LMSC-D973480
10 September 1986

PV MODULES FOR GROUND TESTING

CR 179476

NAS3-24657

FINAL REPORT

Prepared for

NASA-Lewis Research Center
Cleveland, OH 44135

by

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FOREWORD

This report documents the work performed by Lockheed Missiles & Space Co., Inc., Sunnyvale, California, for the Lewis Research Center of the National Aeronautics and Space Administration under contract no. NAS3-24657 on the PV Modules for Ground Testing.

The term of this contract was 4.5 months beginning on 8 August 1985 and concluding on 20 January 1986. This report summarizes the full term effort performed on the subject contract over this entire period. The outcome of this contract was four solar cell test modules which will be tested in a plasma chamber to investigate current loss mechanisms. Henry Curtis of the Power Systems Branch of NASA/LeRC provided technical direction for this work.

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1.0 INTRODUCTION

Increased power requirements for missions in the 1990's will provide the impetus for higher solar array operating voltages. Weight reductions for both cable harnessing and converters will be realized at these higher voltages. However, operation in regions of high plasma density at high voltage could significantly offset any weight savings. In order to realistically assess the performance potential of high voltage solar arrays, the question of the magnitude of the power loss associated with plasma interaction must be answered.

A solar array in space will be surrounded by a plasma sheath. This sheath is the region in which the potential changes from that of the exposed conductors or charged dielectrics on the array to that of the plasma. In general, the current collected by the array will depend upon the voltage, plasma particle density and energy, and the array geometry. Additional factors contributing to current collection include (a) motion of the spacecraft relative to the plasma for heavy ion collection, (b) the earth's magnetic field, (c) potential distribution upon the array, and (d) material properties of the array.

1.1 OBJECTIVE

The main objective of this contract was to design and build a minimum of three photovoltaic test panels for plasma interaction experiments. These experiments are intended to provide data on the interactions between high-voltage solar arrays and the space plasma environment. Data gathered will significantly contribute to the development of design criteria for the space station solar arrays. Electrical isolation between the solar cell strings and the module mounting plate is required for high-voltage bias.

1.2 SCOPE

LMSC is contractually obligated to supply three different solar cell module types utilizing 0.020-0.030 cm (8-12 mils) thick, 2 ohm-cm, silicon solar cells. Interconnected cell series strings must demonstrate an electrical conversion efficiency of at least 11.0% at 1 AM0 and 28 degrees Celsius. Further electrical requirements include a capacitance range of 2000-2500 pf and a resistance greater than 10^{11} ohms between the cells and the module plate. Three 0.91 m (3 ft.) 22 guage Kapton coated copper wire leads exiting from one of the short sides of the plate are required.

In addition to the three different solar cell module types which LMSC was under contract to deliver, a fourth module, utilizing 8 x 8 cm silicon solar cell technology was furnished. A brief description of each of the different module types delivered is given below:

Module	P/N	Description
1	x8512604-501	0.020 cm (0.008 in.) thick, 5.9 x 5.9 cm Si cells, gridded back, wrap-around contacts, 0.013 cm (0.005 in.) thick individual CMX covers, welded Cu/Kapton flexible interconnects, cells are bonded to module plate face up, 28 cells in series
2	x8512604-503	Same as module type #1 except cells are bonded to module plate face down
3	x8517165-501	Same as module #1 except BSR cell and conventional n-bar contact with soldered Ag plated/Mo interconnect
4	x8517166-501	0.020 cm (0.008 in.) thick, 8 x 8 cm Si cells, gridded back, wrap-through contacts, 0.053 cm (0.021 in.) CMX superstrate, welded Cu/Kapton flexible interconnect, cells are bonded to module plate face up, 15 cells in series

2.0 TECHNICAL PROGRESS SUMMARY

The contract was initiated within LMSC during mid August 1985 and completed with the delivery of four solar cell module plates to LeRC in January 1986. A complete contract master schedule is shown in Figure 1.

2.1 TASK 1 - DESIGN AND ANALYSIS

During this task, preliminary engineering drawings were released for procurement of all long lead time items. In addition, adhesive bond evaluation tests were conducted at this time to determine bond strength between FM73M adhesive and a non-acid etched, MIL-C-5541 coated aluminum alloy surface. The flat-wise tensile test set-up employed to evaluate bond strength is shown in Figure 2.

Test results, summarized in Table 1, show that FM73M forms a strong bond to MIL-C-5541 coated aluminum alloy. All bond failures occurred at the unprimed interface. The failure mechanism was primarily cohesive. The use of BR 127 primer gave additional bond strength to the chemically coated aluminum/FM73M bond. The average tensile strength of the samples tested (35.4 MPa/5146 psi) compares favorably to an acid etched aluminum surface/FM73M bond (41.4 MPa/ 6000 psi). Results from this test were incorporated in the fabrication of the aluminum plate assembly (x8512607) as seen on the engineering drawing attached in Appendix A.

2.2 TASK 2 - MODULE FABRICATION

Electrical evaluation tests were performed on "one cell" models (shown in Figure 3) of the three solar cell modules. The purpose of these tests were to verify compliance with the design requirements for resistance greater than 10^{11} ohms and capacitance within the 2000-2500 pf range between solar cells and the module plate. A linear scale-up factor was assumed to predict full scale module capacitance. Fringing field effects at the solar cell edges was neglected since intercell spacing was small compared to capacitor plate spacing.

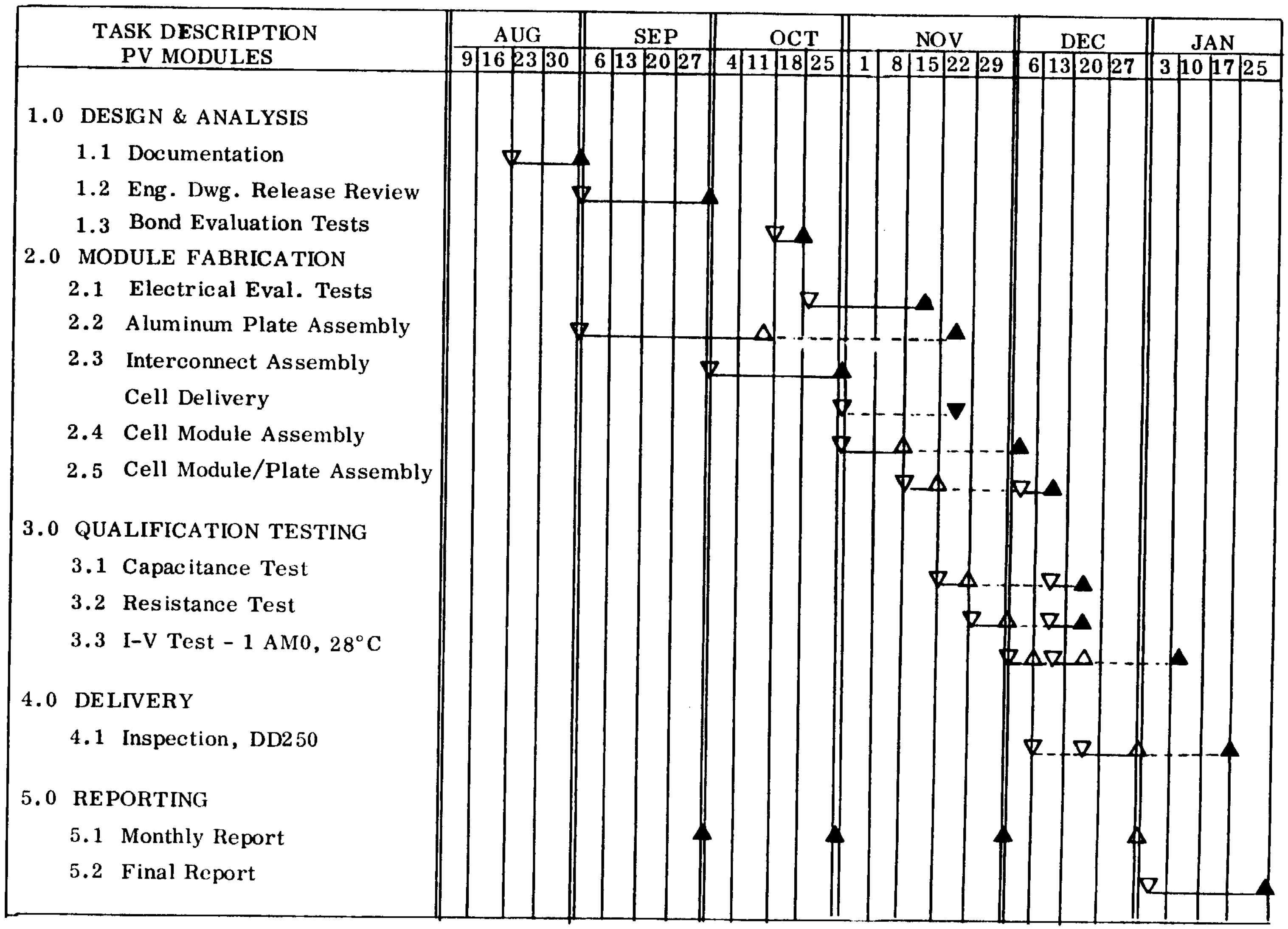


Figure 1 PV Modules for Ground Testing - Master Schedule

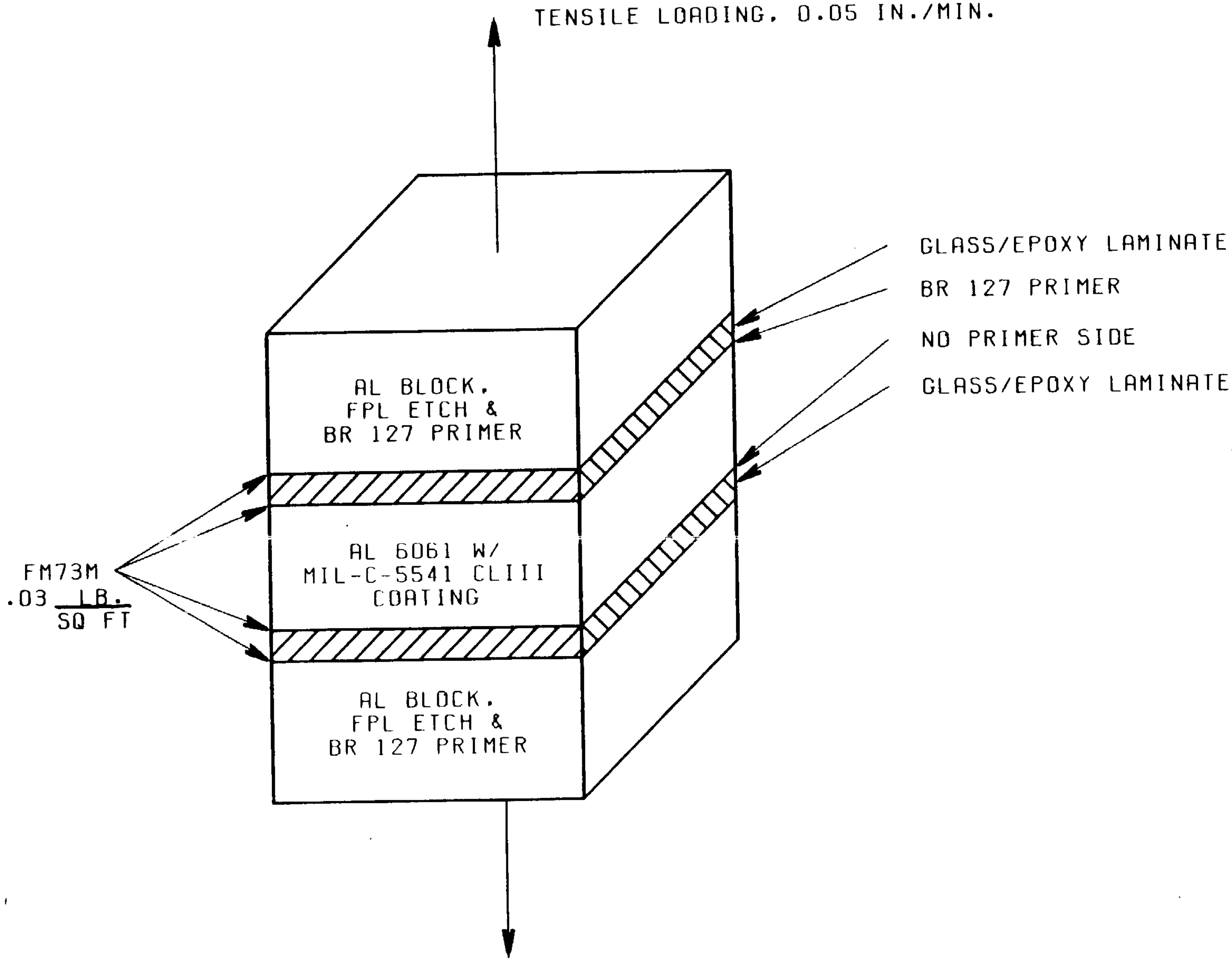


Figure 2 Flat-wise Tensile Specimen

TABLE 1
FLATWISE TENSILE RESULTS

SPECIMEN	TENSILE, PSI	MODE OF FAILURE[1]
1[2]	6073	80% COHESIVE, 20% GLASS DELAM
2	5094	75% COHESIVE, 15% GLASS DELAM, 10% ADHESIVE TO Al (NON PRIMED SIDE)
3	4767	90% COHESIVE, 10% ADHESIVE TO Al
4	4310	95% COHESIVE, 5% ADHESIVE TO Al
5	5486	80% COHESIVE, 10% ADHESIVE TO Al, 10% GLASS DELAM
	AVG = 5146	

[1] All failures occurred at Al without primer interface.

[2] Specimen loaded to 3600 psi and released due to load pin deflection. Specimen was tested to failure using a new pin.

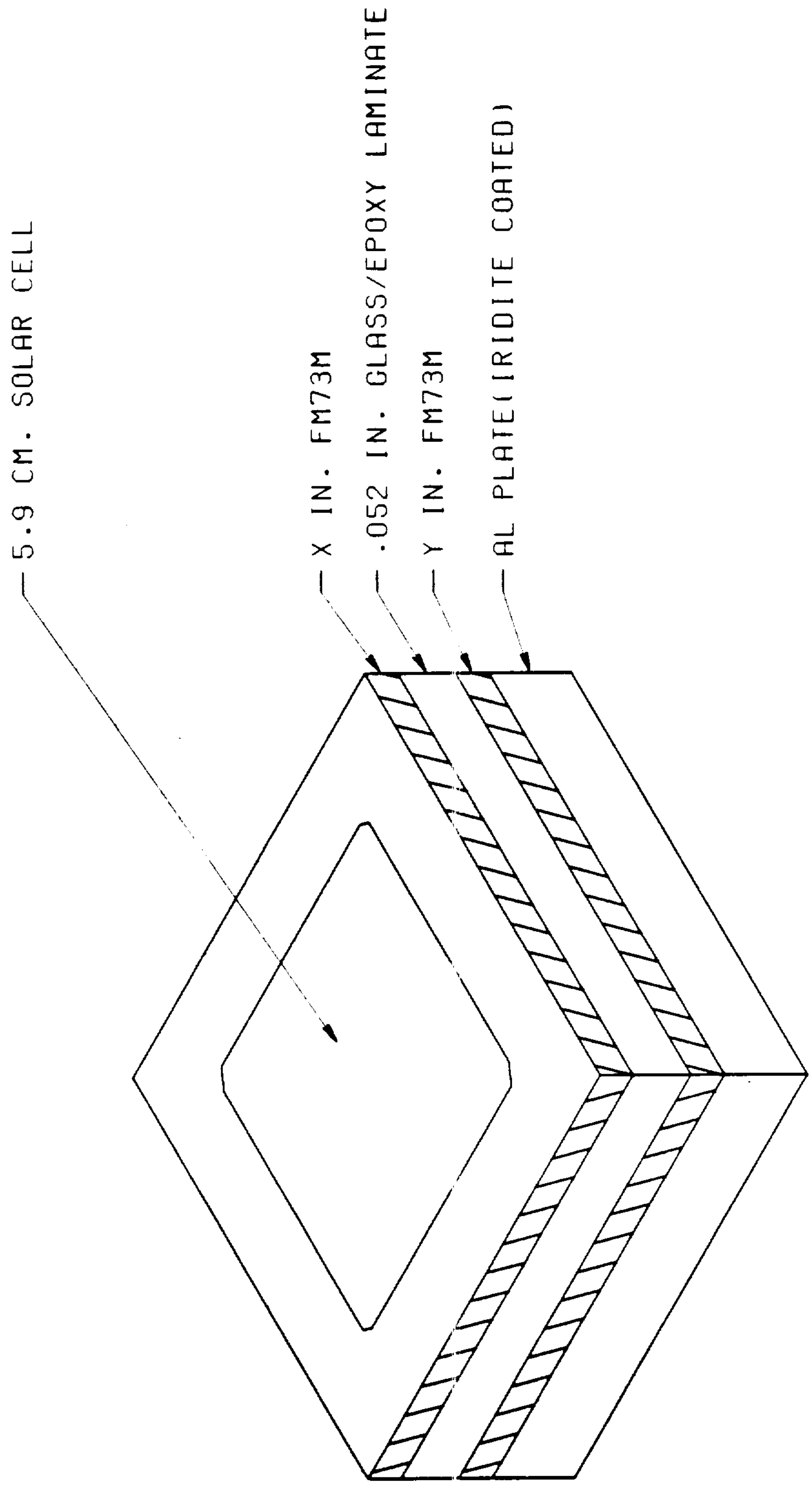


Figure 3 "One-Cell" Electrical Model

Preliminary calculations (see Appendix B) had suggested a dielectric stack of: 0.013 cm (0.005 in.) thick epoxy adhesive, 0.132 cm (0.052 in.) thick glass epoxy laminate, 0.005 cm (0.002 in.) thick silicone adhesive and a 0.002 cm (0.001 in.) thick Kapton film to meet the electrical design requirements. Test results, summarized in Table 2, show that an additional 0.038 cm (0.015 in.) thick layer of epoxy dielectric is needed to approach the electrical design requirements (sample #5). The inaccuracy of the dielectric thickness calculations can be attributed to the approximate and directional nature of the constants used in the preliminary calculations. The added dielectric thickness was incorporated into the design by the addition of FM73M adhesive layers onto the face of the glass/ epoxy laminate. A photograph of the "one cell test" samples is shown in Figure 4.

Upon completion of all testing, hardware fabrication was initiated. Photographic documentation of all completed hardware is shown in Figures 5 through 11.

2.3 TASK 3 - QUALIFICATION TESTING

Results of capacitance and resistance testing of the full scale solar cell modules is summarized in Table 3. Module Type 4 (x8517166-501) was shown to exhibit a comparatively low capacitance of 1100 pf and a low resistance between cell and mounting plate of 8×10^{11} ohms. In addition, module type 2 (x8512604-503). exhibits a capacitance below the required range, probably as a result of the extra thickness of dielectric (coverglass) in the stack. These results do not comply with the contract requirements, however, approval for hardware delivery was given by the contract monitor.

All modules were shown to exhibit an electrical conversion efficiency greater than 11%. Electrical I-V curves are provided in Figures 12 through 18 at 28 degrees Celcius and 1 AM0. It should be noted that Figures 12 through 14 show the I-V characteristics of the solar cell modules before being bonded to the mounting plate. Particular attention should be brought to Figure 13 which is taken as baseline for module type 2 (x8512604-503) rather than Figure 16 which shows the solar cell I-V characteristics when illuminated from the backside only. Thus the electrical conversion efficiencies listed in Table 3 are from Figures 15, 13, 17, and 18

TABLE 2
CAPACITANCE/RESISTANCE TEST RESULTS

Sample No.	Description	Capacitance (pf) Measured for "One Cell" Model*	Capacitance (pf) Extrapolated to Full Scale Model	Resistance (ohm) at 500V**
1	Module Type #1 (Cells Bonded Face Up) X = 0 Y = .005	102.2	2786	1.2×10^{11}
2	Module Type #2 (Cells Bonded Face Down) X = 0 Y = .005	98.5	2758	1.2×10^{11}
3	Module Type #3 Conventional N-Bar Cells Bonded Face Up X = 0 Y = .005	94.6	2649	3.1×10^{10}
4	Module Type #1 (Cells Bonded Face Up) X = .010 Y = .005	89.6	2508	4.5×10^{11}
5	Module Type #1 (Cells Bonded Face Up) X = .010 Y = .010	84.7	2400	1.8×10^{11}
6	Module Type #1 (Cells Bonded Face Up) X = .015 Y = .010	73.4	2054	2.6×10^{11}

Measured by: *HP4274A Multi Frequency LCR Meter (LMSC #121867)
**1620C Megohmeter, Freed Xfmr Co. (MSL #60668)

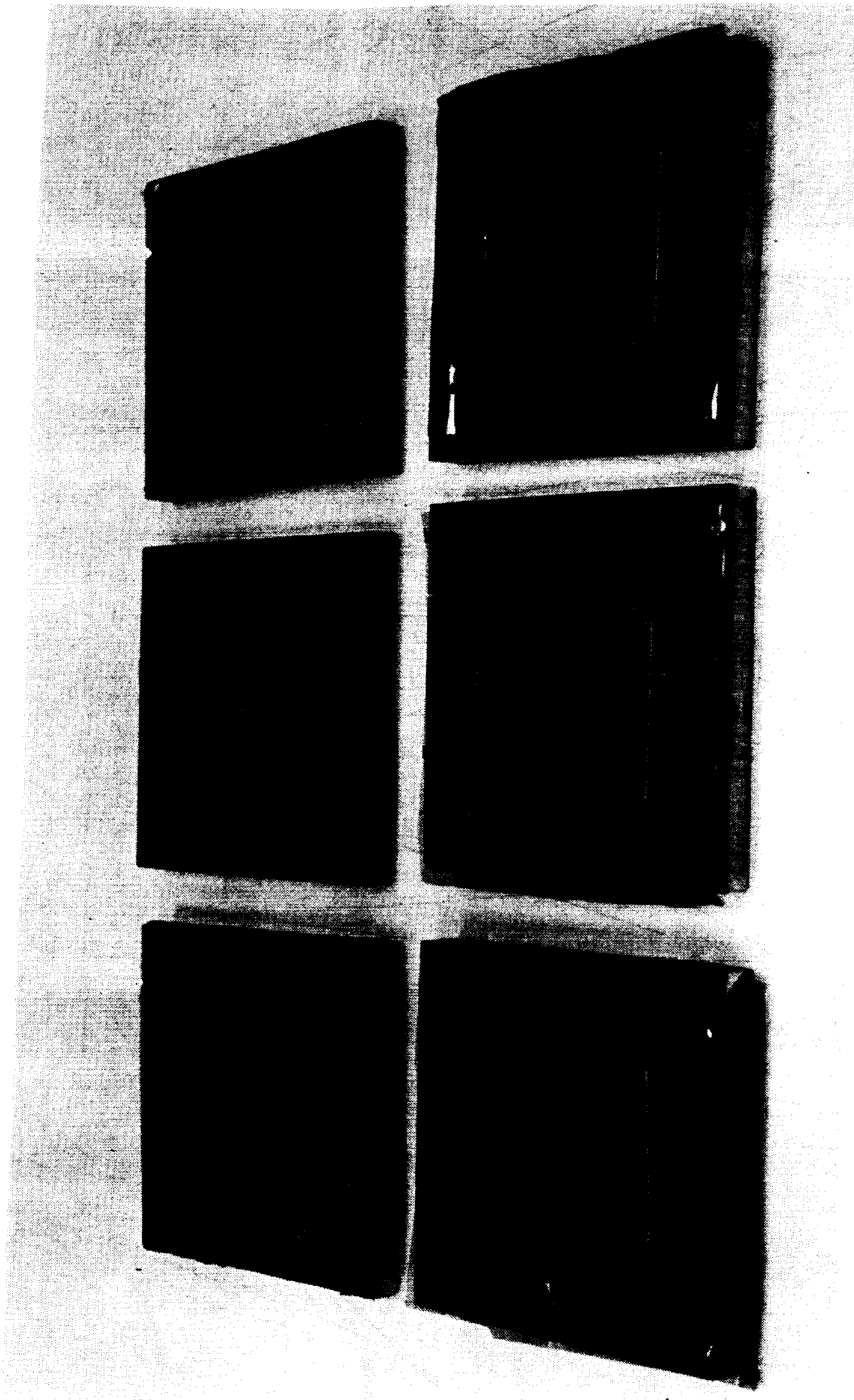


Figure 4 One Cell Test Samples

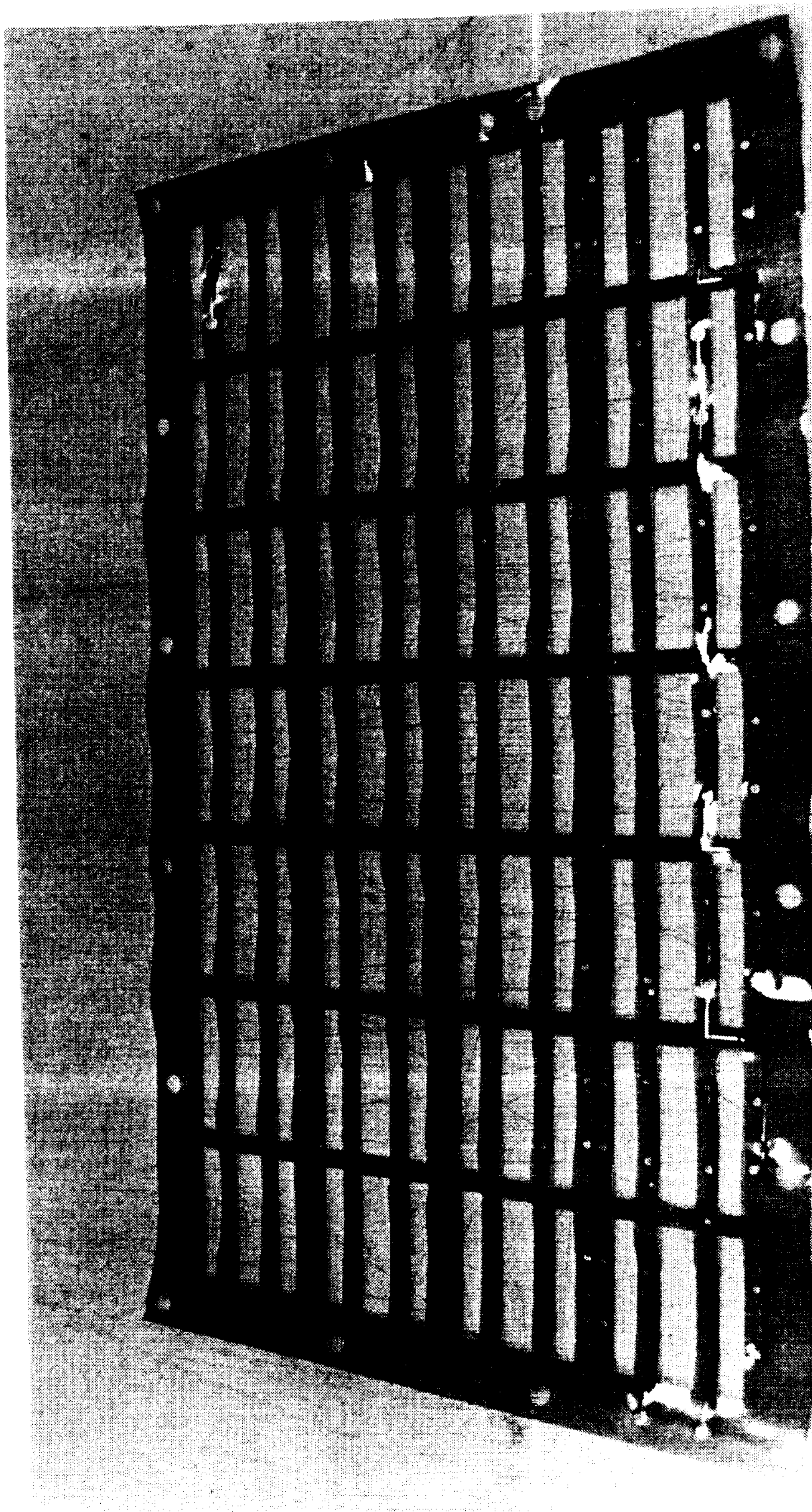


Figure 5 Circuit Assembly x8512605-501

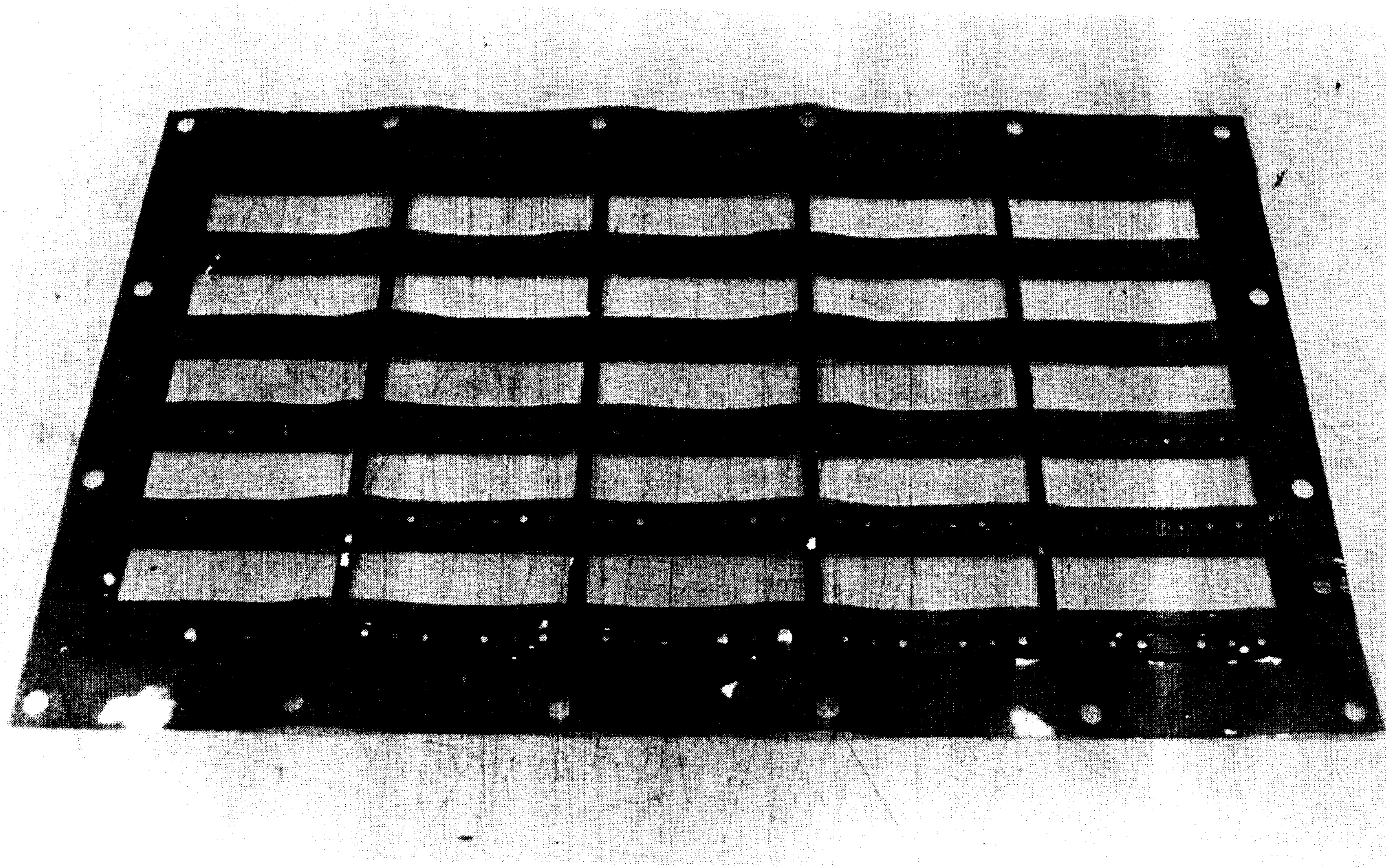
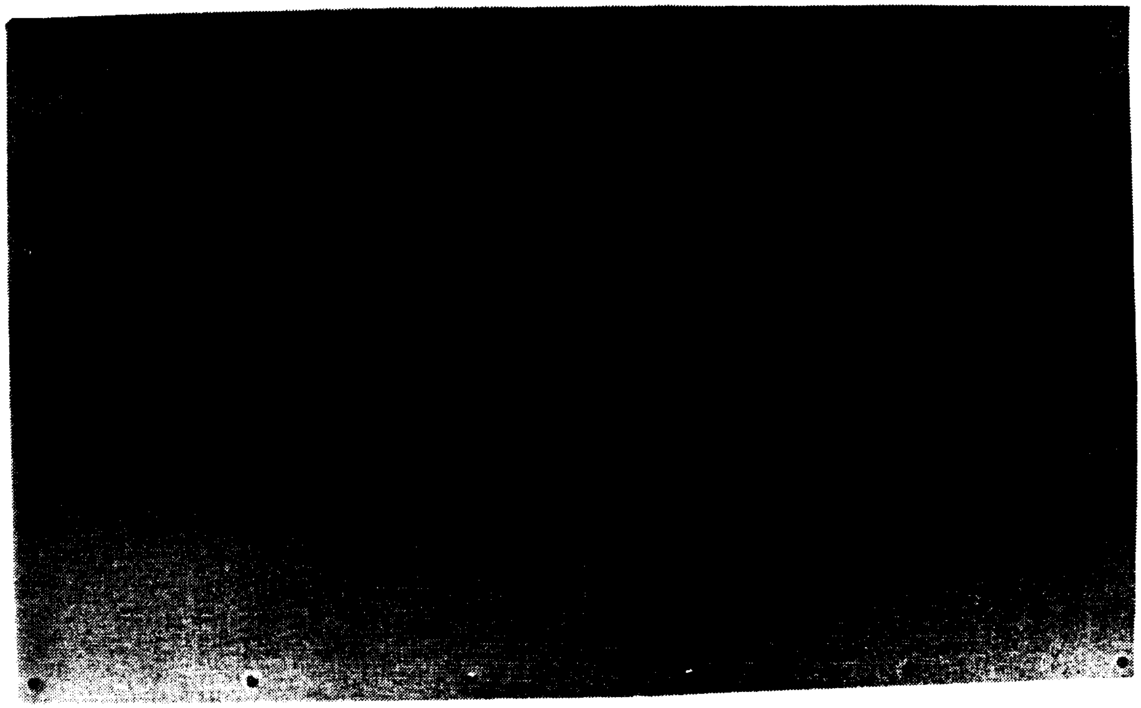
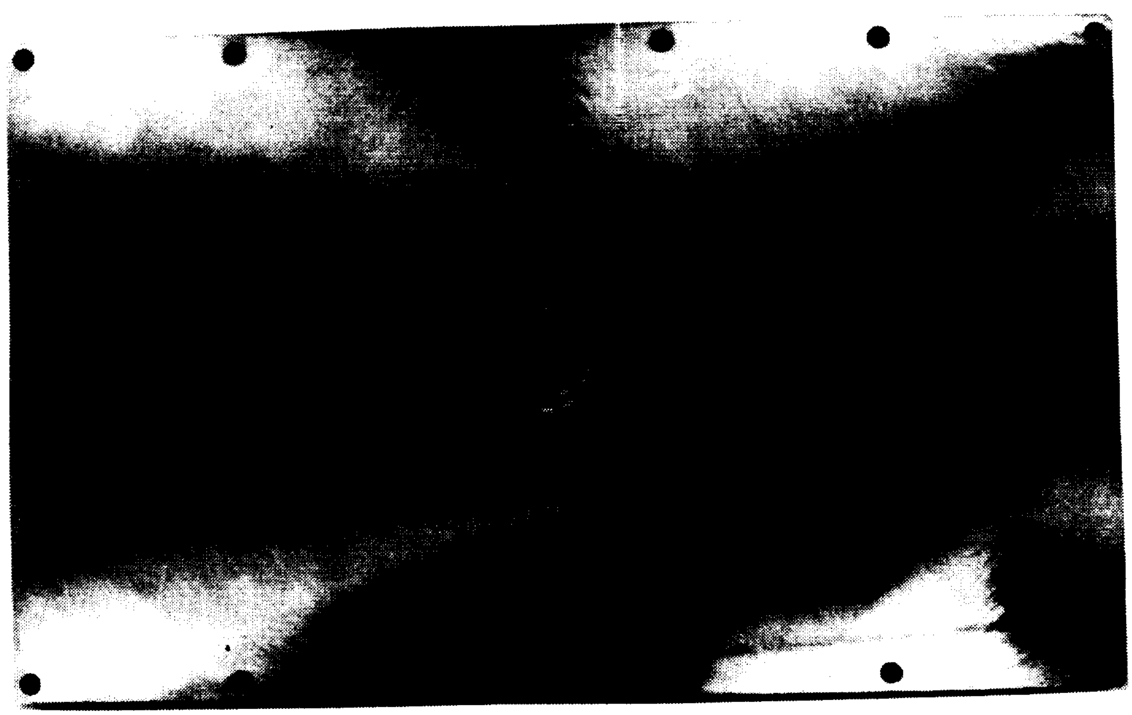


Figure 6 Circuit Assembly 8 x 8 cm Cells x8517161-501



(Front Side)



(Back Side)

Figure 7 Aluminum Plate Assembly (X8512607-501)

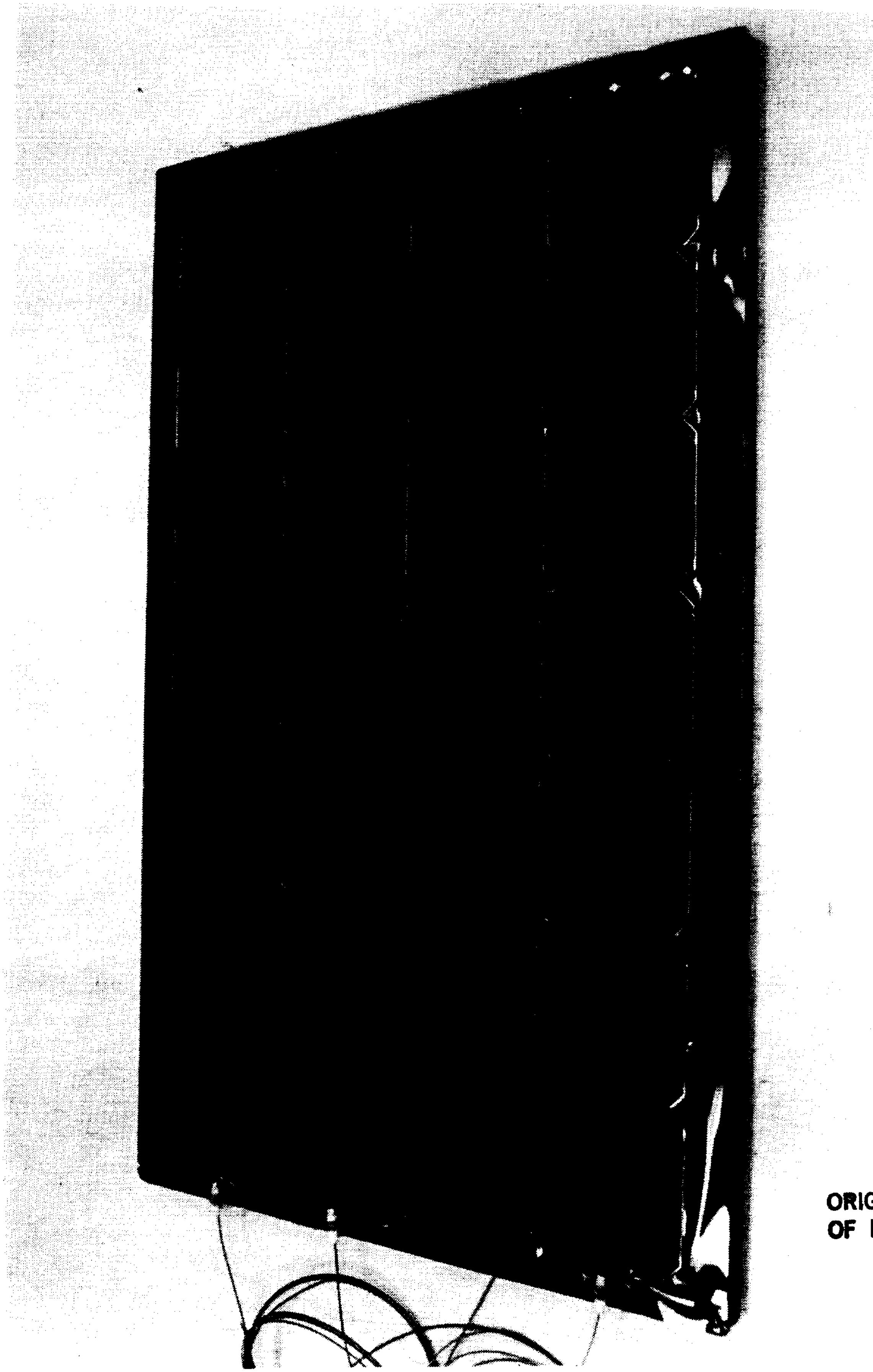


Figure 8 Module/Plate Assembly x8512604-501

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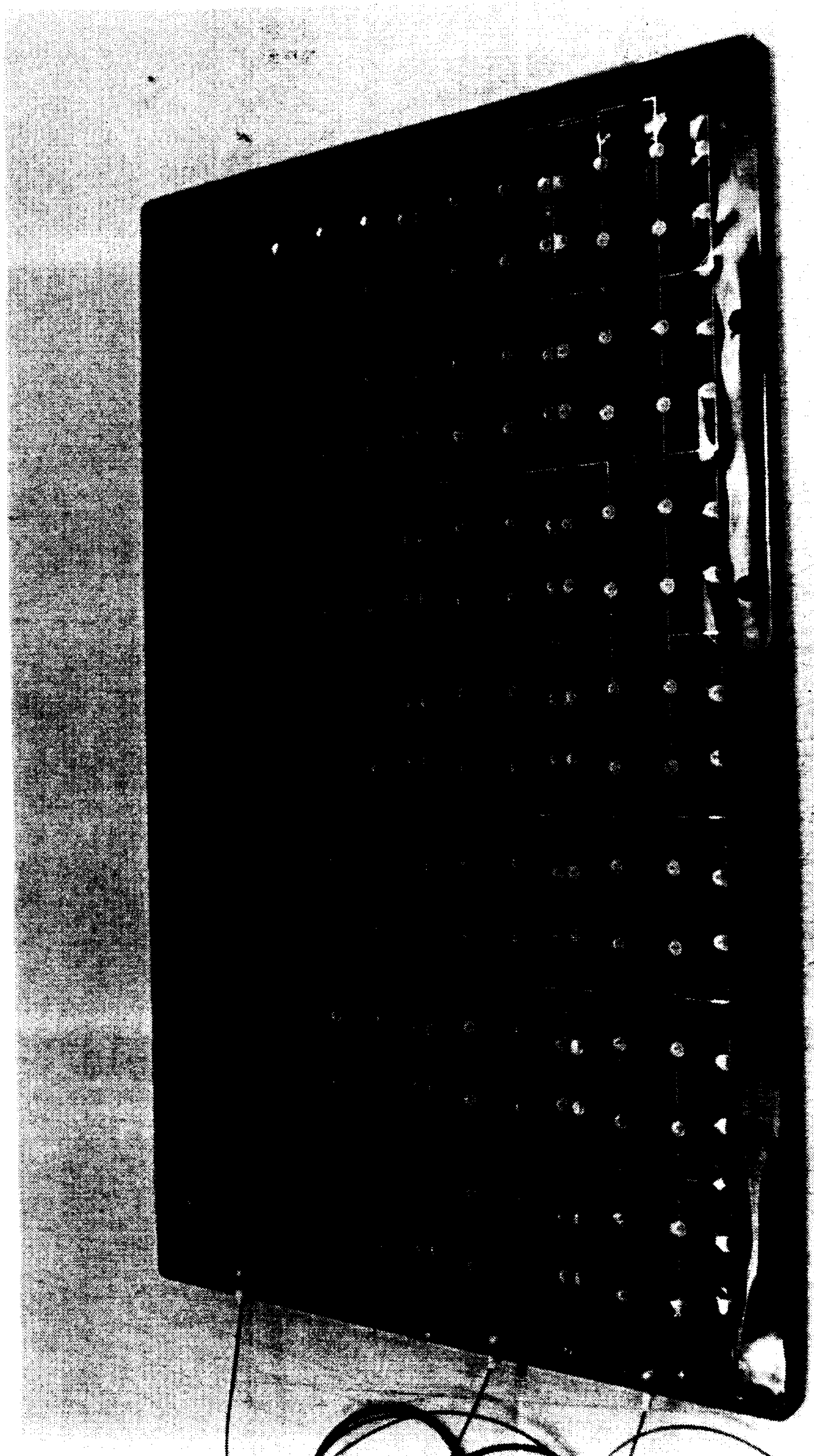

Figure 9 Module/Plate Assembly x8512604-503

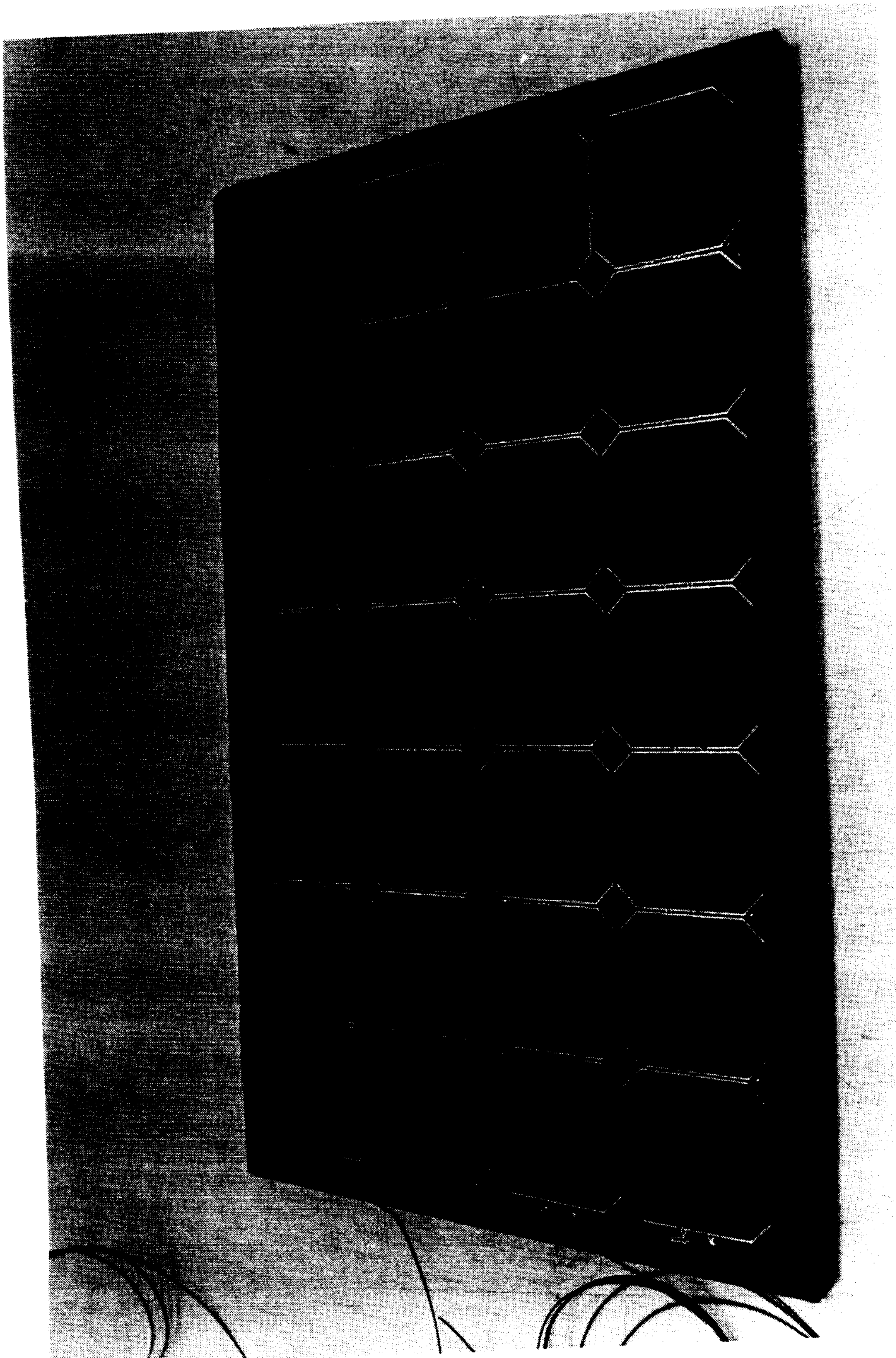

Figure 10 Module/Plate Assembly (Conventional) x8517165-501

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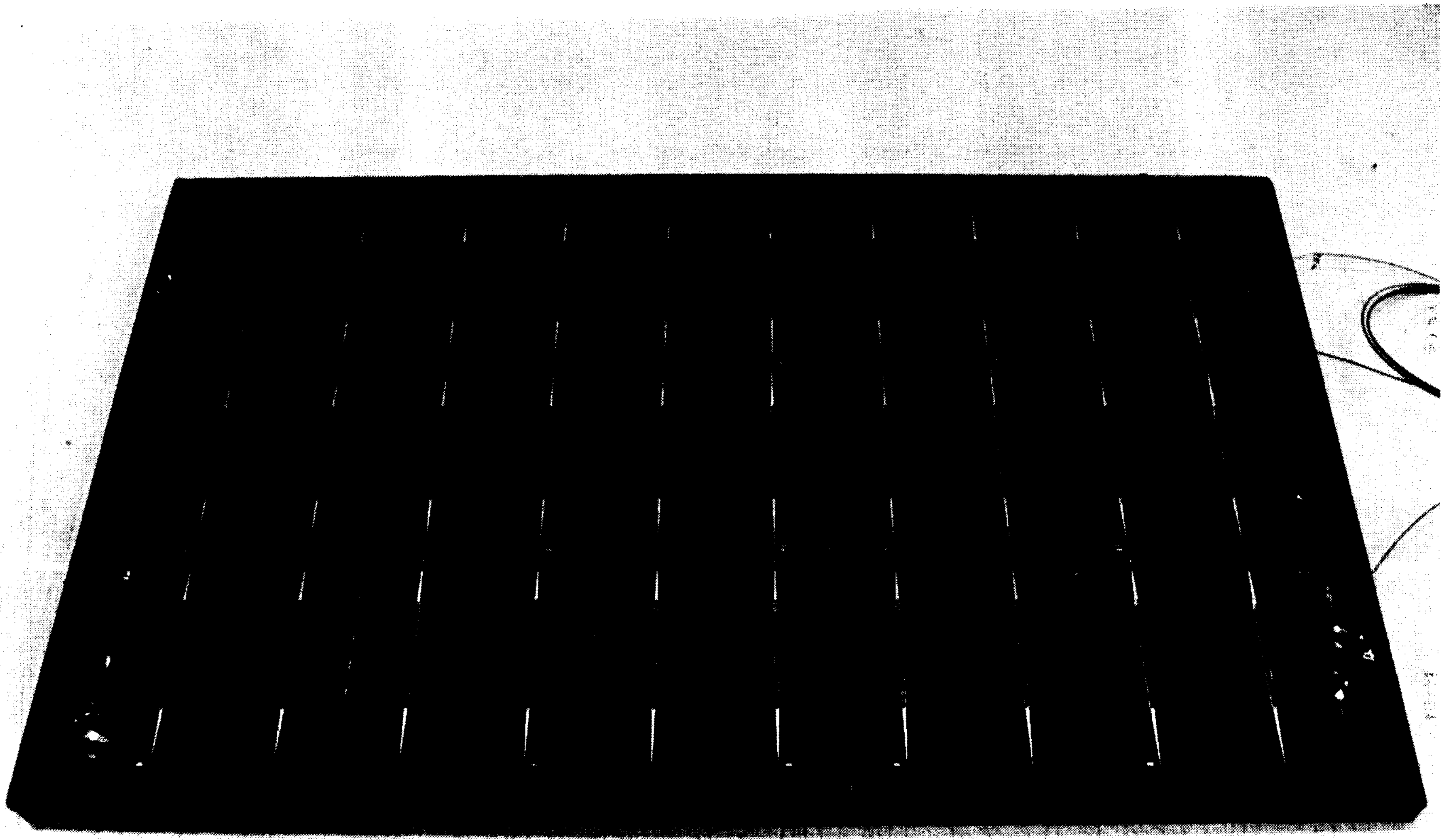

Figure 11 Module/Plate Assembly (8 x 8 cm Cells) x8517166-501

TABLE 3

ELECTRICAL SUMMARY

PV MODULE P/N	*CAPACITANCE (pf) (at 100 Hz)	**RESISTANCE (Ω) (at 500V)	ELECTRICAL CONVERSION EFFICIENCY (%) (at T = 28°C)
X8512604-501	2010	1.2×10^{11}	11.72
X8512604-503	1880	2.0×10^{11}	11.22
X8517165-501	2070	1.6×10^{11}	12.06
X8517166-501	1100	8.0×10^{10}	11.31

MEASURED BY: *HP4274A MULTI-FREQUENCY LCR METER (LMSC #121867)
**1620C MEGOHMETER, FREED XFMR CO. (MSL #60668)

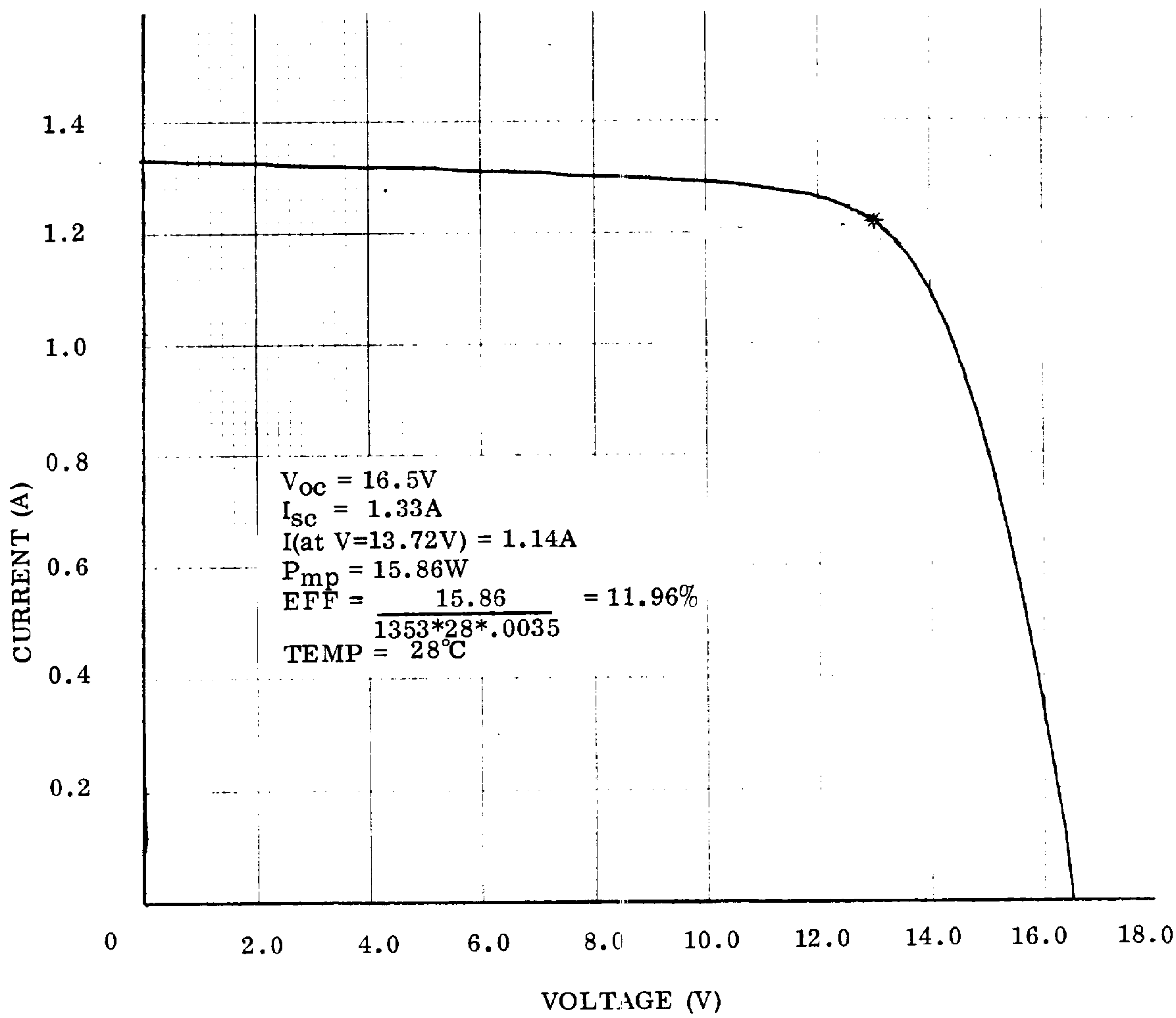

Figure 12 I-V Curve (X8517162-001)

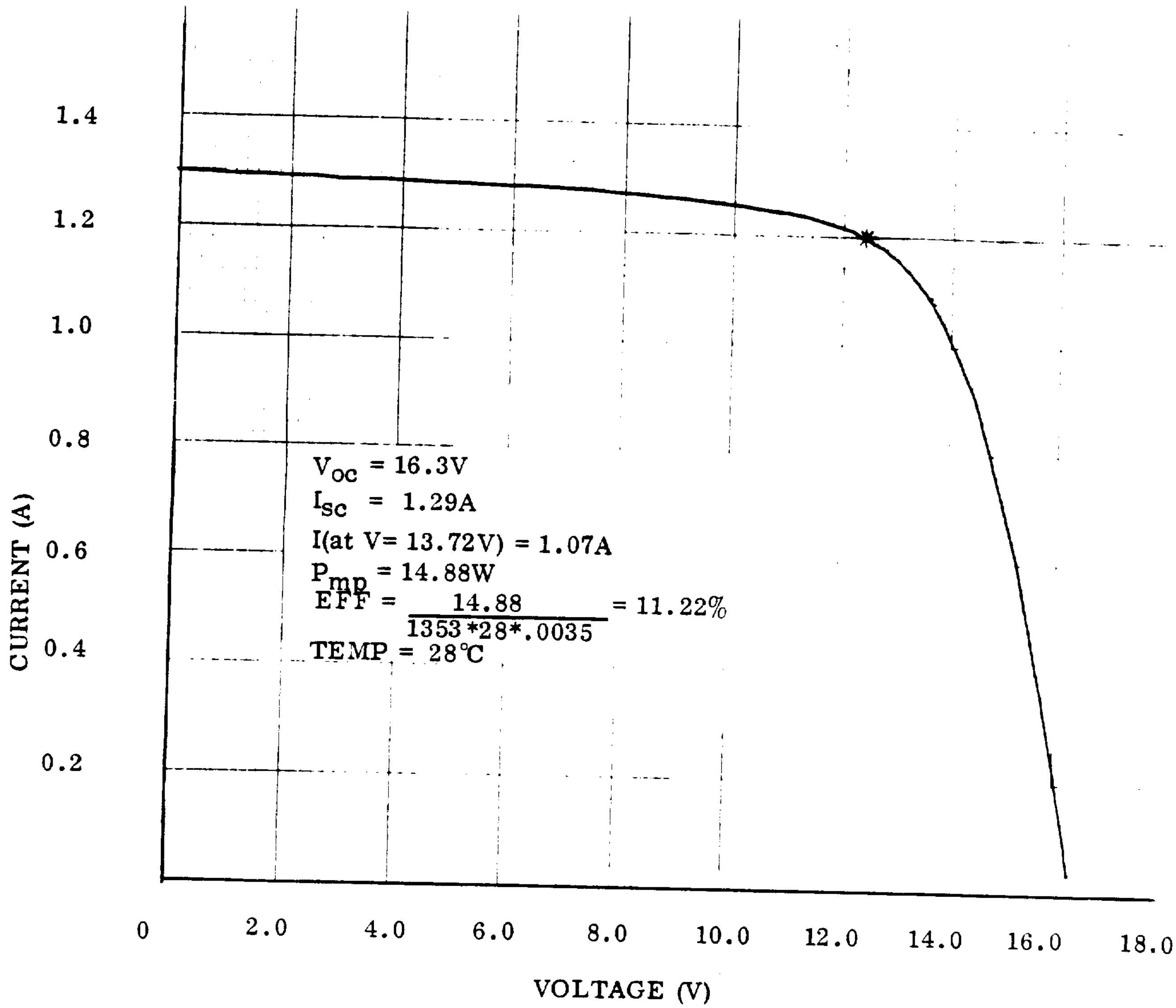

Figure 13 I-V Curve (X8517162-002)

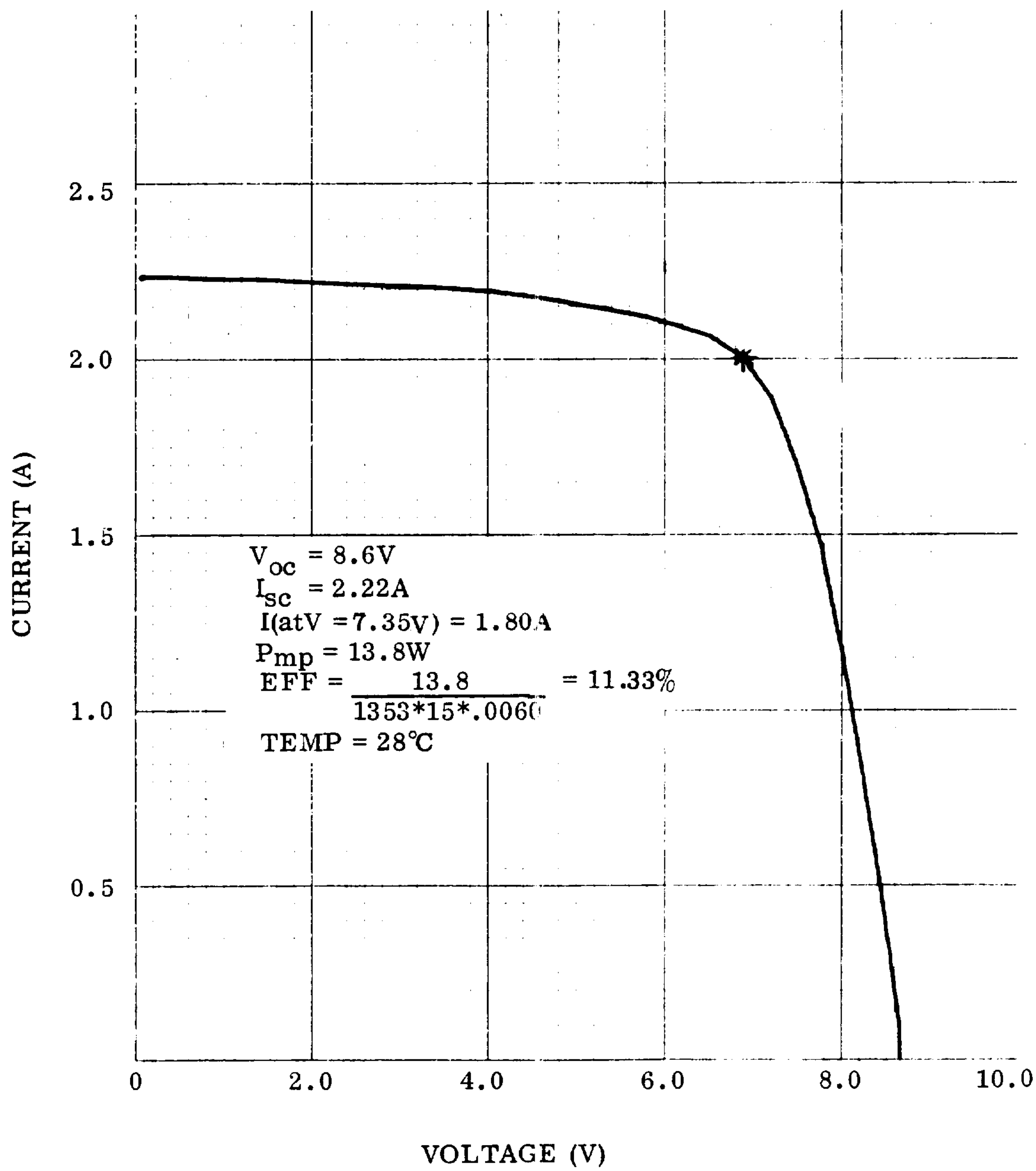

Figure 14 I-V Curve (X8517163-001)

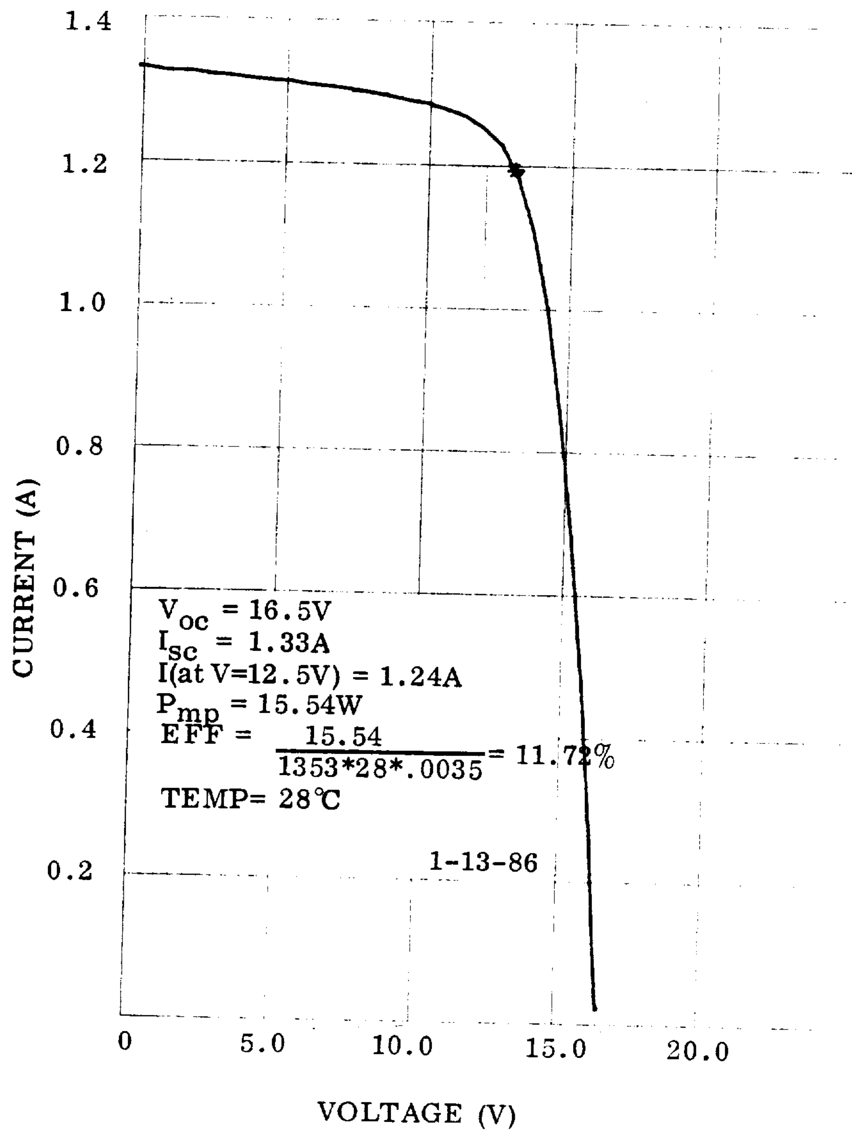

Figure 15 I-V Curve (X8512604-501)

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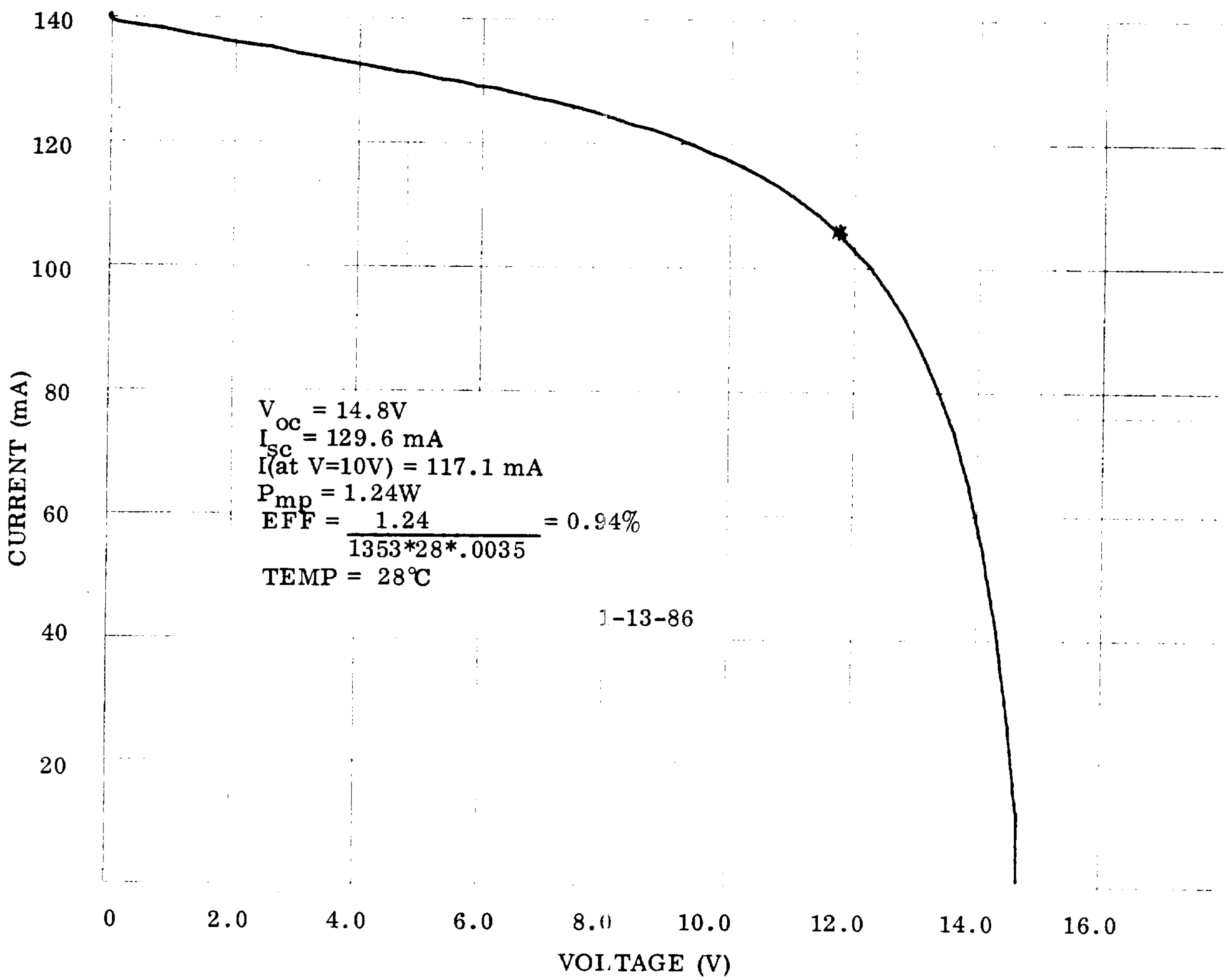

Figure 16 I-V Curve (X8512604-503)

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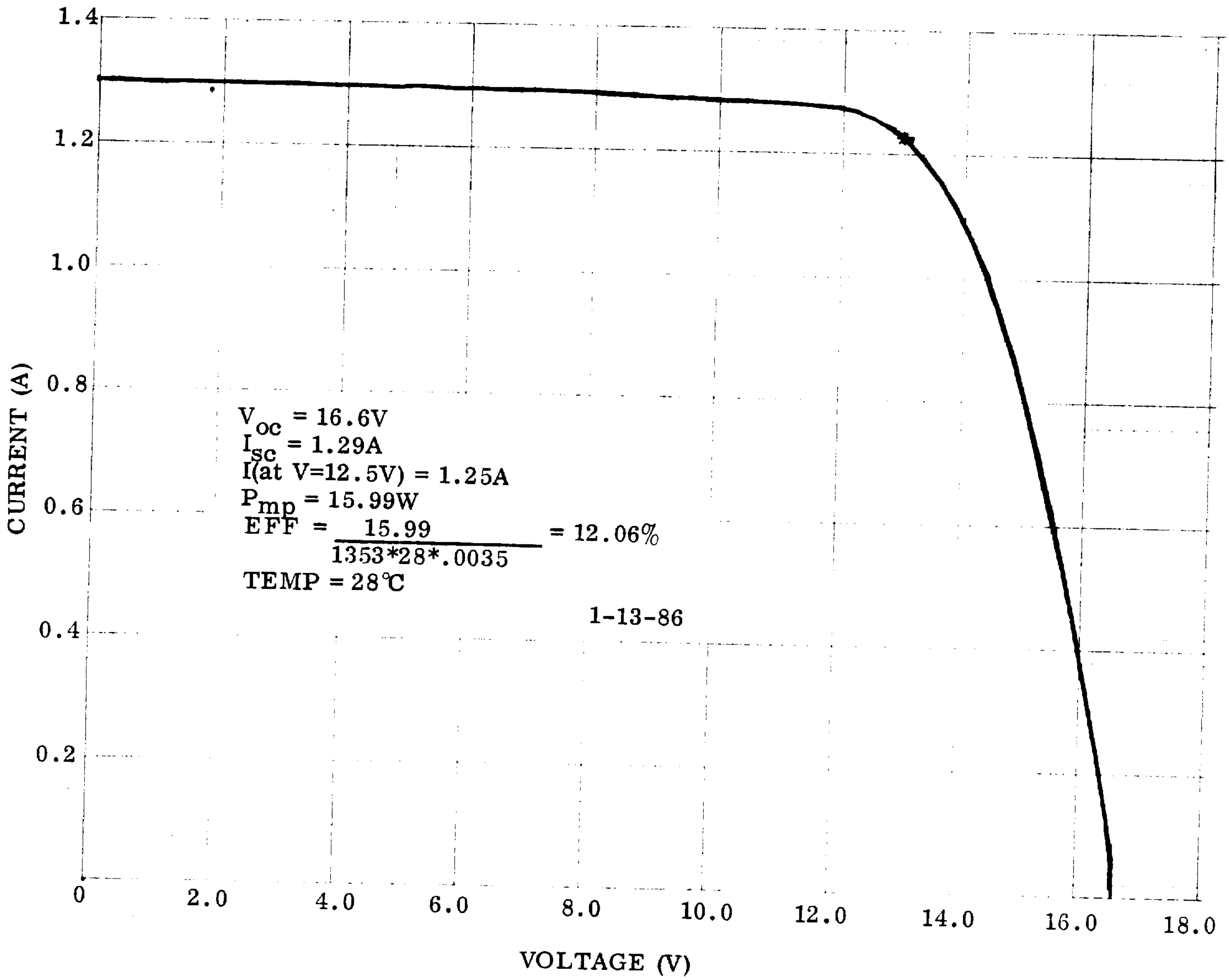

Figure 17 I-V Curve (X8517165-501)

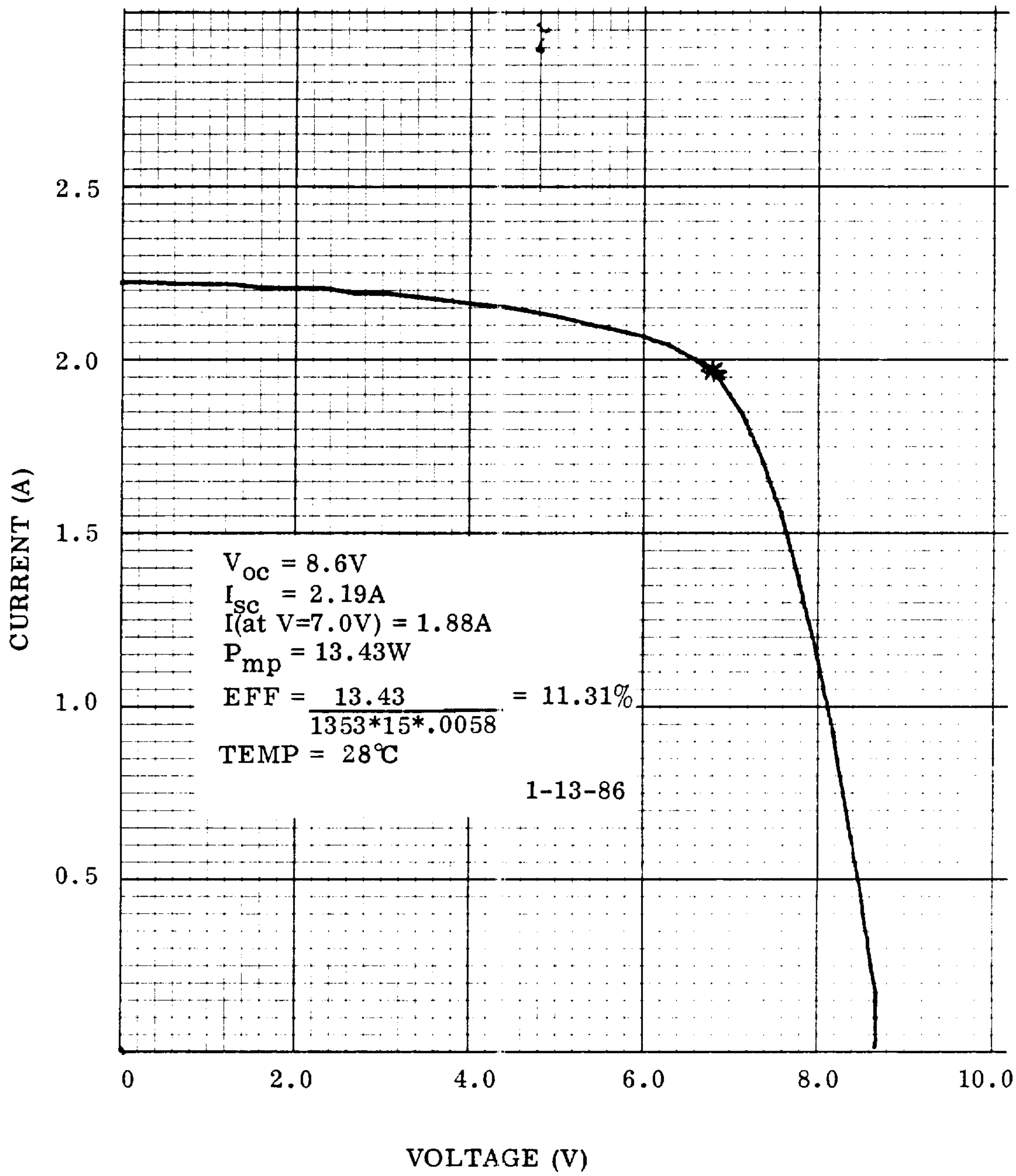

Figure 18 I-V Curve (X8517166-501)

respectively. No damage was incurred to the solar cells during adhesive bonding to the module plate.

2.4 TASK 4 - DELIVERY

The four solar cell module plates were delivered to NASA LeRC, attention Henry Curtis, on 20 January 1986. Subsequent conversation with Mr. Curtis has assured LMSC that the plates arrived safely at their destination.

3.0 FACILITIES AND EQUIPMENT

This section contains a detailed description of the facilities that would be used to support the design effort and fabrication work on Space Station flex arrays. These include areas for solar array engineering design and analysis, development, fabrication, assembly, and testing. The facilities most pertinent to the performance of this project are described in this section, which includes the following:

3.1 DESIGN AND ANALYSIS EQUIPMENT
3.2 THERMAL CYCLING EQUIPMENT
3.3 FLEXIBLE SOLAR ARRAY FABRICATION FACILITIES AND EQUIPMENT
3.4 FLASH/FUNCTIONAL TESTING
3.5 SOLAR ARRAY BLANKET ZERO-GRAVITY TESTING
3.6 FULL-SCALE MAST AND WING EXTENSION TESTING
3.7 FULL-SCALE WING ENVIRONMENTAL TESTING
3.8 SAE ASSEMBLY AND TESTING SEQUENCE

Engineering, development, and fabrication operations for LMSC spacecraft programs, for the most part, are performed at three primary sites located on the San Francisco Peninsula. The main LMSC plant is located in Sunnyvale and contains the Corporate Offices (Building 101). The Astronautics Division (AD) has offices at the main Sunnyvale plant. The Research and Development Division has offices and facilities on the second site, located near Stanford University in Palo Alto. Lockheed Research and Development Laboratory facilities have broad scientific capabilities for investigation of physical sciences. If LMSC were to perform Space Station design and fabrication work, these capabilities are available. The third major LMSC facility is the Santa Cruz Test Base (SCTB). SCTB is located in the Santa Cruz mountains west of Sunnyvale and is the location of a large antenna test range and hazardous test support facilities. It would not be utilized for Space Station work. LMSC-owned/leased facilities provide over 8 million square feet of board and desk, manufacturing, and test facilities.

LMSC has considered all of the facilities needed to support Space Station, and all facilities described herein are available for this design effort and fabrication work.

3.1 DESIGN AND ANALYSIS EQUIPMENT

The Electrical Power Systems (EPS) organization at LMSC, which will be directly responsible for solar array design, is located in Building 151. All necessary space, facilities, and support services such as the data center, reproduction, and document control are available in the immediate area to support this project. In addition, EPS has extensive computer support equipment which is listed below.

Electrical and Mechanical Design

- IBM 4361 CAD/CAM System using CADAM software
- 10 terminals within EPS area (Figure 19)
  395 terminals available throughout LMSC
- 9 electrostatic plotters linked to the CADAM system

Engineering Analysis

- EPS has 3 HP 1000 computers (Figure 20), 1 HP 9000 computer
- 20 HP 150 work stations
- Using a networking hookup, the CRAY 1R computer (Figure 21) and VAX 11/780 computer are available for EPS use (Figure 22)
- 1 VAX 11/780 computer is available for Dynamic Modeling Analysis in the LMSC Star Lab (Figure 23) in Building 104

With the CAD/CAM system, computer analysis equipment and data management support services, the EPS organization minimizes labor inducive tasks and maximizes the design and analysis efforts of its engineers. LMSC educates its employees through company training courses on how to get the most out of available equipment and software.

Figure 19 CADAM System Terminals

Figure 20 Electrical Power Systems H-P 1000 Terminals

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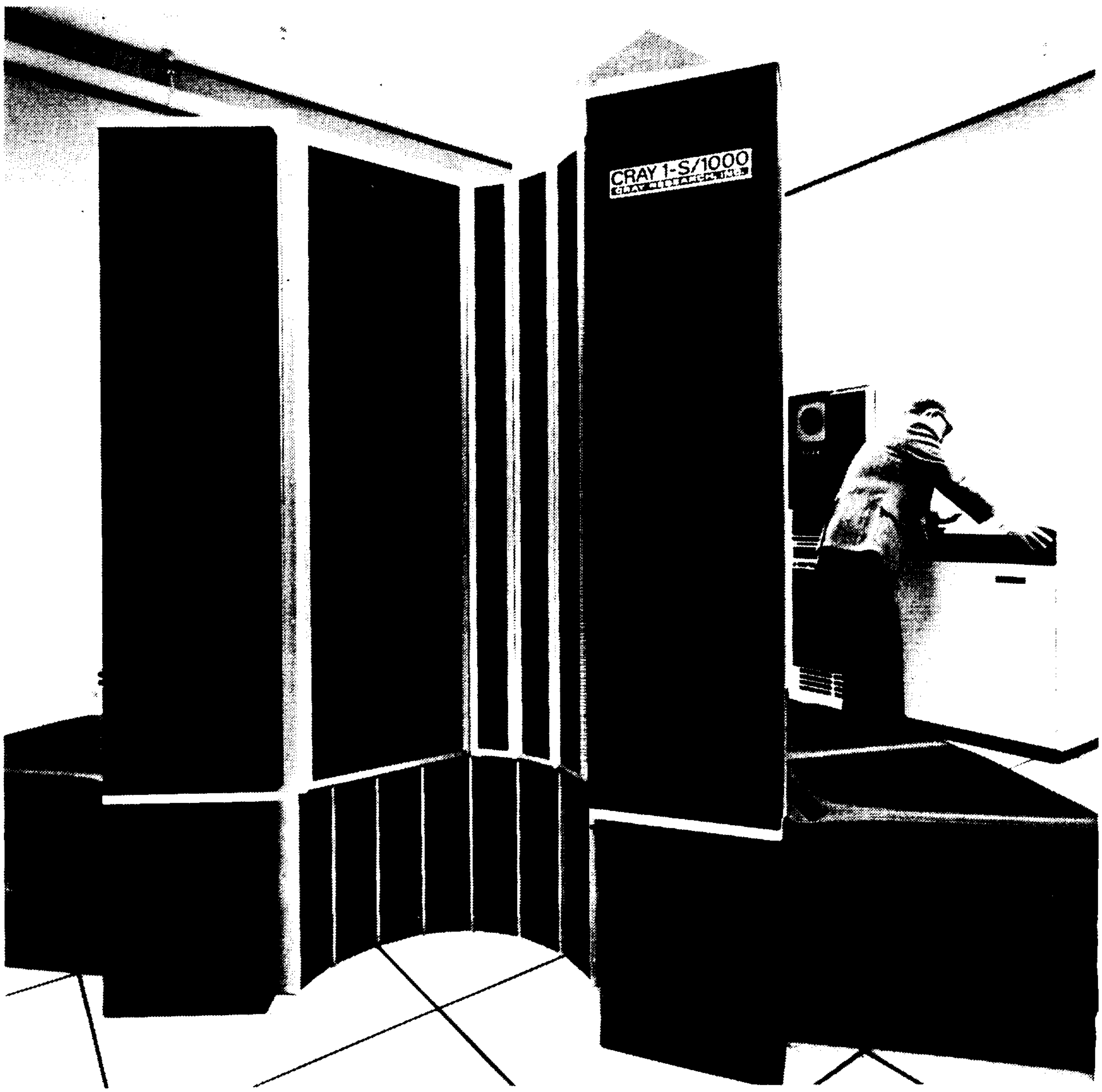

Figure 21 Cray 1R Computer

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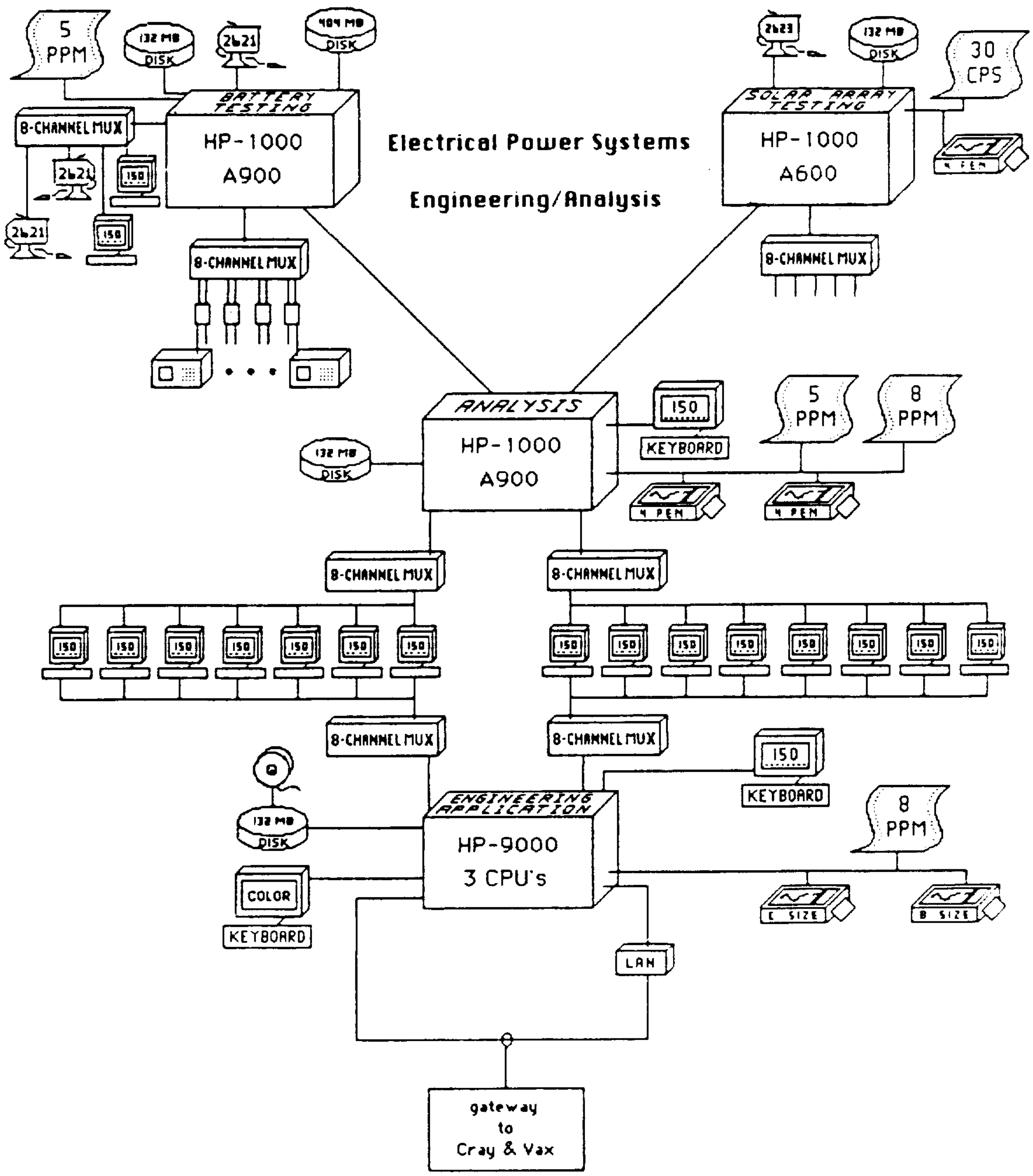

Figure 22 Electrical Power Systems Computer Network

Figure 23 Star Lab VAX II/780 Computer and Terminals

3.2 THERMAL CYCLING EQUIPMENT

The test facilities for thermal cycling are a part of the EPS Laboratory. This lab consists of approximately 5,000 square feet dedicated to power systems test and evaluation. The solar array capabilities in the lab are approximately 2,000 square feet and consist of the necessary facilities and capabilities for completing thermal cycle testing.

Solar Array Laboratory

- 5 Convective Thermal Cycle Chambers

  These chambers are used to perform thermal life cycle testing on solar array panel and substrate assemblies to assess failure modes and determine thermal/electrical performance for a given number of thermal cycles. The EPS lab has over 100 square feet of available chamber space to perform these types of tests.

- 3 Thermal Vacuum Cycling Chambers

  The solar array lab has three chambers capable of performing electrical and thermal performance tests in a 10 (-8) torr environment which can be cycled thermally from -300°F to +200°F. Additionally, each chamber has two fused quartz windows so a light source can be directed at the test samples and electrical measurements can be made at the test conditions.

- 3 Calibrated Light Sources

  The solar array testing facility has three calibrated light sources available for use on test samples. Two Spectrosun X-25 solar simulators capable of >1 sun and a portable XT-10 simulator for special applications and field use.

- Portable Solar Test Facility

  To accommodate special test requirements the solar array lab has a portable solar cell/array test set which includes a 1 sun solar simulator and a data acquisition and control system to take and manage acquired test data.

- Test Data and Control System

  To manage test operations, acquire data, and perform test data analysis; the solar array lab utilizes an HP 1000/A600 minicomputer in a real time mode. This facility is capable of monitoring and controlling eight simultaneous tests with a total data acquisition capability of 500 channels. There is graphics display and hard-copy capability available in the test area.

- Laboratory Layout

  The lab is arranged to provide testing to six test stations from a rotating X-25 solar simulator. This is illustrated in Figures 24 and 25. The floor plan is shown in Figure 26.

Because of its availability and accelerated cycle time, Quick Look Box III would be used to perform thermal cycle testing. This new chamber, shown in Figures 27 and 28, has multi-mode capabilities with three individually controlled sub-chambers. Each sub-chamber can take solar array specimens up to 36" x 36" or a single panel of 36" x 96" if the inside chamber walls are removed. This facility is presently in use to thermally cycle gallium arsenide solar cell strings and a panel segment of 5.9 x 5.9 cm solar cells for one of our program applications. This facility/chamber was designed and fabricated for LMSC, based on our successful thermal cycling in Quick Look Box I of the SAE 2 x 4 cm and 5.9 x 5.9 cm panel segments in support of the panel verification.

3.3 FLEXIBLE SOLAR ARRAY FABRICATION FACILITIES AND EQUIPMENT

The facilities required for the fabrication of the flexible solar array panels are in place in LMSC's new solar array fabrication facility in Building 153 (Figure 29) of the Sunnyvale plant. This area was the home of the SAE assembly and deployment testing for four years. After a $3.2 million upgrade, Building 153 consists of a 30,000 square foot processing area for fabricating polyimide/copper solar cell interconnect circuits, and a final assembly clean room for circuit to substrate bonding, wiring, and testing. The circuit processing area consists of a series of conveyorized equipment for drilling, laminating, photo processing, copper etching, and final cleaning operations.

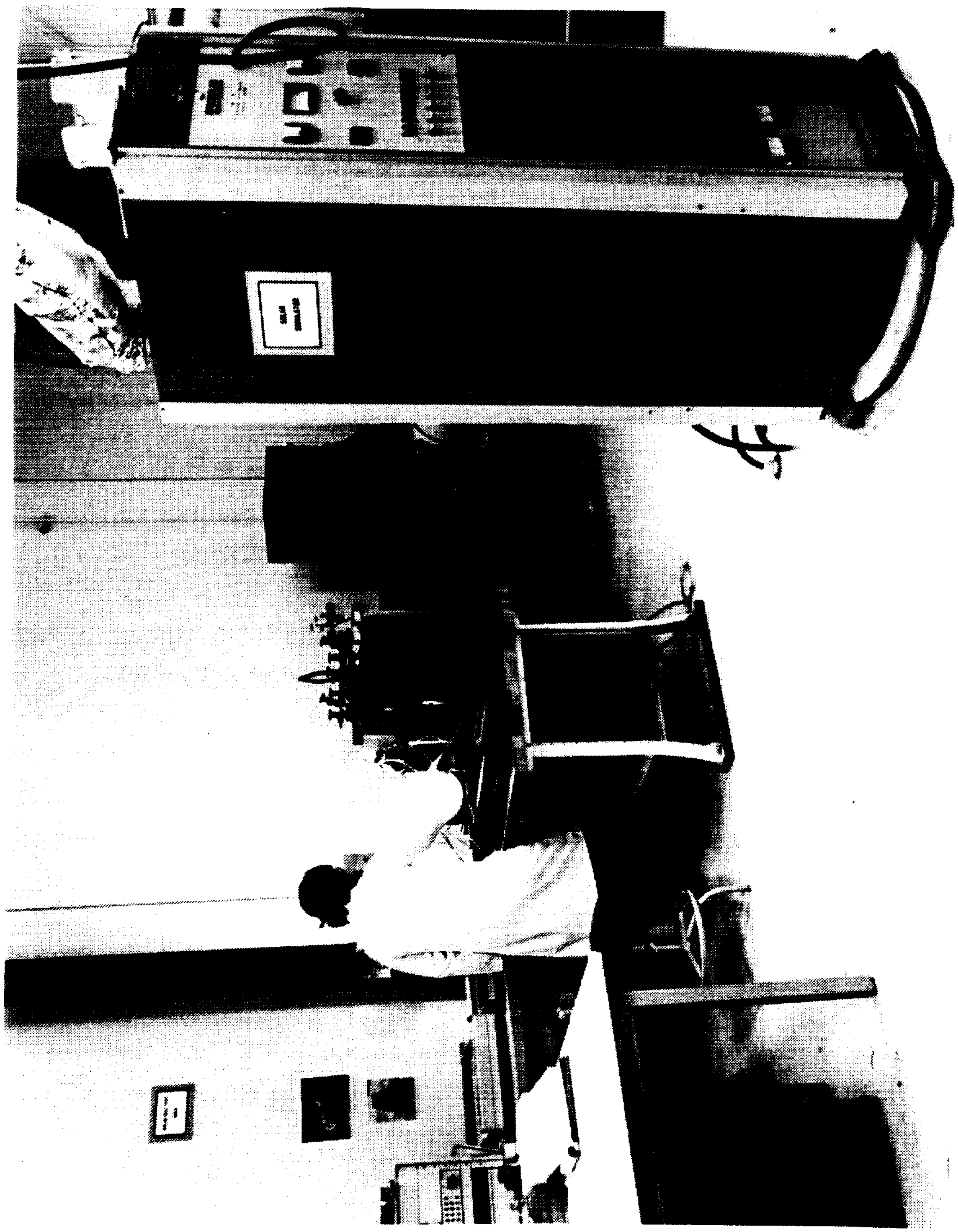

Figure 24 Solar Array Laboratory Solar Cell Testing

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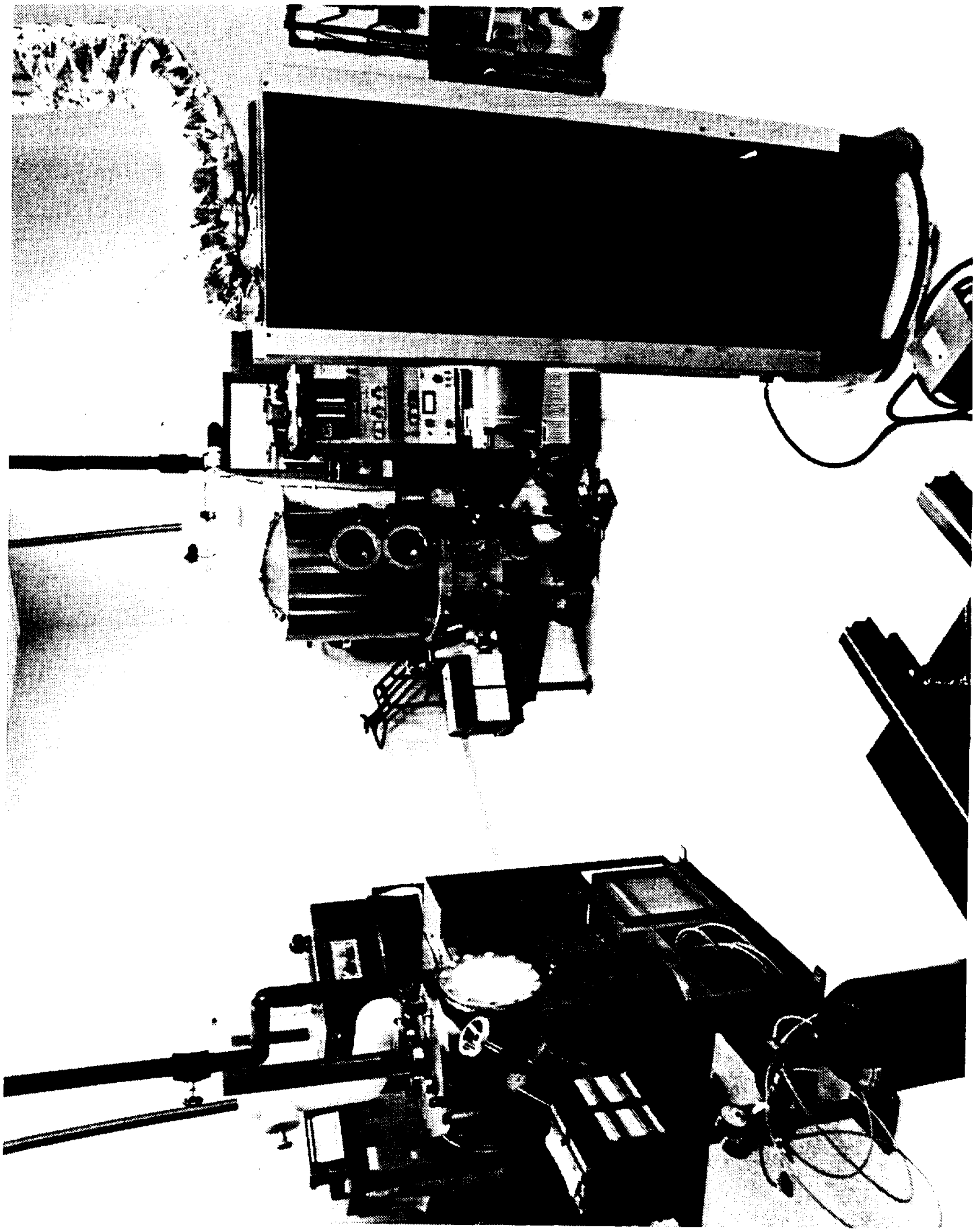

Figure 25 Solar Array Laboratory Thermal Cycling Chambers

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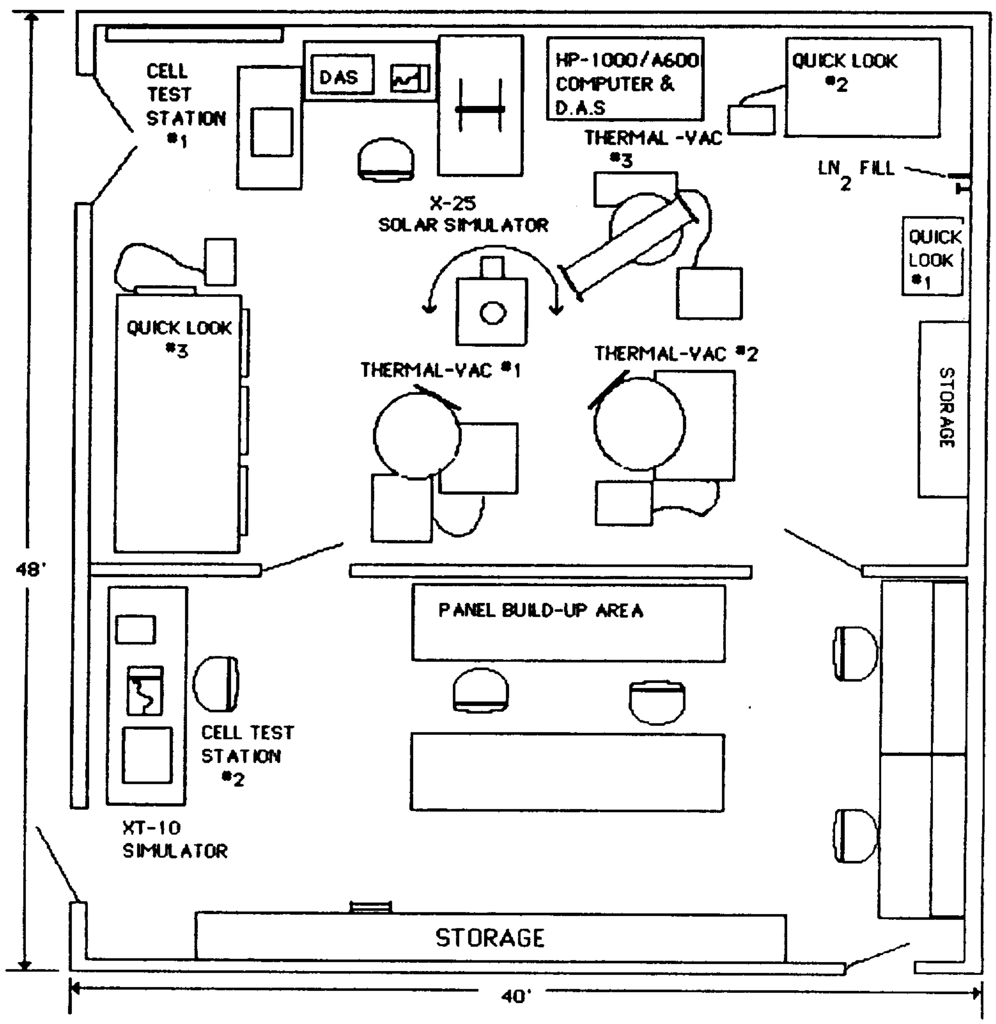

Figure 26 Solar Array Laboratory Layout

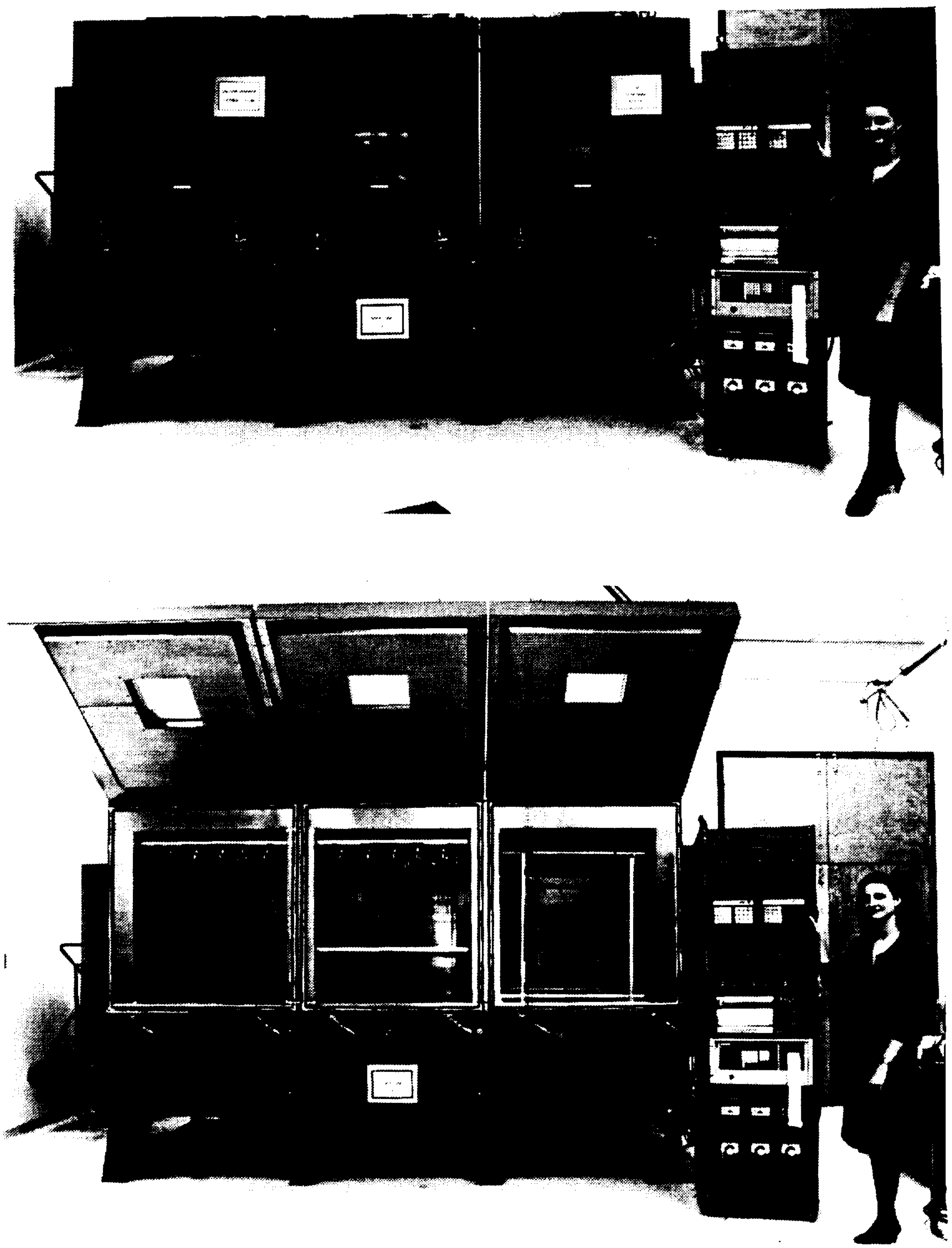

Figure 27 New "Quick Look Box III" Convective Thermal Cycling Chamber

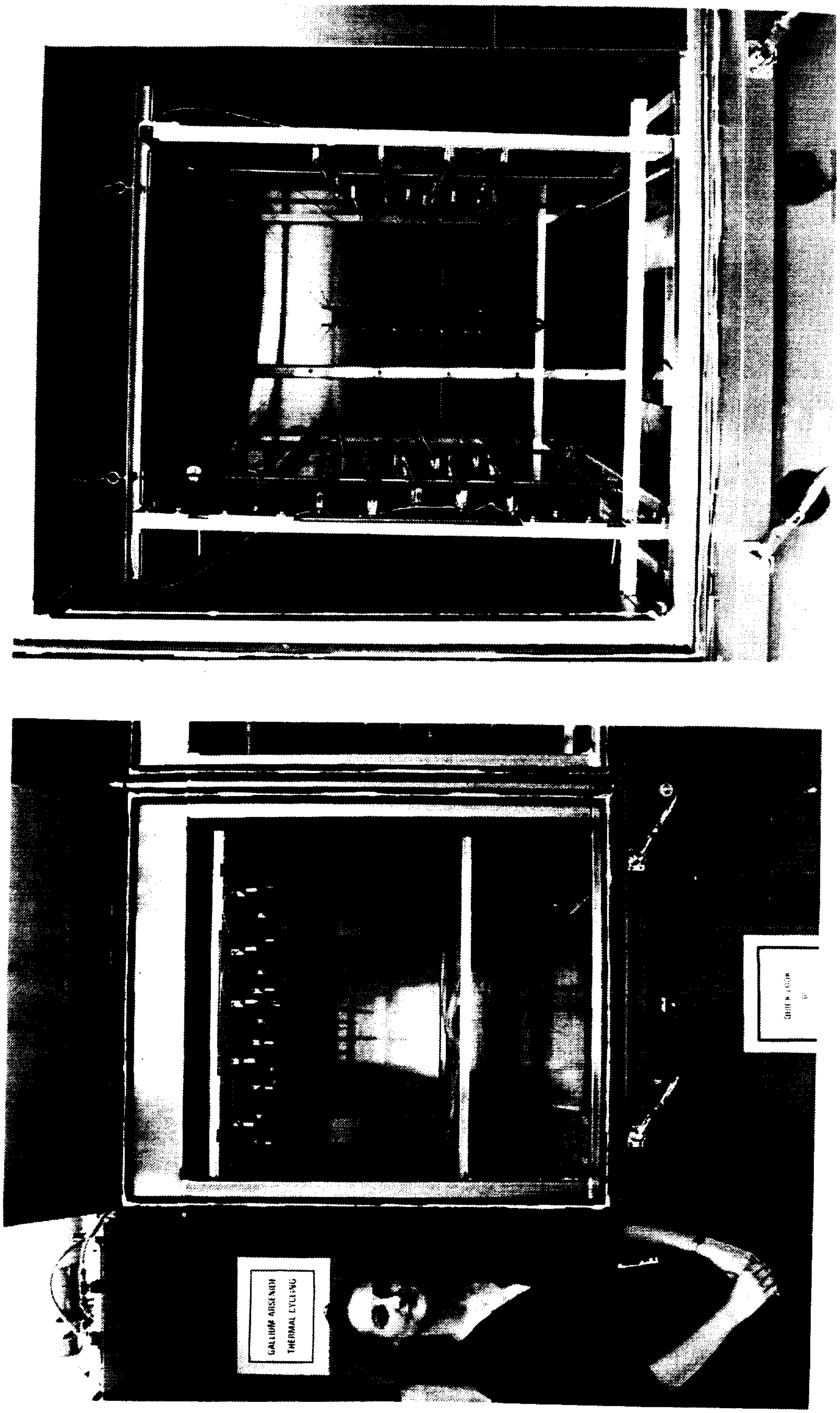

Figure 28 Quick Look Box-III - Specimen Mounted for Test

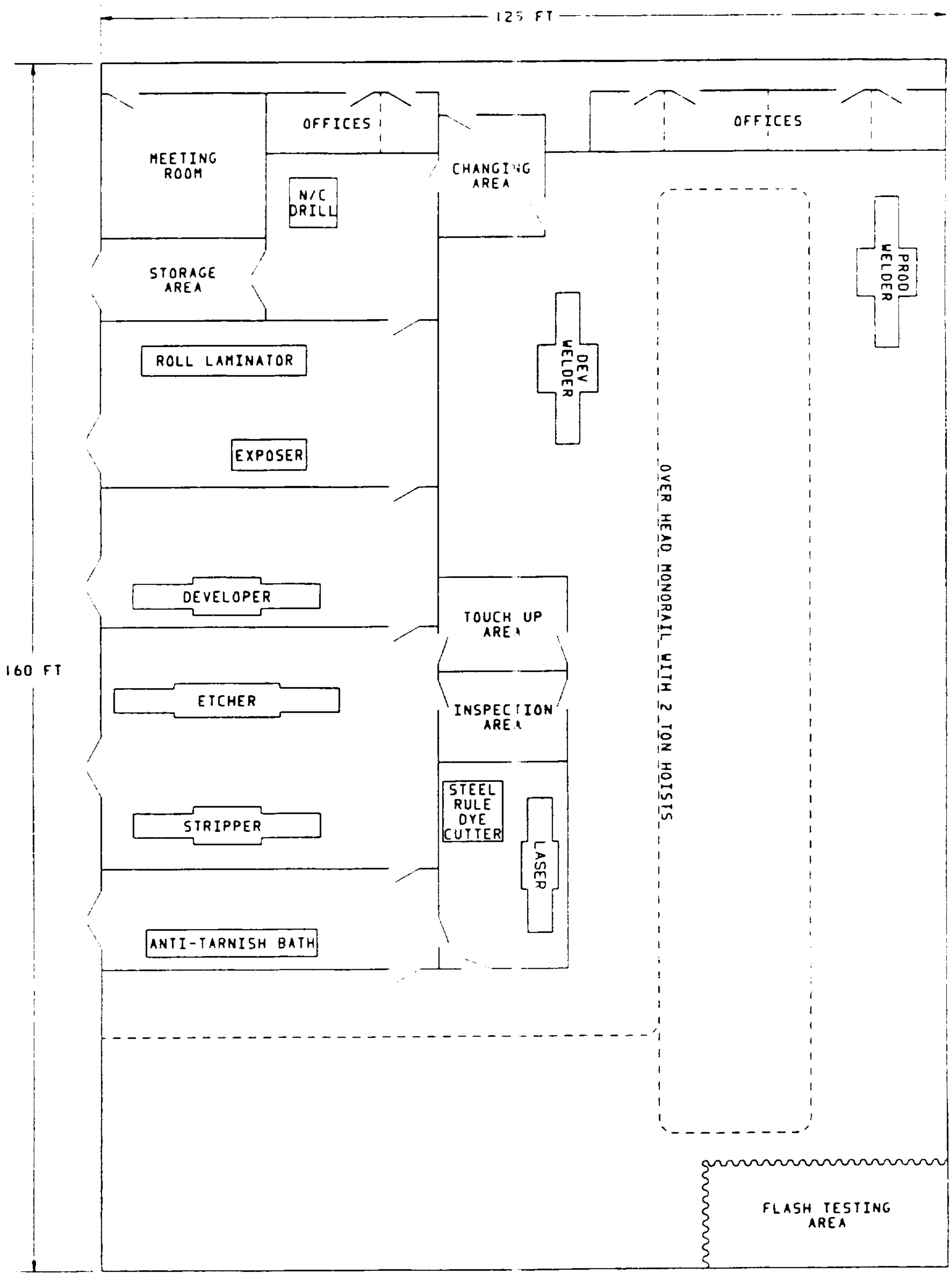

Figure 29 Solar Array Fabrication Facility in Building 153

In addition to the Building 153 solar array fabrication facility, Building 151 has a solar array fabrication facility which supports existing DoD contracts that utilize conventional assembly technology consisting of discrete silver plated molybdenum interconnects soldered to 2 x 4 cm solar cells. The new Building 153A facility is scaled to handle high production assembly requirements for new DoD contracts including the MILSTAR program. The circuit process incorporates the use of a custom design N/C drill (Figure 30) for providing solar cell contact weld access holes in a one mil adhesive coated polyimide (kapton) dielectric film. This machine is capable of drilling a 20" x 80" circuit in a continuous roll set-up. Following the drilling of a quantity of circuits (up to 500 linear feet) the polyimide film is laminated to a roll of copper foil using a continuous roll lamination process. This laminator (Figure 31) is also used for laminating a dry film photo resist which is used for controlling the copper circuit configuration during etching.

Following the resist application, the circuits are processed through the photo etch processes consisting of a UV exposer (Figure 32) to establish circuit configuration, a conveyorized semi-aqueous photo resist developing station (Figure 33) and a copper etcher (Figure 34) to remove unnecessary copper from the circuit. The final circuit processes include a photo resist stripping process (Figure 35) and a final cleaning and anti-tarnish coating process (Figure 36). The completed circuit is then ready for net trim and is stored in nitrogen cabinets until ready for welding of large area wraparound contact solar cells.

The panel assembly area of this facility consists of a 18,000 square foot clean room. In this area the solar cell welding, circuit electrical checks, circuit bonding and final wiring and panel electrical checkout are performed.

The solar cell welding system is a state-of-the-art design using a Hughes parallel gap electrode tip and power supply with several process control and monitoring systems incorporated into the electronics. The primary control for the weld pulse is a Vanzetti I-R sensor that performs an in-process reading of the weld temperature and terminates weld energy when a pre-set temperature is achieved. Other monitors take readings on tip force, weld voltage, current, weld energy, tip contamination and weld duration.

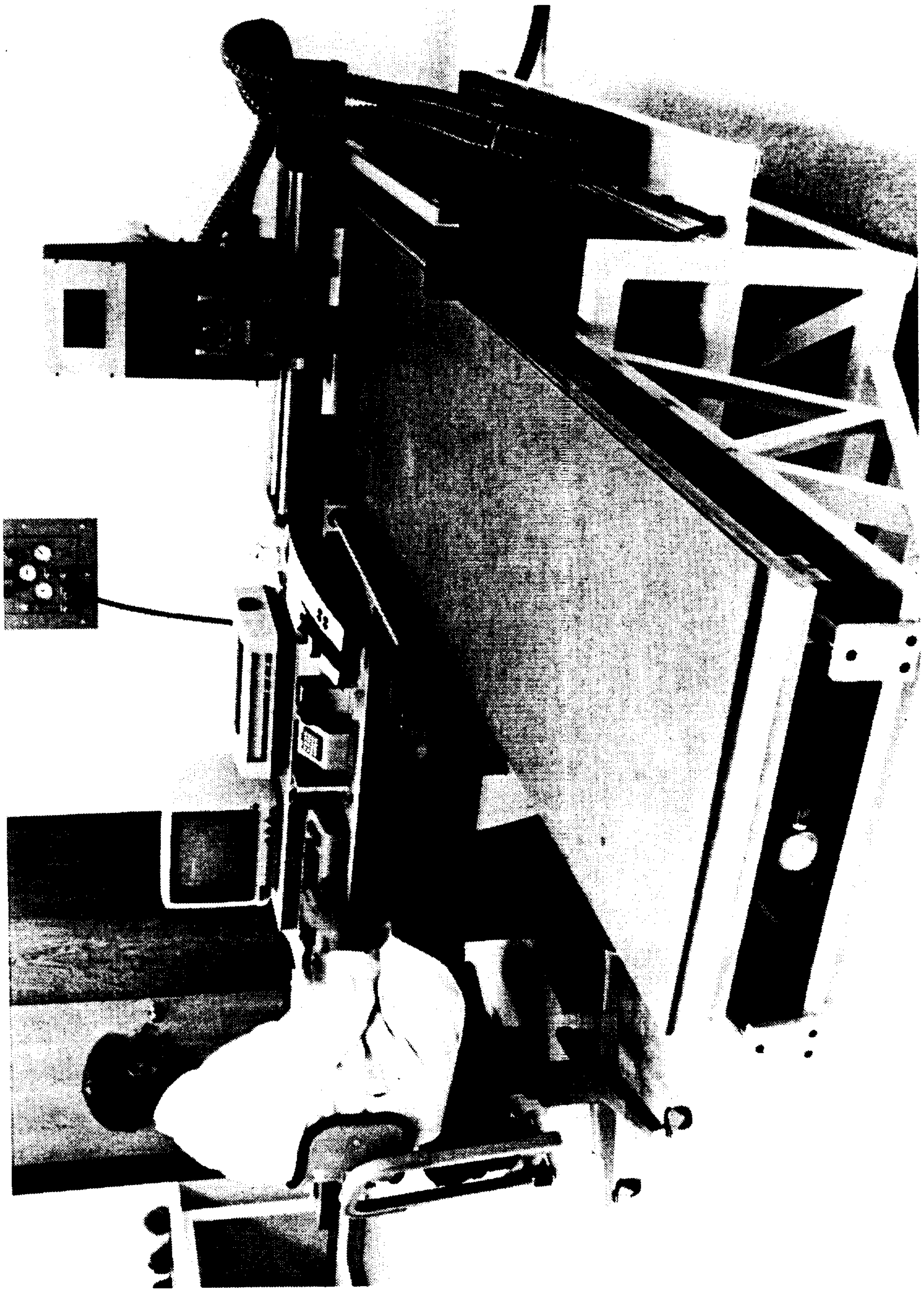

Figure 30 Flexible Circuit N/C Drill Station

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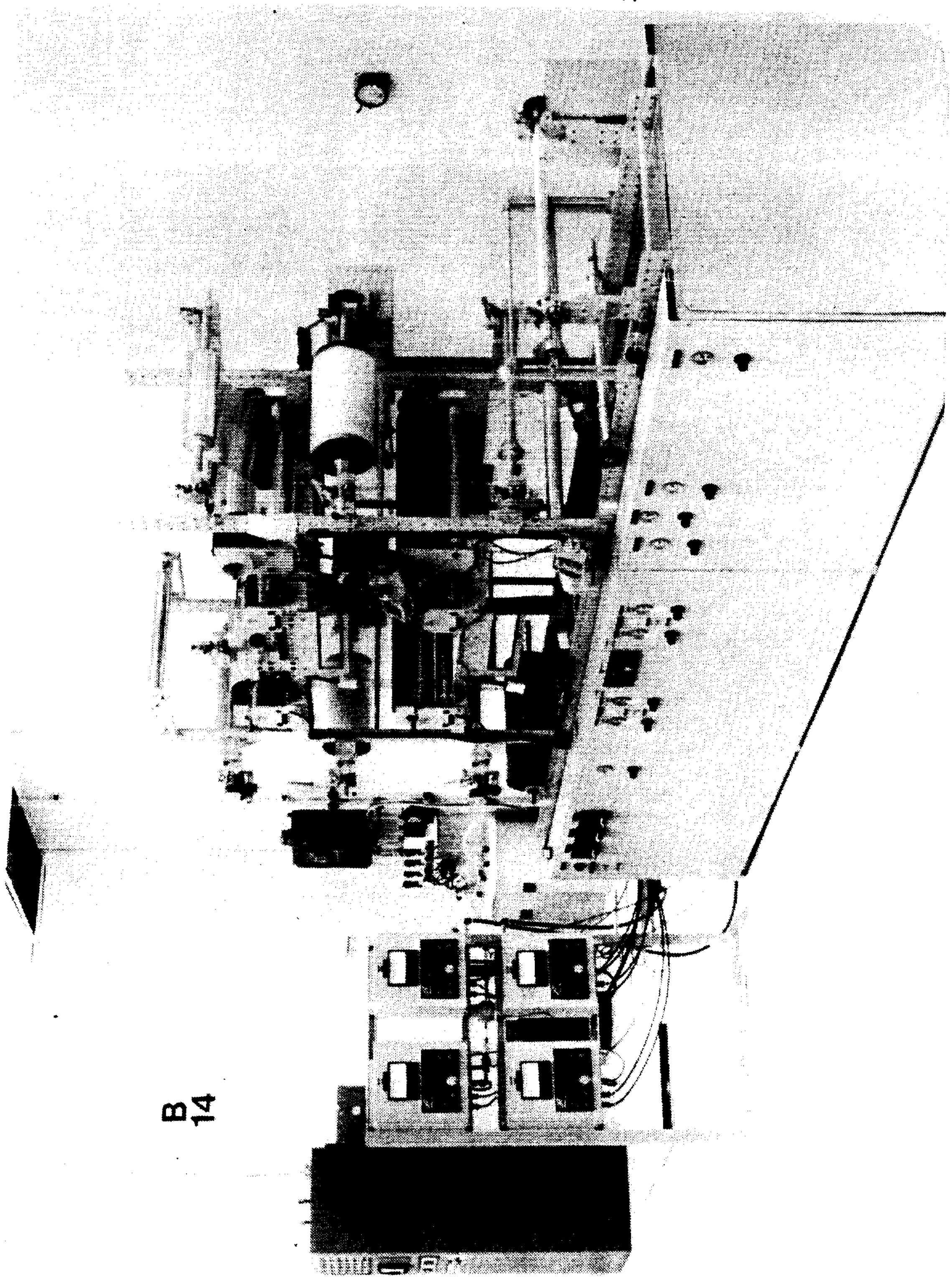

Figure 31 Flexible Circuit Roll Laminator

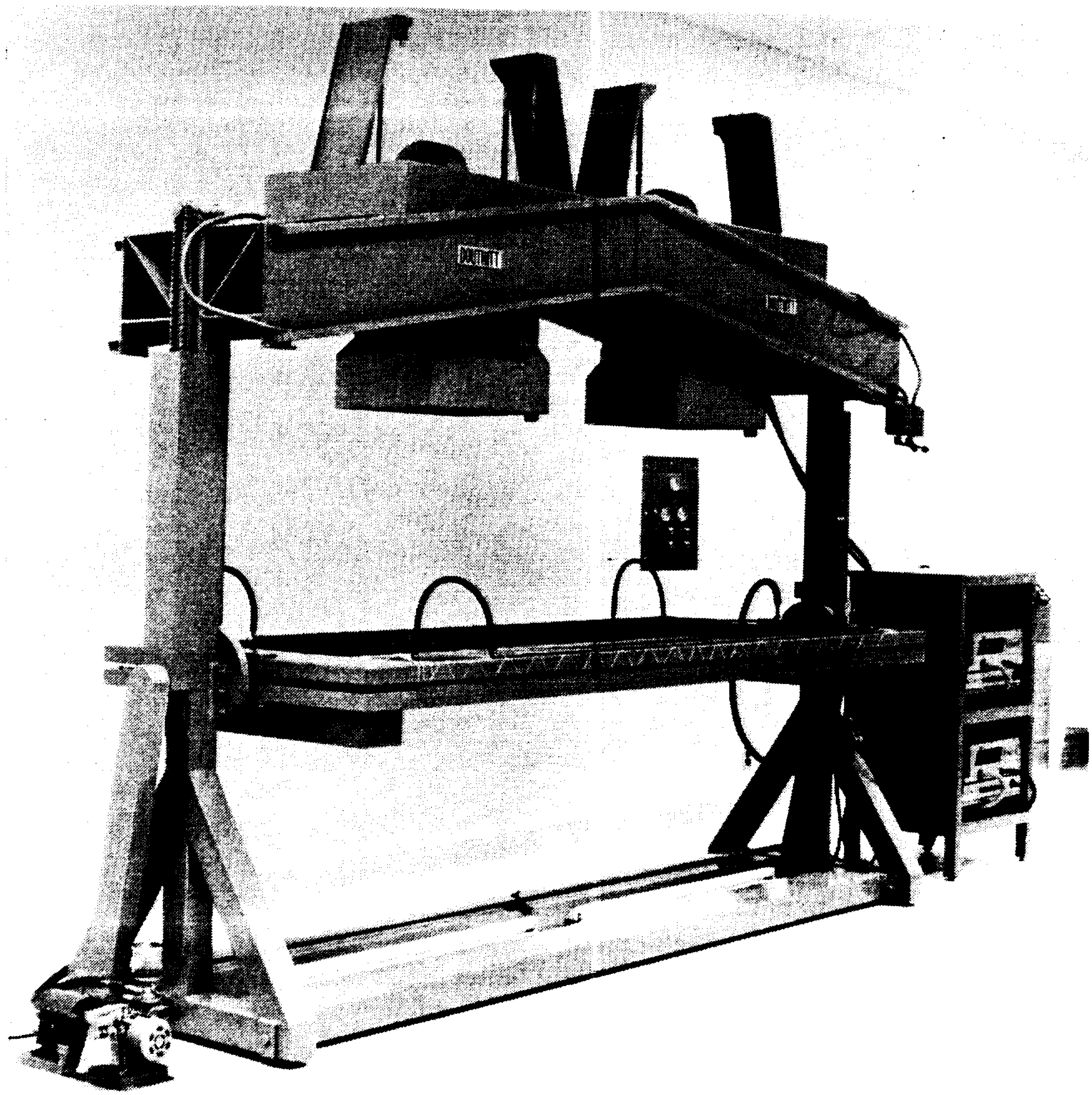

Figure 32 Flexible Circuit Photo Resist Exposer

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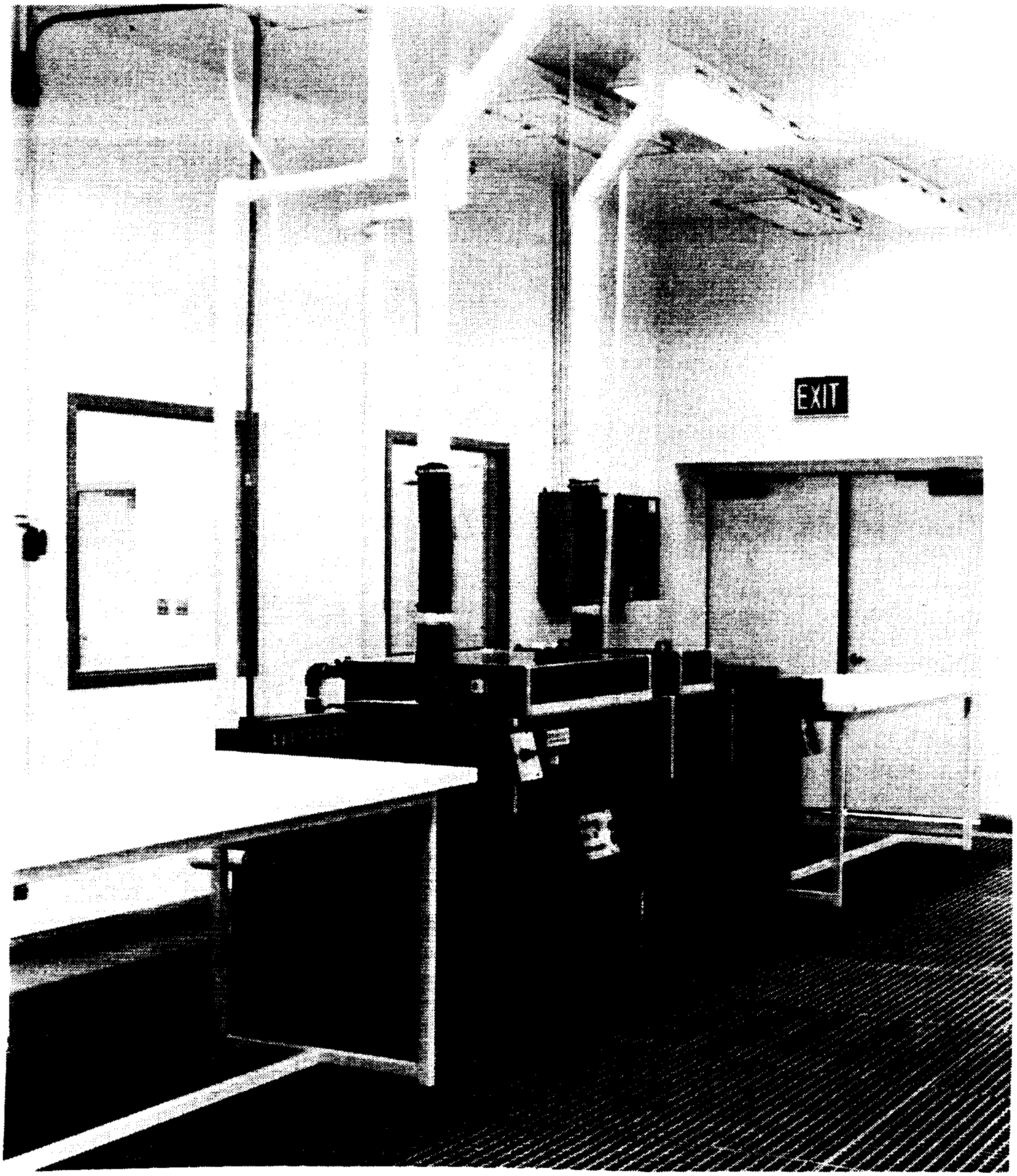

Figure 33 Flexible Circuit Photo Resist Developer

Figure 34 Flexible Circuit Copper Etcher

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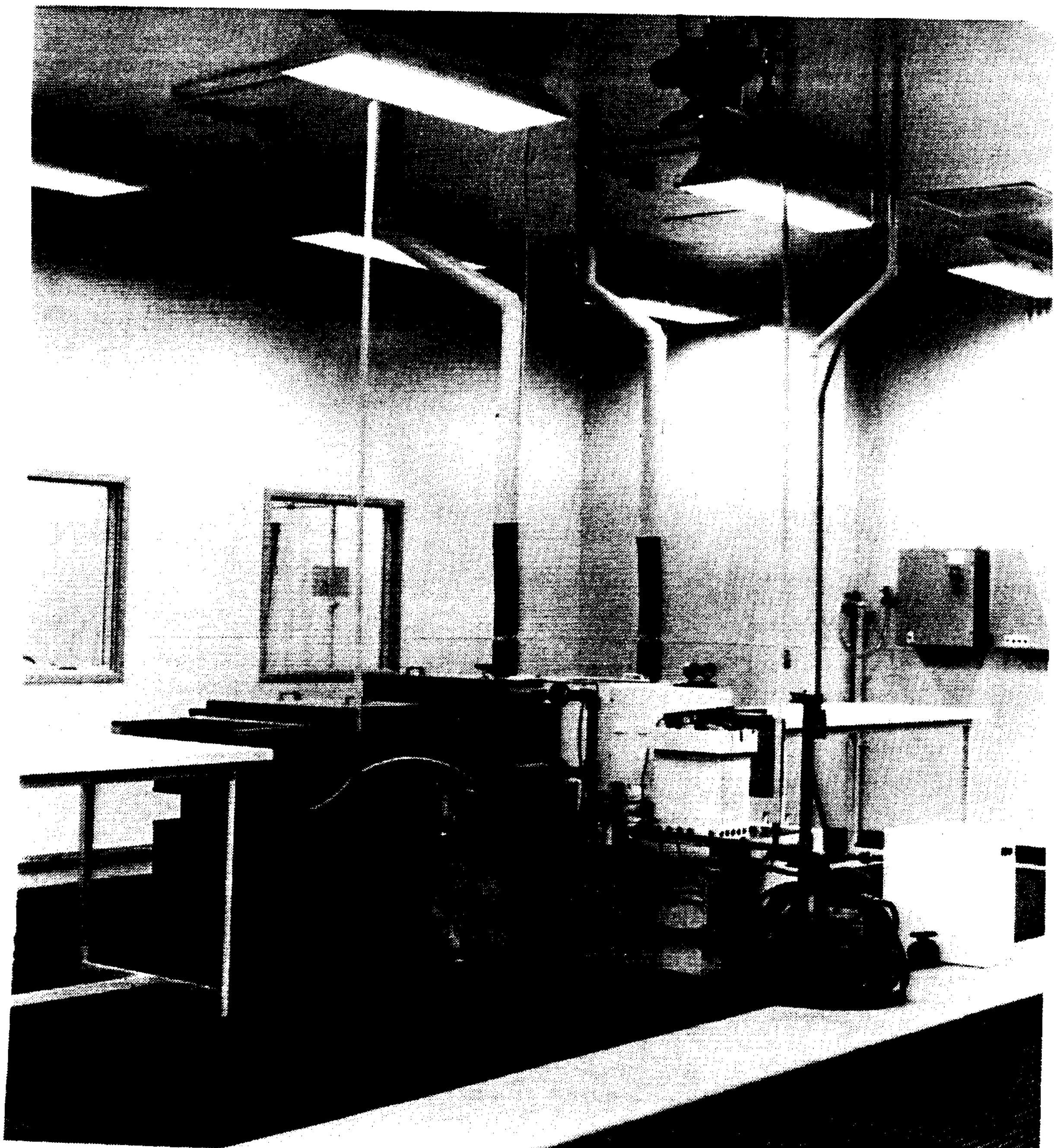

Figure 35 Flexible Circuit Photo Resist Stripper

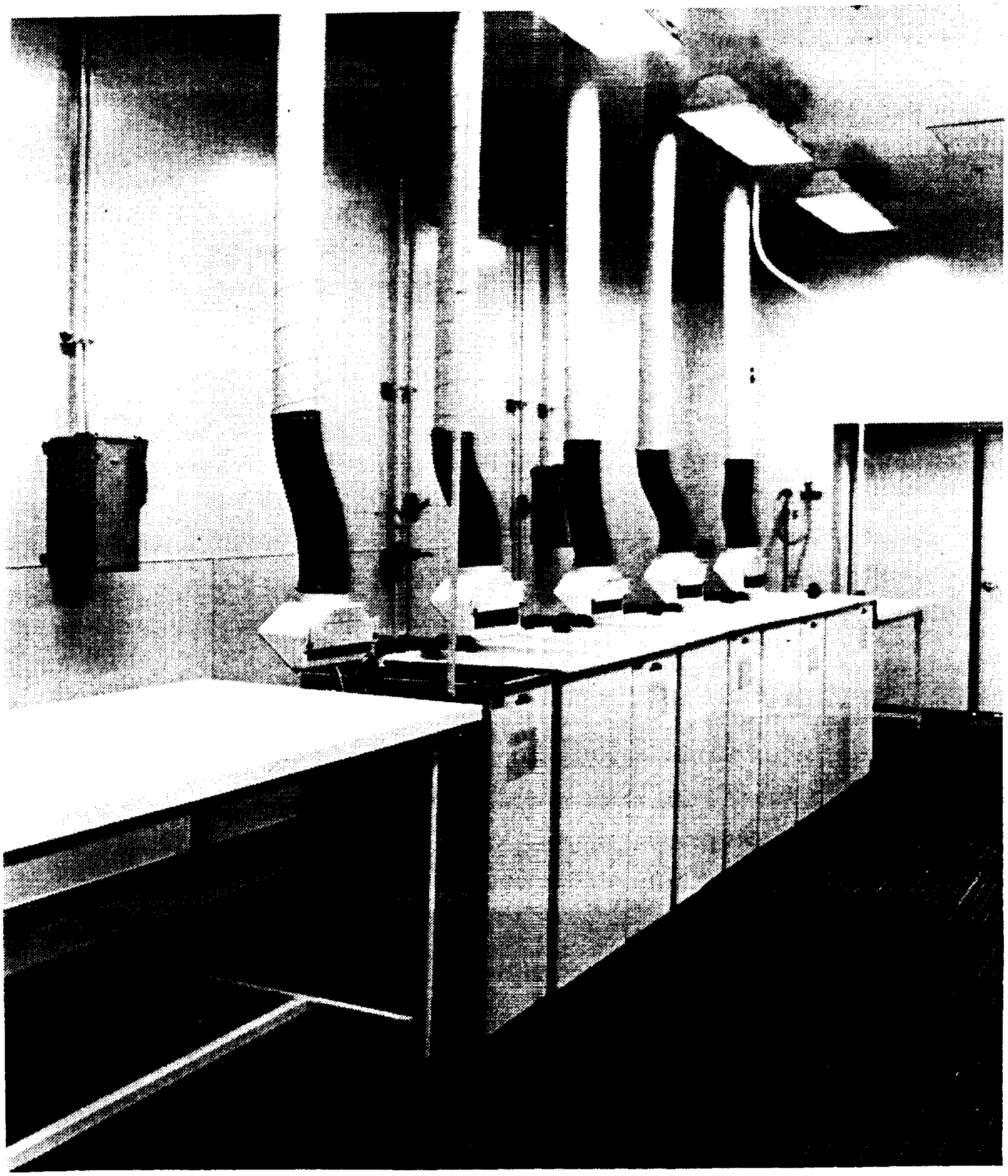

Figure 36 Copper Anti Tarnish Coating

All of this data is stored on a hard disk for later verification of weld quality. This welder incorporates a 20" x 80" N/C controlled table movement. Two camera systems are used for controlling and monitoring the welding in process. A precision locating camera performs final alignment of the weld area under the weld tips prior to each weld. The second camera is a CCTV monitor of the welding process which is displayed on a remote screen. This can be video taped for later correlation with the hard disk data to get complete history of each weld for each circuit. Two welding systems are in place. One welder is used for production work (Figure 37) and the other welder is used for development work (Figure 38). In 1987, the development welder will be moved to the advanced manufacturing area in Building 588, and a second production welder will be installed in Building 153 to accommodate the larger scale production needs of the MILSTAR program.

All flexible solar array fabrication equipment is available in Building 153 except for autoclaves which would be needed if autoclaving of superstrates to welded submodules is required. This capability exists in the main manufacturing shops. If production needs require it, an autoclave would be dedicated to this project to accommodate schedule constraints.

3.4 FLASH/FUNCTIONAL TESTING

LMSC currently has three pulse light test systems available in our manufacturing area to provide full illumination testing of the modules and panels. The 2 x 4 cm and 5.9 x 5.9 cm SAE panel segments were successfully tested prior to and after the flight and ground testing. Figure 39 shows a SAE panel mounted to a pegboard for electrical testing. The new facility will have a Spectrosun pulse light source available for testing small modules and panel wing segments.

3.5 SOLAR ARRAY BLANKET ZERO-GRAVITY TESTING

After developing an advanced solar array, a test will be required to demonstrate the retraction capability of the solar array panel segments in a zero-gravity environment. The Solar Electric Propulsion (SEP) solar array was tested by constructing a test fixture (Figure 40) and flying the experiment in a KC-135 airplane (Figure 41). By performing a parabolic flight maneuver, a simulated zero-gravity environment was

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Figure 37 Flexible Circuit Production Welder

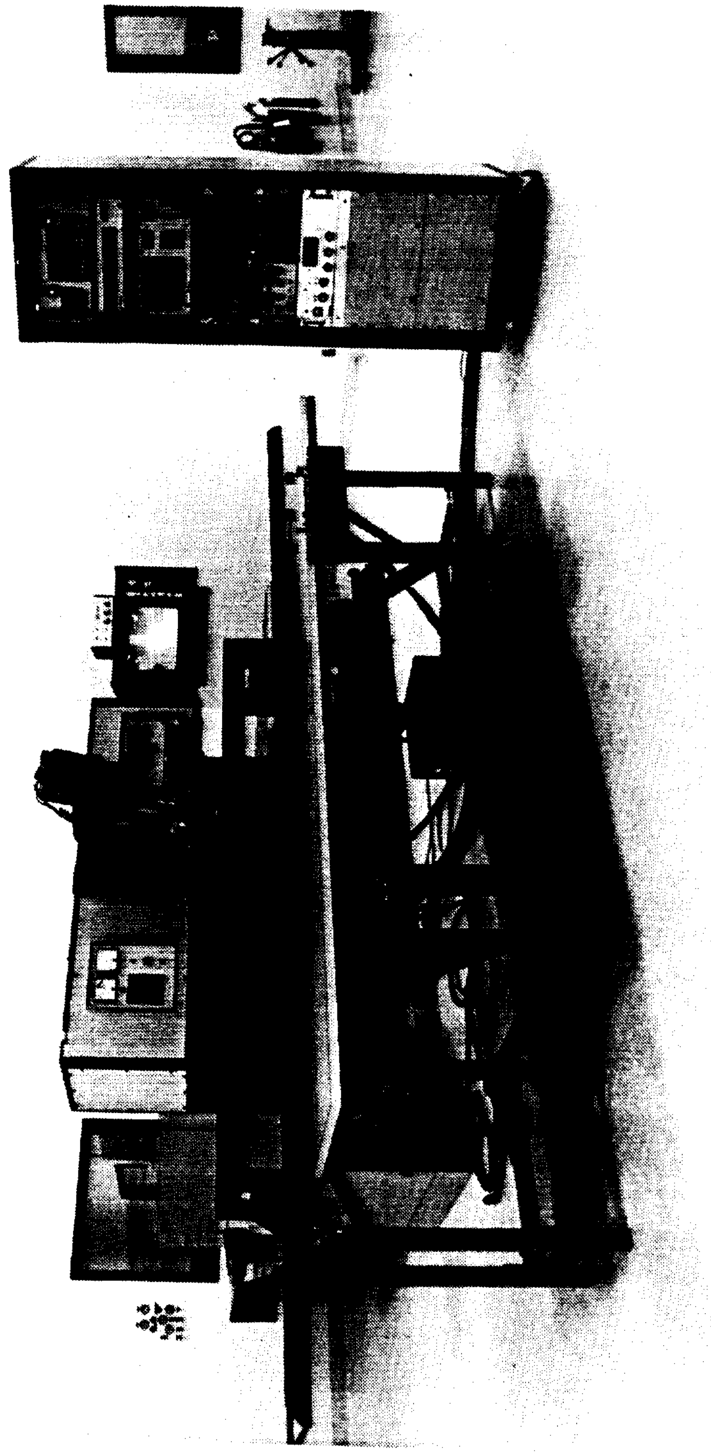

Figure 38 Flexible Circuit Development Welder

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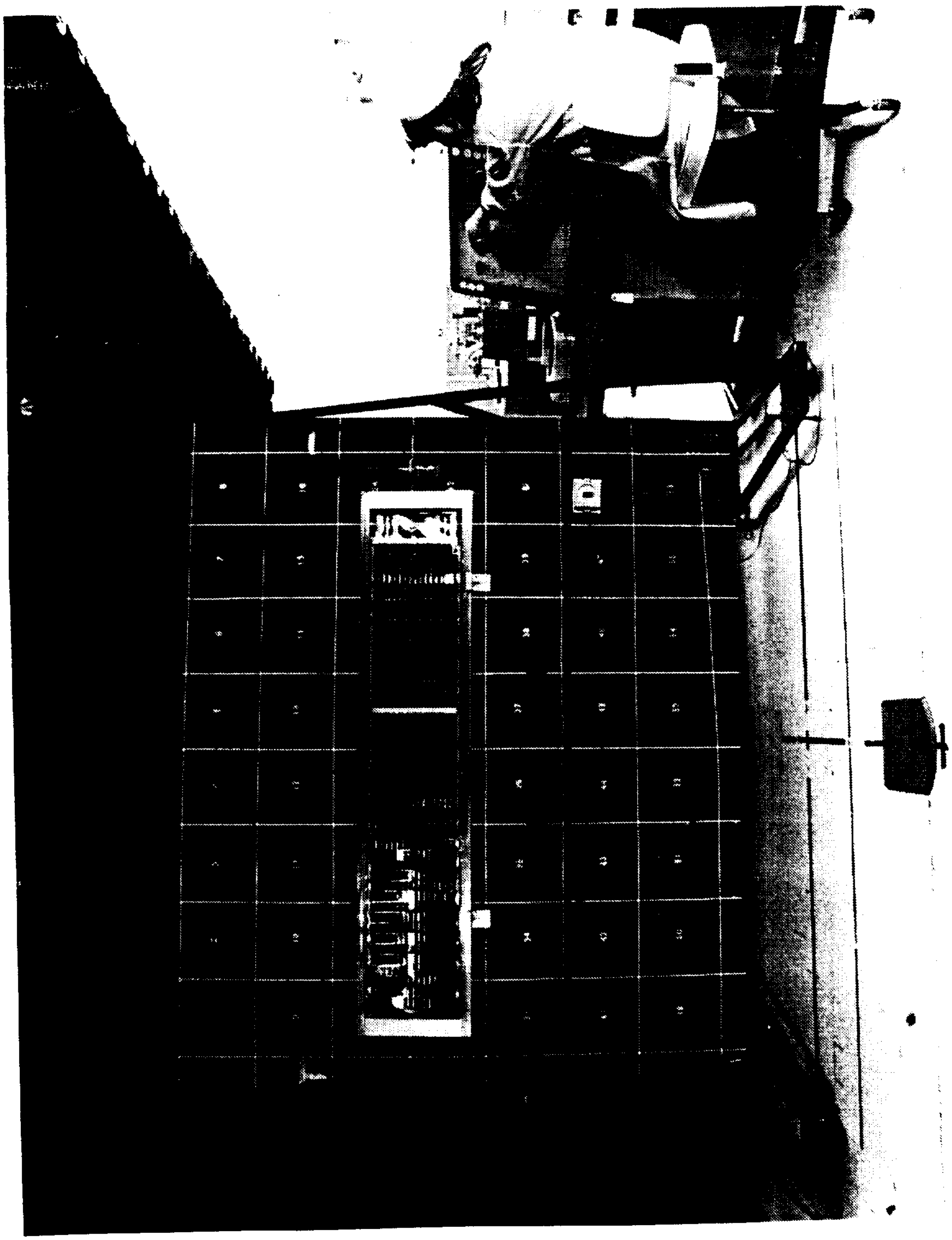

Figure 39 Flash Testing of SAE Flight Panel

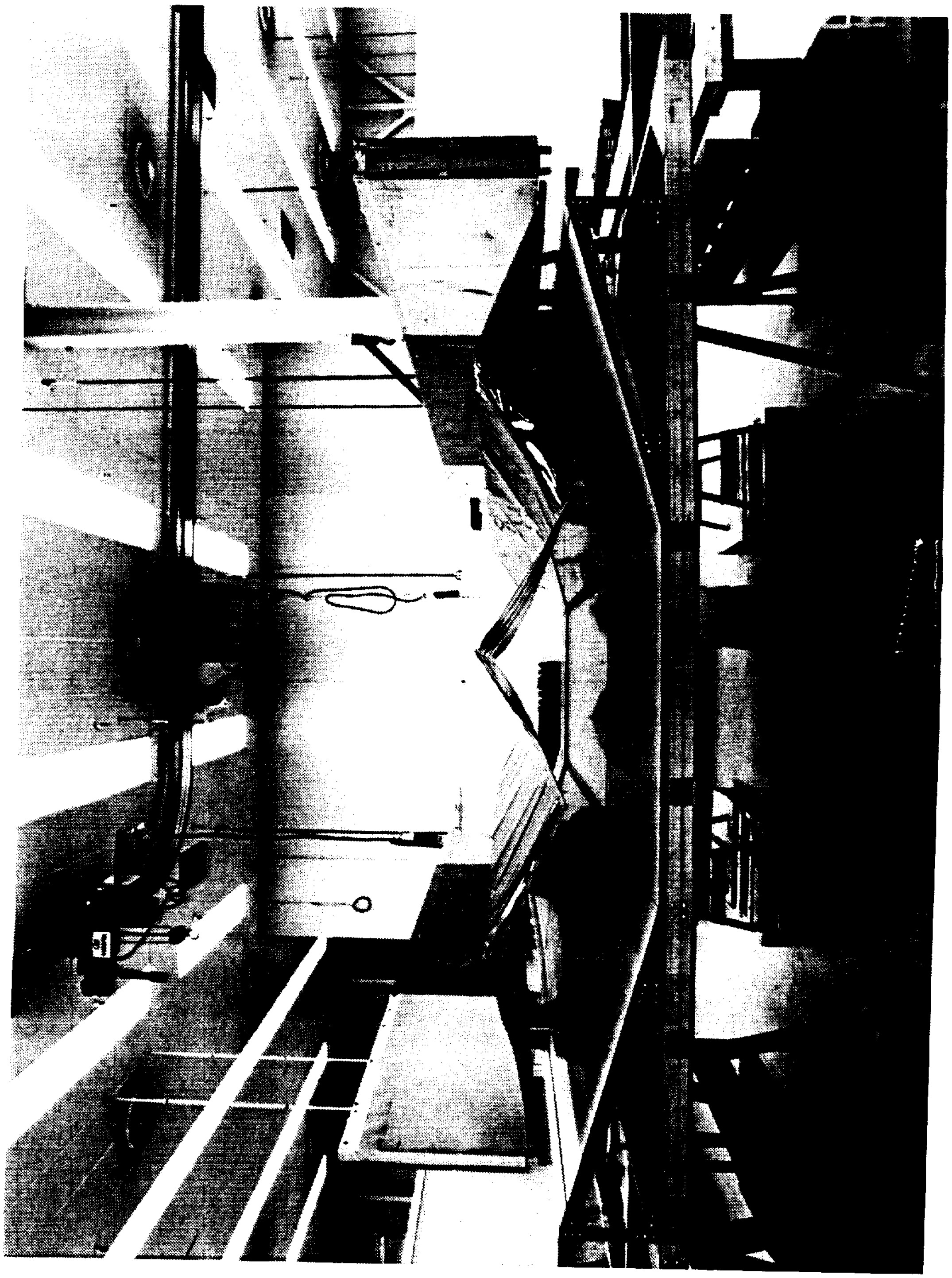

Figure 40 SEP Solar Array Zero-Gravity Experimental Setup

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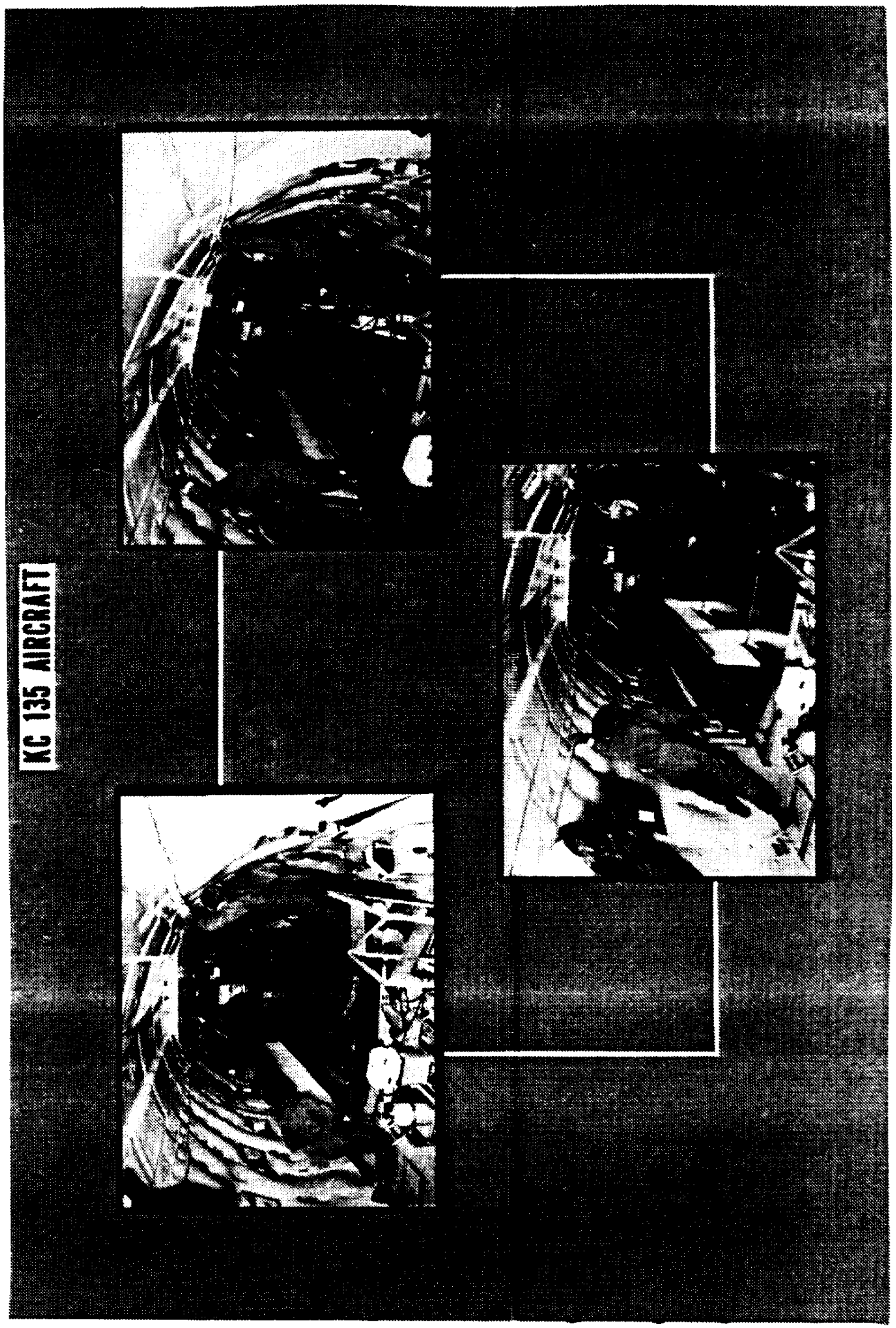

Figure 41 SEP Solar Array Zero-Gravity Aircraft Testing

obtained for approximately 30 seconds. A similar test could be done with the Space Station arrays.

With LMSC's experience performing this test, no problems can be foreseen in repeating it in the future. LMSC would use a KC-135 airplane from NASA-JSC (Ellington AFB) because of our successful teaming arrangement with them in the past. No aircraft availability problem can be foreseen.

3.6 FULL-SCALE MAST AND WING EXTENSION TESTING

In addition to solar array fabrication, the Building 153 facility would also be the location for a series of functional and acceptance tests on the mast and solar array wing. The mast would be tested first as a component, and then the whole solar array wing would be tested.

The mast tests would most likely include functional extension and retraction (both loaded and unloaded), linear and angular alignment measurements at intermediate and fully extended positions, torsional and bending stiffness measurements, flight loading, and lock-up loading tests. To simulate a zero-gravity environment, a water table (Figure 42) would be set up. Because LMSC has done this testing once before, no problems are anticipated.

The solar array wing would need to be functionally tested to demonstrate its capability to properly perform "hands-off" extension/retraction operations. To demonstrate this capability, a simulated zero-gravity test setup would be required. This test was performed once before in the Building 153 facility, see Figures 43 and 44. The monorail which was used to support the wing while being extended and retracted is still in place in the facility. Additional test support equipment would be required, but no problems in completing this task are foreseen.

3.7 FULL-SCALE WING ENVIRONMENTAL TESTING

Three environmental tests would be performed to test a full-scale wing. These tests would include vibration, acoustic noise, and thermal vacuum cycling. The test facilities required for these three tests are located in the Sunnyvale facility. These

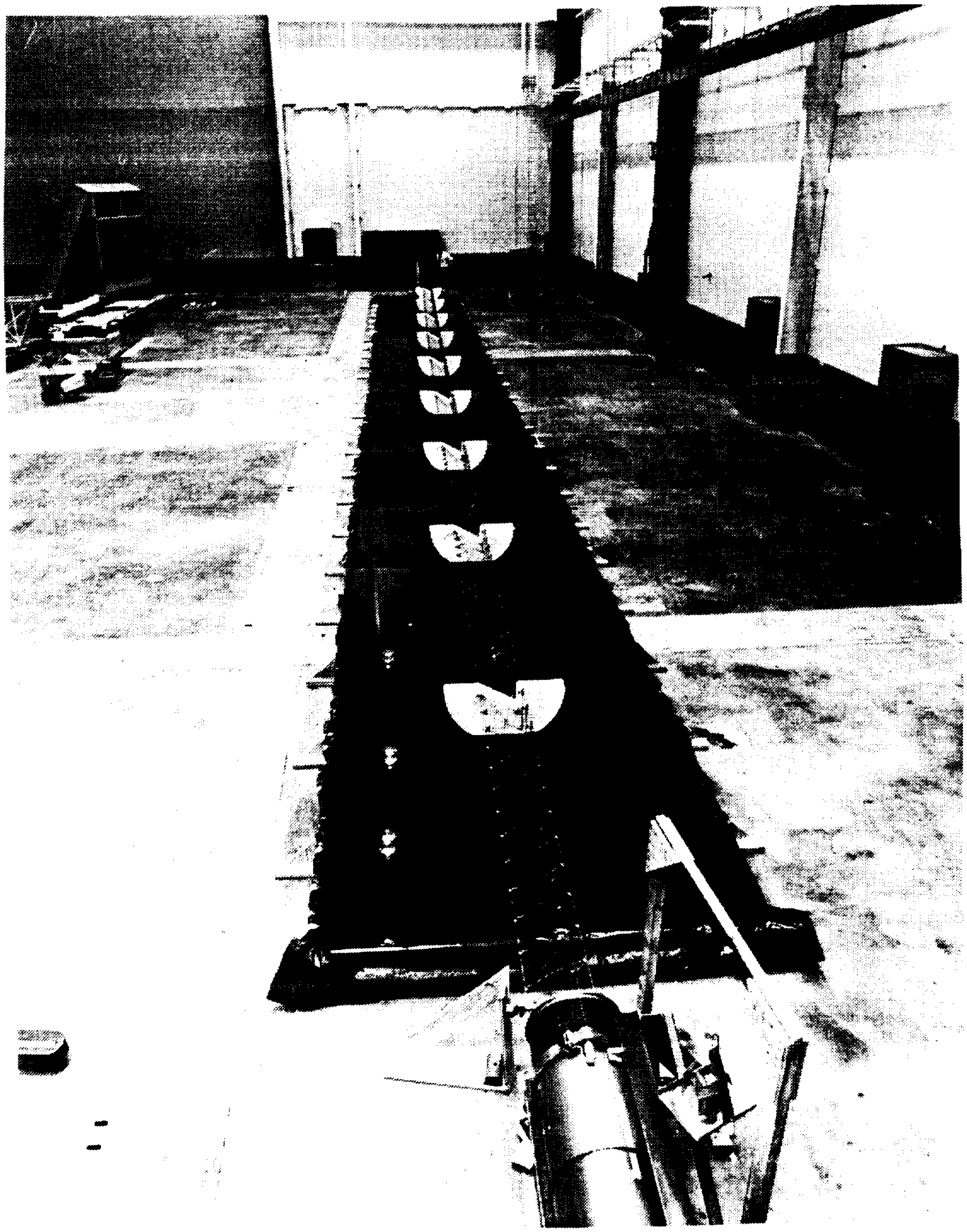

Figure 42 General Test Setup

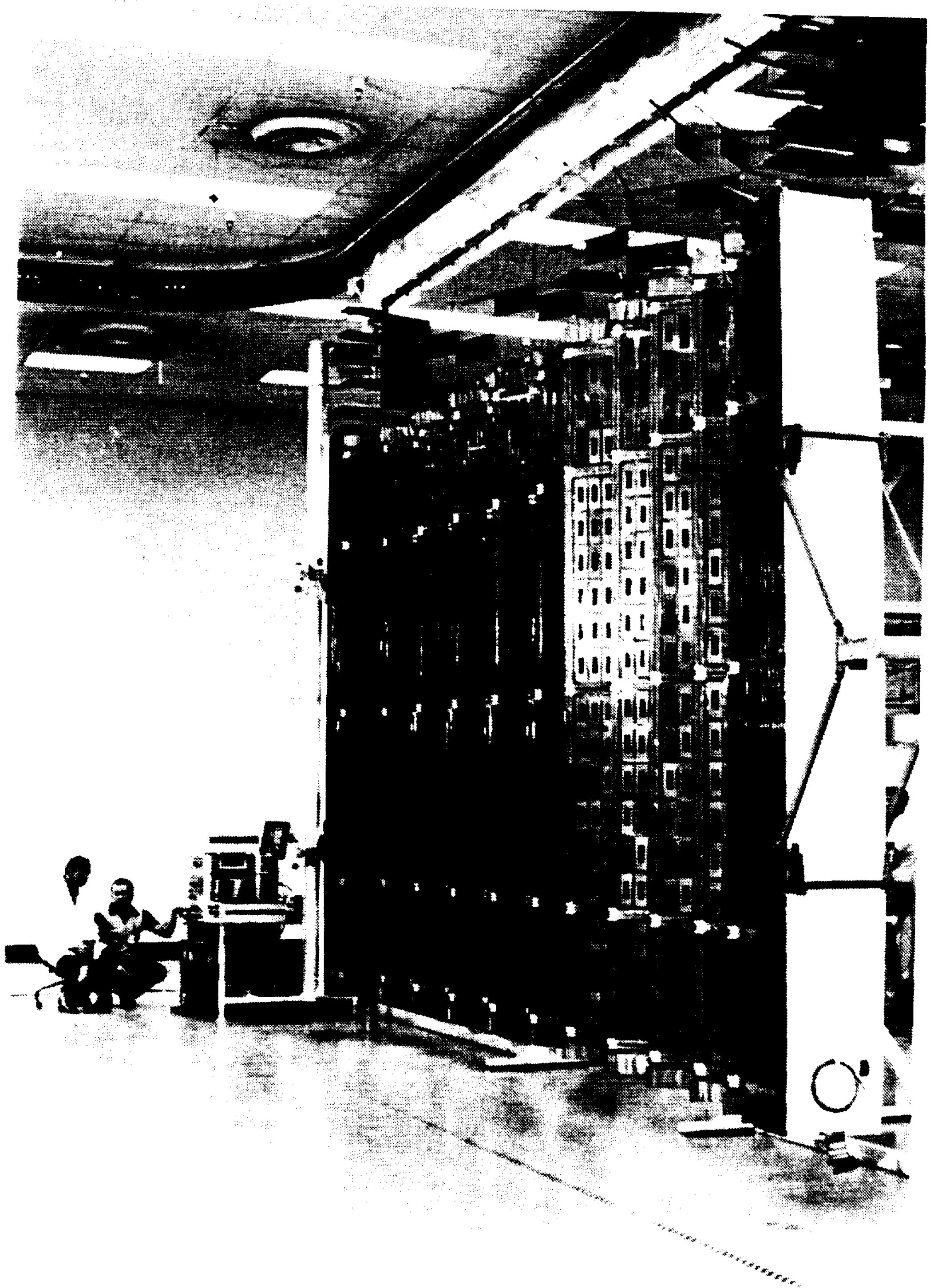

Figure 43 SAE Being Deployed in Building 153

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Figure 44 SAE Fully Deployed in Building 153

facilities are the same as those used on the Solar Array Experiment (SAE). Figures 45 through 48 show the acoustic, vibration, and thermal vacuum cycling setup of the SAE and SEPS hardware. The experience gained on these previous tests would provide the basis of accurate cost and performance estimates if these same facilities were used for this project.

3.8 SAE ASSEMBLY AND TESTING SEQUENCE

The overall SAE fabrication and assembly capabilities and methods are shown in the flow sequence shown in Figure 49. Many of these same methods would be used on Space Station solar arrays if LMSC became involved in fabrication work.

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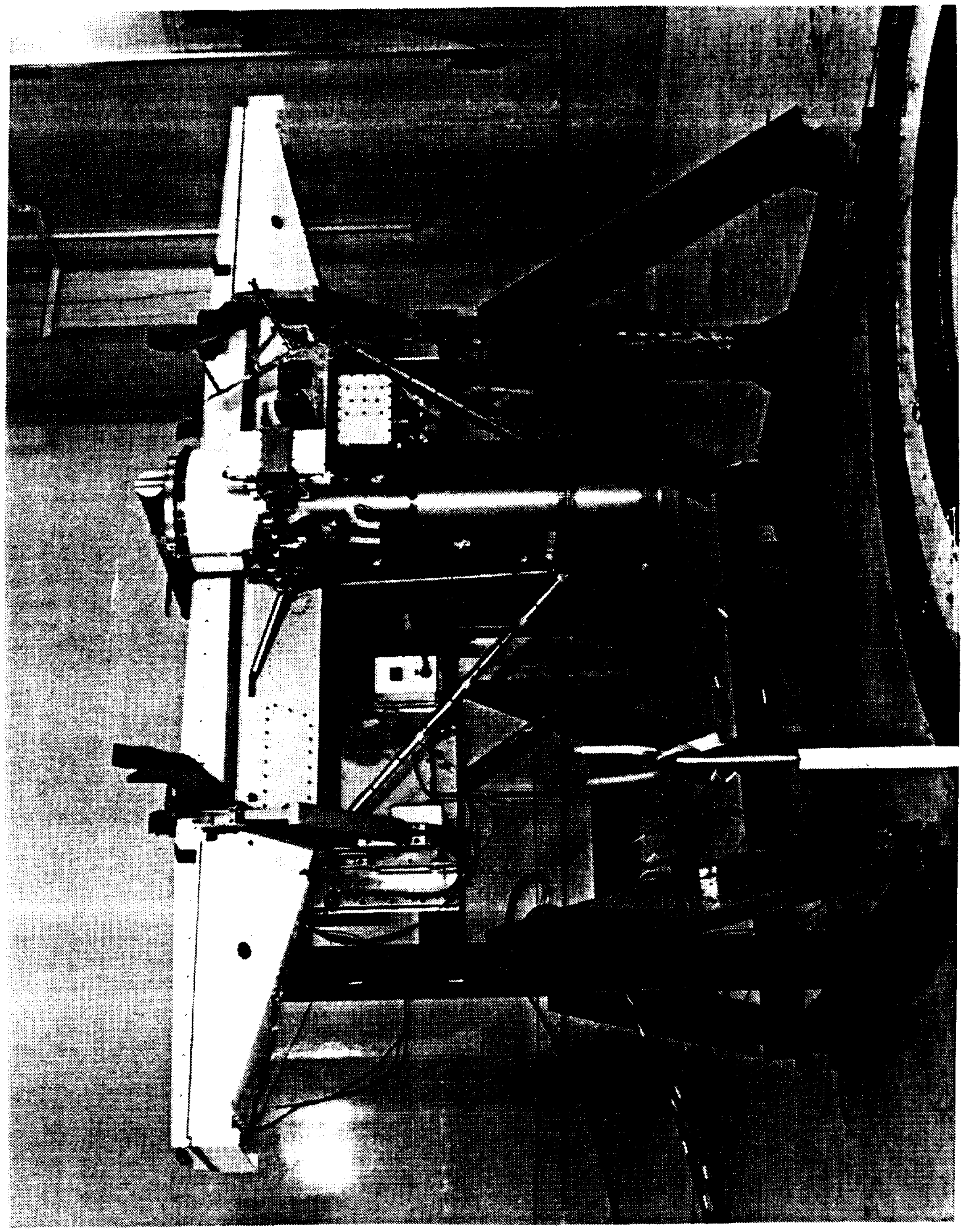


Figure 45 SAE Acoustic Noise Test - Mounted on Simulated Support Structure

DATE: FEBRUARY 1979

FACILITY: LMSC BLDG 156 ACOUSTIC CELL 2 (20 FEET BY 26 FEET BY 31 FEET HIGH)

OBJECTIVE: SUBJECT THE STOWED WING ASSEMBLY TO A QUALIFICATION LEVEL ACOUSTIC ENVIRONMENT (145 dB OAL)

SETUP: SUSPENSION 6 FEET ABOVE CELL FLOOR ON BUNGIE CORD AND WIRE ROPES

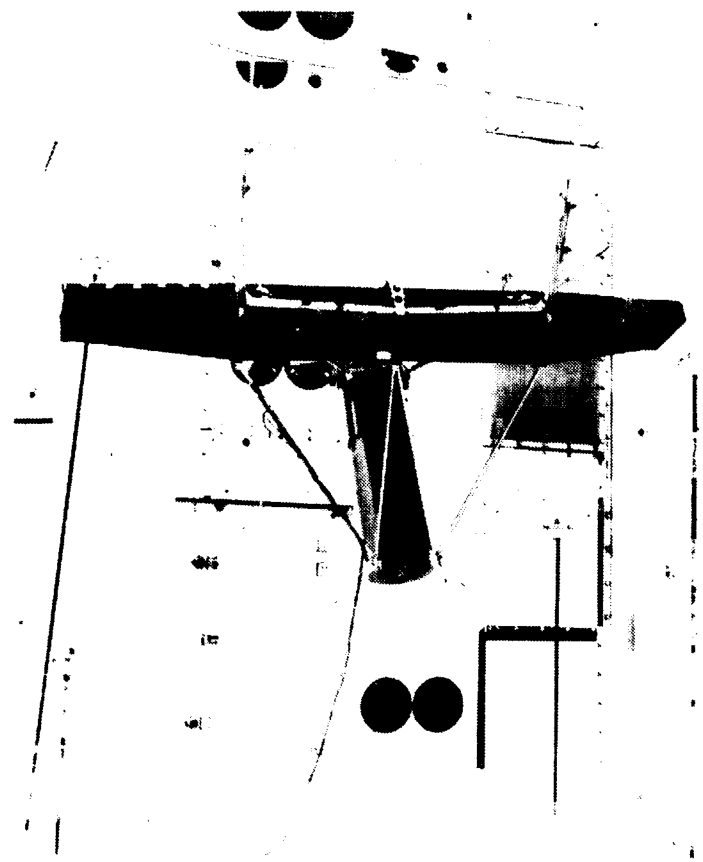


Figure 46 SAE Acoustic Noise Test - No Support Structure

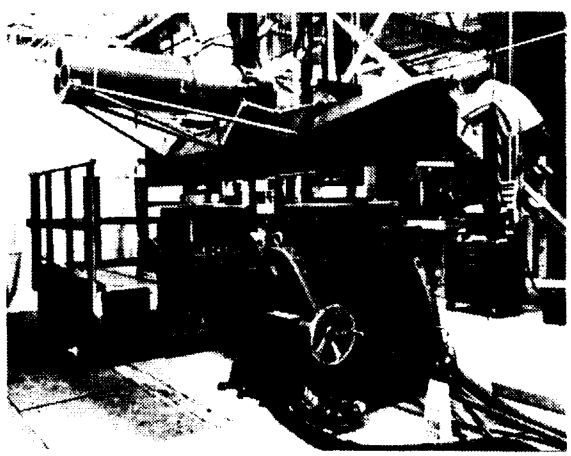
<u>DATE</u>: MAY 1979

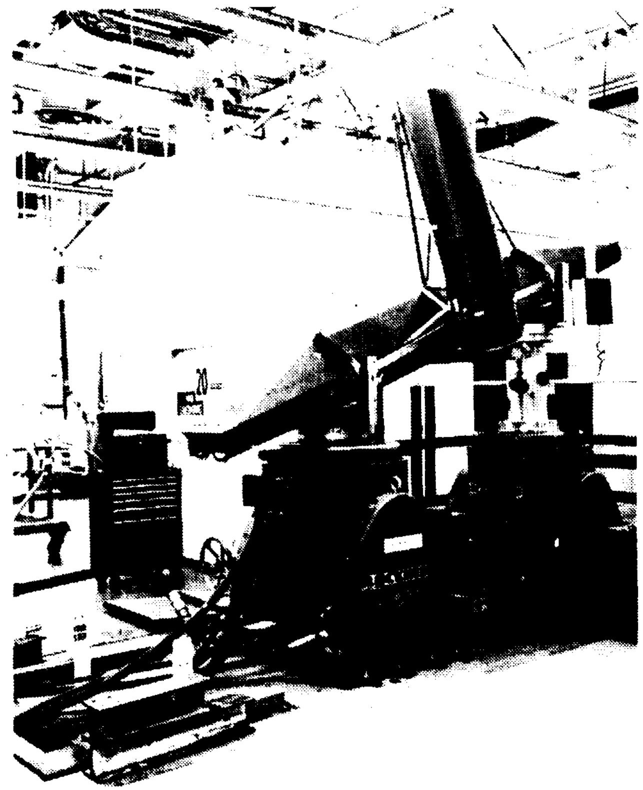
<u>FACILITY</u>: LMSC BLDG 102 HIGH BAY AREA

<u>OBJECTIVE</u>: SUBJECT STOWED WING ASSEMBLY TO THE SPACE SHUTTLE DYNAMIC ENVIRONMENT

<u>SETUP</u>: DUAL SHAKER SYSTEM TO SIMULATE SINUSOIDAL AND RANDOM VIBRATION

Z-AXIS TEST





X Y AXIS TEST

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Figure 47 SAE Vibration Test - Two Large Shaker Tables

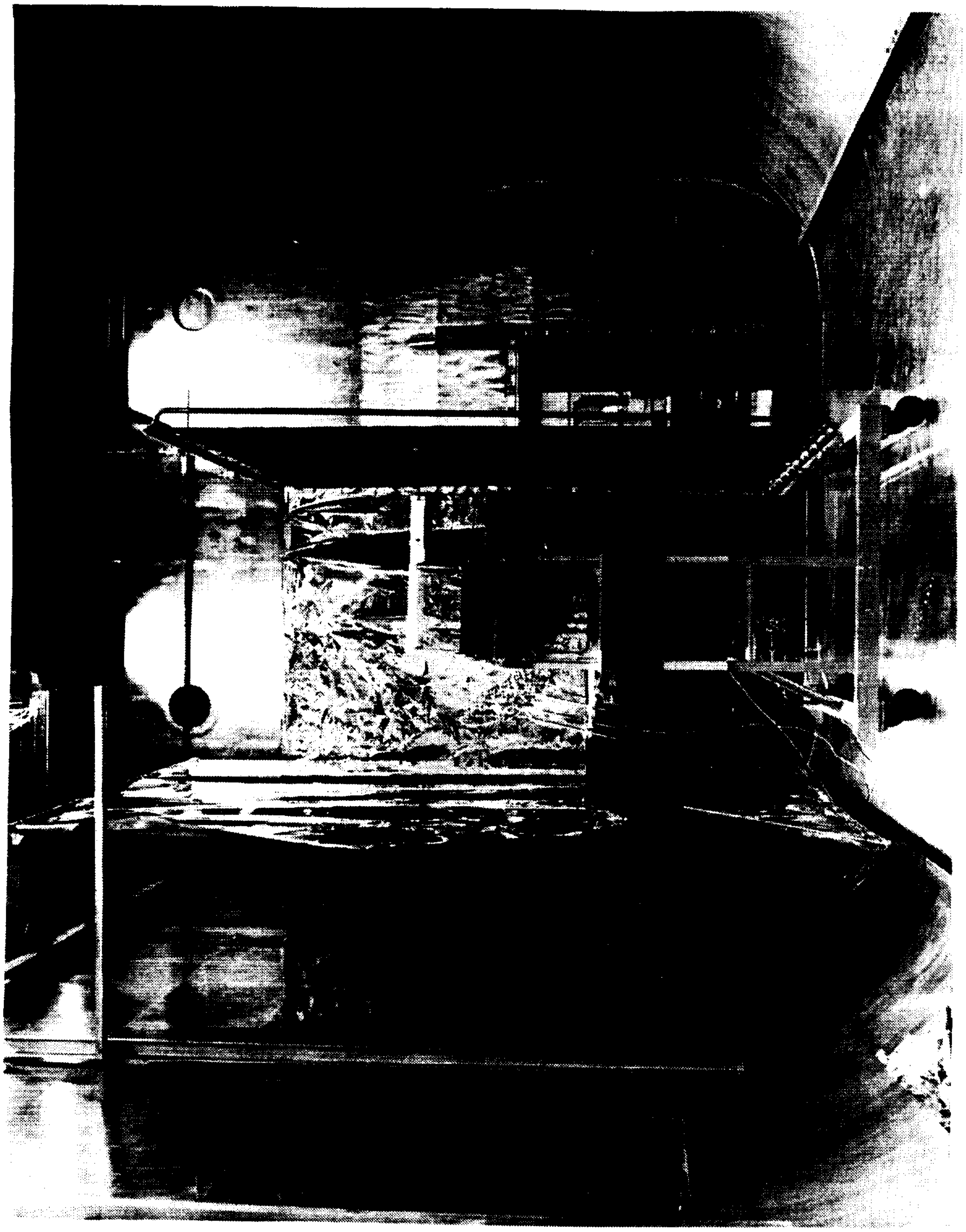
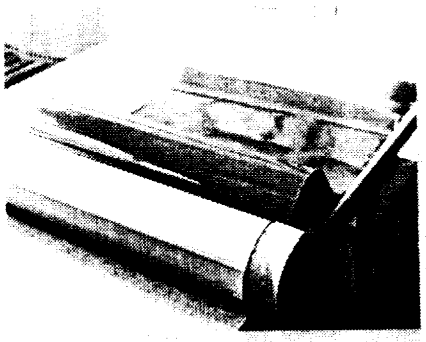


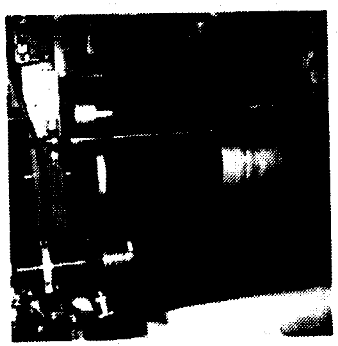
Figure 48 Full-Scale Wing Thermal-Vacuum Test Setup



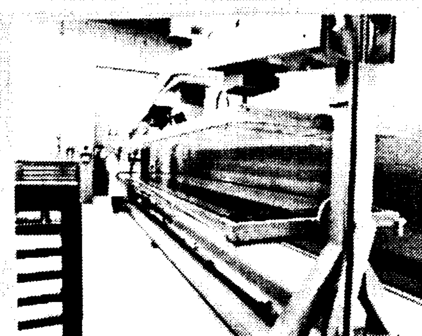
1. .001 IN. THICK POLYIMIDE FILM & .0014 IN. THICK COPPER FOIL

2. PNEUMATICALLY OPERATED PUNCH & DIE ASSEMBLY

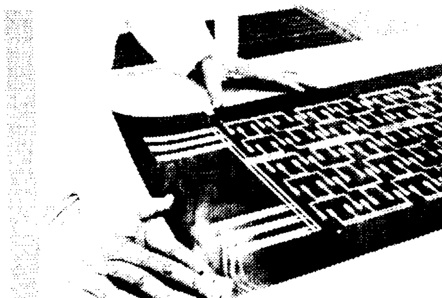
3. PREPUNCHED FILM ON ROLL LAMINATOR



4. PHOTO RESIST ROLL LAMINATED ON COPPER/ POLYIMIDE LAMINATE



5. 4½ FT. × 20 FT. CONTACT PRINTER



6. NETWORK IMAGE ART MASTER

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Figure 49 Fabrication, Assembly, and Test of SAE Wing

Figure 49 Fabrication, Assembly, and Test of SAE Wing (cont.)

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Figure 19 Fabrication, Assembly, and Test of SAE Wing (cont.

Figure 49 Fabrication, Assembly, and Test of SAE Wing (cont.)

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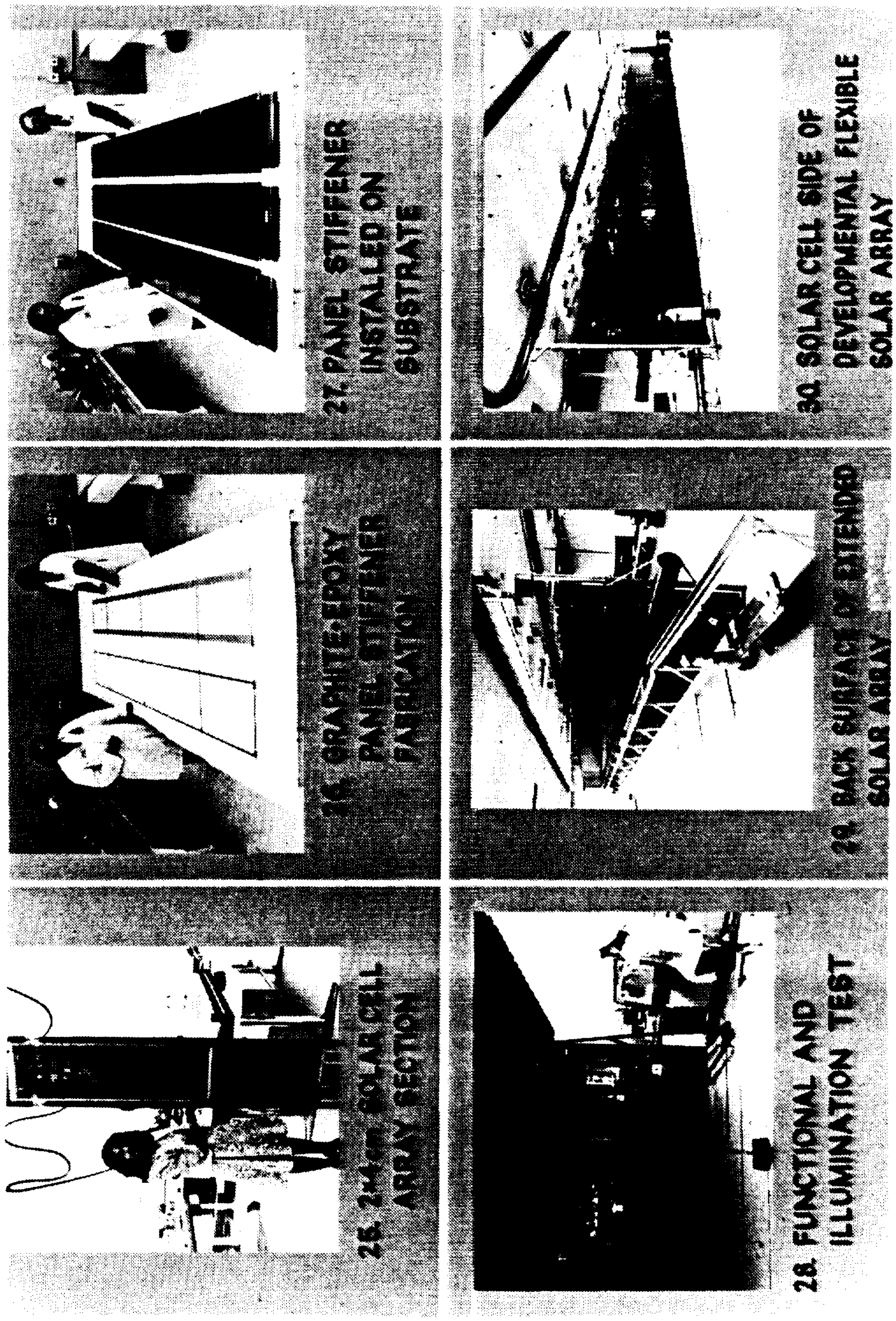

Figure 49 Fabrication, Assembly, and Test of SAE Wing (cont.)

4.0 SUMMARY

Two modules consisting of 28 large area 5.9 cm x 5.9 cm wraparound contact solar cells welded to a flexible Kapton circuit were fabricated. In addition, a soldered conventional n-bar contact 5.9 cm x 5.9 cm-28 cell module was fabricated along with a 15 cell module utilizing 8 cm x 8 cm wrap-through contact solar cells welded to a flexible Kapton circuit. These modules contain features to allow experimental evaluation of the effects of insulation, pin-holes and other factors on several design options to gain a basic understanding of plasma interaction with solar arrays. Pretest I-V measurements were made on each module string. The module plates were delivered to NASA Lewis Research Center where they are currently undergoing plasma testing.

APPENDIX A

QUANTITY REQUIRED PER ASSEMBLY	LOCKHEED DATA: PART NUMBER	NOMENCLATURE	SPECIFICATION	SUPPLIER DATA: CODE IDENT	PART NUMBER	DRAWING NUMBER	NAME AND ADDRESS	NOTES
	X8512603-001	SOLAR CELL	7699230	11536			APPLIED SOLAR ENERGY CORPORATION	
	X8512603-003	SOLAR CELL	7699230				APPLIED SOLAR ENERGY CORPORATION	

NOTES:

1 DOCUMENTATION AND CHANGE CONTROL REQUIREMENTS SHALL BE IN ACCORDANCE WITH THE PROCUREMENT DOCUMENT

2 SPECIFICATION LISTED IN LOCKHEED DATA BLOCK ABOVE GOVERNS THE PROCUREMENT AND ACCEPTANCE OF THIS ITEM.

3 PACKAGING AND PRESERVATION SHALL BE AS SPECIFIED IN THE PROCUREMENT DOCUMENT

4 MAXIMUM WEIGHT: 300 GRAMS PER 100 ASSEMBLIES.

5 WHEN CHANGES ARE MADE TO PROCESS SPECIFICATIONS CONSIDERED TO BE VENDOR PROPRIETARY, THE VENDOR MUST ADVISE LMSC PROCUREMENT OF THE IMPACT OF ANY CONTEMPLATED CHANGE PRIOR TO THE CHANGE AND THE SERIAL OR LOT NUMBER ON WHICH THE CHANGE WILL BECOME EFFECTIVE.

6 MANUFACTURE IN ACCORDANCE WITH PROCESS SPECIFICATIONS LISTED IN LOCKHEED DATA BLOCK ABOVE OR IN NOTES. ANY DEVIATION MADE BY THE VENDOR TO THESE SPECIFICATIONS OR TO PREVIOUSLY APPROVED VENDOR SPECIFICATIONS SHALL BE REPORTED TO LMSC PROCUREMENT. APPROVAL OF ANY DEVIATION SHALL BE FORMALLY INDICATED BY LMSC ISSUANCE OF A NEW OR REVISED SPECIFICATION OR ENVELOPE DRAWING PRIOR TO ACCEPTANCE OF ANY HARDWARE MANUFACTURED IN CONFORMANCE WITH SUCH DEVIATION.

7 PART IDENTIFICATION PER MIL-STD-130. DO NOT MARK PARTS. PART IDENTIFICATION SHALL BE ON UNIT PACKAGES AND SHIPPING CONTAINERS ONLY. NO MORE THAN 40 SOLAR CELLS PER BOX. MARK LOT CODE AND CURRENT GROUP FOR EACH SOLAR CELL ON BOX.

8 GRID CONFIGURATION SHOWN IS FOR REFERENCE ONLY. GRID SHALL MINIMIZE TOTAL AREA AND TOTAL WEIGHT OF SILVER.

9 DIMENSION SHOWN IS THICKNESS OF THE SILICON ONLY.

10 CRACKED SOLAR CELLS SHALL BE CAUSE FOR REJECTION.

11 ACCEPTABLE LIMITS FOR COSMETIC DEFECTS:

A) EDGE CHIPS ON CELLS SHALL NOT EXCEED .030 INCHES IN DEPTH BY .150 INCHES IN LENGTH. CHIPS LESS THAN .005 INCHES IN DEPTH SHALL BE DISREGARDED.

B) CORNER CHIPS ON CELLS SHALL NOT EXCEED .080 INCHES ALONG THE HYPOTENUSE.

12 OPTICAL COATING TO ENHANCE TRANSMISSION BETWEEN 1.1 AND 2.5 μm.

13 SHIPPING CONTAINERS SHALL BE MARKED, "NON-FLIGHT ITEM. OPEN SHIPPING CONTAINERS IN CLEAN ROOM ONLY."

14 AR COATING TO OPTIMIZE SOLAR CELL SHORT CIRCUIT CURRENT FOR AMO OPERATION WITH DC 93-500 AS THE ADHESIVE FOR A MICROSHEET COVERSLIDE .

15 SOLDER COATED ZONE ON THE 'N' CONTACT STRIP SHALL EXTEND A MINIMUM OF .032 FROM THE EDGE OF THE CELL. A MAXIMUM OF .004 FROM THE CELL EDGES MAY BE FREE OF SOLDER.

INTERPRET DWG. PER MIL-D-1000 LEVEL 2	UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON: FRACTIONS = ± 1/16 DECIMALS .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES = ± 2 DEG.
X8512600 / -501 / -503	CONTR
NEXT ASSY / USED ON — APPLICATION	CCA/CEI

DATE	85-06-18
DWN	K.M.BILGER
APVD	
APVD	R. GIVEN
ENGRG	K.M.BILGER
CHKR	A.SAITZEW
APVD	
APVD	

LOCKHEED MISSILES & SPACE COMPANY, INC. SUNNYVALE, CALIFORNIA

SOLAR CELL ENVELOPE DRAWING

SIZE	FSCM NO	DRAWING NO.	REV
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SCALE N/A		SH 1 OF 3	

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VOLT ASSOLAR CELL ENV DWG. K.M.BILGER

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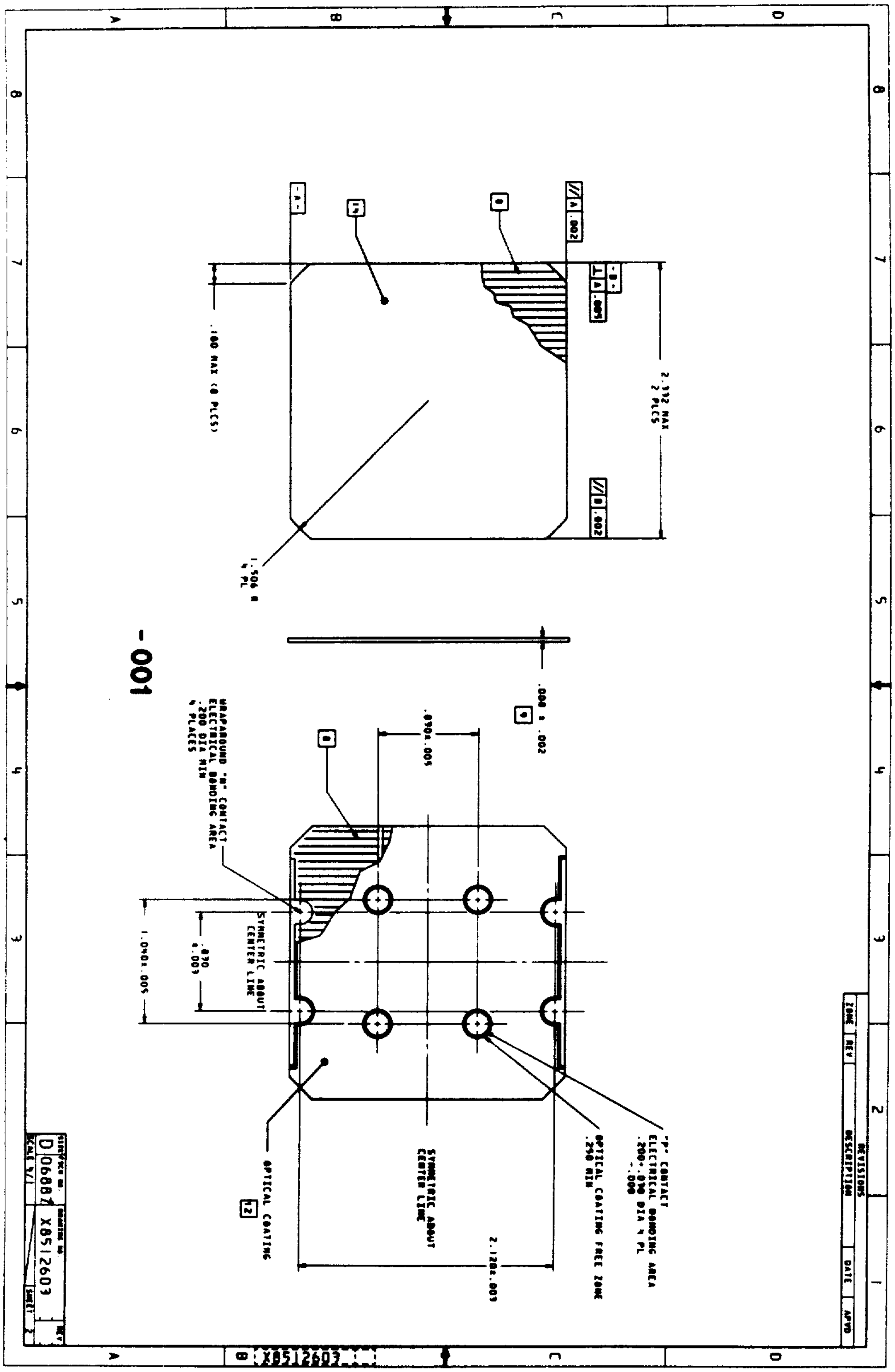

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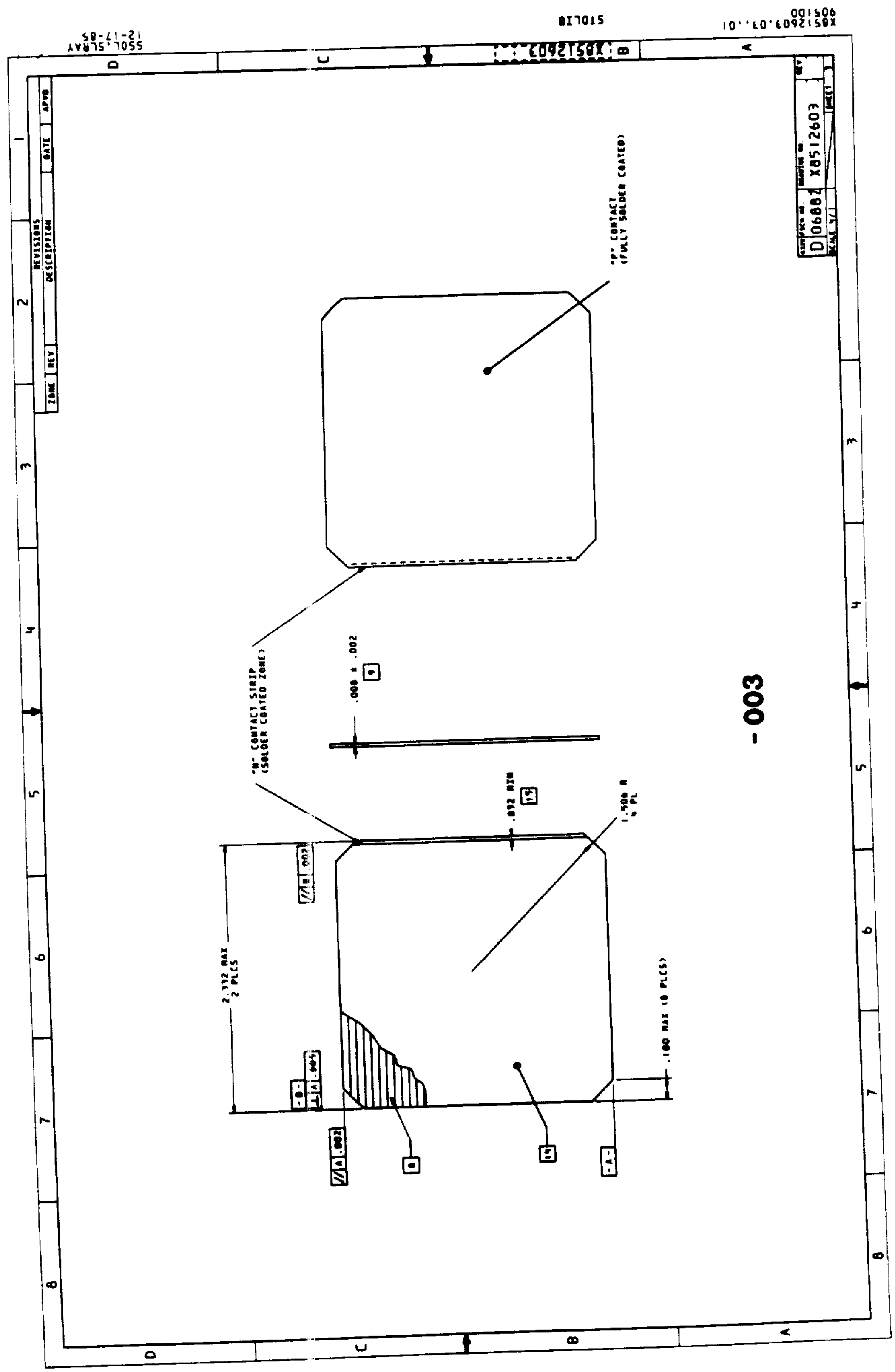

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LOCKHEED DATA				SUPPLIER DATA				
QUANTITY REQUIRED PER ASSEMBLY	PART NUMBER	NOMENCLATURE	SPECIFICATION	CODE IDENT	PART NUMBER	DRAWING NUMBER	NAME AND ADDRESS	NOTES
	X8519617-001	SOLAR CELL	NONE				SPECTROLAB, INC.	

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APVD

NOTES:

1 DOCUMENTATION AND CHANGE CONTROL REQUIREMENTS SHALL BE IN ACCORDANCE WITH THE PROCUREMENT DOCUMENT

2 PACKAGING AND PRESERVATION SHALL BE AS SPECIFIED IN THE PROCUREMENT DOCUMENT.

4 MAXIMUM WEIGHT: 550 GRAMS PER 100 ASSEMBLIES.

4 WHEN CHANGES ARE MADE TO PROCESS SPECIFICATIONS CONSIDERED TO BE VENDOR PROPRIETARY, THE VENDOR MUST ADVISE LMSC PROCUREMENT OF THE IMPACT OF ANY CONTEMPLATED CHANGE PRIOR TO THE CHANGE AND THE SERIAL OR LOT NUMBER ON WHICH THE CHANGE WILL BECOME EFFECTIVE.

5 MANUFACTURE IN ACCORDANCE WITH PROCESS SPECIFICATIONS LISTED IN NOTES. ANY DEVIATION MADE BY THE VENDOR TO THESE SPECIFICATIONS OR TO PREVIOUSLY APPROVED VENDOR SPECIFICATIONS SHALL BE REPORTED TO LMSC PROCUREMENT. APPROVAL OF ANY DEVIATION SHALL BE FORMALLY INDICATED BY LMSC ISSUANCE OF A NEW OR REVISED SPECIFICATION OR ENVELOPE DRAWING PRIOR TO THE ACCEPTANCE OF ANY HARDWARE MANUFACTURED IN CONFORMANCE WITH SUCH DEVIATION.

6 PART IDENTIFICATION PER MIL-STD-130. DO NOT MARK PARTS. PART IDENTIFICATION SHALL BE ON UNIT PACKAGES AND SHIPPING CONTAINERS ONLY. NO MORE THAN 40 SOLAR CELLS PER BOX. MARK LOT CODE AND CURRENT GROUP FOR EACH SOLAR CELL ON BOX.

$\boxed{7}$ GRID CONFIGURATION SHOWN IS FOR REFERENCE ONLY. GRID SHALL MINIMIZE TOTAL AREA AND TOTAL WEIGHT OF SILVER.

$\boxed{8}$ DIMENSION SHOWN IS THICKNESS OF THE SILICON ONLY.

9 CRACKED SOLAR CELLS SHALL BE CAUSE FOR REJECTION.

10 ACCEPTABLE LIMITS FOR COSMETIC DEFECTS:

A) EDGE CHIPS ON CELLS SHALL NOT EXCEED .030 INCHES IN DEPTH BY .150 INCHES IN LENGTH. CHIPS LESS THAN .005 INCHES IN DEPTH SHALL BE DISREGARDED.

B) CORNER CHIPS ON CELLS SHALL NOT EXCEED .080 INCHES ALONG THE HYPOTENUSE.

11 SHIPPING CONTAINERS SHALL BE MARKED, "NON-FLIGHT ITEM. OPEN SHIPPING CONTAINERS IN CLEAN ROOM ONLY."

$\boxed{12}$ AR COATING TO OPTIMIZE SOLAR CELL SHORT CIRCUIT CURRENT FOR AM0 OPERATON WITH DC 93-500 AS THE ADHESIVE FOR A MICROSHEET COVERSLIDE.

INTERPRET DWG PER MIL-D-1000 LEVEL 2 X8517163 -501 NEXT ASSY / USED ON APPLICATION	UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON: FRACTIONS ± 1/16 DECIMALS .X ± .1 .XX ± .03 .XXX ± .010 ANGLES ± 2 DEG CONTR CCA/CEI	DATE 85-06-18 DWN K.M. BILGER APVD APVD R. GIVEN ENGRG K.M. BILGER CHKR A. SAITZEW APVD APVD	LOCKHEED MISSILES & SPACE COMPANY, INC SUNNYVALE, CALIFORNIA SOLAR CELL ENVELOPE DRAWING SIZE D FSCM NO 06887 DRAWING NO X8519617 REV SCALE N/A SH 1 OF 2

62-16

SSOL;SLRAY 03-07-86

STOLIB

X8519617.01..01 9051D

VOLT ASSOLAR CELL ENV DWG, K.M.BILGER

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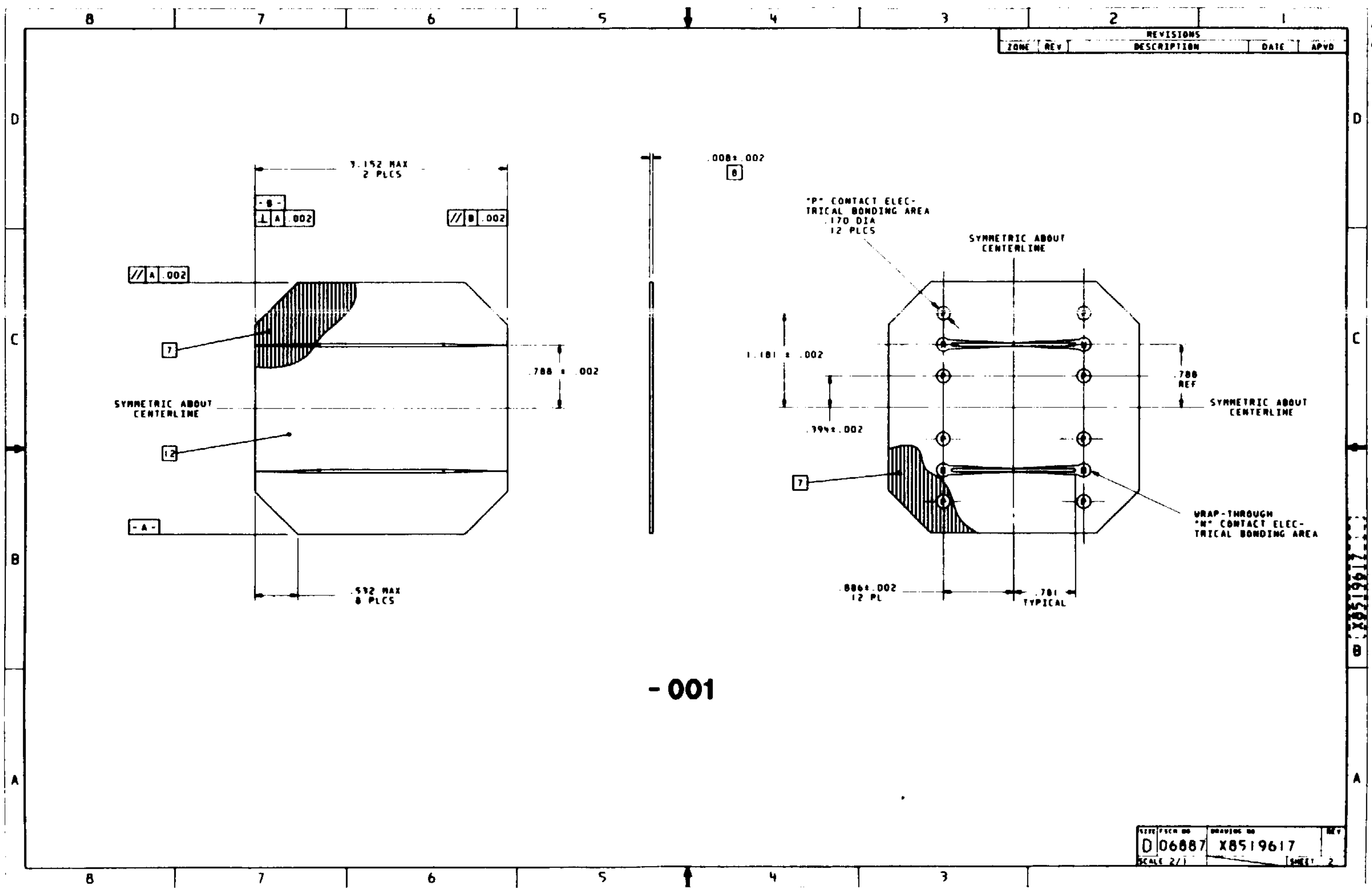

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VOLT ASSOLAR CELL ENV DWG. K.M.BILGER

76

LOCKHEED DATA					SUPPLIER DATA				
QUANTITY REQUIRED PER ASSEMBLY	PART NUMBER	NOMENCLATURE	SPECIFICATION		CODE IDENT	PART NUMBER	DRAWING NUMBER	NAME AND ADDRESS	NOTES
	X8512606-001	COVERSLIDE	7699272					PILKINGTON-PERKIN ELMER	
	X8512606-003	COVERSLIDE	7699272					PILKINGTON-PERKIN ELMER	

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APVD

NOTES:

1. DOCUMENTATION AND CHANGE CONTROL REQUIREMENTS SHALL BE IN ACCORDANCE WITH THE PROCUREMENT DOCUMENT.

2. SPECIFICATION LISTED IN LMSC DATA BLOCK ABOVE GOVERNS THE PROCUREMENT AND ACCEPTANCE OF THIS ITEM

3. PACKAGING AND PRESERVATION SHALL BE AS SPECIFIED IN THE PROCUREMENT DOCUMENT.

4. MAXIMUM WEIGHT: 120.0 GRAMS/100 COVERSLIDES

5. WHEN CHANGES ARE MADE TO PROCESS SPECIFICATIONS CONSIDERED TO BE VENDOR PROPRIETARY, THE VENDOR MUST ADVISE LMSC PROCUREMENT OF THE IMPACT OF ANY CONTEMPLATED CHANGE PRIOR TO THE CHANGE AND THE SERIAL OR LOT NUMBER ON WHICH THE CHANGE WILL BECOME EFFECTIVE.

6. MANUFACTURE IN ACCORDANCE WITH PROCESS SPECIFICATIONS LISTED IN LOCKHEED DATA BLOCK ABOVE OR IN NOTES. ANY DEVIATION MADE BY THE VENDOR TO THESE SPECIFICATIONS OR TO PREVIOUSLY APPROVED VENDOR SPECIFICATIONS SHALL BE REPORTED TO LMSC PROCUREMENT. APPROVAL OF ANY DEVIATION SHALL BE FORMALLY INDICATED BY LMSC ISSUANCE OF A NEW OR REVISED SPECIFICATION OR ENVELOPE DRAWING PRIOR TO ACCEPTANCE OF ANY HARDWARE MANUFACTURED IN CONFORMANCE WITH SUCH DEVIATION.

7. MATERIAL: CERIUM DIOXIDE MICROGLASS.

8. SURFACE FINISH: POLISHED.

$\boxed{9}$ ANTI-REFLECTIVE (AR) COATING: MAGNESIUM FLUORIDE

$\boxed{10}$ DYKEM STAIN AREA MARKING FOR PART IDENTIFICATION AND TO IDENTIFY SURFACES. WITH MARKING IN POSITION SHOWN. THE ANTI-REFLECTIVE COATING IS ON THE UPPER SURFACE.

11. IDENTIFICATION SHALL BE PER MIL-STD-130. DO NOT MARK ON PART.

12. BULK MATERIAL CUT-ON: 350 ± 15 NM

13. NORMAL EMISSIVITY: .82 MINIMUM

INTERPRET DWG. PER MIL-D-1000 LEVEL 2

NEXT ASSY	USED ON
X8512610	
-501	
-503	

APPLICATION

UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON: FRACTIONS = ± 1/16 DECIMALS: .X = ± .1 .XX = ± .03 .XXX = ± .010 ANGLES = ± 2 DEG

CONTR

CCA/CEI

DATE 85-06-17
DWN K.M. BILGER
APVD
APVD R.GIVEN
ENGRG K.M.BILGER
CHKR A. SAITZEW
APVD
APVD

LOCKHEED MISSILES & SPACE COMPANY, INC. SUNNYVALE, CALIFORNIA

COVERSLIDE ENVELOPE DRAWING

SIZE	FSCM NO.	DRAWING NO.	REV
D	06887	X8512606	

SCALE N/A SH 1 OF 2

62-16

SSOL.SLRAY 01-29-86

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VOLT ASCOVERSLIDE ENV DWG, K.M.BILGER

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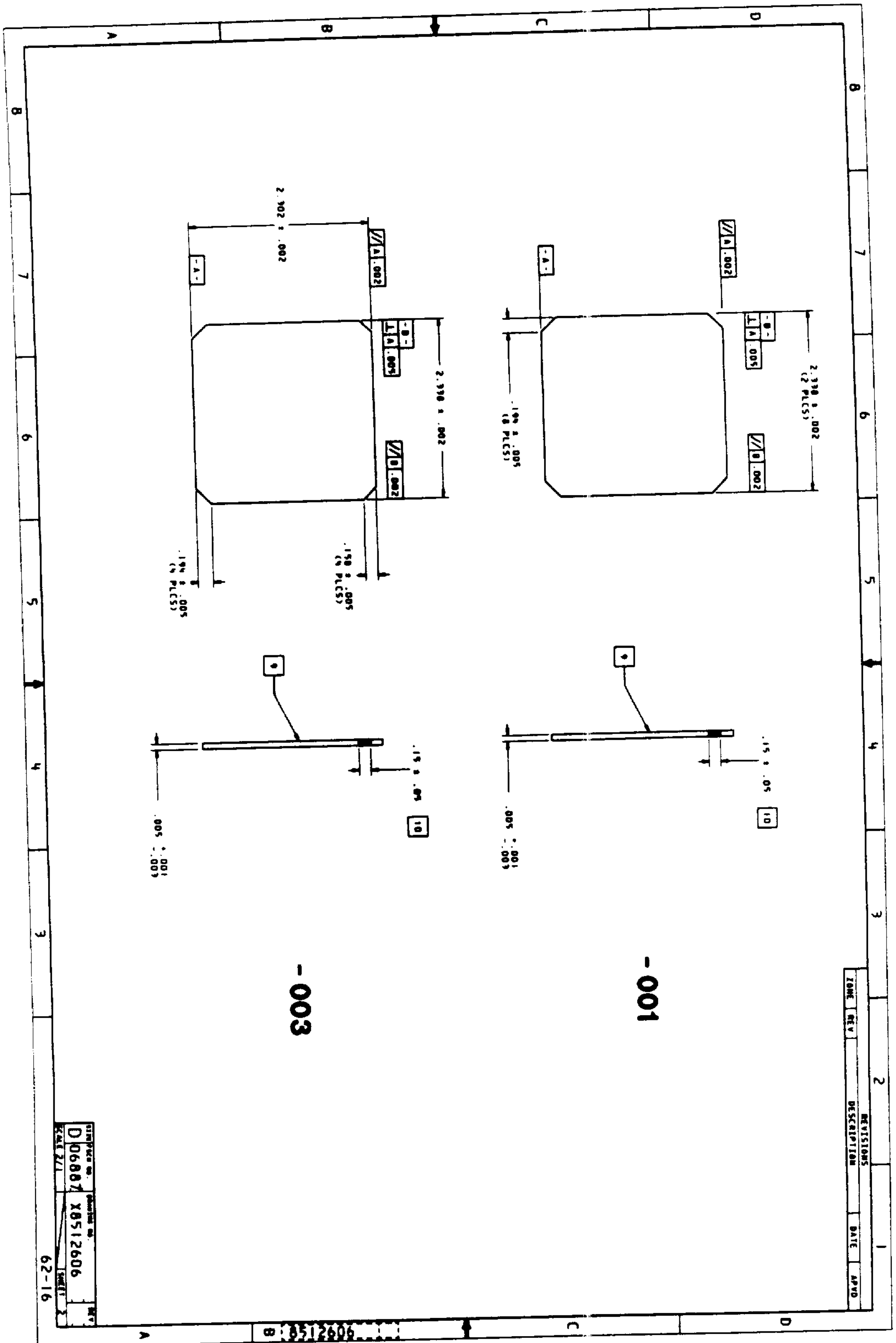

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STOLIB

SSOL.SLRAY
12-17-85

VOLT ASCOVERSLIDE ENV DWG. K M BILGER

30

SSOL.SLRAY
03-07-86

LOCKHEED DATA				SUPPLIER DATA				
QUANTITY REQUIRED PER ASSEMBLY	PART NUMBER	NOMENCLATURE	SPECIFICATION	CODE IDENT	PART NUMBER	DRAWING NUMBER	NAME AND ADDRESS	NOTES
	X8519619-001	SUPERSTRATE	NONE				CORNING GLASS	

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APVD

NOTES:

1. DOCUMENTATION AND CHANGE CONTROL REQUIREMENTS SHALL BE IN ACCORDANCE WITH THE PROCUREMENT DOCUMENT.

2. SPECIFICATION LISTED IN LMSC DATA BLOCK ABOVE GOVERNS THE PROCUREMENT AND ACCEPTANCE OF THIS ITEM

3. PACKAGING AND PRESERVATION SHALL BE AS SPECIFIED IN THE PROCUREMENT DOCUMENT.

4. MAXIMUM WEIGHT: TBD

5. WHEN CHANGES ARE MADE TO PROCESS SPECIFICATIONS CONSIDERED TO BE VENDOR PROPRIETARY, THE VENDOR MUST ADVISE LMSC PROCUREMENT OF THE IMPACT OF ANY CONTEMPLATED CHANGE PRIOR TO THE CHANGE AND THE SERIAL OR LOT NUMBER ON WHICH THE CHANGE WILL BECOME EFFECTIVE.

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7. MATERIAL: CERIUM DIOXIDE MICROGLASS.

8. SURFACE FINISH: POLISHED.

$\boxed{9}$ ANTI-REFLECTIVE (AR) COATING: NONE

10. IDENTIFICATION SHALL BE PER MIL-STD-130. DO NOT MARK ON PART.

11. BULK MATERIAL CUT-ON: 350 ± 15 NM

12. NORMAL EMISSIVITY: .82 MINIMUM

X8519619

STOLIB

INTERPRET DWG PER MIL-D-1000 LEVEL 2	UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES TOLERANCES ON: FRACTIONS ± 1/16 DECIMALS .X ± .1 .XX ± .03 .XXX ± .010 ANGLES ± 2 DEG	DATE 85-06-17	LOCKHEED MISSILES & SPACE COMPANY, INC SUNNYVALE, CALIFORNIA
X8517166 -501	CONTR	DWN K.M. BILGER	SUPERSTRATE ENVELOPE DRAWING
NEXT ASSY / USED ON	CCA/CEI	APVD	SIZE D FSCM NO 06887 DRAWING NO X8519619 REV
APPLICATION		APVD R. GIVEN	SCALE N/A SH 1 OF 2
		ENGRG K.M. BILGER	
		CHKR A. SAITZEW	
		APVD	
		APVD	

62-16

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VOLT ASSUPERSTRATE ENV DWG, K.M.BILGER

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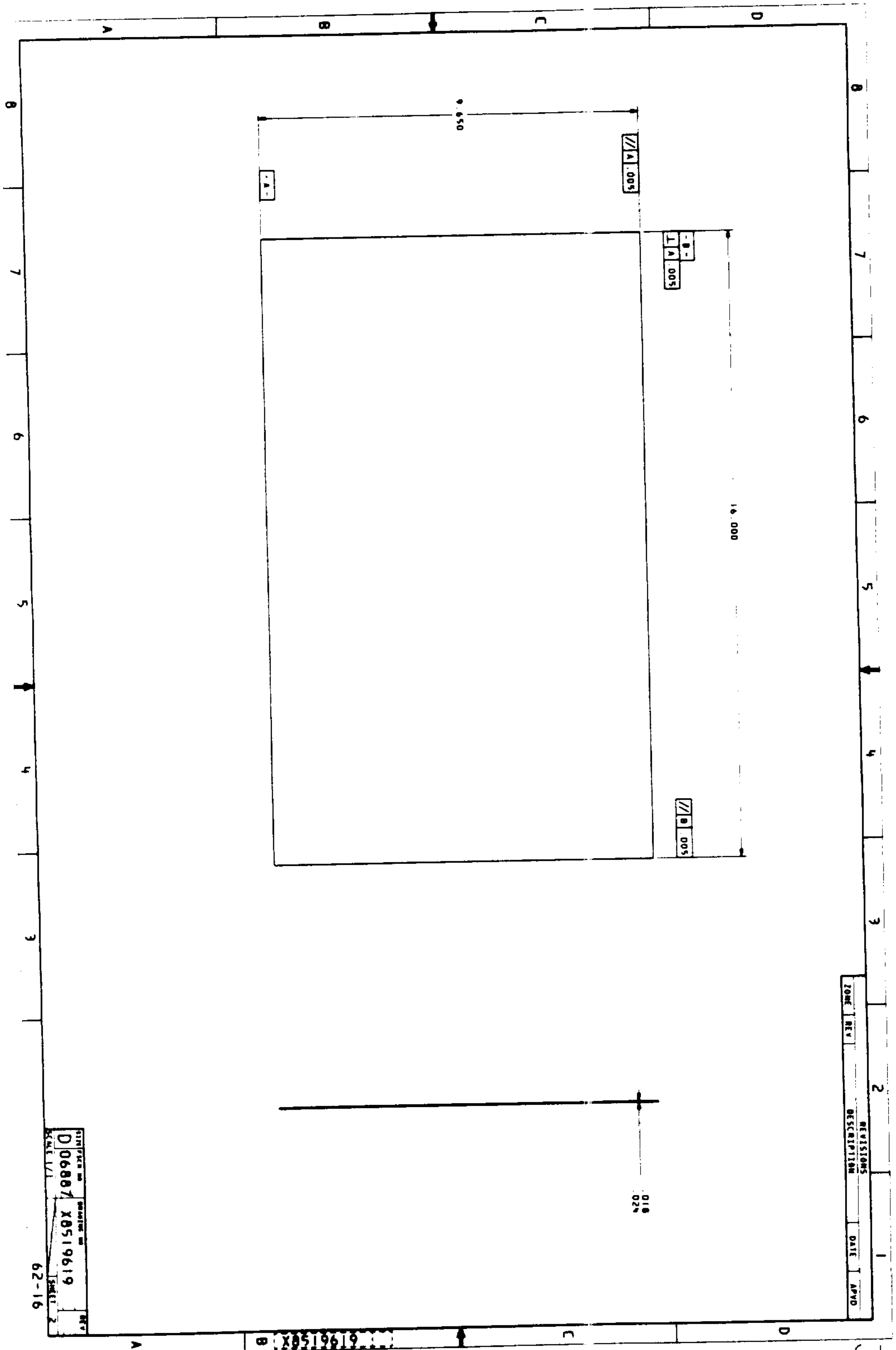

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SSOL.SLRAY
03-07-86

VOLT ASSUPERSTRATE ENV DWG. K M BILGER

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Quantity required per assembly: 503	Quantity required per assembly: 501	Lockheed data: Part number	Lockheed data: Nomenclature	Lockheed data: Specification	Supplier data: Code ident	Supplier data: Part number	Supplier data: Drawing number	Supplier data: Name and address	Supplier data: Notes
	1	X8512603-001	SOLAR CELL	7699230	11536			APPLIED SOLAR ENERGY CORP.	
	1	X8512606-001	COVERSLIDE	7699272				PILKINGTON PERKIN ELMER	10
1		X8512603-003	SOLAR CELL	8501489	11536			APPLIED SOLAR ENERGY CORP.	
1		X8512606-003	COVERSLIDE	7699272				PILKINGTON PERKIN ELMER	10

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APVD

NOTES

1. DOCUMENTATION AND CHANGE CONTROL REQUIREMENTS SHALL BE IN ACCORDANCE WITH THE PROCUREMENT DOCUMENT.

2. SPECIFICATION LISTED IN LOCKHEED DATA BLOCK ABOVE GOVERNS THE PROCUREMENT AND ACCEPTANCE OF THIS ITEM.

3. PACKAGING AND PRESERVATION SHALL BE AS SPECIFIED IN THE PROCUREMENT DOCUMENT.

4. MAXIMUM WEIGHT: 450 GRAMS PER 100 ASSEMBLIES.

5. WHEN CHANGES ARE MADE TO PROCESS SPECIFICATIONS CONSIDERED TO BE VENDOR PROPRIETARY, THE VENDOR MUST ADVISE LMSC PROCUREMENT OF THE IMPACT OF ANY CONTEMPLATED CHANGE PRIOR TO THE CHANGE AND THE SERIAL OR LOT NUMBER ON WHICH THE CHANGE WILL BECOME EFFECTIVE.

6. MANUFACTURE IN ACCORDANCE WITH PROCESS SPECIFICATIONS LISTED IN LOCKHEED DATA BLOCK ABOVE OR IN NOTES. ANY DEVIATION MADE BY THE VENDOR TO THESE SPECIFICATIONS OR TO PREVIOUSLY APPROVED VENDOR SPECIFICATIONS SHALL BE REPORTED TO LMSC PROCUREMENT. APPROVAL OF ANY DEVIATION SHALL BE FORMALLY INDICATED BY LMSC ISSUANCE OF A NEW OR REVISED SPECIFICATION OR ENVELOPE DRAWING PRIOR TO ACCEPTANCE OF ANY HARDWARE MANUFACTURED IN CONFORMANCE WITH SUCH DEVIATION.

7. ASSEMBLY IDENTIFICATION PER MIL-STD-130. DO NOT MARK ASSEMBLIES. ASSEMBLY IDENTIFICATION SHALL BE ON UNIT PACKAGES AND SHIPPING CONTAINERS ONLY.

[8] GRID CONFIGURATION SHOWN IS FOR REFERENCE ONLY AND DOES NOT NECESSARILY REPRESENT THE ACTUAL GRID CONFIGURATION.

[9] DIMENSION SHOWN IS THICKNESS OF THE SILICON ONLY.

[10] TO BE FURNISHED BY LMSC.

[11] COVERGLASS MUST COMPLETELY COVER THE SOLAR CELL EDGES AS SHOWN.

12. THE FOLLOWING DEFECTS SHALL BE CAUSE FOR REJECTION:
   A) CRACKED COVERSLIDE.
   B) CRACKED SOLAR CELL.

13. ACCEPTABLE LIMITS FOR COSMETIC DEFECTS:
   A) ADHESIVE BUBBLES SHALL NOT EXCEED .050 INCHES IN DIAMETER OR EQUIVALENT AREA. THERE SHALL BE NO MORE THAN TEN BUBBLES PER ASSEMBLY. BUBBLES SMALLER THAN .005 INCHES IN DIAMETER SHALL BE DISREGARDED.
   B) EDGE VOIDS OR PULL-OUT IN THE ADHESIVE SHALL NOT EXCEED .025 INCHES IN DEPTH FROM THE EDGE OF CELL OR COVERSLIDE. LENGTH OF EDGE VOID OR PULL-OUT SHALL NOT BE CONSIDERED REASON FOR REJECTION.
   C) DELAMINATION SHALL NOT EXCEED AN AREA GREATER THAN .015 SQUARE INCHES PER ASSEMBLY.
   D) EDGE CHIPS ON CELLS AND COVERSLIDES SHALL NOT EXCEED .030 INCHES IN DEPTH BY .150 INCHES IN LENGTH. CHIPS LESS THAN .005 INCHES IN DEPTH SHALL BE DISREGARDED.
   E) CORNER CHIPS ON CELLS AND COVERSLIDES SHALL NOT EXCEED .080 INCHES ALONG THE HYPOTENUSE.

[14] DYKEM STAIN MARK. (REF)

15. FILTERED ASSEMBLIES SHALL PROVIDE A MINIMUM ELECTRICAL CONVERSION EFFICIENCY OF 11.5% AT 1 AMO-25 DEGREES CELCIUS. THE AVG CELL SHIPPING LOT EFFICIENCY SHALL BE A MINIMUM OF 12%. ELECTRICAL I-V CHARACTERISTICS SHALL BE INCLUDED FOR EACH CELL. CELL ASSEMBLIES SHALL BE CURRENT GROUPED @ 485 MV. IT IS PERMISSIBLE TO MIX CURRENT GROUPS WITHIN A SHIPPING CONTAINER

[16] THE AREAS SHOWN SHALL BE FREE OF ANY ADHESIVE RESIDUE SUCH THAT SUBSEQUENT ASSEMBLY SOLDERING WILL NOT BE INHIBITED.

[17] "N" CONTACT SURFACE SHALL PROVIDE A MINIMUM SOLDERABLE WIDTH OF 0.020 IN.

[18] COVERSLIDE SHALL OVERLAP "N" CONTACT SOLDER BY 0.001 IN. MINIMUM

NEXT ASSY	USED ON
X8517162	
-501	
X8512164	
-501	
APPLICATION	

INTERPRET DWG PER DOD-D-1000, LEVEL 2

UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES. TOLERANCES ON: FRACTIONS = ± 1/16; DECIMALS: .X = ± .1; .XX = ± .03; .XXX = ± .010; ANGLES = ± 2 DEG.

CONTR

CCA/CEI

DATE 85-02-18
DRN K. M. BILGER
APVD
APVD R. W. GIVEN
ENGRG
CHKR A SAITZEW
APVD K. M. BILGER
APVD

LOCKHEED MISSILES & SPACE COMPANY, INC. SUNNYVALE, CALIFORNIA

SOLAR CELL ASSEMBLY ENVELOPE DRAWING

SIZE D | FSCM NO. 06887 | DRAWING NO. X8512610 | REV

SCALE N/A | SH 1 OF 3

EJRT XXX-XXXXX-XXX-XXX

62-16

X8512610.01..01

SSOL.SLRAY 01-29-86

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VOLT ASCELL ASSY ENV DWG. K.M.BILGER.62-16

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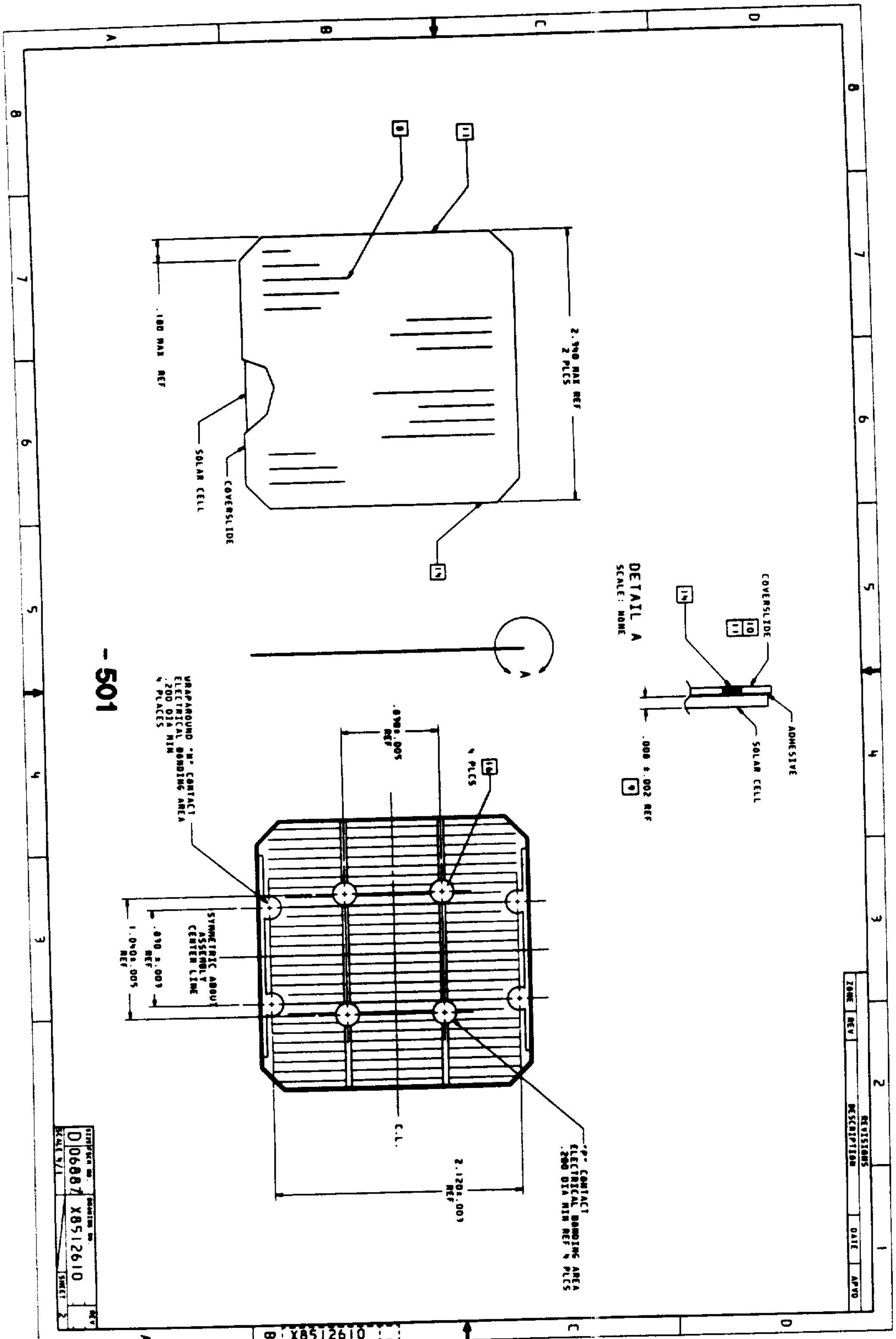

SSOL.SLRAY
12-17-85

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VOLT ASCELL ASSY ENV DWG. K.H.BILGER.62-16

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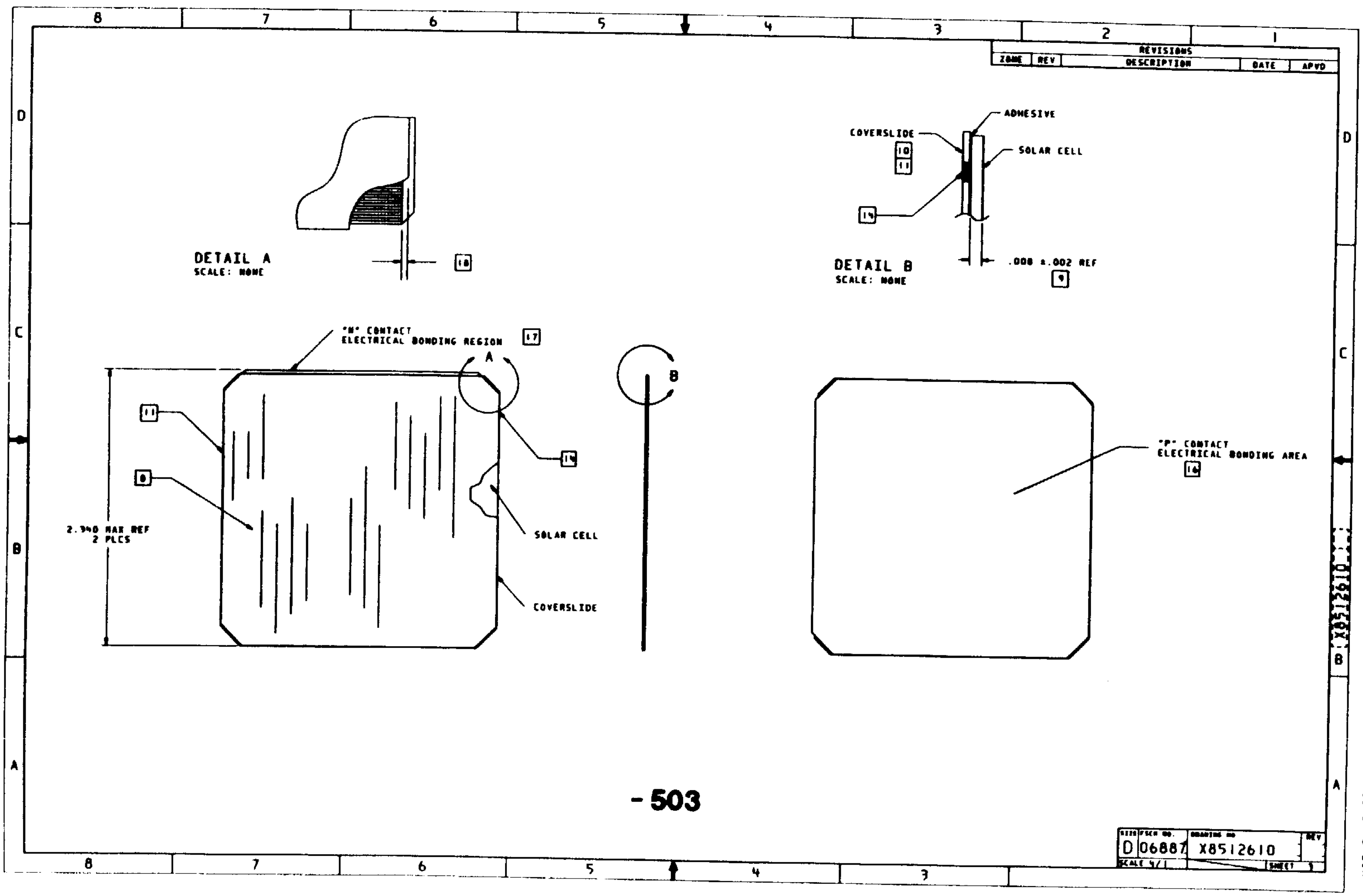

SSOL,SLRAY
12-17-85

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VOLT ASCELL ASSY ENV DWG, K.M.BILGER,62-16

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TITLE	DESIGN ORGN	DATE	PAGE	OF	CFE	CUL		REV
EPOXY BOARD, VOLT A PROJECT	5216	85 OCT 29	1				PL X4512608	-

CONTRACT NUMBER	AUTHORITY	FSCM NO	CCA/CI NO.
VARIOUS	SBM-DAPSL-0001-01	06887	

ENGINEERING PARTS LIST

QUANTITY PER ASSEMBLY: 001

ITEM NO	LOCATION SH	LOCATION ZONE	QUANTITY PER ASSEMBLY 001	UNIT OF MEAS	FSCM NO.	PART/DOCUMENT NUMBER	SEQ NO	CCA/CI NO IDENT	DESCRIPTION	LC	REFERENCE DESIGNATION/ MATERIAL/NOTES	NOTE ITEM NO
200			AR			LAC22-4718-1531			CLOTH, GLASS		.009 THICK	
400			X			1421331			STD PRACTICES		DWG PRAC&STD DEF	
500			X			LAC1001			PKG/HDLG SPEC		PROTECT PER	
501			X			LAC3603-080000			FAB PARTS		FAB PER	
502			X			LAC3575-011998			MARKING METHOD		MARK PART NO. PER	

NOTE NO. NOTE TEXT

*K NOTE LINE INDICATORS (A, B, C, ETC.) ARE NO LONGER REQUIRED AND HAVE BEEN REMOVED

001 ALL LAYERS OF GLASS FABRIC SHOULD BE ORIENTED IN THE WARP DIRECTION SHOWN.

84

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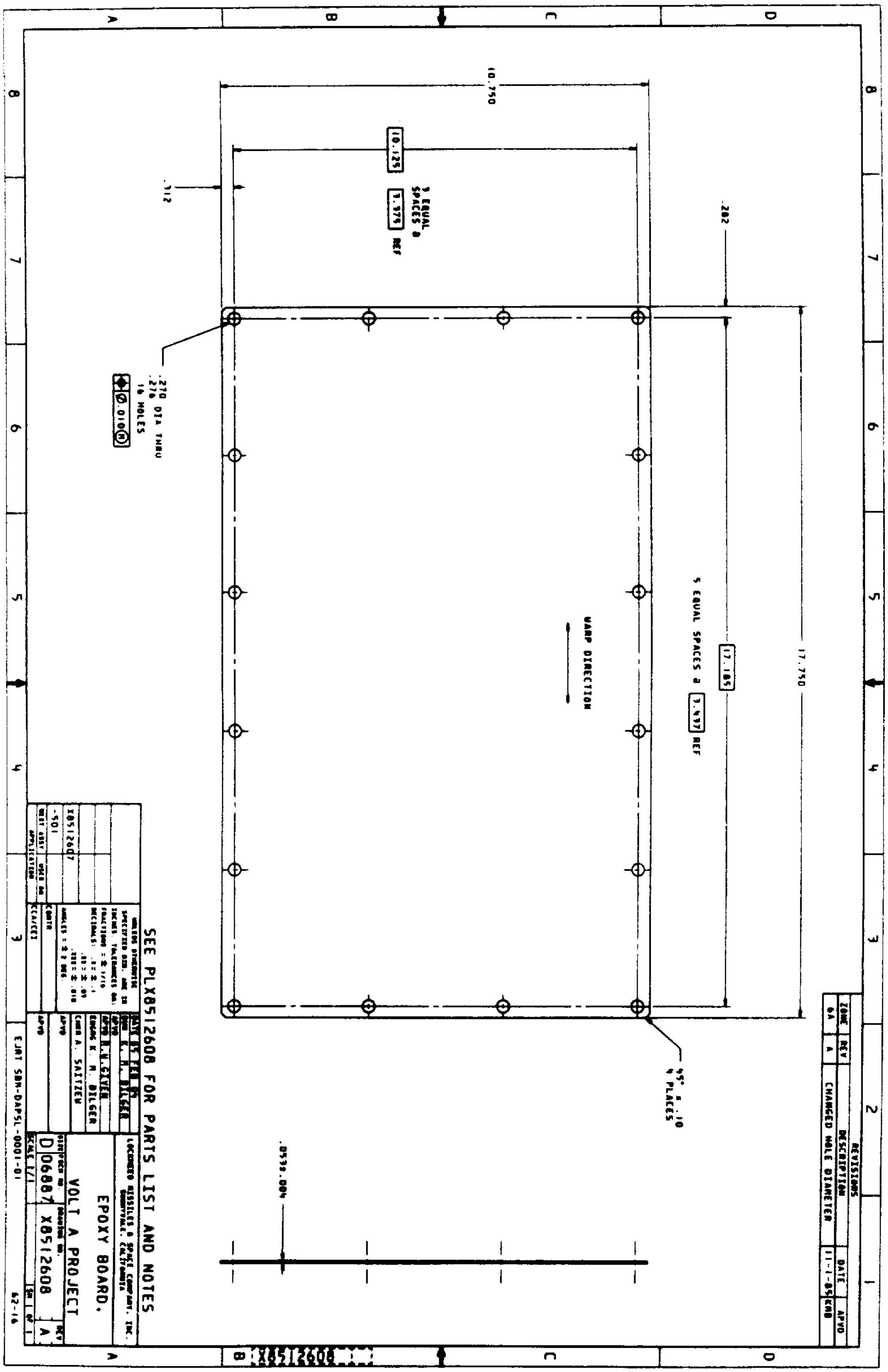
PREPARED BY	DATE	APPROVAL	DATE	APPROVAL	DATE
Kevin M Bilger	85-10-29				
CHECKED BY A. Saltzer	85-10-29				

FORM LMSC 2542 F-10 ABBREVIATIONS LC = LIFE CODE SEQ NO = SEQUENCE NUMBER ORGN = ORGANIZATION

LOCKHEED MISSILES & SPACE COMPANY INC



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STDLIB

SSOL.SLRAY
12-17-85

VOLT A PROJECT. K. M .BILGER. 62-16

TITLE	DESIGN ORGN	DATE	PAGE	OF	CFE	CUL	PL	REV
ALUMINUM PLATE, VOLT A PROJECT	6216	86 FEB 06	1				X8512609	B

CONTRACT NUMBER	AUTHORITY	FSCM NO.	CCA/CI NO.
VARIOUS	SBM-DAPSL-0001-01	06887	

ENGINEERING PARTS LIST

ITEM NO	LOCATION SH	LOCATION ZONE	QUANTITY PER ASSEMBLY 001	501	UNIT OF MEAS	FSCM NO.	PART/DOCUMENT NUMBER	SEQ. NO.	CCA/CI NO. IDENT	DESCRIPTION	LC	REFERENCE DESIGNATION/ MATERIAL/NOTES	NOTE ITEM NO.
001				1			X8512609-001			AL PLATE			
200			AR			81348	QQA250/11			AL ALLOY		.500 THK PLATE 6061-T651	
201				16			NAS1394C3S			INSERT			
202			X			81349	MILC81706			CHEM FILM		CLASS 3, FORM II METHOD B OR C	N02
400			X	X			1421331			STD PRACTICES		DWG PRAC&STD DEF	
500			X	X			LAC1001			PKG/HDLG SPEC		PROTECT PER	N04
501			X			81349	MILC5541			CHEM FILM		CLASS 3	N02
503			X				LAC3601			DIM/TOL MACH		MACHINE PER	
504				X			DS8938-4A			DESIGN STANDARD		INSTL PER	
505			X	X			LAC3575-011998			MARKING METHOD		MARK PART NO. PER	

NOTE NO. NOTE TEXT — STD NOTE

QK NOTE LINE INDICATORS (A, B, C, ETC.) ARE NO LONGER REQUIRED AND HAVE BEEN REMOVED

001 HEAT TREAT FOR 8-10 HOURS AT 450 DEG F BEFORE MACHINING.

002 LOCAL NOTE: AFTER TAPPING, BUT BEFORE INSTALLING INSERTS, PROTECTIVE TREAT ALL SURFACES PER ITEM 501, MATERIAL PER ITEM 202. AFTER COATING HANDLE WITH CLEAN LINT-FREE GLOVES AT ALL TIMES.

003 PACKAGE IN MATERIAL FREE OF OILS AND FOREIGN MATERIALS PER ITEM 500.

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Kevin M. Bilger	86-02-06				
CHECKED BY [illegible]	86-02-06				

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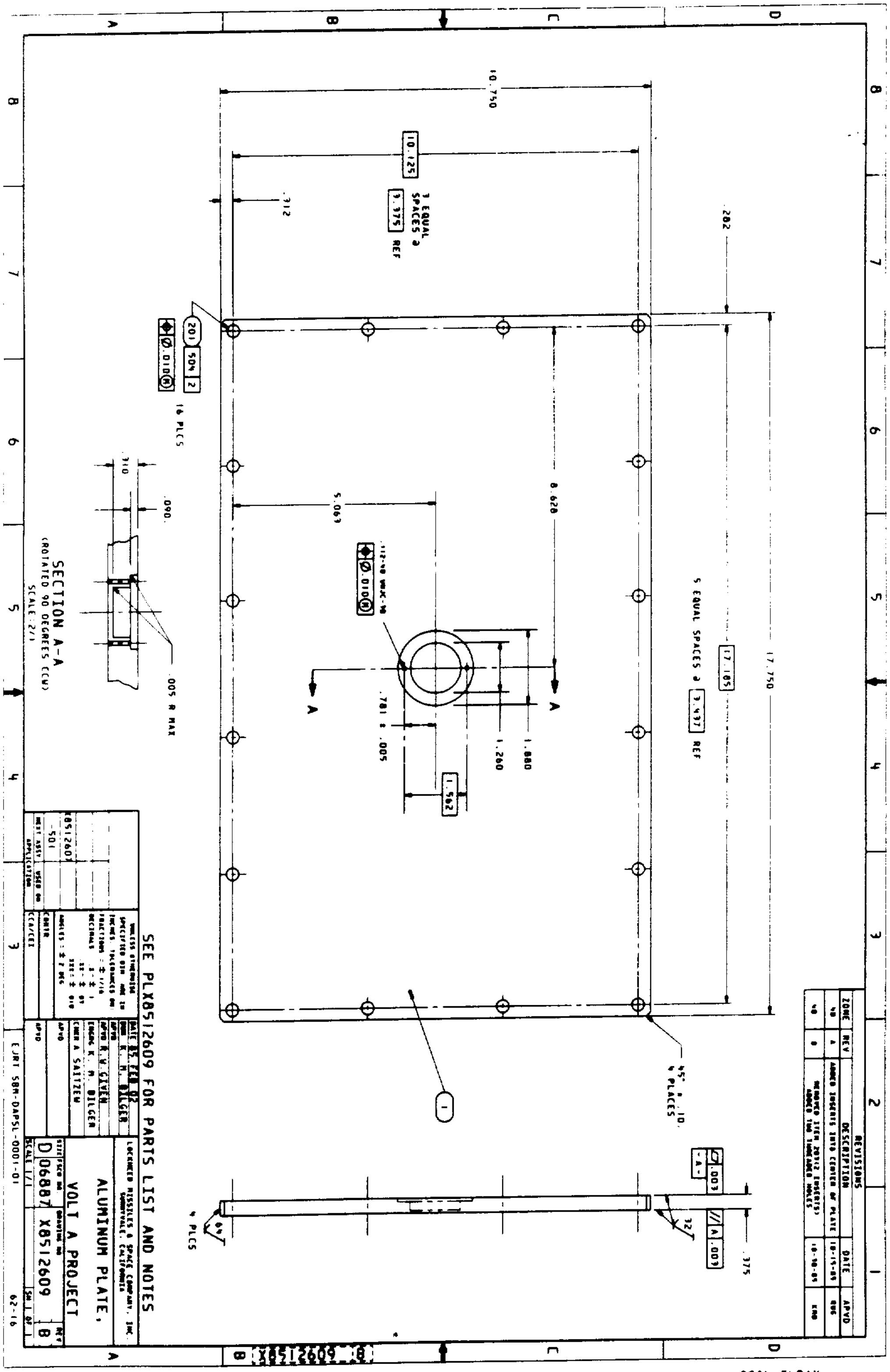

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STDLIB

SSOL.SLRAY
02-05-86

VOLT A PROJECT. K. M .BILGER, 62-16

TITLE	DESIGN ORGN	DATE	PAGE	OF	CFE	CUL		REV
ALUMINUM PLATE ASSY VOLT A PROJECT	6216	85 NOV 20	1				PL X8512607	-

CONTRACT NUMBER	AUTHORITY	FSCM NO	CCA/CI NO.
VARIOUS	SBM-DAPSL-0001-01	06887	

ENGINEERING PARTS LIST

ITEM NO	LOCATION SH	LOCATION ZONE	QUANTITY PER ASSEMBLY 501	UNIT OF MEAS	FSCM NO.	PART/DOCUMENT NUMBER	SEQ NO	CCA/CI NO. IDENT	DESCRIPTION	LC	REFERENCE DESIGNATION/ MATERIAL/NOTES	NOTE ITEM NO.
001			1			X8512609-001			AL PLATE			N01
002			1			X8512608-001			EPOXY BOARD			N01
200			AR			LAC30-4666-0100			ADHESIVE FILM		.30 LB/SQ FT .005 THICK	N01
201			AR			LAC30-4666-0200			PRIMER,LIQUID			
400			X			1421331			STD PRACTICES		DWG PRAC&STD DEF	
500			X			LAC1001			PKG/HDLG SPEC		PROTECT PER	
501			X			LAC3575-019993			MARKING METHOD		MARK PER	
502			X			LAC0170-010000			SOLVENT CLEAN		SOLVENT CLEAN	
503			X			LAC3315-010000			HNYCMB PNL FAB		BOND PER	

NOTE NO. NOTE TEXT

STD NOTE

24 NOTE LINE INDICATORS (A, B, C, ETC.) ARE NO LONGER REQUIRED AND HAVE BEEN REMOVED

88 001 LOCAL NOTE: USE DRILL HOLES PRIOR TO AND DURING ADHESIVE (ITEM 200) CURING TO ALIGN ITEM 001 WITH ITEM 002.

002 LOCAL NOTE: BOND ITEM 2 (EPOXY BOARD) TO ITEM 1 (ALUMINUM PLATE) USING ITEM 200 (ADHESIVE) AND ITEM 201 (PRIMER) AS FOLLOWS:

1. LIGHTLY SCUFF SAND FIBERGLASS/EPOXY BOARD LAMINATE (ITEM 002) ON SURFACE TO BE BONDED USING #400 GRIT SAND PAPER.
2. SOLVENT WIPE ALL SURFACES TO BE BONDED PER ITEM 503 USING ACETONE ONLY.
4. APPLY TWO LAYERS OF ADHESIVE FILM
5. VACUUM BAG AND AUTOCLAVE CURE PER ITEM 504 EXCEPT AS FOLLOWS:
   A. APPLY VACUUM OF 22 INCHES OF HG MINIMUM
   B. APPLY PRESSURE OF 20 +/- PSI AND VENT VACUUM
   C. HEAT TO 250 +/- 10 DEGREES F IN 30-60 MINUTES
   D. HOLD AT 250 +/- 10 DEGREES F FOR 60 MINUTES
   E. COOL AT 10 DEGREES F PER MINUTE MAX TO 200 DEGREES F OR LESS PRIOR TO PRESSURE RELEASE.

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PREPARED BY	DATE	APPROVAL	DATE	APPROVAL	DATE
Kevin M Bilger	11-21-85				
CHECKED BY A. Saltzer	DATE 85-11-25	APPROVAL	DATE	APPROVAL	DATE

FORM LMSC 2542 F 10 ABBREVIATIONS LC = LIFE CODE SEQ NO = SEQUENCE NUMBER ORGN = ORGANIZATION

LOCKHEED MISSILES & SPACE COMPANY, INC.

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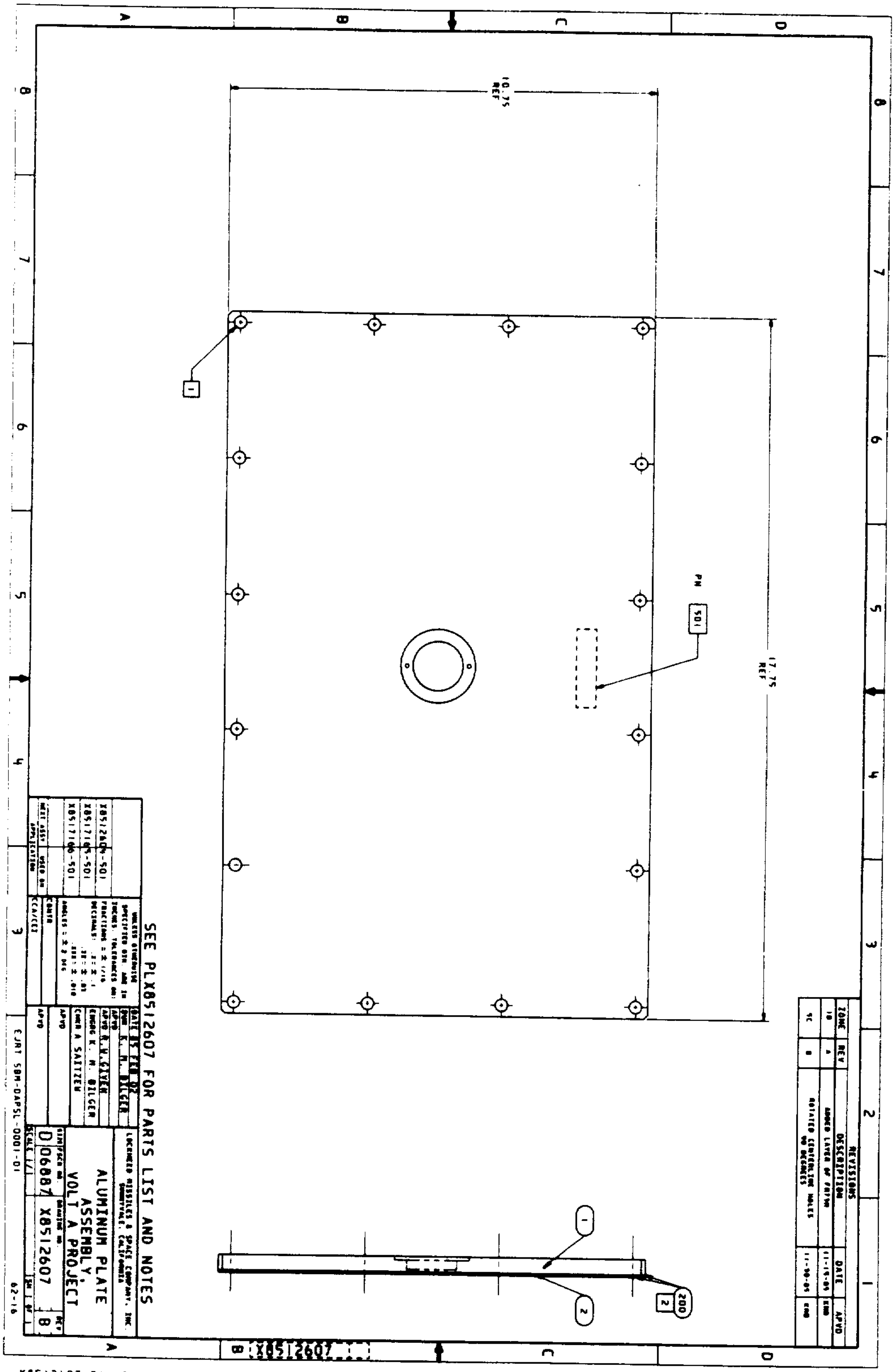

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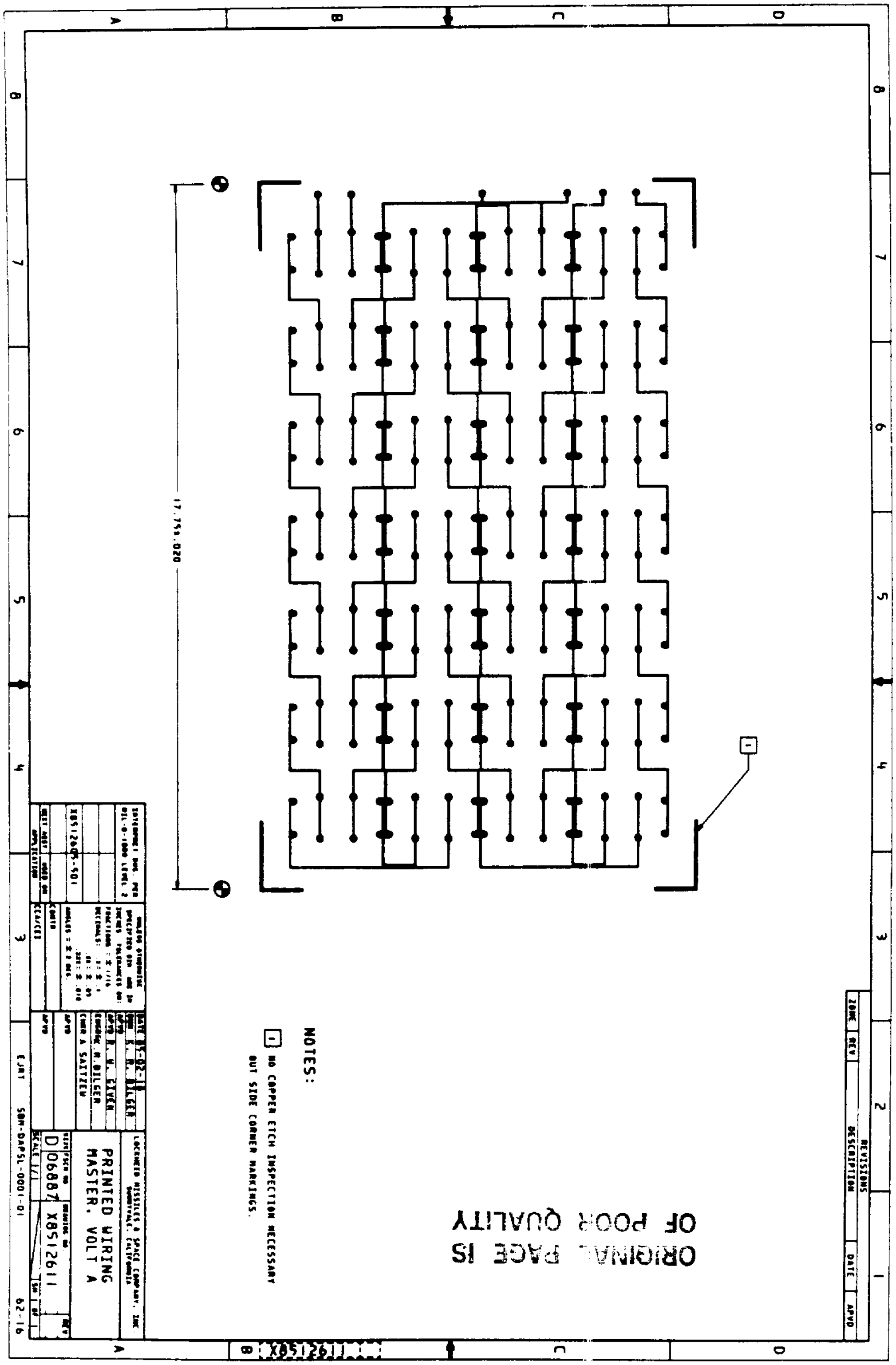
SSOL.SLRAY
01-29-86

VOLT A PROJECT. K. M .BILGER. 62-16



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SSOL.SLRAY
12-17-85

VOLT A PROJECT K M BILGER . 62-16

TITLE	DESIGN ORGN	DATE	PAGE	OF	CFE	CUL	PL	REV
CIRCUIT ASSEMBLY, VOLT A	0216	85 OCT 16	1				X8512505	-

CONTRACT NUMBER	AUTHORITY	FSCM NO.	CCA/CI NO.
VARIOUS	SBM-DAPSL-0001-01	06887	

ENGINEERING PARTS LIST

ITEM NO	LOCATION SH	LOCATION ZONE	QUANTITY PER ASSEMBLY 001	003	501	UNIT OF MEAS	FSCM NO.	PART/DOCUMENT NUMBER	SEQ NO.	CCA/CI NO. IDENT	DESCRIPTION	LC	REFERENCE DESIGNATION/ MATERIAL/NOTES	NOTE ITEM NO
001					1			X8512505-001			INSULATOR			
002					1			X8512505-003			COPPER INTCON			
200			AR					LAC22-4743-1211			POLYIMIDE FILM		0.0015 THK X 12W	
201				AR				IPCCF1-0CF8718			COPPER FOIL		0.0014 THK X 12W	
400			X	X	X			1421371			STD PRACTICES		DWG PRAC&STD DEF	
401					X			X8512511-001			PRNTD WIR MSTR			N01
501					X			LAC3266-010000			FLEX CIRCUITS			
502			X	X	X			LAC1001			PKG/HDLG SPEC		PROTECT PER	

NOTE NO.	NOTE TEXT	STD NOTE
QK	NOTE LINE INDICATORS (A, B, C, ETC.) ARE NO LONGER REQUIRED AND HAVE BEEN REMOVED	
001	LOCAL NOTE: INTERCONNECT OUTLINE TO BE ESTABLISHED BY ITEM 401.	
002	LOCAL NOTE: ITEM 1 (INSULATOR) MUST COMPLETELY OVERHANG ITEM 2 (COPER INTERCONNECT) EVERYWHERE.	

16

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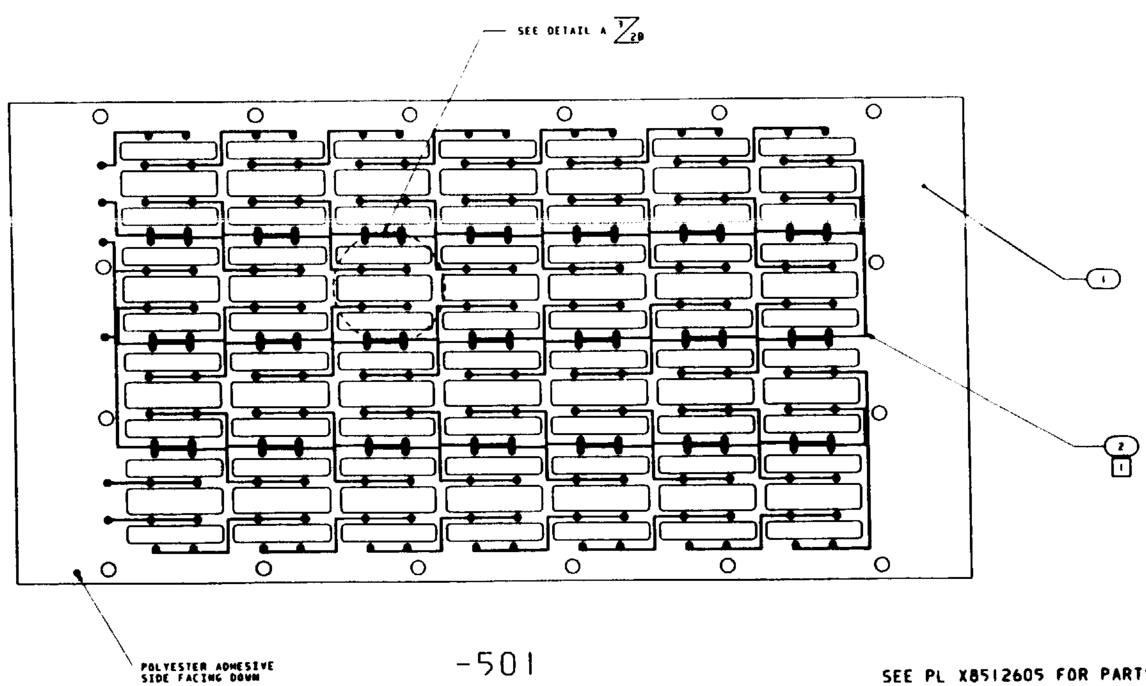
PREPARED BY	DATE	APPROVAL	DATE	APPROVAL	DATE
Kevin M Bilger	85-10-30				
CHECKED BY: A. Saitzew	85-10-30				

FORM LMSC 2532 F | ABBREVIATIONS: LC = LIFE CODE SEQ NO = SEQUENCE NUMBER ORGN = ORGANIZATION

LOCKHEED MISSILES & SPACE COMPANY, INC



-501

SEE PL X8512605 FOR PARTS LIST AND NOTES

INTERPRET DWG. PER MIL-D-1000 LEVEL 2	UNLESS OTHERWISE SPECIFIED DIM. ARE IN INCHES TOLERANCES ON FRACTIONS ± 1/16 DECIMALS .X ± .1 .XX ± .01 .XXX ± .010 ANGLES ± 2 DEG	DATE 85-02-18 DWN K. M. BILGER APVD APVD R. W. GIVEN ENGRG CHKR A. SAITZEW APVD K. M. BILGER APVD	LOCKHEED MISSILES & SPACE COMPANY, INC SUNNYVALE, CALIFORNIA
X8517162 -501 NEXT ASSY / USED ON APPLICATION	CONTR CCA/CCE		CIRCUIT ASSEMBLY VOLT A
			SIZE D FSCM NO 06887 DRAWING NO X8512605 REV SCALE 1/1 SH 1 OF 3

62-16

5501,SLRAY 12-18-85

X8512605

STDLIB

X8512605.01..01 90510

VOLT A PROJECT K M BILGER . 62-16

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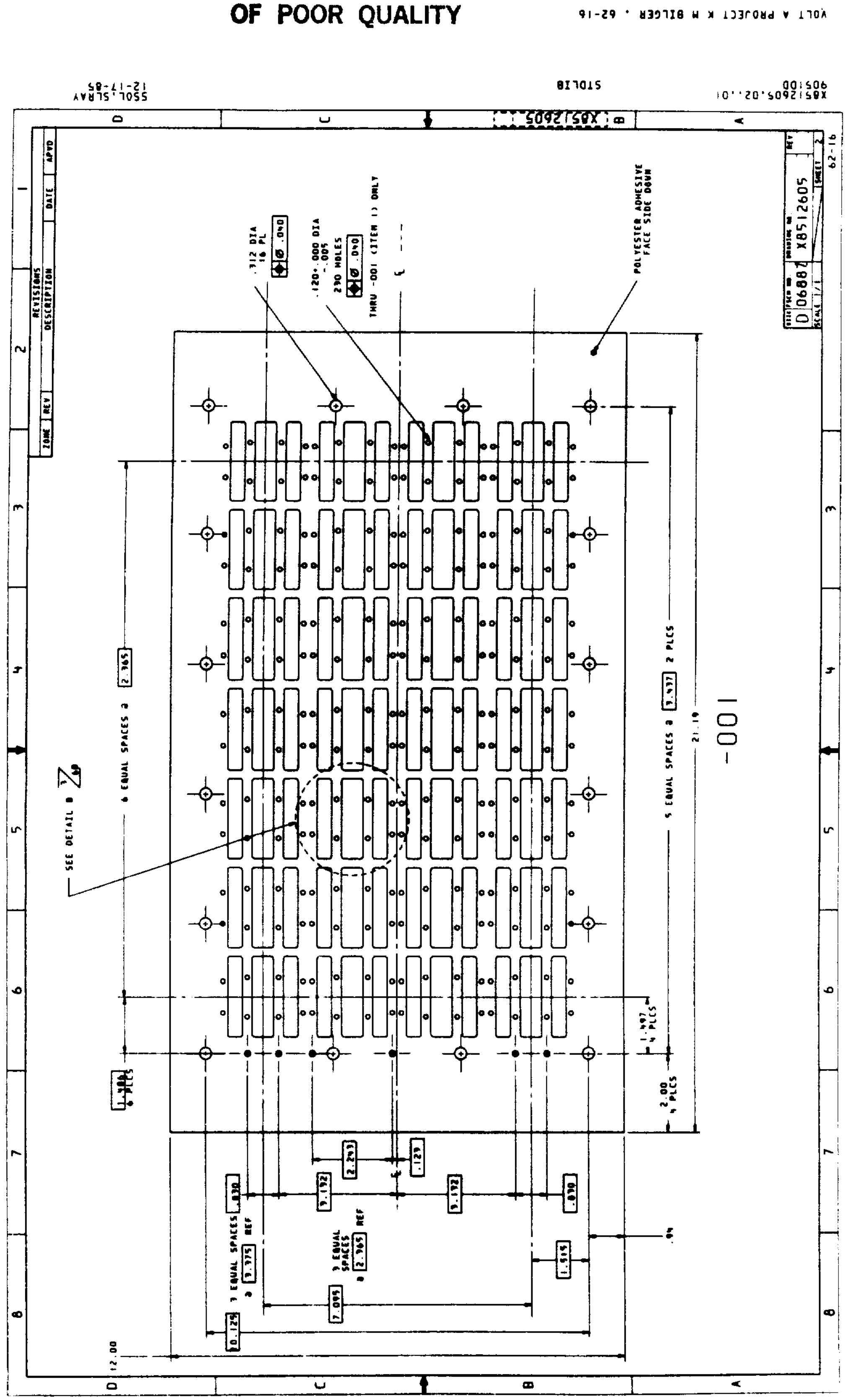

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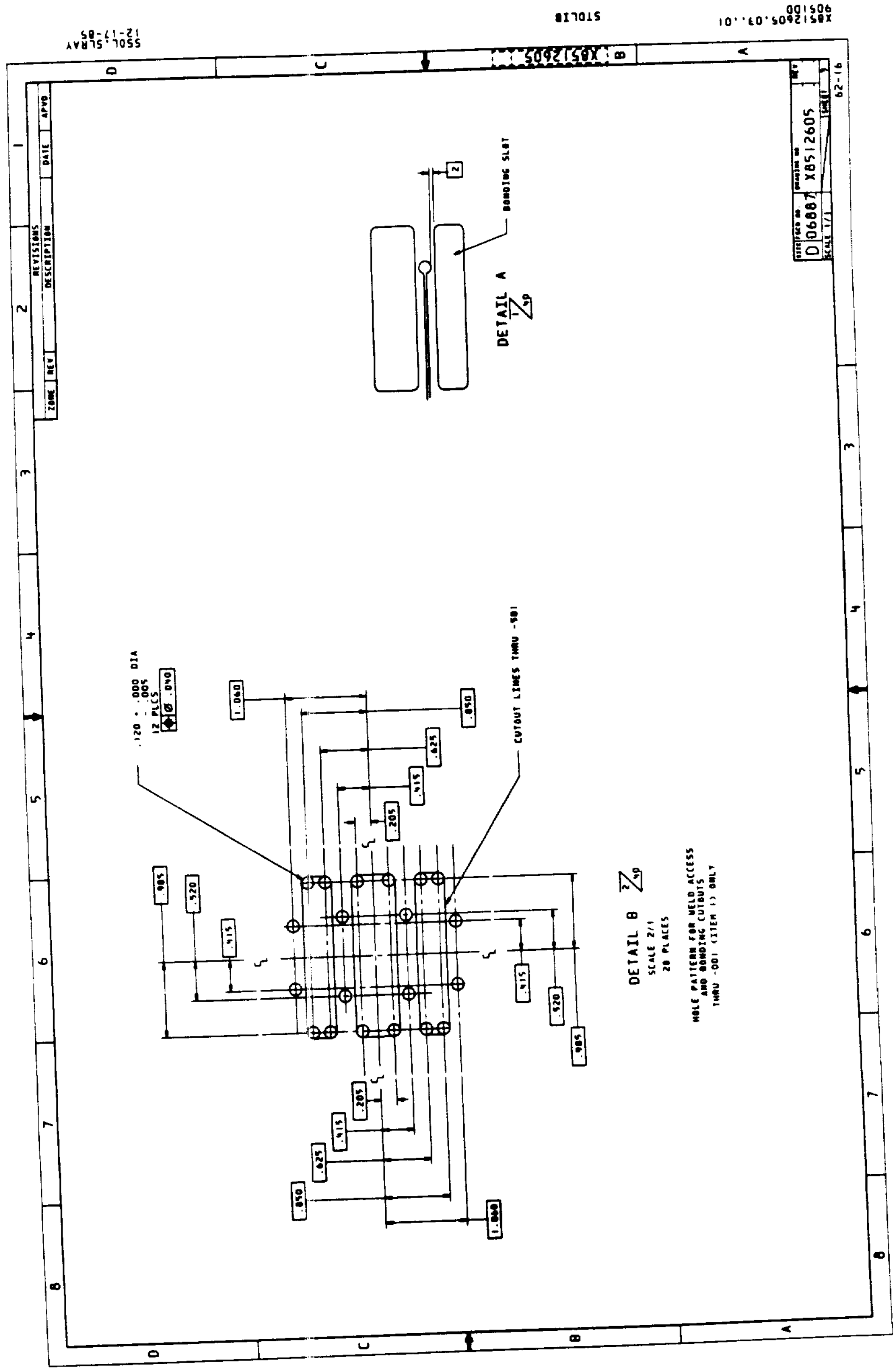
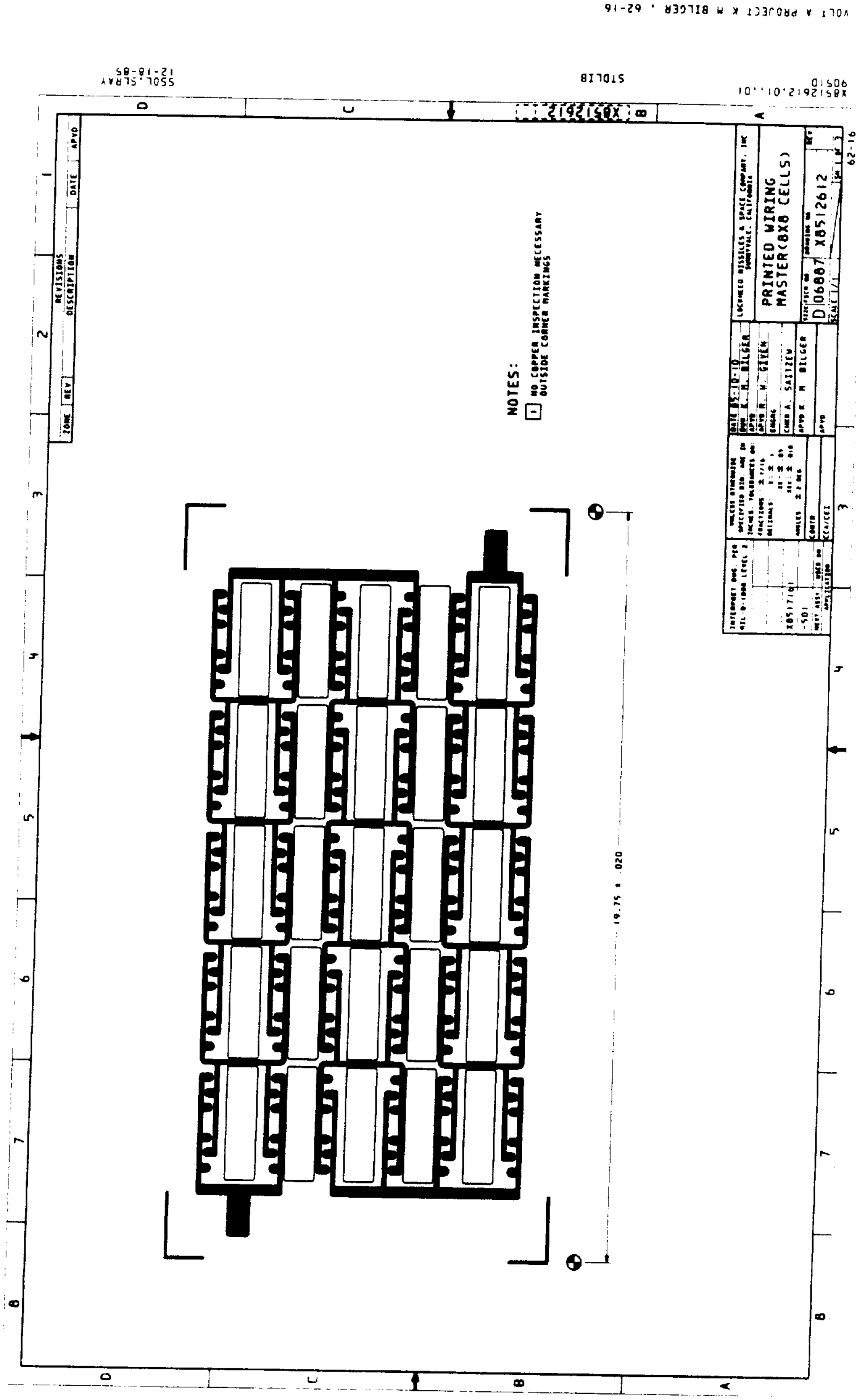




VOLT A PROJECT K M BILGER . 62-16
SSOL.SLRAY
12-18-85
STDLIB
X8512612.01..01
9051D
REVISIONS
ZONE
REV
DESCRIPTION
DATE
APVD
NOTES:
1 NO COPPER INSPECTION NECESSARY OUTSIDE CORNER MARKINGS
19.75 ± .020
LOCKHEED MISSILES & SPACE COMPANY, INC
SUNNYVALE, CALIFORNIA
PRINTED WIRING MASTER(8X8 CELLS)
DATE 85-10-10
DWN K. M. BILGER
APVD R. W. GIVEN
CHKR A. SAITZEW
APVD K. M. BILGER
D 06887 X8512612
SCALE 1/1
62-16
X8517161
-501
NEXT ASSY
USED ON
APPLICATION

ENGINEERING PARTS LIST

TITLE	DESIGN ORGN	DATE	PAGE	OF	CFE	CUL	PL	REV.
CIRCUIT ASSY 8X8CM CELLS	5216	85 NOV 07	1				X8517161	-

CONTRACT NUMBER	AUTHORITY	FSCM NO	CCA/CI NO.
NONE	N11-CL111-0001-01X	06837	

ITEM NO	LOCATION SH	LOCATION ZONE	QUANTITY PER ASSEMBLY 001	003	501	UNIT OF MEAS	FSCM NO.	PART/DOCUMENT NUMBER	SEQ NO	CCA/CI NO. IDENT	DESCRIPTION	LC	REFERENCE DESIGNATION/ MATERIAL/NOTES	NOTE ITEM NO.
001					1			X8517161-001			CIRCUIT ASSY			
002					1			X8517161-003			CIRCUIT ASSY			
200			AR					LAC22-4743- 1211			POLYIMIDE FILM		0.0015 THK X 12W	
201				AR				IPCCF150CFW71P			COPPER FOIL		0.0014 THK X 12W	
400			X	X	X			1421331			STD PRACTICES		DWG PRAC&STD DEF	
401					X			X8512512-001			PRNTD WIR MSTR			001
501					X			LAC5288-010000			FLEX CIRCUITS			
502			X	X	X			LAC1001			PKG/HDLG SPEC		PROTECT PER	

NOTE NO. NOTE TEXT

001 LOCAL NOTE: INTER-CONNECT OUTLINE TO BE ESTABLISHED BY ITEM 401.

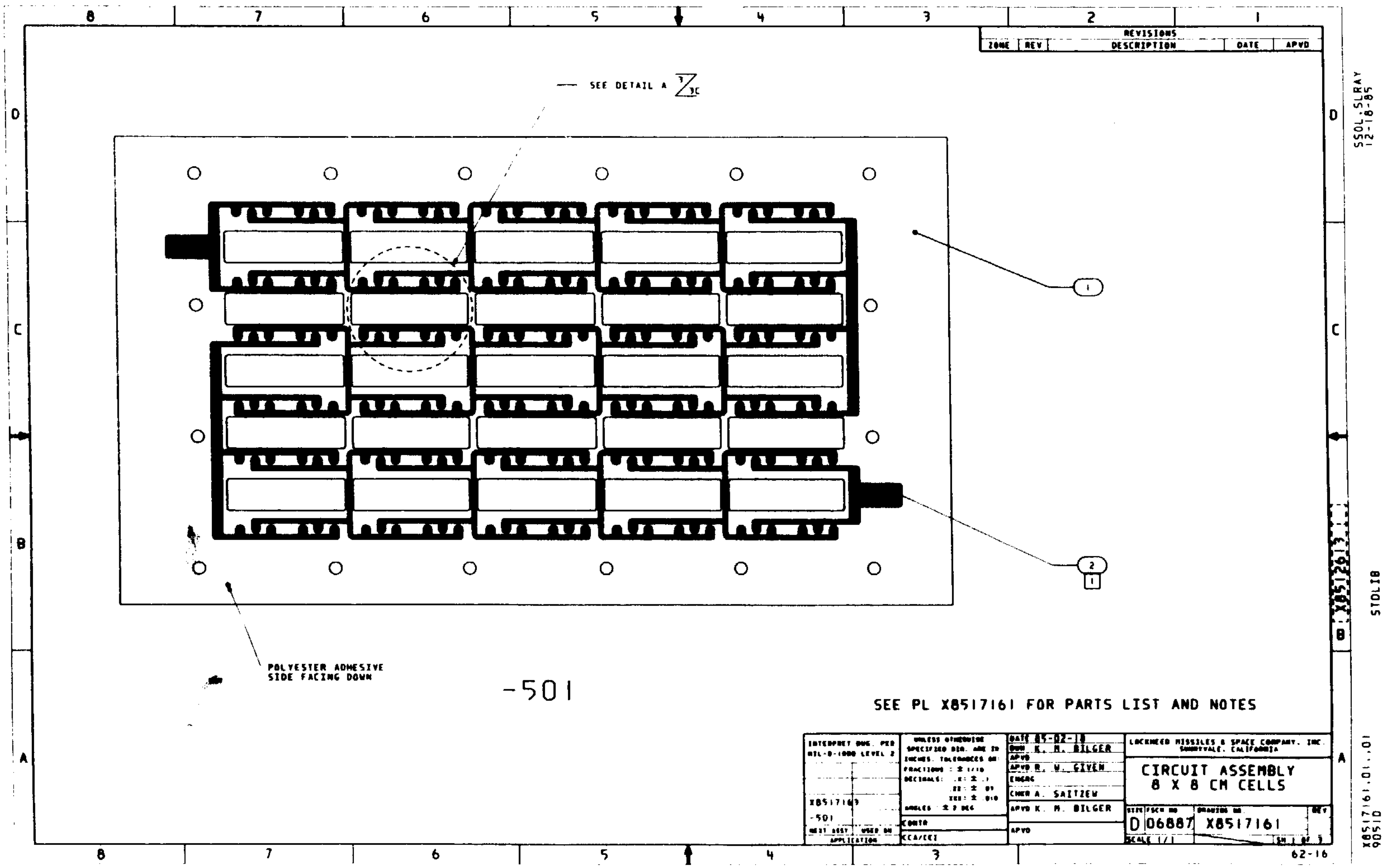
002 LOCAL NOTE: ITEM 1 (INSULATOR) MUST COMPLETELY OVERHANG ITEM 2 (COPPER INTER-CONNECT) EVERYWHERE.

PREPARED BY	DATE	APPROVAL	DATE	APPROVAL	DATE
Kevin H Bilger	85-11-07				
CHECKED BY A. Satzger	85-11-07				

FORM LMSC 2542 F-10 ABBREVIATIONS LC = LIFE CODE SEQ NO = SEQUENCE NUMBER ORGN = ORGANIZATION

LOCKHEED MISSILES & SPACE COMPANY INC

LAST PAGE - TOTAL PAGES THIS LIST 1



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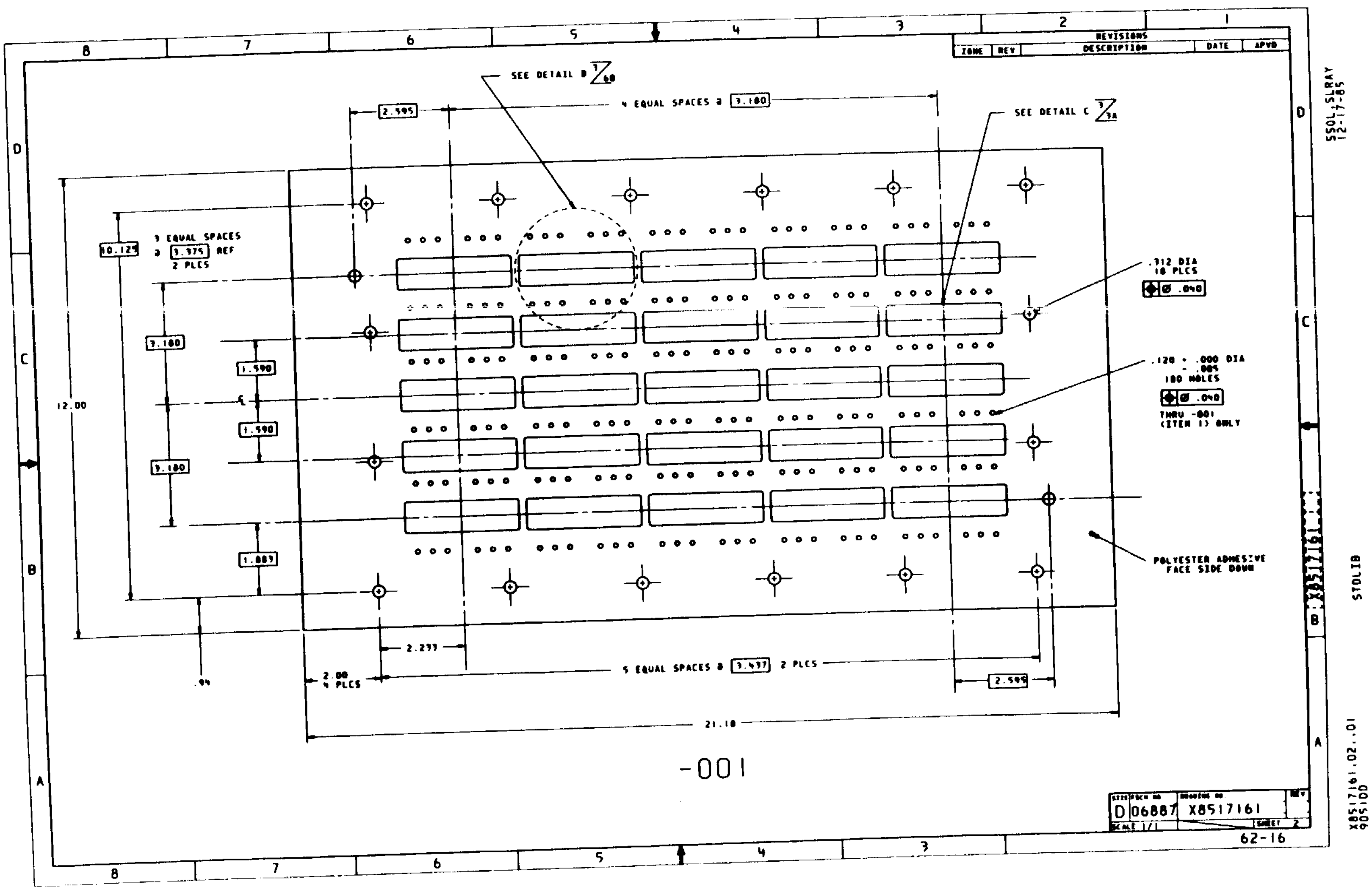
VOLT A PROJECT K M BILGER . 62-16



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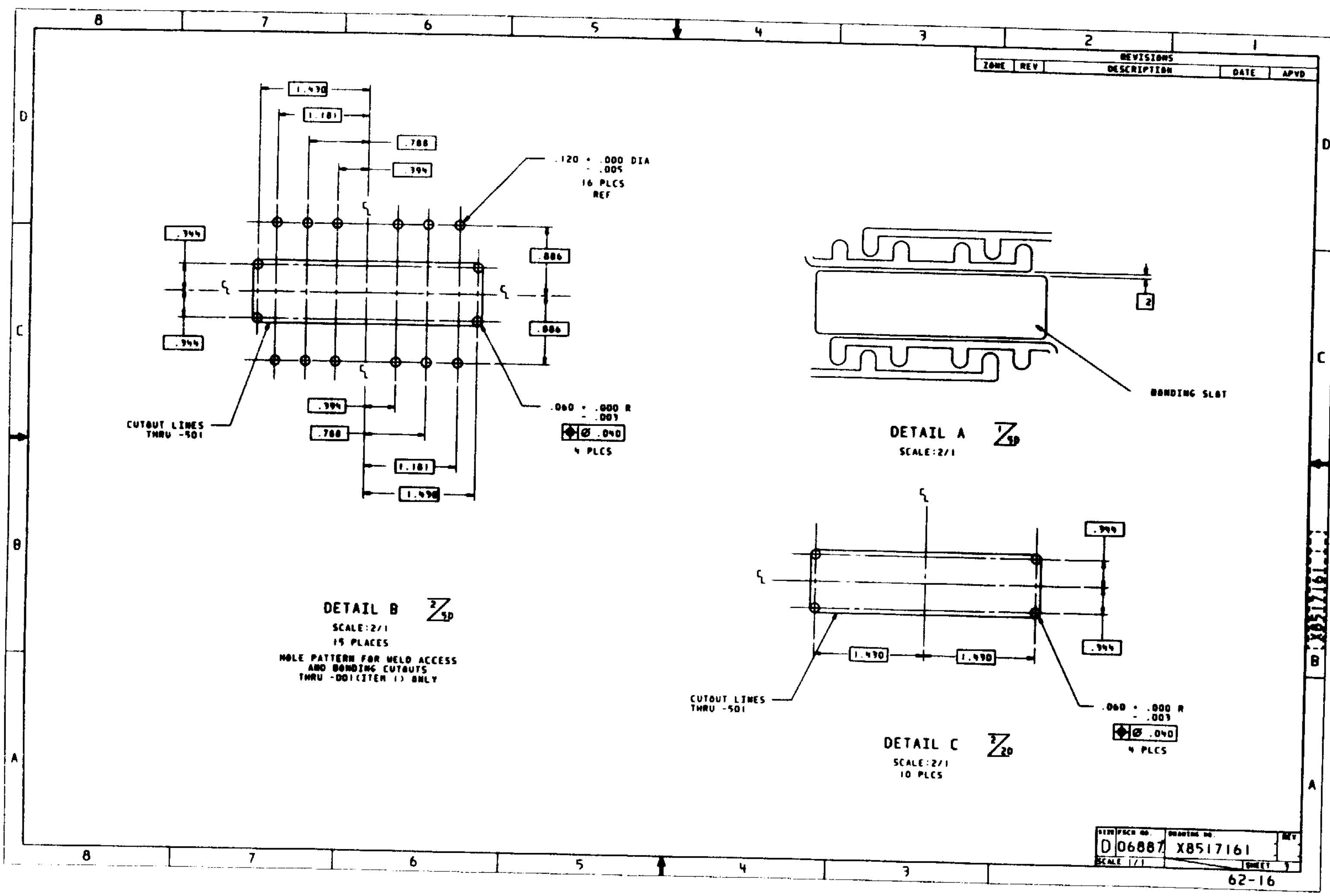
99



5501,SLRAY
12-17-85

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X8517161.03..01
905100

VOLT A PROJECT K M BILGER . 62-16

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TITLE	DESIGN ORGN	DATE	PAGE	OF	CFE	CUL		REV
MODULE ASSY	5216	85 NOV 18	1				PL X8517162	-

ENGINEERING PARTS LIST

CONTRACT NUMBER	AUTHORITY	FSCM NO	CCA/CI NO.
NAS3-24657	N11-CL111-0001-01X	06887	

ITEM NO	LOCATION SH	LOCATION ZONE	QUANTITY PER ASSEMBLY 501	UNIT OF MEAS	FSCM NO.	PART/DOCUMENT NUMBER	SEQ NO	CCA/CI NO. IDENT	DESCRIPTION	LC	REFERENCE DESIGNATION/ MATERIAL/NOTES	NOTE ITEM NO.
001			1			X8512605-501			INTCON ASSY			
002			28			X8512610-501			SOLAR CELL ASSY			
400			X			1421331			STD PRACTICES		DWG PRAC&STD DEF	
401			X			7699230			SOLAR CELL SPEC			N04
500			X			LAC3865			SOLAR CELLS		WELD PER	N06
501			X			LAC3154-010010			SOLAR PANEL			N03
502			X			LAC3575-019993			MARKING METHOD		MARK PER	N04
503			X			LAC1002-020000			PCTC THERM/CONT		PROTECT PER	

NOTE NO. — NOTE TEXT — STD NOTE

001 FOR EACH CELL MODULE ASSY SELECT SOLAR CELL ASSEMBLY (ITEM 2) FROM ONE CURRENT GROUP ONLY. DO NOT MIX CURRENT GROUPS WITHIN EACH CELL MODULE ASSY UNLESS APPROVED BY THE RESPONSIBLE EQUIPMENT ENGINEER (REE).

002 EACH SOLAR CELL ASSEMBLY (ITEM 2) SHALL MEET THE FOLLOWING CRITERIA PRIOR TO TESTING.

1. NO CRACKED SOLAR CELLS WHEN EXAMINED WITH NORMAL OR CORRECTED TO NORMAL VISION.
2. NO MORE THAN FIVE CRACKED COVERSLIDES.
3. ALL SOLAR CELLS MUST BE COMPLETELY COVERED BY A COVERSLIDE.
4. COVERSLIDE DELAMINATION, INCLUDING ADHESIVE BUBBLES, EDGE VOIDS, AND PULL-OUT SHALL BE NO GREATER THAN .25 SQUARE INCHES TOTAL PER SOLAR CELL ASSY.

100

003 PRIOR TO ELECTRICAL TEST CLEAN SOLAR CELL ASSEMBLIES (ITEM 2) PER ITEM 501 AS REQUIRED.

004 LOCAL NOTE: TEST CELL MODULE ASSY IN A SUN CALIBRATED ARTIFICAL LIGHT SOURCE. THE LIGHT SOURCE SHALL MEET REQUIREMENTS OF ITEM 401. RECORD CURRENT OUTPUT AT 13.72 VOLTS AND 25 DEGREES C (CORRECTED). IDENTIFY CELL MODULE ASSY PER ITEM 502 WITH PART NO. CHARACTERS TO BE .1 INCHES HIGH LOCATED APPROX WHERE SHOWN.

005 LOCAL NOTE: "N" CONTACT ELECTRICAL BONDING AREAS OF ITEM 2 (SOLAR CELL ASSY) TO ALIGH WITH WELD ACCESS HOLES IN ITEM 1 (FLEXIBLE CIRCUIT ASSY). WELD ACCESS HOLES SHALL NOT OVERHANG "N" BONDING AREAS.

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PREPARED BY	DATE	APPROVAL	DATE	APPROVAL	DATE
Kevin M Bilger	85-11-18				
CHECKED BY A. Saltzer	85-11-18				

FORM LMSC 2542 F-10 — ABBREVIATIONS LC = LIFE CODE SEQ NO = SEQUENCE NUMBER ORGN = ORGANIZATION

LOCKHEED MISSILES & SPACE COMPANY, INC

TITLE	DESIGN ORGN	DATE	PAGE	OF	CFE	CUL	PL	REV
		85 NOV 18	2				X8517162	-

CONTRACT NUMBER	AUTHORITY	FSCM NO.	CCA/CI NO.

ENGINEERING PARTS LIST

ITEM NO	LOCATION SH	LOCATION ZONE	QUANTITY PER ASSEMBLY	UNIT OF MEAS	FSCM NO.	PART/DOCUMENT NUMBER	SEQ NO	CCA/CI NO. IDENT	DESCRIPTION	LC	REFERENCE DESIGNATION/ MATERIAL/NOTES	NOTE ITEM NO.

NOTE NO. NOTE TEXT STD NOTE

006 LOCAL NOTE: WELD ITEM 1 (CIRCUIT ASSY) THROUGH WELD ACCESS HOLES TO ELECTRICAL BONDING AREAS OF ITEM 2 (SOLAR CELL ASSY) PER ITEM 500 EXCEPT AS FOLLOWS:

1. WELDING INSPECTORS NEED NOT BE FORMALLY TRAINED OR CERTIFIED IN THE PRINCIPLES AND OPERATION OF THE IR STRESS QUANTIZER.

2. SUPPLEMENTAL INFORMATION PROVIDED BY THE IR STRESS QUANTIZER SHALL NOT BE USED IN DEVELOPING THE JOINING PROCEDURE OR AS A BASIS FOR ACCEPTING/REJECTING CELL WELD JOINTS.

007 LOCAL NOTE: NUMERICAL DESIGNATIONS FOR SOLAR CELLS ARE FOR POSITIONAL REFERENCE ONLY AND SHALL NOT APPEAR ON PART.

101

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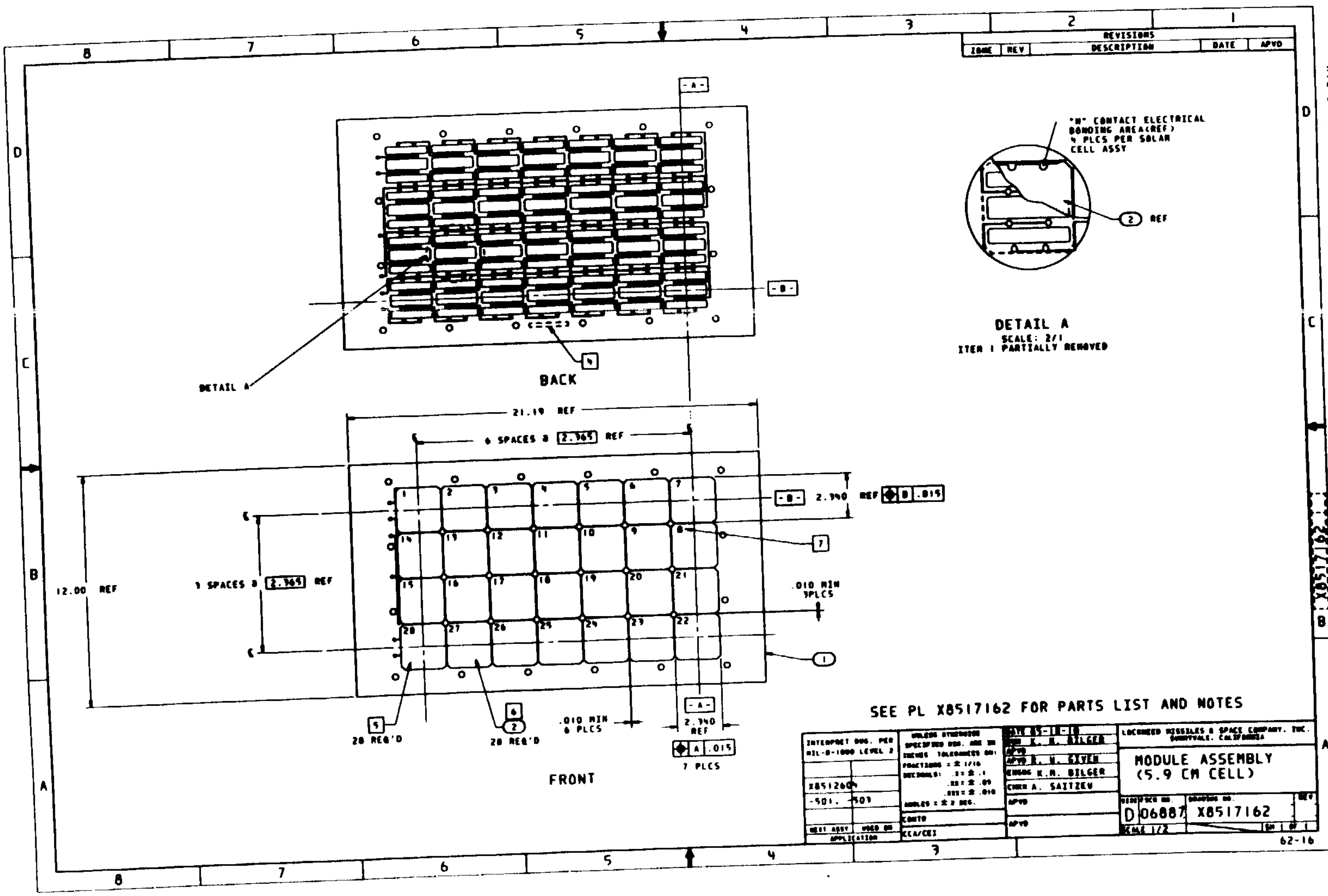
PREPARED BY	DATE	APPROVAL	DATE	APPROVAL	DATE
CHECKED BY	DATE	APPROVAL	DATE	APPROVAL	DATE



SSOL.SLRAY
12-17-85

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90510

VOLT A PROJECT K M BILGER . 62-16

TITLE	DESIGN ORGN	DATE	PAGE	OF	CFE	CUL	PL	REV
CELL MODULE (8X8C" CELL)	6216	86 MAR 12	1				X8517163	-

CONTRACT NUMBER	AUTHORITY	FSCM NO	CCA/CI NO.
NAS3-24657	N11-CL111-0001-01X	06887	

ENGINEERING PARTS LIST

ITEM NO	LOCATION SH	ZONE	QUANTITY PER ASSEMBLY 501	UNIT OF MEAS	FSCM NO.	PART/DOCUMENT NUMBER	SEQ. NO.	CCA/CI NO. IDENT	DESCRIPTION	LC	REFERENCE DESIGNATION/ MATERIAL/NOTES	NOTE ITEM NO.
001			1			X8517161-501			CIRCUIT ASSY			
002			15			X8519617-001			SOLAR CELL			
003			1			X8519619-001			SUPERSTRATE			
200			AR			LAC40-4502			SILICONE SEALNT			
400			X			1421331			STD PRACTICES		DWG PRAC&STD DEF	
401			X			7699230			SOLAR CELL SPEC			
500			X			LAC3866			SOLAR CELLS		WELD PER	N04
501			X			LAC3154-010010			SOLAR PANEL			N06
502			X			LAC3575-019993			MARKING METHOD		MARK PER	N03
503			X			LAC1002-020000			PCTC THERM/CONT		PROTECT PER	N04

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NOTE NO. NOTE TEXT

STD NOTE

001 FOR CELL MODULE ASSY SELECT SOLAR CELL (ITEM 2) FROM ONE CURRENT GROUP ONLY. DO NOT MIX CURRENT GROUPS WITHIN EACH CELL MODULE ASSY UNLESS APPROVED BY THE RESPONSIBLE EQUIPMENT ENGINEER (REE).

002 EACH SOLAR CELL (ITEM 2) SHALL MEET THE FOLLOWING CRITERIA PRIOR TO TESTING: NO CRACKED SOLAR CELLS WHEN EXAMINED WITH NORMAL OR CORRECTED TO NORMAL VISION.

103

003 PRIOR TO ELECTRICAL TEST CLEAN SUPERSTRATE (ITEM 3) PER ITEM 501 AS REQUIRED.

004 LOCAL NOTE: TEST CELL MODULE ASSY IN A SUN CALIBRATED ARTIFICAL LIGHT SOURCE. THE LIGHT SOURCE SHALL MEET REQUIREMENTS OF ITEM 401. RECORD CURRENT OUTPUT AT 7.35 VOLTS AND 25 DEGREES C (CORRECTED). IDENTIFY CELL MODULE ASSY PER ITEM 502 WITH PART NO. CHARACTERS TO BE .1 INCHES HIGH LOCATED APPROX WHERE SHOWN.

005 LOCAL NOTE: "N" CONTACT ELECTRICAL BONDING AREAS OF ITEM 2 (SOLAR CELL) TO ALIGH WITH WELD ACCESS HOLES IN ITEM 1 (FLEXIBLE CIRCUIT ASSY). WELD ACCESS HOLES SHALL NOT OVERHANG "N" BONDING AREAS.

006 LOCAL NOTE: WELD ITEM 1 (CIRCUIT ASSY) THROUGH WELD ACCESS HOLES TO ELECTRICAL BONDING AREAS OF ITEM 2 (SOLAR CELL) PER ITEM 500 EXCEPT AS FOLLOWS:
(NOTE CONTINUED NEXT PAGE)

PREPARED BY Kevin M Bilger	DATE 86-03-12	APPROVAL	DATE	APPROVAL	DATE		
CHECKED BY A. Saitzeff	DATE 86-03-12	APPROVAL	DATE	APPROVAL	DATE		

FORM LMSC 2532 F-1 ABBREVIATIONS LC = LIFE CODE SEQ NO = SEQUENCE NUMBER ORGN = ORGANIZATION

LOCKHEED MISSILES & SPACE COMPANY, INC.

TITLE | DESIGN ORGN | DATE 86 MAR 12 | PAGE 2 | OF | CFE | CUL | PL X8517163 | REV -

CONTRACT NUMBER | AUTHORITY | FSCM NO. | CCA/CI NO.

ENGINEERING PARTS LIST

ITEM NO	LOCATION SH	LOCATION ZONE	QUANTITY PER ASSEMBLY	UNIT OF MEAS	FSCM NO.	PART/DOCUMENT NUMBER	SEQ. NO	CCA/CI NO. IDENT	DESCRIPTION	LC	REFERENCE DESIGNATION/ MATERIAL/NOTES	NOTE ITEM NO.

NOTE NO. NOTE TEXT — STD NOTE

(CONTINUED)

1. WELDING INSPECTORS NEED NOT BE FORMALLY TRAINED OR CERTIFIED IN THE PRINCIPLES AND OPERATION OF THEIR STRESS QUANTIZER.
2. SUPPLEMENTAL INFORMATION PROVIDED BY THE IR STRESS QUANTIZER SHALL NOT BE USED IN DEVELOPING JOINING PROCEDURES OR AS A BASIS FOR ACCEPTING/REJECTING CELL WELD JOINTS.

007 LOCAL NOTE: NUMERICAL DESIGNATIONS FOR SOLAR CELLS ARE FOR POSITIONAL REFERENCE ONLY AND SHALL NOT APPEAR ON PART.

008 LOCAL NOTE: BOND SUPERSTRATE (ITEM 3) TO WELDED CELL MODULE USING ADHESIVE (ITEM 200).

009 LOCAL NOTE: LOCATE ITEM 3 SYMMETRICAL BETWEEN MOUNTING HOLES (BOTH DIRECTIONS) WITHIN .030 TOTAL. COVERGLASS MUST COMPLETELY COVER THE SOLAR CELL EDGES AS SHOWN.

104

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PREPARED BY Kevin M Bilger | DATE | APPROVAL | DATE | APPROVAL | DATE

CHECKED BY A. S. | DATE | APPROVAL | DATE | APPROVAL | DATE

FORM LMSC 2532 F-10 ABBREVIATIONS LC = LIFE CODE SEQ NO = SEQUENCE NUMBER ORGN = ORGANIZATION

LOCKHEED MISSILES & SPACE COMPANY, INC

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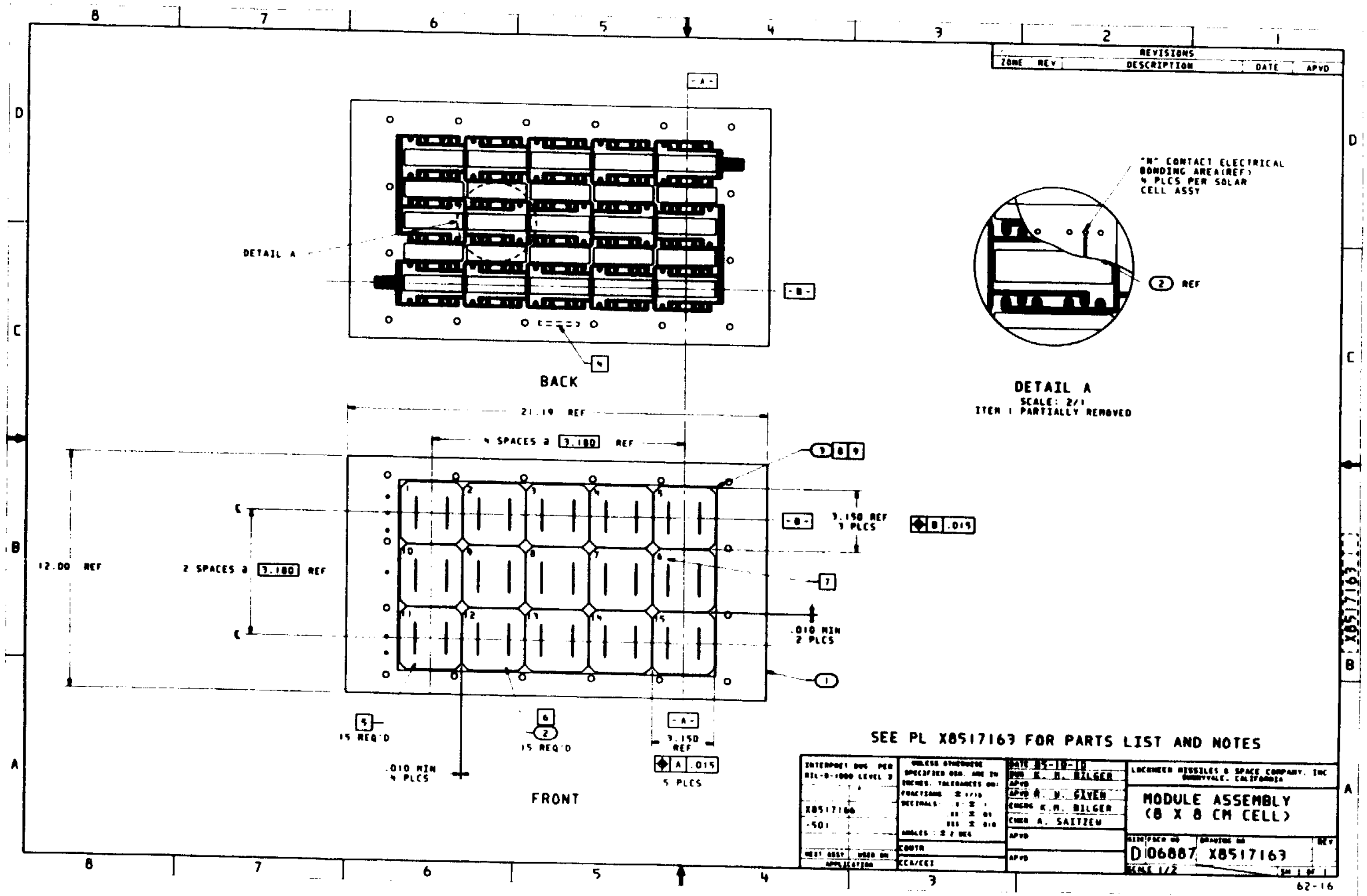

REVISIONS
ZONE REV DESCRIPTION DATE APVD
DETAIL A
BACK
"N" CONTACT ELECTRICAL BONDING AREA(REF) 4 PLCS PER SOLAR CELL ASSY
DETAIL A
SCALE: 2/1
ITEM 1 PARTIALLY REMOVED
21.19 REF
4 SPACES @ 3.180 REF
12.00 REF
2 SPACES @ 3.180 REF
3.150 REF 3 PLCS
.010 MIN 2 PLCS
15 REQ'D
15 REQ'D
.010 MIN 4 PLCS
3.150 REF
5 PLCS
FRONT
SEE PL X8517163 FOR PARTS LIST AND NOTES
LOCKHEED MISSILES & SPACE COMPANY, INC SUNNYVALE, CALIFORNIA
MODULE ASSEMBLY (8 X 8 CM CELL)
K. M. BILGER
A. SAITZEW
D 06887 X8517163
SCALE 1/2
62-16

TITLE	DESIGN ORGN	DATE	PAGE	OF	CFE	CUL	PL	REV
MODULE ASSY (5.9CM N-STRIP)	6216	85 DEC 04	1				X8517164	-

CONTRACT NUMBER	AUTHORITY	FSCM NO	CCA/CI NO.
NAS3-24657	N11-CL111-0001-01X	06887	

ENGINEERING PARTS LIST

ITEM NO	LOCATION SH	LOCATION ZONE	QUANTITY PER ASSEMBLY 501	UNIT OF MEAS	FSCM NO.	PART/DOCUMENT NUMBER	SEQ NO	CCA/CI NO. IDENT	DESCRIPTION	LC	REFERENCE DESIGNATION/ MATERIAL/NOTES	NOTE ITEM NO.
001			28			X8512610-503			SOLAR CELL ASSY			
002			27			8501491-001			CELL INTERCONN			
003			2			8501493-001			CELL INTERCONN			
004			1			8501495-001			CELL INTERCONN			
200			AR		09474	ACSREAGENTGRAD E			2 PROPANOL			
400			X			1421331			STD PRACTICES		DWG PRACSSTD DEF	
401			X			7699230			SOLAR CELL SPEC			
500			X			LAC3575-019993			MARKING METHOD		MARK PER	
501			X			LAC3154-010010			SOLAR PANEL			
502			X			LAC3852-010000			RES SOLDERING		SOLDER PER	
503			X			LAC1002-020000			PCTC THERM/CONT		PROTECT PER	

NOTE NO.	NOTE TEXT	STD NOTE

001 FOR EACH CELL MODULE ASSY SELECT SOLAR CELL ASSEMBLY (ITEM 1) FROM ONE CURRENT GROUP ONLY. DO NOT MIX CURRENT GROUPS WITHIN EACH CELL MODULE ASSY UNLESS APPROVED BY THE RESPONSIBLE EQUIPMENT ENGINEER (REE).

106

002 EACH SOLAR CELL ASSEMBLY (ITEM 1) SHALL MEET THE FOLLOWING CRITERIA PRIOR TO TESTING.
1. NO CRACKED SOLAR CELLS WHEN EXAMINED WITH NORMAL OR CORRECTED TO NORMAL VISION.
2. NO MORE THAN FIVE CRACKED COVERSLIDES.
3. ALL SOLAR CELLS MUST BE COMPLETELY COVERED BY A COVERSLIDE.
4. COVERSLIDE DELAMINATION, INCLUDING ADHESIVE BUBBLES, EDGE VOIDS, AND PULL-OUT SHALL BE NO GREATER THAN .25 SQUARE INCHES TOTAL PER SOLAR CELL ASSY.

003 PRIOR TO ELECTRICAL TEST OF MODULES, CLEAN PER ITEM 501, EXCEPT USE ITEM 200.

004 LOCAL NOTE: TEST CELL MODULE ASSY IN A SUN CALIBRATED ARTIFICAL LIGHT SOURCE. THE LIGHT SOURCE SHALL MEET REQUIREMENTS OF ITEM 401. RECORD CURRENT OUTPUT AT 13.72 VOLTS AND 25 DEGREES C (CORRECTED). IDENTIFY CELL MODULE ASSY PER ITEM 500 WITH PART NO. CHARACTERS TO BE .1 INCHES HIGH LOCATED APPROX WHERE SHOWN.

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PREPARED BY	DATE	APPROVAL	DATE	APPROVAL	DATE
Kevin M Bilger	85-12-04				
CHECKED BY A. Saitzew	85-12-04				

FORM LMSC 2542 F-10 ABBREVIATIONS LC = LIFE CODE SEQ NO = SEQUENCE NUMBER ORGN = ORGANIZATION

LOCKHEED MISSILES & SPACE COMPANY, INC

TITLE	DESIGN ORGN	DATE	PAGE	OF	CFE	CUL		REV
		85 DEC 04	2				PL X8517164	-

CONTRACT NUMBER	AUTHORITY	FSCM NO.	CCA/CI NO.

ENGINEERING PARTS LIST

ITEM NO	LOCATION SH	LOCATION ZONE	QUANTITY PER ASSEMBLY	UNIT OF MEAS	FSCM NO.	PART/DOCUMENT NUMBER	SEQ. NO.	CCA/CI NO. IDENT	DESCRIPTION	LC	REFERENCE DESIGNATION/ MATERIAL/NOTES	NOTE ITEM NO.

NOTE NO.	NOTE TEXT	STD NOTE
005	SOLDER PER ITEM 502 EXCEPT SOLDER JOINT INTERNAL QUALITY SPECIMENS NOT REQUIRED. INSTEAD, FOR PROCESS CERTIFICATION, PERFORM PULL TESTS ON TWENTY REPRESENTATIVE SOLDER JOINTS PER CELL VENDOR (10N & 10P PER VENDOR). N-TAB PULL TEST RESULTS MUST EXCEED 5.0 LBS SHEAR AND P-CONTRACT AREAS MUST EXCEED 3.0 LBS WHEN PULLED AT 0-20 DEG ANGLE.	
006	AFTER MODULE ASSEMBLY AND CLEANING, THE BACK (SILVER) SIDE OF EACH CELL SHALL BE VISUALLY INSPECTED UNDER ULTRAVIOLET LIGHT FOR ANY EVIDENCE OF SOLDER FLUX. ANY SOLDER FLUX RESIDUE SHALL BE REMOVED USING A PRECLEANED COTTON TIPPED APPLICATOR SLIGHTLY WETTED WITH A MIXTURE OF 1 PART BY VOLUME ANHYDROUS ALCOHOL AND 3 PARTS BY VOLUME 1.1.1-TRICHLOROETHANE.	

107

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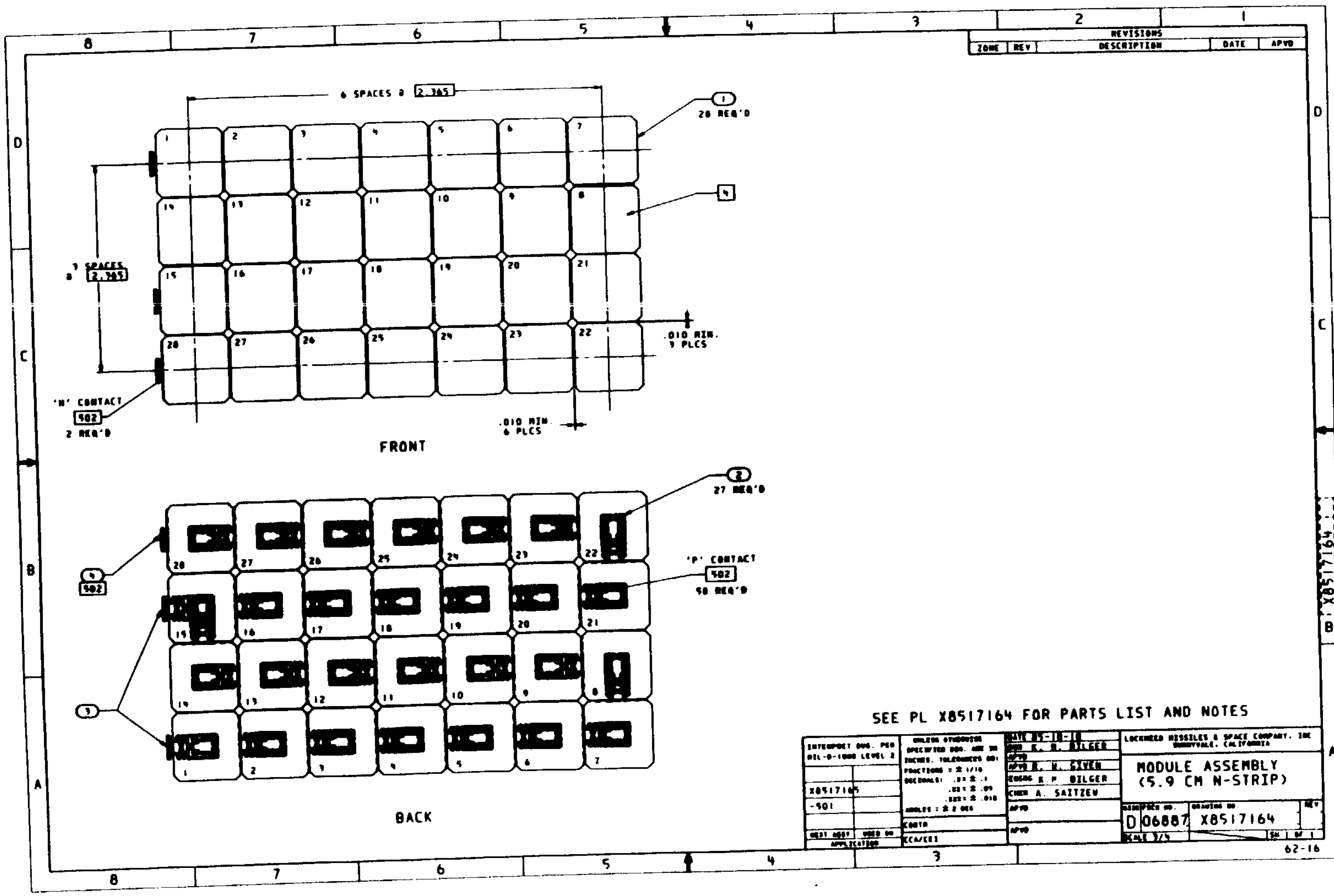
PREPARED BY	DATE	APPROVAL	DATE	APPROVAL	DATE
CHECKED BY	DATE	APPROVAL	DATE	APPROVAL	DATE



SSOL.SLRAY
12-17-85

X8517164.01..01
90510

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VOLT A PROJECT K M BILGER . 62-16

ORIGINAL PAGE IS
OF POOR QUALITY

TITLE	DESIGN ORGN	DATE	PAGE	OF	CFE	CUL	PL	REV
MODULE/PLATE ASSY	6216	86 MAR 07	1				X8512604	-

CONTRACT NUMBER	AUTHORITY	FSCM NO.	CCA/CI NO.
VARIOUS	SSM-DAPSL-0001-01	06887	

ENGINEERING PARTS LIST

ITEM NO	LOCATION SH	ZONE	QUANTITY PER ASSEMBLY 501	503	UNIT OF MEAS	FSCM NO.	PART/DOCUMENT NUMBER	SEQ. NO.	CCA/CI NO. IDENT	DESCRIPTION	LC	REFERENCE DESIGNATION/ MATERIAL/NOTES	NOTE ITEM NO.
001			1	1			X8512607-501			AL PLATE ASSY			
002			1	1			X8517162-501			MODULE ASSY		5.9CM CELL	
200			AR	AR			LAC30-4639-0100			ADHESIVE,EPOXY			
203			AR	AR			ACSREAGGPDE			2 PROPANOL			
204			AR	AR			MD920-22-4			WIRE ELEC			
205			AR	AR		81348	QQS571			SOLDER		SN63 WRMAP 2 OR 3	
206			3	3		80205	NAS1387-1			SPLICE			
400			X	X			1421331			STD PRACTICES		DWG PRAC&STD DEF	
500			X	X			LAC3851-010100			GEN ELEC SOLDER		SOLDER PER	N03
501			X	X			LAC3041-020000			BOND FLEX MOD			N02
502			X	X			LAC3210-010000			FIL & ADH BOND			N01
503			X	X			LAC3154-010000			SOLAR PANEL			N07
504			X	X			LAC3211-020501			COATING SPEC		COAT PER	N09
505			X	X			LAC3575-019993			MARKING METHOD		MARK PER	N04
506			X	X			DS40039-69			DESIGN STD		INSTL PER	

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NOTE
NO. NOTE TEXT STD NOTE

109

QK NOTE LINE INDICATORS (A, B, C, ETC.) ARE NO LONGER REQUIRED AND HAVE BEEN REMOVED

001 LOCAL NOTE: FILLET WIRES (ITEM 204) TO DIELECTRIC SURFACE OF ITEM 001 PER ITEM 502 AS FOLLOWS:

1. SOLVENT CLEAN SURFACES TO BE FILLETED WITH ITEM 203 (2-PROPANOL) USING PRE-CLEANED Q-TIPS AND AIR DRY 10 MINUTES MINIMUM.
2. APPLY ITEM 200 IN A CONTROLLED MANNER.
3. CURE 48 HRS MINIMUM AT 75 +/- 10 DEGREES F. PRIOR TO HANDLING & 7 DAYS MINIMUM AT 75 +/- 10 DEGREES F. PRIOR TO TESTING.

002 LOCAL NOTE: BOND ITEM 002 TO ITEM 001 (AL PLATE ASSY) PER ITEM 501. APPLY ADHESIVE TO PRIMED DIELECTRIC SURFACE OF ITEM 001 (AL PLATE ASSY) IN A CONTROLLED PATTERN AND THICHNESS SUCH THAT THE FOLLOWING REQUIREMENTS ARE MET:
(NOTE CONTINUED NEXT PAGE)

PREPARED BY	DATE	APPROVAL	DATE	APPROVAL	DATE
Kevin M Bilger	86-03-07				
CHECKED BY A. Saltzer	86-03-07				

FORM LMSC 2542 F-10 ABBREVIATIONS LC = LIFE CODE SEQ NO = SEQUENCE NUMBER ORGN = ORGANIZATION

LOCKHEED MISSILES & SPACE COMPANY, INC.

TITLE | DESIGN ORGN | DATE 86 MAR 07 | PAGE 2 | OF | CFE | CUL | PL X8512604 | REV -

ENGINEERING PARTS LIST

CONTRACT NUMBER | AUTHORITY | FSCM NO. | CCA/CI NO.

ITEM NO	LOCATION SH	ZONE	QUANTITY PER ASSEMBLY	UNIT OF MEAS	FSCM NO.	PART/DOCUMENT NUMBER	SEQ NO	CCA/CI NO. IDENT	DESCRIPTION	LC	REFERENCE DESIGNATION/ MATERIAL/NOTES	NOTE ITEM NO.

STD NOTE

NOTE NO. NOTE TEXT (CONTINUED)

1. EACH OF THE 28 SOLAR CELLS SHALL BE BONDED TO THE SUBSTRATE THROUGH 3 BONDING SLOTS.
2. THE MINIMUM BONDING AREA SHALL BE 90% OF THE SLOT AREA FOR ALL SLOTS.
3. BONDLINE THICHNESS SHALL BE .005 IN THICK.
4. THE CURED ADHESIVE SHALL NOT BRIDGE IN MORE THAN ONE PLACE BETWEEN ANY 2 ADJACENT SLOTS.

003 LOCAL NOTE: SOLDER CIRCUIT WIRES ITEM 204 TO ITEM 2 PER ITEM 500 USING ITEM 205.

004 LOCAL NOTE: MARK PART NO. PER ITEM 505 APPROX AS SHOWN.

005 LOCAL NOTE: SPLICE TERMINAL LEADS TOGETHER USING ITEM 206. SINGLE LEADS SHOWN SHOULD BE APPROX 3 FT. LONG.

006 EACH SOLAR CELL ASSEMBLY SHALL BE CHECKED FOR THE FOLLOWING DEFECTS BEFORE TESTING:
1. DELAMINATION SHALL NOT EXCEED AN AREA GREATER THAN .015 INCH PER CELL ASSEMBLY.
2. EXPOSED SILICON AS A RESULT OF CRACKED OR CHIPPED COVERSLIDES.
3. CRACKED SOLAR CELLS.

ALL ASSEMBLIES HAVING ANY OF THE ABOVE DEFECTS SHALL BE RECORDED. REE APPROVAL SHALL BE REQUIRED FOR ALL REWORK OF SOLAR CELL ASSEMBLIES.

007 CLEAN SOLAR PANEL PER ITEM 503 PRIOR TO FIRST FUNCTIONAL TEST AND AS REQUIRED AFTER ALL TESTS SPECIFIED BY THE REE.

008 FUNCTIONAL TEST THE ELECTRICAL PERFORMANCE OF EACH CELL CIRCUIT UNDER REE DIRECTION.

009 CONDUCTOR COAT EXPOSED WIRES OF ITEM 002 (CELL MODULE ASSEMBLY) PER ITEM 504. AREAS TO BE COATED NEED NOT BE CLEANED PRIOR TO APPLICATION UNLESS VISUALLY CONTAMINATED.

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110

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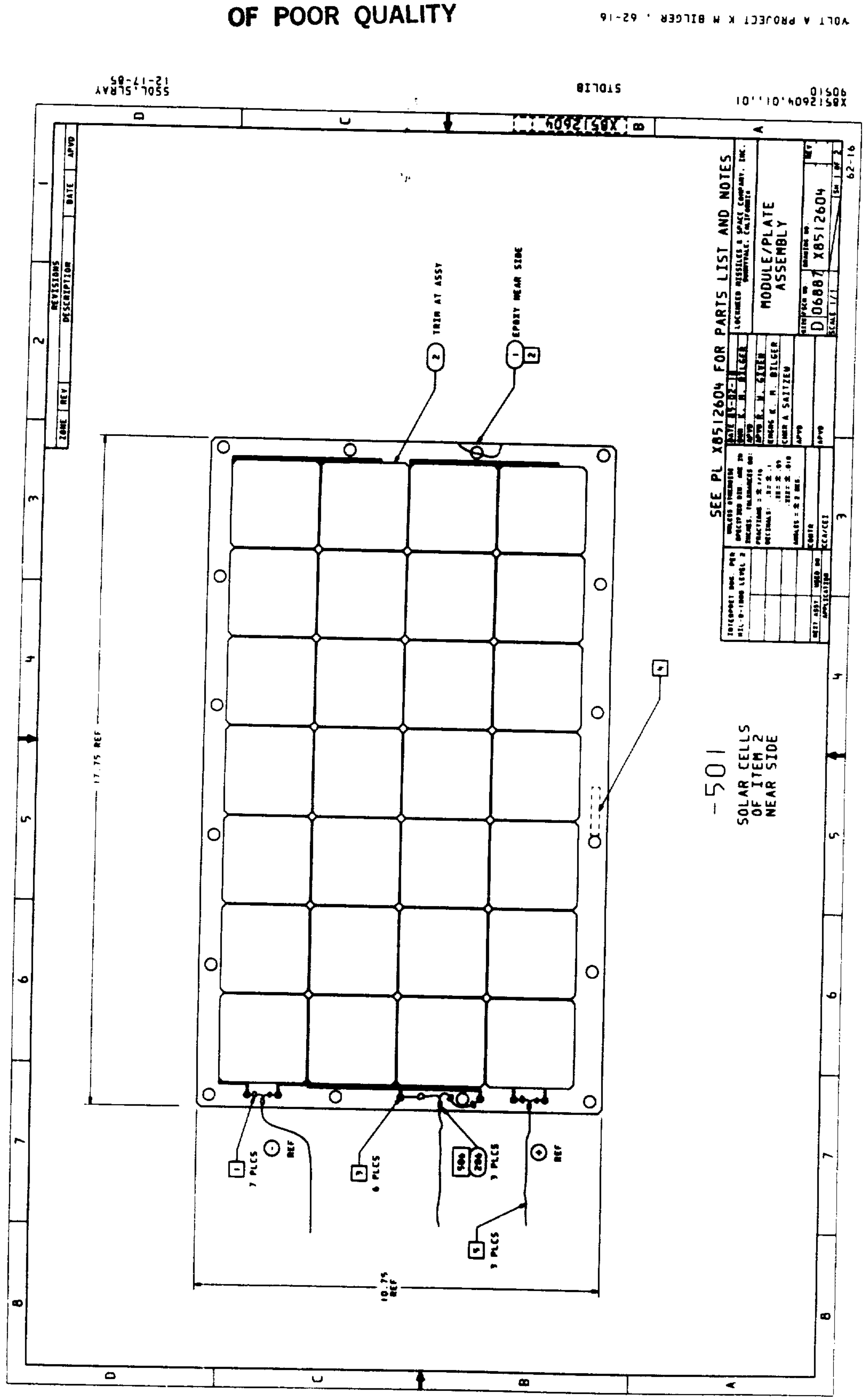
CHECKED BY A.J. | DATE | APPROVAL | DATE | APPROVAL | DATE


VOLT A PROJECT K M BILGER . 62-16
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12-17-85
STDLIB
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90510
X8512604
REVISIONS
ZONE
REV
DESCRIPTION
DATE
APVD
17.75 REF
10.75 REF
7 PLCS
REF
6 PLCS
3 PLCS
REF
TRIM AT ASSY
EPOXY NEAR SIDE
-501
SOLAR CELLS
OF ITEM 2
NEAR SIDE
SEE PL X8512604 FOR PARTS LIST AND NOTES
K. M. BILGER
R. W. GIVEN
K. M. BILGER
A SAITZEW
LOCKHEED MISSILES & SPACE COMPANY, INC.
SUNNYVALE, CALIFORNIA
MODULE/PLATE
ASSEMBLY
D
06887
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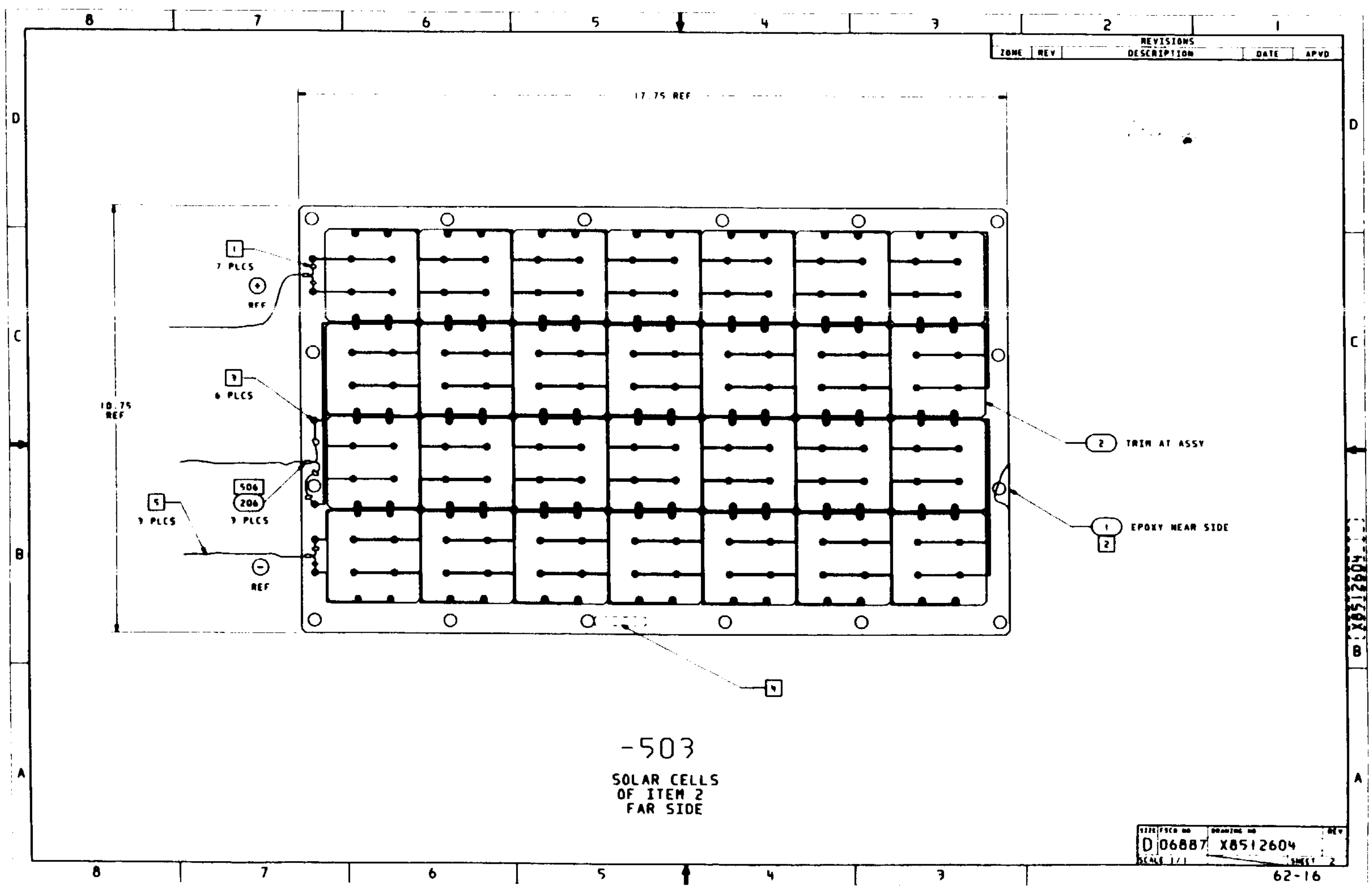
SCALE 1/1
62-16



SSOL.SLRAY
12-18-85

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VOLT A PROJECT K M BILGER . 62-16

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TITLE	DESIGN ORGN	DATE	PAGE	OF	CFE	CUL	PL	REV
MODULE/PLATE ASSY (CONVENTIONAL)	6216	86 MAR 07	1				X8517165	–

CONTRACT NUMBER	AUTHORITY	FSCM NO.	CCA/CI NO.
NAS3-24657	N11-CL111-0001-01X	06887	

ENGINEERING PARTS LIST

ITEM NO	LOCATION SH	LOCATION ZONE	QUANTITY PER ASSEMBLY 501	UNIT OF MEAS	FSCM NO.	PART/DOCUMENT NUMBER	SEQ. NO.	CCA/CI NO. IDENT	DESCRIPTION	LC	REFERENCE DESIGNATION/ MATERIAL/NOTES	NOTE ITEM NO.
001			1			X8512607-501			AL PLATE ASSY			
002			1			X8517164-501			MODULE ASSY		N STRIP	
200			AR			LAC30-4639-0100			ADHESIVE,EPOXY			
203			AR			ACSREAGGRDE			2 PROPANOL			
204			AR			MD920-22-4			WIRE ELEC			
205			AR		81348	QQS571			SOLDER		SN63 WRMAP 2 OR 3	
400			X			1421331			STD PRACTICES		DWG PRAC&STD DEF	
500			X			LAC3851-010100			GEN ELEC SOLDER		SOLDER PER	N03
501			X			LAC3041-020000			BOND FLEX MOD			N02
502			X			LAC3210-010000			FIL & ADH BOND			N01
503			X			LAC3154-010000			SOLAR PANEL			N07
504			X			LAC3211-020501			COATING SPEC		COAT PER	N09
505			X			LAC3575-019993			MARKING METHOD		MARK PER	N04

ORIGINAL PAGE IS OF POOR QUALITY

NOTE NO. NOTE TEXT — STD NOTE

QK NOTE LINE INDICATORS (A, B, C, ETC.) ARE NO LONGER REQUIRED AND HAVE BEEN REMOVED

113

001 LOCAL NOTE: FILLET WIRES (ITEM 204) TO DIELECTRIC SURFACE OF ITEM 001 PER ITEM 502 AS FOLLOWS:

1. SOLVENT CLEAN SURFACES TO BE FILLETED WITH ITEM 203 (2-PROPANOL) USING PRE-CLEANED Q-TIPS AND AIR DRY 10 MINUTES MINIMUM.
2. APPLY ITEM 200 IN A CONTROLLED MANNER.
3. CURE 48 HRS MINIMUM AT 75 +/- 10 DEGREES F. PRIOR TO HANDLING & 7 DAYS MINIMUM AT 75 +/- 10 DEGREES F. PRIOR TO TESTING.

002 LOCAL NOTE: BOND ITEM 002 TO ITEM 001 (AL PLATE ASSY) PER ITEM 501. APPLY ADHESIVE TO PRIMED DIELECTRIC SURFACE OF ITEM 001 (AL PLATE ASSY) IN A CONTROLLED PATTERN AND THICHNESS SUCH THAT THE FOLLOWING REQUIREMENTS ARE MET:

1. EACH OF THE 28 SOLAR CELLS SHALL BE BONDED TO THE SUBSTRATE THROUGH 3 BONDING SLOTS.

(NOTE CONTINUED NEXT PAGE)

PREPARED BY	DATE	APPROVAL	DATE	APPROVAL	DATE
Kevin M Bilger	86-03-07				
CHECKED BY: A. Salzer	86-03-07				

TITLE	DESIGN ORGN	DATE	PAGE	OF	CFE	CUL	PL	REV
		86 MAR 07	2				X8517165	–

ENGINEERING PARTS LIST

CONTRACT NUMBER	AUTHORITY	FSCM NO	CCA/CI NO.

ITEM NO.	LOCATION SH	LOCATION ZONE	QUANTITY PER ASSEMBLY	UNIT OF MEAS	FSCM NO.	PART/DOCUMENT NUMBER	SEQ NO.	CCA/CI NO. IDENT	DESCRIPTION	LC	REFERENCE DESIGNATION/ MATERIAL/NOTES	NOTE ITEM NO

NOTE NO. NOTE TEXT (CONTINUED) — STD NOTE

2. THE MINIMUM BONDING AREA SHALL BE 90% OF THE SLOT AREA FOR ALL SLOTS.
3. BONDLINE THICHNESS SHALL BE .005 IN THICK.
4. THE CURED ADHESIVE SHALL NOT BRIDGE IN MORE THAN ONE PLACE BETWEEN ANY 2 ADJACENT SLOTS.

003 LOCAL NOTE: SOLDER CIRCUIT WIRES ITEM 204 TO ITEM 2 PER ITEM 500 USING ITEM 205.

004 LOCAL NOTE: MARK PART NO. PER ITEM 505 APPROX AS SHOWN.

005 LOCAL NOTE: SINGLE LEADS SHOWN SHOULD BE APPROX 3 FT. LONG.

006 EACH SOLAR CELL ASSEMBLY SHALL BE CHECKED FOR THE FOLLOWING DEFECTS BEFORE TESTING:
1. DELAMINATION SHALL NOT EXCEED AN AREA GREATER THAN .015 INCH PER CELL ASSEMBLY.
2. EXPOSED SILICON AS A RESULT OF CRACKED OR CHIPPED COVERSLIDES.
3. CRACKED SOLAR CELLS.
ALL ASSEMBLIES HAVING ANY OF THE ABOVE DEFECTS SHALL BE RECORDED. REE APPROVAL SHALL BE REQUIRED FOR ALL REWORK OF SOLAR CELL ASSEMBLIES.

114

007 CLEAN SOLAR PANEL PER ITEM 503 PRIOR TO FIRST FUNCTIONAL TEST AND AS REQUIRED AFTER ALL TESTS SPECIFIED BY THE REE.

008 FUNCTIONAL TEST THE ELECTRICAL PERFORMANCE OF EACH CELL CIRCUIT UNDER REE DIRECTION.

009 CONDUCTOR COAT EXPOSED WIRES OF ITEM 002 (CELL MODULE ASSEMBLY) PER ITEM 504. AREAS TO BE COATED NEED NOT BE CLEANED PRIOR TO APPLICATION UNLESS VISUALLY CONTAMINATED.

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PREPARED BY	DATE	APPROVAL	DATE	APPROVAL	DATE
CHECKED BY A.J.	DATE	APPROVAL	DATE	APPROVAL	DATE

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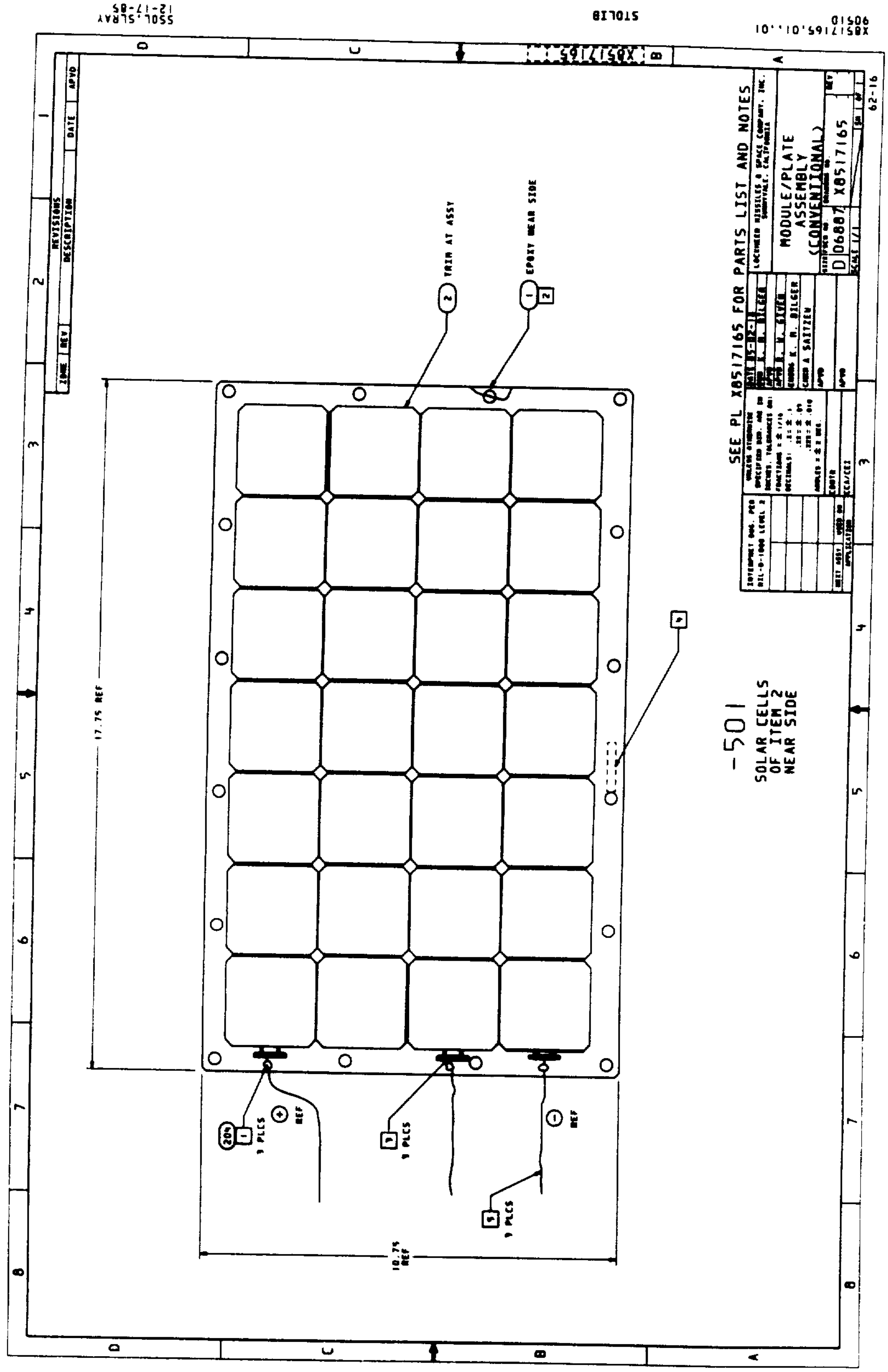

TITLE	DESIGN ORGN	DATE	PAGE	OF	CFE	CUL	PL	REV
MODULE/PLATE ASSY (8X8 CM CELLS)	6216	86 MAR 07	1				X8517166	-

CONTRACT NUMBER	AUTHORITY	FSCM NO.	CCA/CI NO.
NAS3-24657	N11-CL111-0001-01X	06887	

ENGINEERING PARTS LIST

ITEM NO	LOCATION SH	LOCATION ZONE	QUANTITY PER ASSEMBLY 501	UNIT OF MEAS	FSCM NO.	PART/DOCUMENT NUMBER	SEQ NO	CCA/CI NO. IDENT	DESCRIPTION	LC	REFERENCE DESIGNATION/ MATERIAL/NOTES	NOTE ITEM NO
001			1			X8512607-501			AL PLATE ASSY			
002			1			X8517163-501			MODULE ASSY		8X8 CM CELL	
200			AR			LAC30-4639-0100			ADHESIVE,EPOXY			
203			AR			ACSREAGGRDE			2 PROPANOL			
204			AR			MD920-22-4			WIRE ELEC			
205			AR		81348	QQS571			SOLDER		SN63 WRMAP 2 OR 3	
400			X			1421331			STD PRACTICES		DWG PRAC&STD DEF	
500			X			LAC3851-010100			GEN ELEC SOLDER		SOLDER PER	N03
501			X			LAC3041-020000			BOND FLEX MOD			N02
502			X			LAC3210-010000			FIL & ADH BOND			N01
503			X			LAC3154-010000			SOLAR PANEL			N07
504			X			LAC3211-020501			COATING SPEC		COAT PER	N09
505			X			LAC3575-019993			MARKING METHOD		MARK PER	N04

NOTE NO. NOTE TEXT — STD NOTE

QK NOTE LINE INDICATORS (A, B, C, ETC.) ARE NO LONGER REQUIRED AND HAVE BEEN REMOVED

116

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1. EACH OF THE 15 SOLAR CELLS SHALL BE BONDED TO THE SUBSTRATE THROUGH 3 BONDING SLOTS.

(NOTE CONTINUED NEXT PAGE)

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PREPARED BY	DATE	APPROVAL	DATE	APPROVAL	DATE
Kevin M Bilger	86-03-07				
CHECKED BY	DATE	APPROVAL	DATE	APPROVAL	DATE
A. Saltzeb	86-03-07				

FORM LMSC 2542 F-10 ABBREVIATIONS LC = LIFE CODE SEQ NO = SEQUENCE NUMBER ORGN = ORGANIZATION

LOCKHEED MISSILES & SPACE COMPANY, INC.

TITLE	DESIGN ORGN	DATE	PAGE	OF	CFE	CUL	PL	REV
		86 MAR 07	2				X8517166	–

CONTRACT NUMBER	AUTHORITY	FSCM NO	CCA/CI NO.

ENGINEERING PARTS LIST

ITEM NO	LOCATION SH	LOCATION ZONE	QUANTITY PER ASSEMBLY	UNIT OF MEAS	FSCM NO.	PART/DOCUMENT NUMBER	SEQ. NO.	CCA/CI NO. IDENT	DESCRIPTION	LC	REFERENCE DESIGNATION/ MATERIAL/NOTES	NOTE ITEM NO.

NOTE NO. NOTE TEXT (CONTINUED) STD NOTE

2. THE MINIMUM BONDING AREA SHALL BE 90% OF THE SLOT AREA FOR ALL SLOTS.
3. BONDLINE THICHNESS SHALL BE .005 IN THICK.
4. THE CURED ADHESIVE SHALL NOT BRIDGE IN MORE THAN ONE PLACE BETWEEN ANY 2 ADJACENT SLOTS.

003 LOCAL NOTE: SOLDER CIRCUIT WIRES ITEM 204 TO ITEM 2 PER ITEM 500 USING ITEM 205.

004 LOCAL NOTE: MARK PART NO. PER ITEM 505 APPROX AS SHOWN.

005 LOCAL NOTE: SINGLE LEADS SHOWN SHOULD BE APPROX 3 FT. LONG.

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008 FUNCTIONAL TEST THE ELECTRICAL PERFORMANCE OF EACH CELL CIRCUIT UNDER REE DIRECTION.

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117

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CHECKED BY a.l.	DATE	APPROVAL	DATE	APPROVAL	DATE

FORM LMSC 2542 F-10 ABBREVIATIONS LC = EFF CODE. SEQ NO = SEQUENCE NUMBER. ORGN = ORGANIZATION

LAST PAGE – TOTAL PAGES THIS LIST 2

LOCKHEED MISSILES & SPACE COMPANY, INC

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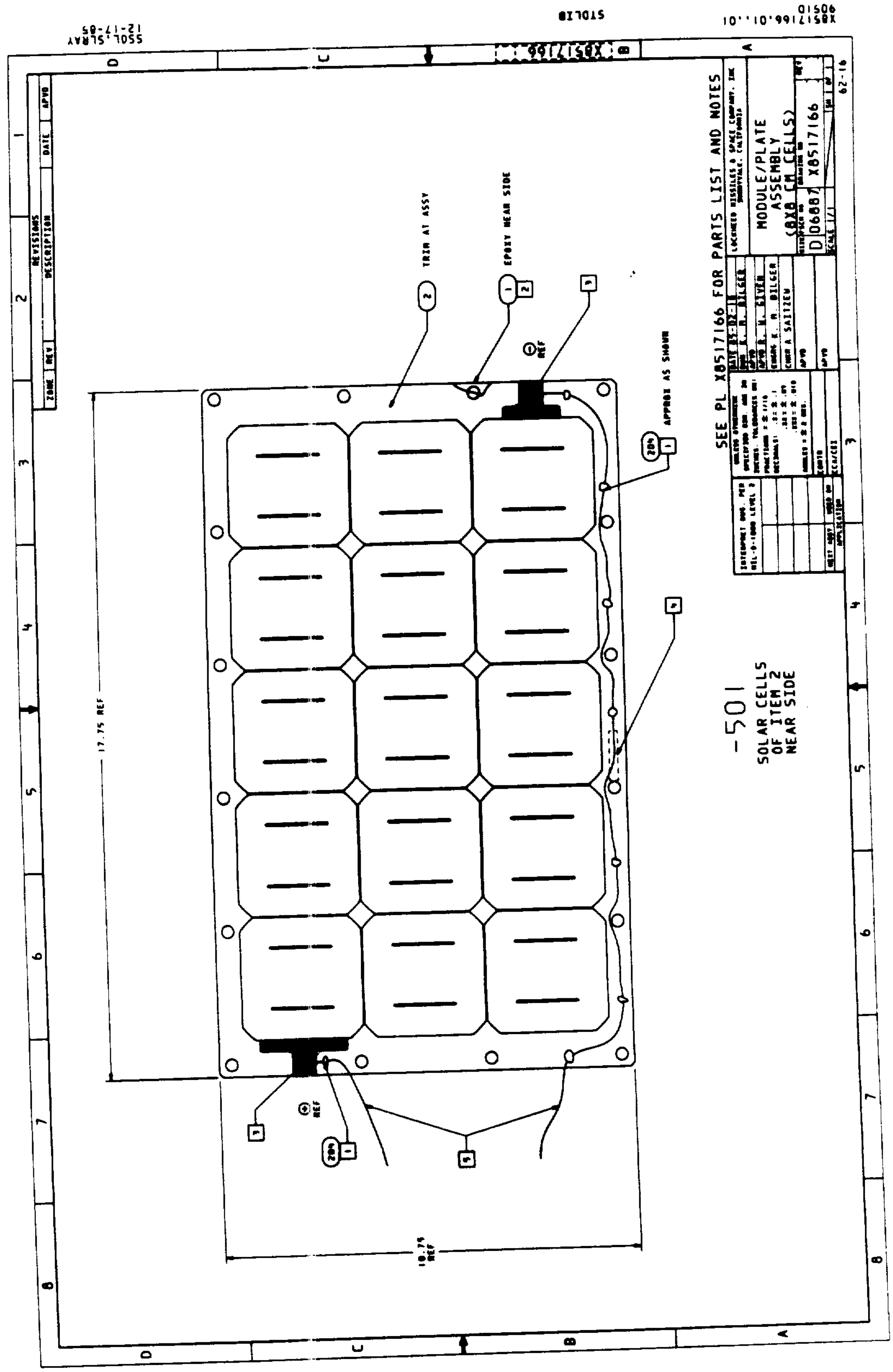


APPENDIX B

MODULE CAPACITANCE AND RESISTANCE

I. Normal Orientation, 28 cells

Use 55 mils silica/epoxy on aluminum

Approx 2250 pf
Approx 1.4×10^{11} ohms

II. Upside Down Orientation, 28 cells, 6 mil covers

Use 50 mils silica/epoxy on aluminum

Approx 2250 pf
Approx 1.5×10^{11} ohms

NORMAL CELL ORIENTATION

I. Materials Properties

MATERIAL	DIELECTRIC CONSTANT in ε_0	VOLUME RESIVITY Ω - cm	DIELECTRIC STRENGTH volts/mil
Silicone	4.3 to 3.4	10^{14} to 10^{16}	400 to 700
Kapton	3.9 to 3.5	10^{15} to 10^{16}	310 to 560
Epoxy	5.2 to 2.8	10^{14} to 10^{16}	400
Silica	3.8	6.3×10^{14}	

II. Capacitance (~DC)

Find capacitance on a per cell basis (34.8 cm²)

Area 1

- Copper interconnect
- 2 mils Silicone
- X mils Silica/Epoxy

} Capacitance $= C_1$

Area 2

- Cell
- 1 mil Kapton
- 2 mils Silicone
- X mils Silica/Epoxy

} Capacitance $= C_2$

$$\boxed{\text{Assume all } \varepsilon \text{ average to } 3.8\varepsilon_0}$$

$$C_1 = \frac{\varepsilon\varepsilon_0 \text{ Area}}{d_1} = \frac{3.8 * 8.85 \times 10^{-14} \text{ Farads/cm} * 34.8 \text{ cm}^2}{(2 + X)\text{mil} * 0.00254 \text{ cm/mil}} = \frac{4607}{(2 + X)\text{mil}} \text{ pico farads}$$

$$C_2 = \frac{\varepsilon\varepsilon_0 \text{ Area}}{d_2} = \frac{3.8 * 8.85 \times 10^{-14} \text{ Farads/cm} * 34.8 \text{ cm}^2}{(3 + x)\text{mil} * 0.00254 \text{ cm/mil}} = \frac{4607}{(3 + x)\text{mil}} \text{ pico farads}$$

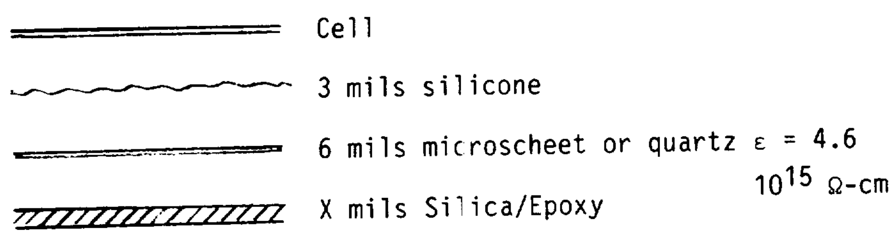
Let C_1 be 25% of area, C_2 = 75% of area

MODULE, UPSIDE DOWN ORIENTATION

I. Material - same as "Normal Cell Orientation"
Assume all εs = $3.8\varepsilon_0$ for silica/epoxy, silicones

II. Capacitance (~DC)

On a per cell basis



$$C = \frac{\varepsilon\varepsilon_0 \text{ Area}}{d} = \frac{3.9 \times 3.85 \times 10^{-14} \text{ farads/cm} * 34.8 \text{ cm}^2}{(3 + 6 + X) * 0.00254 \text{ cm/mil}}$$

$$C = \frac{4729}{(9 + X)} \text{ pf per cell}$$

Module capacitance = 28 * cell capacitance

$$2000 \text{ to } 2500 \text{ pf} = 28 * \frac{4729}{(9 + X)} \text{ pf}$$

$$71 \text{ to } 89 = \frac{4729}{9 + X}$$

$$X = \frac{4729}{71 \text{ to } 89} - 9$$

$$\boxed{2000 \text{ to } 2500 \text{ pf} = X = 58 \text{ mils to } 44 \text{ mils silica/epoxy}}$$

III Resistance

$$\text{Resistance} = \frac{10^{15}\ \Omega\text{-cm } (X + 9)\text{mils} * 0.00254 \text{ cm/mil}}{28 \text{ cells} * 34.8 \text{ cm}^2/\text{cell}}$$

$$\text{Resistance} = 2.607 \times 10^9 * (X + 9)\text{mils}$$

for

X = 58	R = 1.75×10^{11} Ωs
X = 44	R = 1.38×10^{11} Ωs

$$C_{\text{per cell}} = .25C_1 + .75C_2 \text{ or } = \left(\frac{1151}{(2+X)_{\text{mils}}} + \frac{3453}{(3+X)_{\text{mils}}}\right) \text{ pico farads per cell}$$

Module capacitance = 28 * cell capacitance

$$\text{So } 2000 \text{ to } 2500 \text{ pico farads} = 28 * \left(\frac{1151}{(2+X)_{\text{mils}}} + \frac{3453}{(3+X)_{\text{mils}}}\right) \text{ pico farads}$$

or

$$\overset{(1)}{71} \text{ to } \overset{(2)}{89} = \frac{3453 + 1151x + 6906 + 3453x}{6 + 5x + x^2} = \frac{10359 + 4604x}{6 + 5x + x^2}$$

(1) $X^2 - 59.8\,x - 140.0 = 0 \rightarrow x = 62, -4.5$ mils

(2) $X^2 - 46.7X - 110.4 = 0 \rightarrow x = 49, -4.5$ mils

$$\boxed{X = \text{silica/epoxy} \begin{cases} X = 62 \text{ mils at } 2000 \text{ pf} \\ X = 49 \text{ mils at } 2500 \text{ pf} \end{cases}}$$

III. Resistance

Assume average of $>10^{15}$ Ω-cm restivity for silica/epoxy

then,

$$\text{Resistance} = \frac{10^{15}\ \Omega\text{-cm} * (X \text{ mils}) * 0.00254 \text{ cm/mil}}{28 \text{ cells} * 34.8 \text{ cm}^2/\text{cell}}$$

Resistance = $2.607 \times 10^9 * (X \text{ mils})$

for	X = 62 mils	R = 1.62×10^{11} Ωs
	X = 49 mils	R = 1.28×10^{11} Ωs