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Heliosat Production Evaluation and Cost Analysis

Prepared by
General Motors Corporation
Warren, Michigan

MASTER

SERI

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A Division of Midwest Research Institute

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**HELIOSTAT PRODUCTION
EVALUATION AND
COST ANALYSIS**

DECEMBER 1979

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**GM TRANSPORTATION SYSTEMS CENTER
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PREPARED UNDER SUBCONTRACT
NO. XL-9-8052-1

**FOR THE
SOLAR ENERGY RESEARCH INSTITUTE
A DIVISION OF MIDWEST RESEARCH INSTITUTE**

**OPERATED FOR THE
U.S. DEPARTMENT OF ENERGY
CONTRACT NO. EG-77-C-01-4042**

**PROJECT MANAGER
DENNIS HORGAN**

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FOREWORD

THE REPOWERING STRATEGY ANALYSIS

The retrofit of solar central receiver heat supply systems to existing steam-generating stations, an application known as "repowering," is being considered as a major programmatic effort by the Department of Energy's Large Solar Central Power Systems Program. Several promising features of repowering lead to this interest:

- **Technical:** Repowering offers a relatively low-risk technical path to large-scale test and demonstration of central receiver technology. Partial reliance on existing hardware places both cost and technical emphasis on the heat supply system, where the major uncertainties lie. However, the hybrid nature of repowered plants permits them to operate even when the solar heat supply system is not providing heat.
- **Demand:** The confinement of risk to the solar portion of the plant makes utility involvement more attractive and facilitates cost-sharing arrangements between the public and private sectors. Early involvement of the eventual user group promises to increase the market development value of the test and demonstration program in several important areas, including relevance, credibility, information dissemination, and response.
- **Supply:** The requirements for cost effectiveness of the solar heat supply system are possibly less stringent in repowering than in new capacity applications. If this is so, then the opportunity for early hardware sales for repowering may be an important advantage for the development of the supply industry.
- **Energy Displacement:** While the likely population of repowerable plants in the Southwest is not large (roughly 4-6 GWe), it is heavily reliant on oil and gas. Thus the direct effects of repowering on energy displacement are in the desired categories.

The determination of an appropriate government response to the opportunities of repowering is an important policy question and is the major reason the Department of Energy (DOE) has requested SERI to perform the Repowering Strategy Analysis. The repowering study objective is to define a government role in repowering that constitutes an efficient program investment in pursuit of viable private markets for heliostat-based energy systems. In support of that objective, this study is designed to identify the scope and nature of the repowering opportunity within the larger context of its contributions to central receiver technology development and commercialization.

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FOREWORD

HELIOSTAT PRODUCTION EVALUATION AND COST ANALYSIS, FINAL REPORT

This final report was prepared under subcontract AH-9-8052-1 as a part of SERI Task 5121.11, the Supply Task of the Repowering Strategy Analysis. The purpose of the Supply Task is to determine the installed cost of solar systems and components in a repowering program and outline the manufacturing investment required to achieve those costs.

The objective of this production evaluation and cost analysis study is to estimate the factory cost of the current generation of heliostat designs at various production volumes. The methodology used to determine the factory cost was that of detailed production cost analysis. Processes were developed for the manufacture of each component of the heliostat down to the lowest level of purchased material. The tooling, labor, and facilities requirements were defined and costed for each of the processes, and vendor quotations were obtained to determine the cost of purchased material. Finally, indirect factory expenses were added to the direct costs to produce the factory cost.

The focus of this study was limited to factory cost and does not include the cost of installation nor does the study provide for a return on capital. However, several interesting results do emerge from this study. The first result is that the factory cost of the McDonnell-Douglas Prototype Heliostat is estimated to be less than \$96/meter² at a production rate of 25,000 units per year. This cost is between one-half and one-third of the cost estimates for the same product in custom production and clearly shows the benefits of mass production. However, the favorable factory cost estimate is dependent on a projected \$89 million investment in facilities and tooling. A second result of the study is that 81 percent of the factory cost is purchased material. This result implies that heliostat manufacture can be a relatively low value added industry, which is a necessary condition for meeting the program cost goals. The high materials fraction also implies that the estimated cost is relatively insensitive to the cost of processing and that the most important area of heliostat development will be the reduction of materials cost.

Dennis N. Horgan, Jr.
Project Manager

GM Transportation Systems Center

SUMMARY

The U.S. Department of Energy has asked the Solar Energy Research Institute (SERI) to perform a Repowering Strategy Analysis. The supply task of that analysis requires the definition of price-quantity relationships for heliostats in order that existing heliostat designs may be assessed for their suitability for mass production and to determine at what level of production unit costs will reach an acceptable level. In addition, the technical obstacles that present heliostat designs offer to mass production, and the capital investment required for mass production to be initiated, are of considerable importance.

The GM Transportation Systems Center has conducted a production evaluation and manufacturing cost analysis of the McDonnell Douglas Astronautics Company (MDAC) Solar Central Receiver Prototype Heliostat design for SERI and the results of that study are contained in the report of which this summary is a part.

In the study, design and engineering data were collected on the MDAC heliostat design, manufacturing processes defined, a manufacturing plant configured, manufacturing labor developed and finally, a factory cost established for two different production volumes. The production volumes considered were chosen by SERI as 25,000 heliostats per year and 250,000 heliostats per year. To provide some insight to the variability of manufacturing costs as a function of percent changes in production level, heliostat costs were also developed at 75 percent and 125 percent of plant capacity for both the 25,000 and the 250,000 , volumes. These percent changes were accomplished by adjusting labor levels and material flow rates for the two plants configured.

Consideration was given to the location for the heliostat plant and Tucson, Arizona was the selected site. Availability of local labor, land, associated supply industry, taxes and transportation to possible central receiver system sites were factors in this selection.

This study developed a "factory cost" for the manufacture of heliostats and it is very important that the definition of this term is clear and explicit. Factory cost is the sum of all costs necessary to place a finished product on the factory dock ready to ship. Factory cost does not include shipping, field installation, profit, return on investment, distributed general and administrative expenses, state or local product or inventory taxes, general commercial expense, sales and advertising costs, public relations costs, or any other profit and loss items. A summary of the cost analysis is given on the next page.

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Annual heliostat production rate	25,000	250,000
Plant size in square feet	304,384	682,240
Investment required	\$87,330,250	\$392,805,000
Factory cost per heliostat	\$ 4,699.07	\$ 3,301.87
Factory cost per square meter	\$ 95.80	\$ 67.31

Due to the speculative nature of the heliostat production scenario, certain suppliers were reluctant to include their investment and/or tooling costs in their material and part quotations. These are real costs that must be considered if heliostat production is begun at mass production levels. The investments required are given below.

Annual heliostat production rate	25,000	250,000
Investment required	\$1,230,730	\$41,000,000

The Policy Analysis Branch of the Solar Energy Research Institute has developed a profit figure and used an installation cost from a study done for SERI by Battelle Northwest Laboratory to allow a comparison to be made of heliostat installed costs. The results are given below.

Annual heliostat production rate	25,000	250,000
Factory cost	\$ 4,699.07	\$ 3,301.87
Profit	\$ 350.86	\$ 207.96
Factory price F.O.B.	\$ 5,049.31	\$ 3,509.83
Installation cost per unit	\$ 940.38	\$ 879.52
Installed cost per unit	\$ 5,990.31	\$ 4,389.35
Installed cost per square meter	\$ 122.12	\$ 89.48

The Battelle installed costs are:

Installed cost per unit	\$ 4,507.01	\$ 3,948.35
Installed cost per square meter	\$ 91.88	\$ 80.49

TABLE OF CONTENTS

	<u>Page</u>
1.0 Introduction	1
1.1 Scope of Work	1
1.1.1 Heliostat	1
1.1.2 Manufacturing	2
1.1.3 Plant	2
1.1.4 Costs	2
1.2 Study Approach	3
1.2.1 Cost Breakdown Structure	3
1.2.2 Bill of Materials	3
1.2.3 Manufacturing Analysis	3
1.2.4 Plant Design	5
1.2.5 Labor Development	5
1.2.6 Cost Extension	5
1.2.7 Factory Cost	5
2.0 Costing Ground Rules	7
2.1 Production Volumes	7
2.2 Design Data Sources	8
2.3 Site Selection	9
2.4 Costing Procedures	13
2.4.1 Land and Improvements	14
2.4.2 Plant Structure and Equipment	14
2.4.3 Special Tools	14
2.4.4 Standard Tools	15
2.4.5 Purchased Parts	15
2.4.6 Raw Material	15
2.4.7 Consumable Supplies	16
2.4.8 Taxes	16
2.4.9 Direct Labor	16
2.4.10 Indirect Labor	16
2.4.11 Plant Engineering	16
2.4.12 Cost Summary	17
3.0 Heliostat Design	19
3.1 General	19
3.2 Design Description	19

TABLE OF CONTENTS (continued)

	<u>Page</u>
3.3 Heliostat Specifications	19
3.3.1 Reflective Surface	22
3.3.2 Support Structure	22
3.3.3 Reflective Unit	22
3.3.4 Drive Assembly	22
3.3.5 Azimuth Drive Housing - Welded	27
3.3.6 Azimuth Drive	27
3.3.7 Drag Link Assembly	30
3.3.8 Torque Tube Assembly	30
3.3.9 Pedestal Assembly	30
4.0 Processing Description	35
4.1 Production Flow	35
4.2 Make/Buy Decisions	38
4.2.1 Reflective Surface	38
4.2.2 Support Structure	38
4.2.3 Reflective Unit	39
4.2.4 Drive Assembly	39
4.2.5 Electrical/Electronic Equipment	41
4.3 Plant Processing and Equipment.....	43
4.3.1 Reflector Assembly	43
4.3.2 Electrical/Electronic	71
4.3.3 Drive Assembly	83
4.3.4 Pedestal Assembly	116
4.3.5 Final Assembly	121
4.4 Plant Layout	123
5.0 Heliostat Production Costs	131
5.1 Cost Approach	132
5.1.1 Purchased Parts	132
5.1.2 Labor (direct/indirect)	133
5.1.3 Tools and Equipment	133
5.1.4 Production Plant Costs	134
5.1.5 Spare Parts	134
5.2 Cost Summaries	135
5.2.1 Full Production	135
5.2.2 Seventy-Five Percent of Capacity	137
5.2.3 One Hundred Twenty-Five Percent of Capacity	138
5.2.4 Material, Labor, and Burden Summaries ...	139
5.2.5 Burden Per Heliostat Unit	141
5.2.6 Non-Allied Tooling and Plant Costs	141
5.2.7 Investment Per Heliostat Unit	142
5.2.8 Installed Price (a SERI Mongraph)	142

GM Transportation Systems Center

TABLE OF CONTENTS (continued)

	<u>Page</u>
6.0 Technical Obstacles to Production	145
6.1 Fusion Glass Plant Capacity	145
6.2 Mirror Surface Protection	146
6.3 Adhesive Cure Time	146
6.4 Mirror Line Capacity	147
7.0 Design/Production Opportunities	149
7.1 Support Structure Weldment	149
7.2 Harmonic Drive	150
7.3 Fusion Glass Front Lite Size	150
7.4 Flex Spline Shear Bolts	150
7.5 Wire-Race Bearing	151
7.6 Fusion versus Float	151
7.7 Fiber Optics versus Copper Cable	151
7.8 Galvanizing	152
7.9 Existing Plant versus New Construction	152
7.10 Weldment versus Casting Costs	153
8.0 References	155
Appendix A Bill of Materials	A1
Appendix B Material Price Requests	B1
Appendix C Tool and Labor Routings	C1
Appendix D Product Cost Estimates	D1
Appendix E Typical Labor Development	E1

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LIST OF FIGURES

	<u>Page</u>
1-1 Heliostat Unit Cost Breakdown Structure	4
3-1 Baseline Prototype Heliostat	20
3-2 Reflective Surface	23
3-3 Support Structure	24
3-4 Reflective Unit	25
3-5 Drive Assembly	26
3-6 Azimuth Drive Welded Housing	28
3-7 Azimuth Drive	29
3-8 Drag Link Assembly	31
3-9 Torque Tube	32
3-10 Pedestal Assembly	33
4-1 25,000 Annual Volume Production Flow Diagram	36
4-2 250,000 Annual Volume Production Flow Diagram	37
4-3 Reflective Surface Line - 25,000 Annual Volume	44
4-4 Glass Loader - 25,000 Annual Volume	46
4-5 Mirror Module Rotator - 25,000 Volume	48
4-6 Stringer Loader - 25,000 Volume	50
4-7 Stringer - Clinch Nut Subassembly - 25,000/250,000....	
Unit Annual Volume	51
4-8 Rollerized Pallet - 25,000 Annual Volume	52
4-9 Reflective Surface Line - 250,000 Annual Volume	54
4-10 Inboard Beam Die Line	55
4-11 Diagonal Beam Die Line	57
4-12 Mirror Support Structure Welding Line	58
4-13 Heliostat Support Structure Station 1,	
Load/Weld Doublers	59
4-14 Heliostat Support Structure Station 2,	
Load/Weld Gussets	60
4-15 Heliostat Support Structure Station 3,	
Manually Arc Weld Gussets/Auto Turn	61
4-16 Heliostat Support Structure Station 4,	
Load Outboard Beam	62

GM Transportation Systems Center

LIST OF FIGURES (continued)

	<u>Page</u>
4-17 Heliostat Support Structure Station 5, Load/Weld Diagonals	63
4-18 Heliostat Support Structure Station 6, Weld Diagonals.	64
4-19 Heliostat Support Structure Station 7, 8, 9, Weld Diagonals to Gussets	66
4-20 Heliostat Support Structure Station 10, 90° Tip Down	67
4-21 Heliostat Support Structure Stations 11 and 12, Counter-Bore	68
4-22 Heliostat Mirror and Back Support Station 13, Unload .	69
4-23 Reflective Unit Assembly	70
4-24 Electrical/Electronic Assembly and Test Area - 25,000 Annual Volume	72
4-25 Electrical/Electronic Assembly and Test Area - 250,000 Volume	73
4-26 Azimuth Drive Housing Machining-#1 - 25,000 Annual Volume	85
4-27 Azimuth Drive Housing Machining-#2 - 25,000 Annual Volume	87
4-28 Azimuth Drive Housing Machining-#3 - 25,000 Annual Volume	88
4-29 Azimuth Drive Housing Machining - 250,000 Annual Volume	92
4-30 Drag Link Machining - 25,000 Annual Volume	94
4-31 Drag Link Machining - 250,000 Annual Volume	97
4-32 Torque Tube Machining-#1 - 25,000 Annual Volume	99
4-33 Torque Tube Machining-#2 - 25,000 Annual Volume	100
4-34 Torque Tube Machining - 250,000 Volume	102
4-35 Drive Unit Assembly Line - 25,000 Annual Volume	113
4-36 Drive Unit Assembly Line - 250,000 Annual Volume	114
4-37 Azimuth/Elevation Assembly Area - 25,000 Annual Volume	117

LIST OF FIGURES (continued)

	<u>Page</u>
4-38 Azimuth/Elevation Assembly Area -	
250,000 Annual Volume	118
4-39 Final Assembly Bench Pedestal Assembly - 25,000 Unit	
Annual Volume	122
4-40 Plant Layout	125/126
4-41 Plant Layout	127/128

LIST OF TABLES

	<u>Page</u>
2-1 Heliostat Component Design and Source Requirements ...	10
2-2 Plant Location Data Comparison	13
3-1 Heliostat Specifications	21
5-1 Spare Parts Requirements - Line Replaceable Units	135
5-2 Total Cost Per Heliostat Unit	
(100% of Plant Capacity)	136
5-3 Total Cost Per Heliostat Unit	
(75% of Plant Capacity)	137
5-4 Total Cost Per Heliostat Unit	
(125% of Plant Capacity)	138
5-5 Heliostat Cost Summary - 25,000 Unit Annual Volume	
(Material, Labor and Burden)	139
5-6 Heliostat Cost Summary - 250,000 Unit Annual Volume	
(Material, Labor and Burden)	140
5-7 Burden Costs Per Heliostat Unit	141
5-8 Non-Allied Tooling and Plant Costs	141
5-9 Investment Per Heliostat Unit	142
5-10 Heliostat Production Cost Per Unit -	
25,000 Units/Year	144
5-11 Heliostat Production Cost Per Unit -	
250,000 Units/Year	144
7-1 Weldment and Casting Cost Estimates	153

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SECTION 1.0

INTRODUCTION

This final report is of a study conducted by GM Transportation Systems Center to develop a manufacturing cost estimate for a heliostat design. The Solar Central Receiver Prototype Heliostat of the McDonnell Douglas Astronautics Company (MDAC) was chosen by the Solar Energy Research Institute (SERI) for the design concept. The major subcontractor to GM Transportation Systems Center was the F. Jos. Lamb Company which developed the processing, tooling, machines, and plant layouts for manufacture of the heliostat. The Harrison Radiator Division, General Motors Corporation, provided substantial assistance in labor development and cost extension, and other General Motors Divisions and Staffs provided aid and consultation.

1.1 SCOPE OF WORK

Frequently cost studies are performed by parties interested in determining whether the developed cost lies above or below a target cost or "bogey." The results of such studies often are obtained by a "top down" evaluation starting with the cost bogie. In the study addressed by this document, a cost bogey was not established, and the effort was concentrated on developing a cost from the "bottom up." This meant that enough design and engineering data had to be acquired in order to develop manufacturing processes, configure a plant in which to build the heliostats, and then collect material and labor costs on a part-by-part basis. Current (1979) production technology was the basis for the production evaluation and cost results are expressed in 1979 dollars.

1.1.1 Heliostat

The background for the heliostat design is provided by the "low cost heliostat" project which was completed during 1978 under the direction of Sandia Livermore Laboratory. One of the four designs involved in this study was that of the McDonnell Douglas Astronautics Company. For the purpose of the current production evaluation and cost analysis study, the MDAC Solar Central Receiver Prototype Heliostat was chosen as the technological basis for the work to be performed. Design data for this heliostat design was defined in a number of ways. First, information was developed to the extent possible from the MDAC Final Report on the low cost heliostat project. Second, data was obtained directly from drawings provided by MDAC and from MDAC personnel during meetings coordinated by SERI. Third, in at least one instance, the azimuth drive, data was developed from representative hardware by inspection and

measurement as drawings with sufficient detail were unavailable; and fourth, design assumptions were made and documented in cooperation with the SERI Contracting Officers Technical Representative (COTR) to fill any final data gaps.

1.1.2 Manufacturing

The ultimate objective of this task was to define the technical information on materials, methods, and labor as required to conduct a manufacturing cost analysis. Each step in the fabrication and assembly of the heliostat from the initial material (raw or purchased part) through the final assembly and packaging for shipment was addressed in accomplishing this objective.

The work defined under manufacturing was to provide the basis for developing a manufacturing cost per heliostat at two selected production volumes, 25,000 heliostats per year and 250,000 heliostats per year. In addition, to provide some insight to the variability of manufacturing cost as a function of production level changes, manufacturing costs were to be developed for 75 percent and 125 percent of plant capacity at both the low and high standard volumes.

Manufacturing equipment, tooling, fixtures, and other devices required in processing and/or assembly operations were to be identified for each step in the manufacturing process. Labor hours were to be carefully developed for each step in the routing and allowances made for machine downtime, for repair and maintenance.

1.1.3 Plant

For this study, a dedicated facility of new construction was chosen as the plant configuration for both the low and high volumes. Factors to be considered in defining the plant for cost analysis are geographic location, land requirements including allowance for possible expansion, available labor and supporting vendor industry, heliostat transportation requirements, material availability and the physical configuration of the building(s) necessary for an integrated manufacturing site.

1.1.4 Costs

The objective of this task was to bring together the details of cost and cost related factors such that the total manufacturing cost for the production of heliostats at the low and high volumes could be estimated. Facility costs, fixed and variable production costs, material costs, burden costs, and all other allocated cost factors will be considered to develop the total factory cost on a per unit (heliostat) basis*.

*See Section 1.2.7, Factory Cost.

1.2 STUDY APPROACH

In order to understand how the production evaluation and cost analysis were performed, the following section lists the major elements of the work effort in the order in which they were accomplished.

1.2.1 Cost Breakdown Structure

A cost breakdown structure diagrams the categories into which the various costs of manufacturing a product are collected. The cost breakdown structure also effectively collects the work effort to be performed into categories which are product related and, thus, can be referred to as a work breakdown structure. Figure 1-1 is the cost breakdown developed for the heliostat. The control or identification numbers, 4410 through 4480, of the cost breakdown structure are in correspondence with those used in the McDonnell Douglas Final Report, Reference 1 of Section 8.0.

1.2.2 Bill of Materials

The basic document upon which any production or cost analysis of a manufactured product is based is called the "bill of materials."

The bill of materials lists every item, part, or raw material required to complete the manufacture and assembly of the heliostat. Primary reference for each item is the ERD code which refers to the cost breakdown structure. Where applicable, items are identified by a commercial part number or referenced to a drawing number. Unit quantities, material specification, form, shape, and weight are indicated, and finally the material source is shown.

The bill of materials for the heliostat analyzed in this study is Appendix A to this document.

1.2.3 Manufacturing Analysis

After completing a bill of materials, the next step in a manufacturing analysis is to provide initial information for tool and labor routing sheets and material purchase request sheets.

Each step of the manufacturing process must be listed on the tool and labor routing sheets. In order to accomplish this, all manufacturing processes and tools required must be developed and/or defined. This was done and the results are shown in Section 4.0.

Figure 1-1. HELIOSTAT UNIT COST BREAKDOWN STRUCTURE

Equipment required in the manufacturing process is also defined and listed on tool and labor routing sheets.

1.2.4 Plant Design

In order to complete the production analysis and labor development, a plant configuration must be determined. Based on the production flow, processing, and equipment shown in Section 4.4, plant layouts were completed for the low and the high volumes.

1.2.5 Labor Development

The development of the labor content of the manufacturing process is a complex, time-consuming procedure. This activity requires an effort similar to the depth of study required for processing development.

Appendix E, Typical Labor Development, shows the type of detail used to generate the labor content for the manufacturing process. The appendix is provided to show how the labor data that is included on the Tool and Labor Routing Sheets was developed.

With the completion of the Tool and Labor Routing Sheets which are contained in Appendix C, burden costs can be developed and the cost extension completed.

1.2.6 Cost Extension

Material cost, labor hours, labor rate, labor cost, burden rate, and burden cost are collected on the Product Cost Estimate sheets to show the total manufacturing cost. The Product Cost Estimate sheets are contained in Appendix D.

1.2.7 Factory Cost

It is important for the reader to understand that from its inception this study of heliostat production costs intended to develop what is known in industry as "factory cost."

Factory cost is:

the sum of all costs necessary to place a finished product on the factory dock ready to ship.

Factory cost does not include:

shipping, field installation, profit, return on investment, distributed general and administrative expenses, state or local product or inventory taxes, general commercial expense, sales and advertising costs, public relations costs, or any other profit and loss items.

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Outside tooling and plant costs were added to factory cost in order to provide a per square meter equivalent factory cost due to the extraordinary requirement for tools, precious metals, mirroring, glass making, gear making, and box making investments which vendor industries contacted during the study indicated they would not undertake.

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SECTION 2.0

COSTING GROUND RULES

The costs developed during this program are manufacturing costs incurred during the production of a single heliostat unit, produced at the manufacturing facility and prepared for shipment to the generation site. This analysis excludes shipping and site-related costs. The following elements from the MDAC cost breakdown of collector equipment have been considered:

- 4410 Reflective Unit
 - 4411 Reflective Surface
 - 4412 Mirror and Back Support
 - 4413 Assembly and Bond
- 4420 Drive Unit
 - 4421 Azimuth
 - 4422 Elevation
 - 4423 Motors
 - 4424 Position/Limit Indicators
 - 4425 Power Supply/Distribution
- 4430 Control and Instrumentation
 - 4433 Control Signal Equipment
- 4440 Foundation and Site Preparation
 - 4441 Foundation (Tapered Pipe only)
- 4450 Heliostat Support and Protection
 - 4551 Heliostat Support Structure

2.1 PRODUCTION VOLUMES

Two production volumes have been selected for the manufacturing cost estimates of heliostat fabrication and assembly: a low-volume case which represents the heliostat usage in two to four major repowering projects and a high-volume case which represents the achievement of higher DOE goals. The low-volume production capacity has been determined by SERI to be 25,000 heliostats per year. The high volume production capacity has been determined by SERI to be 250,000 heliostat units per year. This capacity represents possible future levels of demand and is intended to supply information on the cost sensitivity of heliostats to production volume.

Each production facility has been analyzed to determine the impact on heliostat cost for operations at full capacity (100 percent) as well as points at 75 and 125 percent of capacity. These capacity modifications are made through labor adjustments. At the 75 percent level, shift reductions will be

utilized. For the 125 percent level, third shift and/or overtime operations are scheduled.

At the 25,000 unit annual volume, plant design is based on two shift operations in all areas with the exception of the reflector panels assembly area. This area operates on only one shift. All plant equipment is used with the assumption of 67 percent operating efficiency. This efficiency considers machine downtime, tool replacement and operating stoppages. Therefore, a particular machine, although designed for an operating speed at 100 percent efficiency will only produce at a 67 percent average rate. As an example, a single part of the heliostat which is to be produced at the rate of 25,000 pieces per year on a two shift basis will be made on a machine with a capacity of:

$$25,000 \frac{\text{piece}}{\text{year}} \cdot \frac{\text{year}}{4000 \text{ hours}} \cdot \frac{1}{0.67 \text{ eff.}} = 9.3 \text{ pieces/hour}$$

At the 250,000 unit annual volume, the machine is designed to be capable of producing 93 pieces per hour.

2.2 DESIGN DATA SOURCES

The level of design detail available from MDAC falls into three general categories:

- Manufacturers' information on available components which are assembled into the heliostat
- Assembly and detail drawings of heliostat components together with engineering instruction sheets
- Functional descriptions of electronic and/or fiber optics hardware.

In addition to these data, information was made available by MDAC on mirror lamination and the harmonic drive.

Where a commercial component is used in the heliostat, the technical data used to define the part for cost analysis is the manufacturers' part number or specification. Cost quotations or engineering cost estimates from the manufacturer are used to generate cost data at the 25,000 and 250,000 unit per year volume levels.

The drawings provided by MDAC have been analyzed to define the processing and tooling required for fabrication. If component fabrication is to be completed through an outside supplier, a quotation or engineering cost estimate has been obtained. If the fabrication is to be completed in the heliostat plant, tooling and fabrication labor cost has been developed.

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Where design data do not exist, as is the case for the control signal equipment, commercially available hardware has been selected to meet the functional requirements defined by MDAC. This equipment, being generic in nature, may not be optimum for the heliostat application but is expected to provide reasonable cost data. For the harmonic drive, detail design and processing information were not available. In this case, a commercially available drive unit was analyzed and detail drawings generated to the proper scale for heliostat operation. These detail drawings were then used as the basis for the manufacturing analysis.

Based on the evaluation of the material supplied by MDAC, Table 2-1 has been prepared to show the components which are part of the heliostat assembly. For each component, the type of design data available and the sourcing policy are listed. The sourcing policy is indicated for the 25,000 unit per year capacity level. Those items which are welded, machined and galvanized in the production facility at the 250,000 unit per year capacity are indicated by an asterisk. Components manufactured complete in the plant at this volume are indicated by two asterisks.

2.3 SITE SELECTION

The selection of a general area for the location of a heliostat production facility is influenced by the need to be close to a major potential market area for repowering sites. The selected area includes the states of Texas, New Mexico, Colorado, Arizona, Utah, Nevada, and California. The need to be central to this area is influenced by the shipping costs for completed heliostat components. These components are of low density and shipping costs can be reduced if short-haul trucking can be used between the manufacturing plant and the repowering site. Central states in this general area include: Arizona, Colorado, New Mexico, and Utah. These four states were selected for a more detailed comparison of the following factors:

- Availability of energy and water
- Availability of industrial sites
- Availability of skilled and unskilled labor
- Availability of supporting industry
- Building costs
- Labor costs
- Taxes

Land costs vary considerably, and have relatively little effect on total cost. Therefore, they are not included in the list of factors affecting site selection. In general the availability of the factors listed preclude the selection of smaller urban areas. This limitation and the consideration of a central

Table 2-1. HELIOSTAT COMPONENT DESIGN AND SOURCE REQUIREMENTS

Bill of Materials Reference Number	Component Identification	Design Detail	Source
4411-0C0	Reflective Surface	Assembly Drawing	Plant Assembly
4411-0C1	Front Lite	Material Specification	Supplier
4411-0C2	Back Lite	Material Specification	Supplier
4411-0C4	Mirroring Chemicals	Material Specification	Supplier
4411-0C6	Adhesive	Material Specification	Supplier
4412-0C0	Mirror Support Structure	Assembly Drawing	Plant Assembly
4412-0C9	Diagonal Beam-LH	Detail Drawing	Plant Processing
4412-010	Diagonal Beam-RH	Detail Drawing	Plant Processing
4412-011	Inboard Cross Beam	Detail Drawing	Plant Processing
4412-012	Outboard Cross Beam	Detail Drawing	Supplier
4412-013	Stringer	Detail Drawing	Plant Processing
4412-060	Doubtler	Detail Drawing	Supplier
4412-065	Gusset	Detail Drawing	Supplier
4412-xxx	Hardware	Material Specification	Supplier
4413-0C0	Assembly and Bond	Process Specification	Plant Assembly
4413-0C7	Adhesive	Material Specification	Supplier
4421-0C0	Azimuth Drive	Assembly Drawing	Plant Assembly
4421-066	Bearing Retainer	Detail Drawing	Plant Machining
4421-067	Cover	Detail Drawing	Supplier
4421-070	Housing	Detail Drawing	Plant Machining
4421-071	Oil Pan	Detail Drawing	Supplier
4421-073	Flexible Spline	Parts Analysis	Plant Fabrication
4421-080	Outer Retainer	Detail Drawing	Plant Machining
4421-081	Helicon Gear	Material Specification	Supplier
4421-082	Plate	Detail Drawing	Supplier
4421-105	Drive Shaft	Detail Drawing	Plant Machining
4421-106	Tube	Detail Drawing	Plant Fabrication
4421-110	Circular Spline	Parts Analysis	Plant Fabrication
4421-115	Wave Generator Plug	Parts Analysis	Plant Fabrication

Table 2-1. HELIOSTAT COMPONENT DESIGN AND SOURCE REQUIREMENTS (2 of 3)

Bill of Materials

<u>Reference Number</u>	<u>Component Identification</u>	<u>Design Detail</u>	<u>Source</u>
4421-120	Bushing	Material Specification	Supplier
4421-130	Wave Generator Bearing	Material Specification	Supplier
4421-xxx	Hardware	Material Specification	Supplier
4422-000	Elevation Drive	Assembly Drawing	Plant Assembly
4422-029	Pin	Detail Drawing	Supplier
4422-030	Spacer, Hinge	Detail Drawing	Supplier
4422-031	Spacer, Hinge	Detail Drawing	Supplier
4422-033	Pin-Hinge	Detail Drawing	Supplier
4422-075	Torque Tube Assembly	Detail Drawing	Supplier*
4422-074	Drag Link Assembly	Detail Drawing	Supplier*
4422-121	Bushing - Clevis	Detail Drawing	Supplier
4422-122	Bushing - Trunnion	Detail Drawing	Supplier
4422-123	Bushing, Hinge - Drag Link	Detail Drawing	Supplier
4422-124	Bushing, Hinge - Torque Tube	Detail Drawing	Supplier
4422-133	Thrust Bearing - Clevis	Detail Drawing	Supplier
4422-134	Thrust Bearing - Trunnion	Detail Drawing	Supplier
4422-137	Shim-Clevis	Detail Drawing	Supplier
4422-138	Shim - Trunnion	Detail Drawing	Supplier
4422-172	Actuator Assembly	Material Specification	Supplier
4423-000	Motors, Total	Assembly Drawing	Plant Assembly
4423-148	Motor - Azimuth	Material Specification	Supplier
4423-149	Motor - Tracking	Material Specification	Supplier
4423-150	Motor - Stowage	Material Specification	Supplier
4424-000	Position/Limit Indicators	Assembly Drawing	Plant Assembly
4424-152	Printed Circuit Board	Functional Description	Plant Assembly
4424-155	Vane Actuator	Detail Drawing	Supplier
4424-180	Sensor, Hall Effect	Material Specification	Supplier
4424-181	Line Driver	Functional Description	Supplier
4424-182	Dual Differential Line Receiver	Functional Description	Supplier
4424-xxx	Electronic Components	Functional Description	Supplier

Table 2-1. HELIOSTAT COMPONENT DESIGN AND SOURCE REQUIREMENTS (3 of 3)

Bill of Materials Reference Number	Component Identification	Design Detail	Source
4425-000	Power Supply/Distribution	Functional Description	Plant Assembly
4425-165	Fiber Optic Cable	Functional Description	Supplier
4425-169	Power Cable	Functional Description	Supplier
4425-170	Control Cable	Functional Description	Supplier
4425-190	Circuit Breaker	Functional Description	Supplier
4425-xxx	Electrical Components	Functional Description	Supplier
4433-000	Control/Signal Equipment	Functional Description	Plant Assembly
4433-161	Box	Functional Description	Supplier
4433-167	Optical Transceiver	Functional Description	Supplier
4433-193	Connector	Functional Description	Supplier
4433-194	Micro Computer	Functional Description	Supplier
4433-195	Quad Differential Line Driver	Functional Description	Supplier
4433-196	Quad Differential Line Receiver	Functional Description	Supplier
4433-197	HEX-D Flip Flop	Functional Description	Supplier
4433-199	Power Supply	Functional Description	Supplier
4433-xxx	Electronic Components	Functional Description	Supplier
4451-000	Heliostat Support Structure	Assembly Drawing	Plant Assembly
4451-068	Cover	Detail Drawing	Supplier
4451-099	Cap	Detail Drawing	Supplier
4451-112	Pedestal	Detail Drawing	Supplier**
4451-175	Tapered Pipe	Detail Drawing	Supplier**

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shipment point narrowed the selection process to the following cities:

- Phoenix, Arizona
- Tucson, Arizona
- Denver, Colorado
- Albuquerque, New Mexico

Data for these four cities are compared in Table 2-2. These data do not indicate significant differences among the locations studied for a plant site. For the purpose of the manufacturing cost analysis, cost data will be developed using Tucson as the plant site.

Table 2-2. PLANT LOCATION DATA COMPARISON

	Total Labor Availability in Area (Mfg. Related)	Supporting Industry	Building Costs (Index)	Labor Costs (Avg. Hourly March 1979)
Phoenix	65,000	yes	102.6	\$6.44
Tucson	12,000	yes	101.0	\$6.05
Denver	96,000	yes	100.5	\$6.61
Albuquerque	14,000	yes	100.0	\$5.25

2.4 COSTING PROCEDURES

The costing ground rules govern the generation of the estimated cost for each heliostat unit as produced in the assembly plant and prepared for shipment to the site for installation. A heliostat unit, for this purpose, is defined in Paragraph 1.1.2. These ground rules cover the methods to be used in the generation of cost estimates for all elements pertinent to cost for a single heliostat unit. These elements include:

- Land and improvements
- Plant structure and equipment
- Special tools
- Standard tools
- Purchased parts
- Raw material
- Consumable supplies
- Taxes
- Direct Labor
- Indirect Labor
- Plant Engineering

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Costs have been collected for both the 25,000 and 250,000 unit per year production volumes and the required production facilities. These facilities will be located in Tuscon, Arizona.

In general, the costs associated with each subassembly are collected and identified with the specific subassembly. These costs include: tools, raw material, purchased parts, and direct labor. Those costs which cannot be directly identified with a particular subassembly are collected on a yearly basis, divided by the production volume and added to the total heliostat cost. These costs include: land, plant, consumables, taxes, indirect labor, and plant engineering. A cost breakdown structure to show the collection of heliostat costing is given in Section 4.0.

The following paragraphs give the detail costing methods which govern the generation of estimates for each cost element of the heliostat.

2.4.1 Land and Improvements

Based on the plant configuration and sizing for the two production volumes and the Tuscon, Arizona, site selection, typical plant sites have been developed and costed. Estimates of land and improvements costs are developed in current (1979) dollars.

2.4.2 Plant Structure and Equipment

Plant layouts have been generated for the two production volumes. The plant layouts are shown in Section 4.0.

The plant and equipment cost estimates consider generally applicable building code requirements. The annual cost for the building and equipment is generated by amortizing the investment. This annual cost is uniformly applied over the yearly heliostat production volume.

2.4.3 Special Tools

Special tools are those units which have been designed and fabricated for heliostat production. These include: glass handling equipment, machine tool lines, automated welding lines, conveyors, hoists, adhesive application equipment, cleaning tanks, welding fixtures, zinc plating equipment, bonding equipment and electronic assembly equipment.

Design definition for this equipment has been established and engineering costs generated or budgetary quotes obtained from vendors. The capital cost of this equipment is amortized to

determine an annual cost. This annual cost is then divided by the heliostat volume and the piece cost applied to the corresponding element of the heliostat assembly.

2.4.4 Standard Tools

Standard tools are those items which are available from tool suppliers on a regular basis and may include modifications specific to heliostat production. These items include: flame cutters, vertical turret lathes, numerical control lathes, automatic lathes, hydrosized machines, punch presses, multiple drill stations, numerical control and standard mills, submerged arc and spot welders, saws, broaches and grinders.

Production machine tool catalogs have been consulted to select machines for heliostat production. For each machine, the vendors have submitted budgetary cost information. The capital cost of this equipment is amortized to determine an annual cost. The annual cost is divided by the heliostat volume and the piece cost will be applied to the corresponding element of the heliostat assembly.

2.4.5 Purchased Parts

Purchased parts include items which are in production at outside sources and special design items which are made to heliostat design requirements. These items include: glass, mirroring, rolled steel sections, weldments, steel stock, motors, gears, bearings, screw jacks, miscellaneous hardware, cable, electronic components, printed wiring boards and fiber optic devices.

Supplier quotes, catalog prices, or budgetary costs have been obtained for all purchased parts in the two production volumes. The piece cost, based on these data, is applied to the corresponding elements of the heliostat assembly.

2.4.6 Raw Material

Raw material purchased for heliostat production operation includes: adhesives and chemicals for cleaning. Items which require further processing in the plant, other than assembly, are also considered raw materials.

Supplier quotes or cost estimates have been obtained for raw material sufficient to meet the two production volumes. The piece cost, based on these costs, is applied to the corresponding elements of the heliostat assembly.

2.4.7 Consumable Supplies

Consumable supplies required for heliostat production include: energy (gas - oil - electric), water, welding supplies, grinding materials, machine tool bits, soldering supplies. Estimates for the annual consumption of these materials have been developed and costs generated for the two production volumes. These annual costs are divided by the production volume and the piece cost applied to the corresponding element of the heliostat assembly.

2.4.8 Taxes

State, and local property taxes which are applicable to the production site, plant and equipment have been estimated for the area of the plant site in Tuscon, Arizona. The applicable tax rates are applied to the capital evaluation to determine an annual tax. The annual cost is divided by the production volume and added to piece cost for each heliostat assembly.

2.4.9 Direct Labor

Tooling and routing sheets are prepared for each component of the heliostat assembly to be processed in the assembly plant. The analysis of these sheets included developing the skill level requirements for each labor operation. Based on the skill level requirements and the plant site location, average wage rates have been determined.

For each heliostat component, the labor hour content, multiplied by the skill rate, is added to the piece cost.

2.4.10 Indirect Labor

Indirect labor requirements include: plant supervision, inspection, materials handling and maintenance. Based on the direct labor force in each plant, the indirect headcount has been estimated. Using the appropriate labor rates, the annual cost of indirect labor has been computed. The annual cost is divided by the annual production volume to determine the cost for each heliostat unit.

2.4.11 Plant Engineering

The initial, one-time plant engineering activities represent a substantial investment. These costs have been estimated and amortized. Annual costs generated by the amortization schedule are divided by the production volume to achieve a unit heliostat cost. In addition, the cost of continuing annual plant engineering activities has been estimated, divided by the production volume, and a unit heliostat cost established.

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2.4.12 Cost Summary

Piece, assembly, overhead and packaging costs have been summed for each heliostat unit. This cost, divided by the area of the reflective unit, is used to determine the estimated cost per square meter. (See Section 5.2.)

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SECTION 3.0

HELIOSTAT DESIGN

3.1 GENERAL

The heliostat design considered in this report was developed by the McDonnell Douglas Astronautics Company. This design is a version of the baseline design which was selected by the DOE for the solar central receiver pilot plant competition. Design detail for this baseline heliostat is contained in the MDAC final report. For this project, design details were collected directly from MDAC in meetings held with the contractor. These meetings produced advanced design drawings which were current as of June 1979. Although the MDAC design continues to evolve, the design detail used in this study contains only information obtained from the contractor through July, 1979.

3.2 DESIGN DESCRIPTION

The design is characterized by reflective panels consisting of laminated glass sheets with bonded sheet metal stringers which stiffen the panel and are used to fasten it to the support structure as shown in Figure 3-1. The support structure is fabricated from roll-formed sheet metal sections which are spot-welded together to form the structure. The azimuth drive housing, drag link, torque tube, pedestal and tapered pipe are all fabricated through cutting, forming, and welding of steel material. The harmonic drive gearing in the azimuth drive is made up of fabricated steel elements which are machined. Drive motors, azimuth drive input gearing, and the elevation/stowage jacks are purchased components. Electrical and electronic elements of the signal and power circuits are fabricated in the assembly plant using the following purchased items: electronic components, printed circuit boards, electrical wire, connectors, and fiber optic cables.

3.3 HELIOSTAT SPECIFICATIONS

Specifications for heliostat performance have been extracted from the MDAC final report. These specifications are shown in Table 3-1. These specifications cover operating and design life requirements for the azimuth, tracking, and stowage actuators. Included with these specifications is a description of drive motor requirements.

Figure 3-1. BASELINE PROTOTYPE HELIOSTAT

Table 3-1. HELIOSTAT SPECIFICATIONS

	<u>Azimuth</u>	<u>Tracking</u>	<u>Stowage</u>
Angular Travel	+270 deg.	90 deg.	90 deg.
Backlash and Hysteresis	+1.0 mrad (0.06 deg.)	+1.6 mrad (0.09 deg.) combined	
Travel Speed	12 deg. per min.	12 deg. per min.	12 deg. per min.
Maximum Starting Load	9,830 N-M (87,000 in-lb)	+ 13,890 N-M (122,900 in-lb)	
Maximum Static Load	10,050 N-M (89,000 in-lb)	+ 32,650 N-M (289,000 in-lb)	
Back Drive	None	None	None
Minimum Stiffness	1.13×10^6 N-M/rad (1.0×10^7 in-lb.rad)	1.52×10^6 N-M/rad (1.34×10^7 in-lb)-combined	
Design Life	30 years	30 years	30 years
Fatigue Life	10,000 cycles (0°-180°-0°)	322 cycles @ 28,000N (6300 lb) - combined	
Drive Motor Power	1/3 hp	1/4 hp	1/4 hp
Drive Motor Type	48 Frame NEMAD Totally Enclosed	42 Frame NEMAC Totally Enclosed	
Drive Motor Input Power	480v-60Hz - 3 phase	480v-60Hz - 3 phase	480v-60Hz - 3 phase
Drive Motor Weight	19.0 lb	10.5 lb	10.5 lb

3.3.1 Reflective Surface

The reflective surface uses a laminated construction to stiffen the assembly and protect the back of the mirror surface. The construction of this lamination is shown in Figure 3-2. The front lite of the reflective surface consists of a 0.060 inch thick piece of low-iron fusion glass which has overall dimensions of 4 ft by 11 ft. The back side of this glass is plated with pure silver and overplated with copper. At assembly, the back surface is sprayed with a two-part polyurethane adhesive that bonds the front and back lites of the reflector. The back lite is a 0.188 inch thick piece of window-grade float glass which also has dimensions of 4 ft by 11 ft.

Two longitudinal, hat-shaped, sheet-metal stringers are bonded to the back of the reflective surface. Each stringer contains two clinch nuts which are used to attach the reflector to the back support structure. These stringers are roll formed from 0.063 inch thick steel and are bonded with a two-part urethane adhesive to the back of the reflective surface.

3.3.2 Support Structure

The support structure is assembled through spot welding of roll-formed sheet steel components. The assembly consists of an inboard cross beam, outboard cross beam, two diagonal beams, two gussets, and two backing plates. The assembly is shown in Figure 3-3. Fabrication of this assembly requires cutting and forming of the beams after shipment from the steel rolling mill. The beams are then welded together and reinforced with the gussets and backing plates. The assembly is finally precision drilled so it can be attached to the torque tube at the field site.

3.3.3 Reflective Unit

The reflective unit is assembled by bolting six reflective surfaces to the support structure using the stringers which have already been bonded to the reflective surface back. (See Figure 3-4.) At this point, the reflective unit is ready for shipment to the field where it will be assembled to the torque tube. Two reflective units are mounted on each heliostat.

3.3.4 Drive Assembly

The drive assembly contains the drive motors and mechanism for the azimuth, elevation and tracking functions. (See Figure 3-5.) The azimuth drive is contained in the housing which provides support for the other units and in the mounting interface with the pedestal. The elevation and stowage

Figure 3-2. REFLECTIVE SURFACE

Figure 3-3. SUPPORT STRUCTURE

Polyurethane
Adhesive

25

Figure 3-4. REFLECTIVE UNIT

Figure 3-5. DRIVE ASSEMBLY

actuators are mounted on this unit and are used for rotation of the torque tube which supports the two reflective units. Elevation and stowage motions are accomplished through the drag link which shares a common pivot with the torque tube. Stowage motion occurs by extension of the actuator between the drag link and the torque tube. Elevation motion occurs by extension of the actuator between the drag link and the azimuth drive housing. This produces motion of the drag link, stowage actuator, and torque tube.

The drive assembly also contains the majority of the signal and control electronics associated with heliostat operation. The heliostat controller is mounted on top of the azimuth drive housing. This unit contains the conversion equipment for the fiber optic signal interface and the power controllers for the three drive motors. The input cable for the heliostat controller is fed down through the center of the drive housing where it connects to the junction box in the pedestal. Cables from the controller contain the power and signal wires for each of the drive motors.

3.3.5 Azimuth Drive Housing - Welded

A welded fabrication has been selected for the design of the azimuth drive housing. (See Figure 3-6.) The basic elements of this component are stock tubular and plate elements for the housing body, bearing flange, top cover, and gear case. The drive motor mount, tracking actuator brackets, and the drag link mounting brackets are welded to the basic assembly. The bearing flange is machined to accept the wire bearing race. The lower flange is also machined for a wire bearing race and is bolted to the bottom of the housing with 12 bolts. The bearing assembly is completed with the installation of the circular spline which is part of the azimuth drive. The welded housing is coated with a galvanized plating prior to machining of the mounting and bearing surfaces.

3.3.6 Azimuth Drive

The azimuth drive (Figure 3-7) provides two levels of reduction gearing between the drive motor and the circular spline. The input ratio is obtained through a purchased "Helicon" gear set with a ratio of 162:1. The output harmonic drive ratio is 242:1. The harmonic drive consists of a machined flexible spline, three-lobe wave generator, flexible bearing, and a circular spline and input shaft. The flexible spline is mounted to the top of the azimuth housing with 12 bolts. The wave generator is driven by the input shaft and produces distortion of the bearing and flexible spline at three points as it rotates. The circular spline contains gear teeth which mate with the flexible spline and bearing grooves for the wire race bearing which joins the circular spline and the azimuth

Figure 3-6. AZIMUTH DRIVE WELDED HOUSING

Figure 3-7. AZIMUTH DRIVE

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housing. The input shaft is machined and center-bored to allow the power and fiber optic cables to be routed from the pedestal junction box to the heliostat controller. The circular spline includes tapped holes for the mounting bolts which join the drive unit to the pedestal.

3.3.7 Drag Link Assembly

The drag link is fabricated from flame-cut steel plates which are welded into the assembly shown in Figure 3-8. After assembly, the weldment is galvanized. This weldment is then machined for mounting to the torque tube, stowage actuator trunnion, and tracking actuator clevis.

3.3.8 Torque Tube Assembly

The torque tube is assembled from standard steel tubing and flame-cut steel plates which are welded into the assembly shown in Figure 3-9. The flange plates which are welded to each end of the tube provide the mounting surface for the two reflective units. Tabs are provided for mounting at the drag link/azimuth housing joint and for the clevis mounting of the stowage actuator. After the support arms for the drag link have been attached to the torque tube, the weldment is galvanized. The weldment is then machined for the actuator mounting and the hinge joint. The end flanges are machined flat and precision drilled with eight holes each for the reflective unit mounting.

3.3.9 Pedestal Assembly

The pedestal assembly (Figure 3-10) consists of the pedestal and the tapered pipe which fits over the heliostat foundation. The tapered pipe is installed prior to pouring the concrete for the foundation and functions as a form for this operation. The tapered pipe is formed from sheet steel stock and seam welded. It is galvanized after fabrication.

The pedestal tube is also formed from steel plate and seam welded. After welding, the taper on the lower section is press-formed. The top cap is fabricated from steel plate stock and welded to the pedestal tube. An access area is provided for mounting the drive assembly, and a cutout is made for mounting the heliostat junction box. After assembly, the pedestal is galvanized. The assembly is then machined for the drive mounting surface and holes are drilled for the eight mounting bolts.

Figure 3-8. DRAG LINK ASSEMBLY

Figure 3-9. TORQUE TUBE

Figure 3-10. PEDESTAL ASSEMBLY

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SECTION 4.0

PROCESSING DESCRIPTION

This section includes descriptions of the manufacturing process, equipment and plant for the two production volumes of 25,000 and 250,000 heliostats per year. Also discussed are the sourcing of heliostat components and the make/buy decisions which led up to the selection of the sources. Each major component of the heliostat processing is described in a section which contains information for both production volumes. The final section contains plant layouts for the heliostat plants for the two production volumes.

4.1 PRODUCTION FLOW

Pictorial representations of material and processing flow through the plants for the 25,000 and 250,000 annual volumes are shown in Figures 4-1 and 4-2.

For the lower production volume, major purchased items include:

- Glass and mirroring
- Roll-formed steel sections
- Tapered pipe
- Pedestal tube
- Torque tube weldment
- Drag link weldment
- Azimuth drive housing weldment
- Drive motors and jacks
- Electronic components

Plant processing includes:

- Mirror module bonding
- Support structure die cutting and welding
- Reflector unit assembly
- Torque tube machining
- Drag link machining
- Azimuth drive housing machining
- Harmonic drive welding and machining (Flex spline, wave generator, bearing retainer, and circular spline)
- Azimuth and elevation drive assembly
- Electronic and cable fabrication
- Inspection and shipment preparation

At the higher production volume, weldment preparation is performed in the heliostat plant. Operations performed include: tube tapering, welding and galvanizing. The items produced in this manner include the tapered pipe, pedestal tube, retainer, torque tube, drag link and azimuth drive housing. In addition, the higher production necessitates redesign of the machines and tooling for the higher flow rates.

Figure 4-1. 25,000 ANNUAL VOLUME PRODUCTION FLOW DIAGRAM.

Figure 4-2. 250,000 ANNUAL VOLUME PRODUCTION FLOW DIAGRAM

4.2 MAKE/BUY DECISIONS

4.2.1 Reflective Surface

Make/buy decisions for the 25,000 volume include the following:

- Purchase float glass - Commercial product with large tooling investment
- Purchase fusion glass - Proprietary process, Corning Glass Company
- Purchase adhesive - Special product, 3M
- Purchase stringers - Commercial production facility designed for high volume; special tools are purchased for heliostat production. Clinch nut insertion is performed in the manufacturing plant.
- Purchase mirroring - Process in fusion glass plant reduces handling cost and breakage
- Make glass laminates and bond stringers - Unproven technology discourages vendor quotes for laminating and bonding. In-house facilities will be required for these operations.

All make/buy decisions for the 250,000 volume remain the same as the 25,000 volume. Additional investment capital is required for fusion glass, because the vendor may not risk capital to expand the facility. Expansion is required because the current plant does not have sufficient capacity.

4.2.2 Support Structure

Make/buy decisions for the 25,000 volume include the following:

- Purchase inboard beams, outboard beams, and diagonal beams - commercial production facility designed for very high volume. Special tools are purchased for heliostat production. Die cutting and shaping of the diagonal and inboard beams is performed in the manufacturing plant.
- Make structure in-house - The welding is a risk item due to the structure design, and process control is best maintained in-house. Shipment of low density structure from supplier to assembly operation would increase costs.

All make/buy decisions for the 250,000 volume remain the same as the 25,000 volume. Additional investment capital is required for the rolled beam sections. The vendor will not risk capital investment for these parts since there is no other usage for the increase in capacity generated by this special product. Therefore, tooling for the roll forming must be purchased by the heliostat producer.

4.2.3 Reflective Unit

Make/buy decisions for the 25,000 volume include the following:

- Assemble units in heliostat plant - Shipping of parts to intermediate point increases cost. Quality control can be maintained at a higher level by in-plant assembly.
- Purchase fasteners - Commercial product

All make/buy decisions for the 250,000 volume remain the same as the 25,000 volume.

4.2.4 Drive Assembly

4.2.4.1 Azimuth Drive Assembly

Make/buy decisions for the 25,000 volume include the following:

- Purchase housing weldment - Specialized manual cutting and welding operations are available from local vendors at reasonable cost.
- In-house machining of housing weldment - Machining volume justifies special purpose machine line which is not available at vendor operations.
- Fabricate harmonic drive components - Proprietary vendor item made under license from USM. Supplier is not willing to fabricate special drive.
- Purchase gears and bearings - Commercial products
- Purchase mounting hardware - Commercial products

Make/buy decisions for the 250,000 volume include the following:

- Fabricate housing weldment in heliostat plant. Specialized welding and plating facility is justified at this volume.
- Remaining decisions are the same at the higher volume.

4.2.4.2 Actuators

Make/buy decisions for the 25,000 volume include the following:

- Purchase tracking and stowage actuators - Commercial products
- Purchase mounting hardware - Commercial products

All make/buy decisions for the 250,000 volume remain the same as the 25,000 volume.

4.2.4.3 Drag Link Assembly

Make/buy decisions for the 25,000 volume include the following:

- Purchase drag link weldment - Specialized manual cutting and welding operations are available from local vendors at reasonable cost.
- In-house machining - Machining volume justifies special purpose machine which is not available at vendor operations.
- Purchase mounting hardware - Commercial products

Most make/buy decisions for the 250,000 volume remain the same as the 25,000 volume with the following exception:

- Fabricate drag link weldment in heliostat plant. Specialized welding and plating facility is justified at this volume.

4.2.4.4 Torque Tube Assembly

Make/buy decisions for the 25,000 volume include the following:

- Purchase torque tube weldment - Specialized manual welding and cutting operations are available from local vendors at reasonable cost.
- In-house machining of torque tube - Machining volume justifies special purpose machine.
- Purchase mounting hardware - Commercial products

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Most make/buy decisions for the 250,000 volume remain the same as the 25,000 volume with the following exception:

- Fabricate torque tube weldment in heliostat plant. Specialized welding and plating facility cost is justified at this volume.

4.2.4.5 Pedestal Assembly

Make/buy decisions for the 25,000 volume include the following:

- Purchase pedestal and tapered pipe, complete, from vendor - Specialized fabricating and plating operations are available from local vendors at reasonable cost.

Make/buy decisions for the 250,000 volume include the following:

- Purchase pedestal end cap - Volume does not justify purchase of punching and piercing equipment to lower production costs.
- In-house fabrication of pedestal tube - Volume justifies purchase of roll- and taper-forming equipment to lower production costs.
- In-house fabrication of tapered pipe - Volume justifies purchase of roll- and taper-forming equipment to lower production costs. This is the same equipment used for pedestal tube processing.
- In-house welding of pedestal cap and tube - Volume justifies purchase of welding equipment.
- In-house galvanized plating - Volume justifies purchase of plating equipment. This equipment is also used for the plating operations on the azimuth drive housing, drag link, and torque tube.

4.2.5 Electrical/Electronic Equipment

4.2.5.1 Control and Signal Electronics

Make/buy decisions for the 25,000 volume include the following:

- Purchase electrical cable and electronic components - Commercial products readily available at this volume.
- Purchase printed wiring boards - Specialized operations are available from local vendors at a reasonable cost.

- In-house cutting, trimming, and terminating of cables - Capital equipment costs are low enough to justify fabrication in heliostat plant to lower production cost.
- In-house component insertion and flow soldering - Capital equipment costs are low enough to justify fabrication in heliostat plant to lower production cost.

All make/buy decisions for the 250,000 volume remain the same as the 25,000 volume. Automatic equipment for component insertion and inspection is justified at this volume level to lower production labor costs.

4.2.5.2 Motors (Position/Limit Indicator)

Make/buy decisions for the 25,000 volume include the following:

- Purchase motors - Commercial product
- Purchase printed wiring boards - Specialized operations are available from local vendors at a reasonable cost
- In-house component insertion and flow soldering - Capital equipment costs are low enough to justify fabrication in heliostat plant. Equipment is shared with control and signal electronics production.

All make/buy decisions for the 250,000 volume are the same as the 25,000 volume.

4.2.5.3 Power Supply and Distribution System

Make/buy decisions for the 25,000 volume include the following:

- Purchase electrical and fiber optic cables - Commercial products readily available at this volume at a reasonable cost.
- In-house cutting, trimming, and terminating of cables - Capital equipment costs are low enough to justify fabrication in heliostat plant to lower production labor cost.

All make/buy decisions for the 250,000 volume are the same as the 25,000 volume.

4.3 PLANT PROCESSING AND EQUIPMENT

This section contains a description of the plant processing for each major component of the heliostat for the production volumes of 25,000 and 250,000 units per year. In addition, the plant equipment used for each operation is shown along with the processing description.

4.3.1 Reflector Assembly

The reflector assembly is made up of the fusion/float glass laminated panel, with the reinforcing stringers bonded to it. Initially vendor supplied laminating and bonding operations were a consideration, but due to the new and unproven technology, firm quotations were not obtainable. Therefore, the decision was made to develop a concept design for a laminating and curing operation at both the low and high annual volumes. These lines together with the production equipment for the mirror support structure and reflector assembly are described in the following paragraphs.

4.3.1.1 Reflective Surface

Processing for the reflective surface involves handling of the float and fusion glass lites, bonding the glass lites together, bonding the hat section stringers to the back of the float glass, and curing of the assembly in an oven. The processing line is shown in Figure 4-3.

The processing for the reflective surface at the 25,000 unit annual volume follows:

- (1) Float glass is loaded in shipping containers at the beginning of the line. The glass loader extracts the glass lites from the container and places them, "tin" side down, on the conveyor. One loader handles all float glass fed to the line. The glass loader is described in a subsequent paragraph.
- (2) The float glass is carried on a conveyor through a jet spray wash, deionized water rinse, warm air dry, and spray application of the urethane adhesive.
- (3) Fusion glass is loaded from shipping containers onto the adhesive-coated surface of the float glass with the mirrored side down.
- (4) The sandwich is conveyed through the pinch rollers which press the sandwich together to assure uniform bonding with the adhesive.

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Figure 4-3. REFLECTIVE SURFACE LINE - 25,000 ANNUAL VOLUME

- (5) The glass sandwich is rotated 180 degrees and moves through the extruder where adhesive is applied in the stringer section areas on the back of the float glass. The mirror module rotater is described in a subsequent paragraph.
- (6) Two stringers are loaded on the back of each glass sandwich. The stringer loader is described below. Prior to loading, the stringer clinch nuts have been installed on the machine described in a subsequent paragraph.
- (7) The sandwich and stringer assembly is conveyed into the rollerized pallets which clamp the stringers in place on the back of the float glass. The rollerized pallet is described in a subsequent paragraph.
- (8) Pallets are conveyed into the curing ovens which operate at a temperature of 150 degrees F and expose the reflector assemblies to a 10 minute curing cycle. Open type clamping fixtures, as opposed to platen-type devices, have been used to maximize the heat transfer into the adhesives.
- (9) The exit area of the ovens includes a cooling area.
- (10) After exiting the oven, the reflector assemblies are removed from the rollerized pallets and unloaded into racks for the completion of the curing cycle. Rack capacity in the plant is sufficient to allow a 3 hour cure before assembly of the reflectors onto the support structure.
- (11) Rollerized pallets are conveyed back to the front of the oven to accept new assemblies for cycling through the oven.

Glass Loader - 25,000 Volume. The glass loader is used to load both the float and fusion-glass panels onto the assembly line. The arrangement and operation of the machine are shown in Figure 4-4. The following is a brief description of the machine operating cycles:

- (1) Float/fusion glass arrives in shipping crates from the supply source.
- (2) Shipping crates are loaded onto the glass loader with forklift trucks.
- (3) Packaging is removed manually from the front side of the shipping crate.

Scale 1/4" = 1'

Figure 4-4. GLASS LOADER - 25,000 ANNUAL VOLUME

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- (4) A single glass lite is removed from the crate with a suction-cup rack mounted on the machine and positioned for rotation to point over the bed of the assembly line. In the case of mirrored fusion glass. This position is maintained while the protective film is engaged by the fingers on the machine.
- (5) The glass lite is then rotated 90 degrees so that it is parallel with the bed of the assembly line. The protective film is removed from the mirrored glass during this motion.
- (6) The glass lite is then moved vertically downward to the bed of the machine and the vacuum is released in the suction cups. In the float glass case, the "tin" side of the glass is placed on the assembly line bed. For the mirrored fusion glass, the "mirror" side is placed on the adhesive-coated surface of the front glass.

Mirror Module Rotator - 25,000 Volume. After the fusion/float glass sandwich has been bonded and passed through the pinch rolls, it is necessary to rotate it 180 degrees for application of the stringers to the back of the fusion glass. The mechanism for accomplishing this is shown in Figure 4-5. The device shown in this figure is capable of handling six sandwich sections simultaneously and is used on the line for the 250,000 unit annual volume. A single-sided version of this machine is used for the low-volume case.

The following is a brief description of the machine operating cycle:

- (1) The glass sandwich is conveyed into the rotator and positioned after passing through the pinch rollers.
- (2) Cam rollers then move to engage the end locating pins which locate the glass sandwich between the sets of large rollers on the machine.
- (3) When clamped, the machine cycles to rotate the glass sandwich and clamp assembly 180 degrees.
- (4) After rotation, the cam rollers release the locating pins and free the sandwich and allow it to be conveyed to the next station for application of adhesive and stringers.

Stringer Loader - 25,000 Volume. The stringer loader is used to place the two stringers, with clinch nuts installed, on top of the adhesive strips which have been extruded on the back of the float glass. The arrangement and operations of this machine

Figure 4-5. MIRROR MODULE ROTATOR - 25,000 ANNUAL VOLUME

are shown in Figure 4-6. The following is a brief description of the machine operating cycles:

- (1) The stringers are packaged in shipping containers which contain groups of 26 stringers in a cartridge.
- (2) Cartridges are forklifted onto the loading machine in a vertical position with the top of the hat section facing the loading mechanism.
- (3) The machine arms pick out a pair of stringers from the cartridge with magnetic clamps. The stringers are positioned with guide pins which engage the clinch nuts. The arm position spacing is equal to the stringer spacing required for the assembly.
- (4) The arms translate out from the pallet to a position which allows rotation over the glass surface and rotates it 90 degrees.
- (5) The arms move vertically downward and press the stringers into the extruded adhesive on the back of the float glass.
- (6) The arms unclamp from the stringers and recycle to pick up the next pair of stringers from the cartridge (one position downward from the previous set).
- (7) When the cartridge is emptied, it is removed with an overhead crane and the remaining cartridges move forward into the loading position.

Stringer - Clinch Nut Subassembly. Clinch nuts are installed, two per stringer, with the machine shown in Figure 4-7. The stringers, loaded in the shipping container, are loaded into the machine with an overhead crane. As the cartridge indexes through the machine, clinch nuts are fed into position and pressed into each stringer.

At the low volume of 25,000 units, only one feeder and press are required. At the higher volume of 250,000 units, one feeder and four presses are used to increase the machine output.

Rollerized Pallets - 25,000 Volume. The rollerized pallet is used to hold the glass sandwich and stringers in position during the curing cycle in the line oven. This assures good alignment between the glass panels and the stringer assemblies. The arrangement and operation of the machine are shown in Figure 4-8. Following is a brief description of the machine operating cycle:

Figure 4-6. STRINGER LOADER - 25,000 ANNUAL VOLUME

Figure 4-7. STRINGER - CLINCH NUT SUBASSEMBLY - 25,000/250,000 UNIT ANNUAL VOLUME

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Figure 4-8. ROLLERIZED PALLET - 25,000 ANNUAL VOLUME

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- (1) The glass sandwich, with stringers attached, is conveyed into the rollerized pallet. At this point, the pallet is in a position with the cam lock held open. This frees the locating pins for the stringers.
- (2) As the pallet moves from this position, the cam lock is released. This engages the edge and pin clamps.
- (3) The pallet is conveyed through the curing oven with all clamps engaged.
- (4) At the exit from the curing oven, the cam lock is released. This allows the cured reflective surface assembly to be conveyed out of the pallet and loaded into storage racks.
- (5) Empty pallets are guided back to the assembly area for recycling through the oven.

There is no inspection at this point. Manual inspection operation is performed at this point for adhesive and stringer bonding.

4.3.1.2 Reflective Surface - 250,000 Volume

For the 250,000 volume a dual reflective surface line is employed (Figure 4-9) and the units are processed in groups of six. The processing of the reflective surface for the 250,000 volume is the same as the 25,000 volume, except that there are six each (three on each side) of the float glass and fusion glass loaders, rotators, and stringer loaders for the higher volume.

4.3.1.3 Mirror Support Structure

The mirror support structure is fabricated from roll-formed sheet steel sections which are used for the inboard, diagonal and outboard beams. In addition, the mounting area between the torque tube and the structure is reinforced with formed doublers and gussets. Prior to welding of the beams, the ends of the diagonal and inboard beams are cut and formed in pressing operations. All components are then assembled into the welding machine for spot welding. This fixture provides good control of the structural alignment for later assembly with the reflector panels. After welding the assembly is drilled and counter sunk for the beam mounting bolts and the frame is straightened. These operations are performed on the machines listed on the following pages.

Inboard Beam. The roll-formed sections for the inboard beam, received from the metal forming supplier, are loaded into the transfer press shown in Figure 4-10. After loading, the beams

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Figure 4-9. REFLECTIVE SURFACE LINE - 250,000 ANNUAL VOLUME

Figure 4-10. INBOARD BEAM DIE LINE

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are automatically transferred through the two stations of the double-ended transfer press. The first stage of the press forms the taper cut in the beam and the second stage removes the flange section. The part is then transferred to the unloading station.

Diagonal Beam. The roll-formed sections for the diagonal beam, received from the metal forming supplier, are loaded into the transfer press shown in Figure 4-11. After loading, the beams are automatically transferred through the three stations of the double-ended transfer press. The first stage of the press forms the ends of the web section. The second stage of the press removes the flange sections of the beam. In the third section, flanges are bent up for the weld attachment to the inboard and outboard beams. The part is then transferred to the unloading section.

Outboard Beam. The outboard beam is received from the metal forming supplier pre-cut to length and punched for the mounting bolts. No die forming operations are required in this part.

Doublers and Gussets. These parts are formed by the supplier and do not require in-plant processing.

Welding Process. The welding line for the assembly of the mirror support structure is shown in Figure 4-12. This line is fed by the die lines which form the inboard and diagonal beams. In addition the outboard beams, doublers and gussets are loaded into this line.

At Station 1 of this line, the doublers are manually loaded and spot welded to the inboard beam (see Figure 4-13).

At Station 2, the gussets are manually loaded and spot welded to the inboard beam (see Figure 4-14).

At Station 3, gussets are manually arc-welded to inboard beam (see Figure 4-15).

At Station 4, outboard beams are manually loaded into the line (see Figure 4-16).

At Station 5, the diagonal beams are loaded from the die line and six spot welds are completed at the joints between the diagonal beams and the inboard and outboard beams (see Figure 4-17).

At Station 6, the spot welding is completed between the diagonal and the inboard and outboard beams (see Figure 4-18).

Figure 4-11. DIAGONAL BEAM DIE LINE

Figure 4-12. MIRROR SUPPORT STRUCTURE WELDING LINE

1. Auto index subassembly 26'
2. Manually load two doublers
3. Depress palm buttons
4. Lifter raises and beam end locator extends
5. Customer's lift and carry automation places inboard beam onto lifter
6. Lifter lowers beam onto doublers and into locators
7. Clamps close and eight equalizing weld guns pivot in
8. Weld eight spots
9. Clamps open, weld guns pivot out, and beam end locator retracts

Figure 4-13. HELIOSTAT SUPPORT STRUCTURE STATION 1,
LOAD/WELD DOUBLERS

1. Auto index subassembly 26'
2. Manually load two gussets onto beam, into locator, as beam trailing end locator extends
3. Depress palm buttons
4. Clamps close on gussets
5. Weld four spots
6. Weld four spots
7. Index weld guns
8. Weld four spots
9. Weld four spots
10. Clamps open, beam end locators retract

Figure 4-14. HELIOSTAT SUPPORT STRUCTURE STATION 2,
LOAD/WELD GUSSETS

1. Auto index subassembly 26'
2. Depress palm buttons
3. Gusset clamps close
4. Manually arc weld using semi-automatic "squirt gun"
5. Depress palm buttons
6. Gusset clamps open
7. Turn over indexes 180°

Figure 4-15. HELIOSTAT SUPPORT STRUCTURE STATION 3,
MANUALLY ARC WELD GUSSETS/AUTO TURN

1. Auto index beams 26'
2. Loader lowers 4'
3. Manually load outboard beam into loader
4. Depress palm button
5. Loader raises 4'

Figure 4-16. HELIOSTAT SUPPORT STRUCTURE STATION 4,
LOAD OUTBOARD BEAM

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1. Customer's lift and carry automation places diagonals into locators
2. Pivot-mounted locators index diagonals to load position
3. Diagonal loaders extend
4. Diagonal loaders grip diagonals

Note: Inboard and outboard beams auto index 26' during Steps 1 - 4.

5. Loaders index diagonals into station
6. Loaders rotate diagonals into position
7. Weld units advance 16" and shift down 5" at center area. Weld units advance at outboard beam areas
8. Weld six spots
9. Index welding units
10. Weld six spots and diagonal loaders release
11. Weld units and diagonal loaders retract

Figure 4-17. HELIOSTAT SUPPORT STRUCTURE STATION 5, LOAD/WELD DIAGONALS

1. Auto index subassembly 26'
2. Weld units advance and shift down at center area.
Weld units advance at outboard beam areas
3. Weld four spots
4. Index welding units
5. Weld four spots
6. Index welding units
7. Weld two spots
8. Index welding units
9. Weld two spots
10. Weld units retract

Figure 4-18. HELIOSTAT SUPPORT STRUCTURE STATION 6, WELD DIAGONALS

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At Stations 7, 8, and 9, the spot welding is completed between the diagonal beams and the gussets (see Figure 4-19).

At Station 10, the assembly, which has been welded in the vertical position, is rotated downward 90 degrees to align it with the transfer table for movement to the next station (see Figure 4-20).

At Stations 11 and 12, the structure assembly is drilled and counterbored for the mounting bolts which are used for assembly to the torque tube (see Figure 4-21).

At Station 13, the structure assembly is straightened and removed from the welding line with an overhead crane (see Figure 4-22).

4.3.1.4 Reflector Assembly

Assembly of the reflector unit consists of bolting the six mirror module units to the mirror support structure. Mirror module units are transported from the storage area to the reflector assembly area and loaded into an assembly fixture. The support structure is then lifted, with an overhead crane onto the assembly fixture. The 24 bolts which pass through the structure and engage the clinch nuts in the stringers are then installed and torqued manually with the assistance of air wrenches. These operations are performed with the machine shown in Figure 4-23.

Six mirror module units are loaded onto the power and free conveyor unit which loads them onto the air table. The modules are positioned on the air table by the operators. The mirror support structure travels on the overhead crane and descends to the position over the air table. In this position, the operators feed and torque the attaching bolts between the structure and the mirror modules. At this station, the operators are positioned on an elevated platform which allows them to work over the inboard beam of the structure. After assembly, the reflector panels move down the conveyor to the inspection station. When inspection is complete, the reflector travels upward along the conveyor and travels to the shipping area. In the shipping area, the reflector is removed from the conveyor with an overhead crane and put into a shipping rack.

In the 25,000 unit annual volume, four operators and one assembly machine are required. At the 250,000 unit annual volume, twelve operators for each of the three assembly machines are required.

1. Auto index subassembly 26'
2. Weld guns advance and lower
3. Weld four spots
4. Index guns
5. Weld four spots
6. Index guns
7. Weld four spots
8. Weld guns raise and retract

Figure 4-19. HELIOSTAT SUPPORT STRUCTURE STATION 7, 8, 9,
WELD DIAGONALS TO GUSSETS

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1. Auto Index (tipped-down) Assembly 26'
2. Empty Tipper Pivots Up 90°
3. Auto Index (up-right) Assembly 26'
4. Tipper Pivots down 90°

Figure 4-20. HELIOSTAT SUPPORT STRUCTURE STATION 10, 90°
TIP DOWN

1. Auto index assembly 26', front locator extends
2. Rear locator extends
3. Drills advance, drill and retract
4. Front and rear locators retract

Figure 4-21. HELIOSTAT SUPPORT STRUCTURE STATIONS 11 AND 12, COUNTER-BORE

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1. Auto index assembly 26'
2. Straighten
3. Manually unload assembly using customer's hoist
4. Depress palm buttons

Figure 4-22. HELIOSTAT MIRROR AND BACK SUPPORT STATION 13, UNLOAD

Power and Free Conveyor
(Mirror Module)
From Curing and Staging Area

Tramrail
(Support Structure)
From Staging Area

One Line, Two Operators = 25K
Three Lines, Six Operators/Line = 250K

Screw Bins

Air Table

Reflective Panel Assembly
to Shipping Area

Figure 4-23. REFLECTIVE UNIT ASSEMBLY

4.3.2 Electrical/Electronic

The plant layouts for the heliostat electrical and electronic components are shown in Figures 4-24 and 4-25 for the 25,000 and 250,000 unit annual volumes, respectively. At the 25,000 unit level of production automatic equipment is used for cable fabrication and termination and for component insertion and flow soldering of the printed wiring boards. At the 250,000 unit level of production, automatic equipment is added for the inspection of the printed wiring boards. Floor space requirements for two levels of production are 5400 and 19,800 square feet. The following paragraphs list the processing operations and production equipment used in the electronic/electrical assembly areas for the following heliostat components:

- Control and signal electronics
- Motors (position/limit indicator)
- Power supply and distribution.

4.3.2.1 Control and Signal Electronics Fabrication

The fabrication and processing of control and signal electronics for the annual volumes of 25,000 and 250,000 are given in the following pages. This equipment includes the heliostat controller, box enclosure, and cable connections. At the lower volume most operations are performed manually with the exception of small-component insertion, flow soldering, and environmental testing. At the higher volume, insertion and inspection is automated.

Completed controllers are fitted with the cable harness for later assembly to the drive unit.

Each process description is followed by a list of the production equipment used in the process.

The control and signal electronics process for the 25,000 volume is:

- (1) Receive and inspect components, connectors, printed circuit boards, and plastic boxes and covers.
- (2) Manually assemble large electronic components, microcomputer, and power supply to two-sided 4-inch x 5-inch printed circuit board.
- (3) Manually load component tubes into automatic insertion machine.
- (4) Automatically insert small components.
- (5) Automatically trim, flow solder, clean, and dry printed circuit board assembly.

Total Floor Area - 5,400 sq. ft.

Figure 4-24. ELECTRICAL/ELECTRONIC ASSEMBLY AND TEST AREA -
25,000 ANNUAL VOLUME

Total Floor Area - 19,800 sq. ft.

Figure 4-25. ELECTRICAL/ELECTRONIC ASSEMBLY AND TEST AREA -
250,000 ANNUAL VOLUME

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- (6) Visually inspect soldered board for voids, bridging, and inclusions.
- (7) Rework soldered units (estimated to be less than 2%).
- (8) Load units (52) into fixture and environmentally test boards (+165°F for two hours).
- (9) Functionally test 52 unit batch, less fallout.
- (10) Recycle failed units (estimated to be less than 2%).
- (11) Manually assemble tested printed circuit boards to base with 6 screws.
- (12) Assemble 4 cable fittings to base of box.
- (13) Assemble elevation, stowage, and azimuth motors and junction box cables to heliostat controller box.
- (14) Install cover.
- (15) Transfer equipment to assembly area.

The control and signal electronics production equipment for the 25,000 volume includes:

- Universal Instruments Corp., automatic insertion machine with special fixtures (20)
- Hollis Engineering Co., automatic flow solder machine with special fixtures (20)
- Falcons Div., Universal Scientific Corp., oven with environmental test fixtures and rack - 3 units
- Special DDI/H.C. functional test stand - 2 stands
- Special assembly fixture
- Handling fixtures (60) - inspection and test
- Work benches (6)
- Storage racks (2)
- Large tote bins (5)
- Small tote bins (15)

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The control and signal electronics process for the 250,000 volume is:

- (1) Receive and inspect components, connectors, printed circuit boards, and plastic boxes and covers.
- (2) Manually assemble large electronic components, microcomputer, and power supply to two-sided 4-inch x 5-inch printed circuit board.
- (3) Manually load component tubes into automatic insertion machine.
- (4) Automatically insert small components.
- (5) Automatically trim, flow solder, clean, and dry printed circuit board assembly.
- (6) Machine inspect printed circuit board for contents and visually inspect for voids or contamination (estimated to be less than 2%).
- (7) Rework soldered units (estimated to be less than 2%).
- (8) Environmentally test boards (+165°F for two hours). This test is performed on 2% of production.
- (9) Functionally check printed circuit boards (110 units every half hour).
- (10) Recycle failed units (estimated to be less than 2%).
- (11) Manually assemble tested printed circuit boards to base with 6 screws.
- (12) Assemble 4 cable fittings to base of box.
- (13) Assemble elevation, stowage, and azimuth motors and junction box cables to heliostat controller box.
- (14) Install cover.
- (15) Transfer equipment to assembly area.

The control and signal electronics production equipment for the 250,000 volume includes:

- Universal Instruments Corp., insertion machine, semi-automatic with special fixtures (120) and transfer machine for handling and metering work flow
- Hollis Engineering Co., automatic flow soldering equipment with special fixtures (150)

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- Automatic inspection scanner
- Falcons Div., Universal Scientific Corp., oven with test fixture racks (3)
- Special DDI/H.C. with functional test stand - 9 stands
- Transfer equipment motors
- Work benches (17)
- Storage racks (10)
- Large tote bins (20)
- Small tote bins (45)

4.3.2.2 Power Supply and Distribution Processing

The fabrication and processing of the power supply and distribution equipment for the 25,000 and 250,000 annual volumes are given in the following pages. This equipment includes the junction box, circuit breaker, cables, and terminations for the heliostat assembly. At the low volume most operations are performed manually with the exception of wire cutting, stripping, and terminating. Fiber optic cable processing is performed manually. At the higher volume fiber optic cables are purchased complete with terminations.

The power and signal cable is connected to the heliostat controller for assembly on the azimuth drive. Cable connectors in this harness are mated with the drive motor connectors at the drive assembly point. The harness between the controller and the junction box is not connected until final assembly of the heliostat unit.

Each process description is followed by a list of the production equipment used in the process.

The power supply and distribution process for the 25,000 volume is:

- (1) Receive and inspect the following components:
 - Junction box
 - Terminal strip
 - Circuit breaker
 - Mounting panel
 - Terminators
 - Cable fitting
- (2) Assemble terminal strip and circuit breaker on mounting panel.

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- (3) Assemble 4 cable terminators and cable fitting into junction box.
- (4) Install cover on junction box and transfer to assembly area.
- (5) Receive and inspect the following components:
 - 10-pin connectors
 - 20-gauge power wire
 - 24-gauge motor controller wire
 - Wire terminals
- (6) Automatically cut to length, strip, and terminate following lengths of 24-gauge wire:
 - 2 - 84 inches
 - 2 - 60 inches
 - 2 - 12 inchesMark wire ends.
- (7) Automatically cut to length, strip, and terminate following lengths of 20-gauge wire:
 - 1 - 84 inches
 - 1 - 60 inches
 - 1 - 12 inchesMark wire ends.
- (8) Assemble wire lengths into power cable harness and onto 10-pin connector per drawing.
- (9) Receive and inspect fiber optic cable, cable terminators, and 25-pin connector.
- (10) Manually cut fiber optic cable to length.
- (11) Remove outer jacket of fiber optic cable (both ends), separate conductors, polish tips of fiber optic cable and install 4 terminators (both ends), and rewrap exposed fiber optic cable.
- (12) Strip both ends of power cable, tin, and attach to 25-pin connector per drawing.
- (13) Attach 3 motor power cables and motor control cable to 25-pin connector per drawing.
- (14) Conduct continuity test on cable harness.
- (15) Rework failed units (estimated to be less than 2%).
- (16) Assemble heliostat controller, motors, and harness for system test, including optical test of fiber optics.
- (17) Rework failed units (estimated to be less than 2%).
- (18) Transfer controller, harnesses, and motors to azimuth/elevation assembly area.

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The power supply and distribution production equipment for the 25,000 volume includes:

- Artos wire cutter, stripper, and terminator, Model CS-9-AT
- DITMCO Test Set
- DDI simulator with digital readout - 2 stations
- Adapter set
- Cutting fixture, special
- Cabling fixture, special
- Storage racks (6)
- Work benches (4)
- Large tote bins (4)
- Small tote bins (4)

The power supply and distribution process for the 250,000 volume is:

- (1) Receive and inspect following components:
 - Junction Box
 - Terminal Strip
 - Circuit Breaker
 - Mounting Panel
 - Terminators
 - Cable Fitting
- (2) Assemble terminal strip and circuit breaker on mounting panel.
- (3) Assemble 4 cable terminators and cable fitting into junction box.
- (4) Install cover on junction box and transfer to assembly area.
- (5) Receive and inspect following components:
 - 10-pin connectors
 - 20-gauge power wire
 - 24-gauge motor controller wire
 - Wire terminals

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- (6) Automatically cut to length, strip, and terminate following lengths of 24 gauge wire:
 - 2 - 84 inch
 - 2 - 60 inch
 - 2 - 12 inchMark wire ends.
- (7) Automatically cut to length, strip and terminate following lengths of 20 gauge wire:
 - 1 - 84 inch
 - 1 - 60 inch
 - 1 - 12 inchMark wire ends.
- (8) Assemble wire lengths into harness and onto 10-pin connector per drawing.
- (9) Receive and inspect fiber optic cable with terminators and 25-pin connector.
- (10) Strip ends of power cables, tin and attach 25-pin connector to one end per drawing. Other end remains bare for assembly connection through hollow azimuth drive shaft and connection to pedestal junction box.
- (11) Attach 3 motor power cables and control cable to 25-pin connector per drawing.
- (12) Conduct cable continuity test.
- (13) Rework failed cable units (estimated to be less than 2%).
- (14) Assemble heliostat controller, motors, harnesses, and fiber optics for system test.
- (15) Conduct system test and optical check.
- (16) Rework failed systems (estimated to be less than 2%).
- (17) Transfer controller, harness, and motors to azimuth/elevation assembly area.

The power supply and distribution production equipment of the 250,000 volume includes:

- Artos wire cutter, stripper, and terminator - Model CS-9-AT - 6 required
- DITMCO Test Set with adaptors - 3 required
- DDI simulator with digital readout - 10 required
- Fab-Tec transfer line to storage

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- Cabling fixture, special - 2 required
- Storage racks (42)
- Work Benches (28)
- Large tote bins (40)
- Small tote bins (8)

4.3.2.3 Motors

The processing of the drive motors for the 25,000 and 250,000 annual volume levels is given in the following pages. This equipment includes the drive motors and mounting hardware. Position/limit indicator hardware is mounted in a separate operation. At the lower volume, the motors are subjected to 100 percent receiving inspection. At the higher volume, motor testing is limited to a 5 percent sample.

Each processing description is followed by a list of the production equipment used in the process.

The motors process of the 25,000 volume is:

- (1) Receive and inspect motors, bolts, and washers.
- (2) Assemble and test each motor on motor test station.
- (3) Return failed motors to supplier (estimated to be less than 2%).
- (4) Transfer motors to stations for assembly of position/limit indicator.

The motors production equipment for the 25,000 volume is:

- Dynamometer with special test stand, 480v - 3 phase, with circuit breakers

The motors process for the 250,000 volume is:

- (1) Receive and inspect motors, bolts, and washers from supplier.
- (2) Assemble and test motors (5% sample) on motor test station.
- (3) Return failed motors to supplier (estimated to be less than 0.5%).
- (4) Transfer motors to station for assembly of position/limit indicator.

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The motors production equipment for the 250,000 volume is:

- Dynamometer with special test stand, 480v - 3 phase, with circuit breakers - 2 required

4.3.2.4 Position/Limit Indicator Processing

The fabrication and processing instructions for the position/limit indicator electronics for the annual volumes of 25,000 and 250,000 are given in the following pages. - This equipment includes the vane actuator and printed circuit board which are mounted on the drive motors. At the low volume components are automatically inserted on the circuit board and flow soldered. Mechanical components and the circuit board are manually assembled on the drive motors. At the higher volume printed circuit board inspection is accomplished automatically.

Each process description is followed by a list of the production equipment used in the process.

The position/limit indicator process for the 25,000 volume is:

- (1) Receive, store, and issue electronic components in tubes as received from supplier. Issue tubes to automatic insertion equipment. Tubes contain (50 each) line drivers, line receivers, triacs, resistors, and capacitors. Issue 50 printed circuit boards.
- (2) Manually load tubes for automatic insertion.
- (3) Automatically insert components; transfer to flow solder equipment.
- (4) Automatically flow solder, clean, and dry.
- (5) Visually inspect for voids, bridging, inclusions, proper component pressure, and position.
- (6) Rework soldered units (estimated to be less than 1%).
- (7) Transfer boards to encoder assembly station.
- (8) Receive and inspect vane actuator and encoder mounting hardware.
- (9) Assemble vane actuator and encoder on drive motor.
- (10) Transfer completed motor assembly to drive assembly station.

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The position/limit indicator production equipment for the 25,000 volume is:

- Universal Instruments Corp., insertion machine with assembly fixtures (60)
- Storage racks (3)
- Tote boxes (19)

The position/limit indicator process for the 250,000 volume is:

- (1) Receive, store, and issue electronic components in tubes as received from supplier. Issue tubes to automatic insertion equipment. Tubes contain (50 each) line drivers, line receivers, triacs, resistors, and capacitors. Issue 50 printed circuit boards.
- (2) Manually load tubes for automatic insertion.
- (3) Automatically insert components; transfer to flow solder equipment.
- (4) Automatically flow solder, clean, and dry.
- (5) Automatically transfer and inspect for proper component pressure and position. Inspect visually (2%) for voids, bridging, and inclusions.
- (6) Rework soldered units (estimated to be less than 1%).
- (7) Transfer boards to encoder assembly station.
- (8) Receive and inspect vane actuators and encoder mounting hardware.
- (9) Assemble vane actuators and encoders on drive motor.
- (10) Transfer completed motor assemblies to drive assembly station.

The position/limit indicator production equipment for the 250,000 volume includes:

- Universal Instruments Corp., insertion machine with assembly fixtures (60)
- Fab-Tec transfer equipment with controls and meters and transfer fixtures (60)
- Hollis Engineering Co., automatic flow solder machine with flow fixtures (60)
- Fab-Tec transfer equipment with controls and meters

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- Automatic insertion scanner
- Fab-Tec transfer equipment with controls and meters (60) transfer fixtures
- Tote boxes (60)
- Fab-Tec transfer equipment with controls and meters and transfer fixtures (100)
- Work benches (4)
- Fab-Tec transfer equipment with controls and meters
- Storage racks (30)

4.3.3 Drive Assembly

The drive assembly comprises the drag link, the torque tube and the azimuth drive assembly. Processing instructions for these elements are included in the following pages.

4.3.3.1 Azimuth Drive Housing

The processing operations and equipment descriptions for the azimuth drive housing at the 25,000 and 250,000 annual volumes are listed on the following pages. For the low volume the housing is purchased as a completed weldment which is plated and ready for machining. At the high volume, welding and galvanizing are performed in the manufacturing plant. Machining is required for the drive motor mounting, input gear bearing, lower wire race bearing, and mountings for the torque tube, drag link, and tracking actuator. In each case, the machining is performed on automatic machines with transfer equipment. At the higher volume, shuttle transfer operations are replaced with noncumulative continuous cycling operations with assistance of a pallet return conveyor to reduce the cycle and match the required production rate, thus reducing labor requirements.

The azimuth drive housing - machining process for the 25,000 volume is:

- (1) Receive and inspect galvanized housing weldment.
- (2) Place housing on custom forklift pallets -- material handling with overhead crane -- qualify gage material handling on conveyor.
- (3) Qualify locating diameter and face; rough turn, face, and bore.

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These operations are performed on a Bullard numerical control vertical turret lathe. This machine is shown on the plant layout in Section 4.4.

(4) Perform part wash and in-process gaging -- material handling on conveyor.

(5) Bore, turn, face, contour, drill, chamfer, and tap.

These operations are performed on the Lamb 3-station shuttle machine shown in Figure 4-26. It requires one operator and occupies a floor area of 16 ft x 20 ft. The operations performed at the three stations are described as follows:

<u>Station Number</u>	<u>Left Hand</u>	<u>Operation</u>	<u>Right Hand</u>
1	Bore, face outside ring. Face and groove bearing bore		Bore, face, turn, and plunge I.D. radius
2	Tap drill (8) cover holes. Tap drill (4) retainer holes		Drill (12) holes through. Tap drill (16) holes
3	Probe, tilt unit, tap (12) holes, tilt unit, probe		Probe, tilt unit, tap (16) holes, tilt unit, probe

(6) Perform part wash and in-process gaging -- material handling on conveyor.

(7) Mill, bore, and chamfer; drill and chamfer; tap motor mounting face.

Scale 1/4" = 1'

Figure 4-26. AZIMUTH DRIVE HOUSING MACHINING-#1 - 25,000 ANNUAL VOLUME

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These operations are performed in the Lamb 5-station shuttle machine shown in Figure 4-27. It requires one operation and occupies a floor space of 37 ft x 14 ft. The operations performed at the 5 stations are described as follows:

<u>Station Number</u>	<u>Left Hand</u>	<u>Operation</u>	<u>Right Hand</u>
1	-		Locate on O.D. and bottom face
2	Generate face		Idle
3	Ream and chamfer (1) hole		Idle
4	Tap drill and chamfer (4) holes		Idle
5	Tap (4) holes		Idle

(8) Perform part wash and in-process gaging -- material handling on conveyor.

(9) Mill, spot drill, drill, bore, and ream arms (4), and press-in 4 antifriction bushings.

These operations are performed on the Lamb 6-station shuttle machine shown in Figure 4-28. It requires one operator and occupies a floor space of 53 ft x 24 ft. The operations performed at the six stations are described as follows:

<u>Station Number</u>	<u>Operation</u>
1	Load/unload
2	Straddle mill (4) arms
3	Spot drill to chamfer (2) holes (both sides)
4	Drill through (2) holes (both sides)
5	Ream (2) holes (both sides)
6	Press bushings (2) holes (both sides)

(10) Perform part wash, master gaging, and hand gaging -- material handling with overhead crane.

Figure 4-27. AZIMUTH DRIVE HOUSING MACHINING-#2 - 25,000 ANNUAL VOLUME

Scale 1/8" = 1'

Figure 4-28. AZIMUTH DRIVE HOUSING MACHINING-#3 - 25,000 ANNUAL VOLUME

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The welding process description, machine and operator requirements for the Azimuth drive housing at the 250,000 unit annual volume are as follows:

<u>Operation</u>	<u>Machine</u>	<u>Operators/ Machine</u>
(1) Weld top plate to center hub	Ring welding machine (2 required)	1.0
(2) Weld top plate to doubler	Ring welding machine (4 required)	1.0
(3) Weld top plate subassembly to main tube	Special welding machine (3 required)	0.5
(4) Weld flange to large tube	Special welding machine (3 required)	1.0
(5) Weld motor tube to top tube	Manual welding operation with fixture (7 required)	7.0
(6) Weld motor flange to motor tube	Special welding machine (1 required)	0.0
(7) Weld small tube subassembly to top plate	Ring welding machine (3 required)	1.0
(8) Weld cross brace to large arms	3-station special welding machine (2 required)	1.0
(9) Weld large arms and cross brace to housing	16-station special welding machine (1 required)	1.0
(10) Weld short arms to subassembly housing	4-station special welding machine (1 required)	1.0
(11) Clean welded surfaces	Wheelabrator	1.0

The welding area and machine layout are shown on the plant layout in Section 4.4. This area of the plant is enclosed and is provided with special ventilation equipment. Welded housings are moved with overhead hoists to the staging area where they are stored on pallets. Housings are taken from the staging area to the galvanized plating area with fork-lift trucks. When they arrive at the plating area, housings are placed on the monorail loop for processing through the galvanizing area.

The galvanizing line is also shown on the plant layout in Section 4.4. This line is also located in the enclosed area of the plant. The galvanizing process is described as follows:

<u>Processing Step</u>	<u>Equipment</u>	<u>Operators/ Machine*</u>
(1) Load housing on monorail	Fork-lift truck (1 required)	1.0
(2) Wash with high-pressure water (30 micron filtration)	Mini-vac filter and pump (1 required)	0.0
(3) Wash with alkaline solution - rinse with water - blow off with heated air	Rinse spray and heated blower (1 required)	0.0
(4) Pickle in sulfuric acid	Fiberglass tank, filter and pump (1 required)	0.0
(5) Fresh water rinse with pH and temperature control - blow dry with heated air	Heated water tank, blower and heater (1 required)	0.0
(6) Flux dip	Flux tank	0.0
(7) Pre-heat housing to 250°F	Heater and blower (1 required)	0.0
(8) Dip and travel in galvanizing tank	20 ft. long hot-dip galvanizing tank (1 required)	0.0
(9) Hot water rinse	Rinse tank (1 required)	0.0
(10) Hoist from monorail and store	Fork-lift truck (1 required)	1.0

* Operations which are shown without operator requirements are monitored and serviced by the five operators who man this line.

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The azimuth drive housing - machining process for the 250,000 volume is:

- (1) Receive pre-cut material ready for welding and deliver to weld area.
- (2) Weld per routing sheets.
- (3) Galvanize.
- (4) Place housing on custom forklift pallets -- material handling with overhead crane -- qualify gage -- material handling on conveyor.
- (5) Qualify bottom and face.

These operations are performed on a Cincinnati horizontal broach. This machine is shown in the plant layout in Section 4.4.

- (4) Perform part wash and in-process gaging -- material handling on conveyor.
- (5) Bore, turn, face, contour, drill, chamfer, and tap; mill, bore, and chamfer; drill and chamfer; tap motor mounting face; mill, spot drill, drill, bore, and ream arms (4), and press-in 4 antifriction bushings.

These operations are performed on the Lamb 18-station palletized transfer machine shown in Figure 4-29. It requires one operator and occupies a floor space of 80 ft x 50 ft. The operations performed on this machine are as follows:

<u>Station Number</u>	<u>Left Hand</u>	<u>Operation</u>	<u>Right Hand</u>
1	Load/unload		
2	Rough contour, rough turn and face		Rough bore, finish, plunge, face and chamfer
3	Finish contour and finish turn		Finish bore
4	Gage contour and hub. Compensate station 3		Gage bore. Compensate Station 3
5	Drill and chamfer (16) holes		Drill and chamfer (12) holes
6	Probe, tap, probe (16) holes		Probe, tap, probe (12) holes
7	Idle		Straddle-mill (4) arms
8	Idle		Mill motor mount face

Figure 4-29. AZIMUTH DRIVE HOUSING MACHINING - 250,000 ANNUAL VOLUME

9	Idle	Idle
10	Ream (12) holes	Idle
11	Spot drill to chamfer (2) holes	Spot drill to chamfer (2) holes
12	Drill through (2) holes	Drill through (2) holes
13	Ream (2) holes	Ream (2) holes
14	Press in bushings (2) holes	Press in bushings(2) holes
15	Future work	---
16	Ream (1) hole	Idle
17	Drill, chamfer (4) holes	Idle
18	Probe, tap, probe (4) holes	Idle

- (6) Perform part wash, master gaging and hand gaging -- material handling with overhead crane.

4.3.3.2 Drag Link

The machining and processing operations for the drag link at the 25,000 and 250,000 annual volumes are listed in the following pages. For the low volume, the drag link is purchased as a completed weldment which is plated and ready for machining. For the high volume, welding and galvanizing are completed in the manufacturing plant. Machining is required for the torque tube hinge mounting trunnion of the stowage jack, and clevis of the tracking actuator. This machining consists of facing the surfaces and boring the pin holes. In each case, the machining is performed on automatic machines with transfer equipment. At the higher volume, continuous cycling machining operations (noncumulative) are added by means of a pallet return system to improve cycle time and reduce labor requirements.

The drag link weldment - machining process for the 25,000 volume is:

- (1) Receive and inspect drag link weldment with galvanized plating.
- (2) Spot drill, ream, mill, press-in bushings.

These operations are performed on the Lamb 6-station shuttle machine shown in Figure 4-30. It requires one operator and occupies a floor space of 46 ft x 20 ft. The operations performed on this machine are as follows:

Scale 1/8" - 1'
Figure 4-30. DRAG LINK MACHINING - 25,000 ANNUAL VOLUME

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<u>Station Number</u>	<u>Left Hand</u>	<u>Operation</u>	<u>Right Hand</u>
1	Spot drill (3) holes		Spot drill (3)holes
2	Drill (3) holes		Drill (3) holes
3	Ream (3) holes		Ream (3) holes
4	Idle		Mill lugs
5	Press in (3) bushings		Press in (3)bushings
6	Load/unload part		

(3) Perform part washing and master gaging.

(4) Transfer to forklift pallets with overhead crane.

At the higher volume, the drag link is assembled from purchased, pre-cut welding blanks. The welding process description, machine and operator requirements for the drag link at the 250,000 unit annual volume are as follows:

<u>Operation</u>	<u>Machine</u>	<u>Operators/ Machine</u>
(1) Weld ears to (2) braces	4-station dial index welding machine (2 required)	1.0
(2) Weld ear/brace sub- assembly and large brace to side links	6-station dial index welding machine (3 required)	1.0
(3) Clean welded surfaces	Wheelabrator	1.0

The welding area and machine layout are shown on the plant layout in Section 4.4. This area of the plant is enclosed and provided with special ventilation equipment. Welded drag links are placed on pallets for staging prior to the galvanizing operation. Drag links are processed through the same galvanizing line with the azimuth drive housings. The process description for the galvanizing operation is contained in paragraph 4.3.3.1.

The drag link weldment - machining process for the 250,000 volume is:

(1) Receive and inspect pre-cut shapes ready for welding and deliver to weld area.

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- (2) Weld per routing sheets.
- (3) Galvanize.
- (4) Spot drill, ream, and mill in 4 places; press-in 4 bushings.

These operations are performed on the Lamb 6-station palletized transfer machine shown in Figure 4-31. It requires one operator and occupies a floor space of 53 ft x 34 ft. The operations performed on this machine are as follows:

<u>Station Number</u>	<u>Left Hand</u>	<u>Operation</u>	<u>Right Hand</u>
1			Load/unload part
2	Spot drill (3) holes		Spot drill (3) holes
3	Drill (3) holes		Drill (3) holes
4	Ream (3) holes		Ream (3) holes
5	Mill slots		Idle
6	Press (3) bushings		Press (3) bushings

- (5) Perform part washing and master gaging.
- (6) Transfer to forklift pallets with overhead crane.

4.3.3.3 Torque Tube

The machining and processing operations for the torque tube assembly at the 25,000 and 250,000 annual volumes are listed in the following pages. For the low production volume the torque tube is purchased as a completed weldment which is plated and ready for machining. For the high volume, welding and galvanizing are performed in the manufacturing plant. Machining is required for the face of the mounting flanges and the tabs for mounting the azimuth drive housing and the clevis of the stowage actuator. Mounting and pin holes are bored and reamed. In each case, the machining is performed on automatic machines with transfer equipment. At the higher volume, continuous cycling, noncumulative machining operations, utilizing a pallet return system, are added to improve cycle time and reduce labor requirements.

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Scale 1/8" = 1'

Figure 4-31. DRAG LINK MACHINING - 250,000 ANNUAL VOLUME

The torque tube weldment machining process for the 25,000 volume is:

- (1) Receive and inspect torque tube weldment with galvanized plating.
- (2) Mill ends; tap drill and tap 4 holes.

These operations are performed on the Lamb 4-station shuttle machine shown in Figure 4-32. It requires one operator and occupies a floor space of 29 ft x 33 ft. The operations performed on this machine are as follows:

<u>Station Number</u>	<u>Operation</u>
1	Load/unload part
2	Mill ends
3	Tap drill and chamfer (8) holes in each end plate. Drill and ream (2) manufacturing holes
4	Tap (8) holes in each end plate

- (3) Perform part washing and in-processing gaging.

- (4) Drill, chamfer, ream, and mill 6 lugs.

These operations are performed on the Lamb 5-station shuttle machine shown in Figure 4-33. It requires one operator and occupies a floor space of 54 ft x 16 ft. The operations performed on this machine are as follows:

<u>Station Number</u>	<u>Operation</u>
1	Load/unload part
2	Mill lug faces
3	Drill lug holes
4	Ream lug holes
5	Chamfer lug holes

- (5) Perform part washing and master gaging.

- (6) Transfer to forklift pallets with overhead crane.

Figure 4-32. TORQUE TUBE MACHINING-#1 - 25,000 ANNUAL VOLUME

Scale 1/8" = 1'

Figure 4-33. TORQUE TUBE MACHINING-#2 - 25,000 ANNUAL VOLUME

At the higher volume, the torque tube is assembled from purchased, pre-cut welding blanks. The welding process description, machine and operator requirements for the torque tube at the 250,000 unit annual volume are as follows:

<u>Operation</u>	<u>Machine</u>	<u>Operators/ Machine</u>
(1) Load pre-cut parts weld end flanges and actuator ears - one side only	Special purpose welding machine (4 required)	1.0
(2) Unload, invert, reload and weld remainingng side		
(3) Clean welded sufaces	Wheelabrator	1.0

The welding area and machine layout are shown on the plant layout in Section 4.4. This area of the plant is enclosed and equipped with special ventilation equipment. Welded torque tubes are placed in pallets in the staging area prior to the galvanizing operation. Torque tubes are processed through the galvanizing area on a line that is separate from the one used for the azimuth housings and drag links. The galvanizing processing is the same as that discussed in paragraph 4.3.3.1, with the following exceptions; two operators are required for load/unload operations. Three operators are required for monitoring and servicing this line.

The torque tube weldment machining process for the 250,000 volume is:

- (1) Receive and inspect pre-cut material and deliver to welding area.
- (2) Weld per routing sheets.
- (3) Galvanize.
- (4) Mill ends; tap drill and tap 4 holes.
- (5) Drill, chamfer, ream, and mill 6 lugs.

Operations in steps 2 and 3 are performed on the Lamb 8-station palletized transfer machine shown in Figure 4-34. It requires one operator and occupies a floor space of 74 ft x 44 ft. The operations performed at the stations of this machine are as follows:

Figure 4-34. TORQUE TUBE MACHINING - 250,000 ANNUAL VOLUME

<u>Station Number</u>	<u>Operation</u>
1	Load/unload part, locate
2	Mill lug faces
3	Drill lugs right and left of center
4	Chamfer both sides of lug holes
5	Ream lug holes right and left hand
6	Mill ends
7	Tap drill and chamfer (8) end plate holes
8	Probe (8) holes, tap (8) holes, and probe (8) holes

(4) Perform part washing and master gaging.

(5) Transfer to forklift pallets with overhead crane.

4.3.3.4 Circular Spline

The circular spline is machined from heavy-wall, seamless, sheet tubing. Spline parts are cut to length and the inner and outer diameters are machined. The cut-off face, outside diameter and bearing roll are ground. Mounting holes are drilled and tapped. The inside diameter spline teeth are shaped. The processing steps and machines used in the processing for the 25,000 and 250,000 unit annual volumes are described in the following pages.

The circular spline process for the 25,000 volume is:

Receive SAE 1018 seamless steel tubing heavy wall 15 inch O.D. x 2-1/2 inch wall - nominal 16 ft lengths.

- (1) Load tube into cut-off machine.
- (2) Turn O.D., bore, chamfer, and face.
- (3) Lay faced surface on magnetic chuck and grind cutoff face to length.
- (4) Demagnetize.
- (5) Chuck on I.D., diamond roll form grind for O.D. and bearing contour to size.

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- (6) Tap drill for eight 1/4-20 holes and eight 5/8-11 holes.
- (7) Tap all holes from operation 6.
- (8) Chuck on finished O.D. and broach I.D. spline teeth.
- (9) Wash.
- (10) Final inspection.

These operations are performed on the following machines:

- Savage abrasive saw and Bullard temple turn vertical turret lathe
- Blanchard grinder (grind, cut off face)
- Landis grinder (grind O.D. and bearing race)
- Buhr N.C. machine (drill and tap holes)
- Fellows gear shaper (shape I.D. spline teeth)

These machines are shown in the plant layout in Section 4.4.

The circular spline process for the 250,000 volume is:

Receive SAE 1018 seamless steel tubing heavy wall 15 inch O.D. x 2-1/2 inch wall - nominal 16 ft lengths.

- (1) Load tube into single spindle N.C. tubing machine.
- (2) Turn O.D., bore and chamfer, face, and cut off.
- (3) Lay faced surface on magnetic chuck and grind cutoff face to length.
- (4) Demagnetize.
- (5) Chuck on I.D., diamond roll form grind for O.D. and bearing contour to size.
- (6) Tap drill for eight 1/4-20 holes and eight 5/8-11 holes.
- (7) Tap all holes from operation 6.
- (8) Chuck on finished O.D. and broach I.D. spline teeth.
- (9) Wash.
- (10) Final inspection.

These operations are performed on the following machines:

- National Acme lathe (turn O.D., bore, chamfer, face, and cut off)
- Blanchard grinder (grind, cut off face)
- Landis grinder (grind O.D. and bearing race)
- Lamb 4-station dial machine
- Fellows gear shaper (broach I.O. spline teeth)

These machines are shown in the plant layout in Section 4.4.

4.3.3.5 Flex Spline

The flex spline is constructed from seamless steel tubing, a die-blanked steel diaphragm and a steel support doubler. The tubing is lathe-turned and hobbled to form the gear teeth. The diaphragm and the doubler are projection-welded together and the assembly is heli-arc welded to the machined tube. After welding the flex spline is drilled for the mounting holes and pilot diameter. A Tuff-tride treatment completes the processing.

The processing steps and machines used in the processing for the 25,000 and 250,000 unit annual volumes are described in the following pages.

The flex spline process for the 25,000 volume is:

Receive the following raw material:

- SAE seamless Rockrite tubing SAE 8620 steel - bearing quality, vacuum degassed, 10-1/4 inch O.D. x 3/8 inch wall in 16 ft minimum length
- Die blanked diaphragm - 9.625 $\pm$ 0.005 8620 steel
- 3.1875 $\pm$ 0.005 I.D. x 1/8 thick
- Support doubler SAE 1018 - 6.250 $\pm$ 0.005
- 3.1875 $\pm$ 0.005 x 3/8 thick

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Plate to be embossed with projections suitable for projection resistance welding.

- (1) Load tube into single spindle special purpose lathe chuck with collet on O.D.
- (2) Rough bore I.D., turn and form O.D., face, and cut off.
- (3) Normalize heat treat for metallurgical grain size.
- (4) Hone I.D.
- (5) Finish tracer turn O.D.
- (6) Hob spline teeth.
- (7) Projection weld doubler to diaphragm.
- (8) Expand the finished tube onto a mandrel.
- (9) Rotate mandrel and tungsten-shielded arc (helium) weld diaphragm to tube.
- (10) Load on full complement mandrel, bore chamfer pilot diameter, pre-drill and chamfer bolt holes, face doubler.
- (11) Buff and clean.
- (12) Tuff-tride.
- (13) Wash.
- (14) Final inspection.

These operations are performed on the following machines:

- National Acme lathe (tube machining)
- Normalizing furnace (vendor treatment)
- Micro-matic hone (hone, I.O.)
- Fellows gear shaper (hob spline teeth)
- Single station welding machine (projection welding)
- Single station welding machine (heli-arc welding)
- Buhr N.C. machine (drill and ream)
- Tuff-tride treatment (vendor process)

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The in-plant machines on this list are shown on the plant layout in Section 4.4.

The flex spline process for the 250,000 volume is:

Receive the following raw material:

- SAE seamless Rockrite tubing SAE 8620 steel - bearing quality, vacuum begassed, 10-1/4 inch O.D. x 3/8 inch wall in 16 ft minimum length.
- Die blanked diaphragm - 9.625 ± 0.005 8620 steel
- 3.1875 ± 0.005 I.D. x 1/8 thick
- Support doubler SAE 1018 - 6.25 ± 0.005
- 3.1875 ± 0.005 x 3/8 thick

Plate to be embossed with projections suitable for projection resistance welding.

- (1) Load tube into single spindle special purpose lathe chuck with collet on O.D.
- (2) Rough bore I.D., turn and form O.D., face, and cut off.
- (3) Normalize heat treat for metallurgical grain size and core hardness.
- (4) Hone I.D.
- (5) Finish tracer turn O.D.
- (6) Hob spline teeth.
- (7) Projection weld doubler to diaphragm.
- (8) Expand the finished tube onto a mandrel.
- (9) Rotate mandrel and tungsten-shielded arc (helium) weld diaphragm to tube.
- (10) Load on full complement mandrel, bore chamfer pilot diameter, pre-drill and chamfer bolt holes, face doubler.
- (11) Buff and clean.
- (12) Tuff-tride.
- (13) Wash.
- (14) Final inspection.

These operations are performed on the following machines:

- National Acme lathe (tube machining)
- Normalizing furnace (vendor treatment)
- Micro-matic hone (hone I.D.)
- Fellows gear shaper (hob spline teeth)
- Single station welding machine (projection welding)
- Single station welding machine (heli-arc welding)
- Lamb 4 station dial machine
- Tuff-tride treatment (vendor process)

The in-plant machines on this list are shown in the plant layout in Section 4.4.

4.3.3.6 Wave Generator Plug

The wave generator for the harmonic drive is machined from steel bar stock which is lathe-cut to the proper thickness, ground on both sides, broached for the inside diameter, and countour-ground in a ganged setup.

The processing steps and the machines used in the processing for the 25,000 and 250,000 unit annual volumes are described in the following pages.

The wave generator plug process for the 25,000 volume is:

Receive SAE 1018 bar stock 7.250 O.D. in nominal 16 ft lengths.

- (1) Load into single spindle 2 AC Warner & Swasey N.C. automatic lathe.
- (2) Turn, face, bore, chamfer, and cut off.
- (3) Blanchard grind both sides to length.
- (4) Demagnetize.
- (5) Key seat broach I.D.
- (6) Gang load on arbor; radial locate on key.
- (7) Contour grind 3-lobe form on O.D. (polygon grinder).
- (8) Wash.
- (9) Inspect.

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These operations are performed on the following machines:

- National Acme Lathe SST-10 5/8
- Blanchard grinder
- Mitts and Merrill broach
- Polygon grinder

These machines are shown in the plant layout in Section 4.4.

The wave generator plug process for the 250,000 volume is:

Receive SAE 1018 bar stock 7.250 O.D. in nominal 16 ft lengths.

- (1) Load into single spindle 2 AC Warner & Swasey N.C. automatic lathe.
- (2) Turn, face, bore, chamfer, and cut off.
- (3) Blanchard grind both sides to length.
- (4) Demagnetize
- (5) Key seat broach I.D.
- (6) Gang load on arbor; radial locate on key.
- (7) Contour grind 3-lobe form on O.D. (polygon grinder)
- (8) Wash.
- (9) Inspect.

These operations are performed on the following machines:

- National Acme Lathe SST-10 5/8
- Blanchard grinder
- Mitts and Merrill broach
- Polygon grinder

These machines are shown on the plant layout in Section 4.4.

4.3.3.7 Drive Shaft

The drive shaft for the harmonic drive is machined from tubular steel stock. Machining is required to turn the outside diameter, thread the ends, mill (4) keyways and grind the bearing and cam diameters.

The machines used for this processing for the 25,000 and 250,000 unit annual volumes are listed below:

- 25,000 Volume
 - Purchased from vendor
- 250,000 Volume
 - 4 station trunnion machine (turn diameter and thread ends)
 - Single station double-ended mill (mill keyways)
 - Landis grinder (grind bearing and cam diameter)

These machines are shown on the plant layout in Section 4.4.

4.3.3.8 Bearing Retainer

The bearing retainer for the azimuth drive housing is machined from a purchased rolled-steel ring at the 25,000 volume level. This ring is then ground, lathe turned, drilled and galvanized. At the higher volume, the bearing retainer is fabricated from purchased steel bar. The bar is cut to length to form the retainer ring, heated, roll formed and expanded. Finish machining at this volume is similar to that performed at the low volume level. After machining, the bearing retainer is galvanized.

The processing steps, machines and operator requirements for the 25,000 and 250,000 unit annual volumes are described on the following pages.

The processing for the bearing retainer at the 25,000 volume level is as follows:

<u>Operation</u>	<u>Machine</u>	<u>Operators/ Machine</u>
(1) Grind sides of ring parallel and flat	Blanchard grinder (1 required)	0.5
(2) Turn inside diameter bearing race contour and "o"-ring grooves	Bullard Templaturn Vertical Turret Lathe (1 required)	1.0

<u>Operation</u>	<u>Machine</u>	<u>Operators/ Machine</u>
(3) Drive and counter - bore (16) holes	Buhr N.C. Machine (1 required)	1.0

After machining, the bearing retainers are transported to the galvanizing area. The bearing retainers are processed and on the same line with the azimuth housings and drag links. The processing for these parts is described in paragraph 4.3.3.1. After galvanizing the bearing retainers are transported to the azimuth drive assembly area and stored in the staging area. The equipment and machining area for the bearing retainers is shown on the plant layout in Section 4.4.

The processing for the bearing retainer at the 250,000 volume level is as follows:

<u>Operation</u>	<u>Machine</u>	<u>Operators/ Machine</u>
(1) Cut purchased steel bar into retainer lengths	W. J. Savage abrasive saw (1 required)	1.0
(2) Heat cut-off parts	Oven (1 required)	---
(3) Transport and roll cut-off part into ring	Grotnes ring roller (5 required)	1.0
(4) Expand ring to final size and round shape	Grotnes expander (5 required)	1.0
(5) Transport and grind both sides parallel and flat	Blanchard grinder (2 required)	1.0
(6) Turn inside diameter contour and (2) "0" ring grooves	Bullard Templaturn Vertical Turret Lathe (6 required)	1.0
(7) Drill (16) holes	Lamb 4-station dial index machine (1 required)	1.0

After machining, the bearing retainers are transported to the galvanizing area. The bearing retainers are processed in the same line with the azimuth housings and drag links. The processing for these parts is described in paragraph 3.3.3.1. After galvanizing, the bearing retainers are transported to the azimuth drive assembly area and stored. The equipment and machining area for the bearing retainer is shown on the plant layout in Section 4.4.

4.3.3.9 Azimuth Drive Unit Assembly Processing

The processing steps for the assembly of the azimuth drive at the 25,000 and 250,000 annual volumes are listed in the following pages. For both production volumes, the housing moves along transfer equipment as the components are installed. These components include: drive gear set and bearings, drive shaft, flexible spline, flexible bearing, circular spline, and wave generator. At the lower volume most components are inserted manually and fasteners are torqued automatically. At the high volume, most component insertion, gaging, shim packing, and fastening are performed automatically. At this stage of assembly, the azimuth drive is complete, except for the installation of the drive motor. The input gear oct is lubricated and the output gear case is oil filled. The completed subassemblies are then placed on pallets for transfer with forklift trucks to the final assembly area.

These operations are performed on an assembly line with manual loading. The machines required and operations for the azimuth drive components for the 25,000 and 250,000 unit annual volumes are given in the following pages.

The processing for the two annual volumes is similar. At the lower volume, a 29-station assembly line with 7 operators is required. This machine is shown in Figure 4-35.

At the higher volume, a 29-station assembly line with 12 operators is required. This machine is shown in Figure 4-36.

Following is a list of the processing steps required for both annual volumes.

The drive unit assembly process for the 25,000 and 250,000 volume is:

- (1) Using overhead crane, load machined azimuth drive housing on transfer line.
- (2) Idle
- (3) Automatically load flex spline on mandrel and orient.
- (4) Idle
- (5) Advance mandrel and wedge flex spline into cavity.
- (6) Press-in 6 bolts through top of housing.
- (7) Install 6 torque nuts through mandrel and flex spline; torque-out nuts and bolts.
- (8) Idle

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- (9) Press-in 6 bolts, alternate locations, through top of housing; remove mandrel and wedge.
- (10) Install 6 torque nuts and torque-out nuts and bolts.
- (11) Idle
- (12) Press-in upper shaft bearing; install retainer and 4 bolts.
- (13) Idle
- (14) Hoist housing with rollover fixture and rotate 90 degrees.
- (15) Idle
- (16) Manually insert wave generator cam bearing and center shaft subassembly with key aligned and press in place -- backup upper bearing.
- (17) Idle
- (18) Install circular spline ring with inner bearing races installed; install upper outer bearing race; install bearing balls.
- (19) Install 2 O-rings, bearing retainer, subassembly with lower outer bearing race; install and torque bolts.
- (20) Idle
- (21) Press-in bushings for torque tube and tracking actuator.
- (22) Oil fill housing cavity and install bottom cover (with sealant) and 8 bolts.
- (23) Hoist housing assembly with rollover fixture and rotate 180 degrees.
- (24) Install drive gear ^ospacer and drive gear; perform automatic electronic shim selection; install shim and drive gear key.
- (25) Idle
- (26) Install drive gear lock washer and retaining nut and torque out; bend tab on washer.
- (27) Idle
- (28) Install top cover and cable elbow.
- (29) Unload

4.3.3.10 Azimuth/Elevation Assembly Processing

The azimuth/elevation assembly consists of the following components:

- Azimuth drive and motor
- Drag link
- Torque tube
- Tracking actuator and motor
- Storage actuator and motor
- Pins and shims
- Electronic controller and harness

At the 25,000 unit annual volume, these operations are performed manually on two assembly benches, each with two positions. This operating also requires two overhead cranes and four operators. A layout of the assembly station is shown in Figure 4-37.

The operations for the 250,000 volume are performed in a similar fashion to the 25,000 volume. These operations, however, are performed on a conveyor type transfer machine with 20 operators. The machine layout and processing are shown in Figure 4-38.

4.3.4 Pedestal Assembly

The pedestal assembly consists of the tapered pipe, the pedestal tube with tapered end, and an end cap which is welded to the top of the pedestal tube. All of these components are galvanized for protection from corrosion. The process description for manufacturing the pedestal assembly for both production volumes is contained in the following pages.

4.3.4.1 Tapered Pipe Foundation Cap Process Description for the 25,000 Volume

- (1) Purchase zinc plated tapered pipe foundation cap complete from vendor.
- (2) Inspect in plant.
- (3) Deliver to site.

Figure 4-37. AZIMUTH/ELEVATION ASSEMBLY AREA - 25,000 ANNUAL VOLUME

Figure 4-38. AZIMUTH/ELEVATION ASSEMBLY AREA - 250,000 ANNUAL VOLUME

Tapered Pipe Foundation Cap Process Description for the 250,000 Volume

- (1) Receive sheet steel from vendor slit to width.
- (2) Manufacture welded tubing complete on tube mill, cut to length.
- (3) Expand pipe over 46 inch length to 0.14 in./ft taper.
- (4) Galvanizing of the tapered pipe is performed on a line that is separate from that used for the torque tube and azimuth drive components. The processing, however, is identical. This processing is described in paragraph 4.3.3.1, with the following exceptions: two operators are required for load/unload operations, three operators are required for monitoring and servicing of this line. The usage of this line is shared between the tapered pipe and the pedestal tube.
- (5) Package for shipment to installation site.

These operations are performed on the following machines:

- Tube mill (roll forming and welding)
- Expanding mandrels (expanding taper)
- Galvanizing tank (galvanized plating)

Note: The tube mill and galvanizing tank are used for manufacture of the tapered pipe as well as the pedestal tube.

These machines are shown on the plant layout in Section 4.4.

4.3.4.2 Pedestal Tube Process Description for the 25,000 Volume

- (1) Purchase complete from vendor.
- (2) Deliver tube to assembly area for buildup with azimuth drive components.

Pedestal Tube Process Description for the 250,000 Volume

- (1) Receive sheet metal in rolls cut to width from vendor.
- (2) Manufacture welded tubing (0.105 wall) complete on tube mill with pipe cut to length at end of process.
- (3) Automatically arc weld cap to pedestal tube.
- (4) Expand one end of tube over 48 inches in length from 24 inches O.D. to 24.5 inches O.D. after cut-off.
- (5) Flame cut round and square hole.
- (6) Galvanizing of the pedestal tube is performed on a line that is shared with the tapered pipe operations. The processing is described in paragraph 4.3.3.1. Operator requirements for this shared line are given in paragraph 4.3.4.1.
- (7) Deliver tube to assembly area for buildup with azimuth drive components.

These operations are performed on the following machines:

- Tube mill (roll forming and welding)
- Pattern torch cutter
- Expanding mandrels (expanding tapered section)
- Single station weld machines (end cap/tube welding)
- Galvanizing tank (galvanized plating)
- Overhead cranes (3)

These machines are shown on the plant layout in Section 2.4.2.

4.3.4.3 End Cap Process Description for the 25,000 and 250,000 Volume

- (1) Purchase end cap complete from vendor, including zinc plate.

4.3.5 Final Assembly

For final assembly, completed azimuth/elevation assemblies and pedestal assemblies are transferred with fork-lift trucks on pallets to the final assembly area. The assembly operation requires the installation of mounting bolts between the drive assembly and the pedestal tube, routing of the cable harness, and connection to the junction box, and installation of the junction box.

4.3.5.1 Final Assembly for the 25,000 Volume

These operations are performed manually with the aid of an assembly fixture and overhead crane. Equipment required includes one bench and two overhead cranes. One operator is required. The following operations are performed at the final assembly station. (See Figure 4-39).

- (1) Receive drive assembly and pedestal from staging areas.
- (2) Crane load drive assembly on three-point cradle, supporting torque tube and housing flange. Crane load pedestal on two "V" block cradles, end cap against drive flange. Rotate pedestal to align holes.
- (3) Through access opening in pedestal, manually insert and tighten with pneumatic wrench, eight 5/8-11 screws.
- (4) Connect and install junction box.
- (5) Electrical functional test of drive motors and electronics is performed at this point.
- (6) Using overhead crane, unload final assembly and place in custom shipping containers at shipping dock.

4.3.5.2 Final Assembly for the 250,000 Volume

These operations for the 250,000 volume are performed in a manner similar to the 25,000 volume. The increased capacity requires 9 benches, each with 2 positions, and 18 overhead cranes. Forty operators are required.

The processing description is the same as that for the lower volume and the assembly station is identical to that shown in Figure 4-39.

Figure 4-39. FINAL ASSEMBLY BENCH PEDESTAL ASSEMBLY - 25,000 UNIT ANNUAL VOLUME

4.4 Plant Layout

The plant layouts for the 25,000 and 250,000 unit annual volume heliostat production are shown in Figures 4-40 and 4-41, respectively. Both plant designs are single-story slab construction and of high-bay design. The low volume plant has floor area of approximately 300,000 square feet and the high volume plant occupies approximately 680,000 square feet.

The plant for the 25,000 unit annual volume, Figure 4-40, has facilities for the manufacture of the following operations:

- Mirror laminating
- Support structure pressing and welding
- Reflector panel assembly
- Azimuth drive housing machining
- Flex spline, wave generator, bearing retainer, and circular spline machining
- Drag link and torque tube machining
- Azimuth and elevation drive assembly
- Electronic/electrical component fabrication and assembly
- Final assembly
- Shipping

Major supplier items which are shipped into this plant include the following:

- Mirrored front lites
- Float glass back lites
- Roll formed sections for the support structure
- Azimuth drive, torque tube, drag link, pedestal and tapered pipe galvanized weldments
- Electronic parts, printed circuit boards and wiring
- Drive motors and linear actuators

Figure 4-40. PLANT LAYOUT
25,000 UNIT ANNUAL VOLUME

Figure 4-41. PLANT LAYOUT
 250,000 UNIT ANNUAL VOLUME

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A major portion of the plant is occupied by the processing equipment for the reflective surface assembly. Glass laminating and stringer bonding are followed by partial curing in the oven located at the front of the plant. Additional curing occurs in the storage area adjacent to the oven. In parallel with the mirror assembly, the support structure components are press formed and welded in the semi-automated welding line. Mirror panels and support structures are assembled in the line adjacent to the shipping area.

Machining and assembly of the drive components take place in the various areas at the rear of the plant. The electronic/electrical fabrication occurs in the closed area which is near the final assembly area. Completed drive units are stored in the staging area which ends at the shipping dock.

The plant for the 250,000 unit annual volume, Figure 4-41, has facilities for the same items which are made in the low-volume plant. In addition, the following items are produced in this plant:

- Azimuth drive housing, torque tube, drag link, fabricating and galvanizing
- Pedestal and tapered pipe forming, welding, and galvanizing

In this plant, the processing line for mirror laminating and stringer bonding handles six panels at a time and includes a larger curing oven and vertical tower for panel post-cure storage. Two lines are installed for the fabrication and welding of the support structure. These operations occupy a major portion of the plant adjacent to the shipping area. This area is enclosed by metal walls and has additional air handling equipment.

The fabrication, welding and galvanizing operation for the azimuth drive housing, torque tube, drag link, pedestal and tapered pipe occupy the central portion of the plant.

Machining operations and electronic/electrical assembly occupy the left-hand side of the plant. These operations all feed the drive assembly area which is near the pre-shipping storage area.

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SECTION 5.0

HELIOSTAT PRODUCTION COSTS

Heliostat production costs have been developed from the processing, machines, and plant designs for the 25,000 and 250,000 unit annual volume of heliostat manufacture. Purchased parts and materials costs were developed from material price requests which were completed for each component of the heliostat. The actual forms used in this analysis are contained in Appendix B of this report. In all cases, material price quotes were obtained from vendors for each purchased heliostat component.

From the machine and plant designs, tooling and routing sheets were prepared. These forms indicate the operations to be performed, timing for manual and automatic operation, and prices for special tools and equipment. Copies of these forms are contained in Appendix C of this report. All special machine designs were developed to the point of detailed concept sketches, and cost estimates were made by suppliers of similar equipment. Where standard machine tools are used, budgetary cost estimates or quotations were obtained from the vendors.

Average hourly labor rates for persons engaged in manufacturing in the southwestern area of the United States were used to establish the base hourly rate in the manufacturing plants. This rate, \$6.30 per hour, was adjusted for typical fringe benefits.

Plant costs were estimated for both the 25,000 and 250,000 volume units and reflect current rates for similar construction in the southwest.

Actual tax rate information for the selected site location of Tuscon, Arizona, was used in the determination of real estate and property taxes.

The factory cost totals for the two production volumes show the allocation of labor, material, burden, fringe benefits, special tools, and plant engineering for each unit of heliostat production at the 100 percent capacity level and provides a factory cost of \$4,699.07 at the low volume and \$3,301.87 at the high volume*. Outside tooling and plant costs which are required to meet supply at the two volumes are also indicated; when these costs are included the total per unit heliostat costs are \$4,708.42 at the 25,000 volume and \$3,333.03 at the 250,000 volume. The corresponding costs per square meter of heliostat surface area are \$95.99 and \$67.95.

*See Section 1.2.7, Factory Cost

The heliostat costs for the two production volumes, adjusted to 75 percent of capacity the total per unit heliostat costs are \$4,909.88 at the 18,750 volume and \$3,438.18 at the 187,500 volume. The corresponding costs per square meter of heliostat surface area are \$100.10 and \$70.10.

The heliostat costs for the two production volumes, adjusted to 125 percent of capacity show that the total per unit heliostat costs are \$4,587.58 at the 31,250 volume and \$3,269.94 at the 312,500 volume. The corresponding costs per square meter of heliostat surface area are \$93.53 and \$66.67.

The breakdown of the burden cost, on a per unit basis for both fixed and variable burden have been indicated in Section 5.2.5. The most significant portion of the burden account is for taxes and depreciation on the buildings and plant equipment.

The investment per unit heliostat at the two production volumes was also determined. The totals indicated have been depreciated to obtain the expense values shown in the burden account. Buildings depreciated over 40 years, equipment and machinery depreciated over 9.5 years, and special tools depreciated over 5 years.

Outside tooling and plant costs are summarized in Section 5.2. Outside expenses result from rolling mill tools and buildings, mirroring equipment, glassmaking equipment, gear tooling, and junction box tooling. These outside costs add \$0.19 and \$0.64 per square meter to the heliostat cost at the two production volumes.

5.1 COST APPROACH

5.1.1 Purchased Parts

The item labeled "Material" in subsequent cost tables includes all the raw materials and purchased parts required for the manufacture of the heliostat unit; examples are: glass, adhesive, steel, weldments, packaging, materials, etc. All indirect material costs are collected as a variable or fixed burden expense.

At both the high and low production volumes, your attention is drawn to the very high relative material cost, much of which can be associated with purchased parts (see the Bill of Materials). Material costs including purchased parts comprise 81 percent of the factory cost at the 25,000 units per year volume and 85 percent of the factory cost at 250,000 units per year.

5.1.2 Labor (direct/indirect)

Direct labor includes all straight time wages of employees who perform manufacturing operations which enhance the value of the heliostat unit and/or who participate directly or indirectly in processing operations which enhance the value of raw materials and purchased parts. Direct labor includes inspectors, some material handlers, and machine attendants, as well as productive operators.

Indirect labor is a burden expense and comprises the following categories:

- Supervision - Foremen, superintendents, and all other supervisory positions
- Clerical - Factory clerks and checkers; office clerks and typists
- Material handling - Truckers, crane operators, and other material handlers not included in direct labor
- Building and property attendants
- Machine, tool, and die setting
- Drafting and engineering
- Inspection - Inspectors of supplies, tools, and materials.

5.1.3 Tools and Equipment

Expense tools and equipment costs are collected as a burden expense. These items include:

- Tools - cutters, drill bits, hand tools, etc.
- Equipment - special holding devices, bins, racks, etc.
- Office furniture and equipment.

Special tools are collected as a factory cost item and depreciated over a 5-year period. The double declining balance method is used with the first year convention. The second year's depreciation is then taken as the average annualized cost for estimating purposes.

5.1.4. Production Plant Costs

The plants for heliostat manufacture at the 25,000 and 250,000 unit annual volume have floor areas of approximately 300,000 and 700,000 square feet, respectively. These plants feature concrete slab construction with a steel structure. The plants are air conditioned, fully sprinklered and have waste water treatment at the secondary level. Plant equipment is included for electric arc welding, compressed air, process water and battery charging for the materials handling equipment. Enclosed areas are provided for the welding and plating areas. These areas have metal walls and special air handling equipment.

Outside storage areas are provided for five days of heliostat production. These uncovered storage pads for heliostat components in shipping racks have areas of 50,000 and 500,000 square feet for the two production volumes. Plant sites are improved for access and storage and are completely fenced. The plant site sizes are 50 and 100 acres for the two production volumes. The site sizes have been selected to provide for possible future expansion.

For the 25,000 unit annual volume, the plant is estimated to cost \$120 per square foot and the land is estimated at \$16,000 per acre. The corresponding rates for the 250,000 unit annual volume plant are \$110 per square foot and \$16,000 per acre. The lower cost rate for the larger plant, approximately 10 percent, represents the cost/area relationship from the economy of scale.

Based on these rates, the total capital needed for the smaller plant is approximately \$87,000,000 of which \$37,000,000 is for the building and \$800,000 for land. The corresponding costs for the larger plant are approximately \$393,000,000 of which \$75,000,000 is for the building and \$1,600,000 for the land.

The buildings are depreciated over a period of 40 years and the land is not depreciated. Total annualized costs for the buildings and land, and investment per heliostat unit are in the sections that follow.

Building depreciation is performed by the double declining balance method with the first year convention. The second year's depreciation is then taken as the average annualized cost for estimating purposes.

5.1.5 Spare Parts

Spare parts requirements for the heliostat have been extracted from the MDAC final report. The component requirements are given in Table 5-1. The spare parts quantities given in this table represent the case for the 25,000 unit annual volume. At the 250,000 unit annual volume, spare part quantities are increased by a factor of ten.

Since these parts requirements have a minimal effect on the production capacity of the two plants, machine and plant volumes have not been modified to reflect increased output required to produce the spare parts.

Table 5-1. SPARE PARTS REQUIREMENTS - LINE REPLACEABLE UNITS

	Initial Spare Parts	Replacement Spare Parts	Total Spare Parts
Drive Assembly, Azimuth	25	13	38
Jack Assembly, Tracking	24	11	35
Jack Assembly, Stowage	3	1	4
Drive Motor, Azimuth	28	14	42
Drive Motor, Elevation	28	14	42
Drive Motor, Stowage	3	1	4
Heliostat Control Electronics	22	7	29
Reflector Panel	107	99	206

The cost of the spare parts is less than 10 cents per square meter and has not been added to the total cost at the annual volumes.

5.2 COST SUMMARIES

This section includes all of the numbers derived from the study assembled in tabular form. In addition, a monograph provided by the Solar Energy Research Institute, Policy Analysis Branch, is included as Section 5.2.8 where an installed price comparison is made to results of the Battelle Northwest Laboratory study.

5.2.1 Full Production

This table reflects the estimated factory cost of heliostats produced at a mature facility operating at 100% of capacity where that design capacity includes allowances for machine, labor, and manufacturing efficiencies.

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Table 5-2. TOTAL COST PER HELIOSTAT UNIT (100% OF PLANT CAPACITY)

	25,000 Volume	250,000 Volume
Direct Labor	63.18	46.65
Material	3,799.37	2,798.67
Variable Burden	178.82	131.93
Fixed Burden	540.60	261.44
Variable Fringe	40.29	24.92
Fixed Fringe	23.97	14.83
Overtime	3.35	2.08
Night Shift	3.10	1.92
C.O.L.A.**	7.74	4.79
Subtotal	4,660.42	3,287.23
Special Tools	30.28	8.02
Plant Engineering	8.37	6.62
*Total Factory Cost	\$4,699.07	\$3,301.87
Outside Tooling and Plant Costs	9.35	31.16
Grand Total	\$4,708.42	\$3,333.03
\$/m ²	\$ 95.99	\$ 67.95

*See Section 1.2.7, Factory Cost

**Cost of living allowance

5.2.2 Seventy-Five Percent of Capacity

Table 5-3 reflects the estimated factory cost of a heliostat produced at a mature facility operating at 75% of capacity where total labor hours have been adjusted to accomplish a lower manufacturing rate.

Table 5-3. TOTAL COST PER HELIOSTAT UNIT (75% OF PLANT CAPACITY)

	18,750 Volume	187,500 Volume
Direct Labor	63.18	46.65
Material	3,799.37	2,798.67
Variable Burden	178.82	131.93
Fixed Burden	720.80	348.59
Variable Fringe	40.29	24.92
Fixed Fringe	31.96	19.77
Overtime	3.35	2.08
Night Shift	3.10	1.92
C.O.L.A.	7.74	4.79
Subtotal	4,848.61	3,379.32
Special Tools	40.37	10.69
Plant Engineering	8.37	6.62
*Total Factory Cost	\$4,897.41	\$3,396.63
Outside Tooling and Plant Costs	12.47	41.55
Grand Total	\$4,909.88	\$3,438.18
\$/m ²	\$ 100.10	\$ 70.10

*See Section 1.2.7, Factory Cost

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5.2.3 One Hundred Twenty-Five Percent of Capacity

Table 5-4 reflects the estimated factory cost of a heliostat produced at a mature facility operating at 125% of capacity where total labor hours have been adjusted to accomplish a higher manufacturing rate.

Table 5-4. TOTAL COST PER HELIOSTAT UNIT (125% OF PLANT CAPACITY)

	31,250 Volume	312,500 Volume
Direct Labor	63.18	46.65
Material	3,799.37	2,798.67
Variable Burden	178.82	131.93
Fixed Burden	432.48	209.15
Variable Fringe	40.29	24.92
Fixed Fringe	19.18	11.86
Overtime	3.35	2.08
Night Shift	3.10	1.92
C.O.L.A.	7.74	4.79
Subtotal	4,547.51	3,231.97
Special Tools	24.22	6.42
Plant Engineering	8.37	6.62
*Total Factory Cost	\$4,580.10	\$3,245.01
Outside Tooling and Plant Costs	7.48	24.93
Grand Total	\$4,587.58	\$3,269.94
\$/m ²	\$ 93.53	\$ 66.67

*See Section 1.2.7, Factory Cost

5.2.4 Material, Labor, and Burden Summaries

Tables 5-5 and 5-6 comprise the detail of cost per heliostat identified by the cost breakdown structure code.

Table 5-5. HELIOSTAT COST SUMMARY - 25,000 UNIT ANNUAL VOLUME
(MATERIAL, LABOR AND BURDEN)

	Material \$	Labor \$	Burden \$	Total \$
4411 - Reflective Surface	1,065.17	7.55	95.35	1,168.07
4412 - Support Structure	286.20	2.40	30.26	318.86
4413 - Assembly	1.13	3.23	40.81	45.17
4410 - Reflective Unit	1,352.50	13.18	166.42	1,532.10
4421 - Azimuth Drive	766.38	23.90	301.80	1,092.08
4422 - Elevation Drive	656.00	8.74	110.39	775.13
4423 - Motors	145.65	1.92	24.28	171.86
4424 - P/L Indicator	93.98	1.79	22.61	118.38
4425 - Power Sup./Dist.	162.56	7.32	92.40	262.27
4420 - Drive & Controls	1,824.57	43.67	551.48	2,419.72
4433 - Control/Sig.- Equip.	145.70	2.95	37.28	185.93
4451 - Structure & Tapered Pipe	358.00	0.08	0.99	359.07
Materials Shipping	116.93	-	-	116.93
Final Assembly	1.67	3.30	41.70	46.67
Total	3,799.37	63.18	797.87	4,660.42

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Table 5-6. HELIOSTAT COST SUMMARY - 250,000 UNIT ANNUAL VOLUME
(MATERIAL, LABOR AND BURDEN)

	Material \$	Labor \$	Burden \$	Total \$
4411 - Reflective Surface	681.77	3.52	33.30	718.59
4412 - Support Structure	258.92	2.25	21.33	282.50
4413 - Assembly	1.04	3.27	30.98	35.29
4410 - Reflective Unit	941.73	9.04	85.61	1,036.38
4421 - Azimuth Drive	496.97	17.15	162.47	676.59
4422 - Elevation Drive	597.69	4.81	45.60	648.10
4423 - Motors	138.38	1.12	10.63	150.13
4424 - P/L Indicator	80.56	1.48	14.02	96.06
4425 - Power Sup./Dist.	153.89	5.91	56.00	215.80
4420 - Drive & Controls	1,467.49	30.47	288.72	1,786.68
4433 - Control/Sig.- Equip.	122.78	2.23	21.10	146.11
4451 - Structure & Tapered Pipe	148.07	1.86	17.64	167.57
Materials Shipping	116.93	-	-	116.93
Final Assembly	1.67	3.05	28.84	33.56
Total	2,798.67	46.65	441.91	3,287.23

5.2.5 Burden Per Heliostat Unit

All indirect material, indirect labor, and other cost incurred by the factory in the course of performing the manufacturing operations are burden expense. These costs are summarized in Table 5-7.

Table 5-7. BURDEN COSTS PER HELIOSTAT UNIT

	25,000 Volume		250,000 Volume	
	Variable	Fixed	Variable	Fixed
Hourly	5.34	1.26	4.81	1.13
Salary	21.10	29.49	6.87	9.60
Supplies	8.33	-	8.33	-
Tools	9.67	24.79	4.88	12.86
Utilities	12.25	18.42	4.74	7.14
Maintenance	14.88	1.53	12.70	1.31
Scrap	98.01	-	81.20	-
Taxes and Depreciation	-	463.92	-	228.21
Sundry	9.24	1.19	8.40	1.19
Total	\$178.82	\$540.60	\$131.93	\$261.44

5.2.6 Non-Allied Tooling and Plant Costs

Due to the speculative nature of the projected heliostat production scenario, certain vendors were reluctant to include investment costs in their quotes. These costs are collected in Table 5-8.

Table 5-8. NON-ALLIED TOOLING AND PLANT COSTS

	25,000 Volume	250,000 Volume
Rolling Mill Tools	104,000.00	2,600,000.00
Rolling Mill Building	--	4,000,000.00
Mirroring Equipment	1,000,000.00	3,000,000.00
Glass Making Equipment	--	32,000,000.00
Gear Equipment	118,227.00	--
Box Tooling	8,500.00	--
Total	\$1,230,730.00	\$41,000,000.00
Annual Cost	\$ 233,838.70	\$ 7,790,000.00
Per Unit Heliostat Cost	\$ 9.35	\$ 31.16
Cost per square meter	\$ 0.19	\$ 0.64

5.2.7 Investment Per Heliostat Unit

Total investment required for heliostat production are discussed in Section 5.1.4. Table 5-9 provides a breakdown of the investment on a heliostat unit basis.

Table 5-9. INVESTMENT PER HELIOSTAT UNIT

	25,000 Volume	250,000 Volume
Building	1,480.00	300.00
Land and Improvements	35.20	6.40
Machinery and Equipment	1,732.75	1,167.83
Tools	151.39	40.10
Operations	93.87	56.89
Total Investment	<u>\$3,493.21</u>	<u>\$1,571.22</u>

5.2.8 Installed Price (a SERI Monograph)

The emphasis of this report is the development of the factory cost of producing the MDAC prototype heliostat. However, the factory cost should not be confused with the price of a heliostat which is delivered and ready to collect energy. That is, a potential customer should not expect to buy a heliostat for factory cost. This section will discuss the additional cost elements which must be added to factory cost to produce a selling price and will compare the cost estimates derived for this study with those produced by Battelle Pacific Northwest Labs.

The factory cost includes the cost of material, labor, burden, etc. (see Table 5-2). Burden includes engineering costs, tooling, various types of supervisory labor, and an allocation of the depreciated capital for the heliostat factory. However, the factory cost does not include all of the costs required to operate a heliostat manufacturing company. It does not include all taxes, the cost of selling and distribution, or the cost of product research and development. Most significantly it does not provide for a return on capital investment. All of these costs must be added to the factory cost to produce a selling price.

The most difficult cost to determine is the return on investment (ROI). ROI is described as a cost because in private business it is the realization of a financial return that allows the capital stock to regenerate and the business to continue. In a mature business the ROI is determined to a great extent by market forces which determine the selling price and thus the allowable profit. However, in the absence of a mature market for heliostats, SERI is using a normative profit

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derived from the anticipated ROI which a heliostat company would need to attract private capital. This approach is part of the SAMICS methodology developed by the Jet Propulsion Laboratory of Pasadena, California.

The target ROI selected by SERI for use on this project is 20 percent, and the cost of debt is 10 percent. (These financial parameters were selected in April 1979 and are intended to reflect long-term trends.) Assuming that a new heliostat corporation will be 80 percent equity financed (typical of many new ventures), the cost of capital will be 17.5 percent using these values. The expected profit is calculated to be \$350.86 per unit at the 25,000 production volume.

Values includes a return on equity for the book value of the initial \$86 million investment and an allowance for the working capital requirements of the facility estimated to be approximately \$20.9 million. Because of the higher capital requirements, this study requires a 6 percent profit on sales to achieve a 20 percent return on equity while the Battelle study requires a 4.2 percent profit on sales to achieve the same return on capital.

This study was not asked to consider to cost of installation or transportation for the heliostats. However, the Battelle study estimated those costs to be \$940/unit at 25,000 units/year and \$880/unit at 250,000 units/year. Using this estimate for installation the installed price may be projected. This information is summarized in Tables 5-10 and 5-11.

The installed price of \$122.12/m² given here for the 25,000 units per year case is subject to one important assumption. The normative price calculation assumes that a 17.5 percent return on capital is sufficient to satisfy the investors, and at the same time that the market will support a selling price high enough to allow such a 17.5 percent return on capital. In this sense, the installed prices given here are not market price projections nor should this study be interpreted as a heliostat price forecast.

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Table 5-10. HELIOSTAT PRODUCTION COST PER UNIT -
25,000 UNITS/YEAR

	Battelle \$	GM \$
Material	2,427.82	3,799.37
Direct Labor	176.14	63.18
Overhead	812.05	836.52
Factory Cost	3,416.01	4,699.07
Profit	150.62	350.86
Factory Price F.O.B.	3,566.63	5,049.31
Installation Cost	940.38	940.38
Installed Cost \$/Unit	4,507.01	5,990.31
Installed Cost \$/m ²	91.88	122.12

Table 5-11. HELIOSTAT PRODUCTION COST PER UNIT -
250,000 UNITS/YEAR

	Battelle \$	GM \$
Material	2,242.35	2,798.67
Direct Labor	98.82	46.65
Overhead	613.33	456.55
Factory Cost	2,954.50	3,301.87
Profit	144.33	207.96
Factory Price F.O.B.	3,068.83	3,509.83
Installation Cost	879.52	879.52
Installed Cost \$/Unit	3,948.35	4,389.35
Installed Cost \$/m ²	80.49	89.48

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SECTION 6.0

TECHNICAL OBSTACLES TO PRODUCTION

Several obstacles have been identified which affect the cost and/or producibility of the components used in the MDAC heliostat design. These obstacles include:

- Insufficient glass plant capacity to produce the fusion glass for the front lite at the 250,000 unit annual volume.
- Lack of corrosion protection for the mirror surfaces during shipment and service.
- Cure times for the adhesives used to bond the glass sandwich together and the steel stringers which are attached to the back lite.
- Inadequate mirror line capacity in a single existing facility.

In this section, these obstacles are clarified and recommendations are made for plans to resolve the technical issues.

6.1 FUSION GLASS PLANT CAPACITY

The Corning Glass plant in Blacksburg, Virginia, is the sole source for the borosilicate fusion glass used in the front lite of the MDAC heliostat panels. This plant has sufficient capacity to supply the front lite requirements for the 25,000 unit annual volume. At the 250,000 unit level, additional melt and processing capacity would have to be added to this plant.

The estimated investment for this capacity would be approximately \$32.5 million. In addition 670,000 grams of precious metal, platinum, would be required to equip the new facility. The platinum need not be purchased since it is not consumed in the process. It has been assumed that the platinum would be made available from federal reserves at no cost.

The plant cost of \$32.5 million has been amortized over a period of 9-1/2 years. This cost has been applied to the investment costs for the 250,000 unit production cost estimates. It contributes \$0.50/m² to the cost of a heliostat.

6.2 MIRROR SURFACE PROTECTION

In mirror production for normal field service, backing paints are applied over the silver/copper surface of the mirror to prevent corrosion of the metallic components. In the MDAC design, application of the backing paint is eliminated and adhesive bonding is used in the assembly of the front and back lites, with the back lite providing mirror protection.

Since chemical attack may occur during shipment from the mirroring facility or storage at the heliostat manufacturing plant, the mirror supplier has recommended that a protective plastic film be applied after the mirroring process and removed prior to assembly of the reflector panels. This film adds a cost of approximately \$0.32/m² to the heliostat assembly and adds extra processing in the heliostat plant for removal and disposition.

The cost of this protective film is comparable to the cost of paint as a protective measure. In addition, recent investigations by MDAC show that an edge-sealing operation will be required to prevent corrosion of the mirror surface in spite of the adhesive used between the front and back lites.

It is recommended similar experiments and studies be conducted to determine if mirror backing paint will perform the protection function for shipment and field service. These investigations should be designed to determine the compatibility of the backing paint and the adhesives as well as the performance of the paint in simulated field testing. A cost comparison can then be made between the cost of the backing paint versus the protective film for shipment and the edge sealing operation for field service.

6.3 ADHESIVE CURE TIME

The long cure time for the polyurethane adhesives used in bonding the mirror to the back lite and the stringers to the back lite has necessitated the use of large and expensive ovens in the manufacturing plant. Data from the 3M Company, which produces both adhesives for this application, indicate that the adhesive will cure to shear strength of approximately 400 psi after 10 minutes at 150 degrees F. The oven designs are based on these data and the 250 psi minimum shear strength required for handling purposes.

Reductions in the cure time would have a significant effect on costs since the oven cost, energy requirements, and plant floor area would all be affected.

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It is recommended, therefore, that two actions be taken in an attempt to reduce the cost of adhesive curing:

- (1) Explore the possibility, with the 3M Company, of modifying the IXA 3504 and EC 3532 adhesives to reduce the cure time
- (2) Perform experiments with actual glass, mirror and stringer samples to determine an acceptable minimum cure time that will allow handling between the oven and storage racks.

6.4 MIRROR LINE CAPACITY

A typical mirror line has the capacity to produce approximately 20 million square feet of mirrored surface per year, based on a 3-shift operation. The capacity required for heliostat production at the 25,000 unit annual volume level is approximately 13 million square feet per year. This requirement can be satisfied with a single mirror line of nominal size. At the higher level of 250,000 heliostats per year, approximately six lines would be required to meet the heliostat production requirements.

In order to more efficiently match the production capacity to heliostat requirements, it is recommended that a mirror line with greater capacity be used at both volume levels. A line designed for a capacity of 40 million square feet per year on a 3-shift basis would easily satisfy the mirroring requirements at the low volume if operated for only one shift. Three lines, with an improved speed capability, could then be used to satisfy the requirements for the higher volume of heliostat production.

To improve operating efficiency by reducing shipping and scrappage, the mirror line should be located in the fusion glass production facility. Corning Glass has agreed that this proposal is beneficial and is willing to consider the installation of mirroring equipment in the glass plant.

The estimated cost of a mirroring line designed for 40 million square feet per year is \$1 million. For the high volume case, three machines are required. The annual costs for these facilities are shown in Table 5-8.

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SECTION 7.0

DESIGN/PRODUCTION OPPORTUNITIES

While the technical obstacles presented in Section 6.0 have a direct impact on the producibility and cost of the MDAC heliostat, several other opportunities for design changes which may improve the cost results have been identified. These opportunities exist because the current design presents manufacturing difficulties that adversely affect the cost of the heliostat. These difficulties are stated so that appropriate design study can be made by the heliostat contractor. These difficulties include:

- Support structure welding in confined area
- Harmonic drive design requires extensive machining operations
- Fusion glass front lite size is not compatible with glass plant equipment
- Shear bolts in flex spline attachment are expensive, air-craft quality
- Wire bearing in the azimuth drive requires stringent quality control to meet required tolerances.

These items are discussed in greater detail in the following paragraphs.

7.1 SUPPORT STRUCTURE WELDMENT

The support structure weldment, which is a "K" frame design, required numerous spot welds to be located in the area where the diagonal beams join the inboard beam. This area is further complicated by the application of the doublers and gussets which reinforce the structure. As described in Section 4.3.1.3, the fabrication and welding line designed to manufacture this part is quite complex and occupies a significant portion of the manufacturing plant. This equipment has high capital costs associated with it and requires significant labor for parts handling and manual arc welding. The concentration of welds in a single area of the structure has caused a significant increase in the cost of this equipment since additional weld stations have been required to allow the various welding heads access to the weld area.

Design changes should be considered which would reduce the number of components, and/or relieve the concentration of welding in the joint area.

7.2 HARMONIC DRIVE

The harmonic drive contains the flex spline, the wave generator, and the circular spline which require extensive fabrication and machining operations. These operations are described in Section 4.3. As an example, a rake angle in the flex spline gear teeth could preclude the use of gear hobbing equipment for this part. Instead, these teeth would be formed by shaping. The total number of components in the drive and the extensive tooling required adversely affect the heliostat cost.

Design changes should be considered which would substitute the harmonic drive gear reduction with other mechanisms which could be manufactured at lower cost.

7.3 FUSION GLASS FRONT LITE SIZE

The 4 ft x 11 ft size selected for the reflective surfaces has an adverse effect on the glass cost since it is not compatible with the facility used to produce the fusion glass. The facility is designed to produce glass panels which are 6 feet wide and 10 feet long. For the production of 4 foot wide panels, the throat of the weir will require modification.

The glass exits vertically from the throat in the molten state and solidifies as it drops through the cooling area. At the exit of the cooling area, the glass sheet is cut into lengths of up to 10 feet and is picked up and then transferred to the conveyor which transfers it to horizontal rolls. This mechanism will require modification in order to accommodate the 11 foot length required for the heliostat.

These modifications to the glass making facility increase the cost of the front lite. Selection of panel dimensions which are closer to the 6 ft x 10 ft capacity of the facility would maintain the lower price for the front lite.

7.4 FLEX SPLINE SHEAR BOLTS

In the harmonic drive, the flex spline is attached to the azimuth drive housing with 12 aircraft-quality shear bolts. These bolts, manufactured by "Hi-Shear" represent a parts cost premium and may not be required for this application.

The supplier indicates that commercial grade fasteners are available for this application at a significant savings in cost.

7.5 WIRE-RACE BEARING

The wire-race bearing which is installed between the azimuth drive housing and the circular spline, requires stringent manufacturing tolerances for proper operation. The manufacturer of this bearing indicates that special tooling will have to be developed in order to maintain the wire forming and welding tolerances. In addition, close tolerances have to be maintained in the azimuth housing, circular spline, and bearing retainer. These special operations increase the cost of the wire race bearing and the associated hardware.

Bearing designs of a more conventional nature should be investigated to determine if a more beneficial cost trade off can be achieved.

7.6 FUSION VERSUS FLOAT

For this study, design constraints dictated the use of .060 fusion glass for the mirrored front lite of the reflective surface. The use of .090 low iron float glass for the front lite may decrease the transmissivity and will increase the weight of the panel. However, it is suggested that a cost/performance trade-off be made between low iron float glass and the solar borosilicate fusion glass, since it may prove more cost effective to sacrifice some transmissivity, increase the field or collector size slightly, and use the float glass. In any event, the trade-off will provide a dollar-based evaluation of a possible decision to use fusion glass in the manufacture of heliostats.

7.7 FIBER OPTICS VERSUS COPPER CABLE

Fiber optic lines are presently in use with great success for communication links. Line costs per running foot for equivalent circuit performance are less for fiber optic transmission lines than for copper cable. However, for short distances, e.g., 20 feet, and multiple control interfaces the use of fiber optic signal systems may not be cost effective because of the cost of connector/interface elements. Signal converters and connectors for fiber optic signal systems become the driving cost function for systems covering short distances between signal interface points. Noise immunity may be a consideration, but again this aspect of fiber optic signal transmission lines is most advantageous for long line lengths. The problems of shielding signal converters for fiber optic systems are as bad if not worse than shielding for standard copper cable connectors.

If heliostats are to be evaluated for cost effectiveness in terms of 1980 construction, it is suggested that cost trade-off studies be conducted on the use of fiber optic signal systems versus conventional shielded copper cable signal systems.

7.8 GALVANIZING

The heliostat design as specified for this study requires the galvanizing of the pedestal, tapered pipe, torque tube, azimuth housing, and drag link to provide a 4 to 5 mil protective coating for exterior corrosion resistance. The galvanizing process involves a sequence of surface treatment including a cleaning high pressure rinse, an alkaline rinse, a hot water rinse, hot blow-off dry, sulfuric acid pickle, followed by a hot water rinse, a flux dip, pre-heat, zinc dip, and finally, dry. Preliminary estimates indicate that approximately \$9,000,000 would be required to acquire and install tanks, drying chambers, monorails, dust and fume ducting, dust and fume scrubbers, waste treatment pipes and tanks, decking and drains for the high volume plant. The alkali, sulfuric acid, flux and zinc processes generate fumes which must be removed from the air by a series of scrubbers. The zinc galvanizing bath generates a dross which must be disposed of, and rinse water must be treated to neutralize alkali and acid. The annual cost of zinc make-up, including that lost in dross removal is about \$6,000,000. Local annual waste treatment is estimated at \$750,000. The cost of removal and disposition of waste has not been evaluated.

The high cost of galvanizing and consideration of the risk entailed in the disposition of waste material from the galvanizing process suggest the thorough investigation of other protective coatings. For example, acrylic resin paints can provide excellent exterior protection and although this application does involve fume and waste control, the problems may be substantially less than those associated with galvanizing. In addition, process energy for paint application should be less than that for galvanizing.

7.9 EXISTING PLANT VERSUS NEW CONSTRUCTION

Plant costs for this study were based on the construction of a dedicated facility on sufficient acreage to allow for normally expected business growth. The high volume plant of approximately 682,000 square feet is comprised of bays with 30 feet of vertical clearance to the bottom of the trusses. One half, or about 341,000 square feet, is made up of 40 ft by 60 ft bays with 12-1/2 lbs of structural steel per square foot with the remainder comprised of 60 ft by 60 ft bays requiring 18 lbs of structural steel per square foot. The floor is 8 inch concrete with 3 lbs of rebar steel per square foot. These requirements were dictated by the manufacturing sequence and plant as defined in this study.

A change in the plant layout or some redefinition of the manufacturing process might allow the use of an existing plant or facility for heliostat production at a lower investment cost than required for new construction. An investigation of

available facilities should be conducted at the time heliostat production is contemplated and consideration given to the cost/manufacturing process trade-offs required in order to weigh the desirability of converting an existing plant versus constructing a new one.

7.10 WELDMENT VERSUS CASTING COSTS

Examination of the MDAC designs for the azimuth drive housing and drag link reveal that these parts may be constructed from either weldments (as designed) or by casting the units in a single piece. Manufacturing development personnel, familiar with the casting process and manufacturing costs, have made estimates of the casting cost based on internal processing. These costs, while not indicative of what an outside supplier might charge for the parts, show a cost savings for the cast parts. A cost comparison for the weldments and castings are shown below. These costs include the galvanized plating for the parts since they are purchased in this form at the low volume.

Table 7-1. WELDMENT AND CASTING COST ESTIMATES

	25,000 Unit Annual Volume		250,000 Unit Annual Volume	
	Purchased Weldment	Casting	Processed Weldment	Casting
Azimuth Drive Housing	\$370.00	\$180.48	\$223.53	\$180.48
Drag Link	\$ 72.00	\$ 42.48	\$ 59.52	\$ 42.48

Although this limited study of weldment versus casting costs includes only gross estimates of comparative costs, it does indicate generally lower costs for the cast parts. Therefore, it is recommended that investigations be pursued to determine if cost benefits can be achieved through substitution of castings for weldments in the MDAC heliostat design.

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SECTION 8.0

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3. "Heliostat Manufacturing Cost Analysis," K. Drumheller, et. al., SERI/TR-8043-1, Solar Energy Research Institute, Golden, Colorado, October 1979.
4. "A Normative Price for a Manufacturing Product: The SAMICS Methodology," Robert Chamberlain, DOE/JPL-1012-79/5, Jet Propulsion Laboratory, Pasadena California, January 1979.

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AZIMUTH		4421	BILL OF MATERIAL-HELIOSTAT ASSEMBLY							
SUBASSEMBLY DETAIL		ERD CCODE	COMM.PT. NO. DRAW NO.	ENGINEERING INSTRUCT SHT.	UNIT QUANT.	MAT'L SPEC.	MAT'L FORM & TYPE	MAT'L WT.	OVERALL SIZE	PUR OR MAT'L SOURCE
Ass'y--Dwing		----	ID-22494	----	---	----	----	---	----	-----
Housing (Mach)		.070	ID-22493	-----	1	1018	Arc Weld *	260.95	24.25x22.25 x19.62	U. S. Steel
Drive Shaft		.105	ID-22495	----	1	1018	Seamless Stl Tubing	8.83	2" O.D x .51 D x12.5	Kelly
Outer Retainer		.080	ID-22489	----	1	1018	Flame Cut Steel	44.5	19.62Dx1.25	U. S. Steel
Helicon Gear (output)		.081	ID-22486	-----	1	Die Case Aluminum	Die Cast Blank	2.43	6.02Dx1.88	Spiroid
Bearing Ret		.066	ID-22482	----	1	1018	Stamping	.33	3.38Dx.188	Compound Die
Cover		.067	ID-22483	----	1	1018	Flame Cut Plate	2.12	7.12Dx.188	U. S. Steel
Bushing		.120	ID-22481-1	-----	1	-----	-----	-----	-----	Sargent
Oil Pan (Weld)		.071	ID-22491	----	1	----	-----	8.8	14.750Dx15"	J & J Burning
Plate		.082	ID-22491-3	----	1	1018	Flame Cut Plate	8.38	.1196x15x15	U.S. Steel
Tube		.106	ID-22491-5	-----	1	1018	Smls Stl Tubing	.42	.625 O.D. .058 wall x15	U.S. Steel
Plug		.017	-----	-----	1	1018	Galv.	-----	3/8-16	McMaster

ISSUE 1 /14/79 ISSUE 4 7/30/79
 ISSUE 2 6/25/79
 ISSUE 3 7/23/79

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AZIMUTH		4421	BILL OF MATERIAL-HELIOSTAT ASSEMBLY							
SUBASSEMBLY		ERD	COMM. PT. NO.	ENGINEERING	UNIT	MAT'L	MAT'L	MAT'L	OVERALL	PUR OR MAT'L
DETAIL		CODE	DRAW NO.	INSTRUCT SHT.	QUANT.	SPEC.	FORM TYPE	WT.	SIZE	SOURCE
Housing (weld)		.072	ID-22493	----	1	----	-----	260.95	24.25x22.25x19.62	-----
Retainer		.083	ID-22493-3	----	1	1018	Flame Cut Plt	42	19.5Dx1.62	U. S. Steel
Tube		.107	ID-22493-5	----	1	1018	Seamless Rnd Tubing	36.48	17Dx5.82	U. S. Steel
Plate		.084	ID-22493-7	-----	1	1018	Flame Cut Plate	30.8	170.D.x3.4 I.D.x.50	U. S. Steel
Tube		.108	ID-22493-9	-----	1	1018	Smls Stl Tubing	5.97	3.38Dx2.5	U. S. Steel
Tube		.109	ID-22493-25	-----	1	1018	Smls Stl Tubing	10.3	7D x 4.50	U. S. Steel
Lug		.085	ID-22493-13	-----	2	1018	Flame Cut Plate	88.0	23x8x1.38	U. S. Steel
Tube		.113	ID-22493-11	-----	1	1018	Smls Stl Tubing	2.7	2.250.D.x 1.75IDx2.75	U. S. Steel
Lug		.086	ID-22493-15	-----	1	1018	Flame Cut Plate	9.7	9x7x1.38	U. S. Steel
Lug		.087	ID-22493-17	-----	1	1018	Flame Cut Plate	9.7	9x7x1.38	U. S. Steel
Mount		.088	ID-22493-21	-----	1	1018	Flame Cut Plate	2.7	5.5x5.5x.38	U. S. Steel
Web		.089	ID-22493-23	----	1	1018	Flame Cut Plate	17.3	17x8.5x.5	U. S. Steel
Plate		.090	ID-22493-27	-----	1	1018	Flame Cut Plate	5.3	6.5 OD x	U. S. Steel
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AZIMUTH		4421	BILL OF MATERIAL-HELIOSTAT ASSEMBLY						
SUBASSEMBLY	ERD	COMM. PT. NO.	ENGINEERING	UNIT	MAT'L	MAT'L	MAT'L	OVERALL	PUR OR MAT'L
DETAIL	CODE	DRAW NO.	INSTRUCT SHT.	QUANT.	SPEC.	FORM TYPE	WT.	SIZE	SOURCE
Flexible Spline	.073	#	----	1	4130 RC33.37	Forge & Weld	20.6	10 O.D. x .15 wall	Timken
Key	.061	-----	----	1	----	-----	----	3/8 sq x 3/4 lg	McMaster
Circular Spline	.110	#	----	1	1018	SMLS St'L Tub g	106.0	15 O.D. x 10 I.D. x 275 lg	U.S. Steel
Wave Gen Bear	.130	#	----	1	----	-----	----	9.50D x 7.25D 1.5 LG. 88 ball	1 Mitsubishi
Key (Gear)	.062	-----	----	1	----	-----	----	3/16 sq x 1 1/8 lg	McMaster
Nut (Gear)	.018	N-06	----	1	----	-----	----	-----	McMaster
Washer (Gear)	.051	N-06	----	1	----	-----	----	-----	McMaster
Locknut	.019	BL-75	----	1	----	-----	----	-----	Appleton
Bolts (Spec)	.020	HL-20-30	----	12	----	-----	----	5/8 NOM	Hi Shear
Nuts (Spec)	.021	HL-86-20	----	12	----	-----	----	5/8 NOM	Hi Shear
Harmonic Drive Ass'y	----	ID-22499	----	1	---	-----	----	-----	-----
Wave Gen. Plug	.115	#	----	1	8620*	Round Bar	21.0	7.250D x 1.5	U.S. Steel

ISSUE 1 6/14/79 ISSUE 4 7/30/79

ISSUE 2 5/25/79

ISSUE 3 7/23/79

UNAVAILABLE
- NOT REQD.

(8)

PUR

AZIMUTH		4421	BILL OF MATERIAL-HELIOSTAT ASSEMBLY							
SUB ASSEMBLY DETAIL		ERD CODE	COMM. PT. NO. DRAW NO.	ENGINEERING INSTRUCT SHT.	UNIT QUANT.	MAT'L SPEC.	MAT'L FORM TYPE	MAT'L WT.	OVERALL SIZE	PUR OR MAT'L SOURCE
Bearing (Drive Shaft)		.131	106KSZZ	----	1	----	----	----	----	MRC Bearing
Bearing Kit		.132	1D 22490	----	1	----	----	----	----	McGill Mfg Co
Packing		.146	2-466N 398-70	----	1	----	----	----	----	Parker Seal
Shim (Gear)		.136	1D22485	----	4	----	----	----	1.50 O.D. x 1.125 I.D.	McMaster
Locknut (Wave Generator)		.022	N-08	----	1	----	----	----	----	McMaster
Washer (Wave Generator)		.052	W-08	----	1	----	----	----	----	McMaster
Packing		.145	2-459N 256-85	----	1	----	----	----	----	Parker Seal
Grease		.140	Alvania EPR	----	1	----	----	----	1 PT.	Shell
Oil		.141	10 W 40	----	1	----	----	----	2 QT	Shell
Pull Cor Elbow		.023	MF-075	----	1	----	----	----	----	O-Z/Gedney Appleton
Screw-Flt Hd.		.024	1/4 - 20 x .63		8	(Oil Pan-Circ. Spline)				McMaster
Bolt L'Washer		.025	#8-32 x .56		8	(Gear Cover-Hsg.)				McMaster
Bolt L' Washer		.026	#10-24 x .63		4	(Br'g. Cover-Hsg)				McMaster
Bolt L' Washer		.027	3/8 - 16 x 2		16	(Br'g. Ret.-Hsg)				McMaster
Bolt 1' Washe		.028	5/8-11 x 4		8	(Circ. Spline-PED)				McMaster
					A10					

UNAVAILABLE
- NOT REQ'D.

[illegible]

ISSUE 1

'14/79

ISSUE 4 7/30/79

ISSUE

6 / 25 / 79

ISSUE 3

7/23/79

UNAVAILABLE

- NOT REQ'D.

MFG

(10)

[illegible]

UNAVAILABLE
- NOT REQ'D. MFG or PU

MFG or PL

[illegible]

UNAVAILABLE
- NOT REQ'D. PUR

PUR

[illegible]

[illegible]

UNAVAILABLE
- NOT REQD.

Pos/Limit/Ind	4424	BILL OF MATERIAL-HELIOSTAT ASSEMBLY							
SUBASSEMBLY DETAIL	ERD CODE	COMM.PT. NO. DRAW NO.	ENGINEERING INSTRUCT SHT.	UNIT QUANT.	MAT'L SPEC.	MAT'L FORM&TYPE	MAT'L WT.	OVERALL SIZE	PUR OR MAT'L SOURCE
Hall Eff Sensor	.180	1AY3A	----	6	---	---	---	---	Micro Switch
Line Driver	.181	9614	-----	3	---	-----	---	----	Fairchild
Dual Diff. Line Rec	.182	9615 or equal	----	3	----	----	---	----	Fairchild
Vane Actuator	.153	ID 22739-3	-----	3	1018	Stl. Sht	-----	2.50 x .04	MDAC
Resistor 1/2 watt	.183	11 Z 13	----	12	----	-----	---	-----	R.C.A.
Capacitor 0.1 F 1400V	.184	-----	----	12	----	----	----	----	R.C.A.
Connector	.185	C09A09C3DBAA	-----	3	----	-----	-----	-----	ITT Cannon
Printed Circuit	.152	1022667-1		3	2 sided epox glass cu clad	-----	----	1.10 x 5.00	Hughe Connector
Cylinder	.156	ID 22479-3	-----	3	1018	Stl. Tube	-----	.25 wall x 3.63	MDAC
Cover	.157	ID 22479-5	----	3	1018	Stl. Sht	-----	.1345 x 7 x 7	MDAC
Supp't. Bracket	.158	ID 22739-5	-----	3	1018	Stl. Sht	-----	5 x 5 x .0293	
Drive Triacs /Opt. Isol.	.186	T2850D	----	12	-----	----	-----	-----	R.C.A. /Motorol
Screw	.037	-----	MS51957-12	3					
Screw	.038	-----	MS51957-14	12					
Washer	.056	-----	AN960C3	15					
Nut	.039	-----	NAS671C4	15					
Set Screw	.040	-----	NAS1081C06A2P	6					
Screw	.041	-----	MS51958-61	9					

ISSUE 2

7/23/79

UNAVAILABLE
- NOT REQ'D.

SUB ASSEMBLY DETAIL		ERD CODE	COMM. PT. NO. DRAW NO.	ENGINEERING INSTRUCT SHT.	UNIT QUANT.	MAT'L SPEC.	MAT'L FORM & TYPE	MAT'L WT.	OVERALL SIZE	PUR OR MAT'L SOURCE
Junction Box	.159									
(dust and water proof)	----	-----	-----		1	----	----	----	6" x 6" x 3"	-----
Terminal Strip	.187									
(5 connectors)	----	-----	-----		1	----	----	----	-----	-----
Mounting Panel	.160				1	----	----	---	5"x5"x3/16"	-----
Terminator	.188									
P/N ALSJ 650(TYP)	-----	-----	-----		4	---	----	----	-----	Crouse & Hinds
Cable Fittings	.189									
P/N 117(TYP)	----	-----	----		5	---	----	---	-----	Crouse & Hinds
Circuit Breaker	.190									
3 phase 15 amp	----	-----	-----		---	----	----	----	-----	-----
Harness---Standard	.169									
Power Cable 3/C	-----	-----	-----		1	---	-----	----	152"	-----
Standard Control Cable	.170				1	----	----	-----	152"	-----
Fiber Optic Cable	.165				1	----	----	----	108"	GRIOT

ISSUE 2 7/23/19

UNAVAILABLE
- NOT REQ'D.

[illegible]

UNAVAILABLE
- NOT REQ'D.

(17)

ISSUE 2 11/23/79

[illegible]

* ASSUMED
UNAVAILABLE
- NOT REQ'D. MFG

MFG

A29

APPENDIX B
MATERIAL PRICE REQUESTS

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MATERIAL PRICE REQUEST - 25,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 8-26-79

DCR
EST NO. _____

PRODUCT 4411 RGFL. SURFACE

SHEET 1 OF 1

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	12	1D224625	.001	FRONT LITE MIRROR	FUSION GLASS MIRRORING	.9850/FT ² .35	4'x11'x .06 THK.	
2						\$1.3350 FT ²	FUSION GLASS MIRROR	
3								
4	12	1D22462-7	.002	BACK LITE		\$.35/FT ²	4'x11'x .18 THK. FLOAT GLASS	
5								
6								
7	16.4#	3MIXA 35043	.006	ADHESIVE		\$15.30/GAL	POLYURETHANE ADHESIVE (SPRAY)	
8								
9								
10	24	1D22462-3	.013	STRINGER		\$476.14/100	1.5x3.0x130x .063TH ROLLED HAT SECT.	
11								
12								
13	30.2#	3MEC 3532	.007	ADHESIVE		\$16.85/GAL	POLYURETHANE ADHESIVE (EXTRUDE)	
14								
15								
16	48	S-0518-1-Z	.015	CLINCH NUTS		\$49.93/1000	PEM ENG & MEG	
17								
18								
19								
20								
21								
22								
23								
24								

REMARKS:

B3

REQUESTED BY:

MATERIAL PRICE REQUEST - 25,000 ANNUAL VOLUME HELICSTAT

TO: _____

DATE RECD. 8-26-79DCR
EST NO. _____PRODUCT 4412 MIRROR SUPP STRUCTURESHEET 1 OF 1

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	2	ID22463-1		ASS'Y DRAWING			#976.48	
2								
3	2	ID22466-1	.009	DIAG BEAM L.H.		47.06	GALV 1018 14 GA (.078) 6x18.75x115 #91.43	
4								
5	2	ID22466-2	.010	DIAG BEAM R.H.		47.06	GALV 1018 14 GA (.078) 6x18.75x115 #91.43	
6								
7	2	ID22465-1	.011	IN. CROSS BEAM		125.80	GALV 1018 14 GA (.078) 6x18.75x278 #326.5	
8								
9	2	ID22467-1	.012	OUT. CROSS BEAM		42.14	GALV 1018 16 GA (.063) 2.5x5.0x275 #89.8	
10								
11	48		.016	BOLT		0.79	5/16 UNC. 18x.75 LG SAE	
12								
13	4	ID22463-3	.060	DOUBLER		5.00	GALV ASTM A-36 .313x2x11.5 #8.1	
14								
15	4	ID22463	.065	GUSSET		18.00	GALV ASTM A-36 .188x8.75x17 #39.8	
16								
17	48		.50	WASHER		.34	5/16 ID SAE	
18								
19								
20								
21								
22								
23								
24								

REMARKS:

MATERIAL PRICE REQUEST - 25,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 8-26-79DCR
EST NO. _____PRODUCT 4421 AZIMUTH DR.SHEET 1 OF 4

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	1D22494			ASS'Y DRAWING				
2								
3								
4								
5								
6								
7	1	1D22486	.081	HELICON GEAR (OUTPUT)		.35	DIE CASE ALUMINUM 6.02x1.88 #2.43	
8								
9	1	1D22482	.066	BEARING RET.		0.69	1018 3.38DX.188 #.33	
10								
11	1	1D22483	.067	COVER & HUB		2.92	1018 7.12DX.188 #2.12	
12								
13	1	1D22481-1	.120	BUSHING		0.03		
14								
15	1	1D22491	.071	OIL PAN (WELD)	} {	6.46	14.7500x15" #8.8	
16								
17	1	1D22491-3	.082	PLATE		-	1018 .1196x15x15 #8.38	
18								
19	1	1D22491-5	.106	TUBE		0.47	.6250.0 .058 WALL x 15 #.42	
20								
21	1		.017	PLUG		0.10	1018 GALV 3/8-16	
22								
23								
24								

REMARKS:

B5

REQUESTED BY: _____

MATERIAL PRICE REQUEST - 25,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 8-26-79

DCR
EST NO. _____

PRODUCT 4421 AZMUTE DR.

SHEET 2 OF 4

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	1	2-466N398-70	.146	PACKING		3.49		
2								
3	4	1D22485	.136	SHIM (GEAR)		3.16	1.50 O.D x 1.125 I.D.	
4								
5	1	N-08	.022	LOCKNUT (WAVE GENERATOR)		3.65		
6								
7	1	W-08	.052	WASHER (WAVE GENERATOR)		3.12		
8								
9	1	2-459N-256-85	.145	PACKING		5.03		
10								
11	1	ALVANIA EPR	.140	GREASE		5.37	1 PINT (SHELL)	
12								
13	1	10W40	.141	OIL		11.01	2 QT (SHELL)	
14								
15	1	MF-075	.023	PULL COR ELBOW		11.44		
16								
17	8	1/4-20x.63	.024	SCREW-FLT HD.		0.06		
18								
19	8	#8-32x.56	.025	BOLT L'WASHER		0.05		
20								
21	4	#10-24x.63	.026	BOLT L'WASHER		.02		
22								
23	16	3/8-16-2	.027	BOLT L'WASHER		0.78		
24	8	5/8-11x4	.028	BOLT L'WASHER		2.56		

REMARKS:

MATERIAL PRICE REQUEST - 25,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 8-26-79

DCR
EST NO. _____

PRODUCT 4421 AZIMUTH DR.

SHEET 3 OF 4

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1								
2								
3	1		.061	KEY		0.03	3/8 SQ x 3/4 LG	
4								
5	1		.130	WAVE GEN BEAR		75.62	9.500x7.250 1.5 LG .88 BALL	
6								
7	1		.62	KEY (GEAR)		0.01	3/16 SQ x 1 1/8 LG	
8								
9	1	N-06	.018	NUT (GEAR)		0.44		
10								
11	1	N-06	.051	WASHER (GEAR)		0.10		
12								
13	1	BL-75	.019	LOCKNUT		0.06		
14								
15	12	HL-20-30	.020	BOLTS (SPEC)		31.80	5/8 NOM	
16								
17	12	HL-86-20	.021	NUTS (SPEC)		21.57	5/8 NOM	
18								
19								
20								
21	1	106K5ZZ	.131	BEARING (DRIVE SHAFT)		3.31		
22								
23		1D22490	.132	BEARING KIT (TURRET)		20.78		
24								

REMARKS:

B7

REQUESTED BY.

MATERIAL PRICE REQUEST - 25,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 8-7-79

DCR
EST NO. _____

PRODUCT 4421 AZIMUTH DR.

SHEET 4 OF 4

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	1	1D22492	.072	HOUSING			SAE1018 - WELD CONST	
2				COST OF WELDMENT		370.00	261#PLATE & TUBE	
3								
4	1		.073	FLEX SPLINE		25.00	SAE4320-BR'G QUAL. (TIMKEN)	
5							#RD TUB'G & PLATE	
6								
7	1		.110	CIRC. SELINE		85.00	SAE1018 - RD.STL. TUBE	
8							#	
9								
10	1		.115	WAVE GEN PLUG		10.92	SAE1040 - RD BAR	
11							#	
12								
13	1	1D22495	.105	DRIVE SHAFT		20.00	SAE1018 - RD.STL. TUBE	
14							9.58#	
15								
16	1	1D22489	.080	OUTER RETAINER		77.00	SAE1018 FL. CUT PLATE	
17							80.22#	
18								
19								
20								
21								
22								
23								
24								

REMARKS:

B6

REQUESTED BY

MATERIAL PRICE REQUEST - 25,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 8-7-79

DCR
EST NO. _____

PRODUCT 4422 ELEVATION DR.

SHEET 1 OF 3

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	1	1D22480	.074	DRAG LINK			SAE1018-WELD CONST	
2				COST OF WELDMENT		72.00	78.5#PLATE	
3								
4	1	1D22464	.075	TORQUE TUBE		169.00	SAE1018-WELD CONST	
5				COST OF WELDMENT			325.5#PLATE & TUBE	
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								

REMARKS:

B9

REQUESTED BY:

MATERIAL PRICE REQUEST - 25,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 8-7-79

DCR
EST NO. _____

PRODUCT 4422 ELEVATION DR.

SHEET 2 OF 3

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	2	1D22747	.121	BUSH-CLEVIS		1.40		
2								
3	4	1D22741-1	.122	BUSH-TRUNNION		1.99		
4								
5	2	1D22742-501	.123	BUSH HINGE (DRAG LINK)		1.00		
6								
7	2	1D22741-503	.124	BUSH HINGE (TORQUE TUBE)		0.43		
8								
9	2	1D22647-1	.030	SPACER-HINGE		0.74		
10								
11	1	1D22647-501	.031	SPACER-HINGE		0.47		
12								
13	1	1D22649	.032	SHOULDER BOLT-HINGE		2.47		
14								
15	1	1D22648	.033	PIN-HINGE		1.84		
16								
17	2	1D22496		ACTUATOR ASS'Y DWG. INCL. (2) TRUN. SHAFTS		—		
18								
19	2	1D22497-1	.172	JACK		400.00		
20								
21								
22								
23								
24								

REMARKS:

B10

REQUESTED BY:

MATERIAL PRICE REQUEST - 25,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 8-7-79

DCR
EST NO. _____

PRODUCT 4422 ELEVATION DR.

SHEET 3 OF 3

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1 4	1D22749-501		.133	THRUST BEAR-CLEVIS		0.42		
2								
3 4	1D22721-501		.137	SHIM-CLEVIS		0.71		
4								
5 2	1D22735-501		.029	PIN-CLEVIS		2.62		
6								
7 4	1D22727-1		.138	SHIM-TRUNNION		0.20		
8								
9 4	1D22749-1		.134	THRUST BRG. TRUNNION		0.71		
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								

REMARKS:

B11

REQUESTED BY:

MATERIAL PRICE REQUEST - 25,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 7-31-79

DCR
EST NO. _____

PRODUCT 4423 MOTORS

SHEET 1 OF 5

QUANTITY PER HS	PART NUMBER	LC	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	1	42R5BFPP	AZIMUTH MOTOR, 1/4 H.P., 480 V,		48.50	W.C. PEART	
2			3 Ø, 1750 R.P.M.				
3	1	42R5BFPP	TRACKING MOTOR, 1/4 H.P., 480 V,		48.50	W.C. PEART	
4			3 Ø, 1750 R.P.M.				
5	1	42R5BFPP	STOWAGE MOTOR, 1/4 H.P., 480 V,		48.50	W.C. PEART	
6			3 Ø, 1750 R.P.M.				
7	12		BOLTS, CLASS 2, 1/4 "DIA. x 1" LONG		.09	McMASTER	
8							
9							
10							
11	12		WASHERS, 1/4 "DIAM. HOLE.		.06	McMASTER	
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							

REMARKS:

B12

REQUESTED BY: _____

DATE _____

APPROVED BY _____

DATE _____

MATERIAL PRICE REQUEST -- 25,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 7-31-79

DCR
EST NO. _____

PRODUCT 4424 POSITION/LIMIT INDICATOR SHEET 2 OF 5

QUANTITY PER HS	PART NUMBER	LC	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	6	1AY3A	HALL EFFECT SENSOR 4AV 1C		19.40	MICRO SWITCH	
2							
3	3	9614 or equal	LINE DRIVER 1 D22738-528		2.73	FAIRCHILD	
4		DS 1488				NATIONAL SEMICONDUCTOR	
5	3	9615 or equal	DUAL DIFFERENTIAL LINE RECEIVER		2.73	FAIRCHILD	
6		DS 1489				NATIONAL SEMICONDUCTOR	
7	12	11Z 13	RESISTOR, 1/2 WATT (CRAMER) 10 OHMS		1.80	R.C.A.	
8							
9	12	PKM10D1	CAPACITOR 0.1 MF, 1400 V		3.60	R.C.A.	
10			(CRAMER), CYLINDRICAL				
11	3	1D22667-1	PRINTED CIRCUIT BOARD, TWO SIDED		19.50	HUGHES CONNECTORS	
12			EPOXY GLASS, CU CLAD 1.10" x 5.00"				
13	3	1D22479-5	COVER: LOW CARBON SHEET STEEL		3.75	MDAC	
14			.1345" x 7" x 7"				
15	3	1D22479-3	CYLINDER: LOW CARBON STEEL TUBE		13.50	MDAC	
16			6.00"D x .25" WALL x 3.63" LENGTH				
17	12	T2850D	OPTICALLY ISOLATED DRIVE TRIACS		11.76	RCA/MOTOROLA	
18							
19	3	C09A09C3DBAA	CONNECTOR		2.91	ITT CANNON	
20							
21	3	1D22739-3	VANE ACTUATOR: 2.5"D x .04" CARBON STEEL		3.30	MDAC	
22							
23	3	1D22739-5	SUPPORT BRACKET 5" x 5" x .0239"		8.25	MDAC	
24			LOW CARBON SHEET STEEL				

REMARKS:

B13

REQUESTED BY: _____ DATE _____ APPROVED BY: _____ DATE _____

MATERIAL PRICE REQUEST - 25,000 ANNUAL VOLUME HELICSTAT

TO: _____

DATE REQD. 7-31-79

DCR
EST NO. _____

PRODUCT 4424 POSITION/LIMIT INDICATOR SHEET 3 OF 5

QUANTITY PER HS	PART NUMBER	LC	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	3	MS51957-12	SCREW		.02		
2							
3	12	MS51957-14	SCREW		.08		
4							
5	15	AN960C3	WASHER		.11		
6							
7	15	NAS671C4	NUT		.17		
8							
9	6	NAS1081C06A20	SET SCREW		.19		
10							
11	9	MS51958-61	SCREW		.17		
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							

REMARKS:

B14

REQUESTED BY: _____ DATE: _____ APPROVED BY: _____ DATE: _____

MATERIAL PRICE REQUEST - 25,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE RECD. 7-31-79

DCR
EST NO. _____

PRODUCT 4425 POWER SUPPLY/DISTRIBUTION SHEET 4 OF 5

QUANTITY PER HS	PART NUMBER	LC	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	1		JUNCTION BOX 6" x 6" x 3"		14.97		
2			(DUST AND WATER PROOF)				
3	1		TERMINAL STRIP		.65		
4							
5	1		MOUNTING PANEL 5" x 5" x 3/16"		2.00		
6							
7	4	ALSJ650	TERMINATOR		19.08	CROUSE & HINDS	
8							
9	5	CGFJ513	CABLE FITTINGS		71.30	CROUSE & HINDS	
10							
11	1		CIRCUIT BREAKER 3 PHASE 15 AMP. 480 V		33.00	SQUARE D	
12							
13	156"	13'	STANDARD POWER CABLE (600 V) CU		1.65	ALFA WIRE .126/FT	
14			THREE WIRE CONDUCTOR 20 GAGE				
15	312"	26'	STANDARD CONTROL CABLE (600 V) CU 24 GAGE		3.30	BELDEN WIRE .126/FT	
16							
17	108"	9'	FIBER OPTIC CABLE		2.97	GRIOT .33/FT	
18			GALLITE 2000 TYPE 200 P				
19	4		FIBER OPTIC TERMINATORS		6.40		
20							
21	1		25 PIN CONNECTOR, MALE & FEMALE		.48		
22							
23	3		10 PIN CONNECTOR, MALE & FEMALE		6.75		
24							

REMARKS:

B15

REQUESTED BY: _____ DATE: _____ APPROVED BY: _____ DATE: _____

MATERIAL PRICE REQUEST - 25,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 7-31-79

DCR
EST NO. _____

PRODUCT 4433 CONTROL & SIGNAL EQUIPMENT SHEET 5 OF 5

QUANTITY PER HS	PART NUMBER	LC	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	1		PRINTED CIRCUIT BOARD; TWO SIDED EPOXY, 4" x 5"		6.80		
2							
3	1	24-28P	24 PIN CONNECTOR, MALE (CRAMER)		1.80	AMP, INC.	
4							
5	1	8748	MICROPROCESSOR (COMPUTER)		45.00	NATIONAL SEMICONDUCTOR	
6							
7	2	DS 1688	QUAD DIFFERENTIAL LINE DRIVER		2.50	NATIONAL SEMICONDUCTOR	
8							
9	2	DS 1689	QUAD DIFFERENTIAL LINE RECEIVER		2.50	NATIONAL SEMICONDUCTOR	
10							
11	3	7474 W	HEX "D" FLIP FLOP		1.80	TEXAS INSTRUMENTS	
12							
13	3		CAPACITOR 0.1 MF, 50 V		.60	BELL	
14							
15	1	3425-0000	POWER SUPPLY, 5 V MODULAR		5.40	SEMICONDUCTOR CIR., INC.	
16							
17	1	24-28 P	CONNECTOR, 24 PIN, FEMALE		1.80	AMP., INC.	
18							
19	1		1 PIECE MOLDED BOX WITH COVER		.55	NEWPORT PLASTIC	
20			5" x 6" x 3"				
21	1	TRANS-WPX4141	OPTICAL TRANSCEIVER		7.00	SPECTRONICS	
22		REC.-SPX4140					
23							
24							

REMARKS:

B16

REQUESTED BY: _____ DATE _____ APPROVED BY: _____ DATE _____

MATERIAL PRICE REQUEST - 25,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 7-31-79

DCR
EST NO. _____

PRODUCT 4451 SUPPORT STRUCTURE

SHEET 1 OF 1

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	1	1D44046	.112	PEDESTAL	J	260.00	1018 24 OD x .105 x 123 #270.0	
2								
3	1	1D22711	.099	CAP			1018 23.8 OD x 11.00 10x25 #75	
4								
5	1	1D40046-7	.068	COVER	J		1018 .03 x 1 OD #4	
6								
7	1		.175	TAPERED PIPE		98.00	1018 24"D x 46 x 7 GA #175.5	
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								

REMARKS:

B17

REQUESTED BY:

MATERIAL PRICE REQUEST - 250,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 8-23-79

DCR
EST NO. _____

PRODUCT 4411 REFL SURFACE

SHEET 1 OF 1

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	12	1D22462-5	.001	FRONT LITE MIRROR	FUSION GLASS OR MIRRORING	\$.344 .315	4' X 11' X .06 THK.	
2						\$.659	FUSION GLASS MIRROR	
3						PER SQ. FT.		
4	12	1D22462-7	.002	BACK LITE		\$.32	4' X 11' X .18 THK.	
5						PER SQ. FT.	FLOAT GLASS	
6								
7	16.4#	3MIXA 35043	.006	ADHESIVE		\$14.00/ GAL.	POLYURETHANE	
8							ADHESIVE (SPRAY)	
9								
10	24	1D22462-3	.013	STRINGER		\$431.82/ 100	1.5 X 3.0 X 150 X .068	
11				ONE TIME TOOL CHARGE \$32,000			ROLLED HAT SECTION	
12								
13	30.2#	3MEL 3532	.007	ADHESIVE		\$15.00/ GAL.	POLYURETHANE	
14							ADHESIVE (EXTRUDE)	
15								
16	48	S-0518-1-E	.015	CLINCH NUTS		\$45.00/ 1000	PEM, ENG. & MFG.	
17								
18								
19								
20								
21								
22								
23								
24								

REMARKS:

B18

REQUESTED BY: _____

DATE _____

APPROVED BY: _____

DATE _____

MATERIAL PRICE REQUEST - 250,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 8-7-79

DCR
EST NO. _____

PRODUCT 4412 MIRROR SUPP. STRUC. SHEET 1 OF 1

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	2	1D22463-1		ASSEMBLY DRAWING		-	#976.48	
2								
3	2	1D22466-1	.009	DIAG. BEAM L. H.		42.50	GALV. 1018 14 GA. (.078) 6 X 18.75 X 115 #91.43	
4								
5	2	1D22466-2	.010	DIAG. BEAM R. H.		42.50	GALV. 1018 14 GA. (.078) 6 X 18.75 X 115 #91.43	
6								
7	2	1D22465-1	.011	IN. CROSS BEAM		111.21	GALV. 1018 14 GA. (.078) 6 X 18.75 X 278 #326.5	
8								
9	2	1D22467-1	.012	OUT CROSS BEAM		38.57	GALV. 1018 16 GA. (.063) 2.5 X 5.0 X 275 #89.8	
10								
11	48		.016	BOLT		0.73	5/16 UNC. 18 X 75 LGSAE	
12								
13	4	1D22463-3	.060	DOUBLER		5.00	GALV. ASTM A-36 .313 X 2 X 11.5 #8.1	
14								
15	4	1D22463	.065	GUSSET		18.00	GALV. ASTM A-36 .188 X 8.75 X 17 #39.8	
16								
17	48		.50	WASHER		0.31	5/16 ID SAE	
18								
19								
20								
21								
22								
23								
24								

REMARKS:

B19

REQUESTED BY: _____

MATERIAL PRICE REQUEST - 250,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 8-7-79

DCR
EST NO. _____

PRODUCT 4421 AZIMUTH DR.

SHEET 1 OF 5

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	1D22494			ASSEMBLY DRAWING				
2								
3	1	1D22486	.081	HELICON GEAR (OUTPUT)		0.22	DIE CASE ALUMINUM 6.02 X 1.88 #2.43	
4								
5	1	1D22482	.066	BEARING RET.		0.69	1018 3.38 DX .188 #.33	
6								
7	1	1D22483	.067	COVER		2.92	1018 7.12 DX .188 #2.12	
8								
9	1	1D22481-1	.120	BUSHING		0.02		
10								
11	1	1D22491	.071	OIL PAN (WELD)		6.46	14.75 OD X 15" #8.8	
12								
13	1	1D22491-3	.082	PLATE			1018 .1196 X 15 X 15 #8.38	
14								
15	1	1D22491-5	.106	TUBE		6.46	.625 O.D. X .058 WALL X 15 #.42	
16								
17	1		.017	PLUG		0.09	1018 GALV. 3/8 - 16	
18								
19								
20								
21								
22								
23								
24								

REMARKS:

B20

REQUESTED BY:

MATERIAL PRICE REQUEST - 250,000 ANNUAL VOLUME HELIOSTAT

TO: _____
 DATE REQD. 8-7-79

DCR
 EST NO. _____

PRODUCT 4421 AZMUTH DR.

SHEET 2 OF 5

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	1	2466N39870	.146	PACKING		3.23		
2								
3	4	1D22485	.136	SHIM (GEAR)		0.16	1.50 O.D. X 1.125 I.D.	
4								
5	1	N-08	.022	LOCKNUT (WAVE GENERATOR)		0.65		
6								
7	1	W-08	.052	WASHER (WAVE GENERATOR)		0.12		
8								
9	1	2459N25685	.145	PACKING		2.77		
10								
11	1	ALVANIAEPR	.140	GREASE		0.37	1 PINT (SHELL)	
12								
13	1	10W40	.141	OIL		1.01	2 QT. (SHELL)	
14								
15	1	MF-075	.023	PULL COR ELBOW		1.44		
16								
17	8	1/4-20X.63	.024	SCREW-FLT. HD.		0.045		
18								
19	8	#8-32X.56	.025	BOLT L' WASHER		0.047		
20								
21	4	#10-24X.63	.026	BOLT L' WASHER		0.019		
22								
23	16	3/8-16-2	.027	BOLT L' WASHER		0.725		
24	8	5/8-11X4	.028	BOLT L' WASHER		2.38		

REMARKS:

B21

REQUESTED BY:

MATERIAL PRICE REQUEST - 250,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 8-7-79

DCR
EST NO. _____

PRODUCT 4421 AZIMUTH DR.

SHEET 3 OF 5

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1								
2								
3	1		.061	KEY		0.02	3/8 SQ. X 3/4 LG.	
4								
5	1		.130	WAVE GEN. BEAR		70.70	9.5 OD X 7.250 1.5 LG. .88 BALL	
6								
7	1		.62	KEY (GEAR)		.008	3/16 SQ. X 1 1/8 LG.	
8								
9	1	N-06	.018	NUT (GEAR)		0.44		
10								
11	1	N-06	.051	WASHER (GEAR)		0.10		
12								
13	1	BL-75	.019	LOCKNUT		0.06		
14								
15	12	HL-20-30	.020	BOLTS (SPEC.)		31.80	5/8 NOM	
16								
17	12	HL-86-20	.021	NUTS (SPEC.)		21.57	5/8 NOM	
18								
19	1	1D-22499		HARMONIC DRIVE ASSEMBLY				
20								
21	1	106X5ZZ	.131	BEARING (DRIVE SHAFT)		3.31		
22								
23	1	1D-22490	.132	BEARING KIT		20.78		
24								

REMARKS:

MATERIAL PRICE REQUEST - 250,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 8-7-79

DCR
EST NO. _____

PRODUCT 4421 AZIMUTH DR.

SHEET 4 OF 5

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1								
2								
3								
4	1		.073	FLEX SPLINE		25.00	SAE 4320-BR'G. QUAL.	
5							(TIMKEN) #RD TUB'G. &	
6							PLATE	
7	1		.110	CIRC. SPLINE		85.00	SAE 1018-RD STL. TUBE	
8							#	
9								
10	1		.115	WAVE GEN. PLUG		10.92	SAE 1040-RD. BAR	
11							#	
12								
13	1	1D22495	.105	DRIVE SHAFT		2.43	SAE 1018-RD. STL. TUBE	
14							9.58#	
15								
16	1	1D22489	.080	OUTER RETAINER		11.39	SAE 1018 FL. CUT PLATE	
17							80.22#	
18								
19								
20								
21								
22								
23								
24								

REMARKS:

B23

REQUESTED BY: _____

MATERIAL PRICE REQUEST - 250,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 8-7-79

DCR
EST NO. _____

PRODUCT 4421 AZIMUTH DR.

SHEET 5 OF 5

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	1	1D22493	.072	HOUSING (WELD)				
2								
3	1	1D22493-3	.083	RETAINER		60.00	19.50 X 1.62 1018 42#	
4								
5	1	1D22493-5	.107	TUBE		33.00	1018 17D X 5.82 36.48#	
6								
7	1	1D22493-7	.084	PLATE		18.06	1018 17D X .50 30.8#	
8								
9	1	1D22493-9	.108	TUBE		4.00	1018 3.38D X 2.5 5.97#	
10								
11	1	1D22493-25	.109	TUBE		9.00	1018 7D X 4.50 10.3#	
12								
13	2	1D22493-13	.085	LUG		37.35	1018 23 X 8 X 1.38 88#	
14								
15	1	1D22495-11	.113	TUBE		0.55	1018 2.7#	
16								
17	1	1D22493-15	.086	LUG		6.64	1018 9 X 7 X 1.38 9.7#	
18								
19	1	1D22493-17	.087	LUG		6.64	1018 9 X 7 X 1.38 9.7#	
20								
21	1	1D22493-21	.088	MOUNT		1.25	1018 5.5 X 5.5 X.38 2.7#	
22								
23	1	1D22493-23	.089	WEB		9.13	1018 17 X 8.5 X.5 17.3#	
24	1	1D22497-27	.090	PLATE		4.00	1018 6.50,D.X.5 5.3#	

REMARKS:

MATERIAL PRICE REQUEST - 250,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 7-31-79

DCR
EST NO. _____

PRODUCT 4422 ELEVATION

SHEET 1 OF 4

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	1	1D22480	.074	DRAG LINK (DETAIL)				
2								
3	1	1D22480-3	.091	SIDE PLATE R.H.		18.26	1018 24.12 X 6.80 X .75 #26.2	
4								
5	1	1D22480-5	.092	SIDE PLATE L.H.		17.02	1018 24.12 X 6.80 X .75 #26.2	
6								
7	1	1D22480-7	.093	BRACE		5.40	1018 15.32 X 5.30 X .50 #11.5	
8								
9	1	1D22480-9	.094	BRACE		3.32	1018 8.80 X 5.12 X .50 #6.4	
10								
11	1	1D22480-11	.095	BRACE		2.08	1018 5.20 X 5.18 X .50 #3.8	
12								
13	2	1D22480-13	.096	LUG		3.32	1018 4.75 X 3.18 X .62 #4.4	
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								

REMARKS:

B25

REQUESTED BY:

MATERIAL PRICE REQUEST - 250,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 7-31-79

DCR
EST NO. _____

PRODUCT 4422 ELEVATION

SHEET 2 OF 4

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	1	1D22464	.075	TORQUE TUBE (DETAIL)				
2								
3	1	1D22464-3	.111	TUBE		32.25	16.0.D. X .105 WALL X 81 IN #153~1018	
4								
5	2	1D22464-5	.097	FLANGE		57.27	1018 .75 X 18 X 18 #137.5	
6								
7	6	1D22464-7	.098	LUG		44.82	1018 62 X 10 X 10 #35.0	
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								

REMARKS:

B26

REQUESTED BY: _____

MATERIAL PRICE REQUEST - 250,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 7-31-79

DCR
EST NO. _____

PRODUCT 4422 ELEVATION

SHEET 3 OF 4

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	2	1D22747	.121	BUSH - CLEVIS		1.40		
2								
3	4	1D22741-1	.122	BUSH - TRUNNION		1.90		
4								
5	2	1D22742-501	.123	BUSH HINGE (DRAG LINK)		0.95		
6								
7	2	1D22741-503	.124	BUSH HINGE (TORQUE TUBE)		0.42		
8								
9	2	1D22647-1	.030	SPACER - HINGE		0.70		
10								
11	1	1D22647-501	.031	SPACER - HINGE		0.46		
12								
13	1	1D22649	.032	SHOULDER BOLT - HINGE		1.89		
14								
15	1	1D22648	.033	PIN - HINGE		1.75		
16								
17	2	1D22496		ACTUATOR ASSEMBLY DWG. INCL.				
18				(2) TRUN. SHAFTS				
19								
20	2	1D22497-1	.172	JACK		400.00		
21								
22								
23								
24								

REMARKS:

B27

REQUESTED BY: _____

MATERIAL PRICE REQUEST - 250,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 7-31-79

DCR
EST NO. _____

PRODUCT 4422 ELEVATION

SHEET 4 OF 4

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	4	1D22749-501	.133	THRUST BEAR - CLEVIS		0.40		
2								
3	4	1D22727-501	.137	SHIM - CLEVIS		0.69		
4								
5	2	1D22735-501	.029	PIN - CLEVIS		2.49		
6								
7	4	1D22727-1	.138	SHIM - TRUNNION		0.20		
8								
9	4	1D22749-1	.134	THRUST BRG. - TRUNNION		0.693		
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								

REMARKS:

B28

REQUESTED BY: _____

DATE _____

APPROVED BY: _____

DATE _____

MATERIAL PRICE REQUEST - 250,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 11-26-79

DCR
EST NO. _____

PRODUCT 4451 HELIOSTAT SUPP. STRUCT.

SHEET 1 OF 1

QUANTITY PER HS	PART NUMBER	LC	ERD CODE	DESCRIPTION	TOOL COST	UNIT COST	REMARKS	BUYER CODE
1	1	1D44046	.112	PEDESTAL		60.34	1018 24 OD X .105 X 123 #270.0	
2								
3	1	1D22711	.099	CAP		46.87	1018 23.8 OD X 11.0 10 X 25 #75	
4								
5	1	1D40046-7	.068	COVER		1.20	1018 .03 X 10D #4	
6								
7	1		.175	TAPERED PIPE		39.22	1018 24" D X 46 X 7GA #175.5	
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								

REMARKS:

MATERIAL PRICE REQUEST - 250,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 7-31-79

DCR
EST NO. 4423

PRODUCT MOTORS

SHEET 1 OF 5

QUANTITY PER HS	PART NUMBER	LC	DESCRIPTION	TOOL COST	UNIT COST	REMARKS : SUPPLIERS	BUYER CODE
1	1	42R5BFPP	AZIMUTH MOTOR, 1/4 H.P., 480V, 3 ϕ ,		46.08	W. C. PEART	
2			1750 RPM				
3	1	42R5BFPP	TRACKING MOTOR, 1/4 H.P., 480V, 3 ϕ ,		46.08	W. C. PEART	
4			1750 RPM				
5	1	42R5BFPP	STOWAGE MOTOR, 1/4 H.P., 480V, 3 ϕ ,		46.08	W. C. PEART	
6			1750 RPM				
7	12		BOLTS, CLASS 2, 1/4" DIA. X 1" LONG		.08	McMASTER	
8							
9	12		WASHERS, 1/4" DIA. HOLE		.06	McMASTER	
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							

REMARKS:

B30

REQUESTED _____ DATE _____ APPROVED BY: _____ DATE _____

MATERIAL PRICE REQUEST - 250,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 7-31-79

DCR
EST NO. 4424

PRODUCT POSITION/LIMIT INDICATOR

SHEET 2 OF 5

QUANTITY PER HS	PART NUMBER	LC	DESCRIPTION	TOOL COST	UNIT COST	REMARKS SUPPLIER	BUYER CODE
1	6	1AY 3A			18.54	MICROSWITCH	
2							
3	3	9614 OR EQUAL	LINE DRIVER 1D22738-528		2.07	FAIRCHILD	
4		DS 1488				NATIONAL SEMICONDUCTOR	
5	3	9615 OR EQUAL	DUAL DIFFERENTIAL LINE RECEIVER		2.07	FAIRCHILD	
6		DS 1489				NATIONAL SEMICONDUCTOR	
7	12	11 Z 13	RESISTOR, 1/2 WATT, 10 OHM		1.80	R.C.A.	
8							
9	12	PKM 10 P1	CAPACITOR, OIL MF, 1400V		3.36	R.C.A.	
10			CYLINDRICAL				
11	3	1D22667-1	PRINTED CIRCUIT BOARD, TWO SIDED,		16.50	HUGHES CONNECTORS	
12			EPOXY GLASS, CU CLAD, 1.10" X 5.00"				
13	3	1D22479-5	COVER: LOW CARBON SHEET		3.15	MDAC	
14			STEEL .1345" X 7" X 7"				
15	3	1D22479-3	CYLINDER: LOW CARBON STEEL TUBE,		11.25	MDAC	
16			6.00" DIA. X .25" WALL X 3.63" LENGTH				
17	12	T2850D	OPTICALLY ISOLATED DRIVE TRIACS		8.16	R.C.A.	
18						MOTOROLA	
19	3	C09A09C3D	B AA CONNECTOR		2.79	ITT CANNON	
20							
21	3	1D22739-3	VANE ACUATOR: 2.5" DIA. X .04"		3.30	MDAC	
22			THICKNESS LOW CARBON STEEL				
23	3	1D22739-5	SUPPORT BRACKET, 5" X 5" X .0239"		6.90	MDAC	
24			LOW CARBON STEEL				

REMARKS:

B31

REQUESTED BY: _____ DATE _____ APPROVED BY: _____ DATE _____

MATERIAL PRICE REQUEST - 250,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 7-31-79

DCR
EST NO. 4424

PRODUCT _____ POSITION/LIMIT INDICATOR _____

SHEET 3 OF 5

QUANTITY PER HS	PART NUMBER	LC	DESCRIPTION	TOOL COST	UNIT COST	REMARKS : SUPPLIER	BUYER CODE
1	3	MS51957-12	SCREW		.019	STANDARD PARTS	
2							
3	12	MS51957-14	SCREW		.079	STANDARD PARTS	
4							
5	15	AN960C3	WASHER		.10	STANDARD PARTS	
6							
7	15	NAS671C4	NUT		.159	STANDARD PARTS	
8							
9	6	NAS_081C0	6A2P SET SCREW		.158	STANDARD PARTS	
10							
11	9	MS5_958-61	SCREW		.153	STANDARD PARTS	
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							

REMARKS:

B32

REQUESTED BY: _____ DATE _____

APPROVED BY: _____ DATE _____

MATERIAL PRICE REQUEST - 250,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 7-31-79

DCR
EST NO. 4425

PRODUCT POWER SUPPLY/DISTRIBUTION

SHEET 4 OF 5

QUANTITY PER HS	PART NUMBER	LC	DESCRIPTION	TOOL COST	UNIT COST	REMARKS : SUPPLIER	BUYER CODE
1	1		JUNCTION BOX 6" X 6" X 3"		14.14		
2			(DUST & WATER PROOF)				
3	1		TERMINAL STRIP		.38		
4							
5	1		MOUNTING PANEL 5" X 5" X 3/16"		2.00		
6							
7	4	ALSJ650	TERMINATOR		19.08	CROUSE & HINDS	
8							
9	5	CGFJ513	CABLE FITINGS		71.30	CROUSE & HINDS	
10							
11	1		CIRCUIT BREAKER, 3 ϕ , 15 AMP., 480V		28.00	SQUARE D	
12							
13	156"		STANDARD POWER CABLE(600V), COPPER THREE		1.65	ALFA WIRE .126/FT.	
14			WIRE CONDUCTOR, 20 GAGE				
15	312"		STANDARD CONTROL CABLE (600V), COPPER		3.30	BELDEN WIRE .126/FT.	
16			24 GAGE				
17	108"		FIBER OPTIC CABLE, GALLITE 2000 TYPE		2.97	GRIOT	
18			200 P; 2 ONE MM				
19	4		FIBER OPTIC TERMINATORS		5.80		
20							
21	1		25 PIN CONNECTOR: MALE AND FEMALE		.47		
22							
23	3		10 PIN CONNECTOR: MALE AND FEMALE		6.45		
24							

REMARKS:

B33

REQUESTED BY: _____ DATE _____ APPROVED BY: _____ DATE _____

MATERIAL PRICE REQUEST - 250,000 ANNUAL VOLUME HELIOSTAT

TO: _____

DATE REQD. 7-31-79

DCR
EST NO. 4433

PRODUCT CONTROL & SIGNAL EQUIPMENT

SHEET 5 OF 5

QUANTITY PER HS	PART NUMBER	LC	DESCRIPTION	TOOL COST	UNIT COST	REMARKS : SUPPLIER	BUYER CODE
1	1		PRINTED CIRCUIT BOARD: TWO SIDED EPOXY,		5.60		
2			4" X 5"				
3	1	24-28P	24 PIN CONNECTOR, MALE		1.65	AMP, INC.	
4							
5	1	8748	MICROPROCESSOR		42.00	NATIONAL SEMICONDUCTOR	
6							
7	2	DS1688	QUAD. DIFFERENTIAL LINE DRIVER		2.40	NATIONAL SEMICONDUCTOR	
8							
9	2	DS1689	QUAD. DIFFERENTIAL LINE RECEIVER		2.40	NATIONAL SEMICONDUCTOR	
10							
11	3	7474W	HEX "D" FLIP FLOP		1.62	TEXAS INSTRUMENT	
12							
13	3		CAPACITOR, 0.1 MF, 50 V		.57	BELL	
14							
15	1	3425-0000	POWER SUPPLY, 5V MODULAR		34.39	SEMICONDUCTOR CIR. INC.	
16							
17	1	24-28P	CONNECTOR, 24 PIN, FEMALE		1.65	AMP, INC.	
18							
19	1		1 PIECE MOLDED 6 OZ. WIRE		.50	NEWPORT PLASIC	
20			COVER, 5" X 6" X 3"				
21	1	TRANS-WPX-414	OPTICAL TRANSCENER		30.00	SPECTRONICS	
22		REC-SPX-4140					
23							
24							

REMARKS:

B34

REQUESTED BY: _____

DATE _____

APPROVED BY: _____

DATE _____

APPENDIX C
TOOL AND LABOR ROUTING

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25,000 ANNUAL VOLUME

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C5

המחבר, ד"ר יצחק שניידר

C6

[illegible]

TOOL AND TECH. REVIEWS

C3

TOOL AND LABOR ROUTING										SHEET		SUPERSEDES		EFFECTIVE		PART NO.	
MIRROR SUPPLY STREET										1 OF 3							
CUSTOMER										EST. DATE		TOOL RELEASE		DRAWING NO.		PREL. NO.	
5E1										4412							
OPERATION DESCRIPTION										REGISTER NO. OR REVIEW DATE		PRODUCTION STD. P.P.H.		HOURS PER 100 PCS.		MACHINE NAME AND NUMBER	
PURCH. ROLL FORMED SECTIONS, DOUBLES & GUSSETS GALVANIZED & ALL HOLES PUNCHED																	
LOAD DIAGONAL BEAM R.H. MANUALLY L.H. (2 OPERATORS)										80		1.250					
AND TRIM ENDS																	
27 SEC. HACH. PER TIME 1 st OPER. PER HACH																	
NOTE: LABOR BALANCED TO 38 SECS. CYCLE OF OPER. #40 (WELD & DRILL --- BOTTLENECK)																	
INSTALLATION																	
5 STA. D.E. DIE LINES COMPLETE																	
HACH. CAPITAL COST																	
SPECIAL TOOLING																	
DURABLE TOOLING																	
NONDURABLE TOOLING																	
MACHINING COST OF THIS TOOLING																	
5 STA. WALKING BEAM TRANSFER MECHANISM																	
VERTICAL PRESSES & TRIM DIES																	
HYDRAULIC BRAKE BENDING DIES																	

M M S S P				PART NAME		TOOL AND LABOR ROUTING										SHEET 2 OF 3		SUPERSEULS		EFFECTIVE		PART NO.		1 MATERIAL		2 SPEC.		3 GAUGE		4 WGT./PC.		5 WGT./BM.									
CUSTOMER				ESTIMATE NO.		TOOL RELEASE		DRAWING NO.		PHIL. NO.		LAST ENG.		MODEL		MT.		VOLUME		PCS./MOD.		PREP. BY		BLANK SIZE		COIL STRIP SHEET		1		2		3		4		5					
50121								4412		-		H36103 FAT				25K		YEAR		MONTH																					
OPER. NO.				DEPT. & GROUP				OPERATION DESCRIPTION				REGISTER NO. OR REVIEW DATE		PRODUCTION STD. P.P.H.		HOURS PER 100 PCS.		T A B		MACHINE NAME AND NUMBER TOOLS AND GAUGES				To To Cost TOOK IN 2000 1/200		EQUIPMENT		TOOLS		1		2		3		4		5			
25				AUTO UNLOAD FIN. DIAG. BEAM				HI		(R.H.)																															
				OUTO RESISTANCE WELD MACH.						(L.H.)																															
26				LOAD INBOARD BEAM								(80)		2,500				JIB CRANE																							
				MANUALLY (2 OPERATORS)																																					
				CRANE LOAD --- 38 SECS ALL D.																																					
30				TRIM ENDS				HI																																	
				27 SEC MACH CYCLE TIME																																					
				1 X OPER PER MACH																																					

ISSUES 1 10 10 10

TOOL AND LABOR ROUTING										SHEET 3 OF 3		SUPERSEDES		EFFECTIVE		PART NO.	
MIRROR SUPRT STREET										ESTIMATE NO.		TOOL RELEASE		DRAWING NO.		PREL. NO.	
CUSTOMER 5821										4412		—		HELIOSTAT		—	
OPERATION DESCRIPTION										REGISTER NO. OR REVIEW DATE		PRODUCTION STD. P.P.H.		HOURS PER 100 P.C.S.		MACHINE NAME AND NUMBER	
36 HAV. LOAD OUTBOARD BEAM										(DBLS)		80		1 250			
37 DOUBLES & GUSSETS ON TO										(GUSSETS)		80		1 250			
38 RESISTANCE WELD MACH.										(OUT. BEAM)		80		1 250			
(3 OPERATORS TOTAL)																	
40 RESISTANCE WELD SUPPORT STRUCTURE COMPLETE & DRILL (8) Htg. HOLES - (AUTOM.)										HI		—		—		INSTALLATION	
38 SEE MACH. CYC. TIME																236,175	
39 MANUALLY ARC WELD (2) GUSSETS, USING SEMI-AUTOMATIC "SQUIRT GUN" - AUTOMATIC TURNOVER DEVICE INDEXES PART 180° (1 OPERATOR)												80		1 250		MACH. CAPITAL COST	
SCRAP ALICE @ 2%												200				1 1,574,500	
45 TRUCKING - MAT'L. HDLG.												2 000				SPEC. TOOLING	
46 REPAIR @ 5% (4 TIMES LABOR COST)												2 000				1 460,800	
AUTO INLOAD WITH O'HEAD TRAMMIL CRANE										LO		—		—		DURABLE TOOLING	
47 INSPECTION - FLOOR INSPECTOR												1 000				1 90,000	
REMARKS										HI - HIGH CAPITAL BURDEN		LO - LOW CAPITAL BURDEN					
APPROVED BY INITIALS & DATE										CHG		SUB. ASSEMBLY NO.		DEPT. AND GROUP		HOURS / 100	
PRODUCTION ENGINEER																15,300	
INDUSTRIAL ENGINEER																	
MANUFACTURING																	
STANDARD P.H.E.S. TERMS & ABBREVIATIONS																	
STAFF INDUSTRIAL ENGR.																	
LABOR CONTROL																	
PROOF READER																	

LOJOLUNE

TOOL AND LABOR ROUTING

13. 5110-1-79

CM M S S P				PART NAME	SHEET		SUPERSEDED		EFFECTIVE		PART NO.				
CUSTOMER				ESTIMATE NO.	TOOL RELEASE	DRAWING NO.	PREL. NO.	LAST ENG	MODEL	YEAR	VOLUME	PCS / MOD.			
5621				4413					HELIOSTAT	25K		2			
OPER NO	DEPT. & GROUP	OPERATION DESCRIPTION	REGISTER NO. OR REVIEW DATE	PRODUCTION STD. P.P.H.	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER	TOOLS AND GAUGES	EQUIPMENT	EST. COST	QTY.	HOURS	EST. COST			
10*		AUTOLOAD HIROR MODULES WITH POWER & FREE CONVEYOR FROM STAGING & CLIPPING AREA ONTO ASSY. BENCH FEED-IN TABLE	LO		1.667		NOTE: THIS DATA SHEET UNBOR MODIFIED TO REFLECT A 1-SHIFT REQ TO								
20		AUTOLOAD SUPPT STRUCT WITH O'HEAD TRAMRAIL CRANE FROM RESIST. WELD AREA.	LO		-										
30		HANDALLY LOAD, HAND START & INQUIRY WRENCH TIGHTEN 245ERS & WASHERS 100 SEC. EACH CYCLE TIME 4 OPER. PER BENCH	LO	(30)	13.333	SINGLE STA. ASSY BENCH	HACH CAPITAL COT		98,200						
		MACH DOWNTIME AUGE @ 5%			833	INSTALLATION	HACHING CONSISTS OF THE FOLLOWING HARDWARE ELEMENTS:		14,550						
40*		AUTOLOAD WITH CONVEYOR TO PALLETIZING & SHIPPING AREA	LO		1.667	ELEVATING AIR TABLES		1	25,000						
41		INSPECTION - FLOOR INSPECTOR			500	HIROR CONVEYOR (72" W)		1	72,000						
		* NOTE: OPERATOR PERFORMING OPERATIONS #10 & 40 ALSO ASSISTS ASSEX OPERATIONS IN ALL ASPECTS, INCLUDING SUPPT. STRUCT POSITIONING, SUPPLY, HOUSEKEEPING, ETC.				HIR WRENCHES		2	1,200						
		TRUCKING - MATERIAL HANDLING			2.500	POUNDER & FREE CONVEYOR (400 FT. @ \$2,000)			800,000						
APPROVED BY INITIALS & DATE				REMARKS				H1 CAPITAL BURDEN				HOURS / 100			
PRODUCTION ENGINEER				INDUSTRIAL ENGINEER				MANUFACTURING				TOTAL			
				ALL EQUIPMENT IS CAPITAL ETC. AIR TABLES				20.500							
				REPLACE WRENCHES 2X PER YR											
STAFF INDUSTRIAL ENGR.				LABOR CONTROL				PROOF READER				PART NUMBER			
												REFERENCE			
												SEQUENCE			

LO-VOLUME

ISSUE 1 1-79

TOOL AND LABOR ROUTING										SHEET 1 OF 2		EFFECTIVE DATE		PART NO.			
CIRCULAR SPLINE										1		2		3			
ESTIMATE NO. 4421										4		5		6			
SERI										7		8		9			
OPERATION DESCRIPTION										10		11		12			
MACHINE NAME AND NUMBER										13		14		15			
TOOLS AND GAUGES										16		17		18			
EQUIPMENT										19		20		21			
TOOLS										22		23		24			
EST. COST										25		26		27			
HOURS PER 100										28		29		30			
5	10	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	
PURCHASE STOCK										LO		40		2500		INSTALLATION	
SAW CUT SLUG FROM TUBE STK										LO		40		2500		W. S. SAVAGE HANDS IN SAW	
PURCHASE STOCK										LO		40		2500		TOOLING - SPECIAL	
SEE NOTE ON OPER. #30 BELOW										LO		40		2500		DURABLE	
TURN, FACE, BORE, CHAMF										H1		14		7,143		NON DURABLE	
1/4 OPER / MACH.										H1		14		7,143		BULLARD TEMPLE TURN	
MACH. CYCLE 200 SEC / PC										H1		14		7,143		VERT TURN LATHE	
BLANCHARD GRIND TO THICKNESS										H1		15		6,667		SPECIAL TOOLING	
1/4 OPER / MACH										H1		15		6,667		DURABLE TOOLING	
MACH. CYCLE 900 SEC / SPARS										H1		15		6,667		NON DURABLE TOOLING	
NOTE: OPER #30 TO ALSO INCLUDE OPER #10 - DURING INTERNAL MACH. TIME										H1		15		6,667		GONDOLA	
GRIND OD. & BRG RACE CON TOUR										H1		28		3,572		BLANCHARD GRINDER MODEL 26 HD - 48" DIA TABLE	
1/2 OPER / MACH.										H1		28		3,572		DURABLE TOOLING	
MACH. CYCLE 90 SEC										H1		28		3,572		NON DURABLE TOOLING	
RELIEF - OPER #50 @ 16-7%										H1		7.5		13,333		GONDOLA	
DRILL TAP 2 SETS OF 8 HOLES 5/8-11 & 1/4-20										H1		7.5		13,333		LANDIS MODEL 4R	
OPER / MACH. 1/2										H1		7.5		13,333		GRINDER	
MACH CYCLE 390										H1		7.5		13,333		SPECIAL TOOLING	
SHAPE SPLINE TEETH										H1		9.0		11,112		NON DURABLE TOOLING	
OPER / MACH. 1/2										H1		9.0		11,112		FELLOWS GEAR SHAPER	
MACH CYCLE 600 SEC										H1		9.0		11,112		MODEL 20-4	
APPROVED BY INITIALS & DATE										H1		9.0		11,112		SPECIAL TOOLING	
REMARKS										H1		9.0		11,112		NON DURABLE TOOLING	
GONDOLAS TO FINAL ASSY. (4) 3,200.00										H1		9.0		11,112		INSTALLATION	
H1 CAPITAL BURDEN										H1		9.0		11,112		BUHR DE MACH. CAPITAL	
(PART WGT. APPROX 106 #)										H1		9.0		11,112		SPECIAL TOOLING	
STANDARD PRESS TAP & ADJUSTMENTS										H1		9.0		11,112		DURABLE TOOLING	
SYMBOLS										H1		9.0		11,112		NON DURABLE TOOLING	
PART NUMBER										H1		9.0		11,112		FELLOWS GEAR SHAPER	
REFERENCE										H1		9.0		11,112		MODEL 20-4	
SEQUENCE										H1		9.0		11,112		SPECIAL TOOLING	

TOOL AND LABOR ROUTING										17466A-17/77		ISSUE 10-1-77												
CUSTOMER				PART NAME		EST. NO.		DRAFTING NO.		PREL. NO.		SHEET		SUPERSEDES		EFFECTIVE		PART NO.						
SERI				CIRCULAR SPLINE		4421						2 OF 2												
OPER. NO.		DEPT. & GROUP		OPERATION DESCRIPTION		REGISTER NO. OR REVIEW DTL		PRODUCTION STD P.P.H.		HOURS PER 100 PCS		MACHINE NAME AND NUMBER		TOOL NUMBER		EQUIPMENT		TOOLS						
62				SCRAP LOSS						072														
				OPER #30 @ 1%						134														
				OPER #30 @ 2%						907														
				OPER #40,50,60 (INCL REL) @ 3%																				
63				REWORK @ 5% (INCL. REL.)						8812														
				(4 TIMES LABOR COST FOR REPAIR)																				
64				MACH. DOWNTIME AUCE @ 5%						2203														
65				FLOOR INSPECTOR						1000														
70				DELIV. TO AZIM. DRIVE ASSEMBLY AREA						1000														
<div style="display: flex; justify-content: space-between;"> <div> <p>APPROVED BY INITIALS & DATE</p> <p>RELEASE FOR: PRODUCTION ENGINEER, INDUSTRIAL ENGINEER, MANUFACTURING AND INSPECTION</p> </div> <div> <p>REMARKS</p> </div> <div> <p>CHG ASSEMBLY NO. DEPT AND GROUP HOURS/100 GROUP TOTAL</p> <p>TOTAL LABOR 58.182</p> </div> </div>																								
<div style="display: flex; justify-content: space-between;"> <div> <p>STANDARD PRESS TERMS & ABBREVIATIONS</p> <p>TF - TONG FEED TD - TONG DISPLAY RF - HAND FEED RD - HAND DISPOSE DRI - DUAL HAND TRIP EST - ELEC FOOT TRIP</p> </div> <div> <p>AF - AIR FOOT TRIP BG - BARRIER GUARD IN - UPON HAND AB - AIR EJECT RE - RUCKER EJECT CP - COIL FEED</p> </div> <div> <p>EST - ESTIMATE TOD - TOOL DESIGN ONLY RFP - RELEASE FOR PRODUCTION CN - CHANGE NOTICE DCR - DRAWING CHANGE REQUEST CR - CHANGE</p> </div> <div> <p>SYMBOLS</p> <p>AL - ALTERNATE METHOD REL - RELIEVED N - NON RECEIVED B - BOTTLE NECK C - CHANGED</p> </div> </div>																								
PART NUMBER															REFERENCE					SEQUENCE				

[illegible]

[illegible]

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[illegible]

TOOL AND LABOR ROUTING										SHEET 2 OF 2		SUPERSEDES		EFFECTIVE		PART NO.																																					
CM	M	S	SS	P	PART NAME	CUSTOMER	ESTIMATE NO.	TOOL RELEASE	DRAWING NO.	PROD. NO.	LAST CM	MODEL	YEAR	VOLUME MONTH	PCS / MOD.	PREP. BY	BLANK SIZE	COIL STRIP SHEET																																			
					4421-072	5521			4421	072		45610		25000																																							
OPER. NO.	DEPT. & GROUP	OPERATION DESCRIPTION	REWORKED NO. -DAYS-	PRODUCTION STD. P.P.H.	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER	TOOLING	TOOLING	EQUIPMENT	EST. COST	QTY.	HOURS	EST. COST	QTY.	HOURS	EST. COST	QTY.	HOURS																																			
R 50		11/22 55000, DRAW BOARD REPAIR 1/2 L.H.S. 1200.0 H.A.S.H. 21.56 TIME 4 H.A.S.H. 10.512.106	LO	10	10.000	45610, 45610, 10.45 NE BORING MILL WAZI, KOTARY TABLES	3%																																														
53		RELIEF - OPER #50 @ 16.7%			1.670	11/22 H.A.S.H. CAPITAL COST 5521, TOOLING DURABLE TOOLING NONDURABLE TOOLING			4,132,000 4,21,000 4,3,000 4,1,000																																												
13		CUSTOM FORKLIFF PALLET							30,900																																												
14		HAT & HAND - O'HEAD CRANE							1,3,000																																												
15		QUAKE GAGE							1,7,000																																												
16		HAT & HAND - CONVEYOR FT.							1,6,900																																												
24		PART WASH							1,3,000																																												
25		IN PROCESS GAGE							1,12,000																																												
26		HAT & HAND - CONVEYOR FT.							1,7,100																																												
34		PART WASH							1,3,000																																												
35		IN PROCESS GAGE							1,20,000																																												
36		HAT & HAND - CONVEYOR FT.							1,8,900																																												
44		PART WASH							1,3,000																																												
45		IN PROCESS GAGE							1,14,000																																												
46		HAT & HAND - CONVEYOR FT.							1,9,200																																												
54		PART WASH							1,3,200																																												
55		MASTER GAGE & HAND GAGES							1,35,000																																												
56		HAT & HAND - O'HEAD CRANE							1,3,000																																												
APPROVED BY INITIALS & DATE						REMARKS						CNC						SUB						DEPT. AND GROUP						HOURS / 100						HOURS						PER 100						TOTAL					
PRODUCTION ENGINEER						INDUSTRIAL ENGINEER						MANUFACTURING						H1 - HIGH CAPITAL BURDEN L0 - LOW CAPITAL BURDEN						(USING: #30A #50)						82.832 34.502						(USE)																	
STAFF INDUSTRIAL ENGR						LABOR CONTROL						PROOF READER						A2DRH56, 25K SHUTTLE PROCESS																																			
STANDARD PRESS TERMS & ABBREVIATIONS						SYMBOLS						PART NUMBER						REFERENCE						SEQUENCE																													
TP - TONG FEED TD - TONG DISPOSE TH - HAND FEED HD - HAND DISPOSE DPT - DUAL HAND TYP DFT - DUAL FOOT TYP						M1 - AIR FOOT TYP M2 - BARRED CHARG M3 - WORK WIND M4 - AIR EJECT M5 - EJECT EJECT M6 - CON. FEED						S1 - ESTIMATE S2 - 100% DUTY ONLY S3 - RELEASE FOR PRODUCTION S4 - CHANGE NOTICE S5 - DRAWING CHANGE REQUEST S6 - CHANGE						A - ALTERNATE METHOD B - BELIEVED C - NON RELEASED D - BOTTLE NECK E - CHANGED																																			

(COMPARISON DATA ONLY)

TOOL AND LABOR ROUTING										SHEET 1 OF 2		SUPERSEDES EFFECTIVE		PART NO.		1 MATERIAL		2 SPEC.		3 GAUGE		4 WGT./PC.		5 WGT./BM.		7-23-79		155061		B-7-79		155062																																																									
CUSTOMER: SERI										ESTIMATE NO. 4421 .072										MODEL HELIOSTAT										VOLUME 25,000										PCS/MOD.										PREP. ST.										BLANK SIZE										COL. STAMP SHEET																			
OPERATION DESCRIPTION										PRODUCTION STD. P.P.H.										HOURS PER 100 PCS										MACHINE NAME AND NUMBER										TOOLS AND GAUGES										EQUIPMENT										TOOLS																													
										PRODUCTIVE AVERAGE																																																																															
10 PURCH. WELDMENT FULLY GALVANIZED READY TO MACHINE																														VENDOR-																																																											
11 POSITION HOUSING ON PALLET - EDGE QUALIFY LOC. DIA & FACE										10										10,000										BULLARD TEMPLA-TURN										3%																																																	
R20 ROUGH TURN, FACE & BORE 732.2 MACH. CYCLE TIME										LO										9.0										11,112										VERT. TURRET LATHE																																																	
2 MACH/OPERATOR																														SPEC. CAM CYCLE																																																											
21 WASH - IN-LINE (AUTOM.)																														INSTALLATION																				129,000																																							
22 GAGE - IN-PROCESS (AUTOM.)																														MACH. CAPITAL COST																				2,860,000																																							
23 RELIEF - OPER #20 @ 16.7%																														SPEC. TOOLING																				2,29,800																																							
																														DURABLE TOOLING																				2,3750																																							
R30 BORE, TURN, FACE & CONTOUR DRILL & TAP LARGE END -										LO										10.6										9,434										GIDDINGS & LEWIS										3%										50										2,1250																			
BORE & FACE BEARING BORE & FACE OUTSIDE RING &																														10 HS N/C MILL																																																											
DRILL & TAP SMALL END -																														W/2 ROTARY TABLES																																																											
BORE, FACE, DRI-L & TAP																														INSTALLATION																				178,000																																							
MOTOR MTG. FACE -																														MACH. CAPITAL COST																				4,132,000																																							
1160 MACH. CYCLE TIME																														SPEC. TOOLING																				4,36,000																																							
4 MACH/OPERATOR																														DURABLE TOOLING																				4,4500																																							
33 RELIEF - OPER #30 @ 16.7%																														NON DURABLE TOOLING																				140										4,1500																													
R40 MILL, S'DRILL, DRILL, BORE, & REAM 4 ARMS										LO										10.3										9,700										GIDDINGS & LEWIS										3%																																							
1200 MACH CYCLE TIME																														10 HS N/C MILL																																																											
4 MACH/OPERATOR																														W/2 ROTARY TABLES																																																											
41 WASH - IN-LINE (AUTOM.)																														MACH. CAPITAL COST																				4,133,000																																							
42 GAGE - MASTER & HAND GAGES																														SPEC. TOOLING																				4,21,000																																							
43 RELIEF - OPER #40 @ 16.7%																														DURABLE TOOLING																				4,3000																																							
																														NON DURABLE TOOLING																				100										4,1900																													

APPROVED BY INITIALS & DATE				REMARKS				SUB ASSEMBLY NO.				DEPT. AND GROUP				HOURS / 100				SUB TOTAL				TOTAL			
PRODUCTION ENGINEER				INDUSTRIAL ENGINEER				MANUFACTURING																			
				H1 - HIGH CAPITAL BURDEN																							
				LO - LOW CAPITAL																							
				A&DR HSG, 25K - MC Process (OPT)																							
				STANDARD PRESS TERMS & ABBREVIATIONS																							
				SYMBOLS																							
				PART NUMBER																							
				REFERENCE																							
				SEQUENCE																							

TOOL AND LABOR ROUTING 11-2

C21

LO-V LUME

ISSUE 1 1-79

PART NAME				TOOL AND LABOR ROUTING				SHEET				SUBMITTER				EFFECTIVE				DATE NO.				MATERIAL							
WAVE GENERATOR								1 OF 1																							
ESTIMATE NO.				DRAWING NO.				MODEL				VOLUME				PCS / MOD.				PREP. BY				BLANK SIZE				SYNOPSIS			
SET 1				4421				HELIOSTAT				25,000																			
OPER. NO.	DEPT. & GROUP	OPERATION DESCRIPTION	REGISTER NO. OR REVIEW DATE	PRODUCTION STD. P.P.H.	HOURS PER 100 PCS.	T A D	MACHINE NAME AND NUMBER	TOOLS AND GAUGES	90% SCRAP	TT. COST / HIR	EQUIPMENT	EST. COST	TOOLS	EST. COST																	
				PRODUCTIVE	AVERAGE																										
10		PURCHASE MAT L.																													
15		TRUCKING - MATERIAL HANDLING			500																										
20		TURN, FACE, BORE, CHAMF, & CUT OFF	H1	15	6.667		NATIONAL ACME MODEL SST-10 5/8 LATHE		3	20	1	975,000																			
		1/4 OPER. / MACH.					SPECIAL TOOLING					71,250		(INSTALLATION)																	
		MACH. CYCLE = 19 SEC.					DURABLE TOOLING					20,000																			
							NONDURABLE TOOLING					97,500																			
							GONDOLA				2	7,500																			
30		BLANCHARD GRIND BOTH SIDES	H1	16	6.250		BLANCHARD GRINDER		2	15	1	18,150																			
		1/4 OPER. / MACH.					MODEL 26 HD 4E DIATABLE					121,000																			
		MACH CYCLE 90 SEC / 6 METS					DURABLE TOOLING					2,000																			
							NONDURABLE TOOLING					1,000																			
40		BROACH KEYWAY	L0	80	1.250		GONDOLA				2	1,600																			
		1/4 OPER. / MACH.					MILTS & MERRIL			5	1	22,000																			
		MACH CYCLE 35 SEC.					KEYSEATER					3,300		(INSTALLATION)																	
		INSPECTION - FLOOR INSPECTOR			400		DURABLE TOOLING					2,000																			
							NONDURABLE TOOLING					1,000																			
50		PROFILE GRIND O.D.	L0	16	6.250		INSTALLATION					31,800																			
		1/4 OPER. / MACH					LANDIS POLYGON GRINDER		3		1	23,000																			
		MACH CYCLE - 180 SEC.					SPECIAL TOOLING					4,000																			
51		REWORK 5%			4.084		NONDURABLE TOOLING			20		2,000																			
		TO ASSEMBLY			500		FORKLIFT					4,000																			
		SCRAP LOSS: O.H.X #20 @ 3%			358		PALLETS					6,000																			
		OPER #30 @ 2%			125																										
		MACH DOWNTIME ALICE @ 5%			1.021																										

APPROVED BY INITIALS & RATE			REMARKS		JOB. ASSEMBLY NO.		DEPT. AND GROUP		HOURS / 100		HOURS PER 100	
PRODUCTION ENGINEER	INDUSTRIAL ENGINEER	MANUFACTURER										
			H1 CAPITAL BUREAU						27.435			

STANDARD PRESS TAP & ANGLE VARIATIONS			SYMBOLS		
ST - LONG TAP	AT - AIR FOOT TAP	ST - ESTIMATE	• - ALTERNATE BLEND	• - BELIEVED	• - NOT BELIEVED
TD - LONG DISPOSE	BD - BARRIER GUARD	TD - TOOL DESIGN ONLY	• - BELIEVED	• - BELIEVED	• - NOT BELIEVED
WD - HAND TAP	PD - HAND TAP	WD - RELEASE FOR PRODUCTION	• - BELIEVED	• - BELIEVED	• - NOT BELIEVED
ND - HAND DISPOSE	AD - AIR GUARD	AD - CHANGE NOTICE	• - BELIEVED	• - BELIEVED	• - NOT BELIEVED
WD - HAND TAP	ED - SHARP TAP	ED - SHARP CHANGE REQUEST	• - BELIEVED	• - BELIEVED	• - NOT BELIEVED
PD - HAND TAP	FD - CON TAP	FD - CON TAP	• - BELIEVED	• - BELIEVED	• - NOT BELIEVED

STAFF INDUSTRIAL ENGR.	LABOR CONTROL	PROOF READER	PART NUMBER	REFERENCE	SEQUENCE

TOOL AND LABOR ROUTING

PART NAME						TOOL AND LABOR ROUTING								SHEET		SUPERSEDES		EFFECTIVE		PART NO.		SPEC.		GAUGE		WGT./PC.		WGT./DM.	
BEARING RETAINER														1 OF 2															
CUSTOMER	ESTIMATE NO.	TOOL RELEASE	DRAWING NO.	FILE NO.	LAST REV.	MODEL	PLT.	VOLUME	PCS / MOD.	PREF. BY	BLANK SIZE	EQUIP. STATION																	
SERI			4421			HELIOSTAT		27,000																					
OPER. NO.	DEPT. & GROUP	OPERATION DESCRIPTION			%	REGISTER NO. OR REVIEW DATE	PRODUCTION STD. P.P.H.	HOURS PER 100 PCS.	T A D	MACHINE NAME AND NUMBER TOOLS AND GAUGES	QTY.	To Cost - \$	EQUIPMENT	EST. COST	TOOLS	EST. COST													
10		PURCHASE ROLLED RING (WGT. APPROX. 50#)						-		AIRCO VIKING RENO, NEVADA																			
15		TRUCKING - MFG'L. HDLG.						500																					
20		GRIND SIDES OF RING PARALLEL & FLAT 2 PARTS/CYCLE 4 PARTS/LOAD MACH CYCLE / PT 55 SEC. .5 OPER/MACH				#1	50	1,000		INSTALLATION BLANCHARD GRINDER DURABLE TOOLING PERISHABLE TOOLING	2	25	1	18,150 121,000															
25		TRANSPORT						250		WOOD PALLET																			
30		TURN I.D. BEARING RACE CONTOUR & O'RING GROOVES 1 OPER / MACH MACH CYCLE 2.15 SEC/LA				#1	12.5	8,000		INSTALLATION BULLARD TEMPERATURE 1/8" T. TORRET LATHE TOOLING SPECIAL DURABLE NON-TOXIC MAKE	5	15	1	64,500 430,000															
35		TRANSPORT						250		WOOD PALLET (SCOTTS)																			

APPROVED BY INITIALS & DATE:

PRODUCTION ENGINEER	INDUSTRIAL ENGINEER	MANUFACTURING

REMARKS: #1 LO CAPITAL BORDON

STANDARD PRESS TERMS & ABBREVIATIONS:

TF - TONG FIRM	AS - AIR FOOT TRIP	EST - ESTIMATE
TP - TONG DISPOSE	BS - BARBER GUARD	TD - TOOL DESIGN ONLY
MP - HAND FEED	DS - DOWN HAND	DP - DELAY FOR PRODUCTION
MS - HAND SHOVE	AS - AIR EFFECT	CS - CHANGE OFFICE
MT - HAND FEED TRIP	ES - EXACT EFFECT	DC - DRIVING CHARGE REDUCT
MF - HAND FEED TRIP	FS - FEED	

SYMBOLS:

* - ALTERNATE METHOD
B - BELTER
N - NOT RELIABLE
T - TOTAL WORN

PART NUMBER Δ

REFERENCE

SEQUENCE

PART NAME						TOOL AND LABOR ROUTING								SHEET NO.				TYPART NO.			
BEARING RETAINER														2 OF 2							
CUSTOMER	ESTIMATE NO.	TOOL RELEASE	DRAWING NO.	PANEL NO.	LAT. ENG.	MODEL	MATERIAL	VOLUME	PCS./MOD.	PLP. ST.	BLANK SIZE	TYPART SHEET									
SERI			4421			HELIOSTAT		25,000													
OPER. NO.	DEPT. & GROUP	OPERATION DESCRIPTION	%	REGISTER NO. OR REVIEW DATE	PRODUCTION STD. P.P.M. PRODUCTIVE AVERAGE	HOURS PER 100 PCS.	TAG	MACHINE NAME AND NUMBER TOOLS AND GAUGES	90% SEARCH	70% INC.	EQUIPMENT	EST. COST	MOVERS DESIGN	HOURLY RATE	EST. COST						
40		DRILL (16) .40 DIA HOLES (1) OPER. / MACH. MACH CYCLE - 360 SEC		H1	8.0	12,500		BUNK V.C. HATCH INSTALLATION CAPITAL COST SPECIAL TOOLING DURABLE TOOLING NON DURABLE TOOLING	3	30%	199,000										
45		TRANSPORT				250		WOOD PALLET (500 @ 25)													
47		REWORK-5% (4 TIMES LABOR COST)				4,610															
50		GALVANIZE				-		VENDOR USE EXISTING EQUIPMENT													
		SCRAP LOSS-OPER #20 @ 2% - OPER #30,40 @ 3%				615															
		MACH. DOWNTIME ALLOW @ 5%				1,075															
54		INSPECTION-FLOOR INSPECTOR				1,000															
65		TRANSPORT TO AZ DRIVE ASS'Y AREA				500		WOOD PALLET (500 @ 25)													
APPROVED BY INITIALS & DATE				REMARKS				CNC				TOTAL HOURS				HOURS SUB TOTAL					
PRODUCTION ENGINEER				INDUSTRIAL ENGINEER				MANUFACTURING				ASSEMBLY NO.				DEPT. AND GROUP					
				H1 LO CAPITAL BUDGET								31,590									
STANDARD PRESS TITLES & ABBREVIATIONS				SYMBOLS				PART NUMBER				REFERENCE				SEQUENCE					
TP - WORK FILE TD - WORK DISPOSE DP - HAND FILE ND - HAND DISPOSE SPT - WORK HAND TRIP LFT - BACK ALONE TRIP				DT - NO FOOT TRIP DB - BARRED CURVE DR - HIGH RUN AE - FOR FIRST RE - PHOTO EJECT CO - END PAGE				EST - ESTIMATE 100 - 100% DESIGN ONLY DRP - RELEASE FOR PRODUCTION CR - CHANGE NOTICE OEP - DRAWING CHANGE REQUEST				* ALTERNATE METHOD R - REVISED N - NEW REVISED C - BOTTLE NECK F - FINAL									

LOW VOLUME

ISSUE 1, -1-74

CM M S SS P				PART NAME	TOOL AND LABOR ROUTING										SHEET		SUPERSEDES		EFFECTIVE		PART NO.	
CUSTOMER				ESTIMATE NO.	TOOL RELEASE	DRAWING NO.	PREL. NO.	LAST EGG	MODEL	YEAR	VOLUME	MONTH	PCS./MOD.	PREP. BY	BLANK SIZE	COL. BY	SHR. BY					
SERI						4421			HELIOSTAT	25,000			1									
OPER. NO.	DEPT. & GROUP	OPERATION DESCRIPTION	REGISTER NO. OR REVIEW DATE	PRODUCTION STD. P.P.H.	HOURS PER 100 PCS.	T A B	MACHINE NAME AND NUMBER	TOOLS AND GAUGES	TOOL COST	TL COST	EQUIPMENT	TOOLS	1									
									TOOL COST	TL COST	EST. COST	HOURS	2									
									SCRAP	/HR.												
10		ASSEMBLE AZIMUTH DRIVE 1 MACHINE / 7 OPERATORS 210.0 SEC MACH. CYCLE (USE SHUTDOWN RELIEF)	H1	(14.3)	49,000		29 STA ASS'Y TRANSFER MACH. INSTALLATION	1%	1,600.00		240,000		5									
13		FLOOR INSPECTOR	H1		2,000		FLOOR FEEDERS INSTALLATION		7	42,000												
		SCRAP LOSS @ 1%	H1		490		BOWL FEEDERS INSTALLATION		6	27,000												
		MACH. DOWNTIME ALICE @ 10%	H1		4,900		BULK OIL FEED SYSTEM INCL STORAGE TANK INSTALLATION		1	11,000												
			H1				SHIM STORAGE & FEED UNIT INSTALLATION		1	1,650												
			H1				LOADING ASSIST HOIST		1	8,000			1									
			H1				HOIST FOR ROTATE		2	16,000			2									
			H1				LOAD, UNLOAD & ROTATE FIAT		4	20,000			4									
			H1				UNLOAD CRANE		2	32,000			5									
			H1				DURABLE TOOLING			32,000												
			H1				PERISHABLE TOOLING INSTALLATION			8,000												
			H1				SPECIAL TRANSFER SKIDS FOR UNLOADING		40	40,000												
			H1				INPROCESS GAGE		1	25,000												

RELEASE FOR	APPROVED BY (INITIALS & DATE)	REMARKS	SUB. ASSEMBLY NO.	DEPT. AND GROUP	HOURS / 100	HOURS PER 100
PRODUCTION ENGINEER		H1 CAPITAL BURDEN			56.390	
INDUSTRIAL ENGINEER		REPLACE WRENCHES 2x/yr				
MANUFACTURING						

STANDARD PRESS TERMS & ABBREVIATIONS				SYMBOLS			
TP - TONG FEED	SP - AIR FOOT TRIP	EST - ESTIMATE	TR - TOOL, REPAIR ONLY	AL - ALTERNATE METHOD			
TD - TONG DISPOSE	SW - SHIMMING GANGED	TRP - TOOL, REPAIR ONLY	TRP - RELEASE FOR PRODUCTION	REL - RELIEVED			
DF - HAND FEED	SD - SHIM HAND	CP - CHANGE NOTICE	CP - CHANGE NOTICE	REL - RELIEVED			
DD - HAND DISPOSE	AD - AIR EJECT	CD - CHANGE NOTICE	CD - CHANGE NOTICE	REL - RELIEVED			
DT - DUAL HAND TRIP	RD - RELOAD EJECT	CD - CHANGE NOTICE	CD - CHANGE NOTICE	REL - RELIEVED			
DPT - DUAL FOOT TRIP	CF - CON. FEED	CD - CHANGE NOTICE	CD - CHANGE NOTICE	REL - RELIEVED			

STAFF INDUSTRIAL ENGR.	LABOR CONTROL	PROOF READER	PART NUMBER	REFERENCE	SEQUENCE

[illegible]

TOOL AND LABOR ROUTING										SHEET		SUPERSEDES		EFFECTIVE		PART NO.		1 MATERIAL		2 SPEC.		3 GAUGE		4 WGT./PC.		5 WGT./BM.													
CUSTOMER										1 OF 1																													
PART NAME										ESTIMATE NO.		TOOL RELEASE		DRAWING NO.		PREL. NO.		LAST		MODEL		VOLUME		PCS/MOD.		PREP. BY		BLANK SIZE		CON. STAMP SHEET									
551										4422		.075		HELIODAT		25.00																							
OPERATION DESCRIPTION										REGISTER NO. OR REVIEW DATE		PRODUCTION STD. P.P.H.		AVERAGE		HOURS PER 100 PCS.		T A B		MACHINE NAME AND NUMBER		TOOLS AND GAUGES		70		75		EQUIPMENT		TOOLS									
13 CUSTOM FORKLIET PALLET																																							
10 PURCH. WELDMENT FULLY GALVANIZED, READY TO MACHINE.																																							
20 MILL ENDS, TAP DRILL (4) & TAP (4)										H1		9.0		11		112				LAMB 4 STA SHUTTLE		190																	
331.0 MACH. CYCLE TIME																																							
1 MACH OPERATOR																																							
25 TRUCKING - MATERIAL HANDLING																																							
31 RELIEF - OPER #30 @ 16.7%																																							
30 DRILL, CHFR, REAM & MILL (6) GUGS										H1		8.0		12		500				LAMB 5 STA SHUTTLE		190																	
391.5 MACH CYCLE TIME																																							
1 MACH OPERATOR																																							
SCRAP LOSS @ 1%																																							
MACH. DOWNTIME #20 & 30 @ 10%																																							
33 INSPECTION - FLOOR INSPECTOR																																							
14 MAT'L HAND - O'HIO CRANE																																							
15 QUALIF GAGE																																							
16 MAT'L HAND - CONVEYER										PT																													
24 PART WASH																																							
25 IN PROCESS GAGE																																							
26 MAT'L HAND - CONVEYER										PT																													
34 PART WASH																																							
35 MASTER GAGE & HAND GAGES																																							
36 MAT'L HAND - O'HIO CRANE																																							
37 REWORK @ 5% (4 TIMES LABOR FOR REV)																																							
APPROVED BY INITIALS & DATE										REMARKS										H1 - HIGH CAPITAL BURDEN										LD - LOW CAPITAL BURDEN									
PRODUCTION ENGINEER										INDUSTRIAL ENGINEER										MANUFACTURING																			
STAFF INDUSTRIAL ENGR.										LABOR CONTROL										PROOF READER																			
TORQUE TUBE 25K - SHUTTLE PROCESS										STANDARD PRICES, TERMS & ABBREVIATIONS										SYMBOLS																			
17 - TONG FEED										18 - TONG FEED										19 - TONG FEED										20 - TONG FEED									
21 - TONG FEED										22 - TONG FEED										23 - TONG FEED										24 - TONG FEED									
25 - TONG FEED										26 - TONG FEED										27 - TONG FEED										28 - TONG FEED									
29 - TONG FEED										30 - TONG FEED										31 - TONG FEED										32 - TONG FEED									
33 - TONG FEED										34 - TONG FEED										35 - TONG FEED										36 - TONG FEED									
37 - TONG FEED										38 - TONG FEED										39 - TONG FEED																			

155551 1-2-79

C23

TOOL AND LABOR ROUTING										SHEET 1 OF 1		SUPERSEDES		EFFECTIVE 7/6/77		PART NO.					
CUSTOMER: MOTORS										ESTIMATE NO.		TOOL RELEASE		DRAWING NO. 4423		PART NO.					
OPERATION DESCRIPTION										REGISTER NO. OR REVIEW DATE		PRODUCTION STD. P.P.H.		HOURS PER 100 PCS.		MACHINE NAME AND NUMBER		TOOL NUMBER			
										PRODUCTIVE		AVERAGE									
10 PURCHASE, STOCK AND ISSUE PUMPERS, KIT AND TEST BILLS AND MATERIAL FOR FIELD ASSEMBLY 300 PER HOUR SET OF THREE 1 MATERIAL HANDLING												10		10:000							
15 ASSEMBLY AND TEST EACH HOUR ON MOTOR TEST STATION 150 PER HOUR TEST CYCLE 2 TEST TECHNICIANS												(20)		10:000		450V, 3φ CANALINE ACCEL. CIRCUIT BREAKERS, DYNA- METER IN SPECIAL TEST SET AND STAND INSTALLATION		2 39,000 4,500			
20 RETURN LAMPS, FIDELITY (LW) TO SUPPLIER														2:400							
30 PROVIDE MOTOR FOR APPLICATION OF MOTOR ENCODER (POSITION/LIMIT INDICATOR 7424)																					
40 TRUCKING - MATERIAL HANDLING														2:000							

APPROVED BY INITIALS & DATE				REMARKS	SUB. ASSEMBLY NO.		DEPT. AND GROUP		HOURS/100 GROUP TOTAL		HOURS PER 100		TOTAL
RELEASE FOR	PRODUCTION ENGINEER	INDUSTRIAL ENGINEER	MANUFACTURING						%	%	SUB TOTAL		
									24,400				

STANDARD PRESS TERMS & ABBREVIATIONS				SYMBOLS			
TP - TONG FEED	MT - AIR FOOT TRIP	EST - ESTIMATE		• - ALTERNATE METHOD			
TD - TONG DISPOSE	SG - SHOWER GARD	TBO - TOOL DESIGN ONLY		• - BELIEVED			
UP - HAND FEED	IB - IRON BAND	SP - RELEASE FOR PRODUCTION		• - NON-BELIEVED			
ND - HAND DISPOSE	AM - AIR MIST	CD - CHANGE NOTICE		• - DOTTED LINE			
EST - HAND FEED TRIP	TS - MACHINIST TEST	SC - SHOWER CHARGE REQUEST		• - CHARGED			
EPT - ELECT FOOT TRIP	CP - CON. FEED	CS - CHANGE					

TOOL AND LABOR ROUTING

SHEET 2 OF 2 SUPERSEDES EFFECTIVE 7/1/68 PART NO.

1	MATERIAL
2	SPEC.
3	GAUGE
4	WGT./PC.
5	WGT./BM.

CUSTOMER: CM M S SS P PART NAME: 10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-31-32-33-34-35-36-37-38-39-40-41-42-43-44-45-46-47-48-49-50-51-52-53-54-55-56-57-58-59-60-61-62-63-64-65-66-67-68-69-70-71-72-73-74-75-76-77-78-79-80-81-82-83-84-85-86-87-88-89-90-91-92-93-94-95-96-97-98-99-100

ESTIMATE NO. TOOL RELEASE DRAWING NO. PREL. NO. LAST MODEL HELIOSTAT

OPER. NO.	DEPT. & GROUP	OPERATION DESCRIPTION	REGISTER NO. OR REVIEW DATE	PRODUCTION STD. P.P.H. PRODUCTIVE AVERAGE	HOURS PER 100 PCS.	T A B	MACHINE NAME AND NUMBER TOOLS AND GAUGES	TOOL NUMBER	EQUIPMENT	TOOLS	1
30		AUTOMATICALLY INSERT COMPONENTS. 20" LONG 1/2" DIA. 1/2" THICK. 1 "B" ASSSEMBLY. TRIM. 40		150	667		UNIVERSAL MACHINING TOOL. 1/2" DIA. 1/2" THICK. 1 "B" ASSSEMBLY. TRIM. 40				
40		ASSEMBLY OF 1/2" DIA. 1/2" THICK. 1 "B" ASSSEMBLY. TRIM. 40									
45		VISUAL INSPECT SOLIDIFIED BOARD FOR VOIDS, BUBBLES, INCLUSIONS. 40		50	2,000						
50		1/2" DIA. 1/2" THICK. 1 "B" ASSSEMBLY. TRIM. 40		(15)	334						
60		ASSEMBLY OF 1/2" DIA. 1/2" THICK. 1 "B" ASSSEMBLY. TRIM. 40		17	5,883						
70		PROVIDE MOTORS TO CONTROL SIGNAL EQUIPMENT OPERATION. 1/2" DIA. 1/2" THICK. 1 "B" ASSSEMBLY. TRIM. 40									

APPROVED BY INITIALS & DATE: RELEASE FOR: PRODUCTION ENGINEER INDUSTRIAL ENGINEER MANUFACTURING

REMARKS: 22.7/8

STANDARD PRESS TERMS & ABBREVIATIONS: 1P - TONG FEED 1B - TONG DISPOSE 1C - HAND FEED 1D - HAND DISPOSE 1E - HAND FEED 1F - HAND DISPOSE 1G - HAND FEED 1H - HAND DISPOSE 1I - HAND FEED 1J - HAND DISPOSE 1K - HAND FEED 1L - HAND DISPOSE 1M - HAND FEED 1N - HAND DISPOSE 1O - HAND FEED 1P - HAND DISPOSE 1Q - HAND FEED 1R - HAND DISPOSE 1S - HAND FEED 1T - HAND DISPOSE 1U - HAND FEED 1V - HAND DISPOSE 1W - HAND FEED 1X - HAND DISPOSE 1Y - HAND FEED 1Z - HAND DISPOSE 1AA - HAND FEED 1AB - HAND DISPOSE 1AC - HAND FEED 1AD - HAND DISPOSE 1AE - HAND FEED 1AF - HAND DISPOSE 1AG - HAND FEED 1AH - HAND DISPOSE 1AI - HAND FEED 1AJ - HAND DISPOSE 1AK - HAND FEED 1AL - HAND DISPOSE 1AM - HAND FEED 1AN - HAND DISPOSE 1AO - HAND FEED 1AP - HAND DISPOSE 1AQ - HAND FEED 1AR - HAND DISPOSE 1AS - HAND FEED 1AT - HAND DISPOSE 1AU - HAND FEED 1AV - HAND DISPOSE 1AW - HAND FEED 1AX - HAND DISPOSE 1AY - HAND FEED 1AZ - HAND DISPOSE 1BA - HAND FEED 1BB - HAND DISPOSE 1BC - HAND FEED 1BD - HAND DISPOSE 1BE - HAND FEED 1BF - HAND DISPOSE 1BG - HAND FEED 1BH - HAND DISPOSE 1BI - HAND FEED 1BJ - HAND DISPOSE 1BK - HAND FEED 1BL - HAND DISPOSE 1BM - HAND FEED 1BN - HAND DISPOSE 1BO - HAND FEED 1BP - HAND DISPOSE 1BQ - HAND FEED 1BR - HAND DISPOSE 1BS - HAND FEED 1BT - HAND DISPOSE 1BU - HAND FEED 1BV - HAND DISPOSE 1BW - HAND FEED 1BX - HAND DISPOSE 1BY - HAND FEED 1BZ - HAND DISPOSE 1CA - HAND FEED 1CB - HAND DISPOSE 1CC - HAND FEED 1CD - HAND DISPOSE 1CE - HAND FEED 1CF - HAND DISPOSE 1CG - HAND FEED 1CH - HAND DISPOSE 1CI - HAND FEED 1CJ - HAND DISPOSE 1CK - HAND FEED 1CL - HAND DISPOSE 1CM - HAND FEED 1CN - HAND DISPOSE 1CO - HAND FEED 1CP - HAND DISPOSE 1CQ - HAND FEED 1CR - HAND DISPOSE 1CS - HAND FEED 1CT - HAND DISPOSE 1CU - HAND FEED 1CV - HAND DISPOSE 1CW - HAND FEED 1CX - HAND DISPOSE 1CY - HAND FEED 1CZ - HAND DISPOSE 1DA - HAND FEED 1DB - HAND DISPOSE 1DC - HAND FEED 1DD - HAND DISPOSE 1DE - HAND FEED 1DF - HAND DISPOSE 1DG - HAND FEED 1DH - HAND DISPOSE 1DI - HAND FEED 1DJ - HAND DISPOSE 1DK - HAND FEED 1DL - HAND DISPOSE 1DM - HAND FEED 1DN - HAND DISPOSE 1DO - HAND FEED 1DP - HAND DISPOSE 1DQ - HAND FEED 1DR - HAND DISPOSE 1DS - HAND FEED 1DT - HAND DISPOSE 1DU - HAND FEED 1DV - HAND DISPOSE 1DW - HAND FEED 1DX - HAND DISPOSE 1DY - HAND FEED 1DZ - HAND DISPOSE 1EA - HAND FEED 1EB - HAND DISPOSE 1EC - HAND FEED 1ED - HAND DISPOSE 1EE - HAND FEED 1EF - HAND DISPOSE 1EG - HAND FEED 1EH - HAND DISPOSE 1EI - HAND FEED 1EJ - HAND DISPOSE 1EK - HAND FEED 1EL - HAND DISPOSE 1EM - HAND FEED 1EN - HAND DISPOSE 1EO - HAND FEED 1EP - HAND DISPOSE 1EQ - HAND FEED 1ER - HAND DISPOSE 1ES - HAND FEED 1ET - HAND DISPOSE 1EU - HAND FEED 1EV - HAND DISPOSE 1EW - HAND FEED 1EX - HAND DISPOSE 1EY - HAND FEED 1EZ - HAND DISPOSE 1FA - HAND FEED 1FB - HAND DISPOSE 1FC - HAND FEED 1FD - HAND DISPOSE 1FE - HAND FEED 1FF - HAND DISPOSE 1FG - HAND FEED 1FH - HAND DISPOSE 1FI - HAND FEED 1FJ - HAND DISPOSE 1FK - HAND FEED 1FL - HAND DISPOSE 1FM - HAND FEED 1FN - HAND DISPOSE 1FO - HAND FEED 1FP - HAND DISPOSE 1FQ - HAND FEED 1FR - HAND DISPOSE 1FS - HAND FEED 1FT - HAND DISPOSE 1FU - HAND FEED 1FV - HAND DISPOSE 1FW - HAND FEED 1FX - HAND DISPOSE 1FY - HAND FEED 1FZ - HAND DISPOSE 1GA - HAND FEED 1GB - HAND DISPOSE 1GC - HAND FEED 1GD - HAND DISPOSE 1GE - HAND FEED 1GF - HAND DISPOSE 1GG - HAND FEED 1GH - HAND DISPOSE 1GI - HAND FEED 1GJ - HAND DISPOSE 1GK - HAND FEED 1GL - HAND DISPOSE 1GM - HAND FEED 1GN - HAND DISPOSE 1GO - HAND FEED 1GP - HAND DISPOSE 1GQ - HAND FEED 1GR - HAND DISPOSE 1GS - HAND FEED 1GT - HAND DISPOSE 1GU - HAND FEED 1GV - HAND DISPOSE 1GW - HAND FEED 1GX - HAND DISPOSE 1GY - HAND FEED 1GZ - HAND DISPOSE 1HA - HAND FEED 1HB - HAND DISPOSE 1HC - HAND FEED 1HD - HAND DISPOSE 1HE - HAND FEED 1HF - HAND DISPOSE 1HG - HAND FEED 1HH - HAND DISPOSE 1HI - HAND FEED 1HJ - HAND DISPOSE 1HK - HAND FEED 1HL - HAND DISPOSE 1HM - HAND FEED 1HN - HAND DISPOSE 1HO - HAND FEED 1HP - HAND DISPOSE 1HQ - HAND FEED 1HR - HAND DISPOSE 1HS - HAND FEED 1HT - HAND DISPOSE 1HU - HAND FEED 1HV - HAND DISPOSE 1HW - HAND FEED 1HX - HAND DISPOSE 1HY - HAND FEED 1HZ - HAND DISPOSE 1IA - HAND FEED 1IB - HAND DISPOSE 1IC - HAND FEED 1ID - HAND DISPOSE 1IE - HAND FEED 1IF - HAND DISPOSE 1IG - HAND FEED 1IH - HAND DISPOSE 1II - HAND FEED 1IJ - HAND DISPOSE 1IK - HAND FEED 1IL - HAND DISPOSE 1IM - HAND FEED 1IN - HAND DISPOSE 1IO - HAND FEED 1IP - HAND DISPOSE 1IQ - HAND FEED 1IR - HAND DISPOSE 1IS - HAND FEED 1IT - HAND DISPOSE 1IU - HAND FEED 1IV - HAND DISPOSE 1IW - HAND FEED 1IX - HAND DISPOSE 1IY - HAND FEED 1IZ - HAND DISPOSE 1JA - HAND FEED 1JB - HAND DISPOSE 1JC - HAND FEED 1JD - HAND DISPOSE 1JE - HAND FEED 1JF - HAND DISPOSE 1JG - HAND FEED 1JH - HAND DISPOSE 1JI - HAND FEED 1JJ - HAND DISPOSE 1JK - HAND FEED 1JL - HAND DISPOSE 1JM - HAND FEED 1JN - HAND DISPOSE 1JO - HAND FEED 1JP - HAND DISPOSE 1JQ - HAND FEED 1JR - HAND DISPOSE 1JS - HAND FEED 1JT - HAND DISPOSE 1JU - HAND FEED 1JV - HAND DISPOSE 1JW - HAND FEED 1JX - HAND DISPOSE 1JY - HAND FEED 1JZ - HAND DISPOSE 1KA - HAND FEED 1KB - HAND DISPOSE 1KC - HAND FEED 1KD - HAND DISPOSE 1KE - HAND FEED 1KF - HAND DISPOSE 1KG - HAND FEED 1KH - HAND DISPOSE 1KI - HAND FEED 1KJ - HAND DISPOSE 1KK - HAND FEED 1KL - HAND DISPOSE 1KM - HAND FEED 1KN - HAND DISPOSE 1KO - HAND FEED 1KP - HAND DISPOSE 1KQ - HAND FEED 1KR - HAND DISPOSE 1KS - HAND FEED 1KT - HAND DISPOSE 1KU - HAND FEED 1KV - HAND DISPOSE 1KW - HAND FEED 1KX - HAND DISPOSE 1KY - HAND FEED 1KZ - HAND DISPOSE 1LA - HAND FEED 1LB - HAND DISPOSE 1LC - HAND FEED 1LD - HAND DISPOSE 1LE - HAND FEED 1LF - HAND DISPOSE 1LG - HAND FEED 1LH - HAND DISPOSE 1LI - HAND FEED 1LJ - HAND DISPOSE 1LK - HAND FEED 1LL - HAND DISPOSE 1LM - HAND FEED 1LN - HAND DISPOSE 1LO - HAND FEED 1LP - HAND DISPOSE 1LQ - HAND FEED 1LR - HAND DISPOSE 1LS - HAND FEED 1LT - HAND DISPOSE 1LU - HAND FEED 1LV - HAND DISPOSE 1LW - HAND FEED 1LX - HAND DISPOSE 1LY - HAND FEED 1LZ - HAND DISPOSE 1MA - HAND FEED 1MB - HAND DISPOSE 1MC - HAND FEED 1MD - HAND DISPOSE 1ME - HAND FEED 1MF - HAND DISPOSE 1MG - HAND FEED 1MH - HAND DISPOSE 1MI - HAND FEED 1MJ - HAND DISPOSE 1MK - HAND FEED 1ML - HAND DISPOSE 1MM - HAND FEED 1MN - HAND DISPOSE 1MO - HAND FEED 1MP - HAND DISPOSE 1MQ - HAND FEED 1MR - HAND DISPOSE 1MS - HAND FEED 1MT - HAND DISPOSE 1MU - HAND FEED 1MV - HAND DISPOSE 1MW - HAND FEED 1MX - HAND DISPOSE 1MY - HAND FEED 1MZ - HAND DISPOSE 1NA - HAND FEED 1NB - HAND DISPOSE 1NC - HAND FEED 1ND - HAND DISPOSE 1NE - HAND FEED 1NF - HAND DISPOSE 1NG - HAND FEED 1NH - HAND DISPOSE 1NI - HAND FEED 1NJ - HAND DISPOSE 1NK - HAND FEED 1NL - HAND DISPOSE 1NM - HAND FEED 1NN - HAND DISPOSE 1NO - HAND FEED 1NP - HAND DISPOSE 1NQ - HAND FEED 1NR - HAND DISPOSE 1NS - HAND FEED 1NT - HAND DISPOSE 1NU - HAND FEED 1NV - HAND DISPOSE 1NW - HAND FEED 1NX - HAND DISPOSE 1NY - HAND FEED 1NZ - HAND DISPOSE 1OA - HAND FEED 1OB - HAND DISPOSE 1OC - HAND FEED 1OD - HAND DISPOSE 1OE - HAND FEED 1OF - HAND DISPOSE 1OG - HAND FEED 1OH - HAND DISPOSE 1OI - HAND FEED 1OJ - HAND DISPOSE 1OK - HAND FEED 1OL - HAND DISPOSE 1OM - HAND FEED 1ON - HAND DISPOSE 1OO - HAND FEED 1OP - HAND DISPOSE 1OQ - HAND FEED 1OR - HAND DISPOSE 1OS - HAND FEED 1OT - HAND DISPOSE 1OU - HAND FEED 1OV - HAND DISPOSE 1OW - HAND FEED 1OX - HAND DISPOSE 1OY - HAND FEED 1OZ - HAND DISPOSE 1PA - HAND FEED 1PB - HAND DISPOSE 1PC - HAND FEED 1PD - HAND DISPOSE 1PE - HAND FEED 1PF - HAND DISPOSE 1PG - HAND FEED 1PH - HAND DISPOSE 1PI - HAND FEED 1PJ - HAND DISPOSE 1PK - HAND FEED 1PL - HAND DISPOSE 1PM - HAND FEED 1PN - HAND DISPOSE 1PO - HAND FEED 1PP - HAND DISPOSE 1PQ - HAND FEED 1PR - HAND DISPOSE 1PS - HAND FEED 1PT - HAND DISPOSE 1PU - HAND FEED 1PV - HAND DISPOSE 1PW - HAND FEED 1PX - HAND DISPOSE 1PY - HAND FEED 1PZ - HAND DISPOSE 1QA - HAND FEED 1QB - HAND DISPOSE 1QC - HAND FEED 1QD - HAND DISPOSE 1QE - HAND FEED 1QF - HAND DISPOSE 1QG - HAND FEED 1QH - HAND DISPOSE 1QI - HAND FEED 1QJ - HAND DISPOSE 1QK - HAND FEED 1QL - HAND DISPOSE 1QM - HAND FEED 1QN - HAND DISPOSE 1QO - HAND FEED 1QP - HAND DISPOSE 1QQ - HAND FEED 1QR - HAND DISPOSE 1QS - HAND FEED 1QT - HAND DISPOSE 1QU - HAND FEED 1QV - HAND DISPOSE 1QW - HAND FEED 1QX - HAND DISPOSE 1QY - HAND FEED 1QZ - HAND DISPOSE 1RA - HAND FEED 1RB - HAND DISPOSE 1RC - HAND FEED 1RD - HAND DISPOSE 1RE - HAND FEED 1RF - HAND DISPOSE 1RG - HAND FEED 1RH - HAND DISPOSE 1RI - HAND FEED 1RJ - HAND DISPOSE 1RK - HAND FEED 1RL - HAND DISPOSE 1RM - HAND FEED 1RN - HAND DISPOSE 1RO - HAND FEED 1RP - HAND DISPOSE 1RQ - HAND FEED 1RR - HAND DISPOSE 1RS - HAND FEED 1RT - HAND DISPOSE 1RU - HAND FEED 1RV - HAND DISPOSE 1RW - HAND FEED 1RX - HAND DISPOSE 1RY - HAND FEED 1RZ - HAND DISPOSE 1SA - HAND FEED 1SB - HAND DISPOSE 1SC - HAND FEED 1SD - HAND DISPOSE 1SE - HAND FEED 1SF - HAND DISPOSE 1SG - HAND FEED 1SH - HAND DISPOSE 1SI - HAND FEED 1SJ - HAND DISPOSE 1SK - HAND FEED 1SL - HAND DISPOSE 1SM - HAND FEED 1SN - HAND DISPOSE 1SO - HAND FEED 1SP - HAND DISPOSE 1SQ - HAND FEED 1SR - HAND DISPOSE 1SS - HAND FEED 1ST - HAND DISPOSE 1SU - HAND FEED 1SV - HAND DISPOSE 1SW - HAND FEED 1SX - HAND DISPOSE 1SY - HAND FEED 1SZ - HAND DISPOSE 1TA - HAND FEED 1TB - HAND DISPOSE 1TC - HAND FEED 1TD - HAND DISPOSE 1TE - HAND FEED 1TF - HAND DISPOSE 1TG - HAND FEED 1TH - HAND DISPOSE 1TI - HAND FEED 1TJ - HAND DISPOSE 1TK - HAND FEED 1TL - HAND DISPOSE 1TM - HAND FEED 1TN - HAND DISPOSE 1TO - HAND FEED 1TP - HAND DISPOSE 1TQ - HAND FEED 1TR - HAND DISPOSE 1TS - HAND FEED 1TT - HAND DISPOSE 1TU - HAND FEED 1TV - HAND DISPOSE 1TW - HAND FEED 1TX - HAND DISPOSE 1TY - HAND FEED 1TZ - HAND DISPOSE 1UA - HAND FEED 1UB - HAND DISPOSE 1UC - HAND FEED 1UD - HAND DISPOSE 1UE - HAND FEED 1UF - HAND DISPOSE 1UG - HAND FEED 1UH - HAND DISPOSE 1UI - HAND FEED 1UJ - HAND DISPOSE 1UK - HAND FEED 1UL - HAND DISPOSE 1UM - HAND FEED 1UN - HAND DISPOSE 1UO - HAND FEED 1UP - HAND DISPOSE 1UQ - HAND FEED 1UR - HAND DISPOSE 1US - HAND FEED 1UT - HAND DISPOSE 1UU - HAND FEED 1UV - HAND DISPOSE 1UW - HAND FEED 1UX - HAND DISPOSE 1UY - HAND FEED 1UZ - HAND DISPOSE 1VA - HAND FEED 1VB - HAND DISPOSE 1VC - HAND FEED 1VD - HAND DISPOSE 1VE - HAND FEED 1VF - HAND DISPOSE 1VG - HAND FEED 1VH - HAND DISPOSE 1VI - HAND FEED 1VJ - HAND DISPOSE 1VK - HAND FEED 1VL - HAND DISPOSE 1VM - HAND FEED 1VN - HAND DISPOSE 1VO - HAND FEED 1VP - HAND DISPOSE 1VQ - HAND FEED 1VR - HAND DISPOSE 1VS - HAND FEED 1VT - HAND DISPOSE 1VU - HAND FEED 1VV - HAND DISPOSE 1VW - HAND FEED 1VX - HAND DISPOSE 1VY - HAND FEED 1VZ - HAND DISPOSE 1WA - HAND FEED 1WB - HAND DISPOSE 1WC - HAND FEED 1WD - HAND DISPOSE 1WE - HAND FEED 1WF - HAND DISPOSE 1WG - HAND FEED 1WH - HAND DISPOSE 1WI - HAND FEED 1WJ - HAND DISPOSE 1WK - HAND FEED 1WL - HAND DISPOSE 1WM - HAND FEED 1WN - HAND DISPOSE 1WO - HAND FEED 1WP - HAND DISPOSE 1WQ - HAND FEED 1WR - HAND DISPOSE 1WS - HAND FEED 1WT - HAND DISPOSE 1WU - HAND FEED 1WV - HAND DISPOSE 1WW - HAND FEED 1WX - HAND DISPOSE 1WY - HAND FEED 1WZ - HAND DISPOSE 1XA - HAND FEED 1XB - HAND DISPOSE 1XC - HAND FEED 1XD - HAND DISPOSE 1XE - HAND FEED 1XF - HAND DISPOSE 1XG - HAND FEED 1XH - HAND DISPOSE 1XI - HAND FEED 1XJ - HAND DISPOSE 1XK - HAND FEED 1XL - HAND DISPOSE 1XM - HAND FEED 1XN - HAND DISPOSE 1XO - HAND FEED 1XP - HAND DISPOSE 1XQ - HAND FEED 1XR - HAND DISPOSE 1XS - HAND FEED 1XT - HAND DISPOSE 1XU - HAND FEED 1XV - HAND DISPOSE 1XW - HAND FEED 1XX - HAND DISPOSE 1XY - HAND FEED 1XZ - HAND DISPOSE 1YA - HAND FEED 1YB - HAND DISPOSE 1YC - HAND FEED 1YD - HAND DISPOSE 1YE - HAND FEED 1YF - HAND DISPOSE 1YG - HAND FEED 1YH - HAND DISPOSE 1YI - HAND FEED 1YJ - HAND DISPOSE 1YK - HAND FEED 1YL - HAND DISPOSE 1YM - HAND FEED 1YN - HAND DISPOSE 1YO - HAND FEED 1YP - HAND DISPOSE 1YQ - HAND FEED 1YR - HAND DISPOSE 1YS - HAND FEED 1YT - HAND DISPOSE 1YU - HAND FEED 1YV - HAND DISPOSE 1YW - HAND FEED 1YX - HAND DISPOSE 1YY - HAND FEED 1YZ - HAND DISPOSE 1ZA - HAND FEED 1ZB - HAND DISPOSE 1ZC - HAND FEED 1ZD - HAND DISPOSE 1ZE - HAND FEED 1ZF - HAND DISPOSE 1ZG - HAND FEED 1ZH - HAND DISPOSE 1ZI - HAND FEED 1ZJ - HAND DISPOSE 1ZK - HAND FEED 1ZL - HAND DISPOSE 1ZM - HAND FEED 1ZN - HAND DISPOSE 1ZO - HAND FEED 1ZP - HAND DISPOSE 1ZQ - HAND FEED 1ZR - HAND DISPOSE 1ZS - HAND FEED 1ZT - HAND DISPOSE 1ZU - HAND FEED 1ZV - HAND DISPOSE 1ZW - HAND FEED 1ZX - HAND DISPOSE 1ZY - HAND FEED 1ZZ - HAND DISPOSE

TOOL AND LABOR ROUTING										SHEET 1 OF 4		SUPERSEDES		EFFECTIVE		PART NO.						
PART NAME POWER SUPPLY DISTRIBUTION										7		67										
CUSTOMER		ESTIMATE NO.		TOOL RELEASE		DRAWING NO.		PREL. NO.		MODEL		VOLUME		PCS/MOD.		PREP. BY		BLANK SIZE		COL. STRIP SHEET		
R 1						4425				22-1051A1		25,000										
OPER. NO.		DEPT. & GROUP		OPERATION DESCRIPTION		REGISTER NO. OR REVIEW DATE		PRODUCTION STD. P.P.B.		HOURS PER 100 PCS.		MACHINE NAME AND NUMBER		TOOL NUMBER		EQUIPMENT		TOOLS		1		
	10			PURCHASE, SEAL AND ISSUE T 100 PARTS INCLUDING TERMINAL SIL. TERMINAL STRIP, CIRCUIT BALANCE, FILLING & LAMP TERMINALS AND FITTING KIT IN BATCHES OF 55 ON WARE DAYS 20 10 CIRCLE 5 SET CIRCLE 7 1 MATERIAL HANDLING		150	607															
	20			ASSEMBLE TERMINAL STRIP AND CIRCUIT BOARD ON CIRCUIT BOARD 3. CIRCLE 7 SET, EACH UNIT 1 "B" ASSEMBLY		100	1000															
	30			ASSEMBLE TERMINAL CHUTE & HINDS TERMINALS (P/M DESIGN) AND ONE (1) CHUTE & HINDS CABLE FITTING INTO KIT 4. CYCLE TIME, EACH UNIT 1 "B" ASSEMBLY		75	1334															
	40			TERMINAL ASSEMBLY CHECK AND SEND TO SHIPPING 20 CYCLE TIME, EACH UNIT 1 "D" ASSEMBLY		125	800															

APPROVED BY (INITIALS & DATE)			REMARKS			SUB. ASSEMBLY NO.			DEPT. AND GROUP			HOURS/100			HOURS PER 100			TOTAL		
PRODUCTION ENGINEER	INDUSTRIAL ENGINEER	MANUFACTURING																		

STANDARD PRESS TERMS & ABBREVIATIONS										SYMBOLS												
TF - LONG FEED	TD - LONG DISPOSE	WD - WARD FEED	WD - WARD DISPOSE	DT - DUAL HAND TRIP	DT - DUAL FOOT TRIP	AF - AIR FUEL TRIP	BA - BANGOR GUNBO	BN - BORN HIND	AE - AIR EJECT	DE - DISCLED EJECT	CE - COL. FEED	EST - ESTIMATE	TD - TOOL DESIGN ONLY	DP - RELEASE FOR PRODUCTION	CH - CHANGE NOTICE	DCR - DRAWING CHANGE REQUEST	CH - CHANGE	AL - ALTERNATE METHOD	BL - BELIEVED	DR - DRILLER	BL - BOTTLE NECK	CH - CHANGED

PART NUMBER		REFERENCE		SEQUENCE	

TOOL AND LABOR ROUTING										SHEET 4 OF 4		SUPERSEDES		EFFECTIVE 7/6/78		PART NO.							
CUSTOMER: SCLM										ESTIMATE NO.		TOOL RELEASE		DRAWING NO. 4425		PREL. NO.							
MODEL: HELICOPAN										YEAR: 1978		MONTH		PCS / MOD.		PREP. BY							
VOLUME: 25,000										BLANK SIZE		CON. BY: BSH		MATERIAL									
OPERATION DESCRIPTION										REGISTER NO. OR REVIEW DATE		PRODUCTION STD. P.P.H.		HOURS PER 100 PCS.		MACHINE NAME AND NUMBER TOOLS AND GAUGES							
										PRODUCTIVE		AVERAGE		TOOL NUMBER		EQUIPMENT							
										QTY.		HOURS PER 100		EST. COST		TOOLS							
										1		2		3		4							
90 PURCHASE STEEL AND 1506 FIBER OPTICS WIRE STEEL, FULCRUM CABLE TERMINALS, AND 55 PIN CONNECTORS												150		667		700657 RANGE RACON FOR FIVE (5) DAYS W/CR 5'X 8' X 3'		2 \$900.00					
6 CABLE AND 1506 RITS UNIT																1 \$20.00							
1 MATERIAL HANDLING																1 \$20.00							
100 CUT TO LENGTH 1000 IN. IN 5'X 8' X 3'												150		667		CUTTING FIXTURE		1 \$500.00					
6 CYCLE TIME, FOR EACH UNIT																							
1 "B" ASSEMBLY																							
110 REMOVE OVER JACKET TO 1 IN. W/ICE, WITH EARS, SEPARATE POWER CONDUCTORS FROM FULCRUM CABLES, POLISH END OF FULCRUM, INSTALL FULCRUM TERMINALS (4) WITH ENDS, AND WELD EXPOSED FULCRUM 360 CYCLE FOR ONE CABLE												8.0		12,500		4' X 8'		1 \$300.00					
1 "A" ASSEMBLY																							
120 STRIP ENDS OF POWER CABLES WITH ENDS, TIN AND ATTACH TO 25 PIN CONNECTOR												25		4,000									
120 CYCLE FOR ONE CABLE																							
1 "A" ASSEMBLY																							
130 ATTACH MOTOR POWER CABLES (3) AND MOTOR CABLES TO 25 PIN CONNECTOR												50		2,000		FIXTURES		1 \$100.00					
60 CYCLE FOR ONE ASSEMBLY																							
1 "B" ASSEMBLY																							

APPROVED BY INITIALS & DATE				REMARKS		SUB. ASSEMBLY NO.		DEPT. AND GROUP		HOURS / 100		HOURS PER 100		TOTAL	
RELEASE FOR	PRODUCTION ENGINEER	INDUSTRIAL ENGINEER	MANUFACTURING			CHG	ASSEMBLY NO.	DEPT. AND GROUP	HOURS / 100	HOURS PER 100	SUB TOTAL	PER 100	TOTAL		

STANDARD PRESS TERMS & ABBREVIATIONS										SYMBOLS									
TP - TONG PRESS TD - TONG DISPOSE MP - HAND FEED MD - HAND DISPOSE DRY - HAND FEED DTF - SILENT FEED					AP - AIR FLOW TEMP BA - BARBER CHAIR W - WIND WARD AB - AIR BLECT BA - EXHAUST SILENT CE - COOL THER					EST - ESTIMATE TBO - TONG DESIGN ONLY DFP - DELIVER FOR PRODUCTION CA - CHANGE NOTICE DCR - DRAWING CHANGE REQUEST CC - CHANGE					A - ALTERNATE METHOD B - BELIEVED C - NON-BELIEVED D - BOTTLE NECK E - CHANGED				

PART NUMBER		REFERENCE		SEQUENCE	

CONTROL & SIGNAL EQUIPMENT										TOOL AND LABOR ROUTING										SHEET 1 OF 3				EFFECTIVE 7/1/77				PART NO.				7/6/77			
CUSTOMER		ESTIMATE NO.		TOOL RELEASE		DRAWING NO.		PREL. NO.		LAST		MODEL		VOLUME		PCS / MOD.		PREP. ST.		BLANK SIZE		COL. STAMP-SHEET		1 MATERIAL		2 SPEC.		3 GAUGE		4 WGT./PC.		5 WGT./BM.			
SCN1						4433				HELIOSTAY		25,000																							
OPER. NO.	DEPT. & GROUP	OPERATION DESCRIPTION										REGISTER NO. OR REVIEW DATE	PRODUCTION STD. P.P.H.	HOURS PER 100 PCS.	T A B	MACHINE NAME AND NUMBER TOOLS AND GAUGES										TOOL NUMBER	EQUIPMENT	EST. COST	QTY.	TOOLS	HOURS	EST. COST			
10		PURCHASE, STORE AND ISSUE COMPONENTS, CONNECTIONS, PRINTED WIRE BOARDS AND PLASTIC BEAMS AND COILS. ISSUE IN BATCHES OF 55 OR MORE DAYS. IN ALL 30 COMPLETE ISSUE CYCLE TIME PER UNIT. 1 MATERIAL HANDLER											60	1.607		TWO (2) STORAGE RACKS 5'X2'X1'										2		700.00							
																LARGE TOOL BINS - 5 2'X3'X1'										5		100.00							
																SMALL TOOL BINS - 15 1'X1'X1'										15		150.00							
20		MANUALLY ASSEMBLE LARGE ELECTRONICS (MICRO COMPUTER, POWER SUPPLY, CONNECTION) ON TWO SIDED 4'X5" PRINTED WIRE BOARD. 30 ASSEMBLY CYCLE TIME PER UNIT. 1 "B" ASSEMBLER											75	1.334		ASSEMBLY PLANT 4'X8'										1		500.00							
30		MANUALLY LOAD TUBES WITH SMALL COMPONENTS (10) FOR USE IN AUTOMATIC INSERTION MACHINE. 25 TUBE LOAD CYCLE PER UNIT. 1 "B" ASSEMBLER											50	1.250																					
40		AUTOMATICALLY INSERT SMALL COMPONENTS. 25 INSERTION CYCLE PER UNIT. 1 "B" ASSEMBLER											150	667		UNIVERSAL INSTRUMENTS CORP. INTEGRAL MACHINE, SEC-11 AUTOMATIC INSTALLATION 20 FIXTURES										1		15,000.00							
																												2,250							
																												800.00							

APPROVED BY INITIALS & DATE				REMARKS				SUB. ASSEMBLY NO.				DEPT. AND GROUP				HOURS / 100				HOURS PER 100				TOTAL			
RELEASE FOR	PRODUCTION ENGINEER	INDUSTRIAL ENGINEER	MANUFACTURING																								

STANDARD PRESS TERMS & ABBREVIATIONS										SYMBOLS									
TP - TONG FEED	SP - AM POKY TAP	EST - ESTIMATE								0 - ALTERNATE METHOD									
TD - TONG DISPOSE	SA - SHARP 1 GAUGE	TPO - TOOL DESIGN ONLY								1 - BELIEVED									
DF - HAND FEED	SD - SHARP 2 GAUGE	DP - RELEASE FOR PRODUCTION								2 - NOT BELIEVED									
DB - HAND DISPOSE	SE - AM 1 JET	CA - CHANGE NOTICE								3 - BOTTLE NECK									
DR - HAND FEED TAP	SC - CHANGE REQUEST	CC - CHANGE								4 - CHANGE									
DT - DIE FOOT TAP	CF - CON. FILE																		

STAFF INDUSTRIAL ENGR.	LABOR CONTROL	PROOF READER	PART NUMBER	REFERENCE	SEQUENCE

15505 10-1-79

C39

250,000 ANNUAL VOLUME

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TOOL AND LABOR ROUTING										SHEET 2 OF 4		PART NO.		MATERIAL		8/28/79 ISSUE 1		
REFL SURFACE										ESTIMATE NO.		TOOL RELEASE		DRAWING NO.		PIRL NO.		
SERIAL										4411		—		HELIOSTAT		VOLUME		
OPERATION DESCRIPTION										REGISTER NO.		PRODUCTION		HOURS PER		MACHINE NAME AND NUMBER		
										DATE		STD. P.P.H.		100 PCS.		TOOLS AND GAUGES		
										DATE		AVERAGE						
20	SUB-ASSEMBLY SUB ASSEMBLY (52) CATHALUTS TEST RINGS (26) PER CYCLE 79 HACH CYCLE TIME 1 HACH OPERATORS										LO		450		INTEGRATED ASSEMBLY STATIONS CAPITAL SPEC. TOOLING		2,500,000 50,000	
21	DESIGNER ELEMENTS STRIKING SUB ASSEMBLY ORIGINAL ELEMENTS TO HIEROP HIEROP ASSEMBLY WITH WITH MOKELINT												170					
30	FINAL DESX ASSEMBLY HIEROP MODULE COMPLETE HACH CYCLE TIME HACH OPERATOR (PRODUCING 6 REFL SURF. UNITS/CYCLE) LINE RATE 1100 PC/H (15) OPERATORS PER LINE												1,500		HIEROP MODULE ASSEMBLY HACH COMPLETE INSTALLATION HACH CAPITAL COST SPEC. TOOLING TURBOCHARGER TOOLING NON DURABLE TOOLING		1,229,650 818,820 5,458,800 1,838,150 1,286,705 551,445	
31	RELIEF - 6 OPERATIONS REQUIRED (4) FOR ASSY LINE PERSONAL PLUS TAKE CARE OF CURE OVEN RUNOUT AT LUNCH (2 1/2 H) NOTE: BUILT SHIFTS SO END OF SHIFT RUNOUT AT END OF NIGHT SHIFT ONLY												363		MACHINE CONSISTS OF THE FOLLOWING HIEROP ELEMENTS			
32	(2) FOR SUPPLY TRUCKERS (6 TRUCKERS AT LINE) OPER. #11-16 & 21 @ 24.2% (1 FULL SHIFT @ 1500 R.S. & 1/2 SHIFT @ 8 OPER. REQ.) LINE BALANCE OPER #30 & REL. OPER. (IND. V. BAL. OF 1/2 OPER. ON HALF SHIFT)												121		POWER & FEED CONVEYOR 161 FOOT LONG BY 10 FOOT WIDE CAPITAL 6 DRIVE SECTIONS CAPITAL		145,000 30,000	30,000
REMARKS										H1 - HIGH CAPITAL BURDEN L0 - LOW CAPITAL BURDEN		675,000						
REF. SURFACES REQD: 1042 STKS/DAY X 12 R.S./STK = 12,504 R.S./DAY																		
NOTE: APPL PRODUCTION TO COVER FOR DOWNTIME RECOVERY IS ATTAINABLE BY RELIEVING DURING LUNCH PERIODS, O.T. WORK, ETC.																		
STANDARD OPERATING PROCEDURE																		
SYMBOLS																		
PART NUMBER 24																		
REMARKS																		
SEQUENCE																		

250,000 ANNUAL VOLUME

TOOL AND LABOR ROUTING

3-4

8/28/79
15000

[illegible]

1550 & 11 - 2-79.

TOOL AND LABOR ROUTING										SHEET 1 OF 3		SUPERSEDES		EFFECTIVE		PART NO.	
CUSTOMER: 5ER1										ESTIMATE NO. 4412		DRAWING NO.		PART NO.		LAST	
OPERATION DESCRIPTION										REGISTER NO. OR REVIEW DATE		PRODUCTION STD. P.P.H.		HOURS PER 100 PCS.		MACHINE NAME AND NUMBER	
OPER. NO. DEPT. & GROUP										PRODUCTIVE		AVERAGE		T A B		TOOLS AND GAUGES	
10 PURCH. ROLL FORMED SECTIONS, DRUGS & GUNNETS GALVANIZED & ALL HOLES PUNCHED														—		VANDER: VAN HUFFEL	
15 LOAD DIAGONAL BEAM R.H. MANUALLY L.H. (OPERATOR) AND TRIM ENDS												FO		1,250			
27 SEC. HIGH CYCLE TIME 1 & 2 OPER. PER HIGH												FO		1,250			
NOTE: LABOR BALANCED TO 38 SEC. CYCLE OF OPER #40 (SHT #3) (BOTTLENECK - WELD & DRILL)																	
																INSTALLATION	
																5 STA. D.C. DIE LINES	
																CONCRETE 2%	
																HIGH CAPITAL COST	
																SPECIAL TOOLING	
																DURABLE TOOLING	
																NON-DURABLE TOOLING	
																MACHINING CONSIST OF THE FOLLOWING MAJOR ELEMENTS:	
																5 STA WALKING BEAM	
																TRANSFER MECHANISM	
																VERTICAL PRESSURE & TRIM DIES	
																HYDRAULIC BRAKE	
																BENDING DIES	

155051 - 1-2-77

[illegible]

TOOL AND LABOR ROUTING										SHEET 3 OF 3		SUPERSEDES		EFFECTIVE		PART NO.															
CUSTOMER: HIRZOR SUPPT STREET										ESTIMATE NO. 4412		DRAWING NO. 4412		PREL. NO. —		LAST CHG.		MODEL HELIOSTAT		RT. 1250K		VOLUME 250K		PCS / MOD. 2		PREP. BY		BLANK SIZE		COL. BYR - BARRY	
OPER. NO.		DEPT. & GROUP		OPERATION DESCRIPTION		REGISTER NO. OR REVIEW DATE		PRODUCTION STD. P.P.H.		HOURS PER 100 PCS.		Y A B		MACHINE NAME AND NUMBER		TOOLS AND GAUGES		EQUIPMENT		TOOLS		1		2		3		4		5	
1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16	
36				MAN. LOAD OUTWARD BEAM, DOUBLES & GUSSETS ON TO RESISTANCE WELD MACH. 3 OPER. HOURS TOTAL				(DOUBLES) 80		1.250																					
40				RESISTANCE WELD SUPPORT STRUCTURE COMPLETE & DRILL (8) Htg HOLES (AUTOM.) 38 SEC MACH CYC. TIME 5 OPER PER MACH.				HI		—																					
37				MANUALLY ARC WELD (2) GUSSETS USING SEMI-AUTOMATIC "SQUIRT GUN" — AUTOMATIC TURN-OVER DEVICE INDEXES PART 180°						80	1.250																				
45				TRUCKING — MATERIAL HANDLING							2.000																				
46				REPAIR — 5%							2.000																				
47				INSPECTION — FLOOR INSPECTOR							1.000																				
50				AUTO UNLOAD WITH O'HEAD TRAILER CRANE TO REM. PANEL ASSEMBLY AREA				LO		—																					
APPROVED BY: INITIALS & DATE				REMARKS: HI - HIGH CAPITAL BURDEN LO - LOW CAPITAL BURDEN				CHG. SUB. ASSEMBLY NO. DEPT. AND GROUP				HOURS / 100				HOURS PER 100				TOTAL											
PRODUCTION ENGINEER				INDUSTRIAL ENGINEER				MANUFACTURING				15.200																			
STAFF INDUSTRIAL ENGR.				LABOR CONTROL				PROOF READER																							

Hi Volume
TOOL AND LABOR ROUTING

C51

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ENTRY	DESCRIPTION	AMOUNT	PART NO.
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C52

[illegible]

Hi Volume TOOL AND LABOR ROUTING

CM H S SS P				PART NAME	SHEET				SUPERSEDES				EFFECTIVE				PART NO.			
CUSTOMER				ESTIMATE NO.	TOOL RELEASE	DRAWING NO.	PART NO.	LAST ENG	MODEL	AT	VOLUME	PCS / MOD.	PREP. BY	BLANK SIDE	COL. BY	CHART	1 MATERIAL			
5821				4421					HELIOSTAT		280 K						2 SPEC.			
																	3 GAUGE			
																	4 WGT./PC.			
																	5 WGT./BM.			
OPER NO	DEPT & GROUP	OPERATION DESCRIPTION	REGISTER NO. OR REVIEW DATE	PRODUCTION STD. P.P.H.	PRODUCTIVE	AVERAGE	HOURS PER 100 PCS.	T A S	MACHINE NAME AND NUMBER	TOOLS AND GAUGES	90	7269	EQUIPMENT	ST	EST. COST	QTY.	HOURS PER 100	EST. COST	1	
65		TRANSPORT					200		GONDOLA (FROM OP10)						17,400					
60		WELD TOP PLATE TO DOWNER	LO			40	2,500		EXPERT WELD SPEC. MACH		3	25	2	140,000					(INSTALLATION)	
		25 SEC. HATCH CYCLE TIME							HATCH CAPITAL COST				2	116,000						
		1 OPER./HATCH							TOOLING: SPECIAL				2	16,000						
									DURABLE				2	6,000						
									NON DURABLE				2	2,000						
65		TRANSPORT					200		GONDOLA (FROM OP10)					17,400					(INSTALLATION)	
70		WELD TOP PLATE TO TUBE	LO			40	2,500		EXPERT WELD SPEC. MACH		3	30	2	140,000						
		65 SEC. HATCH CYCLE TIME							HATCH CAPITAL COST				2	116,000						
		1 OPER./HATCH							TOOLING: SPECIAL				2	16,000						
									DURABLE				2	6,000						
									NON DURABLE				2	2,000						
75		TRANSPORT					200							42,750					(INSTALLATION)	
80		BORE & ENAM. PILOT HOLES	H1			80	1,250		LANG. 4 STA. DIAL MACH		5	30	1	529,000						
		DRILL & ENAM. MTO. HOLES							HATCH CAPITAL COST				1	285,000						
		35 SEC. CYCLE							TOOLING: SPECIAL				1	165,000						
		1 OPER./MACH.							DURABLE				1	55,000						
									NON DURABLE				1	15,000						
85		TRANSPORT					400		CONVEYOR TRIM											
90		PART WASH					1,000		WASH BOOTH				1	5,000						
100		HEAT TREAT - TUBE TRIPS					-		PURCHASE - VENDOR											
105		TRANSPORT TO RE-DRIVER ASSY					400		GONDOLA (FROM OP10)											
		SCRAP LOSS: OPER #10, 30, 50 @ 5%					1,189													
		OPER #10, 70 @ 3%					162													
		MACH. DOWNTIME ALLOW @ 5%					2,124													
109		INSPECTION - FLOOR INSPECTOR					300													

APPROVED BY INITIALS & DATE

PRODUCTION ENGINEER

INDUSTRIAL ENGINEER

MANUFACTURING

REMARKS

H1 CAPITAL BURDEN

STANDARD PRESS TERMS & ABBREVIATIONS

SYMBOLS

PART NUMBER

REFERENCE

SEQUENCE

TOOL AND LABOR ROUTING										SHEET 1 OF 2		PART NO.		7-27-79 155063 B-779 155064															
CUSTOMER: HOUSING - AZIMUTH DR.										ESTIMATE NO. 4421		PART NO. 072		MODEL HELIOSTAT		VOLUME 250,000		PCB / MOD.		PREP. BY		BLANK SIZE		COL. STAMP SHEET					
OPERATION DESCRIPTION										REGISTER NO. OR REVIEW DATE		PRODUCTION STD. P.P.H.		HOURS PER 100 PCS.		MACHINE NAME AND NUMBER		TOOLS AND GAUGES		EST. COST		QTY.		HOURS PER 100		TOTAL			
13																													
10																													
11																													
20																													
21																													
22																													
30																													
31																													
32																													
14																													
15																													
16																													
24																													
25																													
26																													
34																													
35																													
36																													
APPROVED BY (INITIALS & DATE)										REMARKS: H1 - HIGH CAPITAL BURDEN L0 - LOW CAPITAL BURDEN										SHEET 1 OF 2									
STAFF INDUSTRIAL ENGR.										LABOR CONTROL										PROOF READER									
A3 DR H56 250K - IN LINE TRANSFER PROCESS										STANDARD PRESS TERMS & ABBREVIATIONS										SYMBOLS									
W - LONG FEED										M1 - AIR FOOT IMP										B1 - ESTIMATE									
T0 - LONG RESPONSE										B4 - GAMES CHANG										T00 - TOOL DESIGN ONLY									
H0 - HAND FEED										B5 - HIGH HAND										BFF - RELEASE FOR PRODUCTION									
H0 - HAND RESPONSE										A0 - AIR SELECT										C0 - CHANGE NOTICE									
B0 - HAND HAND TRIP										B0 - EXCESS TACT										B00 - CHANGE CHANGE REQUEST									
BFF - ELECT FOOT IMP										C0 - CORR. FEED										C0 - CHANGE									
PART NUMBER										REFERENCE										SEQUENCE									

TOOL AND LABOR ROUTING

ISSUE 1, 1-79

C58

1550CE11 -1-79

C59

TOOL AND LABOR ROUTING										SHEET 2 OF 3		DATE 2-1-79					
PART NAME: BEARING RETAINER										DRAWING NO. 4421		MATERIAL					
ESTIMATE NO. 1										TOOL RELEASE		SPEC.					
OPER. NO. 50										DEPT. & GROUP		GAUGE					
OPERATION DESCRIPTION										REGISTER NO. OR REVIEW DATE		VGT./PC.					
MACHINE NAME AND NUMBER										TOOL COST		VGT./DM.					
TOOLS AND GAUGES										EQUIPMENT		TOOLS					
HOURS PER 100 PCS.										EST. COST		EST. COST					
50	EXPAND RING TO FINAL SIZE & ROUND. 1 MEN/MACH. MACH CYCLE - 30 SEC									90	11/12	1	5	14,625	1	162,625	
55	TRANSPORT									200							
60	GRIND BOTH SIDES PARALLEL & FLAT 2 PARTS / CYCLE 4 PARTS / LOAD MACH CYCLE - 55 SEC / PT 1 OPER / MACH									50	2,000	2	50	24,300	2	24,300	
65	TRANSPORT									200							
REMARKS: H1 ECONOMICAL BURDEN										SUB. ASSEMBLY NO.		DEPT. AND GROUP		REVISIONS		REVISIONS	
APPROVED BY INITIALS & DATE										ESTIMATE		TOOL DESIGN ONLY		TOOL DESIGN ONLY		TOOL DESIGN ONLY	
STANDARD PHASES, TERMS & ABBREVIATIONS										SYMBOLS		PART NUMBER		REFERENCE		SEQUENCE	

1	MATERIAL	
2	SPEC.	
3	GAUGE	
4	WGT./PC.	
5	WGT./DM.	

SHIRT	SUPERSIZED	EFFECTIVE
3 of 3		

3.3

PREP. BY	PLAN SIZE
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८८१८:५११११-५११११

PART NAME			
BEARING RETAINER			
ESTIMATE NO.		TOOL RELEASE	DRAWING NO.
4421			

5EPI

IT IS ALWAYS NO

TYPE CLASS

DRAWING NO.

721 000 000

WE MODEL

24.8	
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VOLUME

0584

[illegible]

TABLE 1

02-20-05

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466
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OPER. NO.	DEPT. & GROUP	OPERATION DESCRIPTION	%I	REGISTER NO. OR REVIEW DATE	PRODUCTION STD. P.P.H.	HOURS PER 100 PCS.	T A G	MACHINE NAME AND NUMBER TOOLS AND GAUGES	TL COST SEAP / HR	EQUIPMENT	QTY.	EST. COST	TOOLS HOURS EST. COST
				PRODUCTIVE	AVERAGE								
70		TURN I.D. - CONTOUR & (2) O'RING GROOVES 1 OPER / MACH. MACH. CYCLE 8 1/2 SEC / PC			12.5	8000		INSTALLATION ROLLARD TURNING VORT. TURRET LATHE SPECIAL TOOLING DURABLE TOOLING PERISHABLE TOOLING	3 1/2	90	6	387,000 2,589,000 48,000 36,000 18,000	
75		TRANSPORT				250		PALLETS FOR TRANS TO DIAL.					
80		DRILL (IG) .40 DIA HOLES 1 OPER / MACH. MACH CYCLE 35 SEC. (20 SECS. TO DRILL THRU)			80	1250		INSTALLATION LAMB 4 STA DIAL MACH CAPITAL COST TOOLING SPECIAL DURABLE UNDURABLE	1 1/2	30	1	78,000 520,000 285,000 165,000 62,000 8,000	
85		TRANSFER				250		WOOD PALLET			135	13,300	
87		REWORK-5%				5605							
90		GALVANIZE				1600		USE EXISTING EQUIP					
100		TO FINAL ASSY				500		WOOD PALLETS. (SEE OP 65)					
		SCRAP LOSS: OPER #20, 40, 50, 80 @ 1%				172							
		OPER #60 @ 1%				040							
		OPER #70 @ 3%				240							
		MACH. DOWNTIME ALICE @ 5%				1356							
110		INSPECTION - FLOOR INSPECTOR				400							

CASE NO.	APPROVED BY INITIALS	RATE
	PRODUCTION ENGINEER	INDUSTRIAL ENGINEER
		MANUFACTURING
	STAFF INDUSTRIAL ENGR.	LABOR CONTROL
		PROOF READER

REMARKS			
HI LO CAPITAL BURDEN			
STANDARD PHISYSYMS & ABBREVIATIONS			
ST - STONE SIZE TB - TONE TUNING NF - NINE FIVE MB - MINE MINE OT - ONE TON TON	MT - MINE TON TON BN - BONE BONE IN - INCH INCH AS - ASH ASH IS - IRON IRON	EST - ESTIMATE TUN - TON TON ONLY BRP - BRIDGE FOR PRODUCTION CO - COAST COAST CCR - COAST COAST REQUEST	A - ALLEGATE WITHIN B - BELIEVE C - NOW BELIEVE F - NOTED WISE

[illegible]

TOOL AND LABOR ROUTING

C62

AZIMUTH HSG. / DIST. 2 LINK *Submarine*

SHORT	SUPERSEDES	EFFECTIVE
1 of 3		8/24/77

TABLE 5

1	MATERIAL
2	SPEC.
3	GAUGE
4	WGT./PC.
5	WGT./#IM.

SERI

ESTIMATE NO.	100 RELEASE	DRAWING NO.	PAGE NO.
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SAFETY MODEL

HELIOSTAT

1	2
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VO

TPC5

PAGE 2

PLAN

5128

728

SYNOPSIS:

KEY

WGT

EC

Abstract

7

[illegible][illegible]

SHEET	SUPPLIES	EFFECTIVE
1 of 5		

C66

Volume TOOL AND LABOR ROUTING

PART NAME: AZIMUTH DRIVE HOUSING - WELD										SHEET 2 of 5		SUPERSEDES		EFFECTIVE		PART NO.							
ESTIMATE NO.		TOOL RELEASE		DRAWING NO.		PREC. NO.		LUT MODEL		VOLUME		PCS. MOD.		PREP. BY		BLANK SIZE							
SERI				1022493				HGI0STAT		250,000		1											
OPCR. NO.	DEPT. & GROUP	OPERATION DESCRIPTION				REGISTER NO. OR REVISION DATE	PRODUCTION STD. P.P.H.	PRODUCTIVE	AVERAGE	HOURS PER 100 PCS.	T A D	MACHINE NAME AND NUMBER TOOLS AND GAUGES				70	TL. COST	EQUIPMENT		TOOLS		1	
																SCRT	/HR.	EST. COST	HOURS	EST. COST			
25		PURCHASE MATERIAL																					
30		WELD TOP PLATE SUB ASS'Y. TO MAIN TUBE 102 SEC MACH CYCLE .5 OPER / MACHINE				H1	25	4,000				EXPERT WELDER SPECIAL WELDING MACH.				2	92	3	300,000.00				
												CAPITAL COST				3	224,000						
												SPECIAL TOOLING				3	59,000						
												DURABLE TOOLING				3	18,000						
												NON DUREABLE TOOLING				3	2,000						
												INSTALLATION					33,600						
35		PURCHASE MATERIAL																					
40		WELD FLANGE TO LARGE TUBE 87 SEC. MACH. CYCLE 1 OPER / 2 MACH.				H1	30	3,334				EXPERT WELDER SPECIAL WELDING MACH				2	140	3	345,000.00				
												CAPITAL COST				3	258,000						
												SPECIAL TOOLING				3	54,000						
												DURABLE TOOLING				3	22,000						
												NON DUREABLE TOOLING				3	11,000						
												INSTALLATION					38,700						

APPROVED BY INITIALS & DATE			REMARKS	SUB. ASSEMBLY NO.		DEPT. AND GROUP	HOURS / 100		HOURS		PER. TO
PRODUCTION ENGINEER	INDUSTRIAL ENGINEER	MANUFACTURER		EST.	TOTAL		EST.	TOTAL			
			H1 CAPITAL BUDGET								

STANDARD MESS. TERMS & ABBREVIATIONS				SYMBOLS			
1P - TONS PER	2P - TONS PER	3P - TONS PER	4P - TONS PER	5P - TONS PER	6P - TONS PER	7P - TONS PER	8P - TONS PER
10 - TONS PER	11 - TONS PER	12 - TONS PER	13 - TONS PER	14 - TONS PER	15 - TONS PER	16 - TONS PER	17 - TONS PER
18 - TONS PER	19 - TONS PER	20 - TONS PER	21 - TONS PER	22 - TONS PER	23 - TONS PER	24 - TONS PER	25 - TONS PER
26 - TONS PER	27 - TONS PER	28 - TONS PER	29 - TONS PER	30 - TONS PER	31 - TONS PER	32 - TONS PER	33 - TONS PER
34 - TONS PER	35 - TONS PER	36 - TONS PER	37 - TONS PER	38 - TONS PER	39 - TONS PER	40 - TONS PER	41 - TONS PER
42 - TONS PER	43 - TONS PER	44 - TONS PER	45 - TONS PER	46 - TONS PER	47 - TONS PER	48 - TONS PER	49 - TONS PER
50 - TONS PER	51 - TONS PER	52 - TONS PER	53 - TONS PER	54 - TONS PER	55 - TONS PER	56 - TONS PER	57 - TONS PER
58 - TONS PER	59 - TONS PER	60 - TONS PER	61 - TONS PER	62 - TONS PER	63 - TONS PER	64 - TONS PER	65 - TONS PER
66 - TONS PER	67 - TONS PER	68 - TONS PER	69 - TONS PER	70 - TONS PER	71 - TONS PER	72 - TONS PER	73 - TONS PER
74 - TONS PER	75 - TONS PER	76 - TONS PER	77 - TONS PER	78 - TONS PER	79 - TONS PER	80 - TONS PER	81 - TONS PER
82 - TONS PER	83 - TONS PER	84 - TONS PER	85 - TONS PER	86 - TONS PER	87 - TONS PER	88 - TONS PER	89 - TONS PER
90 - TONS PER	91 - TONS PER	92 - TONS PER	93 - TONS PER	94 - TONS PER	95 - TONS PER	96 - TONS PER	97 - TONS PER
98 - TONS PER	99 - TONS PER	100 - TONS PER	101 - TONS PER	102 - TONS PER	103 - TONS PER	104 - TONS PER	105 - TONS PER

STAFF INDUSTRIAL ENGR	LABOR CONTROL	PROOF HEADER	PART NUMBER	REFERENCE	SEQUENCE

41 - Volume

C69

1550 10-2-79

SECRET	SUPERSEDES	EFFECTIVE	PARTIAL
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C71

H1 VOLUME

155031, 1-1-79

CUSTOMER				PART NAME				TOOL AND LABOR ROUTING										SHEET				SUPERSEDES				EFFECTIVE				PART NO.													
SERI				4421				Heliostat										1 of 1																									
OPER. NO.				DEPT. & GROUP				OPERATION DESCRIPTION				REGISTER NO. OR REVIEW				PRODUCTION STD. P.P.H.				HOURS PER 100 PCS.				MACHINE NAME AND NUMBER				TOOLS AND GAUGES				EST. COST				EQUIPMENT				TOOLS			
10				ASSEMBLE AZIMUTH DRIVE				H1				(80)				13.750				36 STA ASSY				TRANSFER MACH				1				2,100.00											
				36.0 SEC MACH CYCLE TIME				H1												INSTALLATION								330.00															
				1 MACHINE W/DOUBLE FINISH SECTION				H1												FLOOR FEEDERS				9				54,000.00															
				11 OPERATORS				H1												INSTALLATION								8,100															
				(USE SHUTDOWN RELIEF FOR OPER #10)				H1												BOWL FEEDERS				11				40,500.00															
				SCRAP LOSS @ 3%				H1												INSTALLATION								6,075															
				MACH. DOWNTIME ALLOW @ 10%				H1												BULK OIL FEED SYS.				1				11,000.00															
				INSPECTION - FLOOR INSPECTOR				H1												INCL. STORAGE TANK								1,650															
								H1												INSTALLATION								65,000.00															
								H1												SHIM STORAGE & FEED				1				65,000.00															
								H1												UNIT INTEGRATED WITH																							
								H1												INTROCESS GAGE								9,750															
								H1												INSTALLATION								8,800.00															
								H1												LOADING ASSIST HOIST				1				10,000.00															
								H1												UNLOAD CRANE				2				30,000.00															
								H1												DURABLE TOOLING								50,000.00															
								H1												PERISHABLE TOOLING								12,000.00															
								H1												INSTALLATION								7,200															
								H1												SPECIAL TRANSPORT				50				50,000.00															
								H1												SKIDS FOR UNLOADING																							
								H1												INTROCESS GAGE				1				15,000.00															

APPROVED BY INITIALS & DATE				REMARKS				SUB. AMOUNT				DEPT. AND GROUP				HOURS PER 100				TOTAL			
PRODUCTION ENGINEER				INDUSTRIAL ENGINEER				MANUFACTURING															
				H1 CAPITAL BURDEN												16.238							
				REMARKS: WORKING 24/42																			

STANDARD PRE'S TERMS & ABBREVIATIONS				SYMBOL			
W - TIME FEED	W - TIME FEED	W - TIME FEED	W - TIME FEED	W - TIME FEED	W - TIME FEED	W - TIME FEED	W - TIME FEED
W - TIME FEED	W - TIME FEED	W - TIME FEED	W - TIME FEED	W - TIME FEED	W - TIME FEED	W - TIME FEED	W - TIME FEED

TOOL AND LABOR ROUTING										SHEET 1 OF 1		SUPERSEDES		EFFECTIVE		PART NO.		
CM	W	S	SS	P	PART NAME	ESTIMATE NO.	TOOL RELEASE	WORKING NO.	PRODUCTION	LAST	MODEL	AT	VOLUME	PCB/ MOD.	REF. BY	BLANK SIZE	COL. STRIP-SHEET	
					DRAG LINK-ELEV DR	4422	074				HELIOSTAT		250,000					
CUSTOMER					5ERI													
OPER. NO.	DEPT. & GROUP	OPERATION DESCRIPTION	REGISTER NO. OR REVIEW DATE	PRODUCTION STD. P.P.H.	HOURS PER 100 PCB.	MACHINE NAME AND NUMBER	TOOLS AND GAUGES	%	TECH	EQUIPMENT	EST. COST	QTY.	HOURS PER 100	EST. COST				
10		PURCH WELDMENT FULLY GALVANIZED. READY TO MACHINING				VEUDOR-												
15		TRUCKING-MATERIAL HANDLING			500													
20		PERFORM ALL MACHINING OPERATIONS COMPLETE. 36.0 MACH. CYCLE TIME 1 MACH. OPERATOR SCRAP LOSS @ 1% MACH DOWNTIME ALICE @ 5%	H1	80	1.250	LAKE G. STAPALIZED 170 TRAVELER MACH.					120,000	1	800,000					
						INSTALLATION					1	570,000						
						MACH. CAPITAL COST					1	15,000						
						SPEC. TOOLING					1	5,000						
						DURABLE TOOLING					1	12,500						
						NONDURABLE TOOLING			250		1	3,000						
13		CUSTOM FORKLIET PALETS									1	3,000						
14		NAT'L HAND-O'HEAD CRANE									1	5,000						
15		QUALIF. GAGE									1	9,200						
16		NAT'L HAND-CONVEYER									1	1,830						
						INSTALLATION												
27		PART WASH									1	3,000						
25		MASTER GAGE									1	6,000						
26		NAT'L HAND-O'HEAD CRANE									1	3,000						
						INSTALLATION						900						
27		INSPECTION - FLOOR INSPECTOR			500													
28		REWORK @ 5%			250													
APPROVED BY INITIALS & DATE					REMARKS					SUB. ASSEMBLY NO.		DEPT. AND GROUP		HOURS/100		HOURS PER 100		
					H1-HIGH CAPITAL BURDEN L0-LOW CAPITAL BURDEN (WGT. APPROX. 79 #)									2.576				
					DRAG LINK 250K-INLINE TRANSFER PROCESS													
					STANDARD PRESS TERMS & ABBREVIATIONS													
					SYMBOLS													
					PART NUMBER													
					REFERENCE													
					SEQUENCE													

B-7-79
ISSUES
7-27-79
ISSUE 2

TOOL AND LABOR ROUTING										SHEET 1 OF 1		SUPERSEDES		EFFECTIVE		PART NO.											
CM	M	S	SS	P	PART NAME	ESTIMATE NO.	TOOL RELEASE	QUANTITY	DATE	MODEL	PLT	VOLUME	PCS / MOD.	PREP. BY	BLANK SIZE	COL. BY	BRN										
CUSTOMER					5ER1			4422	.075	HELIOSTAT		250,000															
OPER. NO.	DEPT. & GROUP	OPERATION DESCRIPTION	REGISTER NO. OR REVIEW DATE	PRODUCTION STD. P.P.M.	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER	TOOLS AND GAUGES	90	7.65	EST. COST	QTY.	EST. COST	QTY.	EST. COST	QTY.	EST. COST	QTY.										
10		PURCH. 10' ELEMENT FULLY GALVANIZED, READY TO MACHINE				VAPOR-																					
20		PERFORM ALL MACHINING, OPERATIONS - COMPLETE 36.0 MACH CYCLE TIME 1 MACH / OPERATOR	H1	80	1.250	LANB BSTA PALLETIZED	TRANSFER MACH			24,750																	
						INSTALLATION				1,425,000																	
						MACH CAPITAL COST				525,000																	
						SPEC. TOOLING				42,750																	
						DURABLE TOOLING				14,250																	
						NONDURABLE TOOLING																					
25		TRUCKING - MATERIAL HANDLING			400																						
13		COST. FORK LIFT PALLETS								24,500																	
14		MAT'L HAND - Q/HO CRANE								3,000																	
15		QUALITY GAGE								12,000																	
16		MAT'L HAND - CONVEYER								11,800																	
						INSTALLATION				2,220																	
24		PART WASH								3,500																	
25		MATER GAGE & HAND GAGES								15,000																	
26		MAT'L HAND - Q/HO CRANE								3,000																	
		SCRAP LOSS OPER #2C @ 1%			0.13																						
		MACH DOWN TIME WACE @ 10%			1.25																						
29		INSPECTION - FLOOR INSPECTOR			750																						
30		REWORK @ 5%			250																						
APPROVED BY INITIALS & DATE										REMARKS																	
PRODUCTION ENGINEER					INDUSTRIAL ENGINEER					MANUFACTURING					H1 - HIGH CAPITAL BURDEN L0 - LOW CAPITAL BURDEN												
STAFF INDUSTRIAL ENGR.										LABOR CONTROL					PROOF READER					TORSION TUBE 250K - W/INE TRANSFER PROC.							
STANDARD PRESS TERMS & ABBREVIATIONS										SYMBOLS																	
TP - TONG FEED TD - TONG DISPOSE DP - HAND FEED DR - HAND DISPOSE DPT - DUAL HAND TWP DPT - DUAL FEED TWP AT - AIR FOOT TWP BK - BUNKER SCALES BS - BUSH HAND AS - AIR SACK SS - SECOND SACK CF - CUM FEED EST - ESTIMATE TDO - TOOL DESIGN ONLY MP - RELEASE FOR PRODUCTION CN - CHANGE NOTICE RCR - DRAWING CHANGE REQUEST CA - CHANGE A - ALTERNATE METHOD B - BELIEVED R - NOT BELIEVED S - DOTTED LINE C - CHANGED										PART NUMBER REFERENCE SEQUENCE																	

[illegible]

[illegible]

TOOL AND LABOR ROUTING										SHEET		SUPERSEDES		EFFECTIVE		PART NO.		1 MATERIAL			
CUSTOMER										ESTIMATE NO.		TOOL RELEASE		DRAWING NO.		PREL. NO.		2 SPEC.			
SERI																3 GAUGE					
																4 WGT./PC.					
																5 WGT./BM.					
OPERATION DESCRIPTION										REGISTER NO. OR REVIEW DATE		PRODUCTION STD. P.P.M.		HOURS PER 100 PCS.		MACHINE NAME AND NUMBER		TOOL NUMBER		EQUIPMENT	
07 TRUCKING - SUPPLY														1.250		INDEXING PALLETIZED		*			
08 SUPPLYMAN														1.250		CONVEYOR LOOSE SHIM					
10 POSITION TRACKING ACTUATOR AND PLATE IN POSITION WITH TEMPORARY PINS														1.250		DRIVE FROM LOCATION					
20 MEASURE BETWEEN ACTUATOR AND SUPPORT EARS AND SELECT PROPER SHIMS														1.250		INSTALLATION				350.000	
30 REMOVE TEMPORARY PIN INSERT PERMANENT PIN, SPACER AND SHIM														1.250		INSTALLATION				52.900	
40 INSTALL TRACKING ACTUATOR PINS & PRESS IN PLACE														1.250		PERMANENT TOOLING		21%		15.000	

APPROVED BY INITIALS & DATE				REMARKS				HOURS PER 100				TOTAL			
RELEASE FOR	PRODUCTION ENGINEER	INDUSTRIAL ENGINEER	MANUFACTURER					ASSEMBLY NO.	DEPT. AND GROUP	HOURS / 100	%	HOURS PER 100	%	TOTAL	
				H1 CAPITAL BORDEN											

STANDARD PRESS TERMS & ABBREVIATIONS										SYMBOLS									
1 - LONG FEED	2 - LONG FEED	3 - LONG FEED	4 - LONG FEED	5 - LONG FEED	6 - LONG FEED	7 - LONG FEED	8 - LONG FEED	9 - LONG FEED	10 - LONG FEED	11 - LONG FEED	12 - LONG FEED	13 - LONG FEED	14 - LONG FEED	15 - LONG FEED	16 - LONG FEED	17 - LONG FEED	18 - LONG FEED	19 - LONG FEED	20 - LONG FEED

PART NAME						TOOL AND LABOR ROUTING								SHEET		SUPERSEDES		EFFECTIVE		PART NO.		MATERIAL	
ELEVATION DRIVE Assembly														2 OF 4								SPEC.	
CUSTOMER	ESTIMATE NO.	TOOL RELEASE	DRAWINGS NO.	PANEL NO.	LAST ENG.	MODEL	VOLUME	PCS./MOD.	PREP. BY	BLANK SIZE	COR. BY	SCRAP	TOTAL COST	EQUIPMENT	TOOLS								
SERI						HELIOSTAT	250K																
OPER. NO.	DEPT. & GROUP	OPERATION DESCRIPTION	REGISTER NO. OR REVIEW DATE	PRODUCTION STD. P. M.	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER	TOOLS AND GAUGES	90 TOOL NUMBER SCRAP	Tool Cost	EQUIPMENT EST. COST	QTY.	HOURS	EST. COST										
50		POSITION DRAG LINK ON AZIMUTH AND INERTIAL TEMPORARY PINS 15 SECOND CYCLE TIME 1 OPERATOR	60		1.250	JIB CRANE OVERHEAD MONORAIL STORAGE LUCK FOR DRAG LINK J HOOK HANGERS INSTALLATION		*	1 3,000														
60		MEASURE TRACKING ACTUATOR CLEVIS GAP, CENTRE CLEVIS AND INSTALL CLEVIS PIN AND SHIMS 15 SECOND CYCLE TIME 1 OPERATOR			1.250	PERMANENT TOOLING & GAGING	<1%		1 29,000														
70		INSTALL WASHER & PIN ON ACTUATOR CLEVIS PIN 15 SECOND CYCLE TIME 1 OPERATOR			1.250	SYNTRON PART FEEDER INSTALLATION			1 10,000														
80		MEASURE AZIMUTH HSG EAR GAP & INSTALL SPACERS 25 SECOND CYCLE TIME 1 OPERATOR			1.250	SYNTRON PART FEEDER INSTALLATION			1 5,000														
90		POSITION TORQUE TUBE OVER HINGE POINTS MEASURE GAPS FOR SPACERS 30 SECOND CYCLE TIME 2 OPERATORS			1.250	INSTALLATION BRIDGE CRANE 2TON PERMANENT GAGING			1 900														
										56 SW													
APPROVED BY INITIALS & DATES										REMARKS													
CAPITAL BORDEN																							
STANDARD PRESS TERMS & ABBREVIATIONS										SYMBOLS													
TP - TOOLS FEED TD - TOOLS DISPOSE DP - HAND FEED SD - HAND DISPOSE SPT - SHAL. HAND TOP SPT - SLIC. HAND TOP ST - TOOLS FEED DE - BARBER GRIND DI - WORK STAND AD - AIR EJECT DS - MECH. SILENT CF - CON. FEED EST - ESTIMATE TPO - TOOL DESIGN ONLY DFP - DESIGN FOR PRODUCTION CD - CHANGE NOTICE DCR - DRAWING CHANGES REQUEST CC - CHANGE										* - ALTERNATE METHOD R - RELIEF R - RELIEF R - RELIEF R - RELIEF R - RELIEF													
PART NUMBER										REFERENCE													
SEQUENCE										TOTAL													

CM M S SS P				PART NAME	TOOL AND LABOR ROUTING										SHEET		SUPERSEDES		EFFECTIVE		PART NO.		1 MATERIAL	
CUSTOMER				ESTIMATE NO.	TOOL RELEASE	DRAWING NO.	PREL. NO.	LAST MODEL	PI	VOLUME	PCS / MOD.	PREP. BY	BLANK SIZE	COL. STRIP SHEET	2 SPEC.		3 GAUGE		4 WGT./PC.		5 WGT./BM.			
SERI								1/ELIOTAT		YEAR	MONTH													
OPER. NO.	DEPT. & GROUP	OPERATION DESCRIPTION	REGISTER NO. OR REVIEW DATE	PRODUCTION STD. P.P.M.	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER	TOOL NUMBER	EQUIPMENT	EST. COST	QTY.	HOURS	EST. COST												
100		SELECT POSITION AND INSTALL SPACER & PIN 15 SECOND CYCLE TIME 1 OPERATOR	20		1.250	SALVAGE PIN 1/2" DIA. AIR WRENCH INSTALLATION	16000		100															
110		INSTALL HINGE PIN CATCHER 15 SECOND CYCLE TIME 1 OPERATOR			1.250	HINGE PIN CATCHER INSTALLATION	10000		150															
120		POSITION SHIMMED ACTUATOR INSTALL TEMPORARY PINS 20 SECOND CYCLE TIME 1 OPERATOR			1.250	LIFT CRANE INSTALLATION	3000		450															
130		11" HINGE BETWEEN ACTUATOR & SUPPORT EARS & SELECT SHIM 15 SECOND CYCLE TIME 1 OPERATOR			1.250	INSTALLATION SHIMMED PINS 1/2" DIA. SPRINGING GAGING	600		4000															
140		REMOVE TEMPORARY PINS INSERT PERMANENT PIN, SPACER & PIN 35 SECOND CYCLE TIME 1 OPERATOR			1.250	INSTALLATION	16000		900															
										21000														
APPROVED BY INITIALS & DATE														REMARKS		HOURS PER 100		TOTAL						
RELEASE FOR														CAPITAL BORDEN										
STANDARD PRESS TERMS & ABBREVIATIONS														SYMBOLS		PART NUMBER		REFERENCE		SEQUENCE				
W - WORK FEED TO - TOOL OFFSET SP - SPACER SH - SHIM SW - SWAP SWT - SWAP HAND TOP ST - STICK POST TOP APT - AIR FOOT UP SE - SHIMMER SHIM SE - SHIMMER AE - AIR EJECT SE - SHIMMER EJECT CP - COLD FEED EST - ESTIMATE TPO - TOOL OFFSET ONLY WPT - WRENCH FOR PRODUCTION CO - CHANGE NOTICE DCR - DRAWING CHANGE REQUEST CA - CHANGE A - ALTERNATE METHOD B - BELIEVED C - CORRECTION D - DOTTED LINE E - CHANGE																								

PART NAME						TOOL AND LABOR ROUTING								SHEET		SUPERSEDES		EFFECTIVE		PART NO.																											
CW	M	S	B	P		ELEVATION DRIVE ASSEMBLY										4	OF	4																													
CUSTOMER						ESTIMATE NO.		TOOL RELEASE		DRAWING NO.		PREL. NO.		LAST CDR.		MODEL		VOLUME		PC'S / MOD.		PREF. BY		BLANK SIZE		COL. BY/NO. SHEET																					
SERI														HELIOSTAT		250K																															
OPER. NO.		DEPT. & GROUP		OPERATION DESCRIPTION				REGISTERED NO. OR REVIEW DATE		PRODUCTION STD. P.P.M.		HOURS PER 100 PCS.		T O		MACHINE NAME AND NUMBER TOOLS AND GAUGES				% CRAP		TOOL COST/HOUR		EQUIPMENT EST. COST QTY.		TOOLS HOURS PER HOUR EST. COST																					
150				PRESS IN PERMANENT PINS 10 SECOND CYCLE TIME 1 OPERATOR (SHARED WITH OPER. 140)				LQ				1.250				PERMANENT TOOLING				*		15,000																									
160				ALIGN STORAGE ACTUATOR CLAVIS WITH DRAG LINKS, MEASURE & INSTALL PROPER SPACER 20 SECOND CYCLE TIME 1 OPERATOR								1.250				SYNTRON PART FEEDER INSTALLATION PERMANENT GAGING						16,000 900 15,000																									
170				INSTALL AZIMUTH DRIVE CONTROLLER. INSTALL FLAT WASHER AND COVER PIN ON STORAGE ACTUATOR CLAVIS PIN 30 SECOND CYCLE TIME 1 OPERATOR								1.250				SYNTRON PART FEEDER INSTALLATION						6,000 900																									
220				RELIEF & INSTRUCTION (3 OPERS) INSTALL DRIVE MOTORS (2) & CONNECT WIRING HARNESS 30 SECOND CYCLE TIME 1 OPERATOR								3.750 1.250					AIR CURBENCH				~1%																										
185				ON-LINE INSPECT (2 OPERS)								2.500																																			
190				INSPCT - IDI SYSTEM TEST (1) TEST / SHIFT ROVING INSPECTOR								1.250					PERMANENT GAGING TEST STAND & CONSOLE INSTALLATION				~1%		35,000 13,000 1,800																								
195				REPAIR REJECTS								1.250																																			
200				UNLOAD - TO PACK - PACK IN RACK 2 OPERATORS								2.500					BRIDGE CRANE 3T						6,500																								
210				TRUCKER - RACKS & PACKS (2 OPERS)								2.500					CAPITAL COST - GRAND TOTAL						6,350																								
APPROVED BY INITIALS & DATE						REMARKS						SUB-ASSEMBLY NO.						DEPT. AND GROUP						HOURS FOR SUB-TOTAL						HOURS PER 100 SUB-TOTAL						TOTAL											
RELEASE FOR						PRODUCTION ENGINEER						INDUSTRIAL ENGINEER						MANUFACTURING						HOURS FOR SUB-TOTAL						HOURS PER 100 SUB-TOTAL						TOTAL											
STAFF INDUSTRIAL ENGR.						LABOR CONTROL						PROOF READER						STANDARD PRESS TERMS & ABBREVIATIONS						SYMBOLS						PART NUMBER						REFERENCE						SEQUENCE					
TV - TONG PRESS						AF - AM FOOT TRIP						EST - ESTIMATE						O - ALTERNATE METHOD						PART NUMBER						REFERENCE						SEQUENCE											
TD - TONG DISPOSE						DS - DASHES SHOWN						END - END OF DRAWING ONLY						D - DELIVERED						PART NUMBER						REFERENCE						SEQUENCE											
WF - HAND FED						IS - WORK IN PROGRESS						OFF - OFFERING FOR PRODUCTION						C - CHANGE NOTICE						PART NUMBER						REFERENCE						SEQUENCE											
SD - HAND DISPOSE						AE - AIR EJECT						CA - CHANGE NOTICE						R - REMOVED						PART NUMBER						REFERENCE						SEQUENCE											
DT - DWG. HAND TRIP						DC - DIE CAST						SC - STANDARD CHANGES REQUEST						DITTS - PRICE						PART NUMBER						REFERENCE						SEQUENCE											
BT - BLOC. FOOT TRIP						CF - CON. FEED						CR - CHANGE						CHANGED						PART NUMBER						REFERENCE						SEQUENCE											

155061. 1. 2-79

C82

TOOL AND LABOR ROUTING										SHEET		SUPERSEDES		EFFECTIVE		PART NO.							
MOTORS										1 OF 1				7/21/77									
CUSTOMER		ESTIMATE NO.		TOOL M/L EAM		DRAWING NO.		PART NO.		LAST MODEL		VOLUME		PCS/MOD.		PREP. BY		BLANK SIZE		COL. STAMP		SHEET	
SERI		4423								HELIOSTAT		250,000											
OPER. NO.		DEPT. & GROUP		OPERATION DESCRIPTION		REGISTER NO. OR REVIEW DATE		PRODUCTION STD. P.P.M.		HOURS PER 100 PCS.		T A B		MACHINE NAME AND NUMBER		TOOL NUMBER		EQUIPMENT		TOOLS			
10				PURCHASE, STORE AND						10		10,000											
				ISSUE 5% OF THE																			
				MOTORS FOR FACTORY																			
				SADDLE TEST KIT AND ISSUE																			
				BALANCE OF THE MOTORS,																			
				AND ALL NUTS, BOLTS,																			
				WASHERS TO FIELD ASSEMBLY																			
				300 PER MOTOR SET OF THREE																			
				10 MATERIAL HANDLERS																			
15				ASSEMBLE AND TEST 5% OF						750				TWO SPECIAL MOTOR TEST				2 @ 15,000 each					
				THE MOTORS ON MOTOR TEST										SETS WITH STAND INCL-				2 @ 30,000					
				STAND STATION										UDING DYNAMOMETER AND									
				7.5 EQUIVALENT PER MOTOR										CIRCUIT BREAKER 480V,									
				2 TEST TECHNICIANS										3 @ CURRENT.									
20				RETURN FAILED MOTORS TO						400				INSTALLATION				4,500					
				SUPPLIER (> 0.5%)																			
25				LABOR TO RETURN - PACKING						2,000													
30				PROVIDE MOTORS FOR																			
				APPLICATION OF MOTOR																			
				ENCODER (POSITION LIMIT																			
				INDICATOR #4424)																			
40				TRUCKER - MATERIAL HANDLER						2,000													

TOOL AND LABOR ROUTING										SHEET 1 OF 3		EFFECTIVE 7/1/77		PART NO.		1 MATERIAL		2 SPEC.		3 GAUGE		4 WGT./PC.		5 WGT./BM.							
CUSTOMER										ESTIMATE NO.		TOOL RELEASE		DRAWING NO.		PHIL. NO.		LAST		MODEL		VOL. NO.		PCS / MOD.		PREP. BY		BLANK SIZE		COL. STRIP-SHEET	
SERI										250,000		1		1		1		1		1		1		1		1		1			
OPER. NO.										DEPT. & GROUP		OPERATION DESCRIPTION		REGISTER NO. OR REVIEW DATE		PRODUCTION STD. P.P.H.		HOURS PER 100 PCS.		T A B		MACHINE NAME AND NUMBER		TOOL NUMBER		EQUIPMENT		TOOLS			
10												PURCHASE, STORE AND ISSUE ELECTRONIC COMPONENTS IN TUBES AS RECEIVED FROM SUPPLIER. ISSUE TUBES TO AUTOMATIC INSERTION EQUIPMENT. TUBES CONTAIN ABOUT 50 COMPONENTS EACH, SENSORS, LINE DRIVERS, LINE RECEIVERS, TRIACS, RESISTORS, CAPACITORS AND ISSUE 50 PRINTED CIRCUIT BOARDS. 180 PER CYCLE OF 30 UNITS. 1 MATERIAL HANDLER		2,1		17		5,883				THIRTY TUBE RACKS 1' X 1' X 3'		30		450					
20												MANUALLY LOAD TUBES INTO AUTOMATIC INSERTION MACHINE AND AUTOMATICALLY INSERT COMPONENTS: TWO SHIFTS 20 PER HOUR 1 "B" ASSEMBLER		150		667				UNIVERSAL INSTRUMENTS CORP. INSERTION MACHINE INSTALLATION 60 ASSEMBLY FIXTURES		1		15,000							
30												RECEIVE BOARD FROM AUTOMATIC INSERTION MACHINE WITH TRANSFER EQUIPMENT, IN-PROCESS STORE AS REQUIRED AND FLOW SOLDER AUTOMATICALLY. TWO SHIFTS 20 PER HOUR 1 "B" ASSEMBLER		150		667				PARTIAL TRANSFER EQUIPMENT WITH CONTROLS & FIXTURES TRANSFER FIXTURES INSTALLATION MALLIS ENGINEERING CO. AUTOMATIC FLOW MACHINE FLOW FIXTURES		1		35,000							
APPROVED BY INITIALS & DATE										REMARKS										HOURS PER 100											
RELEASE FOR										STANDARD PRESS TERMS & ABBREVIATIONS										SYMBOLS											
PRODUCTION ENGINEER										STAFF INDUSTRIAL ENGR.										PART NUMBER											
INDUSTRIAL ENGINEER										LABOR CONTROL										REFERENCE											
MANUFACTURING										PROOF READER										SEQUENCE											

TOOL AND LABOR ROUTING										SHEET 2 OF 3		SUPERSEDES 7 31 77		EFFECTIVE		PART NO.			
POSITION/LIMIT INDICATOR										MATERIAL		SPEC.		GAUGE		WGT./PC.		WGT./BM.	
CUSTOMER SERI										ESTIMATE NO.		TOOL MILEAM		DRAWING NO. 4424		PHIL. NO.		LAST MOD.	
MODEL HELIOSTAT										VOLUME YEAR MONTH		PCS/MOD. 1		PMP. BY		BLANK SIZE		COL. BY/INCHMENT	
OPER. NO.	DEPT. & GROUP	OPERATION DESCRIPTION	REGISTER NO. OR REVIEW DATE	PRODUCTION STD. P.P.H.	PRODUCTIVE	AVERAGE	HOURS PER 100 PCS.	T A B	MACHINE NAME AND NUMBER TOOLS AND GAUGES	TOOL NUMBER	EQUIPMENT	EST. COST	QTY.	HOURS PER 100	EST. COST	TOTAL			
35		AUTOMATICALLY TRANSFER SOLDERED, CLEANED, DRIED BOARD TO AUTOMATIC INSPECTION STATION FOR CHECK OF PARTS PRESENCE AND POSITION. SAMPLES INSPECT 2% OF BOARDS FOR VAIDS, DRIPPING, INCLUSIONS 25-PC BOARD 1 INSPECTOR TWO SHIFTS				120	834		FAB-TEC TRANSFER GUID-MENT WITH CONTROLS & METER INSTALLATION	1	35,000								
40		REWORK 41% OF BOARDS 5 CYCLE TIME 1 "A" ASSEMBLER					167												
50		TRANSFER BOARDS TO ENCODER ASSEMBLY STATION (AUTOMATIC)							INSTALLATION FRATE TRANSFER EQUIPMENT WITH CONTROLS & METER FIXTURES	1	5,250								
60		PURCHASE, STAGE AND ISSUE KITS FOR MECHANICAL ASSEMBLY INCLUDING VANE ACTUATORS, SUPPORT BRACKET, NUTS, WASHERS, SCREWS, AND CONNECTOR ISSUE IN KITS FOR 50 UNITS 180 PER CYCLE 1 MATERIAL HANDLER				17	5,883		30 TOTE BOXES 1' X 1' X 1'	20	600								
<div> <div> APPROVED BY INITIALS & DATE PRODUCTION ENGINEER INDUSTRIAL ENGINEER MANUFACTURING </div> <div> REMARKS </div> </div>																			
<div> <div> STANDARD PRESS TERMS & ABBREVIATIONS TO - TONG FEED TD - TONG DISPOSE SD - HAND FEED HD - HAND DISPOSE DUT - DUAL HAND TRIP DPT - DUAL PROF TRIP MT - AIR FOOT TRIP DM - SHARP S BOARD BS - BOW BOARD AE - AIR EJECT BE - BOW EJECT CF - COM FEED EST - ESTIMATE SDO - TOOL DESIGN ONLY DPP - RELEASE FOR PRODUCTION CB - CHANGE NOTICE SCB - CHANGING CANNON REQUEST CB - CHANGE </div> <div> SYMBOLS A - ALTERNATE METHOD B - BELIEVED D - BOW BELIEVED G - BOTTLE NECK S - CHANGED </div> </div>																			
PART NUMBER										REFERENCE		SEQUENCE							

[illegible]

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TOOL AND LABOR ROUTING										SHEET 3 OF 4		SUPERSEDES		EFFECTIVE 7/3/77		PART NO.			
PART NAME POWER/SUPPLY DISTRIBUTION										ESTIMATE NO.		TOOL RELEASE		DRAWING NO.		PANEL NO.			
CUSTOMER SERI										VOLUME 250,000		PCB / MOD.		PREP. BY		BLANK SIZE			
OPERATION DESCRIPTION										REGISTER NO. OR REVIEW DATE		PRODUCTION STD. P.P.N.		HOURS PER 100 PCB.		MACHINE NAME AND NUMBER TOOLS AND GAUGES			
TOOL NUMBER										EQUIPMENT		TOOLS		1		2			
OPER. NO.										EST. COST		QTY.		HOURS PER 100		EST. COST			
80	(CONT)	360	CYCLE TIME, EACH SET OF THREE																
		1	"A" ASSEMBLERS																
90			PURCHASE & STORE AND ISSUE FIBER OPTIC CABLES WITH TERMINATORS																
		6	COLLECT AND ISSUE																
		1	MATERIAL HANDLER																
100			STRIP ENDS OF POWER CABLES																
			TIN AND ATTACH 25 PIN CONNECTOR TO ONE END.																
			OTHER END STAYS BARE FOR FIELD ASSEMBLY THROUGH THE HOLLOW SHAFT INTO THE PEDestal AND TO THE J-BOX FOR FIELD CONNECTION.																
		120	CYCLE FOR ONE CABLE																
		2	"A" ASSEMBLERS																
110			ATTACH MOTOR POWER CABLES (3) AND MOTOR CONTROL CABLES TO 25 PIN CONNECTOR																
		60	CYCLE TIME																
		1	"B" ASSEMBLERS																
115			CONDUCT CABLE CONTINUITY TEST																
		120	TEST CYCLE																
		3	TEST TECHNICIANS																
APPROVED BY INITIALS & DATE										REMARKS		SUB. ASSEMBLY NO.		DEPT AND GROUP		HOURS / 100		HOURS PER 100	
RELEASE FOR										PRODUCTION ENGINEER		INDUSTRIAL ENGINEER		MANUFACTURING		TOTAL		TOTAL	
STAFF INDUSTRIAL ENGR.										LABOR CONTROL		PROOF READER		TOTAL		TOTAL		TOTAL	

PART NAME						TOOL AND LABOR ROUTING								SHEET		SUPERSEDES		EFFECTIVE		PART NO.			
CN	M	S	SS	P		POWER / SUPPLY DISTRIBUTION										4	4			7	7	7	
CUSTOMER						ESTIMATE NO.	TOOL RELEASE	DRAWING NO.	PREL. NO.	LAST ENG.	MODEL	PLT.	VOLUME	PCB / MOD.	PREP. BY	BLANK SIZE	COLLECTING SHEET						
SERI								4425			HELIOSTAT		250,000										
OPER. NO.		DEPT. & GROUP	OPERATION DESCRIPTION		%	REGISTER NO. OR REVIEW DATE	PRODUCTION STD. P.P.H.		HOURS PER 100 PCS.	T A B	MACHINE NAME AND NUMBER TOOLS AND GAUGES		TOOL NUMBER	EQUIPMENT	TOOLS	1							
							PRODUCTIVE	AVERAGE						EST. COST	QTY.	HOURS	EST. COST						
120			REWORK FAILED UNITS - 2%					(15)	200		REWORK BENCH 4' X 8'			1	520								
200			REPAIR CYCLE / UNIT																				
1			A ASSEMBLER																				
130			ASSEMBLE HELIOSTAT CONTROLLER, MOTORS, HARNESSSES FOR SYSTEM TEST, INCLUDING OPTICAL TEST OF FIBER OPTICS					10	10,000		ASSEMBLY BENCHES 4' X 8'		6	3,000									
200			CYCLE TIME																				
6			"A" ASSEMBLERS																				
135			CONDUCT SYSTEM TEST AND OPTICAL CHECK					7.0	14,286		DDI SIMULATOR UNIT DIGITAL READOUT INSTALLATION		10	60,000									
420			CYCLE TEST TIME																				
10			TEST TECHNICIANS																				
140			REWORK FAILED SYSTEMS - 2%						286														
400			REWORK CYCLE / UNIT																				
1			"A" ASSEMBLERS																				
150			PACKAGE AND STORE CONTROLLER, HARNESSSES, AND MOTORS					10	10,000		WIRE BENCHES		8	4,000									
200			PACKAGE CYCLE TIME																				
6			"B" ASSEMBLER								FLO-TEE TRANSFER LINE TO STAGE		1	25,000									
160			TRUCKING - MATERIAL HANDLING						3,000		FITTINGS		2	60									

APPROVED BY INITIALS & DATE:

RELEASE FOR	PRODUCTION ENGINEER	INDUSTRIAL ENGINEER	MANUFACTURING	REMARKS

STANDARD PRESS TERMS & ABBREVIATIONS

T - TOOL D - DRAWING M - MACHINE S - STOCK C - CHANGE R - REVISION E - ESTIMATE P - PART G - GAUGE H - HARDWARE I - INSULATION J - JOINT K - KEY L - LABEL N - NUT O - OIL Q - QUANTITY R - RATE S - SIZE T - TYPE U - UNIT V - VALUE W - WEIGHT X - EXTENSION Y - YIELD Z - ZERO	APT - AM FOOT TRIP BS - BARBERIS GUARD DS - DRUM SHAFT ES - END STOP FS - FEED STOP GS - GRASP HS - HOLD IS - INCH JS - JAW KS - KEY LS - LOCK MS - MOTOR NS - NUT OS - OIL PS - PART QS - QUANTITY RS - RATE SS - SIZE TS - TYPE US - UNIT VS - VALUE WS - WEIGHT XS - EXTENSION YS - YIELD ZS - ZERO	EST - ESTIMATE TPO - TOOL DESIGN ONLY DEF - DELIVER FOR PRODUCTION CH - CHANGE NOTICE DC - DELIVER CHANGE REQUEST CR - CHANGE AL - ALTERNATE METHOD BL - BELIEVE BR - BROKEN CA - CHANGE CL - CLEAR CO - COORDINATE CP - CORRECT CS - CUT CU - CURVE CV - COVER CW - COUNTERWEIGHT CX - CROSS CY - CYCLE CZ - CENTER
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PART NUMBER

REFERENCE

SEQUENCE

[illegible]

PART NAME				TOOL AND LABOR ROUTING				SHEET		SUPERSEDES		EFFECTIVE		PART NO.		1 MATERIAL	
CUSTOMER				ESTIMATE NO.		TOOL RELEASE		DRAWING NO.		PANEL NO.		LAST		MODEL		2 SPEC.	
JERU				4433				4433				HELIOSTAT		254000		3 GAUGE	
OPER. NO.				DEPT. & GROUP		OPERATION DESCRIPTION		REGISTER NO. OR REVIEW DATE		PRODUCTION STD. P.P.H.		HOURS PER 100 P.C.S.		T A B		MACHINE NAME AND NUMBER	
60						AUTOMATICALLY TRIM, FLOW SOLDER CLEAN, DRY 20 CYCLE TIME 1 "B" ASSEMBLY						150		67		MOLLYS ENGINEERING CO AUTOMATIC FLOW SOLDERING EQUIPMENT FIXTURES INSTALLATION	
65						AUTOMATICALLY INSPECT SOLDERED BOARDS FOR COMPONENT PRESENCE VISUALLY INSPECT 2% FOR VOIDS BUBBLING, CONTAMINATION 120 CYCLE TIME FOR 2% 1 INSPECTOR						100				AUTOMATIC INSPECTION SCANNER INSTALLATION	
60						REWORK 2% OF SOLDERED UNITS 120 CYCLE TIME FOR 2% OF ALL UNITS 1 "A" ASSEMBLY						150					
70						ENVIRONMENTALLY TEST 2% OF ALL BOARDS AT TIME IN BATHS AT 20, 120, 180 DEGREE F. TWO HOURS						150				INSTALLATION FALCONS DIV, UNIVERSAL SCIENTIFIC CORP. AVENUE 7'X2'X2' INTERIOR SIZE TEST FIXTURE RACK 4'X3'	
80						BATCH TEST 110 BOARDS EVERY NINE HOURS IN FUNCTIONAL TEST 300 TEST TIME 3 TEST TECHNICIANS, TWO STARTERS						8.0		12,500		INSTALLATION SPECIAL DDL/H.C. FUNCTIONAL TEST STAND (ONE SPARE) TEST BENCH 4'X6'	

PART NAME CONTROL & SIGNAL EQUIPMENT										TOOL AND LABOR ROUTING										SHEET 3 OF 3	SUPERSEDES	EFFECTIVE 7/31/77	PART NO.	1 MATERIAL	2 SPEC.	3 GAUGE	4 WGT./PC.	5 WGT./BM.		
CUSTOMER SERI		ESTIMATE NO.		TOOL WILLIAM		DRAWING NO. 4433		PART NO.		LAST CHG.		MODEL		VOLUME 250,000		YEAR 1980		NORTH		PCS./MOD.		PREP. BY		BLANK SIZE		COR. BY		SHEET		
OPER. NO.		DEPT. & GROUP		OPERATION DESCRIPTION		REGISTER NO. OR REVIEW DATE		PRODUCTION STD. P.P.H.		HOURS PER 100 PCS.		T A B		MACHINE NAME AND NUMBER TOOLS AND GAUGES		TOOL NUMBER		EQUIPMENT		TOOLS		EST. COST		QTY.		HOURS		EST. COST		
90				RECYCLE 2% FAILED UNITS 180 CYCLE TIME FOR 2% 1 "A" ASSEMBLER						250				REWORK BENCH 4' X 6'		1	500													
100				MANUALLY ASSEMBLY TESTED PCB TO BASE WITH SCREWS 30 CYCLE TIME 2 "B" ASSEMBLERS			60		1	667				TWO WORK BENCHES 4' X 6'		2	1,000													
110				ASSEMBLY FOUR (4) CABLES & HINDS CABLE FITTING TO BASE OF BOX 40 CYCLE TIME 2 "B" ASSEMBLERS			60		1	667																				
120				ASSEMBLY ELEVATION, STORAGE, AZIMUTH MOTORS AND JUNCTION BOX CABLES TO HELIOSTAT CONTROLLER BOX 120 CYCLE TIME 3 "B" ASSEMBLERS			25		4	000				RECEIVE MOTORS FROM 4434 OPERATION TO BY USE OF TRANSFER EQUIPMENT THREE WORK BENCHES 4' X 6'		1	85000													
130				INSTALL COVER 20 CYCLE TIME 1 "B" ASSEMBLER			100		1	000																				
140				SEND TO 4435 - OPERATION 130 FOR SYSTEM TEST VIA TRANSFER EQUIPMENT, OPERATION 120																										
150				TRUCKING - MATERIAL HANDLING						3	000																			

APPROVED BY INITIALS & DATE

RELEASE FOR	PRODUCTION ENGINEER	INDUSTRIAL ENGINEER	MANUFACTURING

REMARKS

STANDARD PRESS TAPES & ABBREVIATIONS

TP - TONG PRESS TO - TONG PRESS DP - DUCK PRESS DT - DUCK PRESS DT - DUCK PRESS DT - DUCK PRESS DT - DUCK PRESS	AP - AIR FOOT TRIP DP - DUCK PRESS DP - DUCK PRESS DP - DUCK PRESS DP - DUCK PRESS DP - DUCK PRESS	EST - ESTIMATE TO - TOOL, SINGLE ONLY DP - DELIVER FOR PRODUCTION CP - CHANGE NOTICE DCH - DRAWING CHANGE REQUEST CD - CHANGE
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SYMBOLS

A - ALTERNATE METHOD B - BELIEVED C - CONCLUDED D - DRAFTED E - EXAMINED F - FINISHED G - GROUND H - HOLE I - INSIDE J - JOINT K - KEY L - LEAD M - MOUNT N - NAIL O - OIL P - PILE Q - QUANTITY R - RADIUS S - SIZE T - TAP U - UNDER V - VENT W - WALL X - X-RAY Y - YIELD Z - ZONE
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PART NUMBER

REFERENCE

SEQUENCE

155051 1A -77

C94

155081

C95

1 VOLUME

TOOL AND LABOR ROUTING

ISSUE 1 10-1-79

PART NAME: PEDESTAL FOUNDATION CAP				DRAWING NO.: 4451				PHIL. NO.:				MODEL: HELIOSAT				VOLUME: 250,000				PCB/ MOD.:				PREP. BY:				BLANK SIZE:				COT. STRIP SHEET:				PART NO.:			
ESTIMATE NO.:				TOOL RELEASE:				LAST ENG.:				YEAR:				MONTH:				PREP. BY:				BLANK SIZE:				COT. STRIP SHEET:				PART NO.:							
SERI:				4451																																			
OPER. NO.	DEPT. & GROUP	OPERATION DESCRIPTION	REGISTER NO. OR REVIEW DATE	PRODUCTION STD. P.P.H.	HOURS PER 100 PCS.	T A D	MACHINE NAME AND NUMBER	TOOLS AND GAUGES	%	TI COST	EQUIPMENT	EST. COST	QTY.	HOURS	EST. COST																								
50B		TORCH CUT ACCESS HOLES IN PEDESTAL 1 OPER / MACH. MACH. CYCLE 3/6 SEC.	20	75	1/334		4 TORCH AUTOMATIC BURNING MACH. WITH PART LOCATING MECH. MARK CAPITAL POST TOOLING: SPECIAL DURABLE NON-DURABLE		1%	5	1	40,000																											
												3,000			(INSTALLATION)																								
												20,000																											
												15,000																											
55		TRANSPORT			300							3,000																											
												2,000																											
R60		WELD IN END CAP 1 OPER / 2 MACH. MACH. CYCLE - 44.5 SEC	20	14	7/143		EXPERT MANIP & WELD MACH. MARK CAPITAL POST TOOLING: SPECIAL DURABLE NON-DURABLE		1%	12	13	520,000																											
												62,400			(INSTALLATION)																								
												416,000																											
												73,000																											
61		RELIEF - OPER #60 @ 16.7%			1/193							25,000																											
												6,000																											
70		GALVANIZE (SEE GALV. SHEETS)					USE EXISTING EQUIP																																
75		INSPECTION - FLOOR INSPECTOR			800																																		
80		TO PEDESTAL AREA	10		500		5000, PALLET'S ON FORK LIFT					2,100																											
65		TRANSPORT TO GALVANIZING AREA			500		O'HARD ENGINE 1/2 HOUR					100,000																											

APPROVED BY INITIALS & DATE			REMARKS		TIME / 100		HOURS	
PRODUCTION ENGINEER	INDUSTRIAL ENGINEER	MANUFACTURING			ESTIMATE	ACTUAL	SUB TOTAL	TOTAL
			H1 CAPITAL BUREAU		18.741			

STANDARD PRESS YEARS & ABBREVIATIONS				SYMBOLS			
IF - TONG FEED	DP - AD FOOT TRIP	ST - ESTIMATE	100 - TOOL DESIGN ONLY	0 - ALTERNATE METHOD			
TD - TONG DISPOSE	DD - BARREL GROUND	SIP - RELEASE FOR PRODUCTION	ED - EXCHANGE POWER	1 - DELIVERED			
MP - HAND FEED	MP - HAND FEED	ED - EXCHANGE POWER	ED - EXCHANGE POWER	2 - NOT DELIVERED			
MS - HAND DISPOSE	MS - HAND DISPOSE	ED - EXCHANGE POWER	ED - EXCHANGE POWER	3 - BOTTLE NECK			
DP - DUAL HAND TRIP	DP - DUAL HAND TRIP	ED - EXCHANGE POWER	ED - EXCHANGE POWER	4 - CHANGING			
EP - BLUE FOOT TRIP	EP - BLUE FOOT TRIP	ED - EXCHANGE POWER	ED - EXCHANGE POWER				

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APPENDIX D
PRODUCT COST ESTIMATE

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PRODUCT COST ESTIMATE - 25,000 ANNUAL VOLUME HELIOSTAT
REFLECTIVE UNIT

NO. 93

DATE 11-26-79

SHEET 1 OF 1

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
	Name	Number	Quan.	Spec.	Wgt./BM	Price	Cost	Depl.	Hrs./C/BM	Rate	Cost	Rate	Cost	
1	CLINCH NUT		48	P			2.1600		-		-		-	2.1600
2	STRINGER		24	P			114.2700		-		-		-	114.2700
3	ASSY-CL.NT.&STR.		24				-		(INCL. IN 4411)				-	-
4														
5	BACK LITE		12	P			184.8000		-		-		-	184.8000
6	ADHESIVE			P			29.5300		-		-		-	29.5300
7	MIRROR-FRONT LITE		12	P			704.8800		-		-		-	704.8800
8	ADHESIVE			P			29.5300		-		-		-	29.5300
9	ASSY REFL SUR & STR.	4411	12				-	xxx	95.808	7.88	7.5497	1263	95.3527	102.9024
10	SUB TOTAL	4411					1065.17				7.55		95.35	1168.07
11														
12	BEAM-DIAGONAL RH		2	P			47.0600		-		-		-	47.0600
13	BEAM-DIAGONAL LH		2	P			47.0600		-		-		-	47.0600
14	BEAM-INBOARD		2	P			125.8000		-		-		-	125.8000
15	BEAM-OUTBOARD		2	P			42.1400		-		-		-	42.1400
16	DOUBLER		4	P			5.0000		-		-		-	5.0000
17	GUSSET		2	P			18.0000		-		-		-	18.0000
18														
19	ASSY SUPT. STRUCTURE	4412	2	WELD WIRE			1.1400	xxx	30.400	7.88	2.3955	1263	30.2552	33.7907
20	SUB TOTAL	4412					286.20				2.40		30.26	318.86
21														
22	SCREW		48	P			.7900		-		-		-	.7900
23	WASHER		48	P			.3400		-		-		-	.3400
24	FINAL ASSY-REFL. UNIT	4413	2				-	xxx	41.000	7.88	3.2308	1263	40.8050	44.0358
25	SUB TOTAL	4413		(2) REFLECTIVE UNITS/RACK			-				3.23		40.81	45.17
26				(2 REFLECTIVE UNITS/HELIOSTAT)										
27														
28														
29														
30	TOTAL						1352.50				13.18		166.42	1532.10
31	(REFLECTIVE UNIT)													
32														
33														
34														
35														
36														
37														
38														
39														

PRODUCT COST ESTIMATE - 25,000 ANNUAL VOLUME HELIOSTAT
DRIVE UNIT & ELECTRONICS

NO. 936

SHEET 1 OF 6

DATE 11-26-79

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
	Name	Number	Quan.	Spec.	Wgt./BM	Price	Cost	Depl.	Hrs./C/BM	Rate	Cost	Rate	Cost	
1														
2														
3	HOUSING-AZIMUTH DR.	4421	1	P			370.0000		-		-		-	370.0000
4	MACHINE HOUSING	4421	1				-	xxx	82.832	7.88	6.5272	1263	82.4385	88.9657
5														
6	DRIVE SHAFT	4421	1	P			20.0000		-		-		-	20.0000
7														
8														
9	RETAINING OUTER	4421	1	P			77.0000		-		-		-	77.0000
10	HELICON GEAR (OUTPUT)	4421	1	P			.3528		-		-		-	.3528
11														
12	RETAINER, BEARING	4421	1				.6900		-		-		-	.6900
13	MACHINE-RET. BEARING	4421	1				-	xxx	33.3500	7.88	2.6300	1263	33.1900	35.8200
14														
15	COVER & HUB	4421	1	P			2.9200		-		-		-	2.9200
16	BUSHING	4421	1	P			.0264		-		-		-	.0264
17	OIL PAN (WELD)	4421	1	P			6.4600		-		-		-	6.4600
18	PLATE	4421	1	P	}				-		-		-	
19	TUBE	4421	1	P			.4741		-		-		-	.4741
20	PLUG	4421	1	P			.0984		-		-		-	.0984
21														
22														
23														
24														
25														
26														
27														
28														
29														
30														
31														
32														
33	TUBING-SEAMLESS	4421	1	}										
34	DIAPHRAGM	4421	1											
35	SUPPORT DOUBLER	4421	1		P		25.0000		-		-		-	25.0000
36	HEAT TREAT, WELD MACH,	4421	1				-	xxx	45.058	7.88	3.5506	1263	44.8441	48.3947
37	ASSY FLEXIBLE SPLINE													
38														
39	TOTAL P1	4421					503.02				12.71		5.47	676.70

D4

PRODUCT COST ESTIMATE - 25,000 ANNUAL VOLUME HELIOSTAT
DRIVE UNIT & ELECTRONICS

NO. 936

DATE 11-26-79

SHEET 2 OF 6

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG. COST
	Name	Number	Quan.	Spec.	Wgt./DM	Price	Cost	Depl.	Hrs./C/DM	Rate	Cost	Rate	Cost	
1	KEY	4421	1	P			.0227		-		-		-	.0227
2														
3	SPLINE-CIRCULAR	4421	1				85.0000		-		-		-	85.0000
4	MACH. CIRC. SPLINE	4421	1				-	xxx	58.182	7.88	4.5847	1263	57.9048	62.4895
5														
6	BEARING-WAVE GENERATOR	4421	1	P			75.6200		-		-		-	75.6200
7	KEY (GEAR)	4421	1	P			.0106		-		-		-	.0106
8	NUT (GEAR)	4421	1	P			.4400		-		-		-	.4400
9	WASHER (GEAR)	4421	1	P			.1000		-		-		-	.1000
10	LOCKNUT	4421	12	P			.0600		-		-		-	.0600
11	BOLT (SPECIAL)	4421	12	P			31.8000		-		-		-	31.8000
12	NUT (SPECIAL)	4421	1				21.5700		-		-		-	21.5700
13	ASSY. HARMONIC DR.	4421	1				-	xxx	(INCL. IN MACH. DR. ASSY)	OPER. & AZIM.	-		-	-
14														
15														
16	WAVE GENERATOR PLUG	4421	1				10.9200		-		-		-	10.9200
17	MACH. WAVE GEN. PLUG	4421	1				-	xxx	27.435	7.88	2.1619	1263	27.3048	29.4667
18														
19	BEARING (DR. SHAFT)	4421	1	P			3.3100		-		-		-	3.3100
20	TURRET BEARING	4421	1	P			20.7800		-		-		-	20.7800
21	PACKING	4421	1	P			3.4861		-		-		-	3.4861
22	SHIM (GEAR)	4421	4	P			.1557		-		-		-	.1557
23	LOCKNUT (WAVE GEN)	4421	1	P			.6500		-		-		-	.6500
24	WASHER (WAVE GEN)	4421	1	P			.1200		-		-		-	.1200
25	PACKING	4421	1	P			3.0252		-		-		-	3.0252
26	GREASE	4421	1	P			.3700		-		-		-	.3700
27	OIL	4421	1	P			1.0100		-		-		-	1.0100
28	ELBOW	4421	1	P			1.4400		-		-		-	1.4400
29	SCREW	4421	8	P			.0600		-		-		-	.0600
30	BOLT	4421	8	P			.0500		-		-		-	.0500
31	BOLT	4421	4	P			.0200		-		-		-	.0200
32	BOLT	4421	16	P			.7800		-		-		-	.7800
33	BOLT	4421	8	P			2.5640							2.5640
34														
35	ASSY-AZIMUTH DR.	4421	1				-	xxx	56.390	7.88	4.4435	1263	56.1214	60.5649
36														
37	SUB TOTAL (P1)	4421					263.36				11.19		141.33	415.88
38	SUB TOTAL (P2)	4421					503.02				12.71		160.47	676.20
39	SUB TOTAL	4421					766.38				23.90		301.80	1092.08

PRODUCT COST ESTIMATE - 25,000 ANNUAL VOLUME HELIOSTAT
DRIVE UNIT & ELECTRONICS

NO. 936

DATE 11-26-79

SHEET 3

6

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG. COST
	Name	Number	Quan.	Spec.	Wgt./BM	Price	Cost	Dept.	Hrs./BM	Rate	Cost	Rate	Cost	
1	LINK-DRAG	4422	1	P			72.0000		-		-		-	72.0000
2	MACH-DRAG LINK	4422	1				-	xxx	16.750	7.88	1.3199	1263	16.6703	17.9902
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13	TORQUE TUBE	4422	1	P			169.0000		-		-		-	169.0000
14	TORQUE TUBE-ELEV. DR.	4422	1				-	xxx	35.167	7.88	2.7712	1263	35.0003	37.7715
15														
16														
17														
18														
19														
20														
21														
22	CLEVIS	4422	4	P			.4169		-		-		-	.4169
23	CLEVIS	4422	4	P			.7088		-		-		-	.7088
24	CLEVIS	4422	2	P			2.6200		-		-		-	2.6200
25	TRUNNION	4422	4	P			.1991		-		-		-	.1991
26	TRUNNION	4422	4	P			.7128		-		-		-	.7128
27														
28														
29	BUSHING	4422	2	P			1.4000		-		-		-	1.4000
30	TRUNNION	4422	4	P			1.9922		-		-		-	1.9922
31	HINGE	4422	2	P			.9961		-		-		-	.9961
32	HINGE	4422	2	P			.4326		-		-		-	.4326
33	SPACER	4422	2	P			.7400		-		-		-	.7400
34	SPACER	4422	1	P			.4693		-		-		-	.4693
35	BOLT	4422	1	P			2.4700		-		-		-	2.4700
36	PIN	4422	1	P			1.8400		-		-		-	1.8400
37	ACTUATOR DWG.	4422	2	P			-		-		-		-	-
38	JACK	4422	2	P			400.0000		-		-		-	400.0000
39	SUB TOT** (P3)	4422					656.00				4.09		.67	711.76

PRODUCT COST ESTIMATE - 25,000 ANNUAL VOLUME HELIOSTAT
DRIVE UNIT & ELECTRONICS

NO. 5

SHEET 7

6

DATE 11-26-79

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG. COST
	Name	Number	Quan.	Spec.	Wgt./BM	Price	Cost	Dept.	Hrs./C/BM	Rate	Cost	Rate	Cost	
1	ASSY. ELEVATION DR.	4422	1				-	XXX	59.000	7.88	4.6492	1263	58.7194	63.3686
2	SUB TOTAL (P3)	4422					656.00		35.170		4.0900		51.6700	711.7600
3	SUB TOTAL	4422					656.00		94.17		8.74		110.39	775.13
4														
5	BOLT	4423	4	P			.03		-		-		-	.0300
6	WASHER	4423	4	P			.02		-		-		-	.0200
7	MOTOR	4423	1	P			48.5000		-		-		-	48.5000
8														
9	BOLT	4423	4	P			.03		-		-		-	.0300
10	WASHER	4423	4	P			.02		-		-		-	.0200
11	MOTOR	4423	1	P			48.5000		-		-		-	48.5000
12														
13	BOLT	4423	4	P			.03		-		-		-	.0300
14	WASHER	4423	4	P			.02		-		-		-	.0200
15	MOTOR	4423	1	P			48.5000		-		-		-	48.5000
16	MOTORS	4423	1				-	XXX	24.400	7.88	1.9227	1263	24.2837	26.2064
17	SUB TOTAL	4423					145.65				1.92		24.28	171.86
18														
19	SENSOR-HALL EFFECT	4424	6	P			19.4040		-		-		-	19.4040
20	DRIVER - LINE	4424	3	P			2.7300		-		-		-	2.7300
21	DUAL DIFF. LINE REC.	4424	3	P			2.7300		-		-		-	2.7300
22	ACTUATOR	4424	3	P			3.3000		-		-		-	3.3000
23	RESISTOR	4424	12	P			1.8000		-		-		-	1.8000
24	CAPACITOR	4424	12	P			3.6000		-		-		-	3.6000
25	CONN.	4424	3	P			2.9100		-		-		-	2.9100
26	PRINTED CIRCUIT BOARD	4424	3	P			19.5000		-		-		-	19.5000
27	TRIACS - OPT. ISOL.	4424	12	P			11.76		-		-		-	11.7600
28	SCREW	4424	3	P			.0200		-		-		-	.0200
29	SCREW	4424	12	P			.0850		-		-		-	.0850
30	WASHER	4424	15	P			.1073		-		-		-	.1073
31	NUT	4424	15	P			.1722		-		-		-	.1722
32	SCREW	4424	6	P			.1932		-		-		-	.1932
33	SCREW	4424	9	P			.1652		-		-		-	.1652
34	CYLINDER	4424	3	P			13.5000		-		-		-	13.5000
35	COVER	4424	3	P			3.7500		-		-		-	3.7500
36	BRACKET	4424	3	P			8.2500		-		-		-	8.2500
37	POSITION/LIMIT/IND.	4424	1				-	XXX	-2.718	7.88	1.7902	1263	22.6102	24.4004
38	SUB TOTAL	4424					93.98				1.79		22.61	118.38
39														

PRODUCT COST ESTIMATE - 25,000 ANNUAL VOLUME HELIOSTAT
DRIVE UNIT AND ELECTRONICS

NO. 936
SHEET 5 OF 6

DATE 11-26-79

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG. COST
	Name	Number	Quan.	Spec.	Wgt./BM	Price	Cost	Dept.	Hrs./C/BM	Rate	Cost	Rate	Cost	
1	J-BOX	4425	1	P			14.9700		-		-		-	14.9700
2	TERM. STRIP	4425	1	P			.6500		-		-		-	.6500
3	PANEL - DIST.	4425	1	P			2.0000		-		-		-	2.0000
4	TERMIN.	4425	4	P			19.0800		-		-		-	19.0800
5	FITTING	4425	5	P			71.3000		-		-		-	71.3000
6	CIR. BRKR./HCLDER	4425	1	P			33.0000		-		-		-	33.0000
7	CABLE	4425	1	P			1.6467		-		-		-	1.6467
8	CABLE	4425	1	P			3.3134		-		-		-	3.3134
9	OPTIC CABLE	4425	1	P			2.9700		-		-		-	2.9700
10	TERMIN.	4425	4	P			6.4000		-		-		-	6.4000
11	CONN.	4425	1	P			.4800		-		-		-	.4800
12	CONN.	4425	3	P			6.7500		-		-		-	6.7500
13	POWER SUPPLY/DISTRIB	4425	1				-	XXX	92.839	7.88	7.3157	1263	92.3973	99.7130
14														
15	SUB TOTAL	4425					162.56				7.32		92.40	262.27
16														
17														
18														
19	PRINTED CIR. BOARD	4433	1	P			6.7500		-		-		-	6.7500
20	CONNECTOR	4433	1	P			1.8000		-		-		-	1.8000
21	COMPUTER	4433	1	P			45.0000		-		-		-	45.0000
22	DRIVER	4433	2	P			2.5000		-		-		-	2.5000
23	RECEIVER	4433	2	P			2.5000		-		-		-	2.5000
24	FLIP-FLOP	4433	3	P			1.8000		-		-		-	1.8000
25	CAPACITOR	4433	3	P			.6000		-		-		-	.6000
26	SUPPLY	4433	1	P			45.4000		-		-		-	45.4000
27	CONN.	4433	1	P			1.8000		-		-		-	1.8000
28	BOX	4433	1	P			.5500		-		-		-	.5500
29	TRANS.	4433	1	P			37.0000		-		-		-	37.0000
30	CONTROL/SIGNAL EQUIP	4433	1				-	XXX	37.454	7.88	2.9514	1263	37.2762	40.2276
31														
32	SUB TOTAL	4433					145.70				2.95		37.28	185.93
33														
34														
35														
36	SUPPORT STRUCTURE	4451	1	P			260.00		-		-		-	260.00
37														
38														
39														

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PRODUCT COST ESTIMATE - 25,000 ANNUAL VOLUME HELIOSTAT
FOUNDATION CAP

NO. 936

SHEET 1 OF 1

DATE 11-26-79

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
	Name	Number	Quan.	Spec.	Wgt./BM	Price	Cost	Dept.	Hrs./C/BM	Rate	Cost	Rate	Cost	
1														
2	FOUNDATION CAP	4451	1	P*			98.00	xxx	1.000	7.88	.0788	1263	.9952	99.07
3	(TAPERED PIPE)													
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														
16														
17														
18														
19														
20														
21														
22				*SHIPPED TO OUR PLANT IN OUR RACK (9 PCS/RACK) & INSPECTED.										
23														
24														
25														
26														
27														
28														
29														
30														
31														
32														
33														
34														
35														
36														
37														
38														
39														

PRODUCT COST ESTIMATE - 250,000 ANNUAL VOLUME HELIOSTAT
REFLECTIVE UNIT

NO. 9
SHEET 1

DATE 11-26-79

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG. COST
	Name	Number	Quan.	Spec.	Wgt./BM	Price	Cost	Dept.	Hrs./C/BM	Rate	Cost	Rate	Cost	
1	CLINCH NUT		48	P			2.1600		-		-		-	2.1600
2	STRINGER		24	P			103.6400		-		-		-	103.6400
3	ASSY. - CL.NT. & STR.		24				-		(INCL. IN 4411)					-
4														
5	BACK LITE		12	P			168.9600		-		-		-	168.9600
6	ADHESIVE						29.5300							29.5300
7	MIRROR-FRONT LITE		12	P			347.9500		-		-		-	347.9500
8	ADHESIVE						29.5300							29.5300
9	ASSY REFL SUR & STR.	4411	12				-	XXX	47.460	7.41	3.5168	947	33.3041	36.8209
10	SUB TOTAL	4411					681.77				3.52		33.30	718.59
11														
12	BEAM-DIAGONAL RH		2	P			42.5000		-		-		-	42.5000
13	BEAM-DIAGONAL LH		2	P			42.5000		-		-		-	42.5000
14	BEAM-INBOARD		2	P			111.2100		-		-		-	111.2100
15	BEAM-OUTBOARD		2	P			38.5700		-		-		-	38.5700
16	DOUBLER		4	P			5.0000		-		-		-	5.0000
17	GUSSET		2	P			18.0000		-		-		-	18.0000
18														
19	ASSY. SUPT. STRUCTURE	4412	2	WELD WIRE	3#		1.1400	XXX	30.400	7.41	2.2526	947	21.3321	24.7247
20	SUB TOTAL	4412			LOW CARB		258.92				2.25		21.33	282.50
21														
22	SCREW		48	P			.7300		-		-		-	.7300
23	WASHER		48	P			.3100		-		-		-	.3100
24	FINAL ASSY-REFL. UNIT	4413	2				-	XXX	44.150	7.41	3.2715	947	30.9811	34.2526
25	SUB TOTAL	4413					1.04				3.27		30.98	35.29
26				(2) REFLECTIVE UNITS/RACK										
27				(2 REFLECTIVE UNITS/HELIOSTAT)										
28														
29	REFLECTIVE UNIT													
30	TOTAL						941.73				9.04		85.61	1036.38
31														
32														
33														
34														
35														
36														
37														
38														
39														

PRODUCT CCST ESTIMATE - 250,000 ANNUAL VOLUME HELIOSTAT
DRIVE UNIT & ELECTRONICS

NO. 936

DATE 11-26-79

SHEET 1 OF 6

PART			MATERIAL				LABOR				BURDEN		TOTAL MFG. COST
Name	Number	Quan.	Spec.	Wgt./BM	Price	Cost	Dept.	Hrs./C/BM	Rate	Cost	Rate	Cost	
1 GALV. HOUSING		1			+	-	XXX	3.200	7.41	.2371	947	2.2453	2.4824
2													
3													
4 MACHINE HOUSING	4421	1				-	XXX	18.364	7.41	1.3608	947	12.8868	14.2476
5													
6 DRIVE SHAFT	4421	1	P			2.4300		-		-		-	2.4300
7 MACHINE DR. SHAFT	4421	1				-	XXX	7.787	7.41	.5770	947	5.4642	6.0412
8													
9 RETAINER, OUTER	4421	1	P			11.3900		-		-		-	11.3900
10 HELICON GEAR (OUTPUT)	4421	1	P			.2205		-		-		-	.2205
11													
12 RETAINER, BEARING	4421	1	P			.6900		-		-		-	.6900
13 MACHINE-RET. BEARING	4421	1				-	XXX	39.238	7.41	2.9075	947	27.5340	30.4415
14													
15 COVER	4421	1	P			2.9200		-		-		-	2.9200
16 BUSHING	4421	1	P			.0264		-		-		-	.0264
17 OIL PAN (WELD)	4421	1	P			6.4600		-		-		-	6.4600
18 PLATE	4421	1	P			-		-		-		-	-
19 TUBE	4421	1	P			.4552		-		-		-	.4552
20 PLUG	4421	1	P			.0915		-		-		-	.0915
21													
22 HOUSING (WELD)	4421	1				-	XXX	40.527	7.41	3.0031	947	28.4394	31.4425
23													
24 RETAINER	4421	1	P			60.0000		-		-		-	60.0000
25 TUBE	4421	1	P			33.0000		-		-		-	33.0000
26 PLATE	4421	1	P			18.0600		-		-		-	18.0600
27 TUBE	4421	1	P			4.0000		-		-		-	4.0000
28 TUBE	4421	1	P			9.0000		-		-		-	9.0000
29 LUG	4421	2	P			37.3500		-		-		-	37.3500
30 TUBE	4421	1	P			.5459		-		-		-	.5459
31 LUG	4421	1	P			6.6400		-		-		-	6.6400
32 LUG	4421	1	P			6.6400		-		-		-	6.6400
33 MOUNT	4421	1	P			1.2450		-		-		-	1.2450
34 WEB	4421	1	P			9.1300		-		-		-	9.1300
35 PLATE	4421	1	P			4.0000		-		-		-	4.0000
36													
37 SPLINE - FLEXIBLE	4421	1	P(TUBE, DIAPH & DOUBLER)			25.0000		-		-		-	25.0000
38 HEAT TREAT, WELD, MACH	4421	1				-	XXX	48.151	7.41	3.5680	947	33.7890	37.3570
39 P1 SUP TOTAL	4421					239.30				11.65		11.65	361.31

PRODUCT COST ESTIMATE - 250,000 ANNUAL VOLUME HELIOSTAT
DRIVE UNIT & ELECTRONICS

NO. 936

6

DATE 11-20-79

SHEET

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG. COST
	Name	Number	Quan.	Spec.	Wgt./BM	Price	Cost	Dept.	Hrs./C/BM	Rate	Cost	Rate	Cost	
1	KEY	4421	1	P			.0169		-		-		-	.0169
2														
3	SPLINE-CIRCULAR	4421	1				85.0000		-		-		-	85.0000
4	MACH. CIRC. SPLINE	4421	1				-	XXX	28.775	7.41	2.1322	947	20.1919	22.3241
5														
6	BEARING-WAVE GENERATOR	4421	1	P			70.7000		-		-		-	70.7000
7	KEY (GEAR)	4421	1	P			.0082		-		-		-	.0082
8	NUT (GEAR)	4421	1	P			.4400		-		-		-	.4400
9	WASHER (GEAR)	4421	1	P			.1000		-		-		-	.1000
10	LOCKNUT	4421	1	P			.0600		-		-		-	.0600
11	BOLT (SPECIAL)	4421	12	P			31.8000		-		-		-	31.8000
12	NUT (SPECIAL)	4421	12	P			21.5700		-		-		-	21.5700
13	ASSY. HARMONIC DR.	4421	1				-	XXX	(INCL. IN MACH. OPER. & AZIM. DR. ASSY.)				-	-
14														
15														
16	WAVE GENERATOR PLUG	4421	1				10.9200		-		-		-	10.9200
17	MACH. WAVE GEN. PLUG	4421	1				-	XXX	29.240	7.41	2.1667	947	20.5186	22.6853
18														
19	BEARING - DR. SHAFT	4421	1	P			3.3100		-		-		-	3.3100
20	TURRET BEARING	4421	1	P			20.7800		-		-		-	20.7800
21	PACKING	4421	1	P			3.2291		-		-		-	3.2291
22	SHIM (GEAR)	4421	4	P			.1557		-		-		-	.1557
23	LOCKNUT (WAVE GEN.)	4421	1	P			.6500		-		-		-	.6500
24	WASHER (WAVE GEN.)	4421	1	P			.1200		-		-		-	.1200
25	PACKING	4421	1	P			2.7722		-		-		-	2.7722
26	GREASE	4421	1				.3700		-		-		-	.3700
27	OIL	4421	1				1.0100		-		-		-	1.0100
28	ELBOW	4421	1	P			1.4400		-		-		-	1.4400
29	SCREW	4421	8	P			.0451		-		-		-	.0451
30	BOLT	4421	8	P			.0465		-		-		-	.0465
31	BOLT	4421	4	P			.0186		-		-		-	.0186
32	BOLT	4421	16	P			.7254		-		-		-	.7254
33	BOLT	4421	8	P			2.3845		-		-		-	2.3845
34														
35	ASSY - AZIMUTH DR.	4421	1				-	XXX	16.238	7.41	1.2032	947	11.3943	12.5975
36														
37	SUB TOTAL P2	4421					257.67				5.50		52.11	315.28
38														
39	SUB TOTAL P1	4421					239.30				11.65		110.36	361.31
40	SUB TOTAL	4421					496.97				17.15		162.47	676.59

PRODUCT COST ESTIMATE - 250,000 ANNUAL VOLUME HELIOSTAT
DRIVE UNIT & ELECTRONICS

NO. 936

SHEET 3

6

DATE 11-26-79

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG. COST
	Name	Number	Quan.	Spec.	Wgt./BM	Price	Cost	Dept.	Hrs./C/BM	Rate	Cost	Rate	Cost	
1	GALV. DRAG LINK	4422	1				-	XXX	3.200	7.41	.2371	947	2.2453	2.4824
2	MACH. - DRAG LINK	4422	1				-	XXX	2.576	7.41	.1909	947	1.8078	1.9987
3														
4	PLATE - SIDE RH	4422	1	P			18.2600		-		-		-	18.2600
5	PLATE - SIDE LH	4422	1	P			17.0200		-		-		-	17.0200
6	BRACE	4422	1	P			5.4000		-		-		-	5.4000
7	BRACE	4422	1	P			3.3200		-		-		-	3.3200
8	BRACE	4422	1	P			2.0800		-		-		-	2.0800
9	LUG	4422	2	P			3.3200		-		-		-	3.3200
10	WELD DRAG LINK	4422	1				-	XXX	4.924	7.41	.3649	947	3.4556	3.8205
11														
12														
13	GALV. TORQUE TUBE		1				-	XXX	6.400	7.41	.4742	947	4.4907	4.9649
14	TORQUE TUBE ELEV. DR.	4422	1	MACHINE			-	XXX	2.788	7.41	.2066	947	1.9565	2.1631
15														
16	TUBE	4422	1	P			32.2549		-		-		-	32.2549
17	FLANGE	4422	2	P			57.2700		-		-		-	57.2700
18	LUG	4422	6	P			44.8200		-		-		-	44.8200
19	TORQUE TUBE WELD (MAIN BEAM ASSY.)						-	XXX	5.100	7.41	.3779	947	3.5787	3.9566
20														
21														
22	CLEVIS	4422	4	P			.4049		-		-		-	.4049
23	CLEVIS	4422	4	P			.6900		-		-		-	.6900
24	CLEVIS	4422	2	P			2.4890		-		-		-	2.4890
25	TRUNNION	4422	4	P			.1960		-		-		-	.1960
26	TRUNNION	4422	4	P			.6930		-		-		-	.6930
27														
28														
29	BUSHING	4422	2	P			1.4000		-		-		-	1.4000
30	TRUNNION	4422	4	P			1.9045		-		-		-	1.9045
31	HINGE	4422	2	P			.9522		-		-		-	.9522
32	HINGE	4422	2	P			.4207		-		-		-	.4207
33	SPACER	4422	2	P			.7000		-		-		-	.7000
34	SPACER	4422	1	P			.4567		-		-		-	.4567
35	BOLT	4422	1	P			1.8900		-		-		-	1.8900
36	PIN	4422	1	P			1.7480		-		-		-	1.7480
37	ACT. DWG.	4422	2	P			-		-		-		-	-
38	JACK	4422	2	P			400.0000		-		-		-	400.0000
39	SUBTOTAL	4422					597.69				1.85		53	617.07

PRODUCT COST ESTIMATE - 250,000 ANNUAL VOLUME HELIOSTAT
DRIVE UNIT & ELECTRONICS

NO. 936

DATE 11-26-79

SHEET

6

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG. COST
	Name	Number	Quan.	Spec.	Wgt./BM	Price	Cost	Dept.	Hrs./C/BM	Rate	Cost	Rate	Cost	
1	ASSY. ELEVATION DR.	4422	1				-	XXX	40.000	7.41	2.9640	947	28.0691	31.0331
2	SUB TOTAL (P3)	4422					597.69				1.85		17.53	617.07
3	SUB TOTAL	4422					597.69				4.81		45.60	648.10
4														
5	BOLT	4423	4	P			.0279		-		-		-	.0279
6	WASHER	4423	4	P			.0186		-		-		-	.0186
7	MOTOR	4423	1	P			46.0800		-		-		-	46.0800
8														
9	BOLT	4423	4	P			.0279		-		-		-	.0279
10	WASHER	4423	4	P			.0186		-		-		-	.0186
11	MOTOR	4423	1	P			46.0800		-		-		-	46.0800
12														
13	BOLT	4423	4	P			.0279		-		-		-	.0279
14	WASHER	4423	4	P			.0186		-		-		-	.0186
15	MOTOR	4423	1	P			46.0800		-		-		-	46.0800
16														
17	MOTORS	4423	1				-	XXX	15.150	7.41	1.1226	947	10.6310	11.7536
18	SUB TOTAL	4423					138.38				1.12		10.63	150.13
19														
20	SENSOR	4424	6	P			18.5400		-		-		-	18.5400
21	DRIVER	4424	3	P			2.0700		-		-		-	2.0700
22	LINE REC.	4424	3	P			2.0700		-		-		-	2.0700
23	ACTUATOR	4424	3	P			3.3000		-		-		-	3.3000
24	RESISTOR	4424	12	P			1.8000		-		-		-	1.8000
25	CAPACITOR	4424	12	P			3.3600		-		-		-	3.3600
26	CONN.	4424	3	P			2.7900		-		-		-	2.7900
27	CIRCUIT	4424	3	P			16.5000		-		-		-	16.5000
28	TRIACS	4424	12	P			8.1600		-		-		-	8.1600
29	SCREW	4424	3	P			.0186		-		-		-	.0186
30	SCREW	4424	12	P			.0787		-		-		-	.0787
31	WASHER	4424	15	P			.0995		-		-		-	.0995
32	NUT	4424	15	P			.1593		-		-		-	.1593
33	SCREW	4424	6	P			.1584		-		-		-	.1584
34	SCREW	4424	9	P			.1530		-		-		-	.1530
35	CYLINDER	4424	3	P			11.2500		-		-		-	11.2500
36	COVER	4424	3	P			3.1500		-		-		-	3.1500
37	BRACKET	4424	3	P			6.9000		-		-		-	6.9000
38	POSITION/LIMIT/IND.	4424	1				-	XXX	19.984	7.41	1.4808	947	14.0232	15.5040
39	SUB TOTAL	4424					80.56				1.48		14.02	96.06

PRODUCT COST ESTIMATE - 250,000 ANNUAL VOLUME HELIOSTAT
DRIVE UNIT & ELECTRONICS

NO. 936

SHEET 5

6

DATE 11-26-79

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG. COST
	Name	Number	Quan.	Spec.	Wgt./BM	Price	Cost	Depl.	Hrs./C./BM	Rate	Cost	Rate	Cost	
1	J-BOX	4425	1	P			14.1400		-		-		-	14.1400
2	TERM. STRIP	4425	1	P			.3800		-		-		-	.3800
3	PANEL	4425	1	P			2.0000		-		-		-	2.0000
4	TERMIN.	4425	4	P			19.0800		-		-		-	19.0800
5	FITTING	4425	5	P			71.3000		-		-		-	71.3000
6	CIR. BRKR.	4425		P			28.000		-		-		-	28.000
7	CABLE	4425	1	P			1.6467		-		-		-	1.6467
8	CABLE	4425	1	P			1.6467		-		-		-	1.6467
9	OPTIC CABLE	4425	1	P			2.9700		-		-		-	2.9700
10	TERMIN.	4425	4	P			5.8000		-		-		-	5.8000
11	CONN.	4425	1	P			.4700		-		-		-	.4700
12	CONN.	4425	3	P			6.4500		-		-		-	6.4500
13	POWER SUPPLY/DISTRIB.	4425	1				-	XXX	79.8003	7.41	5.9132	947	55.9980	61.9112
14	SUB TOTAL	4425					153.89				5.91		56.00	215.80
15														
16	PRINTED CIR. BOARD	4433	1	P			5.6000		-		-		-	5.6000
17	CONNECTOR	4433	1	P			1.6500		-		-		-	1.6500
18	COMPUTER	4433	1	P			42.0000		-		-		-	42.0000
19	DRIVER	4433	2	P			2.4000		-		-		-	2.4000
20	RECEIVER	4433	2	P			2.4000		-		-		-	2.4000
21	FLIP-FLOP	4433	3	P			1.6200		-		-		-	1.6200
22	CAPACITOR	4433	3	P			.5700		-		-		-	.5700
23	SUPPLY	4433	1	P			34.3900		-		-		-	34.3900
24	CONN.	4433	1	P			1.6500		-		-		-	1.6500
25	BOX	4433	1	P			.5000		-		-		-	.5000
26	TRANS.	4433	1	P			30.000		-		-		-	30.0000
27	CONTROL/SIGNAL EQUIP.	4433	1				-	XXX	30.069	7.41	2.2281	947	21.1001	23.3282
28	SUB TOTAL	4433					122.78				2.23		21.10	146.11
29														
30	PEDESTAL	4451	1				60.3400		-		-		-	60.3400
31	CAP - END	4451	1	P			46.8700		-		-		-	46.8700
32	COVER	4451	1				1.2000		-		-		-	1.2000
33	SUPPORT STRUCTURE	4451	1				-	XXX	18.741	7.41	1.3887	947	13.1510	14.5397
34														
35	GALV. PEDESTAL &						-	XXX	6.400	7.41	.4742	947	4.4907	4.9649
36	FOUNDATION CAP													
37	SUB TOTAL (P5)	4451					108.41				1.86		17.64	127.91
38	FOUNDATION CAP	4451					39.66							39.66
39	SUB T	4451					148.07				1.86		17.64	167.57

PRODUCT COST ESTIMATE - 250,000 ANNUAL VOLUME HELIOSTAT
FOUNDATION CAP

NO. 936
SHEET 1 OF 1

DATE 11-26-79

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG. COST
	Name	Number	Quan.	Spec.	Wgt./BM	Price	Cost	Dept.	Hrs./C./BM	Rate	Cost	Rate	Cost	
1														
2	FOUNDATION CAP	4451	1				39.2200	LABOR TO FABRICATE						39.2200
3	(TAPERED PIPE)			PACK 9 PCS/RACK			.4400	PEDESTAL						.4400
4														
5														
6														
7	TOTAL						39.66		-		-		-	39.66
8														
9														
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APPENDIX E

LABOR DEVELOPMENT

This appendix is provided as an example so the reader can see the methodology by which the labor data was developed for the tool and labor routing sheets.

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HOUSING - AZIMUTH DRIVE - (25,000/YR)

SUMMARY DATA

<u>Oper. #</u>	<u>Equip't.</u>	<u>Shift[®] @100%</u>	<u>Day @100%</u>	<u>Day Less Downtime</u>	<u>Day Less Scrap @3%</u>	<u>Relief</u>
20	2 Mach's.	80.15	160.30	152.29(@5%)	147.72	Personal, wash-up & lunch
30	3-Sta.in-line	71.69	143.38	129.04(@10%)	125.17	Personal
40	4-Sta.in-line	75.67	151.34	136.20(@10%)	132.11	Personal
50	4 Mach's.	82.50	165.00	156.75(@5%)	152.05*	Personal
OR 50A	5-Sta.in-line	88.53	177.06	159.35(@10%)	154.57	Personal

*Recommend reduction of equipment from (4) to (3) machines, and fully relieve, including wash-up and lunch periods. This would provide a daily (less downtime and scrap) average output of 130/day (daily average production volume for 25,000/yr. @ 104/day).

HOUSING - AZIMUTH DRIVE - (25,000/YR)

OPERATION #20 1 Operator/2 Machines (@ 732.2 Secs./Cycle Time at Machine)

Operation to be relieved for all personal, wash-up and lunch periods. This due to two principal reasons: (1) Long cycle time of operation; (2) To bring production volume level up closer to other operations on this part.

Additionally, if tool changes should be necessary the total output (with one mach. down per time) would not be reduced too drastically. Planned tool changes should be made at end of shift, through the period between shifts, and at the beginning of the 2nd shift (also at end of 2nd shift, when necessary).

AVAILABLE MACHINE OPERATING TIME/SHIFT (2 MACHS.)		960	Mins
Plus: Lunch Period of 30 Mins (x 2 Machs.)		60	Mins
Total Available Production Time		1,020	Mins
Less: Check Station for Tools, etc. at Startup (2 x 5)	10	Mins	
Startup Mach. #1 (#2 Down x 6.1)	6.1	Mins	
Shutdown Mach. #2 (#1 Down x 6.1)	6.1	Mins	
Cleanup at End of Shift (2 x 10 Mins)	20	Mins	42.2 Mins
Available Machine Operating Time/Shift		977.8	Mins

SHIFT PRODUCTION (8 Hrs. + 30 Mins Lunch)

$$977.8 \text{ Mins/Shift} \div \frac{732.2 \text{ Secs/Cycle}}{60 \text{ Secs/Min}} = 80.15 \text{ PCS/Shift}$$

DAILY PRODUCTION (16 Hrs. + 2 x 30 Mins Lunch)

$$80.15 \text{ PCS/Shift} \times 2 \text{ Shifts} = 160.30 \text{ PCS/2 Shifts}$$

$$\text{Less: } 5\% \text{ Machine Downtime} = 152.29$$

$$3\% \text{ Scrap Loss} = 147.72$$

HOUSING - AZIMUTH DRIVE - (25,000/YR)

OPERATION #30 1 Operator/3-Sta. Machine (@ 380 Secs./Machine Cycle)

Operation to be relieved for all personal time only. Normally this operation to be shut down for the washup-lunch period. During this shutdown and between shifts the equipment should be checked for tools quality, etc. to minimize downtime during planned operating time.

AVAILABLE MACHINE OPERATING TIME/SHIFT		480 Mins
Less: Check Station for Tools, etc. at Startup	5 Mins	
1/2-Cycle Loss (Avg.) for Lunch Shutdown	3 Mins	
Wash-up Before Lunch	5 Mins	
1/2-Cycle Loss (Avg.) for End of Shift Shutdown	3 Mins	
Cleanup Work Area, Machine, etc. End of Shift	10 Mins	26 Mins
Available Machine Operating Time/Shift		454 Mins

SHIFT PRODUCTION (8 Hrs.)

$$454 \text{ Mins/Shift} \div \frac{380 \text{ Secs/Cycle}}{60 \text{ Secs/Min}} = 71.69 \text{ PCS/Shift (8.96 PPH Avg.)}$$

DAILY PRODUCTION (16 Hrs.)

$$71.69 \text{ PCS/Shift} \times 2 \text{ Shifts} = 143.38 \text{ PCS/2 Shifts}$$

$$\text{Less: } 10\% \text{ Machine Downtime} = 129.04$$

$$3\% \text{ Scrap Loss} = 125.17$$

*In-Line Machines Projected Downtime @ 10%

HOUSING - AZIMUTH DRIVE - (25,000/YR)

OPERATION #40 1 Operator/4-Sta. Machine (@ 361 Secs./Machine Cycle).

Operation to be relieved for all personal time only. Normally this operation to be shut down for the washup-lunch period. During this shutdown and between shifts the equipment should be checked for tools quality, etc. to minimize downtime during planned operating time.

AVAILABLE MACHINE OPERATING TIME/SHIFT		480 Mins
Less: Check Station for Tools, etc. at Startup	5 Mins	
1/2-Cycle Loss (Avg.) for Lunch Shutdown	3 Mins	
Wash-up Before Lunch	5 Mins	
1/2-Cycle Loss (Avg.) at End of Shift	3 Mins	
Cleanup Work Area, Machine, etc. End of Shift	10 Mins	26 Mins
Available Machine Operating Time/Shift		454 Mins

SHIFT PRODUCTION (8 Hrs.)

$$454 \text{ Mins/Shift} \div \frac{360 \text{ Secs/Cycle}}{60 \text{ Secs/Min}} = 75.67 \text{ PCS/Shift (9.46 PPH Avg.)}$$

DAILY PRODUCTION (16 Hrs.)

$$75.67 \text{ PCS/Shift} \times 2 \text{ Shifts} = 151.34 \text{ PCS/2 Shifts}$$

$$\text{Less: } 10\% \text{ Machine Downtime} = 136.20$$

$$3\% \text{ Scrap Loss} = 132.11$$

*In-Line Machines Projected Machine Downtime @ 10%

HOUSING - AZIMUTH DRIVE - (25,000/YR)

OPERATION #50 1 Operator/4 Machines - (1200 Secs. Cycle Time/Machine).

Operation to be relieved for all personal time only. Normally this operation to be shut down for the washup-lunch period. During this shutdown and between shifts the equipment should be checked for tools quality, etc. to minimize downtime during planned operating time.

AVAILABLE MACHINE OPERATING TIME/SHIFT (4 x 480)		1920 Mins
Less: Check for Tools, etc. (4 x 10 Mins)	40 Mins	
Startup #1 Machine (2,3 & 4 Down x 5 Mins)*	15 Mins	
Startup #2 Machine (3 & 4 Down x 5 Mins)*	10 Mins	
Startup #3 Machine (4 Down x 5 Mins)*	5 Mins	
Shutdown for Washup-Lunch	30 Mins	
1/2 of Machine Cycle Times Loss**(Average)	15 Mins	
Washup (4 x 5 Mins)	20 Mins	
Startup After Lunch	30 Mins	
Shutdown for End of Shift	30 Mins	
1/2 of Machine Cycle Times Loss**(Average)	15 Mins	
Cleanup (4 x 15 Mins)	60 Mins	270 Mins
Available Machine Operating Time/Shift		1650 Mins

SHIFT PRODUCTION (8 Hrs.)

$$1650 \text{ Mins/Shift} \div \frac{1200 \text{ Secs/Cycle}}{60 \text{ Secs/Min}} = 82.50 \text{ PCS/Shift (10.31 PPH)}$$

DAILY PRODUCTION (16 Hrs.)

$$82.50 \text{ PCS/Shift} \times 2 \text{ Shifts} = 165.00 \text{ PCS/2 Shifts}$$

$$\text{Less: } 5\% \text{ Machine Downtime (Individual Machines)} = 156.75$$

$$3\% \text{ Scrap Loss} = 152.05$$

*Loss Due to Each Startup and Shutdown

**Individual Machines Downtime Projected @ 5%

HOUSING - AZIMUTH DRIVE - (25,000/YR)

OPERATION 50A 1 Operator/5-Sta. Machine (@ 305 Secs./Machine Cycle).

Operation to be relieved for all personal time only. Normally this operation to be shut down for the washup-lunch period. During this shutdown and between shifts the equipment should be checked for tools quality, etc. to minimize downtime during planned operating time.

AVAILABLE MACHINE OPERATING TIME/SHIFT		480 Mins
Less: Check Station for Tools, etc. at Startup	5 Mins	
1/2-Cycle Loss (Avg.) for Lunch Shutdown	2.5 Mins	
Washup Before Lunch	5 Mins	
1/2-Cycle Loss (Avg.) for End of Shift	2.5 Mins	
Cleanup Work Area, Machines, etc.	15 Mins	30 Mins
Available Machine Operating Time/Shift		450 Mins

SHIFT PRODUCTION (8 Hrs.)

$$450 \text{ Mins/Shift} \div \frac{305 \text{ Secs/Cycle}}{60 \text{ Secs/Min}} = 88.53 \text{ PCS/Shift (11.07)}$$

DAILY PRODUCTION (8 Hrs.)

$$88.53 \text{ PCS/Shift} \times 2 \text{ Shifts} = 177.06 \text{ PCS/2 Shifts}$$

$$\text{Less: } 10\% \text{ Machine Downtime} = 159.35$$

$$3\% \text{ Scrap Loss} = 154.57$$

*In-Line Machines @ 10% Downtime

RELIEF CALCULATIONS

TAG RELIEF - For Continuous Operation - Lunch Shutdown

(2) Shutdown Relief @ 10 Mins	20 Mins	
(3) Personal Reliefs (9 + 9 + 8)	26 Mins	
Total Relief Operator for Personal		46 Mins
(5) Allowance for Walk to Relief Station @ 3 Mins		15 Mins
Total Relief Operator Time/Operator Relieved		61 Mins

Therefore:

Relief operator can take own personal relief (46 minutes + washup) plus relieve total of (6) machine operators (7 hours only available due to policy of no relief 15 minutes after startup of shift, 15 minutes before and 15 minutes after lunch, and 15 minutes before shift end).

Relief calculated thus at $\frac{100\%}{6 \text{ oper.}} = 16.7\%$ Relief Allowance/Oper. Relieved

(6 oper. @ 61 mins + 51 mins for self + 60 mins no relieve = 477 mins/shift)

TAG RELIEF - For Continuous Operation, Including Washup and Lunch

(2) Shutdown Relief @ 10 Mins	20 Mins	
(3) Personal Relief (9 + 9 + 8)	26 Mins	
Total Relief/Operator for Personal		46 Mins
(1) Relieve for Washup Before Lunch		5 Mins
(1) Relieve for Lunch Period		30 Mins
(6) Allowance for Walk to Relief Station @ 3 Mins		18 Mins
Total Relief Operator Time/Operator Relieved		99 Mins

Therefore:

Relief operator can take own personal relief (46 minutes + 5 minutes washup) plus relieve maximum of (3) machine operators (7 hours only available - see above note). As this leaves a fair amount of time for "other" work relief calculation based on 3 operators @ 99 minutes + 51 minutes for self = 348 mins.

$\frac{348 \text{ Mins. Rel. Time}}{480 \text{ Mins. Avail. Time}} = 72.5\%$ Rel. $\div$ 3 Operators Rel'd. = 24.2%/Operator.

(480 Mins./Shift - 348 Mins. Relief Time = 132 Mins. Available for "other" work)

SUPPORT STRUCTURE - PEDESTAL - TAPERED END

EXPAND TIME INDICATED AT 45 SECONDS (of Total 120 Second Cycle)

#1 - 2 mins.
#2 } 1 1/3 mins. each
(Figure at 1 1/2 Mins.)

1 & 2 = 7 PCS/

8 Hr. Shift
2 Mach. x 480 Mins. = 960 Mins. Avail./2 Mach.
- 30 Mins.*
= 930 Mins. = 620 ÷ 8 = 77.5 x 2 Setups = 155 Available/Hour Avg. (Req'd: 130/Hour Avg.)

Startup 2 x 5 Mins. = 10
Washup 2 x 5 Mins. = 10
Shutdown 2 x 5 Mins. = 10

* 30 Mins. (Rel'd. Personal)

90 secs/cycle
60 secs/min.

RECOMMEND:

- (2) Operators on (4) Machines - (2 Bridge Cranes to Service Setups)
 - (1) Operator for Truck-Moving of Containers (Supply & Fin'd. Parts), Relief, Trouble Shooter, Machines, etc.
 - (3 Operators to Work as a Team)
- Therefore: (4) Machines Required Instead of Indicated (5) Machines (-\$80,000)
(2) Overhead Crane Monorails Instead of (3) Indicated (-\$20,000)

RATE INFORMATION

155/Hours Available from (2) Operators Plus (1) Supply, Relief Operator (3 Operator Team)

Therefore: $\frac{155 \text{ PPH} \times 8 \text{ Hrs/Shift}}{3 \text{ Oper.} \times 8 \text{ Hrs/Shift}} = 51.67 \text{ PPH/Operator}$

Due to Some Time Losses Inherent in an Overlapping Cycle Operation Use: 50 PPH for Est.

MANPOWER REQUIREMENTS @ 250,000/YEAR

ZINC GALVANIZING (3 Systems)	OPERATORS	MAINTEN.	SWEEPERS	MAT'L. HDLRS.	TOTALS
Azim. Hsg./Drag Link	3 + 3 = 6		1 + 1 = 2	1 + 1 = 2	3 + 3 = 6
Pedestal	3 + 3 = 6				3 + 3 = 6
Torque Tube Ass'y.	3 + 3 = 6				3 + 3 = 6
Gen'l. Area		1 + 1 = 2	1 + 1 = 2	1 + 1 = 2	3 + 3 = 6
	9 + 9 = 18	1 + 1 = 2	1 + 1 = 2	1 + 1 = 2	12 + 12 = 24

SUMMARY DATA

TOTAL HELIOSTAT

B/M	25 K (SH/100)	250 K (SH/100)
4418 Reflective Unit (#4418 Not in B/M)	-	-
4411 Reflective Surface (Total for 12)	95.808	47.460
4412 Mirror Back Structure (Total for 2)	30.400	30.400
4413 Assembly & Bond (Refl. Unit) (Total for 2)	41.000	44.150
4420 Drive Unit (#4420 Not in B/M)	-	-
4421 Azimuth (Azim. Dr. Ass'y.) (Azim. Hsg.-Galv.) (Bearing Retainer) (Circular Spline) (Drive Shaft) (Flex Spline) (Housing-Azim. Dr.) (Housing-Azim. Dr.-Weld) (Wave Generator) (Sub-total)	56.390 - 31.590 58.182 (Purch) 45.058 82.832 (Purch) 27.435 (301.487)	16.238 3.200 39.238 28.775 7.787 48.151 18.364 40.527 29.240 (231.520)
4422 Elevation (Drag Link-Elev. Dr.) (Elev.-Dr. Ass'y.) (Drag Link-Weld) (Drag Link-Galv.) (Main Beam Ass'y.) (Torque Tube-Elev. Dr.) (Torque Tube-Galv.) (Sub-total)	16.750 59.000 (Purch) - (Purch) 35.167 - (110.917)	2.576 40.000 4.924 3.200 5.100 2.788 6.400 (64.988)
4423 Motor Total	24.400	15.150
4424 Position/Limit Indicator	22.718	19.984
4425 Power Supply/Distribution	92.839	79.672
4426 Ass'y. Dr./Pedestal/Electr. (#4426 Not in B/M)	-	-
4433 Control/Signal Eq't.	37.454	30.069
4451 Heliostat Support Structure (Pedestal & Found. Cap.) (Pedestal & Taper Pipe-Galv.) (Support Structure-Final) (Sub-total)	(Purch) - 41.900 (41.900)	18.741 6.400 41.100 (66.241)
TOTAL (Std. Hrs./100 Units)	798.923	629.634

Y: EGV DATE: 11/12/79 SUBJECT: Summary Data - Standard SHEET NO: 1 OF: 1
 HKD. BY: DATE: Hours/100 Units (SH/100) & Oper- JOB NO:
 ators Earned by Classif.

DESCRIPTION	TOTAL SH/100	ASSEMBLERS SH/100 OPS	WLD & MACH SH/100 OPS	TRKR/MH SH/100 OPS	INSPECT SH/100 OPS	MISC SH/100 OPS	TOTAL SH/100	ASSEMBLERS SH/100 OPS	WLD & MACH SH/100 OPS	TRKR/MH SH/100 OPS	INSPECT SH/100 OPS	MISC SH/100 OPS
4411 Reflective Surf (12 Tot)	95.808	68.916		11.292	15.600		47.460	31.848 41½		10.812 14	4.800 6½	
4412 Mirror Back Struct (2 Tot)	30.400	24.400		4.000	2.000		30.400	24.400 32		4.000 5	2.000 2½	
4413 Ass'y & Bond (Refl Unit) (2 Tot)	41.000	35.000		5.000	1.000		44.150	38.150 49½		5.000 6½	1½	
4421 Azimuth-Azim Dr Ass'y	56.390	54.390			2.000		16.238	15.538 20			.700 1	
-Azim Hsg-Galv	-						3.200					3.200 4
-Bearing Retainer	31.590		28.840	1.750	1.000		39.238		34.538 45	2.500 3	.400 ½	1.800 2½
-Circular Spline	58.182		56.182	1.000	1.000		28.775		27.975 36	.400 ½	.400 ½	
-Drive Shaft (Purch)	45.058						7.787		6.687 9	.600 1	.500 ½	
-Flex Spline	82.832		41.758	1.800	.500	1.000	48.151		45.051 59	1.800 2	.300 ½	1.000 1½
-Housing-Azim Dr	(Purch)		63.689	8.000	11.143		18.364		6.364 8	8.000 10½	4.000 5	
-Housing-Azim Dr-Wld	27.435						40.527		38.227 50	.800 1	1.500 2	
-Wave Generator	(301.487)		25.035	2.000	.400		29.240		26.840 35	.400 ½	2.000 2½	
(Sub-total)							(231.520)					
4422 Elevation-Drag Link-El Dr	16.750		15.750	.500	.500		2.576		1.576 2	.500 1	.500 1	
-Elev Dr Ass'y	59.000	55.000			4.000		40.000	30.000 39		5.000 6½	3.750 5	1.250 1½
-Drag Link-Wld	(Purch)						4.924		4.324 6	.400 ½	.200	
-Drag Link-Galv	-						3.200					3.200 4
-Main Beam Ass'y	(Purch)						5.100		4.200 5	.400 ½	.500 1	
-Torque Tube-El Dr	35.167		33.667	1.000	.500		2.788		1.638 2	.400 ½	.750 1	
-Torque Tube-Galv	(110.917)						6.400					6.400 8½
(Sub-total)							(64.988)					
4423 Motor Total	24.400	10.400		4.000	10.000		15.150	10.400 13½		4.000 5	.750 1	
4424 Position/Limit Indicator	22.718	20.718			2.000		19.984	19.984 26				
4425 Power Supply/Distribution	92.839	61.267		13.000	18.572		79.672	48.100 62½		13.000 17	18.572 24	
4433 Control/Signal Eq't	37.454	18.287		4.667	14.500		30.069	12.652 16½		4.667 6	12.750 16½	
4451 HelioStat Support Struct												
-Pedestal & Found'n Cap	(Purch)						18.741		15.341 20	2.600 3½	.800 1	
-Ped & Taper Pipe-Galv	-						6.400					6.400 8½
-Support Struct-Final	41.900	12.500		25.400	4.000		41.100	12.500 16		25.400 33	3.200 4	
(Sub-total)	(41.900)						(66.241)					
Grand Totals: SH/100	798.923	360.875	264.921	83.409	88.715	1.000	629.634	243.572	212.761	90.679	59.372	23.250
Daily (Avg) Build Sched	104						1042					
Total Earned Hrs/Day	831 Hrs	375	276	87	100	1	6561 Hrs	2538	2217	945	619	242
Total Earned Manpower	104 OPS	47	34	11	12	-	820 OPS	317	277	118	78	30
% Breakdown by Classif'n	(100%)	(45%)	(33%)	(10%)	(12%)		(100%)	(34%)	(14%)	(14%)	(10%)	(3%)

GM Transportation Systems Center

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