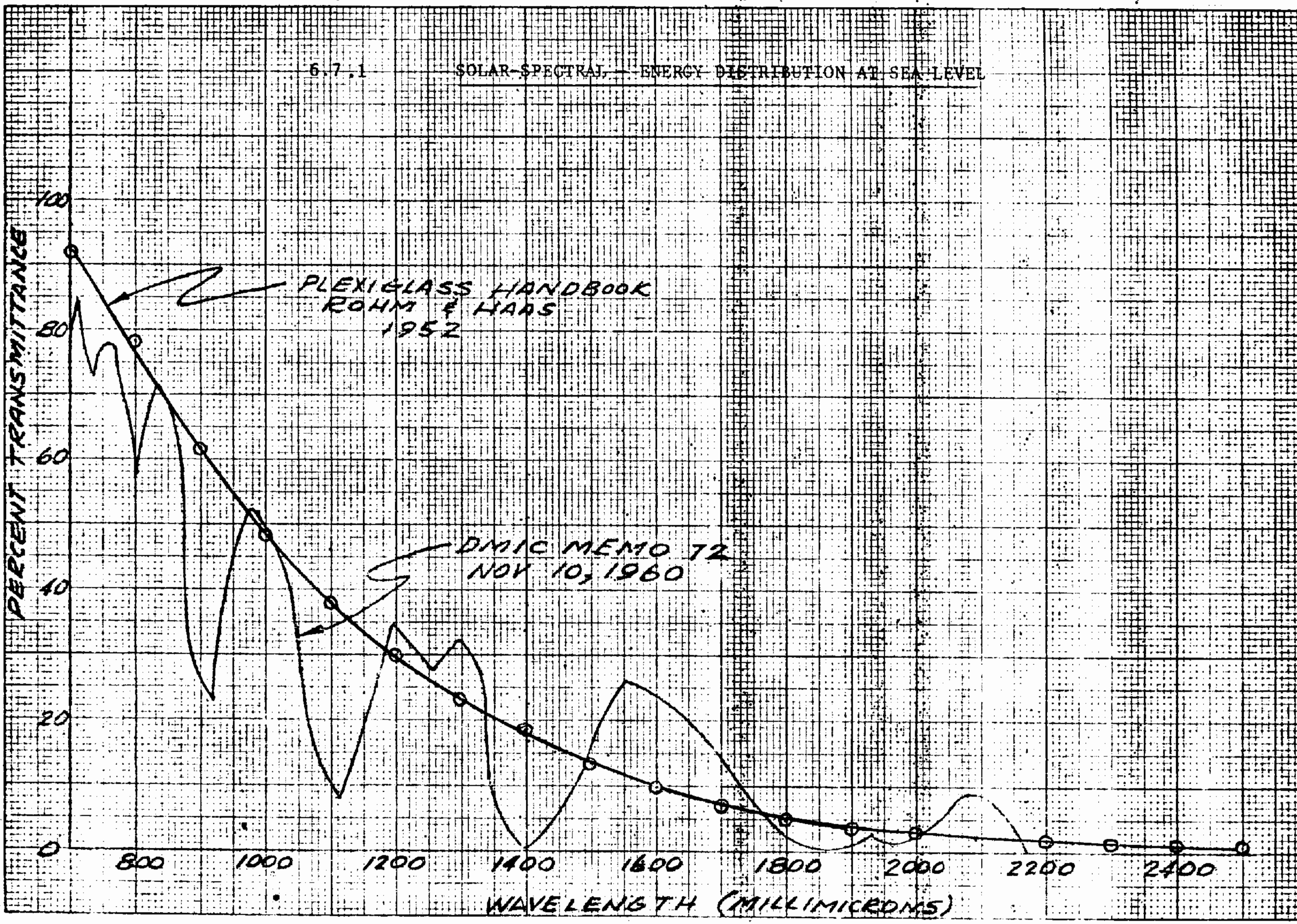
6.7.1 SOLAR-SPECTRAL — ENERGY DISTRIBUTION AT SEA LEVEL



6.8 Light Transmission and Haze Data

Specimen No.	Light Transmission	Haze
1	68.3	1.3
2	71.8	1.0
3	70.6	1.7
4	69.2	1.1
5	70.3	2.6
6	66.2	1.3
7	70.9	1.1
8	69.2	1.1
9	69.6	1.8
10	66.1	1.0
11	69.0	1.4

7.0 DEVIATION AND DISTORTION TEST

7.1 Place and Date of Test

Both the deviation and distortion tests were performed at the Western Avenue Facility of Swedlow, Inc. The deviation test was performed on July 23, 1970 and the distortion test was performed on August 12, 1970.

7.2 Test Witnesses

The tests were witnessed by R. Nitta from the Swedlow Quality Control Department and by D. Holdridge and B. Sarno from the Engineering Department.

7.3 Facilities and Equipment Used

An illuminated box and a lantern slide projector per USAS Z26.1 - 1966 were used during this test.

7.4 Test Specimens

Test specimens one through five and seven through twelve were used for this test.

7.5 Test Method - Deviation Test

The light box was placed against a grid board in the inspection area. All of the test specimens were viewed normal to the line of vision for deviation of the light source.

7.6 Test Method - Distortion Test

A clean white piece of paper was placed against the screen in the distortion test area. The projector was located 25 feet from the screen. With the projector on, the test specimens were cleaned and checked for distortion patterns on the screen by slowly moving the specimens away from the screen. The samples were checked over a distance of zero to five feet from the screen.

7.7 Results

There was no shift in the secondary image outside of a 1-1/2 inch diameter circle on the illuminated box in the deviation test. No light and dark patches appeared on any of the test samples after the outside surfaces were cleaned. Photgraphs showing the test setup, secondary image and projected impages are presented in Section 9.0.

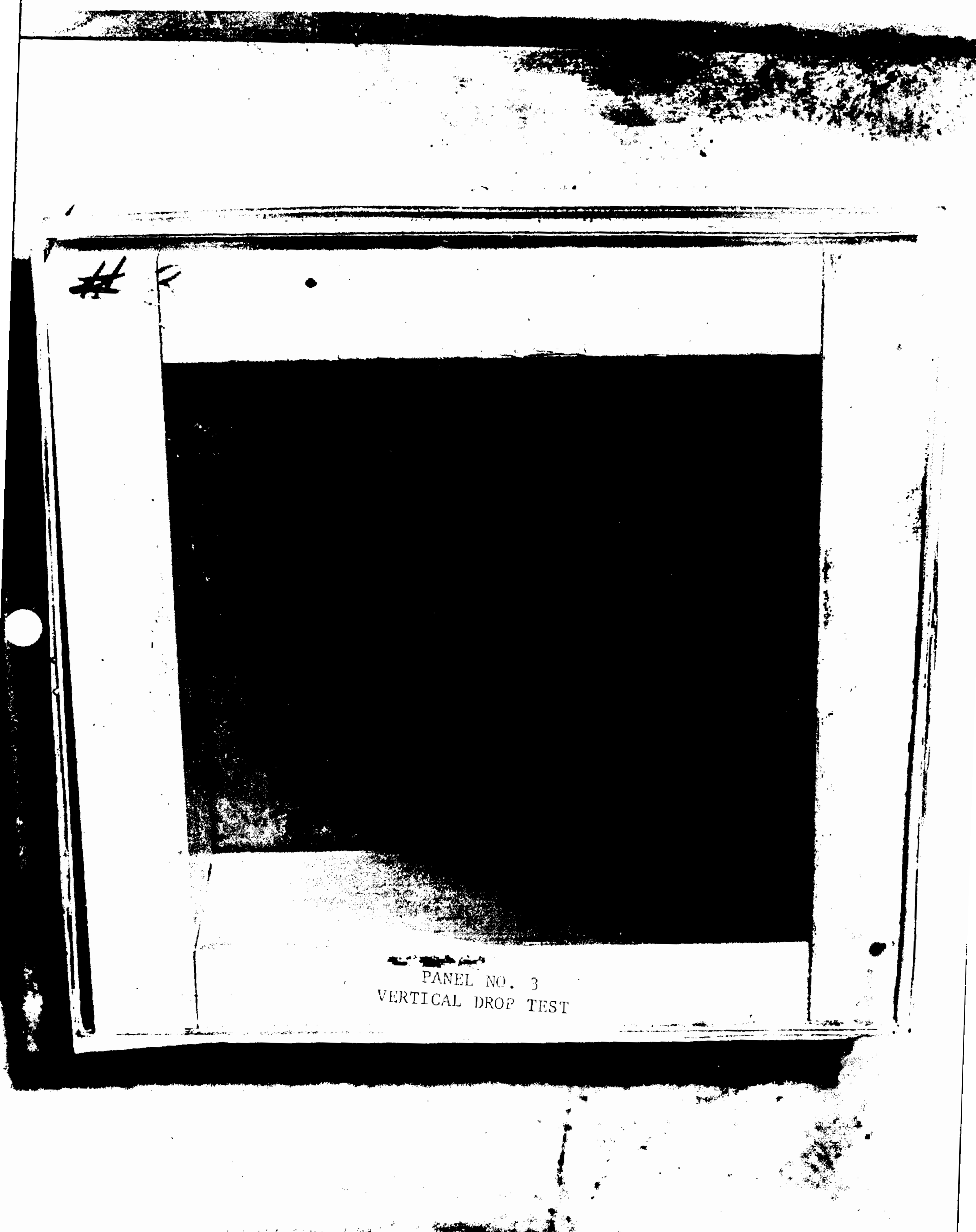
8.0 CONCLUSIONS

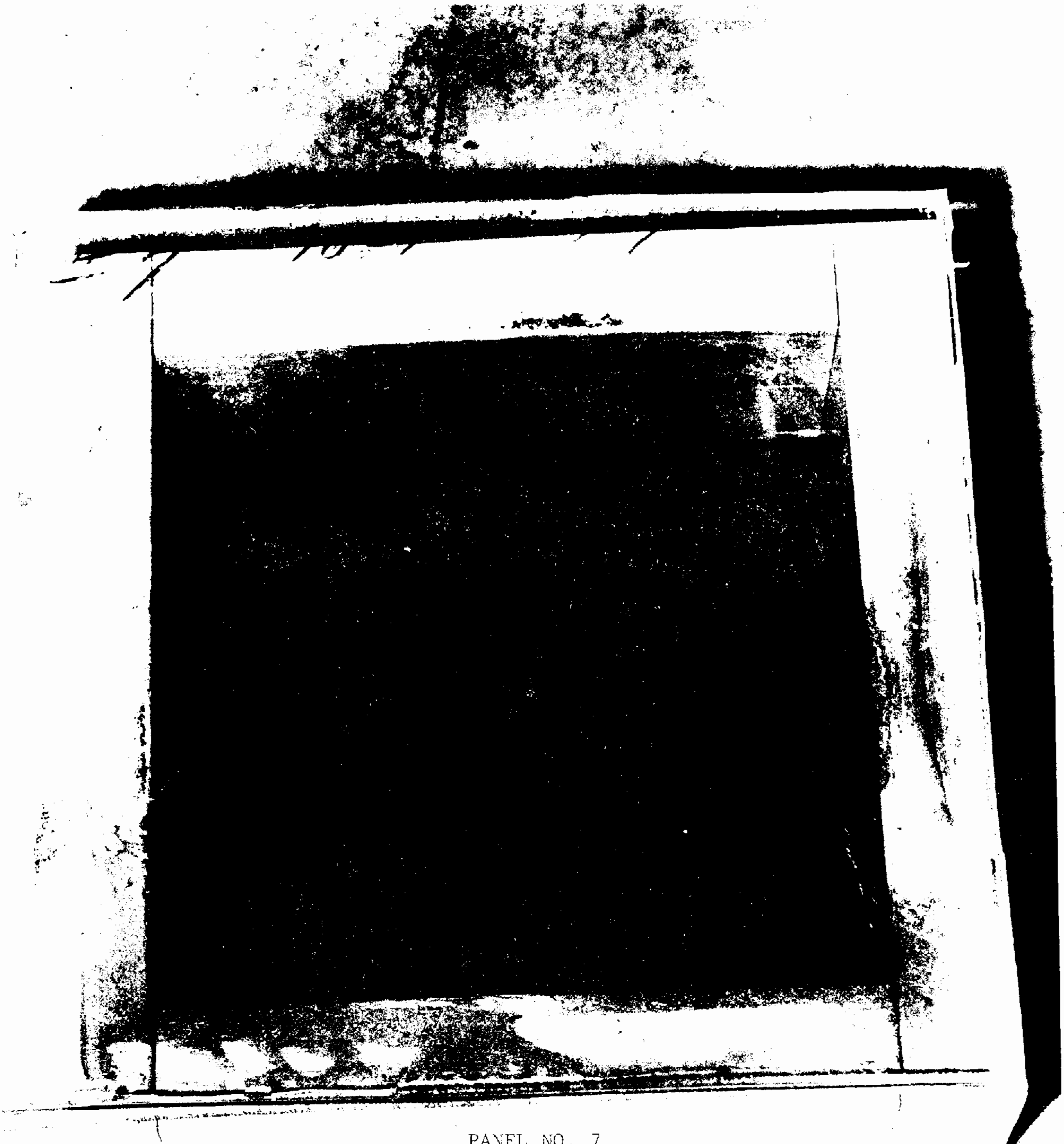
All of the tests were performed in accordance with the Qualification Test Procedure (QTP-002). No failures occurred as the result of testing. The feasibility of the BART windshield design has been demonstrated. Upon approval, all windshields manufactured to this design will be considered qualified.

9.0 APPENDIX

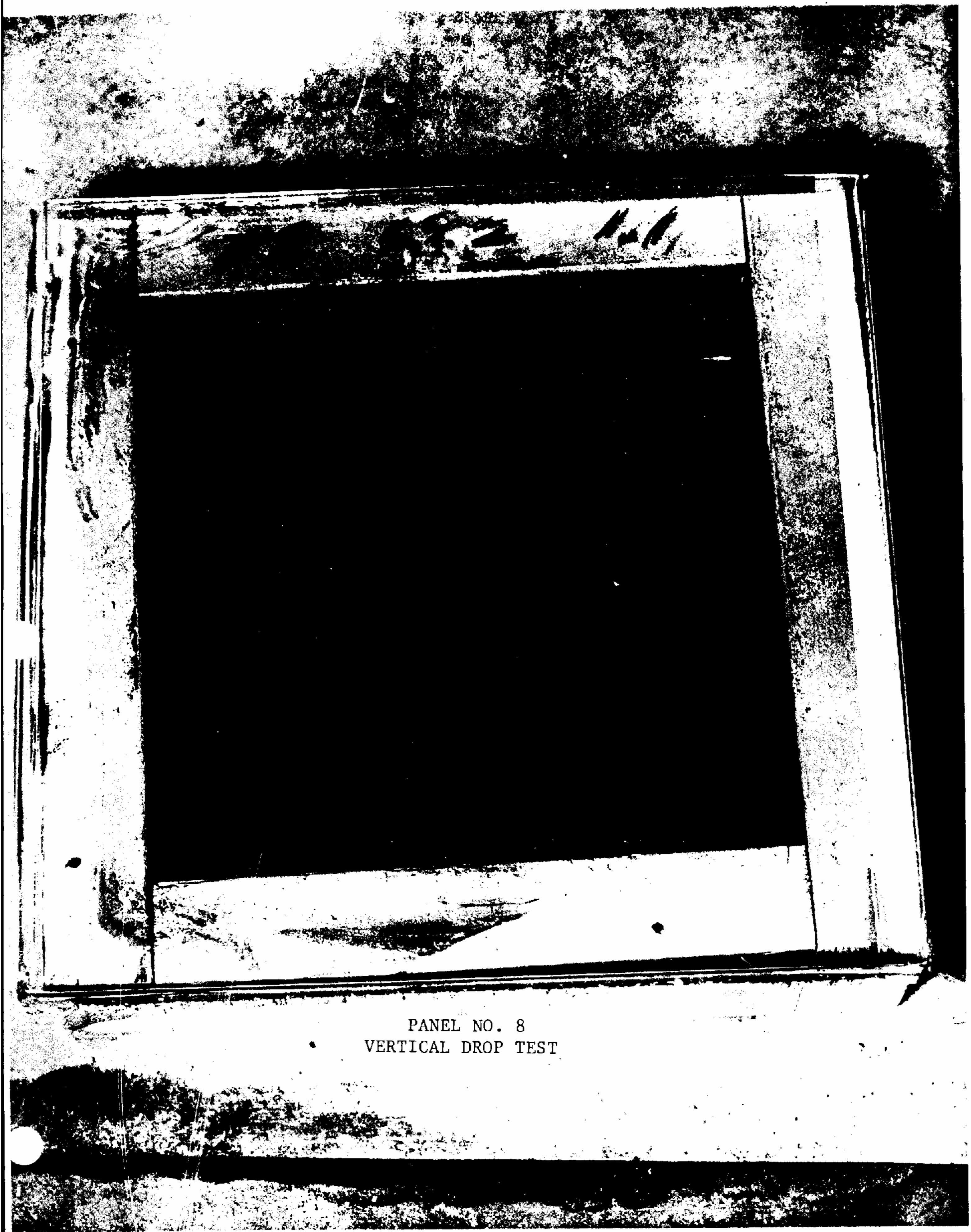
SHEET 260


VERTICAL DROP TEST
11.0 LB. BAG
16 FT DROP
TEST FACILITY
VERTICAL DROP TEST

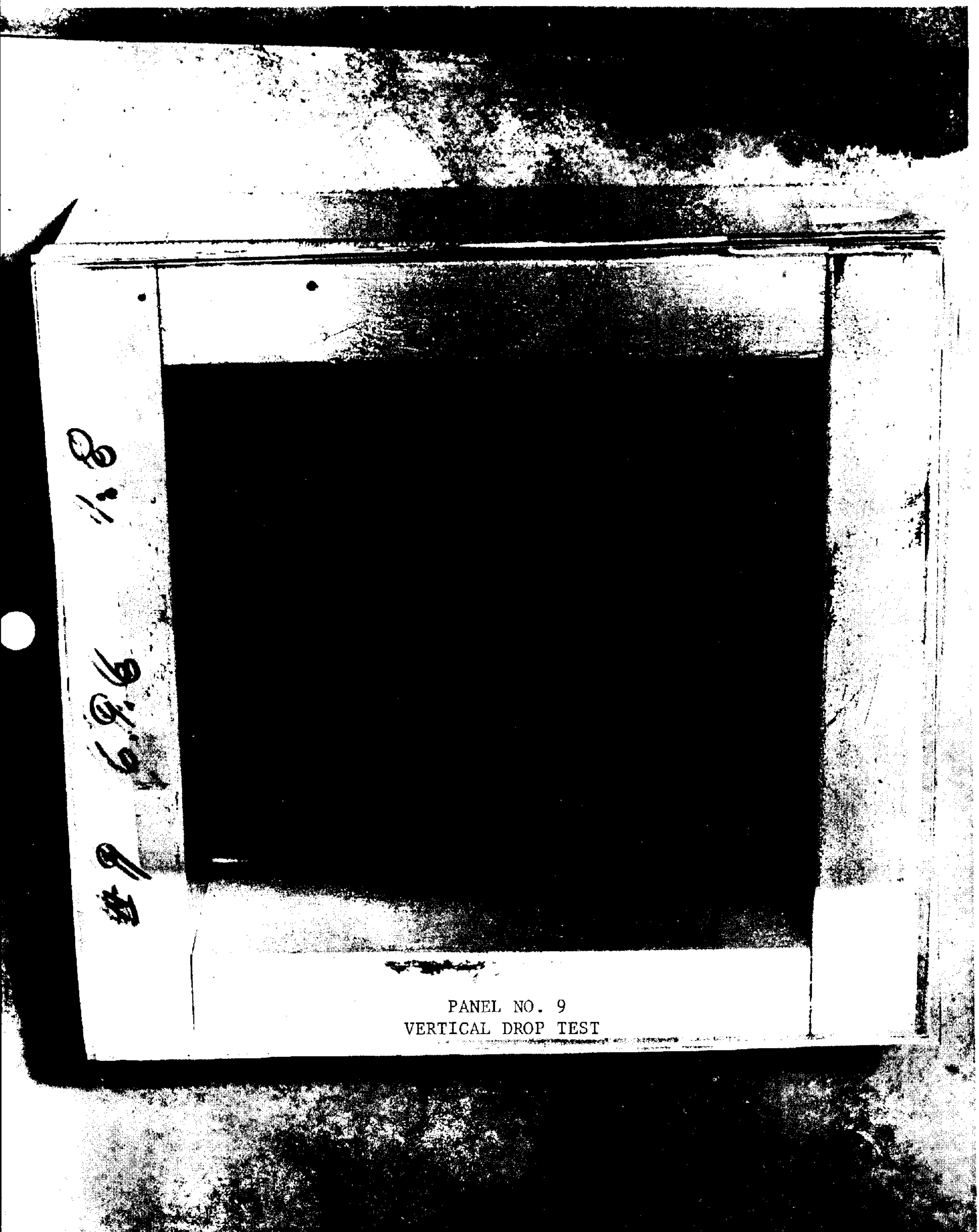

#
PANEL NO. 3
VERTICAL DROP TEST



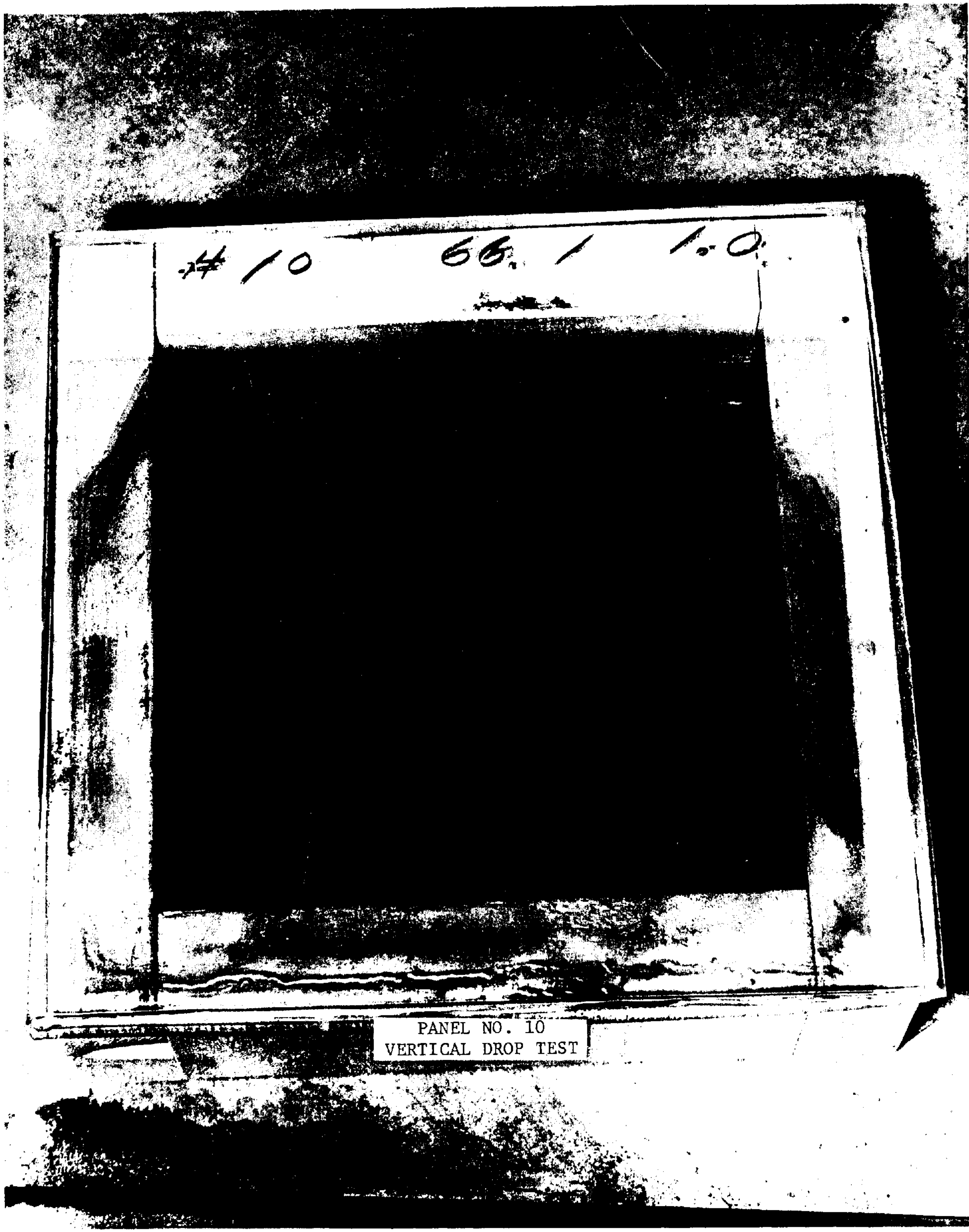
PANEL NO. 7
VERTICAL DROP TEST



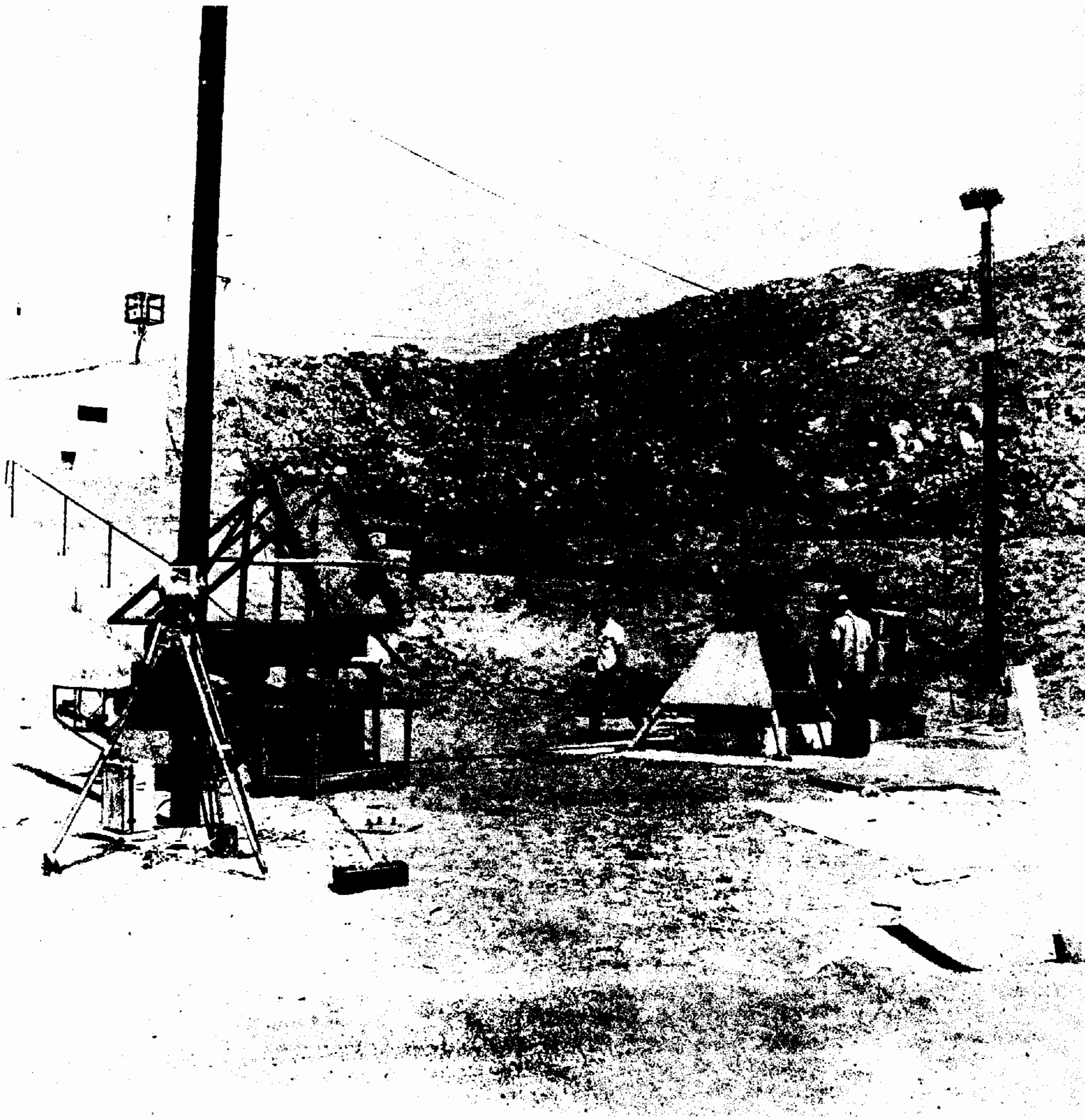
PANEL NO. 8
VERTICAL DROP TEST



PANEL NO. 9
VERTICAL DROP TEST



PANEL NO. 10
VERTICAL DROP TEST



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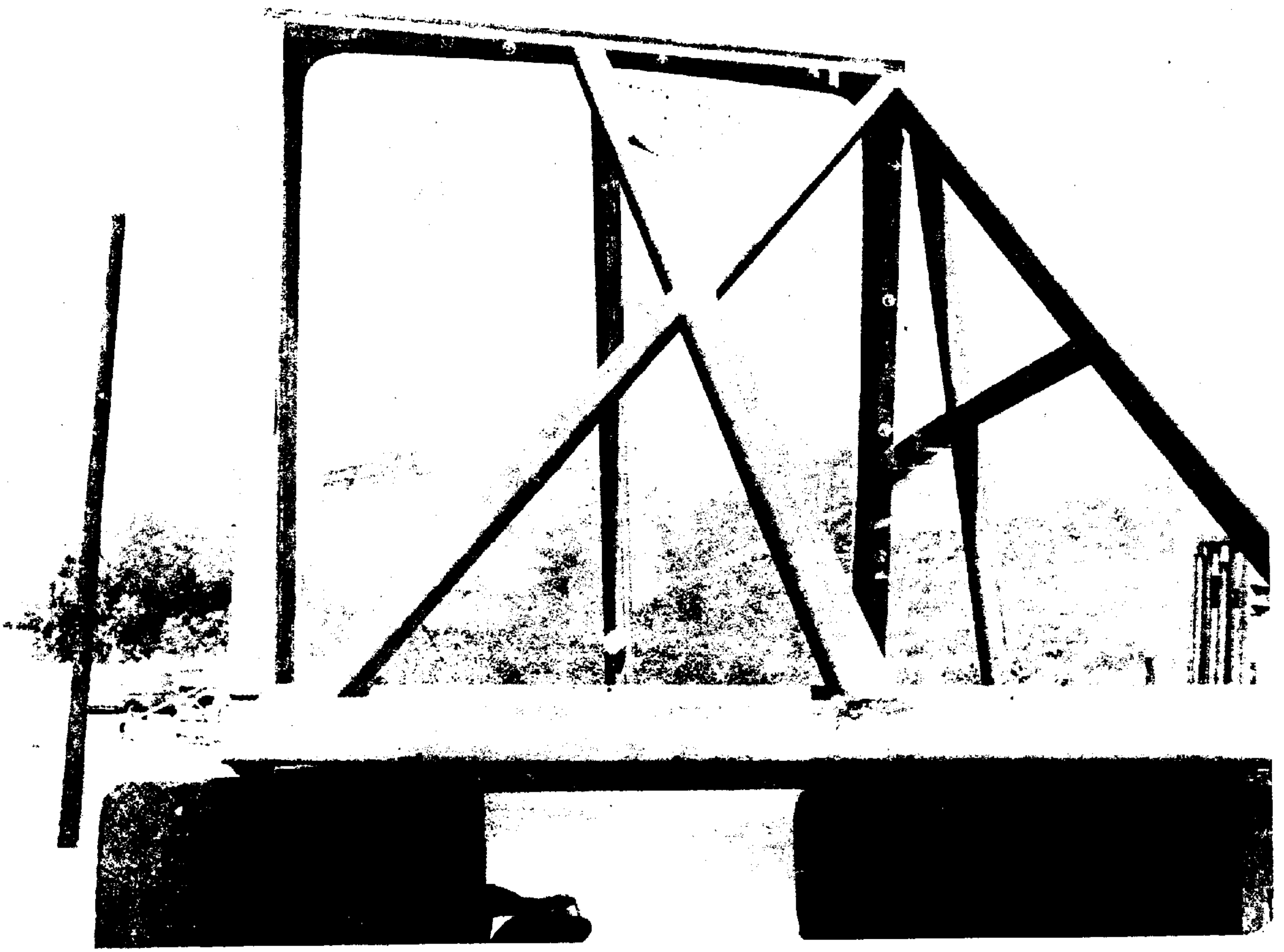

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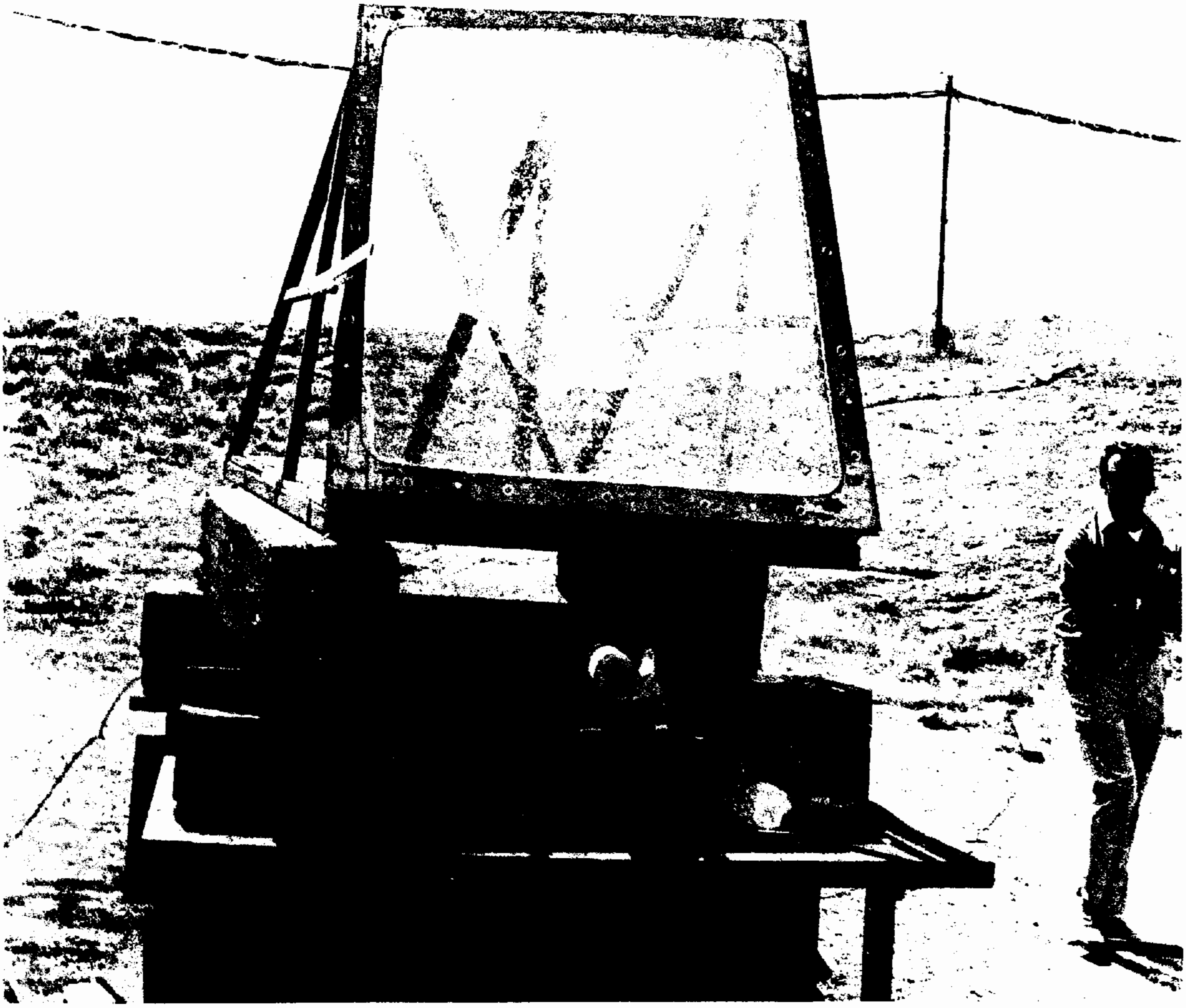
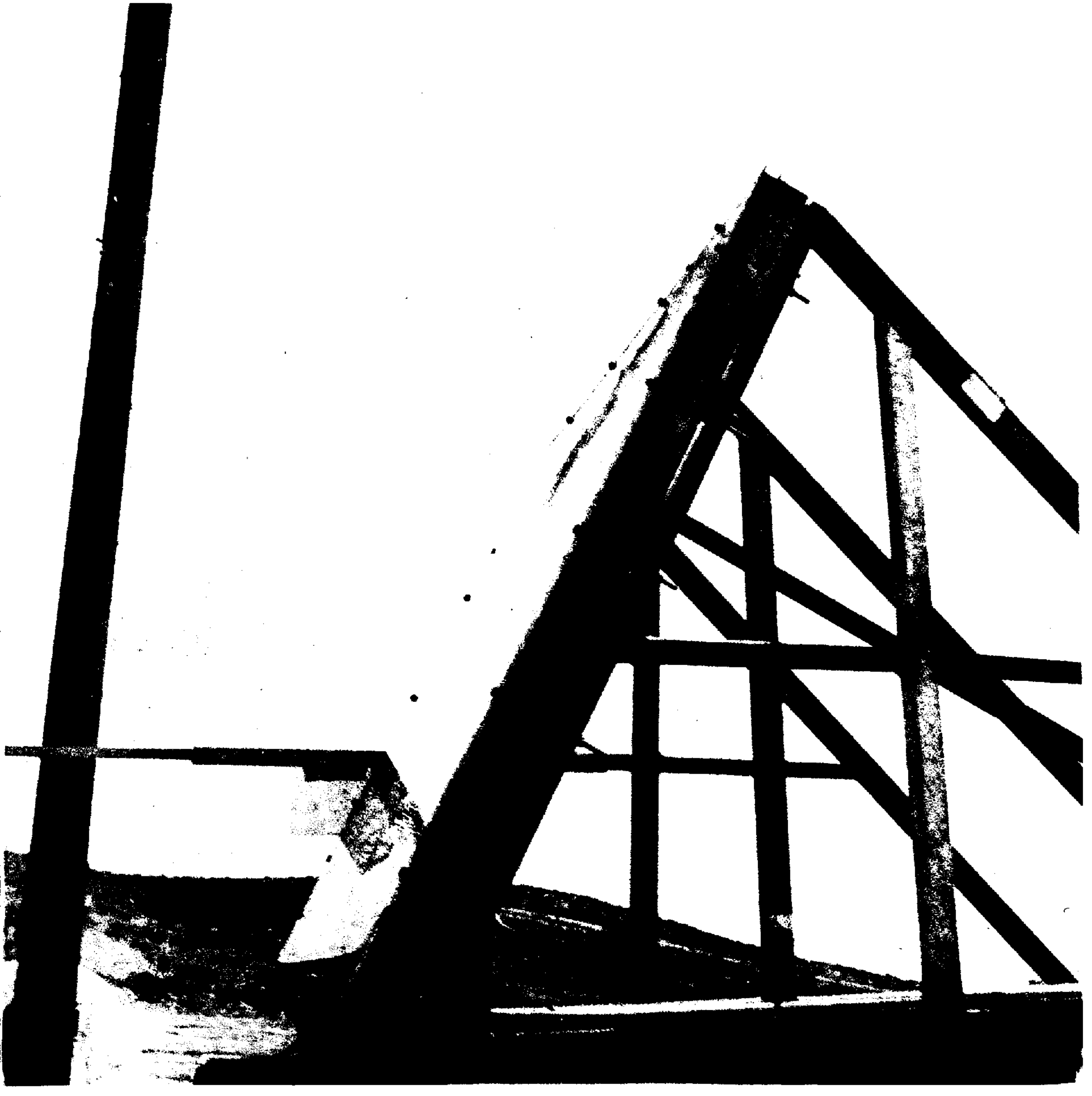
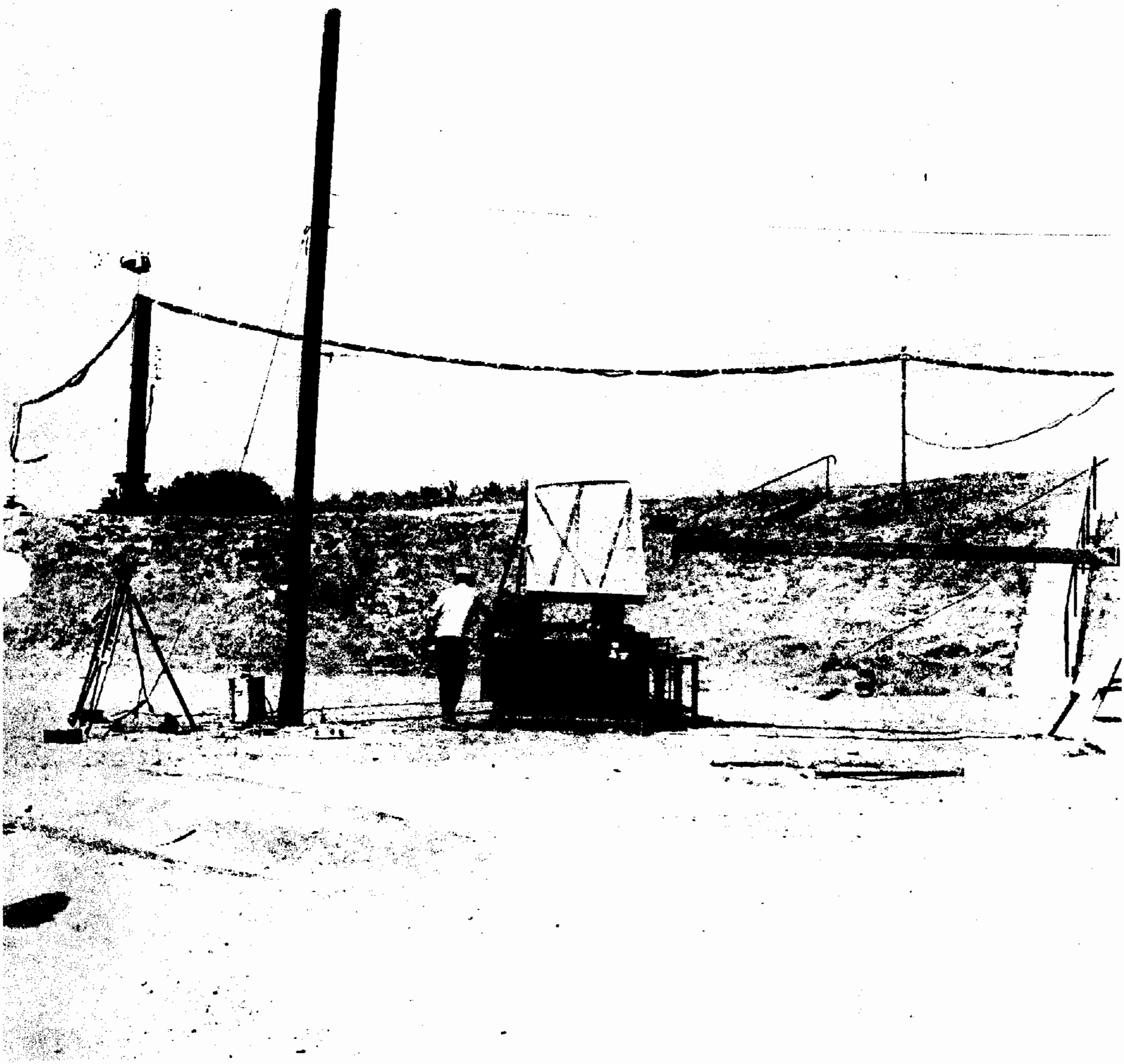
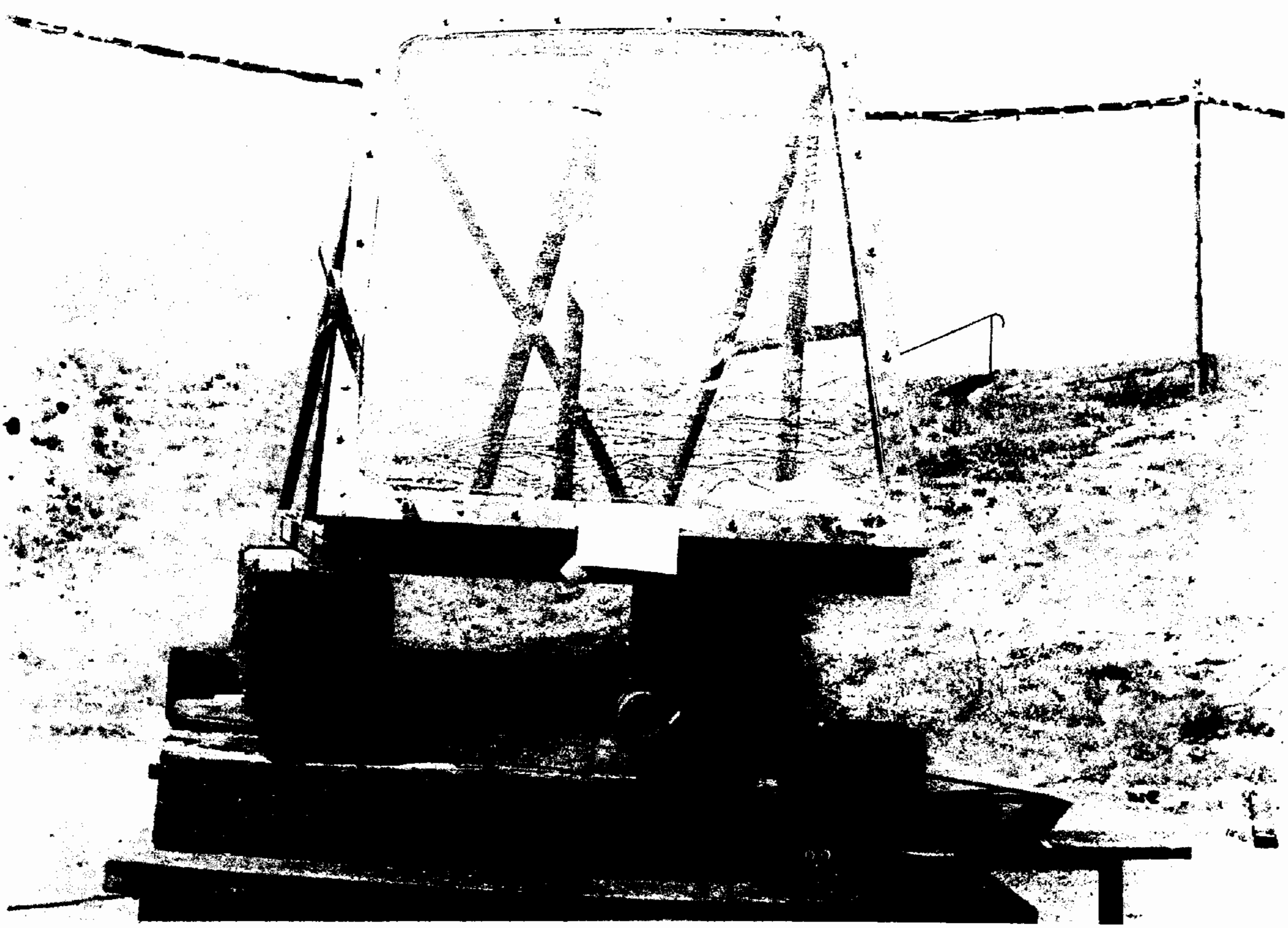


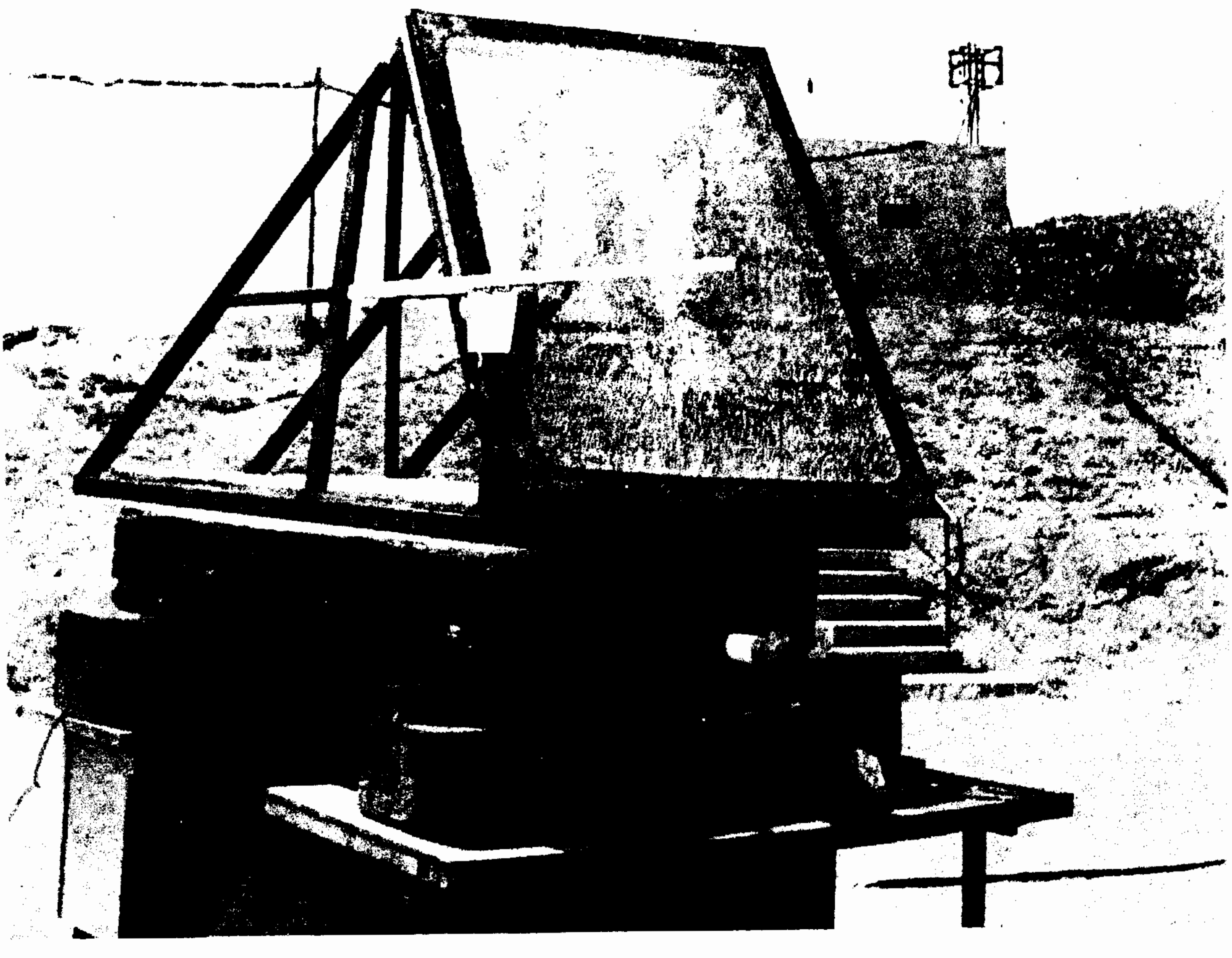


SHEET 271

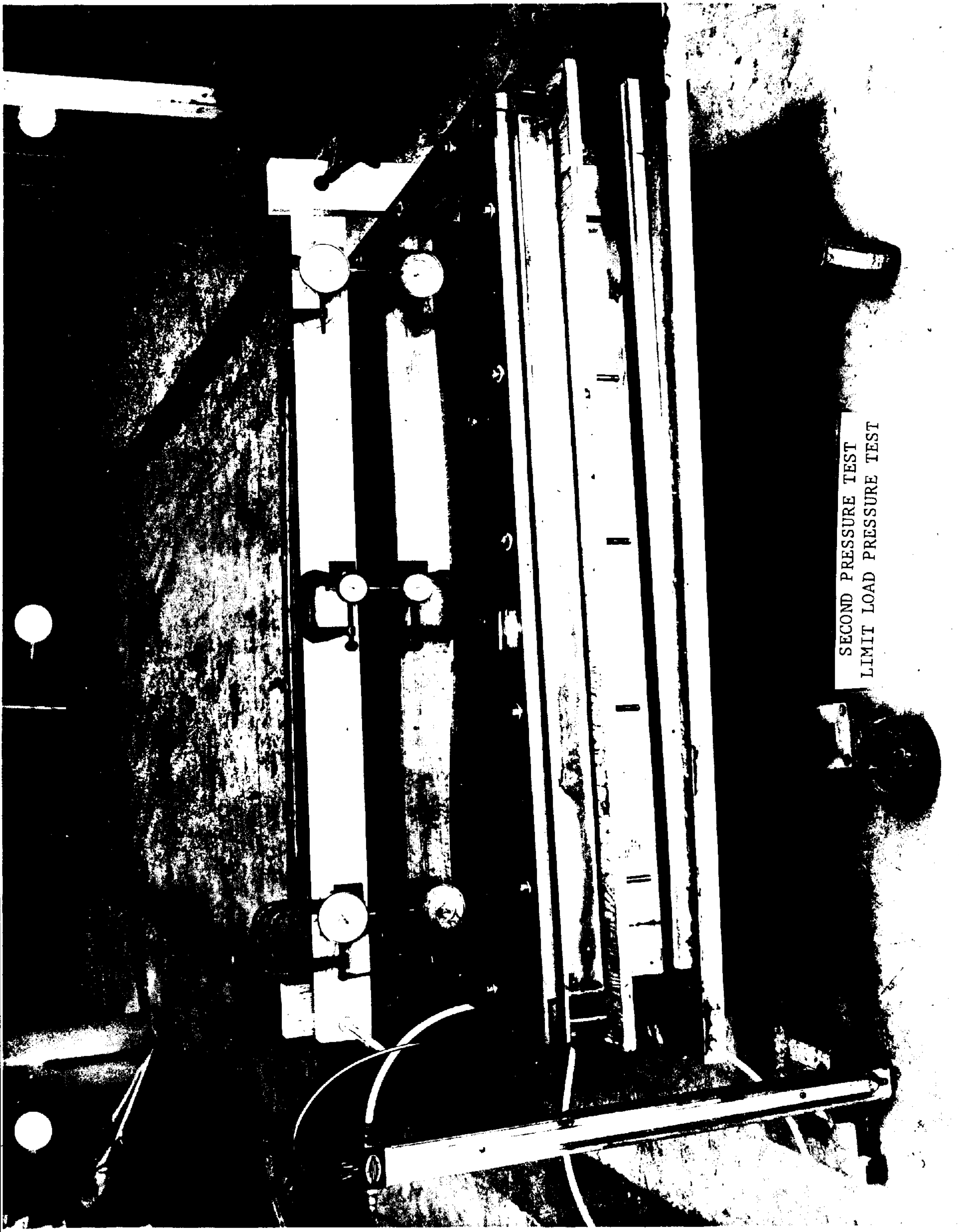


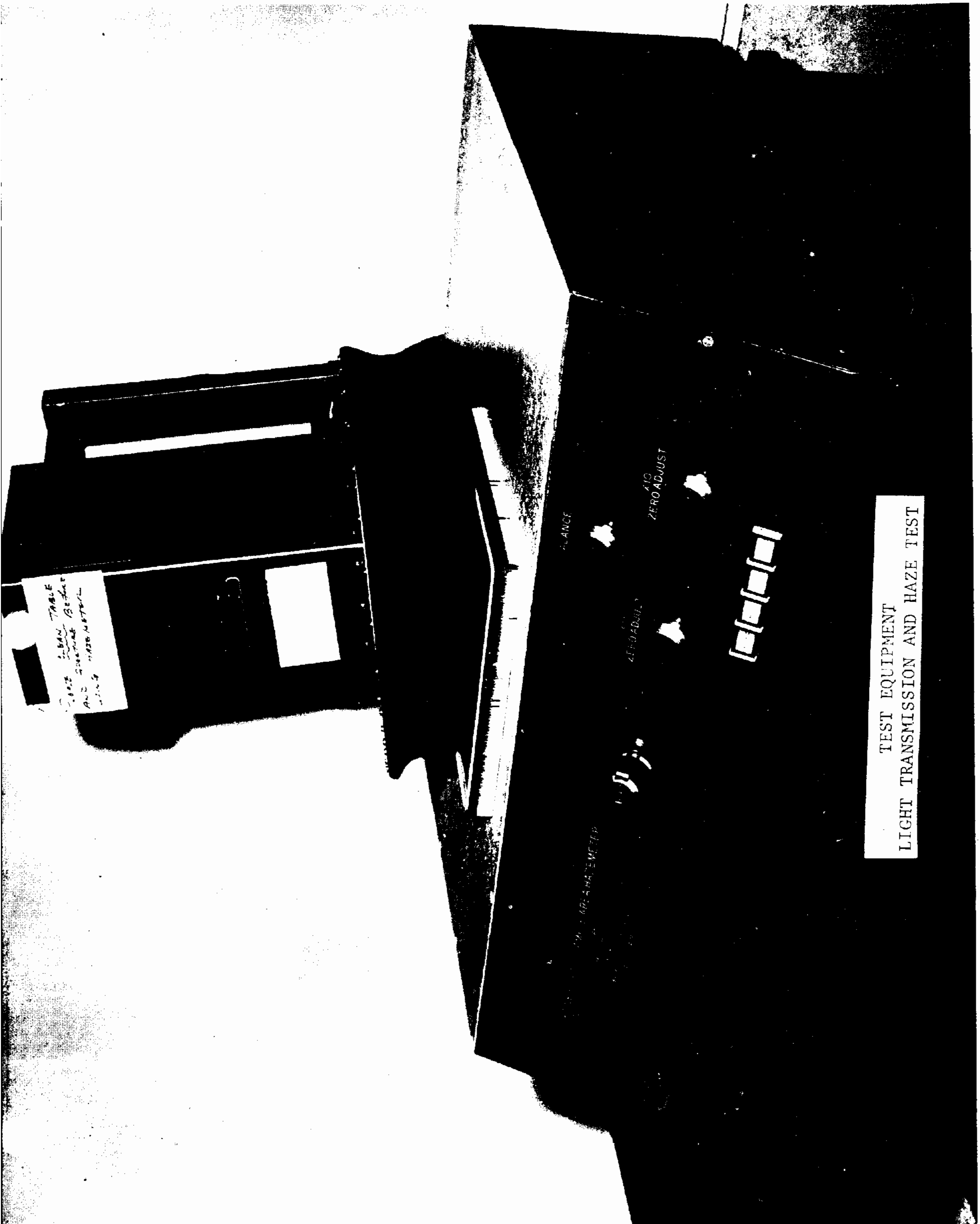


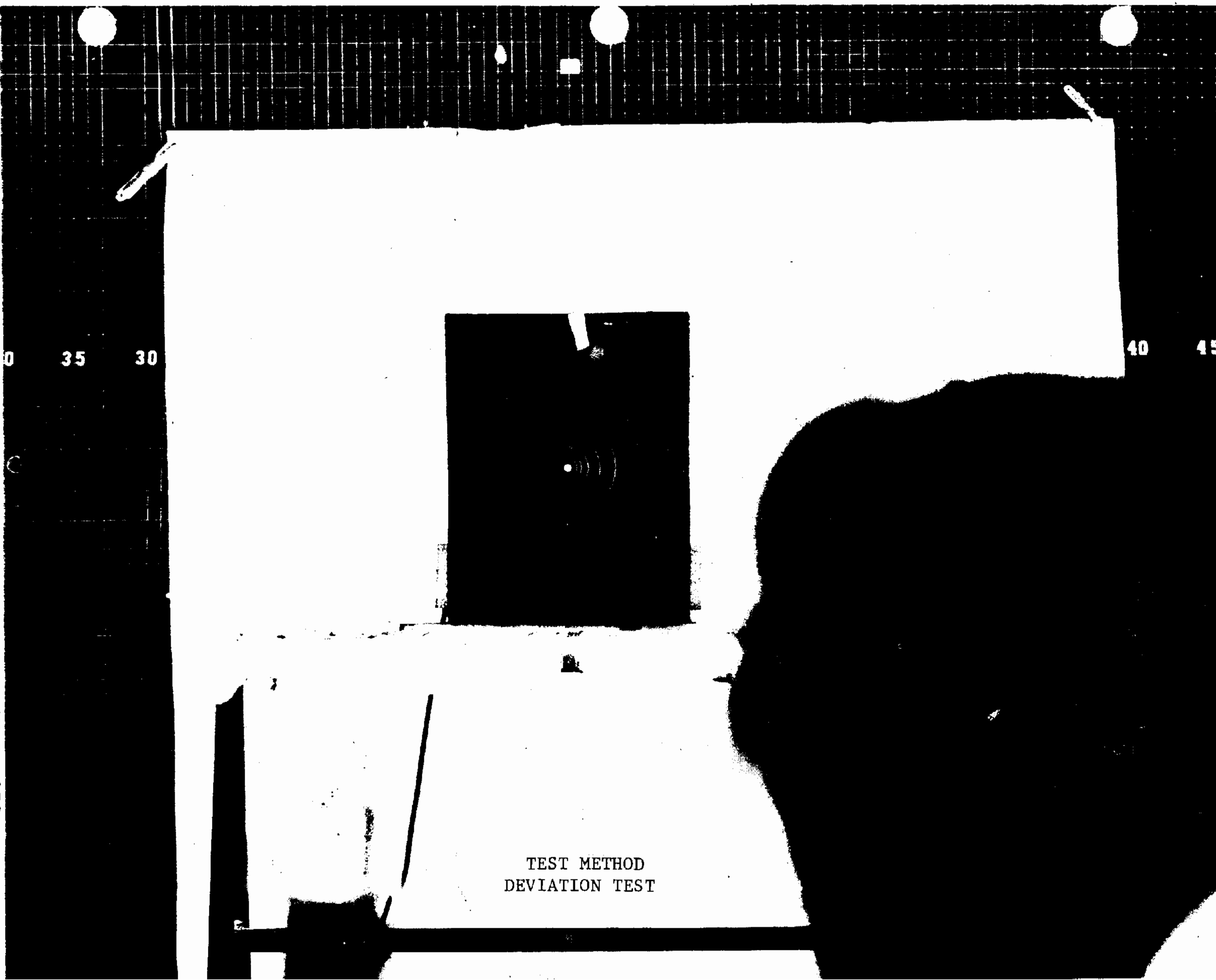
SHEET 273



TEST METHOD
DISTORTION TEST


SECOND PRESSURE TEST
LIMIT LOAD PRESSURE TEST


TEST EQUIPMENT
LIGHT TRANSMISSION AND HAZE TEST
X10
ZERO ADJUST



TEST METHOD
DEVIATION TEST

DATA SHEET REPORT

WYLE LABORATORIES

25 August 1970

Swedlow, Inc.
12605 Beach Boulevard
Garden Grove, California

ATTENTION: A. Domaszewicz
TEST TITLE: Horizontal Impact Test
REFERENCES: Your Purchase Order No. 23162
Wyle Laboratories Job No. NS 52212
Government Contract No. N/A
Wyle Laboratories Report No. 52212

Gentlemen:

This is to certify that the enclosed Test Data Sheets contain true and correct data obtained in the performance of the test program as set forth in your purchase order.

Where applicable, instrumentation used in obtaining this data has been calibrated using standards which are traceable to the National Bureau of Standards.

Test Results:

Test results are presented on the data sheets enclosed in this report.

12 – Page Report

STATE OF CALIFORNIA }
COUNTY OF RIVERSIDE } ss.

Ray C. Myrick, being duly sworn, deposes and says: That the information contained in this report is the result of complete and carefully conducted tests and is to the best of his knowledge true and correct in all respects.

Ray C. Myrick

SUBSCRIBED and sworn to before me this 25th day of August, 19 70

Notary Public in and for the County of Riverside, State of California

My Commission expires 14 July, 19 71

OFFICIAL SEAL
CATHERINE C. NEWMAN
NOTARY PUBLIC - CALIFORNIA
PRINCIPAL OFFICE IN
RIVERSIDE COUNTY

W-781

DEPARTMENT Solid Propellants

DEPT. MGR. J. Ward

TEST ENGINEER E. Alterman

TEST WITNESS

DCAS–QAR VERIFICATION

QUALITY CONTROL

WYLE LABORATORIES

DATA SHEET

Test Title: ACCELERATION IMPACT TEST

Customer: SWEDLOW

Part No. —
S/N: 103 & 104
Spec.: QTP 002
Para.: 312

Job. No.: 52212
Date Test Started: 8-13-70
Date Test Completed: 8-13-70
Amb. Temp.: 70 ± 20 °F
Photo: YES
Test Med.: —
Specimen Temp.: AMB

Specimen: WINDOW

SPECIMEN 103 AND 104 WERE SET UP 114 INCHES FROM POINT OF RELEASE OF 1 POUND & 5 POUND BALL RESPECTIVLY. SPECIMENS WERE POSITIONED IN SUCH A MANNER THAT SUBJECT BALLS IMPACTED WITHIN A 12" SQUARE TO CENTER OF SPECIMEN. THE FOLLOWING ACCELERATION TEST WAS PERFORMED.

I. ONE POUND BALL SPECIMEN S/N 103.
   A. Speed : 80 MPH ± 3 MPH
   B. RPM = 63.3

II FIVE POUND BALL SPECIMEN S/N 104
   A. Speed = 50 MPH ± 3 MPH
   B. RPM = 39.4

Specimen Meets Spec. Requirements YES ☐ NO ☐

Tested By: B. Allen
Witness: ______ Date: ______
Sheet No. ______ of ______
Approved: [signature] Date: 8-15-70

W 616 A QC Form Approval

SPECIMEN Window

CUSTOMER Swedlow

PART NO. —

S/N 103 + 104

JOB NO. 52212

DATE 8-13-70

TEST BY

WITNESS

WYLE LABORATORIES

TEST: ACCELERATION TBST.

EQUIPMENT	MANUFACTURER	MODEL NO.	RANGE	WYLE NO.	CALIBRATION		ACCY.
					LAST	DUE	
CLOCK	STANDARD	B-3	0-60 MIN.	30788	5-1-70	11-1-70	±1 SEC.
Centrifuge	Wyle Labs	—	4B ft 20,000 G/lbs	30505	PRIOR TO TEST		—

W 614 C Q.C. Approval [illegible]

SHEET OF

SHEET 281

WYLE LABORATORIES

REPORT NO. 52212

PAGE No. 4

DATA SHEET

CUSTOMER Swedlow Inc.
Test Title: ACCELERATION

Specimen WINDOW

Part No. —

Job No. 52212
S/N 103 & 104
Date 8-13-70

DATE	TIME	TEMP. (F)	LEVEL (G)	RG	RPM	AXIS	DIRECT.	COMMENT
SPEC.	REQ:	AMB	NOTED	Noted	Noted			
8-13	1140	AMB	80 MPH	200 IN.	63.3			RUN FIRST ACCELERATION
								TEST. USING 1lb. BALL.
								SERIAL NO. 103
8-13	1500	AMB	50 MPH	200 IN	39.4			RUN SECOND ACCELERATION
								TEST USING 5lb. BALL
								SERIAL NO. 104

TEST BY: [signature] DATE

APPROVED: DATE 8-13-70

Q.C. Form Approval

SHEET 282 OF

APPENDIX IV

SEAT STRENGTH

SHEET 284

STATE OF THE ART

HIGH DENSITY CAR SEATING

STRENGTH AND PERFORMANCE DATA

APRIL 14, 1972

SHEET 286

STATE OF THE ART

HIGH DENSITY CAR SEATING

AMERICAN SEATING COMPANY

TITLE: STRENGTH AND PERFORMANCE DATA

Compiled by: A. J. Hogan — Date 4-14-72
A. J. Hogan
Senior Product Designer

J. R. Knoblaugh — Date 4-14-72
J. R. Knoblaugh
Senior Product Designer

Approved by: C. J. Barecki — Date 4-14-72
C. J. Barecki
Manager - Transportation Engineering

SHEET 288

TABLE OF CONTENTS

SCOPE:

Data contained herein deals with the technical aspects required for design, performance and tests for seat assemblies for the "STATE OF THE ART" vehicle.

The general design of the seat and its structure is based on requirements defined to obtain seating of good quality with superior product and functional values.

Product values are those construction features which insure strength, durability and satisfactory performance. These values are determined by means of strength analysis and relevant mechanical tests.

Functional values are the features which offer the passenger a maximum of postural comfort with seating unit requiring a minimum of repair and maintenance.

TECHNICAL DATA:

In supplement to the detailed drawings and seat prototypes, the contents has documents dealing with loading conditions, strain and deflections recorded in actual tests of representative seats.

The tests were conducted on equipment designed to determine the integrity of the seat assembly under various simulated conditions.

In addition to the specification prescribed for static load tests, this report contains supplemental static and performance tests applied as AmSeCo seat design criteria.

SUMMARY ESTIMATED SEAT WEIGHTS

		Quantity	Weight	Total in Pounds
I.	THREE PASSENGER LONGITUDINAL SEAT	16	78.9#	1262.4
II.	FOUR PASSENGER TRANSVERSE SEAT	6	110.8#	664.8
III.	MOTORMANS SEAT	1	36.5#	36.5
			TOTAL	1963.7 Pounds

THREE PASSENGER LONGITUDINAL SEAT

SHEET 293

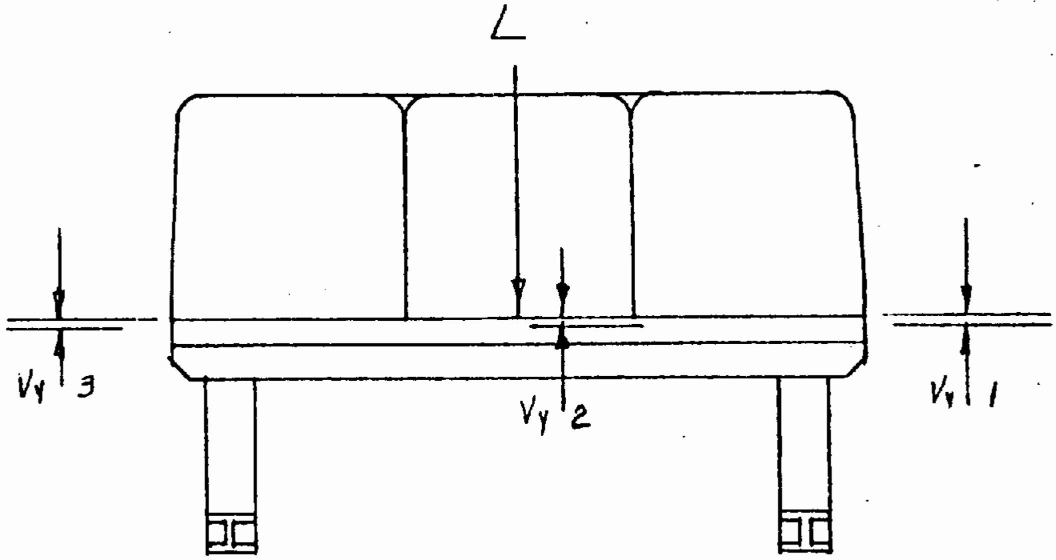
STATIC LOAD TEST DATA

TEST I SEAT ASSEMBLY - DOWNWARD VERTICAL STATIC LOAD.

TEST EQUIPMENT:

The seat assembly mounted on two angle uprights was placed on a Toledo scale.

A special motorized load device applied the vertical-downward load in the middle of the center sitting as shown



LOAD	DEFLECTION (INCHES) #1	#2	#3	PERMANENT SET (INCHES) #1	#2	#3
100	1/32	1/16	1/32	-	-	-
200	1/16	7/64	1/16	-	-	-
300	3/32	5/32	3/32	-	-	-
400	1/8	7/32	1/8	-	-	-
500	5/32	9/32	5/32	-	-	-
600	3/16	3/8	3/16	0	1/64	0
700	7/32	7/16	7/32	0	1/64	0
800	17/64	1/2	17/64	0	1/64	0

TEST RESULTS: After removal of load inspection found no failures; or permanent deformation other than shown above.

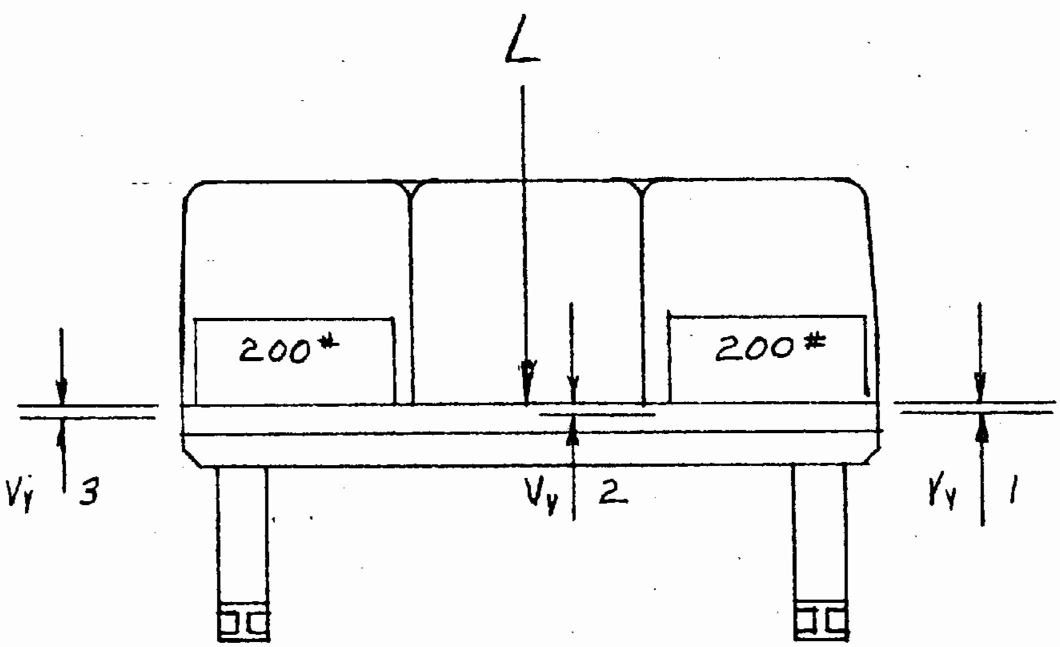
STATIC LOAD TEST DATA

TEST II SEAT ASSEMBLY-DOWNWARD VERTICAL FIXED PLUS VARIABLE STATIC LOAD.

Fixed Load of 400# (200# in each outboard sitting) along with variable load.

TEST EQUIPMENT:

The seat assembly mounted on two angle uprights was placed on a Toledo scale. Fixed loads of 200# each were placed in the center of both outboard sitting position. A varying load of 800# was applied by means of a special motorized loading device.



LOAD#	DEFLECTION (INCHES) #1	#2	#3	PERMANENT SET (INCHES) #1	#2	#3
200+0+200	3/32	1/8	3/32	-	-	-
200+800+200	11/32	19/32	11/32	-	-	-
200+0+200	3/32	1/8	3/32	-	-	-
0+0+0	-	-	-	0	0	0

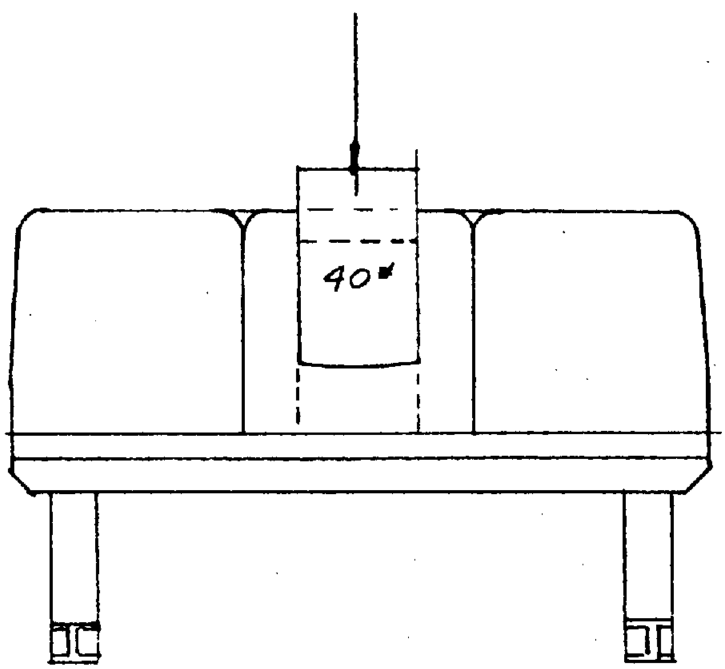
TEST RESULTS: After removal of loads no permanent set or deformation was found.

PERFORMANCE TEST

TEST A. VERTICAL DROP IMPACT TEST

TEST EQUIPMENT:

The seat assembly mounted on two angle uprights simulating actual car attachment, was subjected to a vertical drop impact test with a 40 lb. weight on the middle sitting. The weight impacted the fiberglass seat 1,000 times from heights of 6", 8", 10" & 12".



TEST RESULTS: Inspection during and after completion of test revealed no failures or deformation.

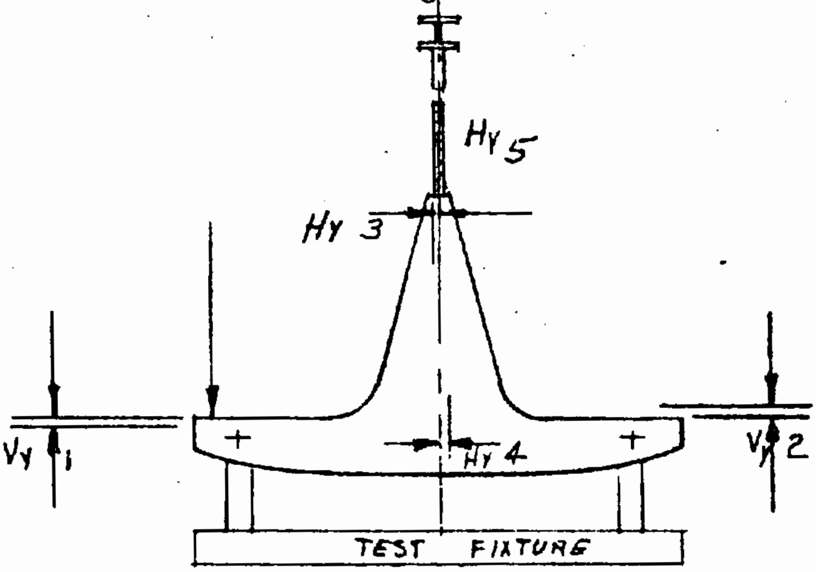
FOUR PASSENGER TRANSVERSE SEAT

STATIC LOAD TEST

Test III SEAT ASSEMBLY - VARIABLE VERTICAL STATIC LOAD

TEST EQUIPMENT: The seat assembly, mounted on a test fixture was placed on a toledo scale.

A special motorized load device applied a vertical-downward load at center of aisle setting.



LOAD (LBS.)	DEFLECTION (INCHES)					PERMANENT SET (INCHES)				
	1	2	3	4	5	1	2	3	4	5
100	1/32	1/32	1/32	0	-	-	-	-	-	-
200	1/16	1/16	1/16	0	-	-	-	-	-	-
300	3/32	5/64	1/16	0	-	-	-	-	-	-
400	5/32	7/64	3/32	1/64	-	-	-	-	-	-
500	3/16	5/32	1/8	1/32	1/16	-	-	-	-	-
600	15/64	3/16	5/32	1/32	3/32	0	1/64	0	0	0
700	9/32	15/64	3/16	3/64	5/64	0	1/64	0	.010	1/64
800	5/16	9/32	3/16	1/16	3/32	1/64	1/64	0	.010	1/64
900	3/8	5/16	7/32	1/16	1/8	1/64	1/64	0	1/64	1/64

A. Removed 2 & loosened 1/8" 2 stanchion overhead mounting bolts:

LOAD (LBS.)	DEFLECTION (INCHES)					PERMANENT SET (INCHES)				
	1	2	3	4	5	1	2	3	4	5
100	1/16	1/32	1/32	0	-	-	-	-	-	-
200	1/8	1/32	1/32	0	-	-	-	-	-	-
300	3/16	3/32	3/32	0	-	-	-	-	-	-
400	15/64	1/8	7/64	0	1/64	-	-	-	-	-
500	9/32	3/16	9/64	1/64	3/64	-	-	-	-	-
600	5/16	7/32	5/32	1/32	1/16	1/32	0	0	0	0

Point 5. is the stanchion bow measured with a 3 foot rule 18 inches from top seat back.

TEST RESULTS: After removal of load inspection found no failures;or deformation other than noted above.

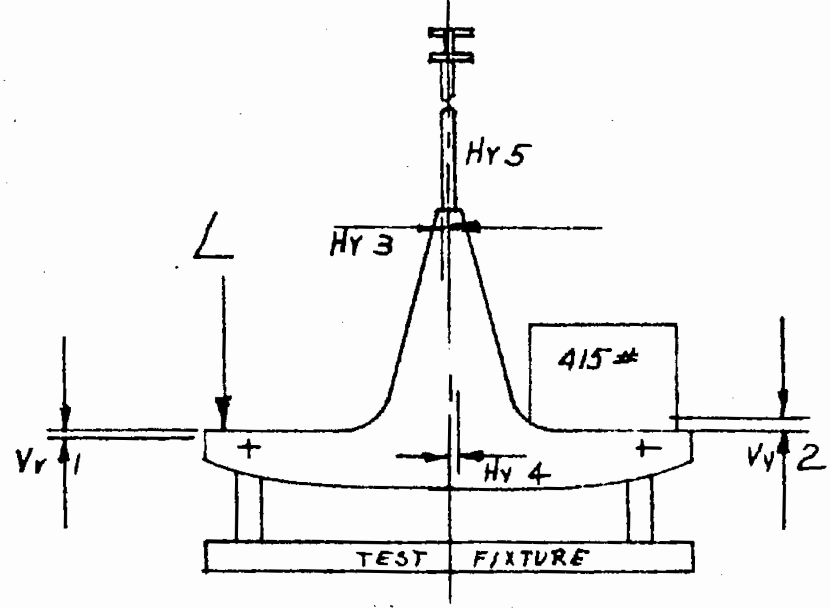
STATIC LOAD TEST

TEST IV SEAT ASSEMBLY - FIXED PLUS VARIABLE VERTICAL STATIC LOAD

TEST EQUIPMENT:

The seat assembly, mounted on a test fixture was placed on a Toledo scale. A fixed load of 415# was placed in aisle sitting of one side.

A special motorized load device applied a vertical-downward load at center of opposite aisle sitting.



LOAD LBS.	DEFLECTION (INCHES) 1	2	3	4	5	PERMANENT SET (INCHES) 1	2	3	4	5
0+415	-3/32	-1/8	-1/16	-1/64	0	-	-	-	-	-
415+415	3/32	0	1/32	0	-	-	-	-	-	-
515+415	9/64	3/64	1/16	1/64	-	0	1/64	0	1/64	-

TEST RESULTS: After removal of load inspection revealed no failures;or deformation other than noted above.

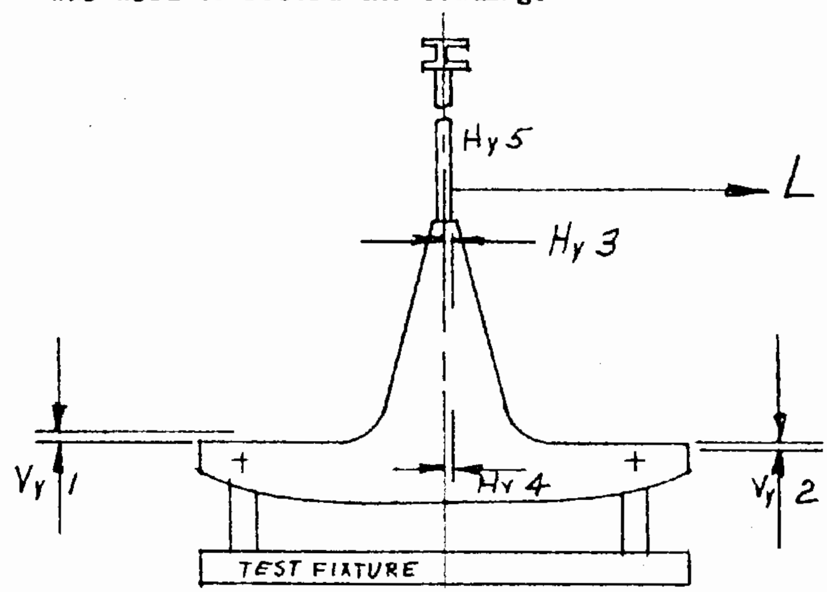
STATIC LOAD TEST

TEST V SEAT ASSEMBLY - VARIABLE HORIZONTAL STATIC LOAD.

TEST EQUIPMENT:

The seat assembly mounted in the test fixture was subjected to a horizontal load applied to the stanchion.

A Martin-Decker (Dynamometer) and Readout Scale (0-6000#) was used to record the loading.



LOAD LBS.	DEFLECTION (INCHES)					PERMANENT SET (INCHES)				
	1	2	3	4	5	1	2	3	4	5
100	3/64	1/32	5/64	3/64	-	-	-	-	-	-
200	3/32	1/16	3/16	3/32	-	-	-	-	-	-
300	1/8	3/32	9/32	7/32	-1/64	-	-	-	-	-
400	3/16	1/8	7/16	19/64	-3/64	1/64	.010	1/32	1/64	0
500	7/32	5/32	19/32	13/32	-1/16	3/64	.010	1/32	1/32	0

A. Load applied with loosened stanchion:

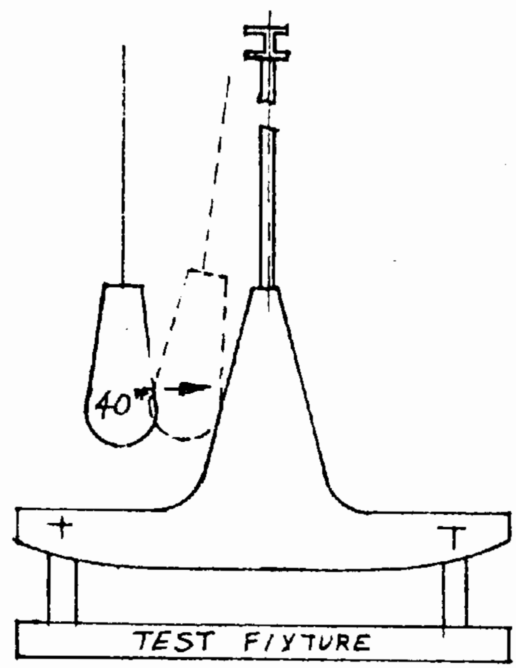
LOAD LBS.	DEFLECTION (INCHES)					PERMANENT SET (INCHES)				
	1	2	3	4	5	1	2	3	4	5
100	3/64	1/32	3/32	1/16	--	-	-	-	-	-
200	3/32	1/16	7/32	11/64	–	-	-	-	-	-
300	5/32	7/64	11/32	1/4	--	-	-	-	-	-
400	13/64	9/64	1/2	11/32	-3/32	0	0	1/64	1/32	0

TEST RESULTS: After removal of load inspection revealed no failures or other deformation.

TEST B. SWINGING IMPACT TO BACK TEST

TEST EQUIPMENT:

The seat frame assembly mounted on a test fixture, simulating actual car attachment, was subjected to a horizontal swinging impact test with a 40 lb. weight. The weight impacted the fiberglass aisle back 10,000 times with strokes of 6", 8", 10" and 12" each.



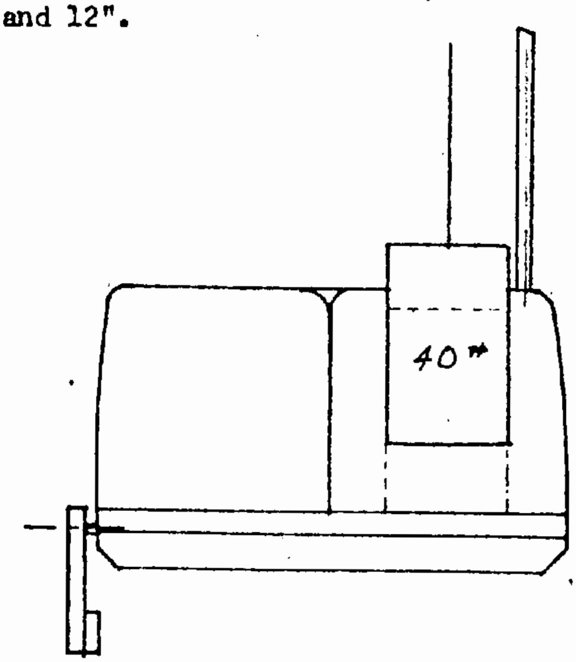
TEST RESULTS: Inspection during and after completion of test revealed no failures or deformation.

PERFORMANCE TESTS

TEST C. VERTICAL DROP IMPACT TO SEAT TEST

TEST EQUIPMENT:

The seat assembly mounted on the test fixture simulating actual car attachment, was subjected to a vertical drop impact test with a 40 lb. weight on the aisle sitting. The weight impacted the fiberglass seat 1,000 times from heights of 6", 8", 10" and 12".



TEST RESULTS: Inspection during and after completion of test revealed no failures or deformation.

DISCUSSION OF RESULTS

The seat as proposed by the American Seating Company has undergone thorough testing by the AmSeCo Testing Laboratory. The results were very favorable and are listed herein as a matter of record.

Static tests have been supplemented by AmSeCo design test. In these tests, the load was applied incremently as shown and then removed at each load to measure permanent set.

The static tests determine strength, deflection and any deformation of a representative unit. The loading established by AmSeCo requirements simulate possible shock condition induced by decelerative impact or rough usage in the car. Static tests determine strength and deflection whereas the performance test designed by AmSeCo determine approximate functional effectiveness and approximate life of the seat.

Impact test generate loads induced in drop or swinging fashion reveal possible weakness in component members, welds, failure due to deflection, torsion or fatigue.

It is, therefore, concluded that the seat structure and attachment system will retain structural integrity under typical loadings imposed by normal use conditions.

SHEET 304

APPENDIX V

MATERIALS - FIRE RESISTANCE

AMERICAN SEATING

AMERICAN SEATING COMPANY • 901 BROADWAY AVENUE, N.W. • GRAND RAPIDS, MICHIGAN 49504

May 18, 1973

WWS 5-23-73

Mr. William W. Seary
Assistant Manager of Quality Assurance
Mail Drop P-4102
Boeing-Vertol Company
P.O. Box 16858
Philadelphia, Pennsylvania 19142

RECEIVED

SEP 25 1973

Reference: State of the Art Cars
G.R. Order No. 373358 (Low Density)
373359 (High Density)

Dear Mr. Seary:

This is to confirm Jack R. Knoblauch and my telephone conversation with you earlier today.

The woven fabric was used in the low density car only and was Craftex No. K-16924N.

This fabric was ordered from the mills with specifications calling for compliance with FVMSS-302.

Enclosed is one-half yard of this same fabric in X-5575 Magenta Red. Also enclosed is a copy of the 302 Test we ran today on this same fabric. You can readily see that it more than meets all the 302 requirements.

At your request we are also enclosing a copy of FVMSS-302 which became effective September 1, 1972.

I believe the confusion centers around the fabric number you gave me as Craftex 140. We have no knowledge of any Craftex number like this and it does not relate to any Craftex fabric coding that we have ever seen at American Seating Company.

We are convinced that the SOAC order was furnished with Craftex K-16924N (in both the blue and red colors) and that it meets No. 302.

After you have had a chance to review this and there still may be any questions, please get in touch with me.

Very truly yours,

L. M. Wickman

L. M. Wickman
Manager of Special Products
Transportation Products Division

mg

Enclosures

FLAMMABILITY TEST REPORT

Federal Motor Vehicle Safety Standard 302

Material Description: Woven Fabric Craftex - K16924 N - #X5575 Magenta Date of Test 5-18-73

Lot Number:

P.O. of Material:

B.O. Material to be Used on:

Date Material Received:

Quanity of Material Received:

Side of Sample Down Pile (Fill)

Specimen No.	Size of Specimen (Inches)	Thickness of Specimen (Inches)	Distance of Flame Travel (Inches)	Time Of Burning (Seconds)	Burn Rate (Inches/Min.)	Flammability Rating
1-P-i-F	4" X 14"	As received	0	0		SE
2-P-i-F	" "	" "	1 7/8"	145 sec.	0.8"	SE/B 0.8"
3-P-i-W	" "	" "	0	0		SE
4-P-d-W	" "	" "	11/16"	82 sec.	0.5"	SE/B 0.5"
5-P-d-F	" "	" "	11/16"	93 sec.	0.4"	SE/B 0.4
6-P-d-F	" "	" "	1 3/8"	122 sec.	0.7"	SE/B 0.7

GMC PGS-1-200

No. of Specimens Tested	Applicable table	Maximum Burn Rate (Inches/Min.)	Burn Rate Range (Inches/Min.)	Acceptable or Rejectable Burn Rate
3	1A	0.8"	0.4"	Acceptable

COPIES TO: R. W. Clay, D. N. Humphries, J. C. Radeke, E. F. Saukas, M. E. Stoner, E-13 Upholstery Crib, File

R. Mankowski 5-18-73

SHEET 309

QCR 73-56

Attachment 1
Page One

TEST RESULTS

LAB LOG NO.	MATERIAL IDENTIFICATION SPECIMEN	SPEC NO.	FLAME TEST (1) AFTER-FLAME TIME (SECS.)	AFTER-GLOW TIME (SECS.)	CHAR LENGTH (INCHES)	REMARKS
73B2312	Seats - Shell	1	334	0	0.1	Self-Extinguishing
73B2312	Seats - Shell	2	330	0	0.1	Self-Extinguishing
73B2313	Seats - Cushion	1	6	0	5.0	Self-Extinguishing
73B2313	Seats - Cushion	2	6	0	4.5	Self-Extinguishing
73B2315	Seats - Inmont Vinyl	1	7	0	4.5	Self-Extinguishing
73B2315	Seats - Inmont Vinyl	2	6	0	4.3	Self-Extinguishing
73B2424	Flooring-Met-L-Wood Fire Retard.	1	0	0	0	Did not ignite
73B2425	Flooring-Met-L-Wood Plain	1	0	0	0	Did not ignite
73B2426	Flooring-Vinyl Leaded Sheathing	1	86	79	9.0 (2)	Total Combustion
73B2426	Flooring-Vinyl Leaded Sheathing	2	85	76	9.0 (2)	Total Combustion
73B2427	Flooring-Underpad	1	5	0	0.5	Self-Extinguishing
73B2427	Flooring-Underpad	2	3	0	0.4	Self-Extinguishing
73B2428	Flooring-Carpeting	1	38	0	0.25	Self-Extinguishing
73B2428	Flooring-Carpeting	2	35	0	0.2	Self-Extinguishing
73B2429	Ceiling-Formica, B/V-A	1	0	0	0	Did not ignite
73B2430	Ceiling-Formica, B/V-B	1	0	0	0	Did not ignite
73B2431	Ceiling-Formica, B/V-C	1	0	0	0	Did not ignite
73B2432	Ceiling-Formica, B/V-D	1	0	0	0	Did not ignite
73B2434	Window Glass	1	0	0	0	Did not ignite
73B2435	Insulation-Ultralite	1	0	0	0	Did not ignite

TEST RESULTS

MATERIAL IDENTIFICATION LAB LOG NO.	SPECIMEN	SPEC NO.	FLAME TEST (1) AFTER-FLAME TIME (SECS.)	AFTER-GLOW TIME (SECS.)	CHAR LENGTH (INCHES)	REMARKS
73B2436	Side Signs - Mylar	1	29	0	6.5 (2)	Total Combustion
73B2436	Side Signs - Mylar	2	28	0	6.5 (2)	Total Combustion
73B2437	Elastomeric Window Glazing Rubber	1	408	0	10.5 (2)	Total Combustion
73B2438	Elastomeric Door Weather Seal/Door Sensitive Edge	1	180	>1600	3.0	After-Glow Time Greater than 26 mins.
73B2439	Lights - Interior Lenses	1	0	0	0	Did not ignite
73B2440	Electrical Wiring - Hypalon	1	0	0	0	Did not ignite
73B2441	Car Ends-Molded Reinforced Fiberglass	1	44	0	0.25	Self-Extinguishing
73B2441	Car Ends-Molded Reinforced Fiberglass	2	40	0	0.25	Self-Extinguishing

Foot Notes:

(1) Fed. Test Method Std. No. 191, Method 5903.2

(2) Total Length of Specimen