ELECTRONIC SPACE SYSTEMS CORPORATION
OLD POWDER MILL ROAD CONCORD, MASSACHUSETTS 01742
ESSCO

TELEPHONE 617-369-7200
TELEX 92-3480

IN REPLY REFER TO E5817

12 METER MILLIMETER WAVE TELESCOPE
MEMO No. 55

June 24, 1981

NOTE BY JWF:
This memo is essentially all that is new in the ESSCO proposal. Appendix A is our #42 which you already have.

National Radio Astronomy Observatory
Edgemont Road
Charlottesville, Virginia 22901

Attention: J. Marymor
Manager, Contracts

Reference: Request for Proposal #228 -
Millimeter Wave Telescope Panels

Gentlemen:

Electronic Space Systems Corporation (ESSCO) is pleased to respond to the referenced RFP to provide millimeter wave telescope panels to resurface the 12 meter radio telescope at Kitt Peak. Our offer consists of the Technical Proposal, Pricing Proposal, the completed certifications, and this letter. ESSCO has been producing millimeter wave radio telescopes for over ten years, and has the expertise, tooling, and measuring equipment necessary for construction of the surface panels to the required accuracy.

We are in general agreement with the contract terms and conditions contained in Schedule B of RFP #228, except as follows:

1. Article 2. Inspection. Notwithstanding the inspection clause, ESSCO's offer is based on our standard warranty, which covers defects in material and workmanship, freight paid by Purchaser, within a reasonable period after discovery, and in any event within a period of one year from date of acceptance at ESSCO's factory.

2. Article 3. Drawings, Designs, Specifications. The design, design data, specifications, and manufacturing processes for ESSCO telescope panels were developed entirely at private expense, and remain the sole property of ESSCO. Any data provided in conjunction with this contract will be delivered with Limited Rights. This article should be amended to reflect these points.

3. Article 15. Disclosure of Inventions. See discussion above. This article should be deleted.

ESSCO is aware of the 4 month delivery requested, and could accommodate this time scale. However, due to the nature of the work involved, we feel that delivery of approximately 5 months is more appropriate, in order to produce the best possible panels. While we are confident of producing panels with a .05mm rms, recent developments indicate that we may be able to achieve close to .025mm rms panels for this program. The additional time will assist us in pursuing this goal.

We would of course be happy to discuss any aspect of this proposal in detail at your convenience. We look forward to working with NRAO on this program.

Very truly yours,

ELECTRONIC SPACE SYSTEMS CORPORATION

Susan M. Cuevas
Sales Manager

SMC/msf

DEPARTMENT OF DEFENSE
CONTRACT PRICING PROPOSAL

Form Approved
Budget Bureau No. 22-R0160

This form is for use when submission of cost or pricing data (see ASPR 3-807.3) is required

PAGE NO. 1 | NO. OF PAGES 2

NAME OF OFFEROR: Electronic Space Systems Corp.	SUPPLIES AND/OR SERVICES TO BE FURNISHED: Millimeter Wave Telescope Panels
HOME OFFICE ADDRESS (Include ZIP Code): Old Powder Mill Road, Concord, Massachusetts 01742	QUANTITY: Lot; TOTAL AMOUNT OF PROPOSAL: $ 161,000
DIVISION(S) AND LOCATION(S) WHERE WORK IS TO BE PERFORMED: Concord, Massachusetts	GOVERNMENT SOLICITATION NO.: RFP #228

COST ELEMENTS	PROPOSED CONTRACT ESTIMATE: TOTAL COST[1]	UNIT COST[2]	REFERENCE[3]
1. DIRECT MATERIAL[4] a. PURCHASED PARTS[5]			
1. DIRECT MATERIAL[4] b. SUBCONTRACTED ITEMS[6]			
1. DIRECT MATERIAL[4] c. OTHER MATERIAL (1) RAW MATERIAL[7]	$ 30,228		See p. 2
1. DIRECT MATERIAL[4] c. OTHER MATERIAL (2) STANDARD COMMERCIAL ITEMS[8]			
1. DIRECT MATERIAL[4] c. OTHER MATERIAL (3) INTERDIVISIONAL TRANSFERS (at other than cost)[9]			
2. MATERIAL OVERHEAD[10]			
3. INTERDIVISIONAL TRANSFERS AT COST[11]			
4. DIRECT ENGINEERING LABOR[12]	22,931		See p. 2
5. ENGINEERING OVERHEAD[10]	33,250		145%
6. DIRECT MANUFACTURING LABOR[12]	14,108		See p. 2
7. MANUFACTURING OVERHEAD[10]	20,457		145%
8. OTHER COSTS[13]			
9. SUBTOTALS	120,974		
10. GENERAL AND ADMINISTRATIVE EXPENSES[10]	30,244		25%
11. ROYALTIES[14]			
12. FEDERAL EXCISE TAX[15]			
13. SUBTOTALS	151,218		
14. PROFIT OR FEE	9,782		6.5%
15. TOTAL PRICE (Amount)	$ 161,000		

I. HAVE THE DEPARTMENT OF DEFENSE, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, OR THE ATOMIC ENERGY COMMISSION PERFORMED ANY REVIEW OF YOUR ACCOUNTS OR RECORDS IN CONNECTION WITH ANY OTHER GOVERNMENT PRIME CONTRACT OR SUBCONTRACT WITHIN THE PAST TWELVE MONTHS?

☒ YES ☐ NO IF YES, IDENTIFY BELOW.

NAME AND ADDRESS OF REVIEWING OFFICE (Include ZIP Code): DCAA, 424 Trapelo Rd, Waltham, MA 02154

TELEPHONE NUMBER: 617-894-2400 x728

II. WILL YOU REQUIRE THE USE OF ANY GOVERNMENT PROPERTY IN THE PERFORMANCE OF THIS PROPOSED CONTRACT?

☐ YES ☒ NO IF YES, IDENTIFY ON A SEPARATE PAGE.

III. DO YOU REQUIRE GOVERNMENT CONTRACT FINANCING TO PERFORM THIS PROPOSED CONTRACT?

☒ YES ☐ NO IF YES, IDENTIFY: ☐ ADVANCE PAYMENTS ☒ PROGRESS PAYMENTS ☐ GUARANTEED LOANS

IV. HAVE YOU BEEN AWARDED ANY CONTRACTS OR SUBCONTRACTS FOR SIMILAR ITEMS WITHIN THE PAST THREE YEARS?

☒ YES ☐ NO IF YES, SHOW CUSTOMER(S) AND CONTRACT NUMBERS BELOW OR ON A SEPARATE PAGE.

V. DOES THIS COST SUMMARY CONFORM WITH THE COST PRINCIPLES SET FORTH IN ASPR, SECTION XV (see 3-807.2(c)(2))?

☒ YES ☐ NO IF NO, EXPLAIN ON A SEPARATE PAGE

This proposal is submitted for use in connection with and in response to RFP #228

_____ * and reflects our best estimates as of this date,

in accordance with the instructions to offerors and the footnotes which follow:

*DESCRIBE RFP, ETC.

TYPED NAME AND TITLE: Susan M. Cuevas, Sales Manager	SIGNATURE
NAME OF FIRM: Electronic Space Systems Corporation	DATE OF SUBMISSION: June 25, 1981

Essco

	LABOR HOURS Engineering	Drafting	Production	Mat'l Costs
Production Panels	288	-	792	
Panels	-	-	-	$ 2,749
Surface Sheet	-	-	-	2,801
Support Grillage	-	-	-	11,761
Panel Assembly & Hardware	-	-	-	153
Targets	-	-	-	792
				18,256
Prototype Panel Construction	72	-	198	4,572
Mold Contour Analysis	299	-	456	1,000
Modification to the Holding Fixture Routing Template, Mold, & Slitting Template for the Outer Panel	80	-	80	1,000
Documentation of Outer Panel	8	56	-	-
Documentation of Outer Panel Tool Mods	8	56	-	-
Software for Processing Measurement & Final Report	40	-	-	-
Modifying 8 Outer Panels to Provide Cut-Out for Spar Attachments	40	-	40	-
Panel Crate Design - 2 Types	20	40	-	-
Panel Crates (3) & Packing/ Loading	-	-	144	5,400
Program Management	400	-	-	-
Total	1,255	152	1,710	$ 30,228

Totals:

Engineering	1,255 hrs. @ $17.00	$21,335
Drafting	152 hrs. @ $10.50	1,596
		$22,931
Production	1,710 hrs. @ $ 8.25	$14,108

Essco

Technical Proposal
for
Millimeter Wave
Telescope Panels

Submitted To:

National Radio Astronomy Observatory
Edgemont Road
Charlottesville, Virginia 22901

In Response To:

Request For Proposal No. 228

Submitted By:

Electronic Space Systems Corporation
Old Powder Mill Road
Concord, Massachusetts 01742

Esco

THE FOLLOWING APPLIES TO THIS ENTIRE DOCUMENT

This data furnished in this document shall not be disclosed outside the customer's organization, or be duplicated, used or disclosed in whole or in part for any purpose other than to evaluate the proposal; PROVIDED, that if a contract is awarded to this offeror as a result of or in connection with the submission of such data, the customer shall have the right to duplicate, use or disclose this data to the extent provided in the contract. This restriction does not limit the right to use information contained in such data if it is obtained from another source.

Electronic Space Systems Corporation
Old Powder Mill Road
Concord, Massachusetts 01742

INTRODUCTION

This Technical Proposal responds to the National Radio Astronomy Observatory's "Specification for 12-Meter Telescope Surface Panels", June 10, 1981, included as Schedule C in RFQ No. 228. The Proposal will cover the following topics, as required by the above specification:

1.0 General Description of Surface Panels

2.0 Detailed Surface Panel Description

3.0 Coordinate Measuring Machine (CMM) Description

4.0 Method of Mounting and Measuring Panels on CMM

5.0 Data Presentation

6.0 Surface Accuracy

1.0 General Description of Surface Panels

The surface panel complement for the 12-meter reflector consists of 24 inner and 48 outer panels.

The inner panels outline a central hole in the reflector surface, which is a 24-sided regular polygon into which can be inscribed a 47.21 inch (1.199 meter) diameter circle. The inner panels are spaced evenly around the dish on 15 degree centers.

The 48 outer panels are spaced evenly around the dish on 7.5 degree centers, and define a regular 48-sided polygon at the perimeter of the dish. This polygon can be inscribed by a 472.4 inch (12.0 meter) circle.

The inner panels are supported at eight points and the outer panels at six points as described in ESSCO Document D81-15. (See Appendix A.) The nominal gaps between properly set panels are .10 inch (2.54 mm). The panels weigh approximately 1.75 lb/sq.ft. (8.56 kg/m^2), so that each inner panel weighs approximately 39 lbs. (17.7 kg), and each outer panel weighs approximately 30 lbs. (13.6 kg).

2.0 Detailed Surface Panel Description

Each surface panel is a .040 inch (1 mm) thick aluminum surface sheet that is supported by a structural grillage as shown in Figure 1. The grillage members consist of two longitudinal ribs (radial to the reflector surface) made from formed aluminum channels to which an aluminum strap is bonded as shown in Figure 2, and a series of transverse ribs that are made from the same aluminum channel. The grillage members are bonded to the surface sheet and to one another on a mold while being held in place with a holding fixture that maintains the spatial relationship of the structure during the curing cycle. After bond cure, the transverse ribs are rivetted to the longitudinal ribs while the panel is on the mold.

ESSCO Drawing D793-317 "Inner Panel Assembly, 45' Diameter Reflector", is included as Appendix B for reference.

The surface skin, radial strap, and formed channels (see Figure 2) are made from 5052-H32 aluminum, and the rivets have a 5056 aluminum body with a coated steel mandrel. Bonding is performed using Hysol EA 9410 epoxy. Properties of the above material are included in Appendix C.

3.0 Coordinate Measuring Machine (CMM) Description

Control of tooling fabrication and surface panel measurement at ESSCO is obtained through use of a 3-axis coordinate measuring machine (CMM), shown in Figure 3. The CMM has a measurement capability of 180 inches in X, 70 inches in Y and 24 inches in Z. All axes of the CMM are equipped with Farrand linear inductosyn position transducers to obtain position readout and visual display with a resolution of .0001 inches (2.54 μm). ESSCO has recently measured and aligned the CMM using a laser interferometer and jig transit to determine that position accuracies of ± .00025 inches (6.35 μm) in Z, ± .0003 inches (7.62 μm) in Y, and ± .000875 (22.23 μm) in X are obtained over full travel. Readout repeatability was also measured and found to be better than ± .0001 inches (2.54 μm).

The CMM is made up of a large granite slab supporting a bridge which travels over the length of the slab in the X direction. The bridge is supported on the slab with air bearings to assure low friction and excellent repeatability.

The slab is 17 feet (5.2 meters) long by 7.2 feet (2.2 meters) wide by 2.2 feet (.67 meter) deep, and is supported on its own concrete footings.

The bridge is a granite beam 3 inches (7.6 cm) wide by 11 inches (27.9 cm) deep, and travels in the X direction approximately one meter above the slab. The beam is supported by steel legs extending down to the slab. The beam supports a steel housing which travels in the Y direction on air bearings.

The housing contains a pair of linear ball bearings supporting a shaft which travels in the Z (vertical) direction.

At the bottom of the shaft is a precision guage block which is used by the machine operator to set the probe.

All three axes are driven by DC stepper motors with rotating lead screws and travelling units attached to the driven components.

The machine operator uses forward/reverse switches and speed control knobs at the control console to position the probe to the desired point in X, Y, and Z.

4.0 Method of Mounting and Measuring Panels on CMM

The bracketry and fasteners supporting the panel on the standard ESSCO backstructure are shown in Figure 1. For panel measurement, the aluminum "panel mounting bracket" is replaced by an aluminum angle, which is mounted on the bed of the coordinate measuring machine (CMM), as shown in Figure 4. All other hardware remains the same.

Extending through the slot in the top of the bracket is a steel 1/2-20 UNF hollow threaded rod, supported by a pair of spherical washer sets and nuts. The slots in the bracket allow for radial and circumferential panel adjustment on the backstructure, while the threaded rod/spherical washer/nut arrangement permits panel adjustment normal to the reflecting surface, as well as correction of angular misalignment between the top of the bracket and the backside of the panel. This angular correction minimizes any tendency for the panel supporting hardware to deform the panel, and thus degrade the panel surface accuracy. Any small deformations which do occur are included in the panel accuracy measurements on the CMM.

Finally, the panel is fastened to the top of the threaded rod by a 1/4-20 UNC bolt which extends through the full length of the threaded rod, and is held in place with a washer and locking nut, as shown in Figure 1.

For surface accuracy measurements, the panel is supported on the bed of the CMM as shown in Figure 3, using the hardware described above. The inboard tooling holes (hole A of the inner panel and hole C of the outer panel shown in Document D81-15 in Appendix A) are set to the proper X and Y coordinate, and the outer tooling holes (B0 and D) to the proper Y coordinate only, all to a tolerance of $\pm$ 25 μm. Then the target holes (1 through 4 on the inner panel and 5 through 7 on the outer panel) are adjusted to within 25 μm of their proper height using the adjustment screws positioned directly below each target hole. The tooling hole positions are checked and adjustments are made as required until all hole positions are within tolerance.

The panel surface position is calculated by an on-line computer (using the "PDAS" program in Document D81-15) which directly reads the X_2 and Y_2 coordinates of the CMM probe tip, calculates the theoretical Z_2 panel position, compares it to the measured Z_2 position of the probe tip and informs the operator as to the difference. Thus, the operator can find the panel surface error at any point on the surface.

Once the panel is properly set up on the CMM, 72 data points are read on the inner panel, and 51 on the outer panel. These points are pre-selected such that each point represents an equivalent surface area of the panel.

5.0 Data Presentation

The individual panel surface readings will be included with the delivery of the panels, along with individual panel and aggregate rms accuracy results. The calculations will be performed as described in Section 4.0 of Document D81-15.

A typical panel data sheet for a panel identical to the inner 12-meter panels is included as Figure 4.

6.0 Surface Accuracy

Data taken on panels manufactured recently using the same tooling, personnel, and material as those for the 12-meter panels indicate that an aggregate rms surface accuracy considerably better than 50 μm (2.0 mils) can be expected.

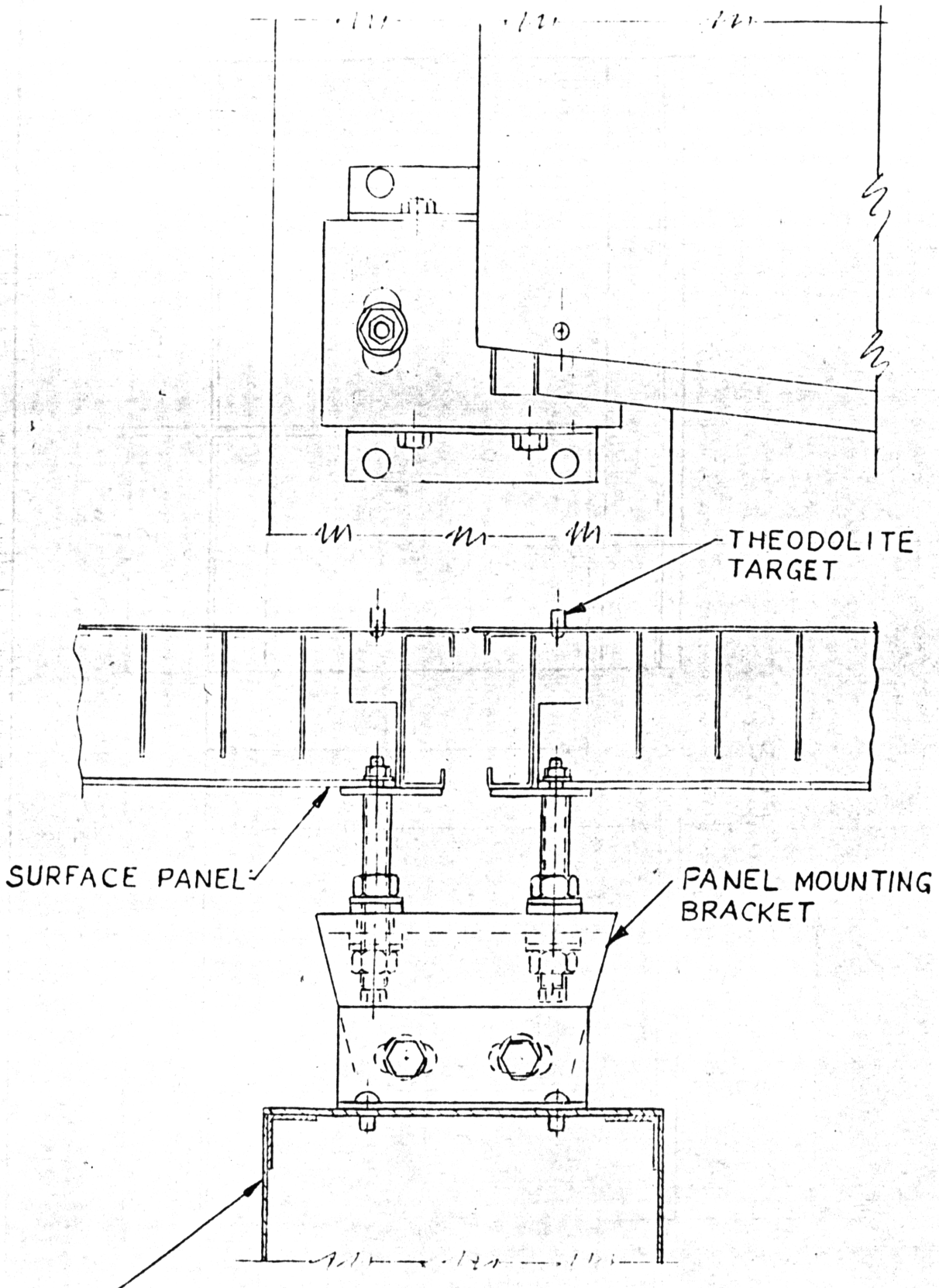

FIGURE 1

SURFACE PANEL MOUNTING BRACKET

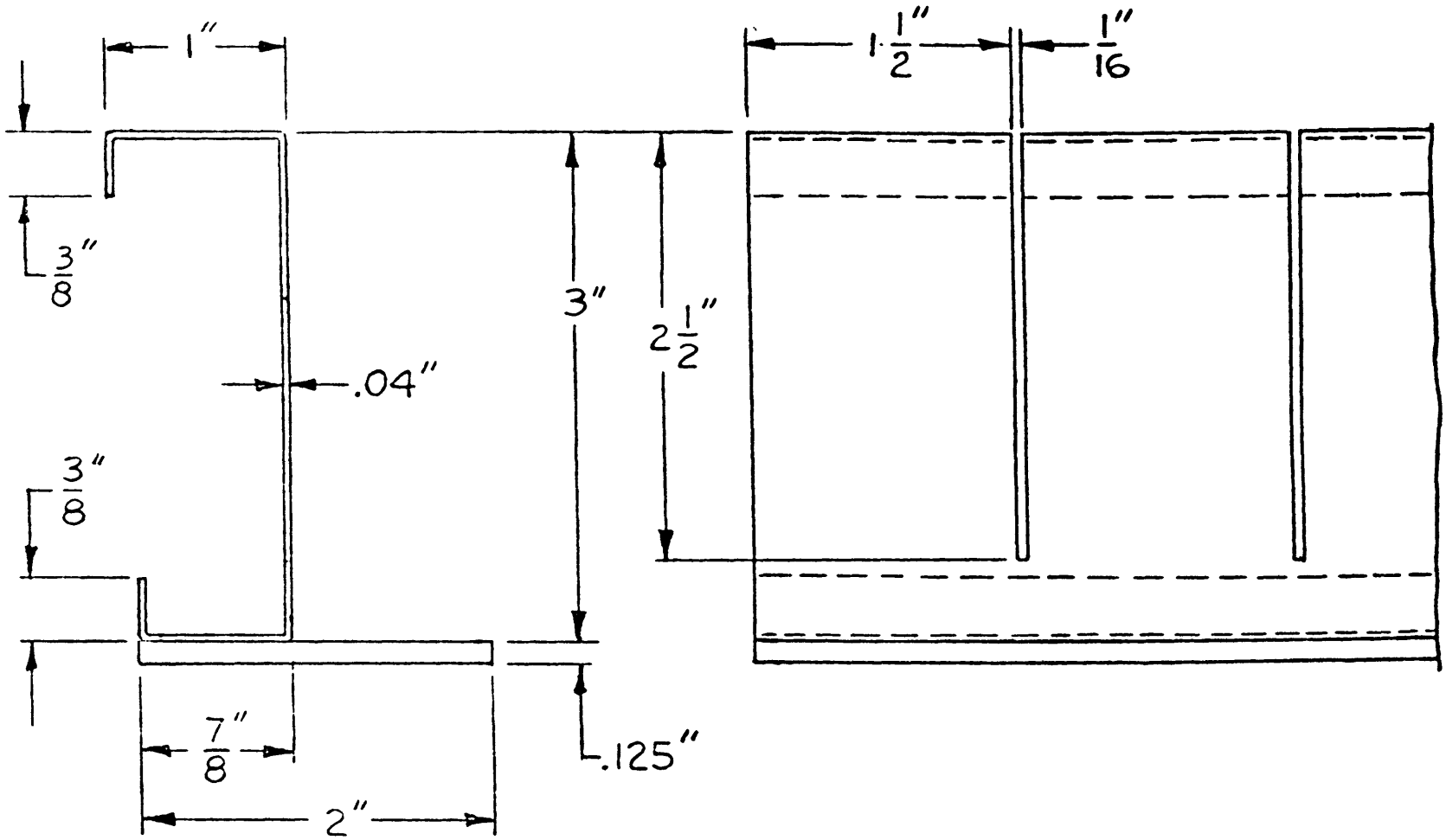

FIGURE 2

TYPICAL LONGITUDINAL GRILLAGE MEMBER

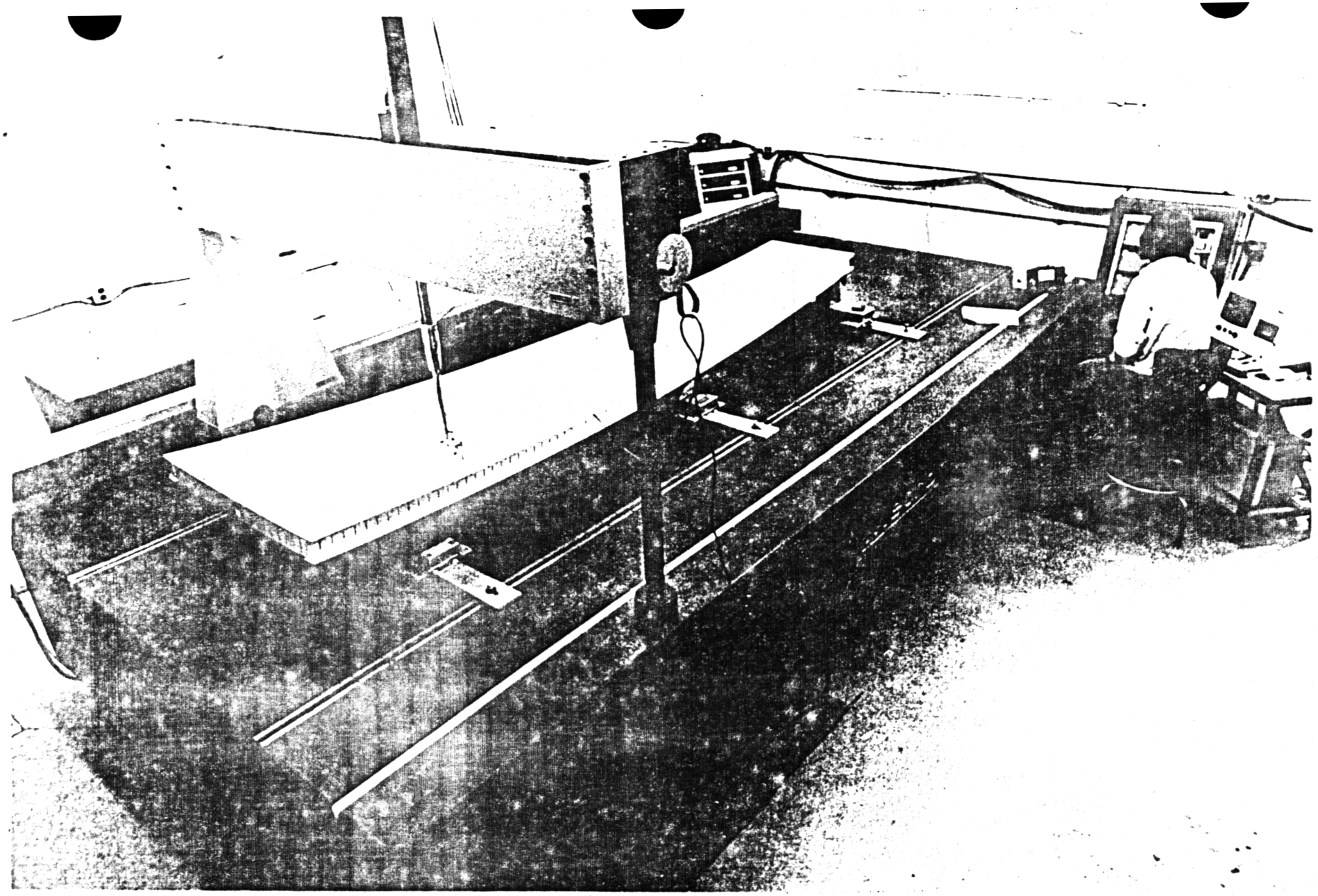

Figure 3 ESSCO Reflector Panel Being Measured on XYZ Coordinate Measuring Machine

ESSCO
ELECTRONIC SPACE SYSTEMS CORPORATION
OLD POWDER MILL ROAD • CONCORD, MASSACHUSETTS 01742
PHONE 617-369-7200 • TELEX 92-34-80

INNER PANEL NO 9007

X (IN.)	Y (INCHES) -17.5	-14	-10	-5	-2.5	0	2.5	5	10	14	17.5
5	0.0	-1.5	-1.1	1.3		1.5		0.7	0.0	-0.7	0.0
15	0.3	-2.4	-1.1	-0.7		0.0		-0.5	-0.2	-1.0	-1.1
25		-2.0	-1.6	-1.0		-1.9		-0.7	-0.1	-1.4	
35		-1.8	-1.6	-0.7		1.5		0.9	0.6	-0.4	
45		-1.6	-0.4	1.6		2.8		1.5	-1.9	0.2	
55			-0.7	-0.6		-0.4		0.8	1.2		
65			0.1	1.9		3.6		2.0	1.3		
75			1.9	0.8		4.1		3.0	3.3		
85				-0.5		1.9		0.8			
95				1.3		0.6		-0.9			
105				1.5		3.2		-0.7			
115				3.5		0.0		0.0			
125					1.0	1.5	0.9				
134					1.0	-6.8	-0.7				

N = 72

RMS = 1.67(MILS) AVE DEV = 0.20(MILS)

TYPICAL INNER PANEL DATA SHEET

Figure 4