FINAL REPORT

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APRIL 1981

MCDONNELL DOUGLAS

SECOND GENERATION HELIOSTAT

WITH HIGH-VOLUME MANUFACTURING FACILITY DEFINED BY GENERAL MOTORS

VOLUME II

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY-HUNTINGTON BEACH

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SECOND GENERATION HELIOSTAT FINAL REPORT

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MCDONNELL DOUGLAS ASTRONAUTICS COMPANY-HUNTINGTON BEACH

5301 Bolsa Avenue Huntington Beach, California 92647 (714) 896-3311

PREFACE

This report provides the results of a heliostat development program performed by the McDonnell Douglas Astronautics Company for Sandia National Laboratories, Livermore, California, under Contract 830024A. This program involved design, fabrication, and test of prototype heliostats which, when produced in high volume, support the Department of Energy goals for solar central receiver power plant economics.

Volume factory design and output costs were provided under a subcontract by the General Motors Energy Systems Group and the F. Jos Lamb Company. MDAC incorporated these costs into price analysis including factory and field installation costs, a return of investment, and profit. The price followed previous program projections and substantiated the potential for attaining DOE goals.

The heliostat design was based substantially on previous MDAC development effort. The prototype heliostat, in conjunction with MDAC-developed controls hardware and software, exceeded all performance requirements.

The next requirement is a market demand, which will determine sales volume and in turn dictate production processes and costs. MDAC and its suppliers are ready to supply this market at any volume level. The design developed under this contract is the property of the US Department of Energy for any Government applications. MDAC reserves the commercial rights to the subsystem and components through proprietary developments by MDAC and its suppliers of controls system hardware and software, drive components, and mirror module fabrication technology.

This report consists of two volumes. Volume I summarizes the subsystem design, test substantiation, and operations and provides the MDAC price analysis and detail subsystem cost analysis. Volume II provides the volume factory design, manufacturing process design, and factory costs as developed by General Motors Energy Systems and the F. Jos Lamb Company.

DEFINITION OF A HELIOSTAT MANUFACTURING FACILITY
FINAL REPORT

prepared for

McDonnell Douglas Astronautics Company
Subcontract No. 80712011

prepared by

The Energy Systems Group
GM Worldwide Truck & Transportation Systems Center
GM Technical Center
Warren, Michigan 48090

J. F. Britt
Project Manager

F. Jos. Lamb Company
5663 East Nine Mile Road
Warren, Michigan

H. L. Davey
D. A. McCarroll

ENERGY SYSTEMS

JANUARY 1981
EP-80133

FOREWORD

GM Transportation Systems Center (GM TSC) completed a study in December 1979, of the manufacturing cost of the McDonnell Douglas Astronautics Company solar central receiver prototype heliostat under contract to the Solar Energy Research Institute (SERI) of Golden, Colorado. That study is documented in a final report SERI/TR-8052-1, and in an executive summary report SERI/TR-8052-2. Both reports are available through the National Technical Information Service, Springfield, Virginia.

The primary objective of that study was to estimate the factory cost for the production of heliostats at production volumes of 25,000 and 250,000 units per year. The factory costs generated at those volumes were $\$95.99/m^2$ and $\$67.95/m^2$, respectively. The Policy Analysis Branch of the Solar Energy Research Institute concluded that this implied an installed price of $\$122.12/m^2$ at the 25,000 unit per year volume.

During the time that GM TSC was performing that study, the McDonnell Douglas Astronautics Company continued heliostat development activity leading to a simpler, more cost effective design identified as the McDonnell Douglas Second Generation Heliostat. The design activity was funded under a Sandia Laboratories contract. McDonnell Douglas has subcontracted GM Transportation Systems Center of General Motors Corporation to assist in the development of plant and manufacturing costs associated with the production of 50,000 McDonnell Douglas Second Generation Heliostats per year. The factory cost generated at that volume is $\$64.13/m^2$.

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1.0 INTRODUCTION

This is the final report of a study conducted by GM Transportation Systems Center to develop the definition of a heliostat manufacturing facility with a production capacity of 50,000 units per year.

In order to provide a self-contained document, this final report contains information from the Heliostat Production and Cost Analysis (Final Report, SERI/TR-8052-1) completed for SERI (December 1979).

1.1 CONTRACT PARTICIPANTS

In June 1980 the McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation contracted with the GM Transportation Systems Center, General Motors Corporation to provide services and assist in the development of a conceptual design for a heliostat manufacturing facility sized to produce 50,000 heliostats per year and to aid in estimating facility and manufacturing costs. The heliostat design used in this effort is one developed by the McDonnell Douglas Astronautics Company (MDC) under contract to Sandia National Laboratories, Livermore, and is a refinement of the design used by GM Transportation Systems Center (GM TSC) in performing a 1979 heliostat production evaluation and cost analysis study for the Solar Energy Research Institute (SERI).

The F. Jos. Lamb Company (Lamb) of Warren, Michigan, was the major subcontractor to GM TSC and developed processing, tooling requirements, machine estimates and the plant layout for the manufacture of the MDC heliostat.

The Harrison Radiator Division of General Motors developed labor estimates and performed the cost extension required to develop a heliostat factory cost and other GM Divisions and Staffs provided aid and consultation.

Edgar G. Wright, P.E. of Lockport, New York, provided industrial engineering consulting service during the contract effort.

1.2 SCOPE OF WORK

The work activity involved the collection and generation of engineering data on the specified heliostat design and a detailed buildup of all manufacturing costs. In addition, required capital investment was estimated and a factory layout defined.

The manufacturing processes, labor development, material costs and plant configuration resulting from the contract effort for this study are based on detailed design and engineering data. Therefore, the final factory cost is a figure based on collected detail and is not an estimate generated to meet a predetermined target cost. The production evaluation is based on current technology and all cost figures are expressed in 1980 dollars.

1.3 DATA SOURCES

The heliostat design data was provided by MDC on detail and assembly drawings, in basic manufacturing and process data and during interchanges with MDC personnel at Huntington Beach, California; Warren, Michigan and Lockport, New York. The heliostat itself is a pedestal mounted, non-inverting, azimuth and elevation tracking unit having a mirrored glass reflecting surface of $57m^2$ (612 ft^2).

Fusion-glass manufacturing and cost data was provided by the Corning Glass Works of Blacksburg, Virginia.

Float glass (back lite) cost data were provided by C-E Glass of Pennsauken, New Jersey.

Mirroring process and cost data were provided by Binswanger Mirror Products of Memphis, Tennessee.

Rolling mill cost data was provided by the Van Huffel Tube Corporation of Warren, Ohio.

Reflector support structure welding data was provided by the Dollar Electric Company of Madison Heights, Michigan.

In addition to the aforementioned major data sources, outside vendors were contracted and quotations or engineering cost estimates obtained for all material and purchased parts.

2.0 HELIOSTAT DESIGN

The heliostat design studied was developed by the McDonnell Douglas Astronautics Company under contract to Sandia National Laboratories, Livermore. The current design does not have an inverted stow mode eliminating the need for a separate stow actuator, and has an inverted azimuth drive that mounts in the top of the pedestal. Design efficiency has been improved over early designs by adding two mirror modules to increase the reflective surface area, (14 modules, each 4 ft by 11 ft) and reorienting the heliostat so its long axis is parallel to the ground thus reducing shadowing and blocking.

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 2-1. The reflector support structure is fabricated from roll-formed sheet metal sections which are welded together. The azimuth drive, main beam, elevation drive support assembly, and pedestal 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 jack 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, and electrical wire and connectors.

2.1 MIRROR MODULE

The reflective unit is a 4-foot by 11-foot laminated glass fabrication. Construction detail is shown in Figure 2-2.

The front lite of the reflective surface is 0.060 inch low-iron fusion glass manufactured by the Corning Glass Works of Blacksburg, Virginia. The rear surface of the front lite is plated with pure silver, overplated with copper and finally sprayed with a protective coating of mirror backing paint.

The back lite is 0.188 inch thick window grade float glass which is bonded to the front lite in an autoclave using a polyvinyl butyral sheet as the adhesive.

Silicone adhesive is applied to all four edges of the mirror module, to seal out moisture, and a metal channel is fitted over each edge for mechanical protection. The channel is formed of painted steel.

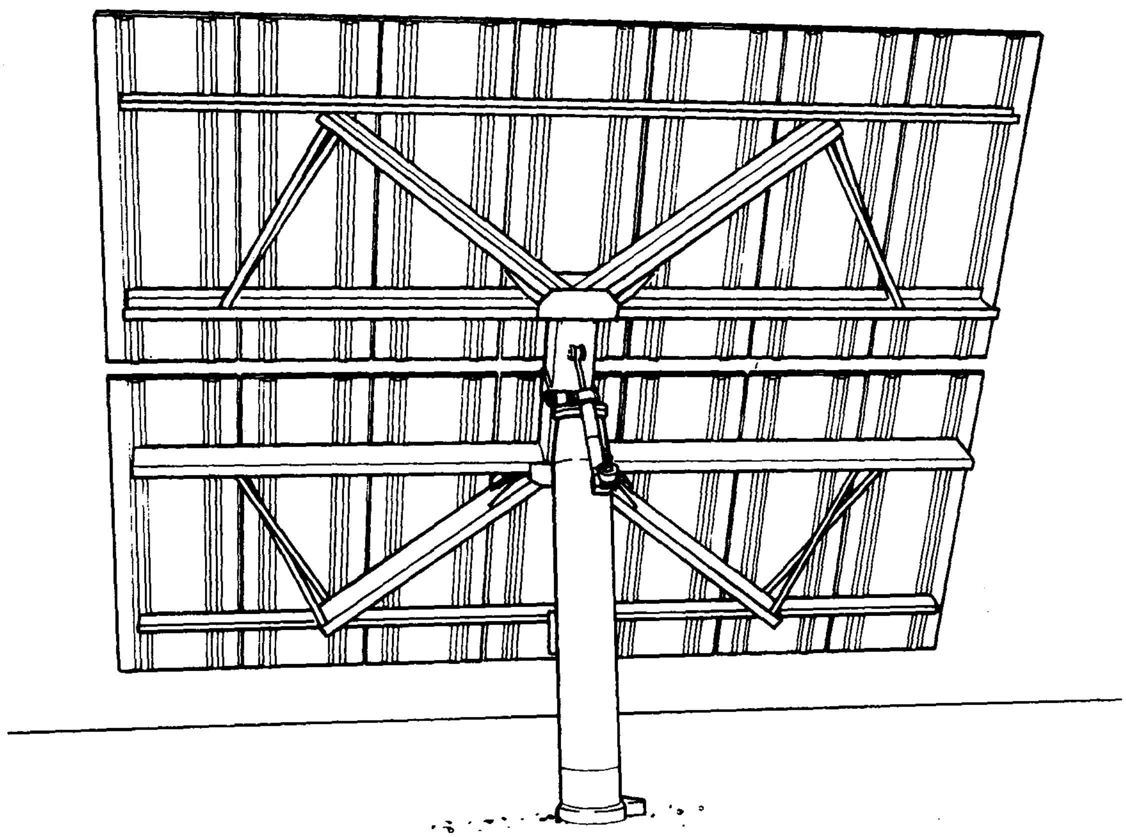

FIGURE 2-1. MCDONNELL DOUGLAS SECOND GENERATION HELIOSTAT

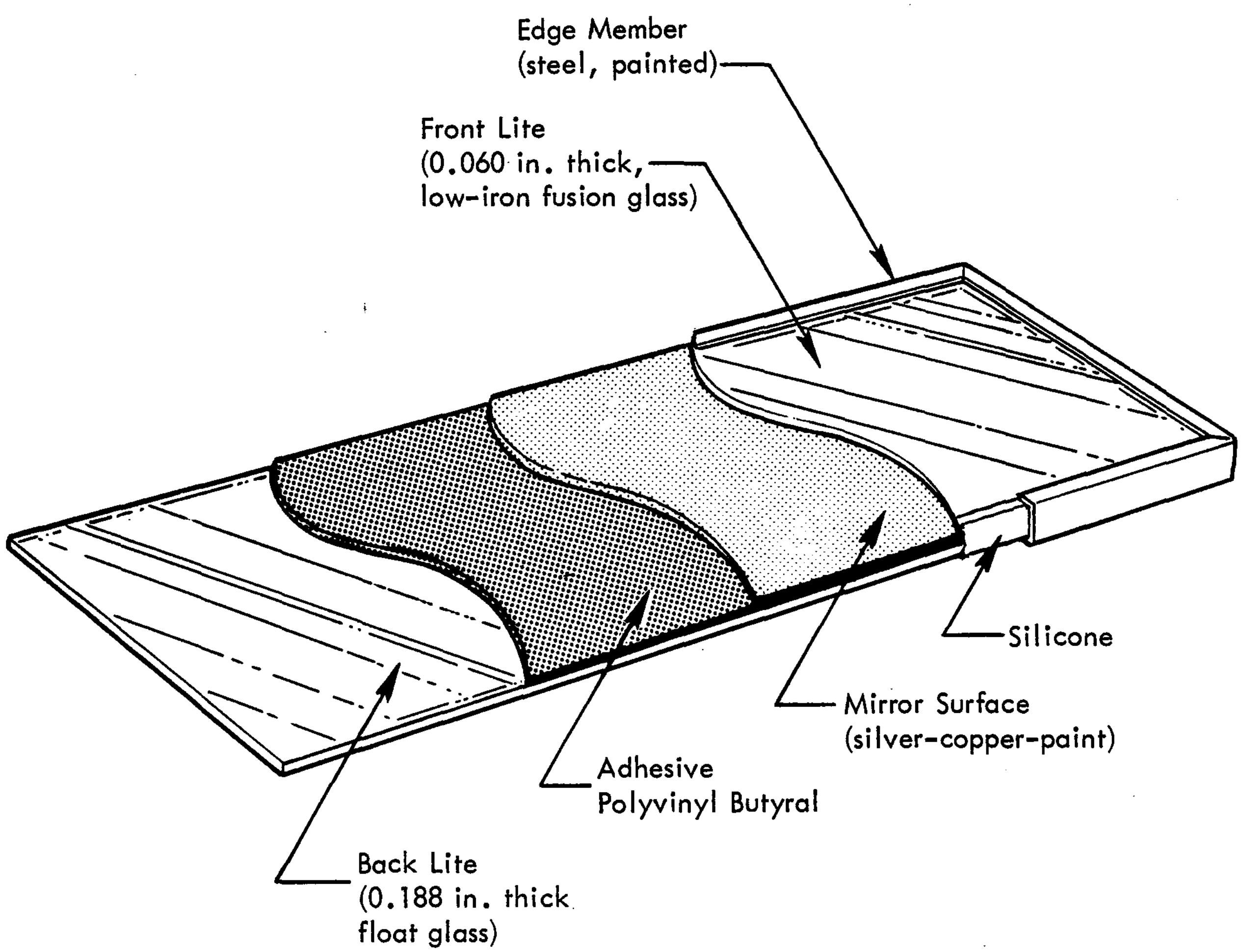

FIGURE 2-2. REFLECTIVE UNIT

Metal shims are bonded lengthwise to the glass lamination using a commercial adhesive, Stabond, and then hat-shaped sheet metal stringers are bonded to the shims using 3M EC 3532 as an adhesive. Each stringer has been roll formed from .063 inch steel and has two clinch nuts attached for use in securing the mirror module to the reflector support structure. Detail of the stringer, shim configuration is in Section 2.3 (Figure 2-4), Relector Assembly.

2.2 REFLECTOR SUPPORT STRUCTURE

The reflector support structure is assembled by spot welding roll formed sheet steel components together with gussets, backing plates and angle braces. The assembly shown in Figure 2-3 comprises an inboard cross beam, an outboard cross beam, two diagonal beams, two gussets, two backing plates and four angle braces. Fabrication requires cutting the beams after receipt from the steel roll forming mill, and then welding the beams and the reinforcing plates, gussets and angle braces. For this study, two changes have been made in the reflector support structure to reduce manufacturing cost.

1. The inboard cross beam has square cut ends instead of diagonally clipped ends, simplifying the processing.

2. The diagonal beam flanges are not cut, simplifying processing and reducing the number of different parts by eliminating the need for right and left hand beams.

2.3 REFLECTOR ASSEMBLY

The reflector assembly (see Figure 2-4) is fabricated by bolting seven mirror modules to the support structure using studs driven into the clinch nuts previously assembled into the mirror module stringers. Nuts are driven onto the studs where they project through the inboard main beam and outboard cross beam.

After the reflector assembly is complete it is racked for shipment; for a detailed illustration see Section 2.11.

2.4 AZIMUTH DRIVE

The azimuth drive (Figure 2-5) 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, a three-lobe wave generator, a flexible bearing, a circular spline and an input shaft. The

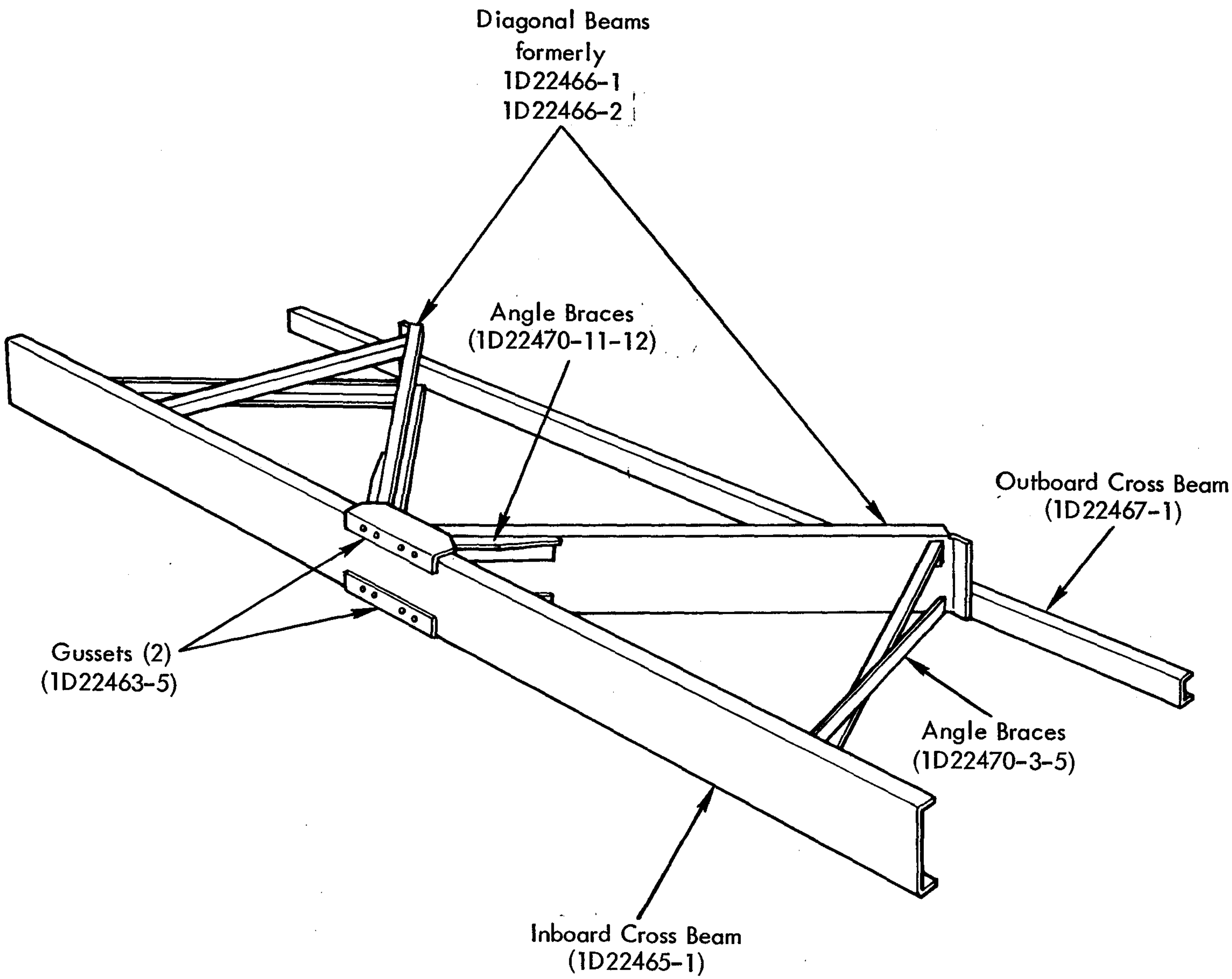

FIGURE 2-3. REFLECTOR SUPPORT STRUCTURE (1D22463-1)

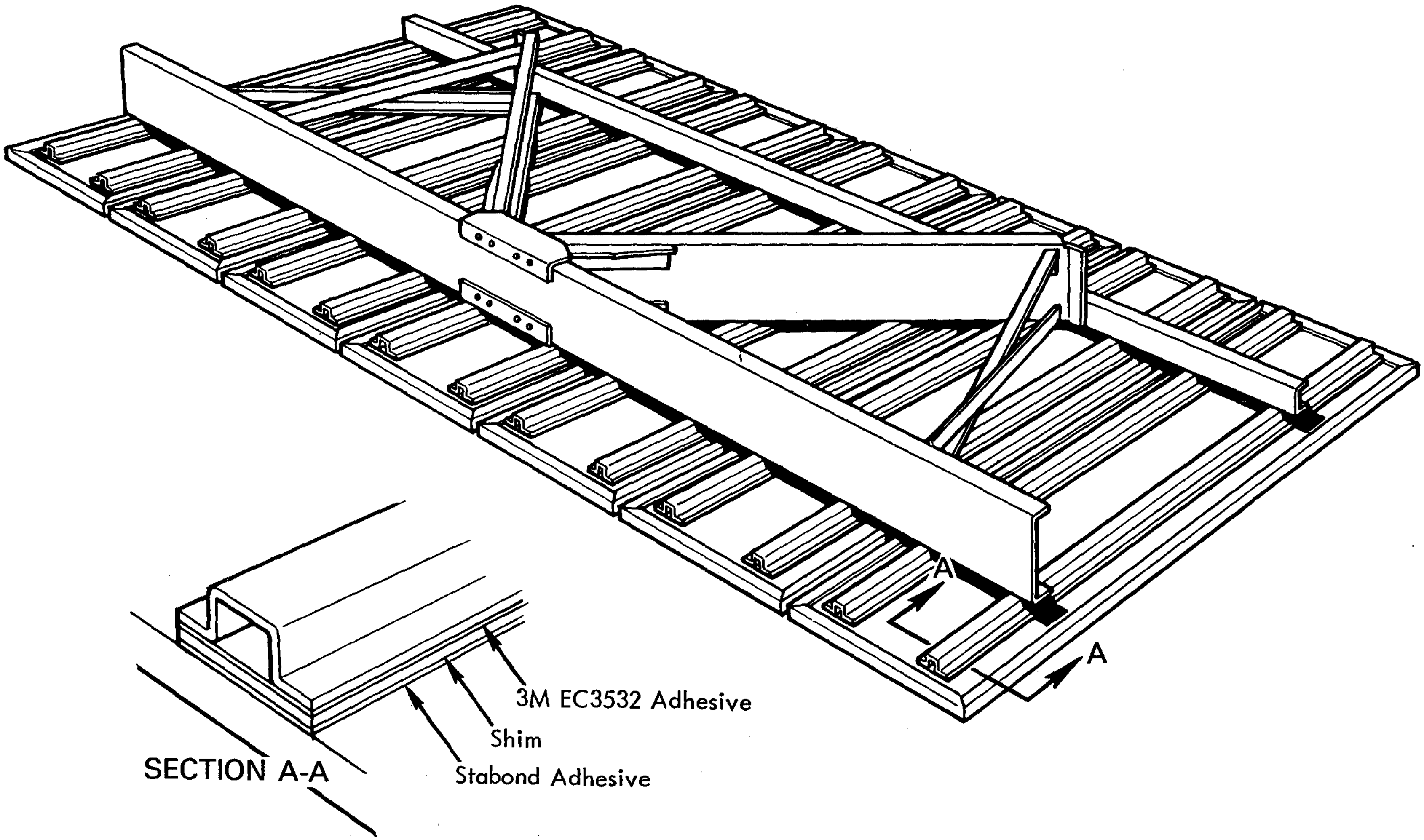

FIGURE 2-4. REFLECTOR ASSEMBLY

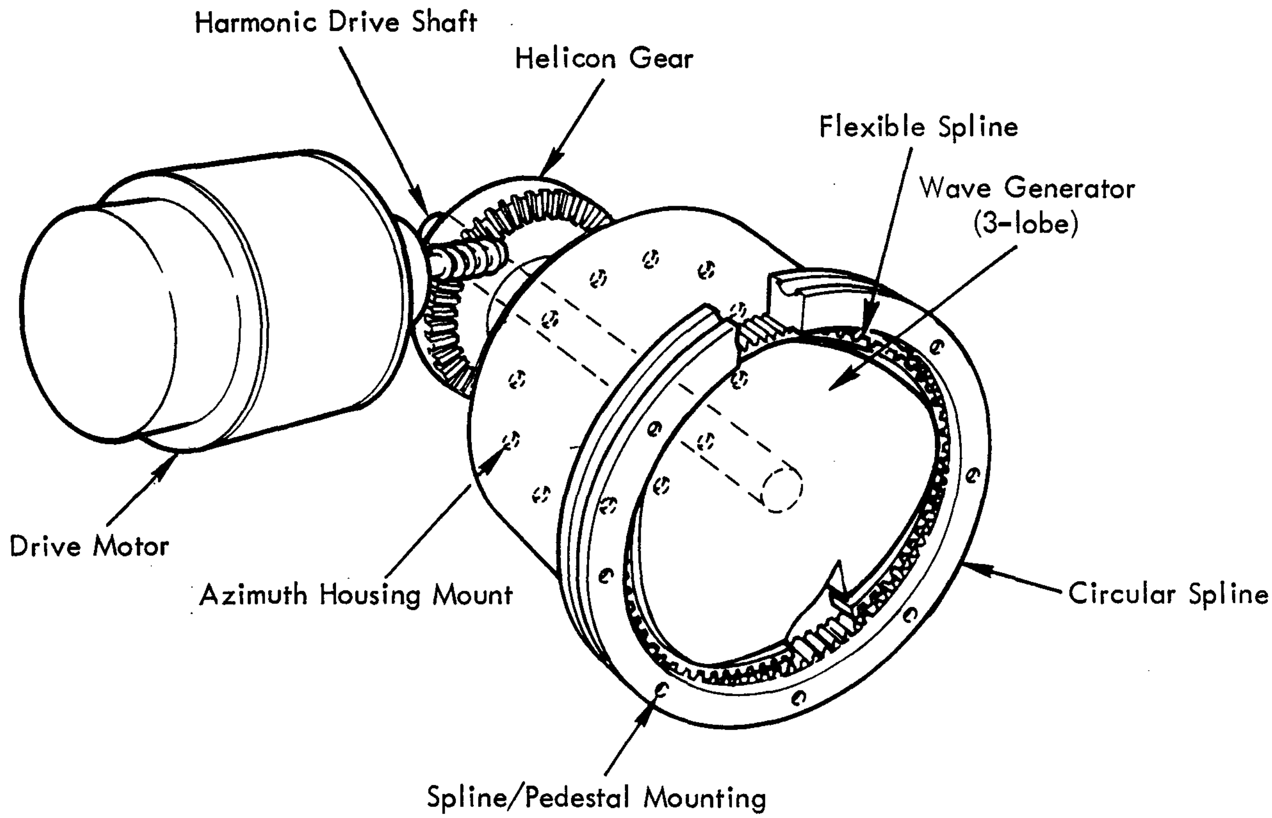

FIGURE 2-5. AZIMUTH DRIVE

flexible spline is fixed to the bottom of the azimuth housing by 12 plug welds. 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 housing. The input shaft is machined and center-bored to allow the power and control cables to be routed from the elevation motor and sensors to the heliostat controller. The drive housing includes holes for the mounting bolts which join the drive unit to the pedestal.

For this study, four changes have been made in the azimuth drive assembly to facilitate production and lower manufacturing costs. First (1), 12 plug welds are used in place of 12 pins and collars to mount the circular spline to the bottom of the azimuth drive housing. Second (2), the housing itself is now fabricated from a deep drawn part, reducing the amount of gear oil needed to fill the housing as well as simplifying the manufacturing process. Third (3), the filler block has been replaced by a toroid formed from two drawn parts connected with a snap joint. Fourth (4), the azimuth drive cover is now a stamping. These detail design changes are shown in Figure 2-6.

2.5 ACTUATOR ASSEMBLY, ELEVATION

The actuator assembly consists of an elevation jack, a drive motor, an incremental encoder electrical assembly, and various electrical and mechanical components.

2.6 SUPPORT ASSEMBLY, ELEVATION DRIVE

The elevation drive support assembly (Figure 2-7) is a casting that supports the main beam/reflector assembly and provides an attach point for the elevation actuator assembly. It is fixed to the azimuth drive/pedestal assembly by four bolts. This is a modification of the prototype where a weldment was used.

2.7 AZIMUTH/ELEVATION DRIVE ASSEMBLY

This assembly is an intermediate assembly not identified in the cost breakdown structure, but which occurs as a necessary element in the manufacturing process. The assembly contains the drive motors and mechanisms for the azimuth and elevation tracking functions as well as most signal and control electronics, and cables associated with heliostat operation.

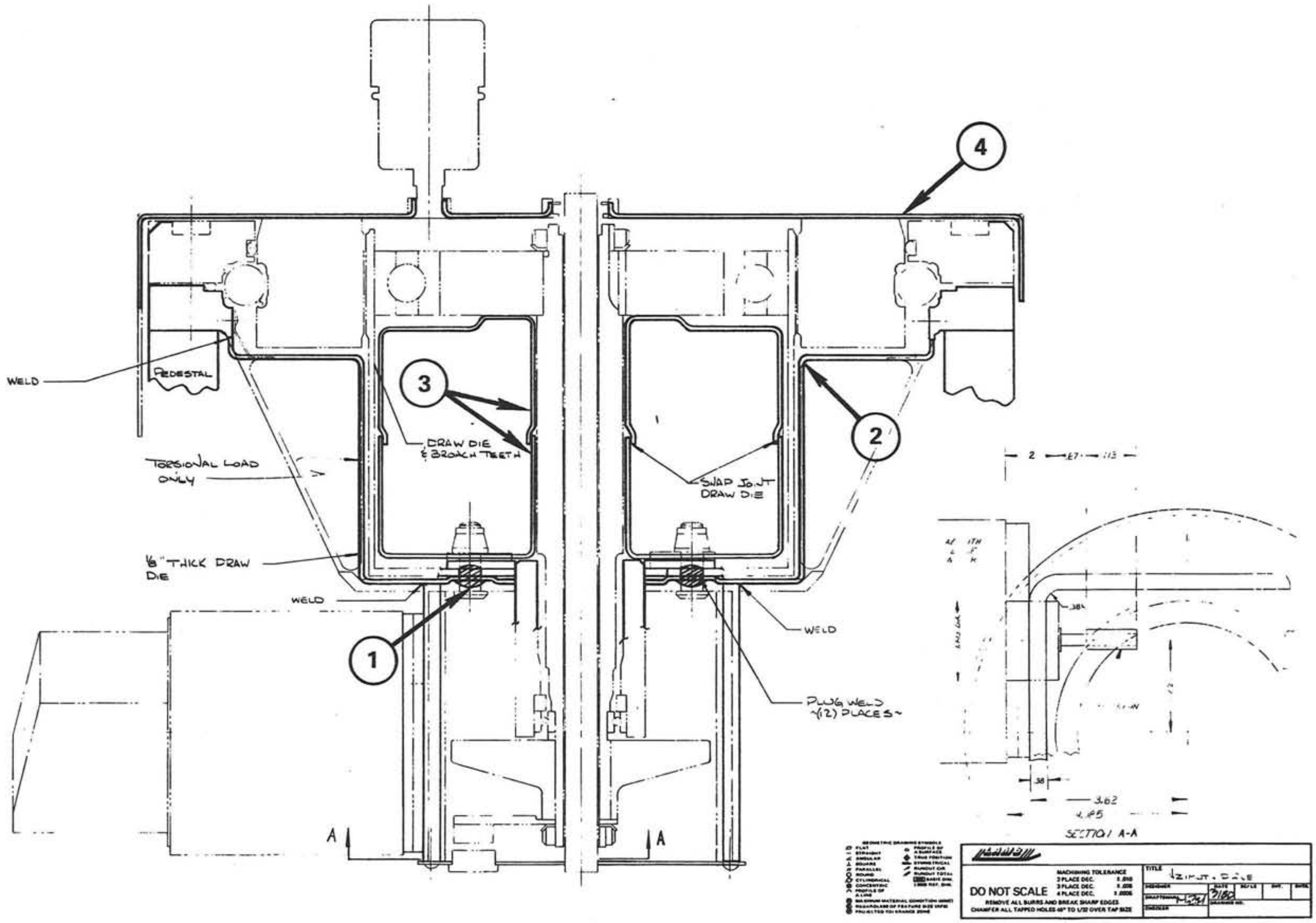

FIGURE 2-6. AZIMUTH DRIVE WITH HOUSING AND COVER

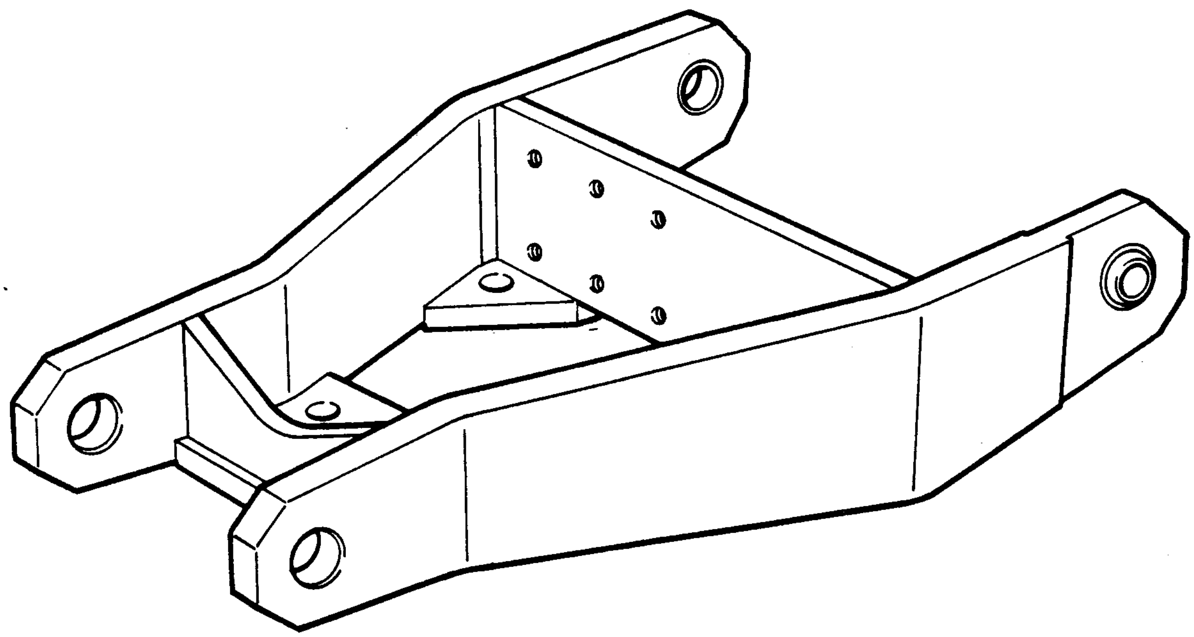

FIGURE 2-7. SUPPORT ASSEMBLY, ELEVATION DRIVE (1D22439-1)

2.8 MAIN BEAM

The main beam (Figure 2-8) is a fabricated weldment to which each reflector assembly is attached with 8 bolts. Tabs welded to the main beam provide attach points for the elevation drive support assembly and the elevation actuator.

2.9 PEDESTAL ASSEMBLY

The pedestal assembly (Figure 2-9) comprises a steel ring welded to a truncated cone which is, in turn, welded to a pipe. Subsequently, the lower end of the pipe is expanded to provide a 44 inch taper. Figure 2-9 shows the cutout for mounting the electrical/control junction box, but does not show the box itself.

2.10 DRIVE/PEDESTAL/MAIN BEAM ASSEMBLY

In the production process the elevation drive, azimuth drive, and main beam assembly are joined together by the elevation drive support assembly (see Figure 2-10). Together with the control electronics and power cable harnesses the drive/main beam assembly comprises the azimuth/elevation drive main beam assembly. This assembly is married to the pedestal in a final in-plant assembly process and the drive/pedestal/main beam assembly thus created is then racked for shipping (Figure 2-11).

2.11 HELIOSTAT ASSEMBLY

The heliostat arrives at the installation site in the form of two major assemblies, the reflector assembly (Figure 2-4), and the drive/pedestal/main beam assembly shown racked for shipping in Figure 2-11. The reflector assembly is shipped three to a rack (Figure 2-12) and the drive/pedestal/main beam assembly is shipped four to a rack.

At the site, two reflector assemblies are married to one drive/pedestal/main beam assembly to form a complete heliostat, thus three racks of drive/pedestal/main beam assemblies together with eight racks of reflector assemblies provide for twelve complete heliostats. The assembly process is straightforward and uncomplicated. Each reflector assembly is attached to the main beam by eight bolts (see Figures 2-4 and 2-8) after the drive/pedestal/main beam assembly has been erected on its foundation. The completed heliostat is shown in Figure 2-1.

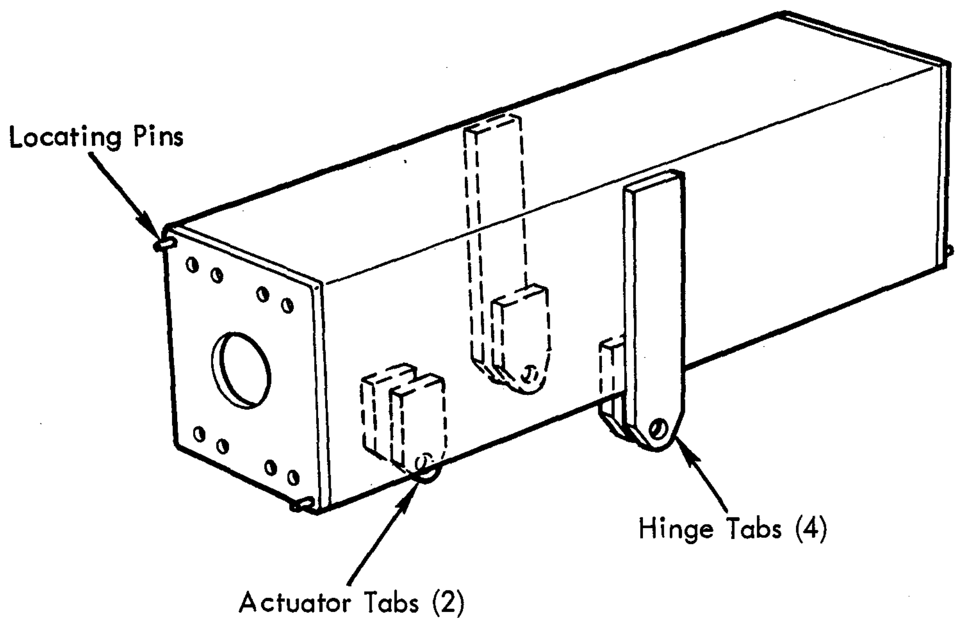

FIGURE 2-8. MAIN BEAM (1D22464-1)

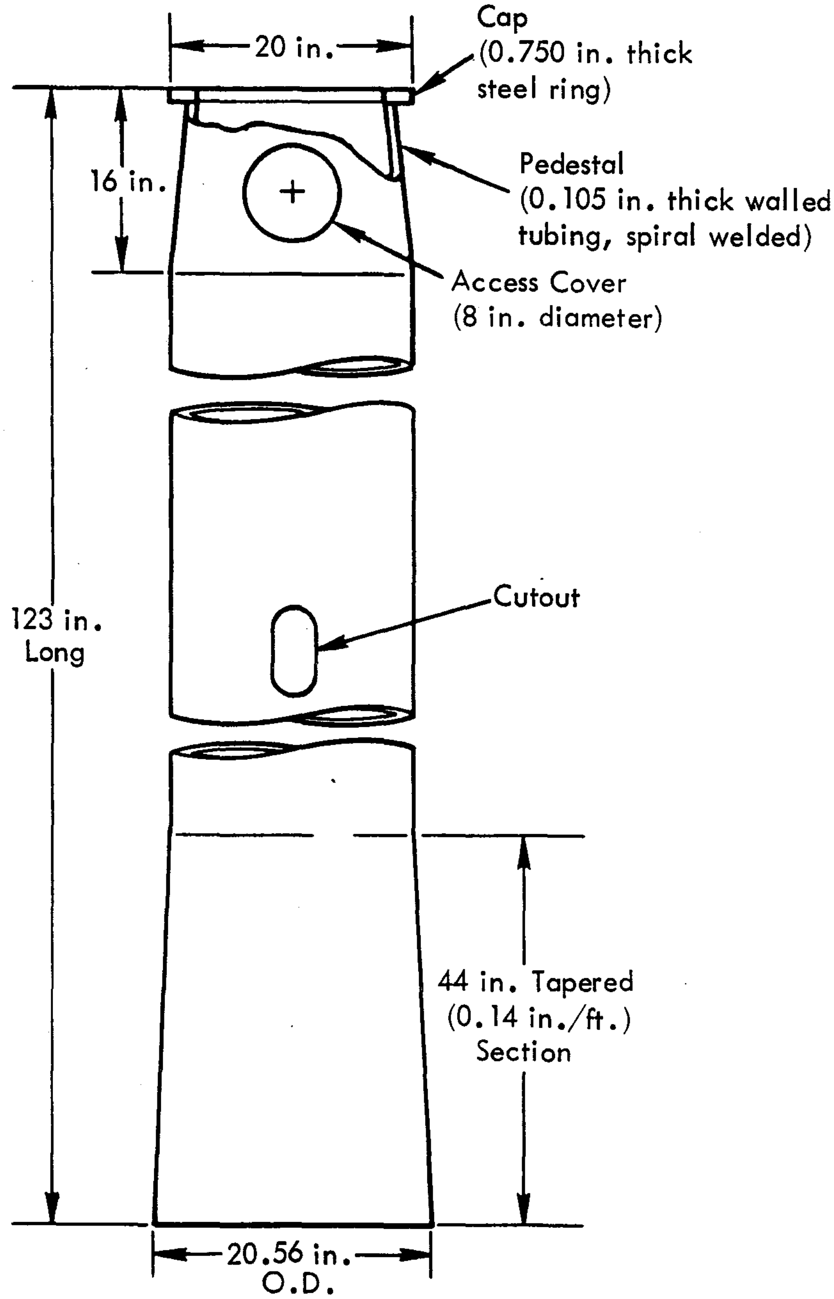

FIGURE 2-9. PEDESTAL ASSEMBLY(1D22461-1)

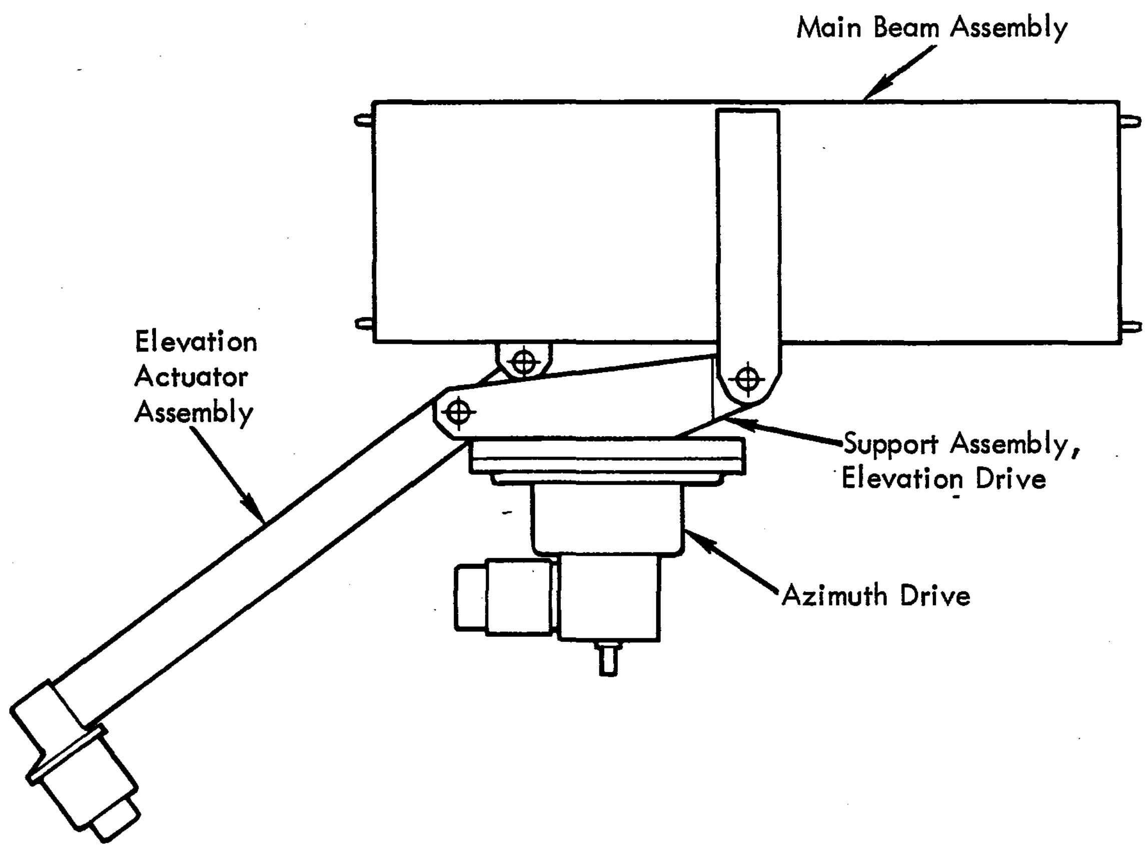

FIGURE 2-10. AZIMUTH/ELEVATION DRIVE/MAIN BEAM ASSEMBLY

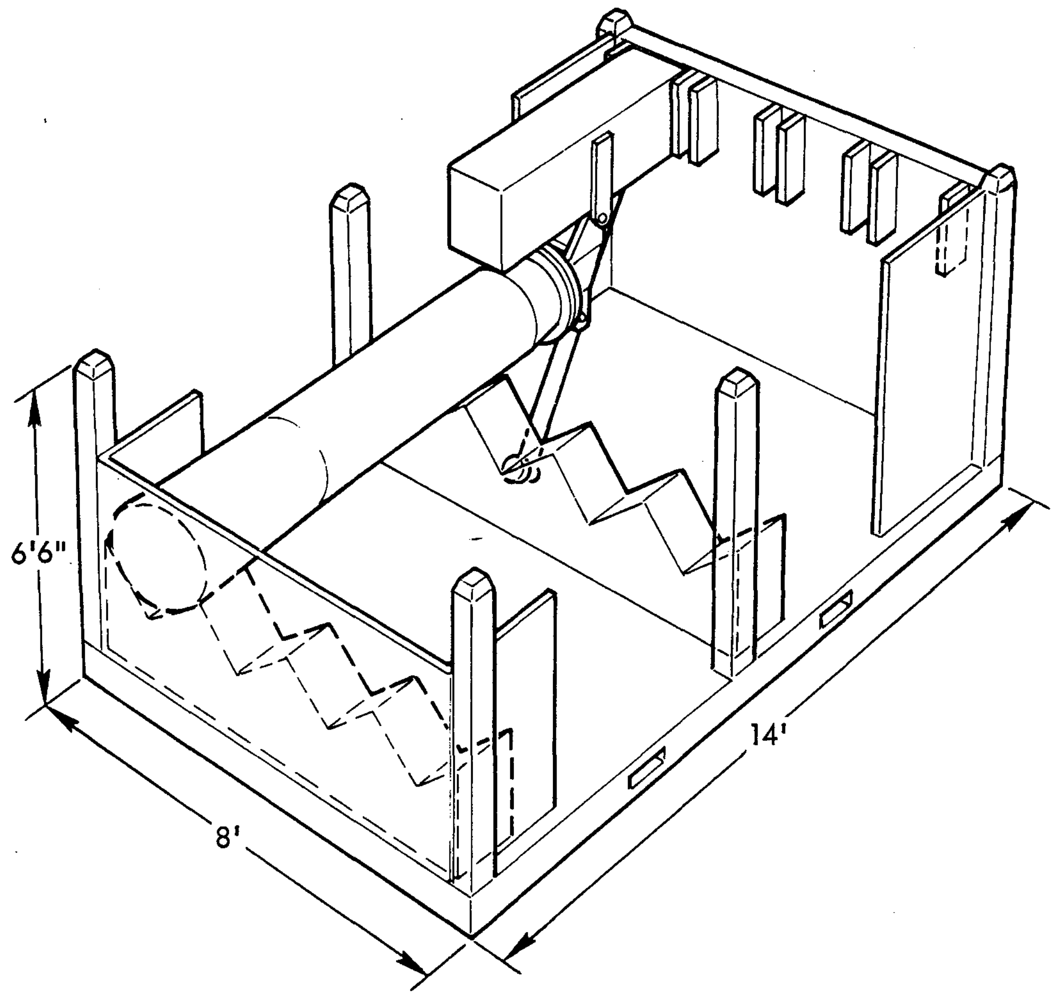

FIGURE 2-11. DRIVE/PEDESTAL/MAIN BEAM ASSEMBLY, RACKED FOR SHIPPING

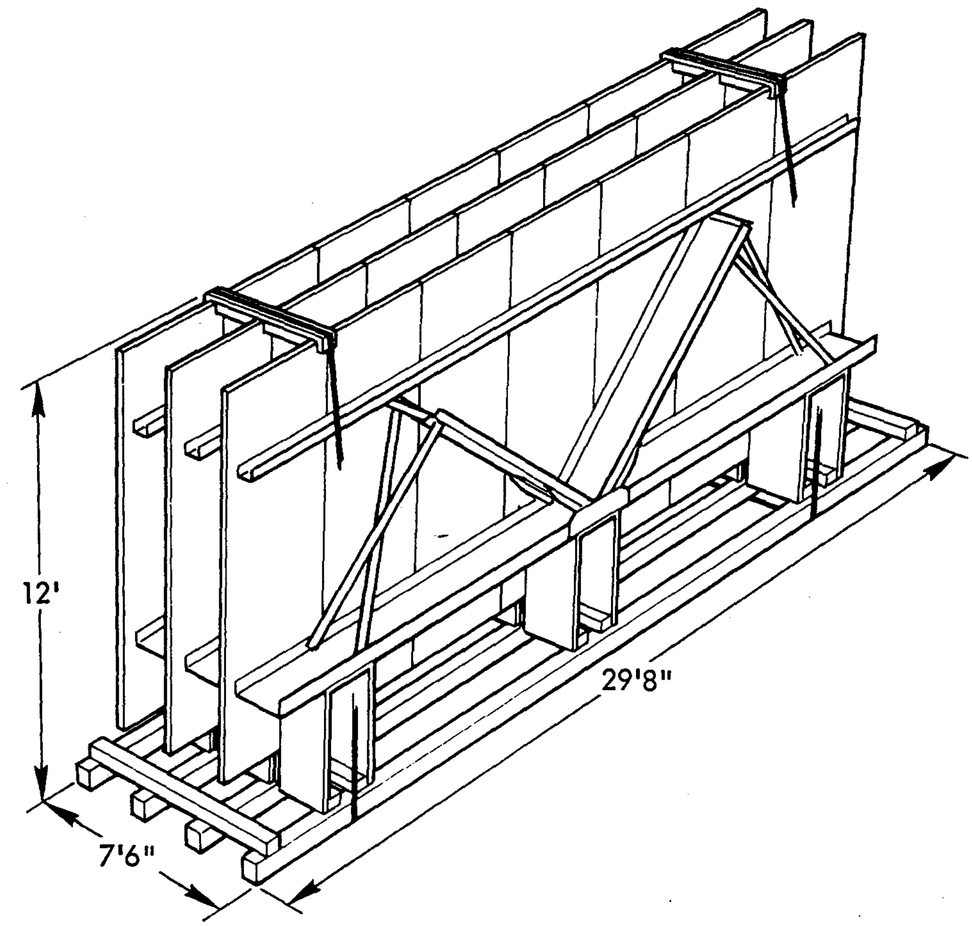

FIGURE 2-12. REFLECTOR ASSEMBLIES, RACKED FOR SHIPPING

3.0 STUDY APPROACH

The intent of this study is to provide the definition of a heliostat manufacturing facility capable of producing 50,000 heliostats per year and to generate the manufacturing costs associated with that level of production. This requires a cost breakdown structure, a bill of materials or parts list, preferably fully indentured, a detailed manufacturing analysis, a plant design, the development of the labor associated with the manufacturing processes and finally an extension of costs.

3.1 COST BREAKDOWN STRUCTURE

A cost breakdown structure defines the categories into which the various costs of manufacturing a product can be placed. 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 3-1 is the cost breakdown developed for the heliostat. The control or identification numbers, 1D22XXXX, of the cost breakdown structure are those used by McDonnell Douglas in their drawing and part numbering system for the Second Generation Heliostat.

3.2 INDENTURED PARTS LIST

One basic document used in a production cost analysis is 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 drawing or part number 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 the material source is shown.

In this study an indentured parts list was used in lieu of a bill of materials. The indentured parts list combined information from a bill of materials together with material and purchased part costs. The primary reference is the part number taken directly from the McDonnell Douglas part numbering system for the Second Generation Heliostat. This is followed by the part or material name or description, the quantity, the make (M) or buy (B) designation and finally the unit cost in 1980 dollars. The indentured parts list was generated by McDonnell Douglas and then modified and updated by GM TSC and the F. Jos. Lamb Co. to reflect the specific heliostat configuration costed in this study. The indentured parts list is Appendix A to this document.

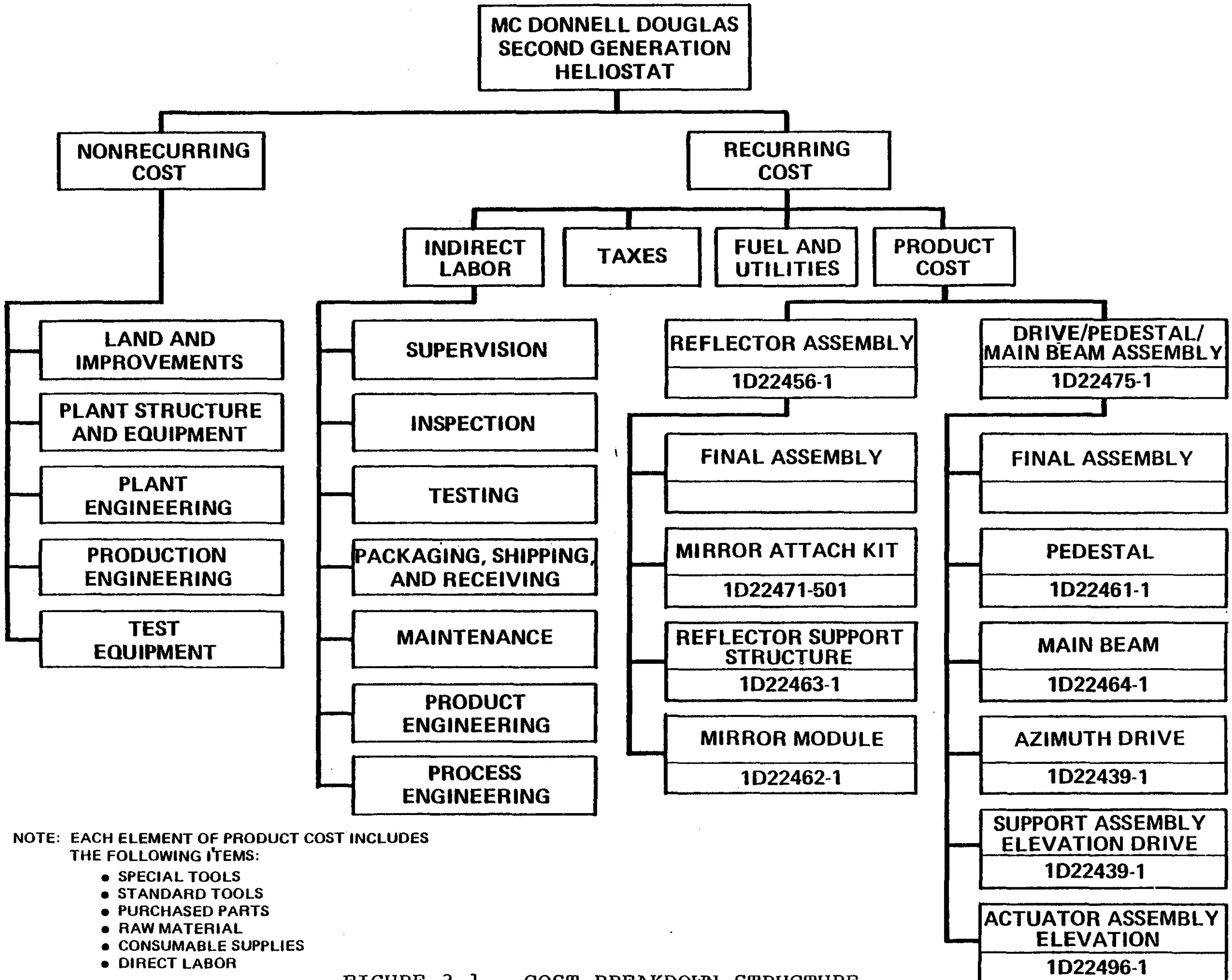

FIGURE 3-1. COST BREAKDOWN STRUCTURE

3.3 MANUFACTURING ANALYSIS

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

The work defined under the manufacturing analysis provides the basis for developing a manufacturing cost per heliostat at the selected production volume, 50,000 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 developed for 75 percent and 125 percent of plant capacity at the standard volume.

Manufacturing equipment, tooling, fixtures, and other devices required in processing and/or assembly operations were identified for each step in the manufacturing process. Each step of the manufacturing process was then listed on tool and labor routing sheets. The tool and labor routing sheets present the manufacturing process, in terms of operation description, the machine cycle time, the machine description, tools and gauges, percent scrap, tool costs, and the capital costs for machines. Background effort required to provide the information contained on the tool and labor routing sheets included the development of a specific process for each operation listed. Spindles, speeds, feeds (rate, stroke, time) and thrust are examples of the detail level to which the manufacturing process was analyzed.

The manufacturing analysis is the foundation upon which the plant design is based and from which the labor development took place. The "Tool and Labor Routings" for the McDonnell Douglas Second Generation Heliostat at a production rate of 50,000 units per year are Appendix B to this document.

3.4 PLANT DESIGN

To complete the manufacturing cost analysis, a manufacturing plant configuration must be defined. The plant design must consider whether the facility is new construction or a renovated structure, and must address all appropriate OSHA and EPA regulations. In addition, plant design and size is a function of the quantity and type of production machines necessary to manufacture a product at a given production rate. The production rate is a function of the production efficiency and the annual production volume. This study of heliostat manufacture considers a 2 shift, 5 day, 48 week per year operation with a production efficiency of 67-1/2 per cent. The design and specification of the heliostat manufacturing equipment has been adjusted for this efficiency so that an annual volume of 50,000 heliostats can be produced. This means that any machine producing a single part for the heliostat must be capable of producing at least 19.29 parts per hour (74,074 parts per year) at 100 per cent efficiency in order to meet the 50,000 parts per year volume. In terms of productive machine time the part cycle is 187 seconds at this efficiency.

For this study, a dedicated facility of new construction was chosen as the plant configuration. Factors considered in defining the plant for cost analysis were 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. In addition, all factors associated with the manufacturing process, such as welding fumes, humidity control, air temperature control, and bay height for hoist clearance were factored into the plant design.

Section 5.0 discusses the result of this activity and shows the plant developed.

3.5 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 D, 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.

The Harrison Radiator Division of General Motors is the lead division for solar energy development and has an active program for the design, test and evaluation of flat plate collector systems. Harrison Radiator participated with GM TSC in the manufacturing cost study of the McDonnell Douglas prototype heliostat for SERI in 1979 and because of that background and their solar expertise were chosen to participate in the current study. Using information provided by the F. Jos. Lamb Co. on "Tool and Labor Routings" (see Appendix B), the Harrison Radiator Division did the labor development and subsequently the cost extension for the manufacturing cost analysis.

Edgar G. Wright, an industrial engineering consultant of Lockport, New York, provided substantial service in the area of labor development and performed the material handling analysis for this study.

3.6 COST EXTENSION

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 could be estimated. Facility costs, fixed and variable production costs, material costs, burden costs, and all other allocated cost factors are considered in developing the total factory cost on a per unit (heliostat) basis. All costs, including 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 C.

3.7 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 as a "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.

Outside tooling and plant costs can be added to factory cost in order to provide a per square meter equivalent factory cost including the extraordinary investment for tools, precious metals, mirroring, glass making and gear making investments.

4.0 COSTING GROUND RULES

Ground rules under which the definition of a heliostat manufacturing facility and the development of manufacturing costs can take place were generated and jointly agreed on by GM TSC and MDC. Included in these ground rules are those which govern the design and operation of the facility capable of producing 50,000 Second Generation Heliostats per year. This MDC heliostat design comprises the following elements:

- Reflector Assembly
- Drive/Pedestal/Main Beam Assembly
  - Main beam
  - Controller
  - Power and control cable harnesses
  - Pedestal
- Foundation

Under the costing ground rules, the controller, foundation and erection system are not part of this study. However, all elements associated with the reflector assembly, the elevation/azimuth drive assembly, the main beam, the power and control cable harnesses and the pedestal as produced in a manufacturing facility and prepared for shipment to a site are considered in the cost analysis. Under this guideline, the cost breakdown structure (CBS) was finalized (see Figure 3-1).

Costing ground rules cover the methods to be used in the generation of cost estimates for all elements pertinent to a single heliostat. 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
- Other Appropriate Cost Factors

The level of design detail available from MDC 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 electrical hardware

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

The drawings provided by MDC were analyzed to define processing and fabrication tooling. For component fabrication through an outside supplier, a cost quotation or an engineering cost estimate was obtained. For fabrication completed in the manufacturing plant, tooling and fabrication costs were developed.

For components or parts for which detail design data did not exist, commercially available hardware meeting the functional requirements of the design were selected, approved by MDC, and costs obtained.

A particular production level was chosen for this study by McDonnell Douglas. That level is 50,000 heliostats per year, shipped. In general, the costs associated with each subassembly were collected and identified. These costs include: tools, raw material, purchased parts, and direct labor. Costs which could not be directly identified with a particular subassembly were collected on a yearly basis, divided by the production volume and added to the total cost. These costs include: land, plant, consumables, taxes, indirect labor and plant engineering.

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

4.1 PLANT SITE, STRUCTURE AND EQUIPMENT

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 will 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 finally 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, but 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 precludes the selection of smaller urban areas. This limitation and the consideration of a central 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 4-1. 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 was developed using Tucson as the plant site.

TABLE 4-1. PLANT LOCATION DATA COMPARISON

	Total Labor Availability in Area (Mfg. Related)	Supporting Industry	Building Costs (Index)	Labor Costs (Avg. Hourly March 1980)
Phoenix	65,000	yes	102.6	$7.20
Tucson	12,000	yes	101.0	$6.78
Denver	96,000	yes	100.5	$7.15
Albuquerque	14,000	yes	100.0	$5.87

The plant is of modern, single story design incorporating both high and low bay areas. The plant features concrete slab construction with a steel structure. The plant is air conditioned with humidity control, fully sprinklered and has 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. A plant layout was generated and shows locations that have special requirements for air handling, air filtration, and water treatment such as welding and machining areas.

The plant and equipment cost estimates consider generally applicable building code requirements. A budgetary cost estimate for the building and equipment is generated. The annual cost for the building and equipment is generated by amortizing the investment. This annual cost is applied over the appropriate yearly production volume. Estimates of land and improvements costs are developed in current (1980) dollars.

All plant equipment is identified and cost quotes obtained or catalog prices used for standard machines or equipment. All special machines are developed to the point of detailed concept sketches and cost estimates obtained from suppliers of similar equipment.

Outside storage areas are provided for two and one-half days of heliostat production. This uncovered storage pad for heliostat components in shipping racks has an area of 452,000 square feet. The plant site is improved for access and storage and is completely fenced. The plant site size is 40 acres. The site size has been selected to provide for possible future expansion.

4.2 TOOLS

Special tools are those units which must be designed and fabricated for heliostat production. These may include: material handling equipment, conveyors, hoists, adhesive application equipment, cleaning tanks, welding fixtures, bonding equipment and assembly equipment.

Summary design definition for this equipment is established and engineering costs generated or budgetary quotes obtained. The capital cost of this equipment is amortized to determine an annual cost. This annual cost is divided by the production volume and the piece cost applied to the corresponding element of the heliostat assembly.

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, hydrosize 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.

4.3 PURCHASED PARTS, MATERIAL AND SUPPLIES

Price quotations, catalog prices, or vendor supplied engineering estimates are used to provide costs for all 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 controls.

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

Raw material purchased for the production operation includes: steel, wire, adhesives, material for plating operations, chemicals for cleaning and plating, and packaging materials.

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

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 50,000 unit production volume. These annual costs are divided by the production volume and the piece cost applied to the corresponding element of the heliostat assembly.

4.4 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 and determining the labor content. Based on the skill level requirements and the plant site location, average wage rates have been determined. For each heliostat component, the direct labor hour content, multiplied by the skill rate, is added to the piece cost.

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.

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.

4.5 TAXES, FUEL AND UTILITIES

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 Tucson, 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.

5.0 HELIOSTAT PLANT

Development of the heliostat plant configuration paralleled the manufacturing process development on an interactive basis. The final plant layout was available after the completion of manufacturing processes and determination of the necessary outside storage. The plant itself is configured of bays, 60' x 60' x 30' and 60' x 40' x 30', with an eight inch reinforced concrete floor (3 lbs per square foot of 3/4" rebar) and fabricated steel walls. The 60' x 40' bays require 12.5 lbs of steel per square foot and the 60' x 60' bays require 18 lbs of steel per square foot. The plant is air conditioned, by a 1200 ton a/c unit, and humidity is controlled. The plant electrical power requirement is estimated at 7500 kVA including air conditioning. The plant is fully sprinklered with an 8" fire loop around the building and a 200,000 gallon ground suction tank as a source. The site is fully fenced with a monitoring system installed for fire and security.

5.1 SITE

The heliostat plant site chosen is in the general area of Tucson, Arizona. The site, shown in Figure 5-1, is fully improved, perimeter fenced, and sized to allow for possible plant expansion. The site dimensions are approximately 1610 feet by 1080 feet for a total parcel size of 40 acres.

5.2 PLANT LAYOUT

The plant layout for the 50,000 unit annual volume heliostat production is shown in Figure 5-2. The plant design is single-story slab construction of high-bay configuration. The plant has floor area of approximately 260,000 square feet.

The plant 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
- Main beam fabrication and welding

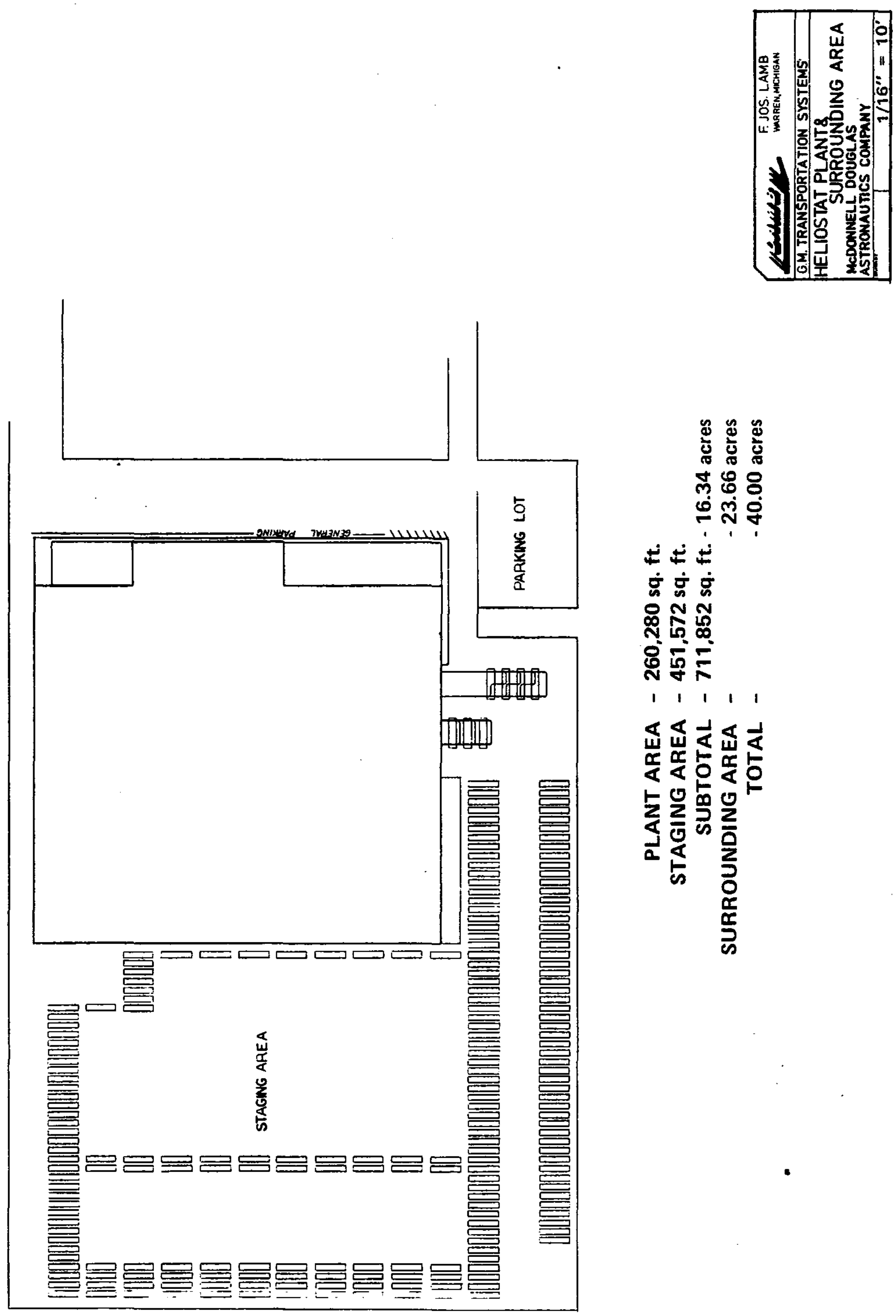

FIGURE 5-1. HELIOSTAT PLANT SITE

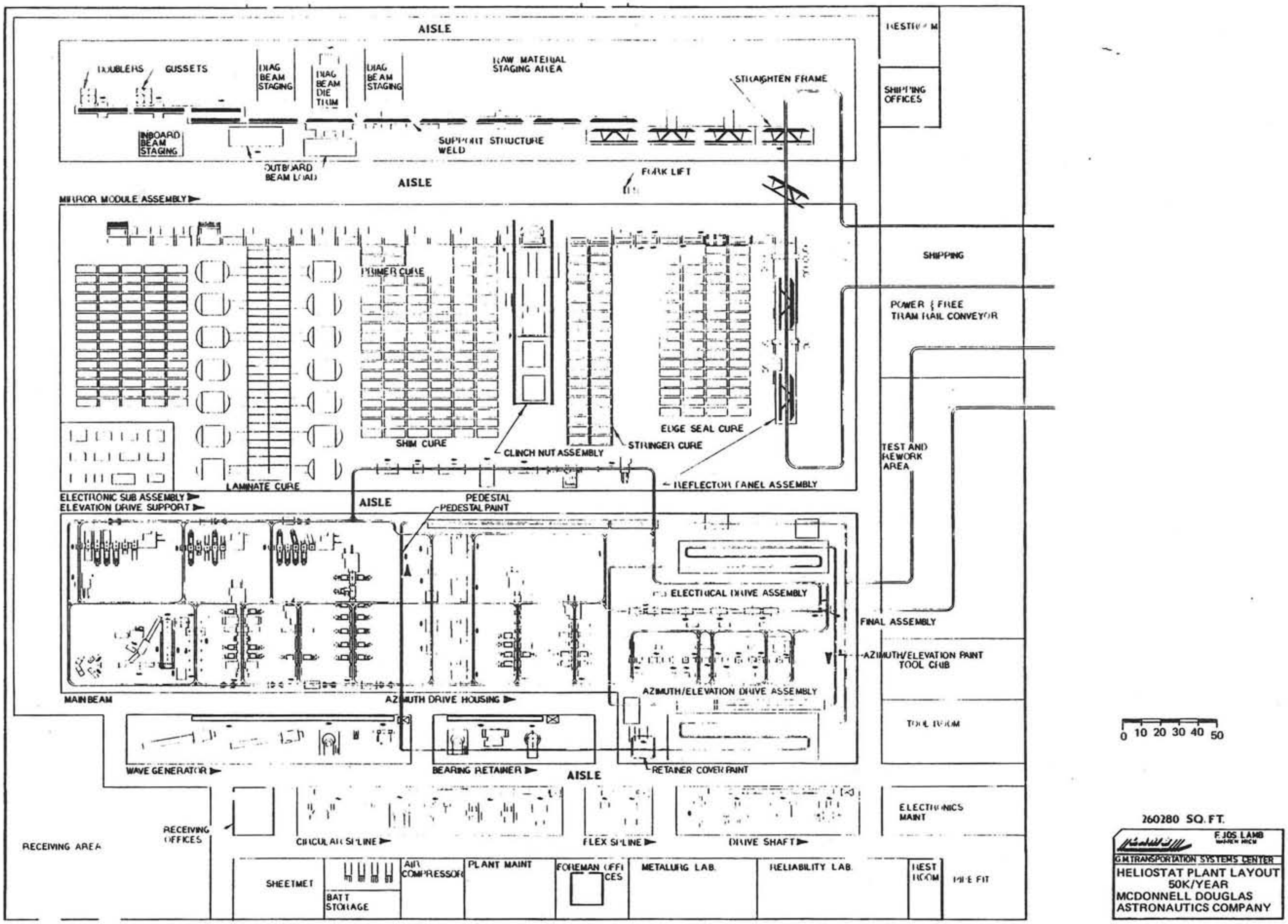

FIGURE 5-2. PLANT LAYOUT

- 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 and pedestal weldments
- Electronic parts, printed circuit boards and wiring
- Drive motors and the elevation actuator

A major portion of the plant is occupied by the processing equipment for the reflective surface assembly. This processing includes glass laminating which is accomplished using polyvinyl butyral sheet as an adhesive. Curing takes place in the autoclaves shown in the upper left of Figure 5-2. After laminating is complete, shims, stringers, and the edge seal are added and finally the reflective surface assembly is attached to its support structure to become the reflector assembly. Completed reflector assemblies are racked 3 to a rack and stored for shipment in the staging area external to the plant.

Machining and assembly of the drive components takes 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 racks in the staging area which is external to the plant.

Located nearest the offices and general parking area is the automated weld and assembly line for the reflector support structure. Due to the length of the inboard and outboard beams and the size of the diagonal beams this activity posed a challenge. Two possible assembly techniques are shown in the isometric figures that follow. Figure 5-3, Team Weld Assembly, shows a straightforward, manpower intensive team welding concept. Figure 5-4, Line Weld Assembly, shows the manufacturing process that was incorporated in this study.

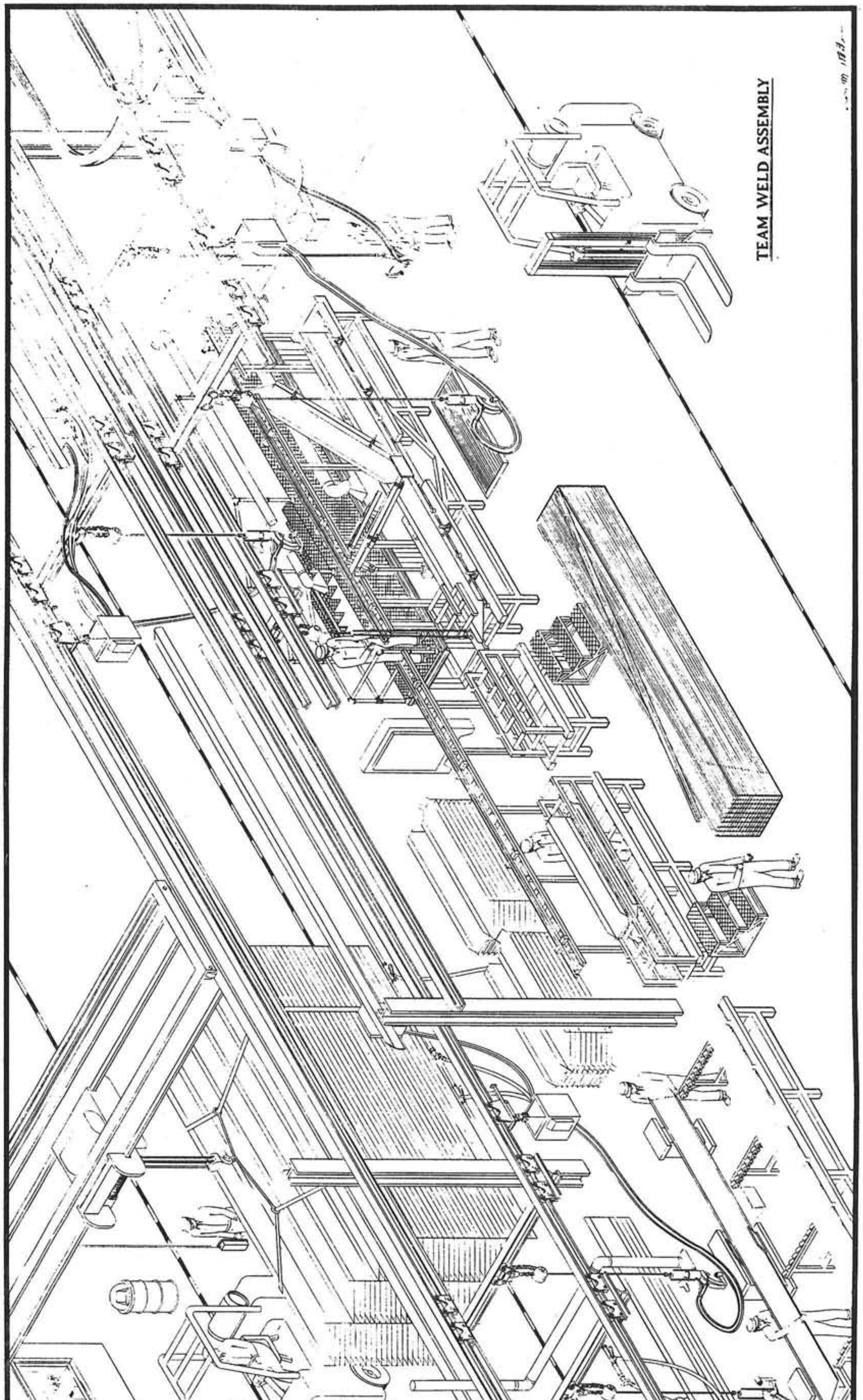

FIGURE 5-3. TEAM WELD ASSEMBLY

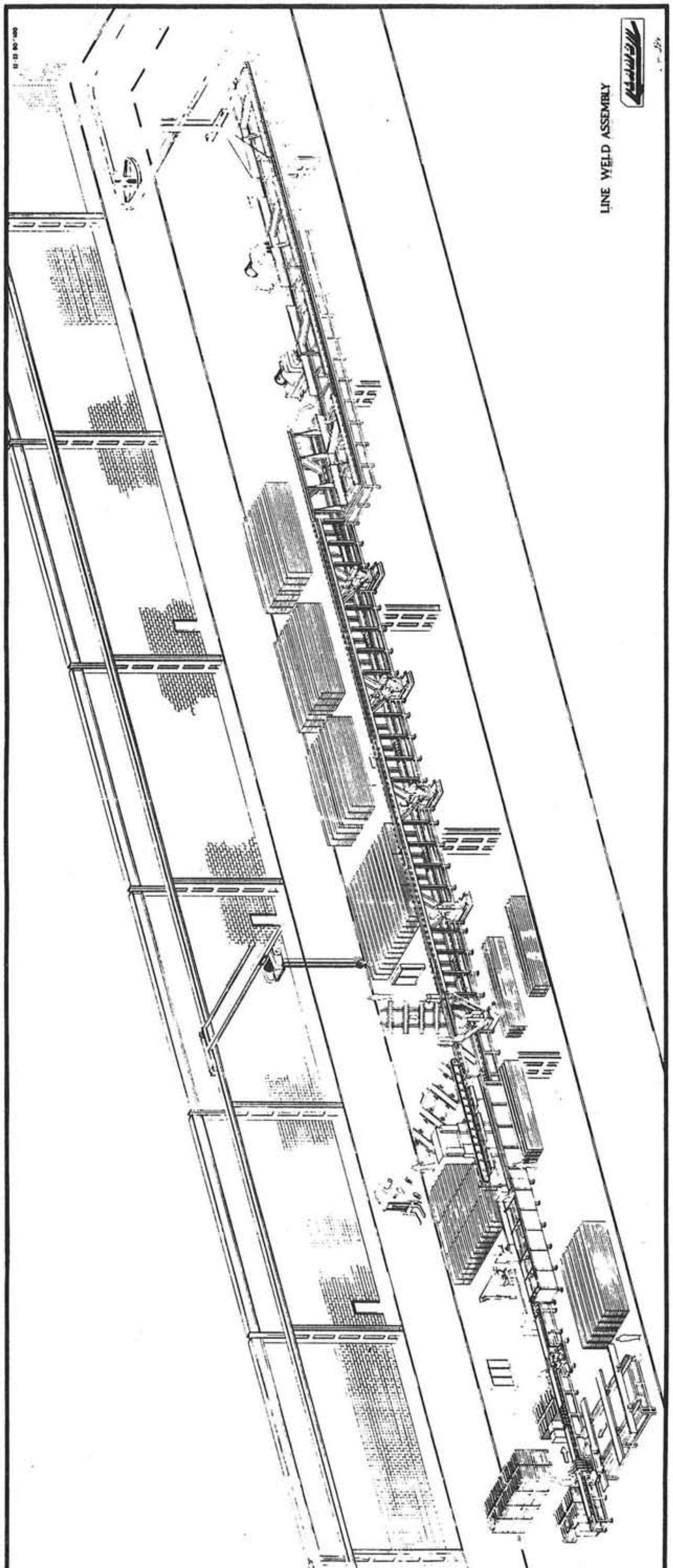

FIGURE 5-4. LINE WELD ASSEMBLY

5.3 REFLECTOR ASSEMBLY

The line layout to accomplish mirror module manufacture and subsequent reflector assembly was a major challenge due to the space requirements for autoclaving, time requirements for adhesive and paint cure and the difficulty in handling due to the size of the completed reflector. Figure 5-4 is a schematic plan view of the reflector assembly line. The final assembly of the mirror module to the reflector support structure is accomplished without assembly labor by using automatic stud drivers, nut drivers and material handling equipment. Figure 5-5 is a perspective drawing of the reflector final assembly line.

5.4 COST

The cost of suitable industrially zoned land in the Tucson area is estimated at $16,000 per acre with a resultant cost of $640,000 for an unimproved 40 acre site. An estimated $160,000 will be the cost of improving the site and thus a total cost of $800,000 will be incurred for a 40 acre improved plant site.

The total cost for the plant building and the staging area slab that is external to the plant is estimated to be $36,000,000.

The following cost elements were included in the development of total plant cost:

- Architecture
- HVAC (including humidity control)
- Process plumbing
- Process sewers
- Process waste treatment to the secondary level
- Sanitary plumbing
- Sanitary sewers
- Compressed air supply
- Makeup air supply
- Exhaust air filtration to EPA requirements
- Firehouse including diesel and electric pumps
- Fire loop for water supply

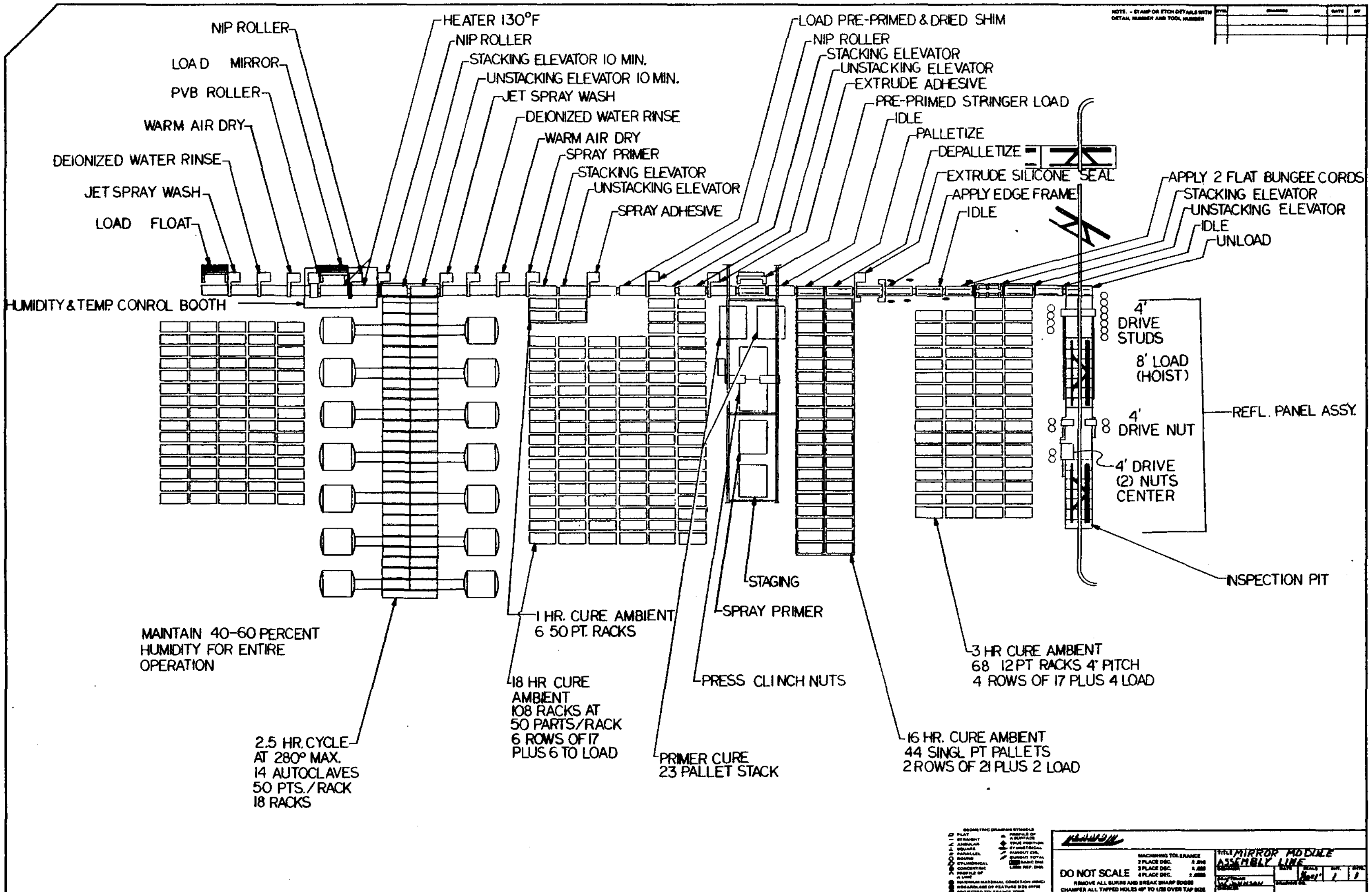

FIGURE 5-4. REFLECTOR ASSEMBLY LINE

GM ENERGY SYSTEMS

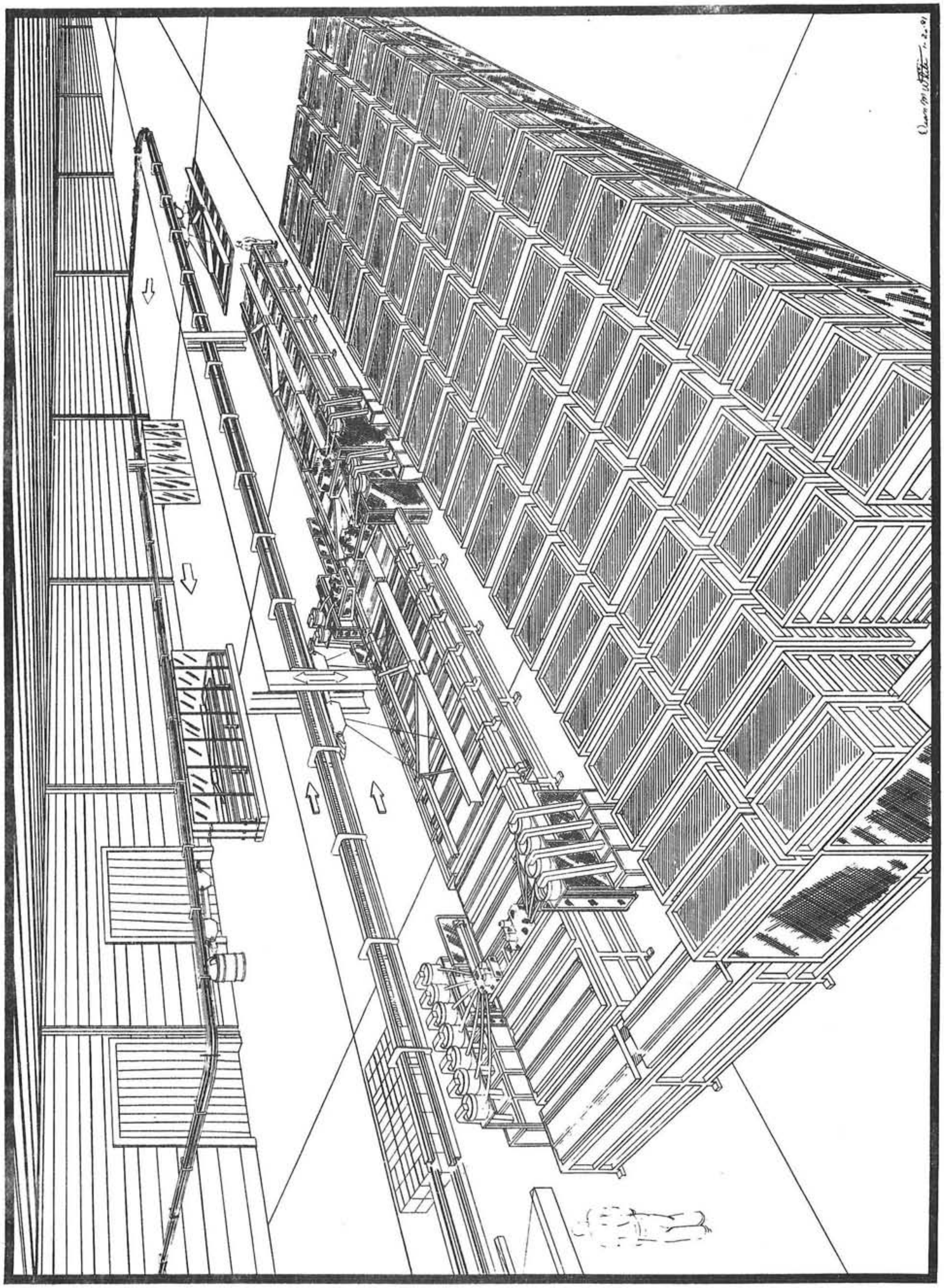

FIGURE 5-5. REFLECTOR FINAL ASSEMBLY LINE

- Underground suction tank
- Building sprinklers
- Fire and proprietary monitoring system
- Reinforced concrete flooring
- Electrical power substation
- Electrical power distribution
- Site perimeter fencing
- Reinforced concrete staging area outside of building
- Parking lot pavement
- Building permits, surveys and contingencies

This list, while not exhaustive, provides the scope of costs considered. Check points of costs associated with recently constructed (since 1977) manufacturing plants were obtained and compared to the developed estimate for the heliostat plant.

Costs estimated in this study are reported in 1980 dollars. If current trends in construction costs continue, future cost projections should include an annual inflation factor of 10 to 12 percent.

6.0 HELIOSTAT MANUFACTURING DESCRIPTION

One of the first tasks completed in this study was the definition of production flow in terms of purchased parts and materials, manufacturing process sequencing, final assembly, and packaging. All make/buy decisions are shown in Appendix A. The production flow definition was followed by process development, equipment definition and the completion of tool and labor routings. The last element of the manufacturing process to be considered was packaging.

6.1 PRODUCTION FLOW

A representation of material and processing flow through the plant is shown in Figure 6-1.

For the 50,000 production volume, major purchased items include:

- Glass and mirroring
- Roll-formed steel sections
- Pedestal tube
- Torque tube weldment
- Elevation support
- Azimuth drive housing parts
- Drive motors and elevation actuator
- Electronic components

Plant processing includes:

- Mirror module laminating
- Support structure die cutting and welding
- Reflector unit assembly
- Main beam fabrication
- Elevation drive support
- Azimuth drive housing fabrication
- Harmonic drive welding and machining (Flex spline, wave generator, bearing retainer, and circular spline)

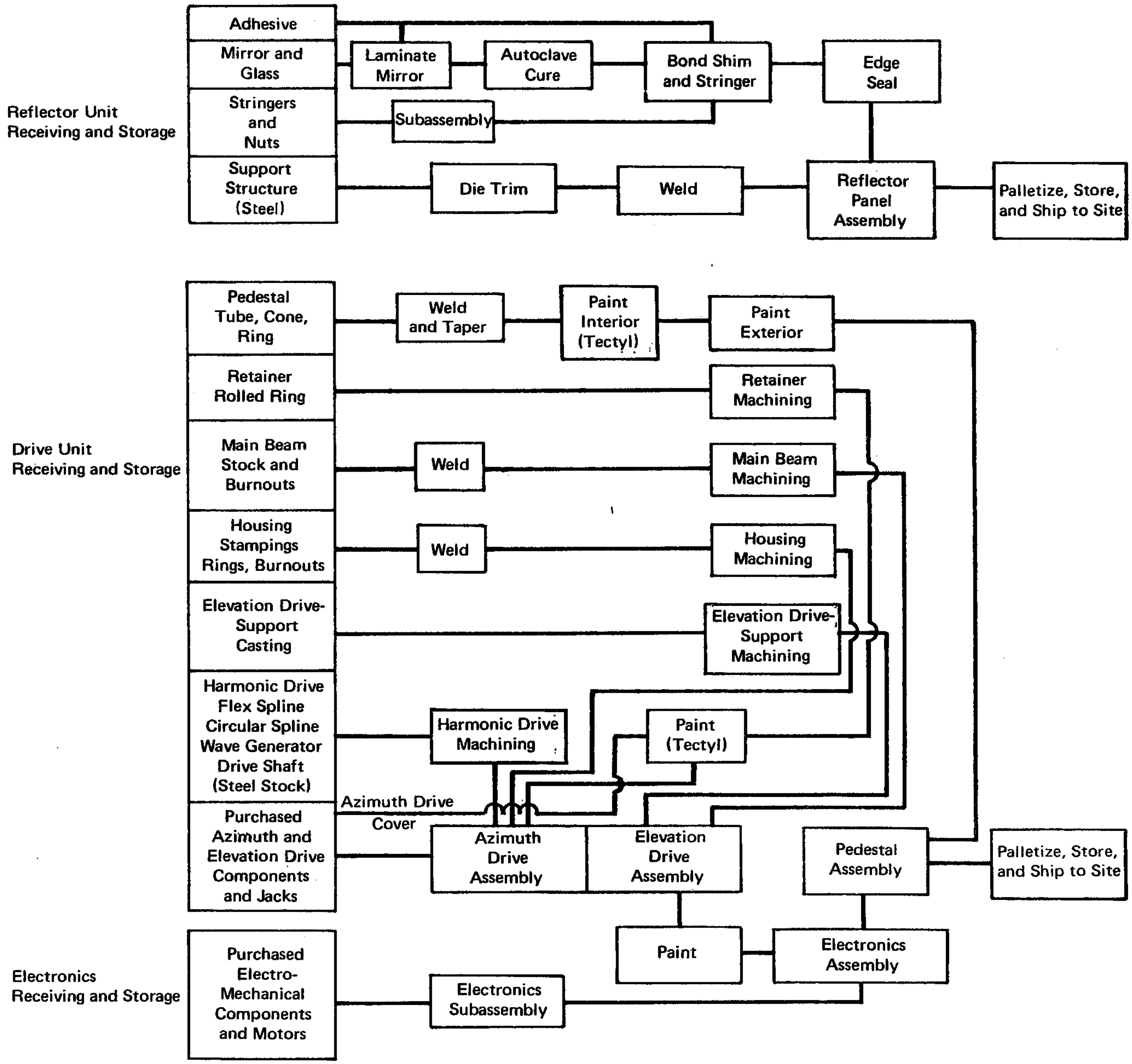

FIGURE 6-1. PRODUCTION FLOW

- Azimuth and elevation drive assembly
- Electronic and power cable fabrication
- Inspection and packaging for shipment

6.2 PROCESSES AND EQUIPMENT

A complete description of the manufacturing process, operation by operation, is contained in Appendix B on the Tool and Labor Routings. In addition to process description, the Tool and Labor Routings also include the process cycle time, the direct labor content and the cost of capital equipment and tools for each manufacturing process.

6.3 PACKAGING

Packaging for shipment was a major concern for in addition to the temporary storage problem in the staging area, height, weight and width had to be considered for highway movement of the reflector and drive/pedestal/main beam assemblies.

The storage/shipping rack for the reflector assembly is shown in Figure 6-2. Three assemblies are mounted in each rack, supported as shown, and held in place by shipping bands at two points. As racked, the assemblies are within the 96 inch highway width regulation and when mounted on a low-boy trailer, meet height clearance restrictions for Interstate or major U.S. Highways.

Drive/pedestal/main beam assemblies are racked four to a rack for storage and shipping as shown in Figure 6-3. The external dimension of the rack allows three racks to fit on a standard 45 foot flat bed trailer, meet Interstate and U.S. Highway width regulations and have adequate height clearance on all Interstate, U.S. and most secondary highways.

The number of racks and their cost to meet the study objective of 50,000 heliostats per year produced and shipped is discussed in Section 8, Heliostat Production Costs.

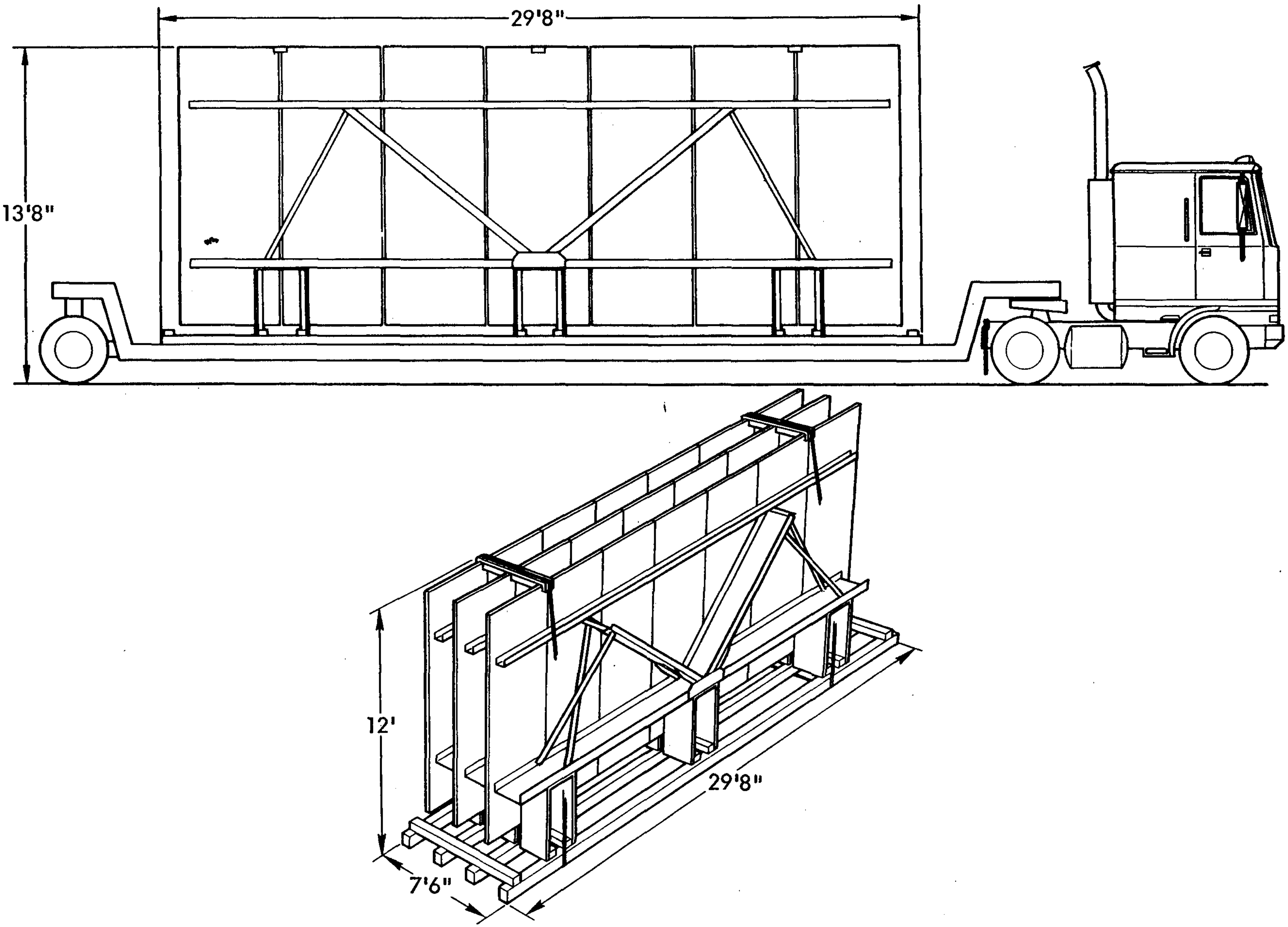

FIGURE 6-2. REFLECTOR ASSEMBLY SHIPPING CONFIGURATION

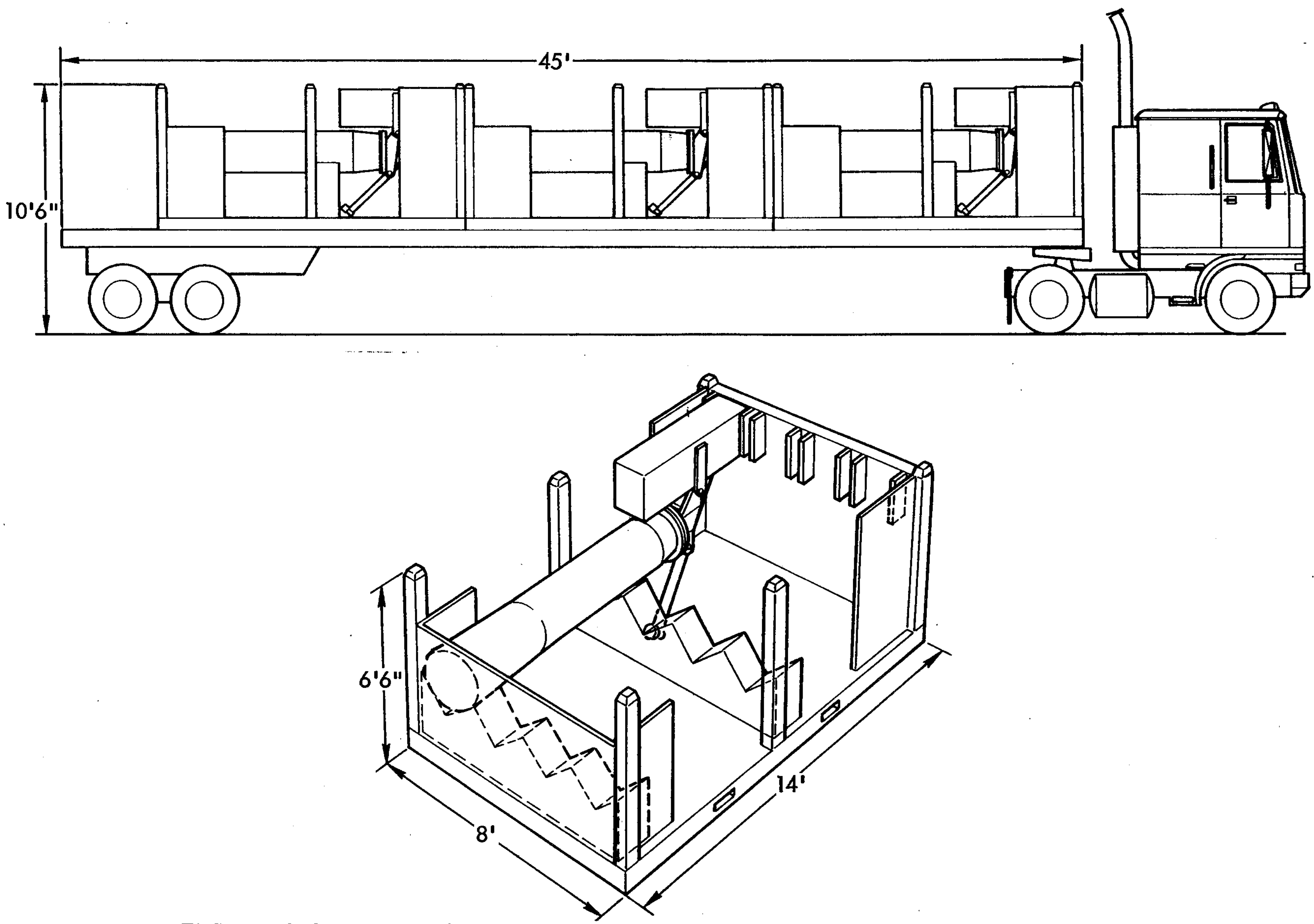

FIGURE 6-3. DRIVE/PEDESTAL/MAIN BEAM ASSEMBLIES,RACKED FOR SHIPPING

7.0 HELIOSTAT MIRROR, SPECIAL REQUIREMENTS

There are special requirements associated with fusion glass due to its limited availability. In addition, because of the fragility of the large, thin glass sheets, it is desirable to perform the mirroring function at the fusion glass works to minimize handling and shipping.

7.1 FUSION GLASS

Fusion glass as specified for the back mirrored front lite of the reflecting surface is available at only one source, the Corning Glass Works of Blacksburg, Virginia. The present capacity of that source does not meet the 50,000 unit per year heliostat production volume requirement, however, there is more than sufficient space in Corning's Blacksburg facility to add capacity, and to install a mirroring line on site. This would avoid the additional handling and shipping problems that would be incurred if the .060" fusion glass lites had to be sent elsewhere for mirroring. Corning supplied the plant layout shown in Figure 7-1 with the fusion glass expansion shown by dashed lines on the left side of the plant. Although modification of the tank is required, a single tank is sufficient to feed both the existing and the added line.

Corning has estimated that the cost of expanding the melting furnace, adding a new forehearth, forming process, annealer, take-out, and handling equipment will cost between $7,312,500 and $12,187,500 in 1980 dollars. This cost includes structural, mechanical and service elements to support the added equipment as well as the design, engineering and installation of the line. This cost does not include the cost of 160,000 grams of precious metals required to implement the new process.

The cost of the fusion line expansion as used in this study is $9,750,000 and the cost of precious metals is $2,443,000; both costs are in 1980 dollars.

7.2 MIRRORING LINE

Large, thin glass sheets are fragile and to minimize the handling and shipping problems, the possibility of installing a mirroring line at the output end of the fusion glass line at the Corning Glass Works in Blacksburg, Virginia was explored. Joint meetings with Corning and Binswanger Mirror Products established the practicality of such an installation, and subsequently Binswanger provided the following information. The cost of installing a 7,800 square foot per hour mirroring line at Corning in Blacksburg is $750,000. Binswanger would

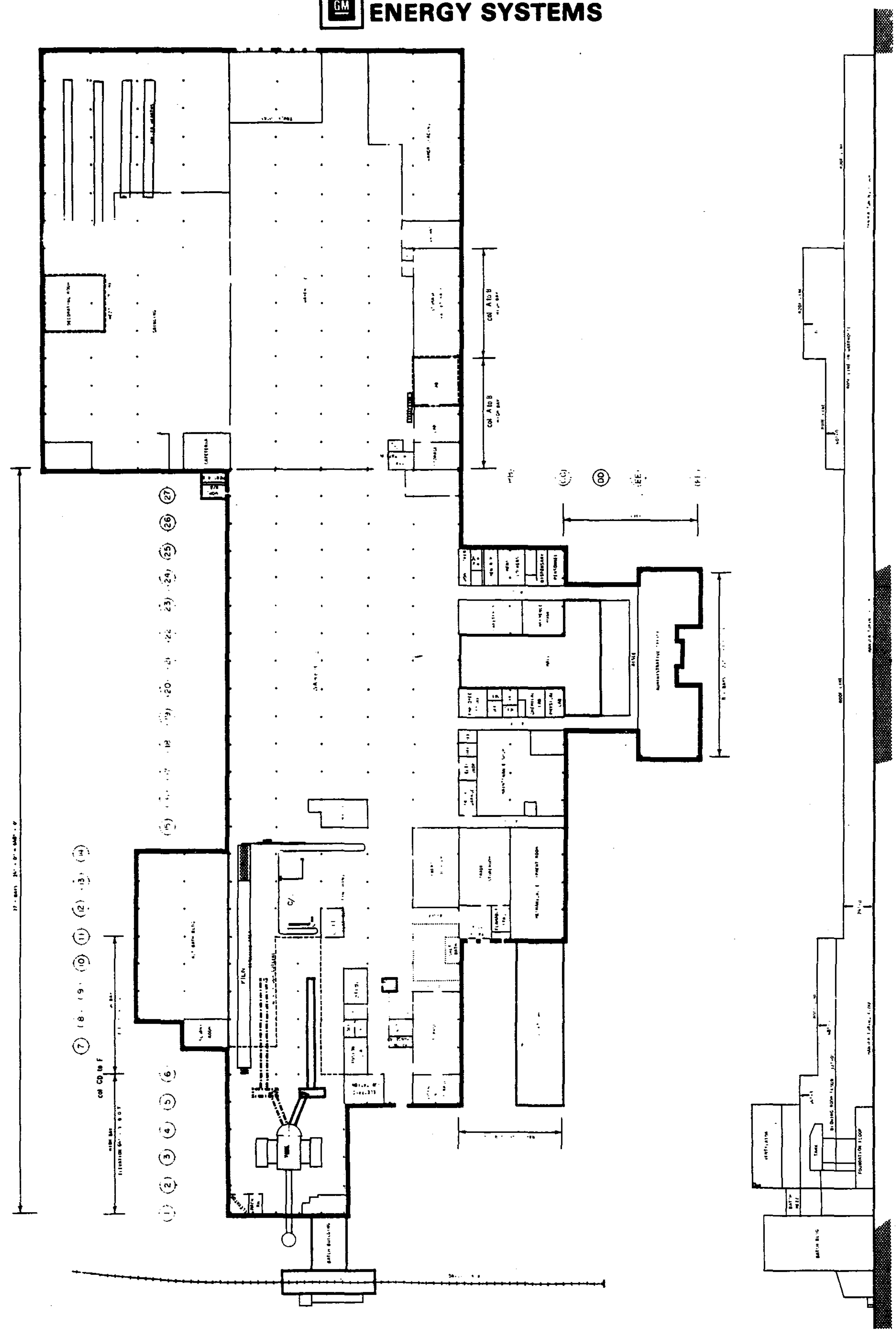

FIGURE 7-1. CORNING GLASS WORKS, BLACKSBURG, VIRGINIA

lease the line space and operate the line to produce a silvered/coppered/painted surface on the fusion glass for 35 cents per square foot (.35/ft^2) F.O.B. Blacksburg. This price does not include the amortization of the capital required for line installation. The above costs are those used in this study.

8.0 HELIOSTAT PRODUCTION COSTS

Heliostat production costs have been developed from the processing, machines, and plant designs for the designated 50,000 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 C of this report. In all cases, material price quotes were obtained from vendors for each purchased heliostat component.

From the machine and plant designs, tool and labor 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 B 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, $7.27 per hour, was adjusted for typical fringe benefits and labor efficiency.

Plant costs were estimated and reflect current rates for construction in the southwest.

Actual tax rate information for the selected site location of Tucson, Arizona, was used in determining 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 $3,655.37. Outside tooling and plant costs which are required to meet supply are also indicated; when these costs are included the total per unit heliostat costs are $3,684.49. The corresponding cost per square meter of heliostat surface area is $64.64.

The total heliostat cost for production volume adjusted to 75 percent of capacity is $3,819.09 at the 37,500 volume. The corresponding cost per square meter of heliostat surface area is $67.00.

The total heliostat cost for production volume adjusted to 125 percent of capacity is $3,603.73 at the 62,500 volume. The corresponding cost per square meter of heliostat surface area is $63.22.

The breakdown of the burden cost, on a per unit basis for both fixed and variable burden have been indicated in Section 8.2.5. The most significant portion of the burden account is for taxes and depreciation on the buildings and plant equipment.

The totals indicated have been depreciated to obtain the expense values shown in the burden account. Buildings are depreciated over 40 years, equipment and machinery depreciated over 10 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, mirroring equipment, glassmaking equipment, and gear tooling. These costs are amortized over a 10-year period on a straight line basis.

8.1 COST APPROACH

8.1.1 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.

8.1.2 LABOR (Direct/Indirect)

Direct labor includes all straight time wages of employes 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

8.1.3 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 - jigs, fixtures, machines, special holding devices, bins, racks, etc.
- Office furniture and equipment.

The equipment, including shipping racks, is depreciated over a 10-year period using the double declining balance method with the first year convention.

Special tools are collected as a factory cost item and depreciated over a 5-year period. Straight line depreciation is used.

8.1.4 PRODUCTION PLANT COSTS

The total capital needed for the plant is approximately $88,600,000 of which $36,000,000 is for the building and $800,000 for 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 straight line method using a rule of thirds. That is, straight line depreciation is followed at an annual rate of three and three quarters percent (3.75%) for the first 160 months (1/3 x 40 years), then at an annual rate of two and one-half percent

(2.5%) for the second 160 months (1/3 x 40 years) and finally at an annual rate of one and one-quarter percent for the third 160 months (1/3 x 40 years). The second year's depreciation is taken as the average annualized cost for estimating purposes.

8.2 COST SUMMARIES

This section includes all of the numbers derived from the study assembled in tabular form.

8.2.1 FULL PRODUCTION

Table 8-1 reflects the estimated factory cost of heliostats produced at a mature facility operating at 100 percent of capacity where that design capacity includes allowances for machine, labor, and manufacturing efficiencies.

TABLE 8-1. MDC SECOND GENERATION HELIOSTAT TOTAL COST (DOLLARS PER UNIT)
PRODUCTION VOLUME: 50,000 UNITS PER YEAR

Direct Labor	90.80
Material	2,921.36
Variable Burden	187.06
Fixed Burden	299.05
Variable Fringe	63.30
Fixed Fringe	36.93
Overtime	4.39
Night Shift	3.60
Cola*	10.03
Special Tools	28.68
Product Engineering	12.17
Factory Cost	3,655.37
Outside Plant and Tool Costs	29.12
Total Cost Per Heliostat	3,684.49
Total Cost Per Square Meter	64.64

*Cost of Living Allowance

8.2.2 THREE PRODUCTION RATES

Table 8-2 reflects the estimated cost of a heliostat produced at a mature facility operating at a reduced production rate (75 percent) and at an increased production rate (125 percent) compared to the standard volume (50,000 units per year) where total labor hours have been adjusted to accomplish the change in manufacturing rate.

TABLE 8-2. MDC SECOND GENERATION HELIOSTAT
TOTAL COST (DOLLARS PER UNIT), THREE PRODUCTION RATES

Production Volume (Units Per Year) (Percent of Plant Capacity)	37,500 75%	50,000 100%	62,500 125%
Material	2,921.36	2,921.36	2,921.36
Labor	90.80	90.80	90.80
Burden	713.63	602.36	535.59
Special Tools and Product Engineering	54.47	40.85	32.68
Factory Cost	3,780.26	3,655.37	3,580.43
Outside Plant and Tool Costs	38.83	29.12	23.30
Total Cost	3,819.09	3,684.49	3,603.73
Total Cost Per Square Meter	67.00	64.64	63.22

8.2.3 HELIOSTAT COST SUMMARY, COMPONENT DETAIL

Table 8-3 comprises the detail cost per heliostat identified by the cost breakdown structure.

8.2.4 BURDEN AND LABOR PER HELIOSTAT UNIT

All indirect material, indirect labor and other costs of a similar nature incurred by the factory while performing manufacturing operations are burden expense. These costs are summarized in Table 8-4.

TABLE 8-3. MDC SECOND GENERATION HELIOSTAT TOTAL COST (DOLLARS PER UNIT), COMPONENT DETAIL
PRODUCTION VOLUME: 50,000 UNITS PER YEAR

	Material	Labor	Burden	Special Tools and Prod. Eng.	Outside Plant and Tool Costs	Total
Drive/Pedestal/Main Beam Assembly (1D22475-1)						
Actuator Assembly, Elevation	412.17	1.28	8.48			421.93
Support Assembly, Elevation Drive	192.96	3.47	22.90			219.33
Azimuth Drive	392.82	39.72	262.56			695.10
Main Beam	105.40	14.74	97.47			217.61
Pedestal	140.47	4.51	29.80			174.78
Final Assembly	42.66	7.62	50.38			100.66
Factory Cost	1,286.48	71.34	471.59	31.36		1,860.77
Total Cost	1,286.48	71.34	471.59	31.36	1.02	1,861.79
Reflector Assembly (1D22456-1)						
Mirror Module (14)	1,129.28	9.58	63.28			1,202.14
Reflector Support Structure (2)	466.24	3.14	20.77			490.15
Final Assembly	39.36	6.74	44.57			90.67
Factory Cost	1,634.88	19.46	128.62	9.49		1,792.45
Total Cost	1,634.88	19.46	128.62	9.49	28.10	1,820.55
Heliostat						
Factory Cost	2,921.36	90.80	602.36	40.85		3,655.37
Total Cost	2,921.36	90.80	602.36	40.85	29.12	3,684.46
Total Cost per Square Meter	51.38	1.60	10.57	.72	.51	64.64

TABLE 8-4 . MDC SECOND GENERATION HELIOSTAT BURDEN AND LABOR DETAIL (DOLLARS PER UNIT)
PRODUCTION VOLUME: 50,000 UNITS PER YEAR

	Fixed	Variable	Total
Supplies	--	11.60	11.60
Tools	13.83	5.85	19.68
Utilities	21.44	15.72	37.16
Maintenance	2.70	28.34	31.04
Scrap	--	87.51	87.51
Taxes and Depreciation	233.34	--	233.34
Direct Labor	--	90.80	90.80
Indirect Labor-Hourly	1.93	8.39	10.32
Indirect Labor-Salary	24.04	14.74	38.78
Sundry	1.77	14.91	16.68
Total	299.05	277.86	576.91

8.2.5 OUTSIDE 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 8-5.

TABLE 8-5. OUTSIDE TOOLING AND PLANT COSTS

Rolling Mill Tools and Scotchbrite Equipment (Van Huffel)	$ 132,000
Mirroring Line (Binswanger)	750,000
Stamping Tools and Dies (Bossert)	508,800
Corning Glass Works	
Fusion glass line	9,750,000
Precious metals	2,443,000*
Total Investment	$13,583,800

*Included as a cost per unit of $6.84 (14 percent per year).

8.2.6 INVESTMENT PER HELIOSTAT UNIT

The total investment required to produce the McDonnell Douglas Second Generation Heliostat at a production rate of 50,000 units per year is summarized in Table 8-6.

TABLE 8-6. MDC SECOND GENERATION HELIOSTAT REQUIRED INVESTMENT (DOLLARS)
PRODUCTION VOLUME: 50,000 PER YEAR

Plant	$ 36,000,000
Land and Improvements	800,000
Machinery and Equipment	41,250,000
Tools	8,150,000
Operations	2,970,000
Total	$ 89,170,000

8.2.7 SHIPPING RACK ANALYSIS

Tables 8-7 and 8-8 summarize the shipping rack analysis and the resultant cost for the drive/pedestal/main beam assembly and the reflector assembly.

TABLE 8-7. DRIVE/PEDESTAL/MAIN BEAM ASSEMBLY (1D 22475-1) SHIPPING RACK ANALYSIS

Production Volume: 50,000 Heliostats per year	
Assemblies per day: 208	
Assemblies per rack: 4	
Number of Racks	
At plant	260
In plant for loading	104
In repair	26
In route	260
At site	260
TOTAL	910

Estimated Cost: $1,327,690

TABLE 8-8. REFLECTOR ASSEMBLY (1D22456-1)
SHIPPING RACK ANALYSIS

Production Volume:	50,000 Heliostats per year
	Assemblies per day: 416
	Assemblies per rack: 3
Number of Racks	
At plant	693
In plant for loading	277
In repair	69
In route	693
At site	693
TOTAL	2,425

Estimated Cost: $7,420,375

8.2.8 LABOR RATE ANALYSIS

To arrive at a representative labor rate for the heliostat direct labor, U.S. Department of Labor figures for seven southwestern states were averaged and extrapolated to provide a composite labor rate estimated for September 1980. A labor efficiency factor was applied, and an industry premium added. The results of this analysis are shown in Table 8-9.

TABLE 8-9. LABOR RATE (DOLLARS PER HOUR)*

	March 1979	March 1980	September 1980 (est.)
California	$6.79	$7.44	$7.77
Nevada	6.88	7.36	7.60
Utah	6.03	6.88	7.31
Arizona	6.40	7.14	7.51
Colorado	6.60	7.13	7.40
New Mexico	5.12	5.72	6.02
Texas	6.27	6.96	7.31
AVERAGE	$6.30	$6.96	$7.27
Labor efficiency factor - 92 percent			$ .63 7.90
Industry factor = 115 percent			1.19
Labor rate used			$9.09

*U.S. Department of Labor

8.2.9 INDUSTRIAL ENGINEERING SUMMARY

Table 8-10 provides an example and some insight into the level of detail to which the manufacturing process, as displayed on the Tool and Labor Routings, was reviewed.

Table 8-11 summarizes the industrial engineering results in determining the production labor hours and operators earned at the standard volume (50,000 units per year).

8.2.10 HELIOSTAT TOOLS AND EQUIPMENT

The detail and totals for the cost of heliostat tools and equipment as partitioned under the cost breakdown structure are shown in Table 8-12.

TABLE 8-10. EQUIPMENT REQUIREMENT ANALYSIS (TYPICAL)

Azimuth Drive Housing (Oper. #20, Page B-19)

Equipment Required (Original)	
Bullard Templa-Turn Vertical Turret Lathe (4)	$1,720,000
Installation	258,000
Special Tools (4)	49,600
Durable Tools (4)	7,500
Nondurable Tools (4)	2,500
TOTAL	$2,037,600

Recommendations:

1. Reduce equipment from four to three units.
2. Develop a three to five day parts bank (624-1040 pieces) as a reserve in the event of major equipment downtime.
3. Provide full relief during lunch, washup and personal time to achieve maximum uninterrupted output from the three machines.
4. If required, (due to excessive machine downtime) use overtime to stretch bank days on hand for emergency.

Equipment Required (Revised)	
Bullard Templa-Turn Vertical Turret Lathe (3)	$1,290,000
Installation	193,500
Special Tools (3)	37,200
Durable Tools (3)	5,625
Nondurable Tools (3)	1,875
TOTAL	$1,528,200

TABLE 8-11. MDC SECOND GENERATION HELIOSTAT STANDARD HOURS AND OPERATORS EARNED BY CLASSIFICATION - SUMMARY

	Per 100 Pieces	No of Pieces	Per 100 Heliostats	Assembly	Welding & Machining	Material Handling	Inspection	Rework	Downtime	Misc.
Mirror Module	7.522	14	105.308	62.986	--	22.652	14.000	--	3.794	1.876
Reflector Support Structure	17.288	2	34.576	--	22.500	4.000	2.000	4.500	1.126	.450
Final Assembly	24.091	2	48.182	--	--	25.936	12.968	6.666	1.946	.666
Packaging	13.000	2	26.000	--	--	--	--	--	--	26.000
Pedestal, Weld	30.478	1	30.478	--	13.580	8.000	4.500	3.516	.679	.203
Pedestal, Paint	19.125	1	19.125	--	6.250	9.250	3.000	.500	--	.125
Azimuth Drive Housing, Weld	22.892	1	22.892	--	15.385	2.600	3.500	--	1.005	.402
Azimuth Drive Housing, Machine	29.210	1	29.210	--	19.668	2.000	2.000	4.134	1.034	.374
Main Beam, Weld	128.078	1	128.078	--	88.250	8.000	8.000	17.650	4.413	1.765
Main Beam, Machine	34.126	1	34.126	--	18.750	8.000	2.500	3.750	.938	.188
Elevation Drive Support, Machine	38.113	1	38.113	--	21.692	6.500	3.500	4.939	1.235	.247
Flex Spline	11.040	1	11.040	--	4.723	3.000	1.000	.945	.236	1.136
Circular Spline	53.049	1	53.049	--	31.188	9.000	3.000	7.438	1.560	.863
Wave Generator	26.146	1	26.146	--	16.749	2.500	2.000	3.650	.838	.409
Drive Shaft	13.346	1	13.346	--	6.287	3.000	2.000	1.558	.315	.186
Bearing Retainer, Azimuth	22.831	1	22.831	--	10.847	5.500	3.000	2.570	.643	.271
Cover and Retainer, Paint	11.563	1	11.563	--	6.250	3.000	2.000	.250	--	.063
Azimuth/Elevation Drive, Assembly	127.275	1	127.275	95.525	--	8.000	8.000	15.000	--	.750
Azimuth/Elevation Drive, Paint	25.688	1	25.688	--	12.500	8.250	4.000	.750	--	.188
SUBTOTAL	--	--	(807.026)	(158.511)	(294.619)	(139.188)	(80.968)	(77.816)	(19.762)	(36.162)
Incremental Encoder	14.106	2	28.212	11.876	--	4.000	12.336	--	--	--
Sensor/Controller Cable	5.528	5	27.640	13.055	--	9.585	5.000	--	--	--
Motor/Controller Cable	5.528	2	11.056	5.222	--	3.834	2.000	--	--	--
Encoder Cable	4.228	2	8.456	3.832	--	2.834	1.790	--	--	--
Sensor Cable	2.459	5	12.295	5.210	--	4.585	2.500	--	--	--
Motor Cable	2.222	2	4.444	1.054	--	2.392	1.000	--	--	--
Encoder/Controller Cable	5.200	2	10.400	4.566	--	3.834	2.000	--	--	--
Elec. Installation, Az/El Drive	37.500	1	37.500	25.000	--	6.250	6.250	--	--	--
SUBTOTAL	--	--	(140.003)	(69.815)	--	(37.312)	(32.876)	--	--	--
Final Assembly	51.900	1	51.900	12.500	--	25.400	4.000	--	--	--
Packaging	10.000	1	10.000	--	--	--	--	--	--	10.000
TOTAL (Std. hours/100 units)			998.929	240.826	294.619	201.900	117.844	77.816	19.762	46.162
Average Daily Build Schedule:	208 Heliostats									
Total Earned Hours per Day:			2078	501	613	420	245	162	41	96
Total Earned Manpower per Day:			260	63	77	52	31	20	5	12
Labor Breakdown by Classification:			100%	24.2%	29.6%	20.0%	12.0%	7.7%	1.9%	4.6%

TABLE 8-12. MDC SECOND GENERATION HELIOSTAT TOOLS AND EQUIPMENT (DOLLARS)
PRODUCTION VOLUME: 50,000 PER YEAR

	Tools					
	Special	Durable	Nondurable	Total	Equipment	Total
Drive/Pedestal/Main Beam Assembly (1D22475-1)						
Pedestal, Paint	--	--	--	--	622,167	622,167
Pedestal, Weld	282,594	39,968	17,459	340,021	838,326	1,178,347
Azimuth Drive Housing, Weld	70,168	25,060	5,012	100,240	612,910	713,150
Azimuth Drive Housing, Machine	1,452,100	58,220	19,407	1,529,727	4,171,963	5,701,690
Main Beam, Weld	125,370	44,775	8,955	179,100	867,180	1,046.280
Main Beam, Machine	1,870,000	70,500	23,500	1,964,000	3,662,400	5,626,400
Elevation Drive Support, Machine	1,899,000	147,200	23,900	2,070,100	3,734,000	5,804,100
Flex Spline	46,700	7,700	87,920	142,320	370,645	512,965
Circular Spline	81,200	23,100	50,450	154,750	2,085,740	2,240,490
Wave Generator	50,600	12,650	6,050	69,300	1,661,930	1,731,230
Drive Shaft, Azimuth	102,405	48,783	13,522	164,710	552,580	717,290
Bearing Retainer, Azimuth	190,300	77,000	13,200	280,500	1,124,875	1,405,375
Cover and Retainer, Paint	--	--	--	--	393,740	393,740
Azimuth/Elevation Drive, Assembly	120,000	35,000	10,000	165,000	2,382,500	2,547,500
Azimuth/Elevation Drive, Paint	--	--	--	--	216,500	216,500
Incremental Encoder	--	--	--	--	73,750	73,750
Sensor/Controller Cables	--	--	--	--	3,000	3,000
Motor/Controller Cable	--	--	--	--	1,200	1,200
Encoder Cable	--	--	--	--	44,300	44,300
Sensor Cables	--	--	--	--	1,000	1,000
Motor Cable	--	--	--	--	400	400
Encoder/Controller Cable	--	--	--	--	1,200	1,200
Elec. Installation, Az/El Drive	--	--	--	--	119,750	119,750
Final Assembly	--	--	--	--	45,508	45,508
Shipping Racks	--	--	--	---	1,327,690	1,327,690
TOTAL	6,290,437	589,956	279,375	7,159,768	24,915,254	32,075,022
Reflector Assembly (1D22456-1)						
Mirror Module	371,675	--	--	371,765	7,245,931	7,617,696
Reflector Support Structure	508,125	101,720	13,079	622,924	4,072,691	4,695,615
Final Assembly	--	--	--	--	559,475	559,475
Shipping Racks	--	--	--	--	7,420,375	7,420,375
TOTAL	--	--	--	--	19,293,472	20,293,161
Heliostat Total	7,170,237	691,676	292,454	8,154,367	44,213,726	52,368,183

ENERGY SYSTEMS

APPENDIX A

INDENTURED PARTS LIST

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HELIOSTAT ASSEMBLY

SEP 22 1980

PART NUMBER	CHG	NOMENCLATURE	QUANTITY							M or B	UNIT COST (Dollars)	
1D22459-1	--	Heliostat Assembly (Reference)	1									
1D22456-1	--	Reflector Assembly		2							(See Pg 2)	
1D22475-1	B	Drive/Pedestal/Main Beam Assembly		1							(See Pg 4)	
		(Detail Assembly Parts)									(See Pg 4)	
1D22439-1	F	Support, Assembly Elevation Drive			1						(See Pg 7)	
1D22461-1	C	Pedestal			1						(See Pg 8)	
1D22464-1	E	Main Beam			1						(See Pg 9)	
1D22494-1	C	Azimuth Drive			1						(See Pg 10)	
1D22496-1	A	Actuator Assembly - Elevation			1						(See Pg 15)	
1D22513-1	A	Controller Assembly			1						(Ref. Only)	

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HELIOSTAT ASSEMBLY

SEP 22 1980

PART NUMBER	CHG	NOMENCLATURE	QUANTITY							M or B	UNIT COST (Dollars)	
1D22456-1	--	Reflector Assembly		2						M	XXX	
1D22461-2	C	Mirror Module Assembly			7					M	XXX	
1D22462-3		Stiffener				2				B	5.235	
1D22462-11		Edge Member				2				B	} .935	
1D22462-13		Edge Member				2				B		
1D22462-17		Shim				2				B	1.48	
S-0518-1-Z		Clinch Fastener				4				B	.02	
PR1506		Glass Primer				1 Fl Oz				B	.02	
CORDGARD 9		Steel Primer				2 Fl Oz				B	.12	
STABOND 1894		Adhesive-Glass to - 17 Shim				1/2 Lb				B	1.88	
LC3532		Adhesive-17 to - 13				3/4 Lb				B	4.0367	
SCS1202		Edge Sealant - 17 and - 3 Bond Lines				17 Oz				B	.0631	
SCS1202		Edge Sealant - 11 and -13				13 Oz				B	.0631	
1D22428-1	--	Laminated Mirror				1				M	XXX	
1D22428-3		Mirror Glass, Silver, Copper, Paint } Ref. 1D22430 Mirror Spec.					1			B	} 33.00	
1D22428-5		Backlite					1			B	15.40	
PVB		Adhesive (single sheet)					1			B	10.56	
1D22471-501	A	Mirror Attach Kit (4 Point)			1					M	XXX	
1D22778-501	A	Stud				28				B	.5411	
1D22591-501	A	Shoulder Washer				14				B	.08	
1D22591-503	A	Shoulder Washer				14				B	.07	
21SFF51618		Flangenut				28				B	.03	
.312-18		Hexnut				28				B	.0568	
1D22463-1	A	Reflector Support Structure Assembly			1					M	XXX	
1D22465-1	C	Inboard Crossbeam				1				B	66.49	
1D22465-003-5		Doubler Angle				14				B	.41	
1D22466-1	B	Diagonal Beam				1				B	38.92	
1D22466-2		Diagonal Beam				1				B	38.92	
1D22467-1	A	Outboard Crossbeam				1				B	59.25	
1D22463-3		Doubler				2				B	2.69	
1D22463-5		Gusset				2				M	XXX	
1D22463-7		Plate					1			B	3.52	
1D22463-9		Bar					1			B	3.47	
1D22470-1	B	Braces				1				B	XXX	

HELIOSTAT ASSEMBLY

SEP 2 2 1980

PART NUMBER	CHG	NOMENCLATURE	QUANTITY	M or B	UNIT COST (Dollars)	
1D22470-3		Angle	1	B	1.11	
1D22470-5		Angle	1	B	1.11	
1D22470-11		Angle	1	B	1.11	
1D22470-12		Angle	1	B	1.11	

HELIOSTAT ASSEMBLY

SEP 2 2 1980

PART NUMBER	CHG	NOMENCLATURE	QUANTITY							M or B	UNIT COST (Dollars)	
1D22475-1	B	Drive/Pedestal/Main Beam Assembly		1						M	XXX	
1D22416-1	A	Cover,			1					B	.62	
1D22417-1	--	Mount, Elevation Sensor			2					B	.16	
1D22418-1	A	Bracket, Magnet, Elevation			1					B	.10	
1D22419-1	A	Bracket, Elevation Sensor			1					B	.41	
1D22419-3		Plate				1				B	XXX	
1D22419-5		Base				1				B	XXX	
1D22432-1	A	Pin, Trunnion			2					B	2.52	
1D22433-1	--	Mount, Sensor Output			1					B	.12	
1D22438-1	A	Cap, Rod End Pin			2					B	.08	
1D22455-1	--	Pin, Hinge			1					B	3.00	
1D22478-1	--	Pin, Rod End			1					B	1.50	
		Pin (1D22475-3 see Main Beam Page 9)										
1D22594-1	--	Cover Elevation Drive			1					B	.16	
1D22405-1	--	Hinge, Half Assembly			1					B	.13	
1D22405-3	--	Angle				1				B	.13	
1D22405-7	--	Pin				1				B	.03	
1D22405-501	--	Hinge, Half Assembly			1					B	.13	
1D22405-3	--	Angle				1				B	.13	
1D22405-9	--	Pin				1				B	.03	
1D22405-503	--	Hinge, Half Assembly			1					B	.13	
MS24665-374		Cotter Pin			1					B	.03	
MS24665-377		Cotter Pin			2					B	.04	
NAS1314-16		Bolt			4					B	.98	
NAS1316-42D		Bolt			1					B	1.30	
NAS1308-15		Bolt			8					B	.99	
NAS1081-4A12P		Set Screw			1					B	.02	
NAS1081-6A10P		Set Screw			2					B	.02	
M2		Magnet			2					B	.165	
5710-67-10		Washer			30					B	.02	
5710-245-90		Washer			2					B	.02	
A3-17		Shaft			2					B	.195	
.190-32UNF-2Ax.75		Flat Head Brass Screw			2					B	.02	
.190		Split Lock Washer			2					B	.016	
.190-32UNF-2B		Hexnut			2					B	.003	
.250-20UNC-2Ax.50		Hex Cap Screw			16					B	.009	
.250-20UNC-2Ax.75		Hex Cap Screw			2					B	.011	
.250-20UNC-2Ax.88		Hex Cap Screw			8					B	.012	
.250		Split Lock Washer			26					B	.003	

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PART NUMBER	CHG	NOMENCLATURE	QUANTITY							M or B	UNIT COST (Dollars)	
.250-20UNC-2B		Hexnut			8					B	.005	
.500		Split Lock Washer			8					B	.02	
.875		Split Lock Washer			4					B	.07	
AN960-1616		Washer			1					B	.09	
AN130-15		Nut			1					B	.08	
.062x.50		Cotter Pin			1					B	.01	
.250-28UNF-2Ax.50		Hex Cap Screw			1					B	.01	
ST263-09CC		Jumper			1					B	.65	
1D22414-1	A	Sensor, Electronic Assembly			1					M	XXX	
120-1809-000		Connector				1				B	.37	
110238-0040		Contact, Pin				2				B	.04	
110238-0085		Contact, Socket				2				B	.07	
~~225-0072-000~~	--	~~Plug, Sealing~~				~~0~~				B	XXX	
~~PLT1M-CP0~~	--	~~Cable Ties~~				~~0~~				B	XXX	
STM0069-13-A6-02		1" Dia. Black Shrink Tubing				4"				B	.09	
DPM2617-15		1/8" Dia. Black Shrink Tubing				1½"				B	.0225	
LC2P-1839-1A-60		Proximity Switch				2				B	.69	
1D22414-501	A	Sensor, Electronic Assembly			1					M	XXX	
120-1807-000		Connector				1				B	.37	
110238-0040		Contact, Pin				1				B	.04	
110238-0085		Contact, Socket				1				B	.07	
~~225-0072-000~~	--	~~Plug, Sealing~~				~~0~~				B	XXX	
~~PLT1M-CP0~~	--	~~Cable Ties~~				~~4~~				B	XXX	
STM0069-13-A6-02		1" Dia. Black Shrink Tubing				4"				B	.09	
DPM2617-15		1/8" Dia. Black Shrink Tubing				1"				B	.0225	
LC2P-1839-1A-60		Proximity Switch				1				B	.69	
1D22445-1	--	Electrical Installation, Pedestal			1					M	XXX	
ST253C6		Clamp				1				B	.10	
ST263-16CC		Jumper				1				B	.65	
.190-32UNF-2Ax.50		Roundhead Screw				1				B	.01	
.190		Split Lock Washer				1				B	.01	

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HELIOSTAT ASSEMBLY

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PART NUMBER	CHG	NOMENCLATURE	QUANTITY	M or B	UNIT COST (Dollars)
~~PLT1M-CPO~~ *		~~Cable Ties~~	~~2~~	~~B~~	~~.01~~
1D22514-501	--	Cable, Assembly Pedestal	1	M	XXX
120-1869-000		Connector	1	B	.37
110238-0040		Contact, Pin	3	B	.04
110238-0085		Contact, Socket	5	B	.07
225-0072-000		Plug, Filler	2	B	.015
~~PLT1M-CPO~~ *		~~Cable Ties~~	~~0~~	B	XXX
AIA		Splice	1	B	.06
8918		#18 Awg Wire	30'	B	.107
8451		#22 2 SJ Wire	6'	B	.095
DPM2617-15		1/2" Black Shrink Tubing	4"	B	.05
STM0069-13-A6-02		1" Black Shrink Tubing	4"	B	.09

* REPRESENTS 100 PIECES

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PART NUMBER	CHG	NOMENCLATURE	QUANTITY							M or B	UNIT COST (Dollars)	
1D22439-1	F	Support Assembly, Elevation Drive			1					M	XXX	
~~1D22439-3~~		~~Lug~~				~~1~~					XXX	
~~1D22439-5~~		~~Lug~~				~~1~~					XXX	
~~1D22439-7~~		~~Web~~				~~1~~					XXX	
~~1D22439-9~~		~~Plate~~				~~2~~					XXX	
~~1D22439-11~~		~~Plate~~				~~1~~					XXX	
~~1D22439-13~~		~~Web~~				~~1~~					XXX	
1D22415-501		Bearing - TFE Lined				1				B	9.17	
MS21230-16		Bearing				1				B	8.79	
		Supp't. Ass'y.-Elev. Dr. Casting				1				B	175.00	

HELIOSTAT ASSEMBLY

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PART NUMBER	CHG	NOMENCLATURE	QUANTITY							M or B	UNIT COST (Dollars)	
1D22461-1	C	Pedestal			1					M	XXX	
1D22461-3		Tube				1				B	62.15	
1D22461-5		Plate				1				B	48.28	
1D22461-9		Cone				1				B	21.58	
1D22461-11		Ring				1				B	7.30	
1.00-8		Nut				4				B	.29	

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HELIOSTAT ASSEMBLY

PART NUMBER	CHG	NOMENCLATURE	QUANTITY							M or B	UNIT COST (Dollars)	
1D22464-1	E	Main Beam			1					M	XXX	
1D22464-3		Body				2				B	21.69	
1D22464-5		Web				2				B	2.93	
1D22464-7		Lug				2				B	4.84	
1D22464-9		Lug				2				B	2.68	
1D22464-11		Lug				2				B	3.03	
1D22464-15		Gusset				2				B	.94	
1D22464-17		Bar				4				B	2.39	
1D22464-25		Pad				2				B	2.20	
1D22464-27		Stiffener				1				B	1.00	
1D22464-29		Stiffener				1				B	.52	
1D22464-31		Channel				2				B	1.20	
1D22464-33		Stiffener				1				B	.30	
1D22415-1	A	Bearing-TFE Lined				2				B	4.50	
1D22464-19		Pin (Same 1D22475-3)				4				B	1.50	

1D2[illegible]59
HELIOSTAT ASSEMBLY

SEP 2 2 1980

PART NUMBER	CHG	NOMENCLATURE	QUANTITY							M or B	UNIT COST (Dollars)	
1D22494-1	C	Azimuth Drive			1					M	XXX	
1D22499-1	A	Harmonic Drive Kit				1				M	XXX	
		Wave Generator Plug					1			M	6.66	
		Wave Generator Bearing					1			B	83.18	
		Flex Spline					1			M	10.77	
		Circular Spline					1			M	36.96	
		Diaphram Hub (Collar)					1			M	.79	
1D22490-1	B	Bearing Kit - Turret				1				B	}	
		Balls					52			B	}	
		Wire Race - Inner					2			B	} 22.86	
		Wire Race - Outer					2			B	}	
1D22486-1	A	Gear - Helicon Output				1				B	15.00	
1D22443-1	B	Shim Turret Bearing				1				B	1.60	
1D22485-1	--	Shim Helicon Gear				4				B	.18	
1D22482-1	A	Plate Bearing Retainer				1				B	.52	
1D22495-1	C	Shaft, Harmonic Drive Input				1				M	4.87	
1D22489-1	C	Retainer, Turret Bearing				1				M	19.90	
1D22424-1	A	Bracket, Magnet, Azimuth Helicon				1				B	1.10	
1D22449-1	--	Spacer, Shaft Seal				1				B	.69	
1D22481-1	A	Bushing, Guide Drive Shaft				1				B	.50	
~~1D22421-1~~	~~--~~	~~Filler Block Circular Spline~~				~~1~~				~~B~~	XXX	
1D22422-1	--	Filler Block Flex Spline				1				B	5.45	
~~1D22420-1~~	~~--~~	~~Retainer Clip, Circular Spline Block~~				~~4~~				~~B~~	XXX	
1D22442-1	A	Lube Pan Assembly				1				B	}	
1D22442-3		Pan					1			B	}	
1D22442-5		Tube					1			B	} 4.15	
1D22442-7		Boss					1			B	}	
1D22593-1	--	Tube Assembly				1				B	}	
1D22593-3		Tube					1			B	}	
1D22593-5		Washer					1			B	} 4.98	
1D22411-501	--	Bracket, Electrical Azimuth				1				B	.10	
1D22474-1	B	Weld Assembly, Flex Support				1				M	XXX	
~~1D22474-7~~	~~--~~	~~Plate~~					~~1~~			~~B~~	XXX	
~~1D22474-17~~	~~--~~	~~Boss~~					~~1~~			~~B~~	XXX	
~~1D22474-3~~	~~--~~	~~Retainer~~ Retainer					1			~~B~~	XXX	
~~1D22474-5~~	~~--~~	~~Cone~~ Shell					1			B	12.75	
~~1D22474-9~~	~~--~~	~~Tube~~ Tube					1			B	7.42	
~~1D22474-11~~	~~--~~	~~Tube~~ Tube					1			B	8.50	
~~1D22474-13~~	~~--~~	~~Tube~~					~~1~~			~~B~~	2.99	
[illegible]-15		Mount					1			B	XXX	
											1.4[illegible]	

HELIOSTAT ASSEMBLY

SEP 2 2 J

PART NUMBER	CHG	NOMENCLATURE	QUANTITY							M or B	UNIT COST (Dollars)
1D22429-1	D	Azimuth Drive Cover				1				B	6.76
~~1D22429-3~~		~~Plate~~					~~1~~			~~B~~	XXX
~~1D22429-5~~		~~Ring~~					~~1~~			~~B~~	XXX
~~1D22429-7~~		~~Ring~~					~~1~~			~~B~~	XXX
~~1D22429-9~~		~~Support~~					~~1~~			~~B~~	XXX
~~1D22429-11~~		~~Ring~~					~~1~~			~~B~~	XXX
1D22411-1	--	Bracket, Electrical Azimuth					1			B	.10
106-KSZZ		Bearing				1				B	.81
2-133V747-75		Seal				1				B	.26
2-275V747-75		Seal				1				B	.65
2-386V747-75		Seal				1				B	.49
2-459V747-75		Seal				1				B	.49
506-325G		Seal				2				B	.98
~~HLT314-16-16~~		~~Pin~~				~~12~~				~~B~~	XXX
~~HLT294-LP-16~~		~~Collar~~				~~12~~				~~B~~	XXX
9651		Viton Seal				1				B	.98
N-06		Nut				1				B	.67
N-08		Nut				1				B	.67
W-06		Washer				1				B	.23
W-08		Washer				1				B	.23
NAS558-606-24		Key				1				B	.05
NAS558-1212-15		Key				1				B	.05
1010-104000		Expansion Chamber				2				B	2.605
M2 1		Magnet				1				B	.16
AN970-3		Washer				3				B	.016
.190-32UNF-2Ax.38		Round Head Screw				4				B	.004
.190-32UNF-2Ax.50		Round Head Screw				15				B	.004
.190-32UNF-2Ax.88		Flat Head Brass Screw				1				B	.022
.190		Split Lock Washer				20				B	.016
.190-32UNF-2B		Hexnut				2				B	.003
.250-20UNC-2Ax.63		Hex Cap Screw				8				B	.010
.250-20UNC-2Ax.75		Hex Cap Screw				4				B	.011
.250		Split Lock Washer				12				B	.003
.375-24UNF-2Ax1.75		Hex Cap Screw				16				B	.039
.375		Split Lock Washer				16				B	.007
TA4064E0610		Bracket				1				B	.07
1/8-27ANPT		Plug				1				B	.05
3/8-18NAPT		Plug				2				B	.13
ST253C6		Clamp				1				B	.10

HELIOSTAT ASSEMBLY

SEP 2 2

PART NUMBER	CHG	NOMENCLATURE	QUANTITY							M or B	UNIT COST (Dollars)	
DPM2766		Tape 1/2" Wide Antisieze Mil-T-2773D				1	ft			B	.05	
DPM5793		Plastic Gasket - Product 49-XX								B	.25	
DPM3279		Adhesive (1P20025-Class 1)								B	.12	
MOBILE626		Gear Oil				4	qt			B	.25	
ALUANIA EP2		Grease				4	lb			B	.40	
~~1D22575-1~~	B	Azimuth Motor/Incremental Encoder Electrical Assembly			-	1				M	XXX	
1D22487-501	D	Motor					1			B	60.93	
~~1D22571-1~~	A	Incremental Encoder Electrical Assy.					1			M	XXX	
1D22573-1	A	CCA Incremental Encoder						1		B	3.00	
1D22574-1	A	PWB Incremental Encoder							1	B	.12	
M39014-101-1513		Capacitor							1	B	.34	
RCR05G512JS		Resistor							2	B	.05	
DM7830JB		I.C.							1	B	4.98	
AAVIC-T1		Micro Switch							2	B	.765	
~~RT08-01-01-01~~		~~Standoff~~							2	B	XXX	
~~TC08-01-01-01~~		~~Standoff~~							2	B	XXX	
DMP3891		Solder							*	B	.03	
CMP3627-37875		Ink							*	B	.01	
#22-2SJ		Wire							6'	B	.095	
A1A		Splice							1	B	.06	
DPM2617-15		1/8" Black Shrink Tubing							3"	B	.0225	
MS35489-122		Grommet						1		B	.05	
110238-0040		Pin Contacts						2		B	.04	
110238-0085		Socket Contacts						5		B	.07	
NAS43DD-3-20		Spacer						1		B	.01	
NAS1715-D5T		Clamp						1		B	.05	
NAS601-10P		Screw						1		B	.02	
NAS620-6		Washer						1		B	.01	
~~RT102-3/8~~		~~Tubing~~						0		B	XXX	
MS24693-C28		Screw						2		B	.03	
~~1D22576-1~~	~~B~~	~~Baseplate~~						~~1~~		~~B~~	XXX	
~~1D22578-1~~	~~C~~	~~Vane Assembly~~					~~1~~			~~B~~	XXX	
~~1D22578-3~~		Vane						1		B	2.82	
~~SRS-C-16555-9~~		~~Collar~~						1		~~B~~	XXX	
~~1D22588-1~~	B	Cover, Incremental Encoder					1			B	.17	
~~MS51957-35~~		~~Screw~~					~~2~~			~~B~~	XXX	
NAS601-5P		Screw					6			B	.017	
MS35338-41		Lock Washer					8			B	.002	

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HELIOSTAT ASSEMBLY

SEP 22

PART NUMBER	CHG	NOMENCLATURE	QUANTITY							M or B	UNIT COST (Dollars)	
NAS620-6		Washer					8			B	.005	
PLT8H-LP0		Strap					1			B	.18	
120-1869-000		Connector					1			B	.37	
STM0069-13A6-02		1" Black Shrink Tubing					4"			B	.09	
~~DPM2617-15~~		~~1/2" Black Shrink Tubing~~					~~0~~			B	XXX	
~~DPM2617-15~~		~~1/4" Black Shrink Tubing~~					~~0~~			B	XXX	
1D22414-503	A	Sensor, Electronic Assembly				1				M	XXX	
120-1807-000		Connector					1			B	.37	
110238-0040		Contact, Pin					1			B	.04	
110238-0085		Contact, Socket					1			B	.07	
~~225-0072-000~~		~~Plug Sealing~~					0			B	XXX	
~~PLTIM-CP0~~		~~Cable Ties~~					0			B	XXX	
STM0069-13-A6-02		1" Black Shrink Tubing					4"			B	.09	
DPM2617-15		1/8" Black Shrink Tubing					1"			B	.0225	
~~DPM2617-15~~		~~1/4" Black Shrink Tubing~~					~~0~~			B	XXX	
LC2P-1839-1A-60		Proximity Switch					1			B	.69	
1D22596-1	A	Electrical Installation				1				M	XXX	
NAS601-6P		Screw					1			B	.02	
NAS620-10L		Washer					2			B	.01	
NAS671-10		Nut					1			B	.08	
MS35338-43		Washer					1			B	.002	
120-1806-000		Receptacle					1			B	.37	
120-1870-000		Receptacle					1			B	.33	
351-1641-000		Grommet					2			B	.44	
351-1634-000		Grommet					1			B	.45	
120-1805-000		Receptacle					1			B	.37	
STM0069-13-A6-02		1" Shrink Tubing, Black					4"			B	.09	
MS21919WDG-6		Clamp					1			B	.05	
1D22514-1	--	Wire Harness				1				M	XXX	
120-1869-000		Connector					2			B	.72	
120-1873-000		Connector					1			B	.37	
120-1865-000		Connector					1			B	.44	
120-1804-000		Connector					2			B	.29	
120-1870-000		Connector					1			B	.33	
110238-0040		Contact, Pin					31			B	.04	
110238-0085		Contact, Socket					27			B	.07	
225-0072-000		Plug, Filler					4			B	.0125	
351-1634-000		Grommet					2			B	.445	
~~PLTIM-CP0~~		~~Cable Ties~~					0			B	XXX	

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HELIOSTAT ASSEMBLY

PART NUMBER	CHG	NOMENCLATURE	QUANTITY	M or B	UNIT COST (Dollars)	
AIA		Splice	4	B	.12	
8918		Wire #18 AWG	100'	B	.107	
8451		Wire #22-2SJ	145'	B	.095	
DPM2617-15		1-1/2" Red Shrink Tubing	1/4"	B	.24	
DPM2617-15		1-1/2" Yellow Shrink Tubing	1/4"	B	.24	
DPM2617-15		1-1/2" White Shrink Tubing	1/4"	B	.24	
DPM2617-15		1/8" Black Shrink Tubing	9"	B	.0225	
DPM2617-15		1/2" Black Shrink Tubing	4"	B	.05	
STM0069-13-A6-02		1" Black Shrink Tubing	28"	B	.09	
DPM2617-15		1 1/2 Orange Shrink Tubing	1/4"	B	.24	

1D2[illegible]9
HELIOSTAT ASSEMBLY

SEP 22

PART NUMBER	CHG	NOMENCLATURE	QUANTITY							M or B	UNIT COST (Dollars)	
1D22496-1	A	Actuator Assembly - Elevation			1					M	XXX	
1D22497-1	D	Jack - Elevation				1				B	332.08	
1D22487-1	D	Motor					1			B	60.93	
~~1D22571-501~~		Incremental Encoder Electrical Assy.								M	XXX	
1D22573-501	B	CCA Incremental Encoder					1			B	3.00	
1D22574-1	A	PWB Incremental Encoder						1		B	.12	
M39014101-1513		Capacitor						1		B	.34	
RCR05G512JS		Resistor						2		B	.05	
DMT830JB		I.C.						1		B	4.98	
4AVIC-T1		Microswitch						2		B	.765	
~~RT08-01-01-01~~		~~Standoff~~						~~2~~		B	XXX	
~~RC08-01-01-01~~		~~Standoff~~						~~2~~		B	XXX	
DPM3891		Solder								B	.03	
DPM3627-37875		Ink								B	.01	
8451		Wire, #22-2SJ						21'		B	.095	
AIA		Splice						1		B	.06	
DPM2617-15		1/8" Black Shrink Tubing						3"		B	.0225	
MS35489-122		Grommet					1			B	.05	
11D238-0040		Pin Contacts					2			B	.04	
11D238-0085		Socket Contacts					5			B	.07	
NAS43DD-3-20		Spacer					1			B	.05	
NAS1715-05T		Clamp					1			B	.08	
NAS601-10P		Screw					1			B	.02	
NAS620-6		Washer					1			B	.005	
RJ102-3/8		Tubing					8"			B	.0213	
MS24693-C28		Screw					2			B	.03	
~~1D22576-1~~	~~B~~	~~Baseplate~~					~~1~~			B	XXX	
~~1D22578-1~~	~~C~~	~~Vane Assembly~~				~~1~~				B	XXX	
1D22578-3		Vane								B	1.00	
~~SPS-E-16555-9~~		~~Collar~~					~~1~~			B	XXX	
1D22588-1		Cover, Incremental Encoder								B	.16	
~~MS51957-35~~		~~Screw~~				~~2~~				B	XXX	
NAS610-6P		Screw				3				B	.03	
MS35338-43		Washer				3				B	.002	
NAS610-5P		Screw				6				B	.015	
MS35338-41		Washer				2				B	.002	
NAS620-6		Washer				6				B	.005	
NAS620-10L		Washer				3				B	.007	
ST253C2		Clamp				2				B	.25	

HELIOSTAT ASSEMBLY

SEP 22

PART NUMBER	CHG	NOMENCLATURE	QUANTITY	M or B	UNIT COST (Dollars)	
ST253C6		Clamp	1	B	.10	
S0985C50D		Clamp	3	B	.0633	
S0985C60D		Clamp	2	B	.065	
120-1808-000		Plug	1	B	.37	
120-1869-000		Plug	1	B	.37	
110-238-0040		Pin	6	B	.04	
110-238-0085		Socket	7	B	.07	
~~STM0069-7-08-02~~		~~Sleeving~~	~~0~~	B	XXX	
STM0069-13-A6-02		Sleeving, Black Shrink Tubing	4"	B	.09	
1D22595-1	--	Shroud	1	B	1.10	
1D22595-501	--	Shroud	1	B	.89	
					*As required	

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ENERGY SYSTEMS

APPENDIX B

TOOL AND LABOR ROUTING

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	MIRROR MODULE	14	50,000/YR		1 OF 6
CUSTOMER MDC	**DRAWING NUMBER** 1D22462-1				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
10	Purchase Front Lite Mirror,		-					
	Adhesive, Back Lite, Shims,							
	Adhesive, Stringer, & PVB,							
	Clinch Nuts, Edge Frames							
	Sealant & Primers							
11	Load Back Lite (3/16" THK-112#)		120					
	With Spec. Shipping Pallets							
	With Forklift							
	(Magaz: 1600#WGT + 112# = 15/MAG = 4.5 MINS)							
12	Load Adhesive in Spray Oper.		060	Fork Truck with Drum Rotate Capital			1	33,000
	With Forklift (50 gal. drum)							
13	Load Front Lite Mirror (1/16" THK)		050	Fork Truck Capital			1	27,500
	With Spec. Shipping Pallets							
14	Load Adhesive in Extru. Oper.		020	Installation				9,075
	With Forklift (50 gal. drum)			(Chargers, Stands, Power Drops,				
				Water, Wash, Safety Items)				
15	Load Scotchbrited Stringers (in Spe-		060					
	cial Shipping Pallets) With Forklift							
	Into Sub-Ass'y Mach. (Use 2 Stringers/							
	Refl. Surf. Ass'y)							
16	Load Clinch Nuts To Vibratory Bowl		020					
	Feeder With Forklift							
	Chute Feed Into Sub-Ass'y. Mach.							
	(Use 4 Clinch Nuts/Refl. Surf. Ass'y.)							

REMARKS

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	MIRROR MODULE	14	50,000/YR		2 OF 6
CUSTOMER MDC	**DRAWING NUMBER** 1D22462-1				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
20	Sub-Assembly (2 shift operation)		1 340					
	Subassemble (56) Clinch Nuts			Integrated Assembly Station				
	To Stringers (28) per Cycle			Complete With Pallet				
	180 Sec. Mach. Cycle Time			(1) Indexing Mechanism, (2)Vibrating				
	1 Mach./3 Operators			Bowl Hoppers & (2) Air Presses To				
	(Use 2 Stringers/Refl. Surf. Ass'y)			Drive Clinch Nuts				
21	Deliver Clinch Nuts		170	Capital			1	165,000
	Stringer Sub-Assemblies In			Special Tools				5,500
	Original Pallets to Mirror			Installation - Sub-Ass'y				24,750
	Module Assembly Mach.			Installation - Spray Mach.				10,250
	With Forklift							
22	Mat'l Handling		060	Bridge Crane			3	49,500
23	Spray Primer - Autom.		-	Bridge Type Spray Mach.			1	68,300
				Special Tooling			1	1,850
29	Acid Etch, Rinse, Prime Shim Coil			Lt. O'hd Man. Conveyor and (3) 80 gal.			1	6,800
	(Semi-auto Dip and Stage Dry in			Tanks				
	Receiving Bay)							
30	Assemble Mirror Modul		2 226	Mirror Module Ass'y				
	Complete			Mach. Complete				
	12 Mach. Cycle Time			Installation				
	6 Operators/Mach.			Mach. Capital Cost				
				Special Tooling				
				Durable Tooling				
				Non-Durable Tooling				

REMARKS

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	MIRROR MODULE	14	50,000/YR	3 OF 6

CUSTOMER	DRAWING NUMBER
MDC	1D22462-1

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
	8 Operators/Complete Ass'y Oper'n			Machine Consists of the following				
	(Relief provided for personal &			major elements:				
	lunch due to operation flow)			Mainline				
31	Relief for 8 Operators @ 24.2%		718	Power & Free Conveyor				
				360 ft. long x 5 ft. wide Capital			1	158,400
32	Relief for Trucking/Supply @ 24.2%		136	30 Drive Sections Capital			1	61,875
33	Line Bal. Oper. #30, 7 & 27/Rel. Opers.		395					

REMARKS

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	MIRROR MODULE	14	50,000/YR		4 OF 6
CUSTOMER MDC	**DRAWING NUMBER** 1D22462-1				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
	STA. NO.			Installation - All Capital Items				145,605
				This Page (*)				
30	1 Load Back Lite Glass			Glass Loader - Back Lite Capital			1	110,000*
				Special Tools				1,100
	5 Load Front Lite Mirror			Glass Loader - Front Lite Capital			1	165,000*
				Special Tools				1,650
	19 Load Stringer			Stringer Loader Capital			1	137,000*
				Special Tools				330
	(See Autoclave Oper.)							
	2&9 Jet Spray Wash			Spray Washer Capital			2	55,000*
				Special Tools				1,100
	3&10 Deionized Water Rinse			Deionized Water Rinser Capital			2	77,000*
				Special Tools				440
	4&11 Warm Air Dry			Warm Air Dryer Capital			2	55,000*
	14 Spray Adhesive (Stabond)			Adhesive Sprayer Capital			1	37,500*
				Special Tools				550
	6&15 Nip Roller			Pinch Roller Capital			3	99,000*
	*15 See bottom of page B-6			Special Tools				1,980
	18 Extrude Adhesive (EC3532)			Adhesive Extruder Capital			1	38,500*
				(4 Strips)				
	Offline } Stringer Cure			Pallets			44	117,040
				Special Tools				356,400
	21 } Stringer Cure			Pallet Load Sta. Capital			1	33,800*
	Stringer							
	Offline } Cure			Pallet Conveyor			1	52,500*
				(210 ft. Circuit)				
	22 } Stringer Cure			Pallet Unload Sta. Capital			1	110,400*
				(w/Shuttle to Load Sta.) Special Tools			1	275

REMARKS

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	MIRROR MODULE	14	50,000/YR		5 OF 6
CUSTOMER: MDC	DRAWING NUMBER: 1D22462-1				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
	STA. NO.			Installation				2,100
30	5 PVB Roller			Auto Apply & Cut-Off			1	14,000
				PVB Film				
	5&6 PVB Tack Heater (130°F)			Heating Elements Between Rollers			1	8,500
	7&8 Load, Unload, Shuttle Racks			(2)Stacking Elevators With Shuttle To			3	510,000
			.371	Reload Empty Racks - Installation				76,500
				(.75" Pitch - 50 Indexes)				
	27&28 Load,Unload,Shuttle Racks		.371	Same As Above Exc.			1	160,000
				(4" Pitch - 12 Indexes) Installation				24,000
	7,12,16 Racks			Racks - 50 Pts. @ .75" Pitch			126	1,039,500
				Sq. Tube Frame, Open Ends				
				Soft, Slotted Edge Pt. Guides				
				(5'W x 11'L x 42"H)				
	27 Racks			Same As Above Exc.			68	561,000
				Roller Support Guides				
				12 Pts. @ 4" Pitch				
				(5'W x 11'L x 52"H)				
	Off 7 90° Roll			Rack Rotate 90° CW			2	56,000
				(1)To Conveyor (1)To Line				
	Scrap Loss @ 3%		.134	Comb. 180° Rotation Installation				8,400
	Mach. Downtime @ 5%		.271					
	Inspection (Including Relief)(2 Opers.)		1.000					

REMARKS

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	MIRROR MODULE	14	50,000/YR	6 OF 6

CUSTOMER	DRAWING NUMBER
MDC	1D22462-1

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
	STA. NO.							
30	Off 7 Conveyor			Power & Free Roller Index			1	91,000
	(Autoclave Branch Circuit)			W/Elec. Interlock To Mainline,				
				Rotates & Autoclaves 364 ft.				
	Off 7 Autoclave Laminate Cure			Autoclave - Hot Air & Pres.			14	2,517,886
				10' Dia. x 15' L w/Auto.				
				Open-Close Door & Timer				
	Off 12 Conveyor-Primer Cure 20'			Power & Free Roller Index			1	5,000
	" -Shim Cure 540'			W/Elec. Interlock To			1	135,000
	" -Silicone Cure 350'			Mainline - Total 910 ft.			1	87,500
	23 Apply Sealant (Silicone)			Auto Extruder - 8 Beads			1	58,800
	24 Apply Edge Frames			Load Jig (11 ft.)			2	18,000
	4 Operators			Gondolas			4	600
	26 Apply (2)Bungee Cords (Flat)							
	2 Operators			Flat Rubber Bands			200	50
	30 Unload To Refl. Panel Ass'y.			Auto Unload Interface			1	10,000
	Line			To Conveyor				
	*STA. 15, Page B-4							
	Uncoil, Straighten & Cut Shims			Spec. Uncoiler, cutter			1	14,300

REMARKS
Total Labor - 7.522

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	REFLECTOR SUPPORT STRUCTURE	2	50,000/YR	1 OF 2

CUSTOMER	DRAWING NUMBER
MDC	1D22463-1

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
10	Purch. Roll Formed Sections, Doublers			Vendor: VanHuffel				
	& Gussets - Galvanized and all holes							
	punched							
15	Load, Diagonal Beam	80	1 250					
20	Manually	80	1 250					
	and			Installation				95,700
	Trim Ends			5 Sta. D.E. Dieline				
	27 Sec. Mach. Cycle Time			Complete 2%				
	1 Oper. Per Mach.			Mach. Capital Cost				319,000
	(Symetrical Trim - No Opp. Hand)			Special Tooling				33,825
				Durable Tooling				3,720
				Non-Durable Tooling				7,279
	Note: Labor Balanced to 38 Secs.							
	Cycle of Oper. #40 (Weld			Machines consist of the following				
	and Drill -- Bottleneck)			major elements:				
				5 Sta. Walking Beam				
				Transfer Mechanism				
				Vertical Presses &				
				Trim Dies				
				Hydraulic Brake				
				Bending Dies				
25	Autounload Fin. Diag. Beam Into							
	Oper. 40 Resist. Weld Mach.							

REMARKS
Annual Tool Useage 60% Non-Durable

Wgt. of R.H. Beam Approx. 46#
L.H. Beam Approx. 46#

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	REFLECTOR SUPPORT STRUCTURE	2	50,000/YR	2 OF 2
CUSTOMER MDC	**DRAWING NUMBER** 1D22463-1			

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
26	Load Inboard Beam Manually onto							
	Resist. Weld Mach. (2 Opers.)		2.500					
36	Man. Load Outboard Beam(Dblrs.&Ctr.Braces)	80	1.250					
37	Doublers & Gussets Onto (Gussets)	80	1.250					
38	Resistance Weld Mach. (Out.Beam							
	(4 Operators Total) & X-Braces)	(80)	2.500					
39	Manually Arc Weld (2) Gussets	80	1.250					
	Using Semi-Automatic "Squirt Gun" -							
	Automatic Turnover Device Indexes							
	Part 180° (1 Operator)							
				Installation				276,046
40	Resistance Weld Support Structure			Resistance Welding, Drilling and				
	Complete, Drill (8) Mtg. Holes (Autom.)			Straightening Mach. (13 Sta.)				
	and Straighten Frame			Machine Capital Cost			1	2,273,945
	38 Sec. Mach. Cycle Time			Special Tooling			1	474,300
				Durable Tooling			1	98,000
				Non-Durable Tooling				5,800
	Scrap @ 2%		.225					
	Mach. Downtime @ 5%		.563					
45	Trucking - Mat'l. Hdlg.		2.000					
46	Repair @ 5% (4 Times Labor Cost)		2.250					
43	Auto Hole Loc. Gage @ Sta. 10		-	Gage			1	8,000
	Auto Unload with O'Head			Power & Free O'Head Conveyor				
	Tramrail Crane			500' @ $2,200 (11/2/79)			1	100,000
47	Inspection - Floor Inspectors		1.000					

REMARKS Hours/100 Group Total - 17.288

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	REFLECTOR ASSEMBLY	2	50,000/YR	1 OF 2

CUSTOMER	DRAWING NUMBER
MDC	1D22456-1

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
				Installation				3,750
10	Auto Load Mirror Modules From Their			Power Roller Conveyer w/Direct			1	25,000
	Assembly Line			Interface to Glassline 100 ft.				
				.33 FPS				
15	Supply & Maintain Equipment (2 Oper.)	(36)	5 556					
33	Autoload "K" Frame From Weld Line	(36)	5 556	Power & Free Monorail			1	352,500
	(2 Operators)			22 Hooks 448 ft.				
				Monorail Hoist 8 ft.		(Load)	1	22,000
						(Unload)	1	22,000
30	Progressive Ass'y. of Panel on							
	Continuous Moving Line as follows:							
31	Drive (28) Studs 3 Sec. Cycle			4 Spin Air Wrench Head w/Spacing			1	14,000
				Pins				
42	Relief for (6) Operators @ 16.7%		2 784	Manifolded Bowl Feeders			11	46,200
43	Repair @ 5% (4 x Labor)		3 334					
	Mach. Downtime Allce. @ 5%		973					
32	Locate (7) Mirror Mod Panels			8' Indexing Spacing Guide			1	9,300
34	Drive Nuts w/Washers (14)			2 Spin Air Wrench Head			1	9,400
	Outboard Beam 3 Sec. Cycle			Manifolded Bowl Feeder			2	8,400
35	Drive Nuts w/Washers (12)			2 Spin Air Wrench Head			1	11,20[illegible]
	Inboard Beam 6 Sec. Cycle			Manifolded Bowl Feeders			2	8,400
36	Drive Nuts & Washers (2)			2 Spin Air Wrench Head			1	12,600
	Inboard Beam 6 Sec. Cycle			Manifolded Bowl Feeder			2	8,400
40	Insp. & Unload (2 Operators)		5 556					

REMARKS Replace Wrenches two times a year.

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	REFLECTOR ASSEMBLY	2	50,000/YR	2 OF 2
CUSTOMER	DRAWING NUMBER			
MDC	1D22456-1			

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
50	Load to Shipping Rack and Strap			Overhead Crane				5,500
	3 Places (2 Operators)	(15)	13.333	Installation				825

REMARKS
Total Labor 37.091

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	PEDESTAL (Weld)	1	50,000/YR	1 OF 3

CUSTOMER	DRAWING NUMBER
MDC	1D22461-1

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
10	Purchase Weld Components							
15	Mat'l. Handling		2.000	Custom Pallets			4	308
				Monorail Hoist			1	15,000
20	Weld Access Hole Ring to Main Column	35	2.900	Dollar Weld Machine Installation	1	12	1	10,000
	85.0 Mach. Cycle Time			Mach. Capital Cost			1	68,000
	1/2 Mach./Operator			Spec. Tooling			1	11,900
				Durable Tooling			1	4,250
				Non-Durable Tooling			1	850
25	Mat'l. Handling		1.000	Lt. Monorail 288'				72,000
				Trolleys & Hooks 96			96	24,000
				Monorail Hoist			1	15,000
30	Weld Ring to Cone	37.5	2.700	Dollar Weld Machine	1	12		
	80.0 Mach. Cycle Time			Installation			1	6,000
	1/2 Mach./Operator			Mach. Capital Cost			1	38,400
				Spec. Tooling			1	6,720
				Durable Tooling			1	2,400
				Non-Durable Tooling			1	480
35	Mat'l. Handling		1.000	Monorail Hoist			1	15,000

REMARKS

Wt. 456# Appr.

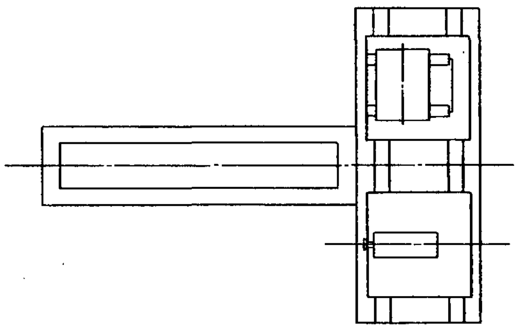
TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	PEDESTAL (Weld)		50,000/YR	2 OF 3
CUSTOMER	**DRAWING NUMBER**			
MDC	1D22461-1			

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
40	Weld Cone Sub-Assy.			Dollar Weld Mach.	1	12		
	To Main Column	27	3.704	Installation			1	5,000
	110.0 Mach. Cycle Time			Mach. Capital Cost			1	33,280
	1 Mach./Operator			Spec. Tooling			1	5,824
				Durable Tooling			1	2,080
				Non-Durable Tooling			1	416
45	Mat'l. Handling		1.000	Monorail Hoist			1	15,000
50	Expand Taper	75	1.334	Grotnes Expand Mandrel	3	5		
	38.0 Mach. Cycle Time			Installation				16,088
	1 Mach./Operator			Mach. Capital Cost			1	107,250
				Spec. Tooling			1	35,750
				Durable Tooling			1	23,238
				Non-Durable Tooling			1	12,513
55	Mat'l. Handling		1.000	Monorail Hoist			1	15,000
60	Mill & Drill Flange	34	2.942	Lamb 2 Sta. Spec. (Figure B-1)	1	20		
	86.5 Mach. Cycle Time			Purpose Mach.				
	1/2 Mach./Operator			Installation			1	48,000
				Mach. Capital Cost			1	320,000
				Spec. Tooling			1	214,400
				Durable Tooling			1	8,000
				Non-Durable Tooling			1	3,200

REMARKS

MACHINE CYCLE	SEC
UNLOAD, LOAD, CLAMP, & UNCLAMP PART	45.0
RAPID ADVANCE	1.0
FEED	20.0
SHUTTLE	1.5
RAPID ADVANCE CROSS SLIDE	1.0
FEED CROSS SLIDE	14.0
RAPID RETURN CROSS SLIDE	1.0
RETURN SHUTTLE	3.0
TOTAL SECONDS	86.5



GM ENERGY SYSTEMS

PART - PEDESTAL
PT. # 1022461

OPERATION - # 60

APPROXIMATE FLOOR AREA
17'-0" x 16'-0"

DO NOT SCALE

MACHINING TOLERANCE
2 PLACE DEC. ±.010
3 PLACE DEC. ±.005
4 PLACE DEC. ±.0005

REMOVE ALL BURRS AND BREAK SHARP EDGES
CHAMFER ALL TAPPED HOLES 45° TO 1/32 OVER TAP SIZE

TITLE LAMB (2) STATION SHUTTLE MACHINE

FIGURE B-1. LAMB TWO STATION SHUTTLE MACHINE

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	PEDESTAL (Weld)	1	50,000/YR	3 OF 3

CUSTOMER	DRAWING NUMBER
MDC	1D22461-1

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
65	Mat'l. Handling		1 000	Monorail Hoist			1	15,000
67	Master Gage - Inspect		3 000	Spec Tool			1	8,000
	Taper & Mounting Holes							
68	Mat'l. Handling to Paint Booth		1 000					
	(See Oper #25)							
	Scrap Loss							
	Oper. #20, 30, 40, 60 @ 1%		163					
	Oper. #50 @ 3%		040					
	Rework @ 5% (4xLabor)		3 516					
	Mach. Downtime @ 5%		679					
	Floor Inspector		1 500					

REMARKS

Total Labor 30.478

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	PEDESTAL (Paint)	1	50,000/YR	1 OF 1
CUSTOMER MDC	**DRAWING NUMBER** 4451			

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
5	Mat'l. Handling from Weld Bay		1.000	Overhead Monorail 12 ft.			1	9,000
10	Load/Unload Paintline/Operator	16	6.250	Monorail Hoist			1	15,000
	186 Secs. Cycle Time							
20	Spray Tectyl/Interior	16	6.250	Binks Prime & Paint	1	--		
	Spray Prime, Paint & Cure			Sprayline - Special				
	Exterior Pedestal			Capital			1	436,667
	1 Operator/Mach.			Installation			1	65,500
	186 Secs. Cycle Time							
25	Mat'l. Handling to		2.000	Lt. Overhead Monorail 288'			1	72,000
	Final Ass'y. Bench			Trolley & Hooks			96	24,000
	Scrap @ 1%		.125					
	Rework @ 1% (4xLabor)		.500					
	Floor Inspector		3.000					

REMARKS

Main Beam Interior is Sprayed With Tectyl On This Line.

Total Labor 19.125

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	AZIMUTH DRIVE HOUSING (Weld)	1	50,000/YR		1 OF 3
CUSTOMER	**DRAWING NUMBER**				
MDC	1D22474-1				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
10	Purchase Weld Components		-					
15	Mat'l. Handling		.400	Gondolas			8	1,200
20	Weld Bearing Sleeve to Lower Housing	75	1.334	Dollar Weld Machine	2	29		
				Installation				5,250
	40.0 Mach./Cycle Time			Mach. Capital Cost			1	34,960
	1/2 Mach./Operator			Spec. Tooling			1	6,118
				Durable Tooling			1	2,185
				Non-Durable Tooling			1	437
25	Mat'l. Handling		.300	Lt. Monorail 192 ft.				48,000
				Trolleys & Hooks 48			48	12,000
				Monorail Hoist			1	15,000
30	Weld Mounting Ring to Lower Housing	30	3.334	Dollar Weld Machine	2	140		
				Installation				12,000
	95.0 Mach. Cycle Time			Mach. Capital Cost			1	77,600
	1 Mach./Operator			Special Tooling			1	13,580
				Durable Tooling			1	4,850
				Non-Durable Tooling			1	970
35	Mat'l. Handling		.300	Monorail Hoist			1	15,000

REMARKS

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	AZIMUTH DRIVE HOUSING (Weld)	1	50,000/YR	2 OF 3

CUSTOMER	DRAWING NUMBER
MDC	1D22474-1

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
40	Plug Weld Lower Housing and Inner			2 Sta. Dollar Weld Mach.	2	120		
	Ass'y.			Installation				14,000
	Index to Brush and Flush Station			Mach. Capital Cost			1	92,000
		26	3.746	Special Tooling			1	16,100
	115.0 Mach. Cycle Time			Durable Tooling			1	5,750
	1 Mach./Operator			Non-Durable Tooling			1	1,150
45	Mat'l. Handling		.300	Monorail Hoist			1	15,000
50	Weld Housing Extension			Dollar Weld Mach.	2	32		
	to Lower Housing Sub-Ass'y.	46	2.174	Installation				10,500
	Manual Weld Corners			Mach. Capital Cost			1	70,000
	65.0 Mach. Cycle Time			Special Tooling			1	12,250
	1/2 Mach./Operator			Durable Tooling			1	4,375
				Non-Durable Tooling			1	875
55	Mat'l. Handling		.300	Monorail Hoist			1	15,000
60	Weld Motor Mounting Plate to Housing			Dollar Weld Mach.	2	8		
	Sub-Ass'y.	60	1.667	Installation				9,000
	50.0 Mach. Cycle Time			Mach. Capital Cost			1	58,000
	1/2 Mach./Operator			Special Tooling			1	10,150
				Durable Tooling			1	3,625
				Non-Durable Tooling			1	725

REMARKS

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	AZIMUTH DRIVE HOUSING (Weld)	1	50,000/YR		3 OF 3
CUSTOMER	**DRAWING NUMBER**				
MDC	1D22474-1				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
65	Mat'l. Handling		.300	Monorail Hoist			1	15,000
70	Weld Upper and Lower Filler Stampings	33	3.030	Dollar Weld Mach.	2	140		
				Installation				10,000
	90.0 Mach. Cycle Time			Mach. Capital Cost			1	68,400
	1 Mach./Operator			Special Tooling			1	11,970
				Durable Tooling			1	4,275
				Non-Durable Tooling			1	855
74	Mat'l. Handling		.300	Monorail Hoist			1	15,000
75	Master Gage		2.500					
76	Mat'l. Handling to AZ. Drive Mach.		.400					
	(See Oper. #25)							
	Scrap Loss @ 2%		.402					
	Mach. Downtime @ 5%		1.005					
80	Inspection		1.000					

REMARKS

Total Labor 22.892

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	AZIMUTH DRIVE HOUSING (Machine)	1	50,000/YR	1 OF 3
CUSTOMER: MDC	DRAWING NUMBER: 1D22474-1			

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
10	Bring Weldment from Welding Bay Ready							
	To Machine							
16	Mat'l. Hand. - Mono.		.500	Monorail Conveyor 135 ft.			1	33,750
17	Hoist		-	Hoist - Monorail			1	15,000
				Trolleys & Hooks			34	8,500
20	Qualify Loc. Dia. & Face	14	7.143	Bullard Templa - Turn	3			
	(2) Mounting Surfaces			Vert. Turret Lathe				
	732 Mach. Cycle Time			Special Cam Cycle				
	4 Mach./Operator			Installation				193,500
				Mach. Capital Cost			3	1,290,000
	Relief - Oper. #20 @ 24.2%		1.729	Special Tooling			3	37,200
	(Relieve for all periods, including			Durable Tooling			3	5,625
	lunch, washup, personal time)			Non-Durable Tooling		50	3	1,875

REMARKS Wt. 66# Approx.

TOOL AND LABOR ROUTING

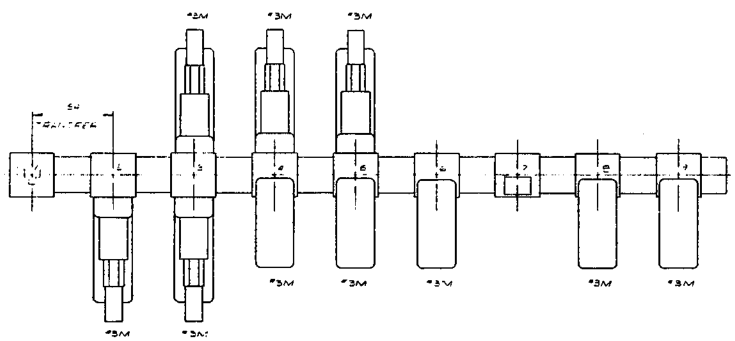
MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	AZIMUTH DRIVE HOUSING (Machine)	1	50,000/YR	2 OF 3

CUSTOMER	DRAWING NUMBER
MDC	1D22474-1

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
27	Hoist		-	Hoist			1	15,000
25	In Process Gage		-	Special Tooling			1	12,400
26	Mat'l. Handling - Mono.		500	Monorail Conveyor 135 ft.			1	33,750
				Trolleys & Hooks 34			34	8,500
30	Plunge Face	16	6 250	Lamb 9-Sta. Shuttle (Figure B-2)	1			
	Bore, Tap Drill & Tap			Mach. Dbl. End				
	186.0 Mach. Cycle Time			Installation				189,338
	1 Mach./Operator			Mach. Capital Cost				1,262,250
				Special Tooling			1	841,500
				Durable Tooling			1	31,557
				Non-Durable Tooling		261	1	10,519
				Hoist-Monorail			1	15,000
34	Part Wash		-				1	3,850
35	In Process Gage		-				1	13,200
36	Mat'l. Hand. - Mono.		500	Monorail Conveyor 75 ft.			1	18,750
				Trolleys & Hooks 26			26	6,500
A-O	Tap Drill & Tap (37)	22	4 546	Lamb 6-Sta. Shuttle (Figure B-3)	1			
	134.0 Mach. Cycle Time			Mach. Dbl. End				
	1 Mach./Operator			Installation				126,225
				Mach. Capital Cost				841,500
				Special Tooling			1	561,000
				Durable Tooling			1	21,038
				Non-Durable Tooling		100	1	7,013
				Hoist - Monorail			1	15,000

REMARKS

STA #2L	STA #3LH	STA #4LH	STA #5LH	STA #6L	STA #7L	STA #8L	STA #9L
IDLE	SEMI FINISH BORES "B" & "F" (1/2 WAY)	SEMI FINISH BORE "C" & "F" (1/2 WAY)	FINISH BORES "B" & "C"	IDLE	IDLE	IDLE	IDLE



STA #	STA #2RH	STA #3RH	STA #4RV	STA #5RV	STA #6RV	STA #7RV	STA #8RV	STA #9RV
LOAD & UNLOAD PART	SEMI FINISH BORE "F" & FINISH SURFACE "J"	FINISH BORE "F"	DRILL & CHAMFER HOLE # 45.	CORE DRILL HOLE # 45.	TAP DRILL & CHAMFER HOLES # 26 THRU 29, 42, 43 & 44	PROBE HOLES # 26 THRU 29, 42, 43 & 44	TAP HOLES # 26 THRU 29 & 43	TAP HOLES # 42 & 44

LAMB STANDARD WAY TYPE UNIT				
SIZE NO	WIDTH ACROSS WAYS	STROKE SHORT	STROKE LONG	CROSS SECTION OF WAYS
2	9.25		18	[illegible]
3	14.5	18	30	1.5 X 3.62
4	19.5	18	28	2.25 X 4.75
5	27.0	24	33	3" X 7"
SPEC				

MACHINE CYCLES

UNLOAD, LOAD CLAMP & UNCLAMP PART	33.0
SHUTTLE TO STA #2	2.5
LOCATE & CLAMP	1.5
RAPID ADVANCE	1.0
FEED	13.0
RAPID RETURN	1.0
UNCLAMP	.5
SHUTTLE TO STA #3	2.5
LOCATE & CLAMP	1.5
RAPID ADVANCE	1.0
FEED	20.0
RAPID RETURN	1.0
UNCLAMP	.5
SHUTTLE TO STA #4	2.5
LOCATE & CLAMP	1.5
RAPID ADVANCE	1.0
FEED	20.0
RAPID RETURN	1.0
UNCLAMP	.5
SHUTTLE TO STA #5	2.5
LOCATE & CLAMP	1.5
RAPID ADVANCE	1.0
FEED	10.0
RAPID RETURN	[illegible]
UNCLAMP	.5
SHUTTLE TO STA #6	2.5
LOCATE & CLAMP	.5
RAPID ADVANCE	.0
FEED	[illegible]
RAPID RETURN	[illegible]
UNCLAMP	.5
SHUTTLE TO STA #7	2.5
LOCATE & CLAMP	.5
PROBE IN	2.0
PROBE OUT	[illegible]
UNCLAMP	.5
SHUTTLE TO STA #8	2.5
LOCATE & CLAMP	1.5
RAPID ADVANCE	1.0
TAP IN	2.5
TAP OUT	2.5
RAPID RETURN	1.0
UNCLAMP	.5
SHUTTLE TO STA #9	2.5
LOCATE & CLAMP	1.5
RAPID ADVANCE	1.0
TAP IN	[illegible]
TAP OUT	2.5
RAPID RETURN	1.0
UNCLAMP	.5
RETURN SHUTTLE TO STA #1	20.0
TOTAL SECONDS	[illegible]

ESTIMATED PRODUCTION

19 PARTS/HR. @ [illegible]% EFF.

PARTS: DRIVE HOUSING FOR [illegible]

PT# 1022[illegible]

MATERIALS

OPERATION # 30

APPROXIMATE FLOOR AREAS

24'-0" x 19'-0"

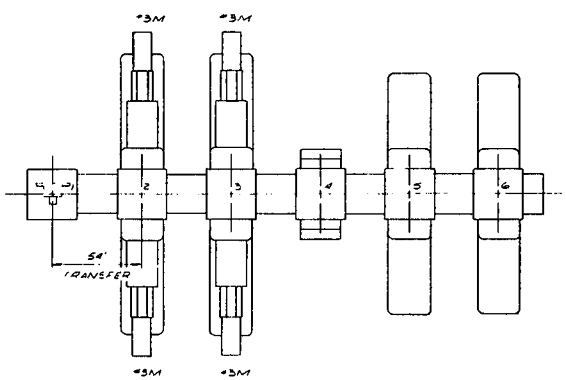
LAMB	PROPOSAL DEPT.
LAMB (9) STATION SHUTTLE MACHINE	
	G.M.

GM ENERGY SYSTEMS

FIGURE B-2. LAMB NINE STATION SHUTTLE MACHINE

STA #2 LH	STA #3 LH	STA #4 LH	STA #5 LH	STA #6 LH
TAP DRILL & CHAMFER HOLES #1 THRU 8.	TAP DRILL & CHAMFER HOLES #9 THRU 24.	PROBE HOLES #1 THRU 24.	TAP HOLES #1 THRU 8.	TAP HOLES #9 THRU 24.

LAMB STANDARD WAY TYPE UNIT				
J.T.C. NO	WIDTH ACROSS WAYS	STROKE SHORT	STROKE LONG	CROSS SECTION OF WAYS
2	9.25		18	1"X2"
3	14.5	18	30	1.5"X3.62"
4	19.5	18	28	2.25"X4.75"
5	27.0	24	33	3"X7"
SPEC				



STA #1	STA #2 RH	STA #3 RH	STA #4 RH	STA #5 RH	STA #6 RH
AUTO LOAD & UNLOAD (1) PART.	TAP DRILL & CHAMFER HOLES #38 THRU 41 & 25.	TAP DRILL & CHAMFER HOLES #30 THRU 37.	PROBE HOLES #30 THRU 41 & 25	TAP HOLES #38 THRU 41 & 25.	TAP HOLES #30 THRU 37.

MACHINE CYCLES:

UNLOAD, LOAD, CLAMP & UNCLAMP PART	33.0
SHUTTLE TO STA #2	2.5
LOCATE & CLAMP	1.5
RAPID ADVANCE	1.0
FEED	4.0
RAPID RETURN	1.0
UNCLAMP	.5
SHUTTLE TO STA #3	2.5
LOCATE & CLAMP	1.5
RAPID ADVANCE	1.0
FEED	14.0
RAPID RETURN	1.0
UNCLAMP	.5
SHUTTLE TO STA #4	2.5
LOCATE & CLAMP	1.5
PROBE IN	2.0
PROBE OUT	2.0
UNCLAMP	.5
SHUTTLE TO STA #5	2.5
LOCATE & CLAMP	.5
RAPID ADVANCE	1.0
TAP IN	[illegible]
TAP OUT	[illegible]
RAPID RETURN	[illegible]
UNCLAMP	.5
SHUTTLE TO STA #6	2.5
LOCATE & CLAMP	5
RAPID ADVANCE	[illegible]
TAP IN	6.[illegible]
TAP OUT	[illegible]
RAPID RETURN	[illegible]
UNCLAMP	5
RETURN SHUTTLE TO STA #	2.5
TOTAL SECONDS	13[illegible]

ESTIMATED PRODUCTION:

26.8 PARTS/HR. @ 100% EFF.

PART: DRIVE HOUSING FOR HEL[illegible]

PT. # 1022474

MATERIAL:

OPERATION: #40

APPROXIMATE FLOOR AREA:

29'-0" X 19'-0"

GM ENERGY SYSTEMS

LAMB	PROPOSAL DEPT
LAMB 6 STATION SHUTTLE MACHINE	
	DRAWN BY G M

FIGURE B-3. LAMB SIX STATION SHUTTLE MACHINE

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	AZIMUTH DRIVE HOUSING (Machine)	1	50,000/YR	3 OF 3

CUSTOMER	DRAWING NUMBER
MDC	1D22474-1

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
43	Inspection - Floor Inspector		1.000					
44	Part Wash		-				1	3,850
45	Master Gage &						1	38,500
	Hand Gages		1.000					
46	Mat'l. Hand. to Drive Ass'y. Line		.500	Hoist - Monorail			1	15,000
				Monorail Conveyor 80 ft.			1	20,000
				Trolleys & Hooks			20	5,000
	Scrap Loss							
	Oper. #20 @ 3%		.266					
	Oper. #30, 40 @ 1%		.108					
	Rework @ 5% (4 x Labor)		4.134					
	Mach. Downtime @ 5%		1.034					

REMARKS
Total Labor 29.210

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET 1 OF 1
HELIOSTAT	MAIN BEAM (Weld)	1	50,000/YR		
CUSTOMER MDC	**DRAWING NUMBER** 1D22464-1				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
10	Purchase Weld Component		-					
15	Mat'l. Handling & Parts Supply		4.000	Custom Pallets			28	10,780
20	Weld Main Beam	(17)	88.250	Dollar Weld. Machine (Figure B-4)	2			
	Complete			20 Sta.				
	180.0 Mach. Cycle Time			Installation			1	107,500
	15 Mach./Operators			Mach. Capital Cost			1	716,400
				Special Tooling			1	125,370
				Durable Tooling			1	44,775
				Non-Durable Tooling		80	1	8,955
24	Material Handling		2.000	Lt. Monorail Hoist				
25	Master Gage		2.000				1	8,000
28	Mat'l. Handling to		2.000	Lt. Monorail 32 ft.			1	8,000
	Main Beam Machining			Trolleys & Hooks			6	1,500
				Monorail Hoist			1	15,000
	Scrap @ 2%		1.765					
	Rework @ 5% (4 x Labor)		17.650					
	Mach. Downtime @ 5%		4.413					
	Inspection (1 Inspector)		6.000					

REMARKS
Wt. 370.9# Approx.   Total Labor 128.078

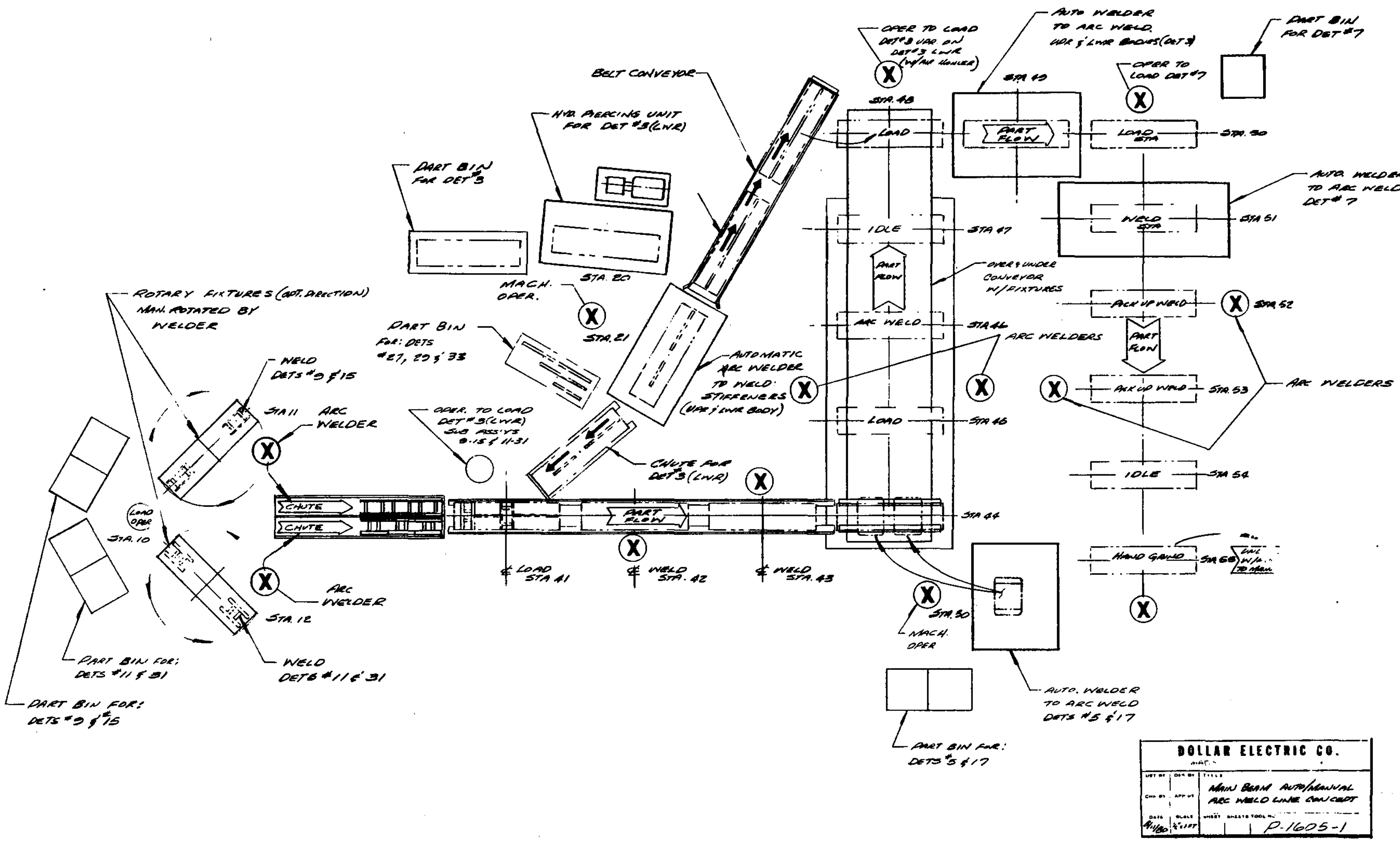


FIGURE B-4. DOLLAR ELECTRIC MAIN BEAM WELDING LINE

TOOL AND LABOR ROUTING

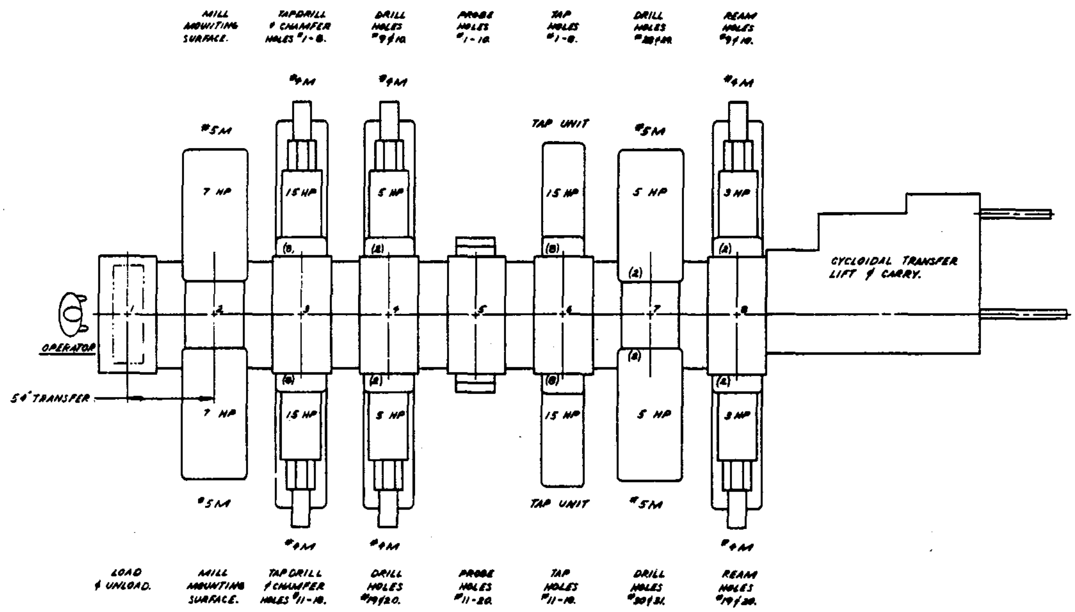
MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	MAIN BEAM (Machine)	1	50,000/YR	1 OF 2

CUSTOMER	DRAWING NUMBER
MDC	1D22464-1

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.		MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
10	Bring Weldment from Welding Bay		1	500					
	Ready to Machine								
14	Hoist		-		Hoist - Monorail			1	15,000
20	Mill Ends, Tap Drill (16)	16	6	250	Lamb 8-Sta. Shuttle (Figure B-5)	1			
	& Tap (16), Drill (4), Ream (4), &				Mach. Dbl. End				
	Press (4) Locating Pins				Installation				169,600
	186.0 Mach. Cycle Time				Mach. Capital Cost				1,123,000
	1 Mach./Operator				Spec. Tooling			1	748,000
					Durable Tooling		400	1	9,400
24	Part Wash		-					1	3,850
25	In Process Gage		-					1	13,200
26	Hoist		-		Hoist			1	15,000
27	Mat'l. Hand. - Mono.		1	500	Monorail Conveyor 75 ft.				56,250
28	Hoist		-		Hoist				15,000
					Trolleys & Hooks 26			26	19,500
30	Tap Drill & Tap	16	6	250	Lamb 4-Sta. Shuttle (Figure B-6)	1			
	(2) Lugs				Mach. Dbl. End				
	186.0 Mach. Cycle Time				Installation				84,200
	1 Mach./Operator				Mach. Capital Cost				561,000
					Spec. Tooling			1	374,000
					Durable Tooling			1	14,100
					Non-Durable Tooling		240	1	4,700

REMARKS

Wt. 370.9#/Piece



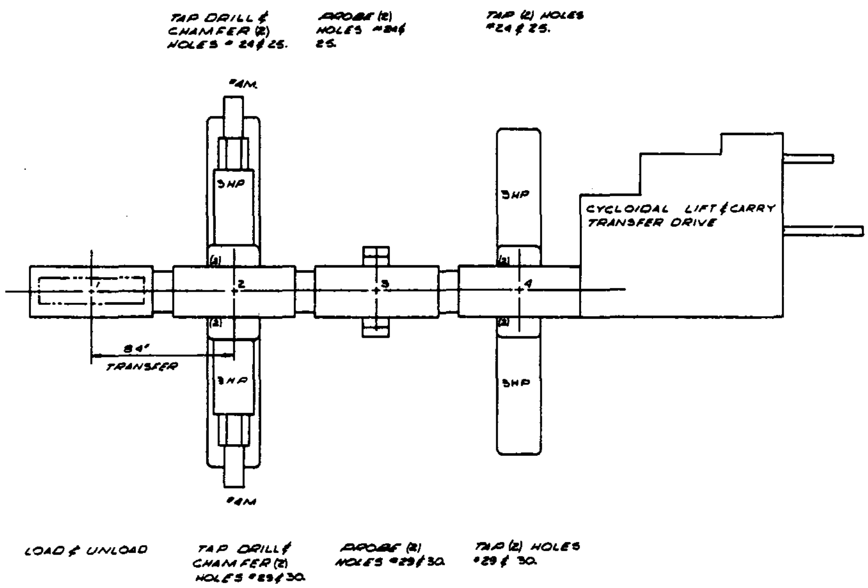
MACHINE CYCLES		SECONDS
	UNLOAD, LOAD, CLAMP ∮ UNCLAMP	30.0
	SHUTTLE TO STA. #2.	2.5
	LOCATE ∮ CLAMP	2.0
	RAPID ADVANCE	1.0
(MILL)	FEED	12.5
	RAPID RETURN	1.5
	UNCLAMP	1.0
	SHUTTLE TO STA. #3.	2.5
	LOCATE ∮ CLAMP	2.0
	RAPID ADVANCE	1.0
(DRILL)	FEED	12.5
	RAPID RETURN	1.5
	UNCLAMP	1.0
	SHUTTLE TO STA. #4.	2.5
	LOCATE ∮ CLAMP	2.0
	RAPID ADVANCE	1.0
(DRILL)	FEED	12.5
	RAPID RETURN	1.5
	UNCLAMP	1.0
	SHUTTLE TO STA. #5.	2.5
	LOCATE ∮ CLAMP	2.0
(PROBE)	PROBE IN	1.5
	PROBE OUT	1.5
	UNCLAMP	1.5
	SHUTTLE TO STA. #6.	2.5
	LOCATE ∮ CLAMP	2.0
	RAPID ADVANCE	1.0
(TAP)	TAP IN	6.0
	TAP OUT	6.0
	RAPID RETURN	1.5
	UNCLAMP	1.0
	SHUTTLE TO STA. #7.	2.5
	LOCATE ∮ CLAMP	2.0
	RAPID ADVANCE	1.0
(DRILL)	FEED	12.5
	RAPID RETURN	1.5
	UNCLAMP	1.0
	SHUTTLE TO STA. #8.	2.5
	LOCATE ∮ CLAMP	2.0
	RAPID ADVANCE	1.0
(REAM)	FEED	12.5
	RAPID RETURN	1.5
	UNCLAMP	1.0
	RETURN SHUTTLE TO STA. #1.	17.5
	TOTAL TIME	186.0 SECONDS

PART: MAIN BEAM ~ HELIOSTAT
2ND GENERATION
PT #182464

OPERATION #20

LAMB (8) STATION SHUTTLE MACHINE
PROPOSAL DEPT.

FIGURE B-5. LAMB EIGHT STATION SHUTTLE MACHINE



MACHINE CYCLE:

	UNLOAD, LOAD, CLAMP & UNCLAMP PART	20.0
	SHUTTLE TO STATION #2	2.5
	LOCATE & CLAMP	1.5
	RAPID ADVANCE	1.0
(DRILL)	FEED	10.0
	RAPID RETURN	1.0
	UNCLAMP	.5
	SHUTTLE TO STATION #3	2.5
	LOCATE & CLAMP	1.5
(PROBE)	PROBE IN	1.5
	PROBE OUT	1.5
	UN CLAMP	.5
	SHUTTLE TO STATION #4	2.5
	LOCATE & CLAMP	1.5
	RAPID ADVANCE	1.0
(TAP)	TAP IN	5.0
	TAP OUT	5.0
	RAPID RETURN	1.0
	UN CLAMP	.5
	RETURN SHUTTLE TO STATION #1	7.5
	TOTAL SECONDS	68.0

OPERATION: # 30

PART: MAIN BEAM
PT# 1022466

PROPOSAL DEPT.

FIGURE B-6. LAMB FOUR STATION SHUTTLE MACHINE

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	MAIN BEAM (Machine)	1	50,000/YR	2 OF 2
CUSTOMER	**DRAWING NUMBER**			
MDC	1D22464-1			

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
31	Part Wash		-				1	3,850
32	In Process Gage		-				1	13,200
33	Hoist		-				1	15,000
34	Mat'l. Hand. - Mono.		1.500	Monorail Conveyor 75 ft.				56,250
				Trolleys & Hooks 26			26	19,500
35	Hoist		-				1	15,000
40	Drill, Chf., Mill & Ream	16	6.250	Lamb 8-Sta. Shuttle (Figure B-7)	1			
	(6) Lugs Press Bushing			Mach. Dbl. End				
	186.0 Mach. Cycle Time			Installation				168,400
	1 Mach./Operator			Mach. Capital Cost				1,122,000
				Special Tooling			1	748,000
				Durable Tooling			1	28,200
				Non-Durable Tooling		350	1	9,400
42	Mat'l. Handling		1.500	Monorail - Hoist			1	15,000
43	Inspection - Floor Inspector		2.500					
44	Part Wash		-				1	3,850
45	Master Gage & Hand Gages						1	38,500
46	Mat'l. Handling to Drive Ass'y. Line		2.000	Lt. Monorail 32 ft.			1	8,000
				Hooks & Trolleys			5	1,250
	Scrap @ 1%		.188					
	Rework 5% (4 x Labor)		3.750					
	Mach. Downtime @ 5%		.938					

REMARKS Wt. 370.9#/Piece Total Labor 34.126

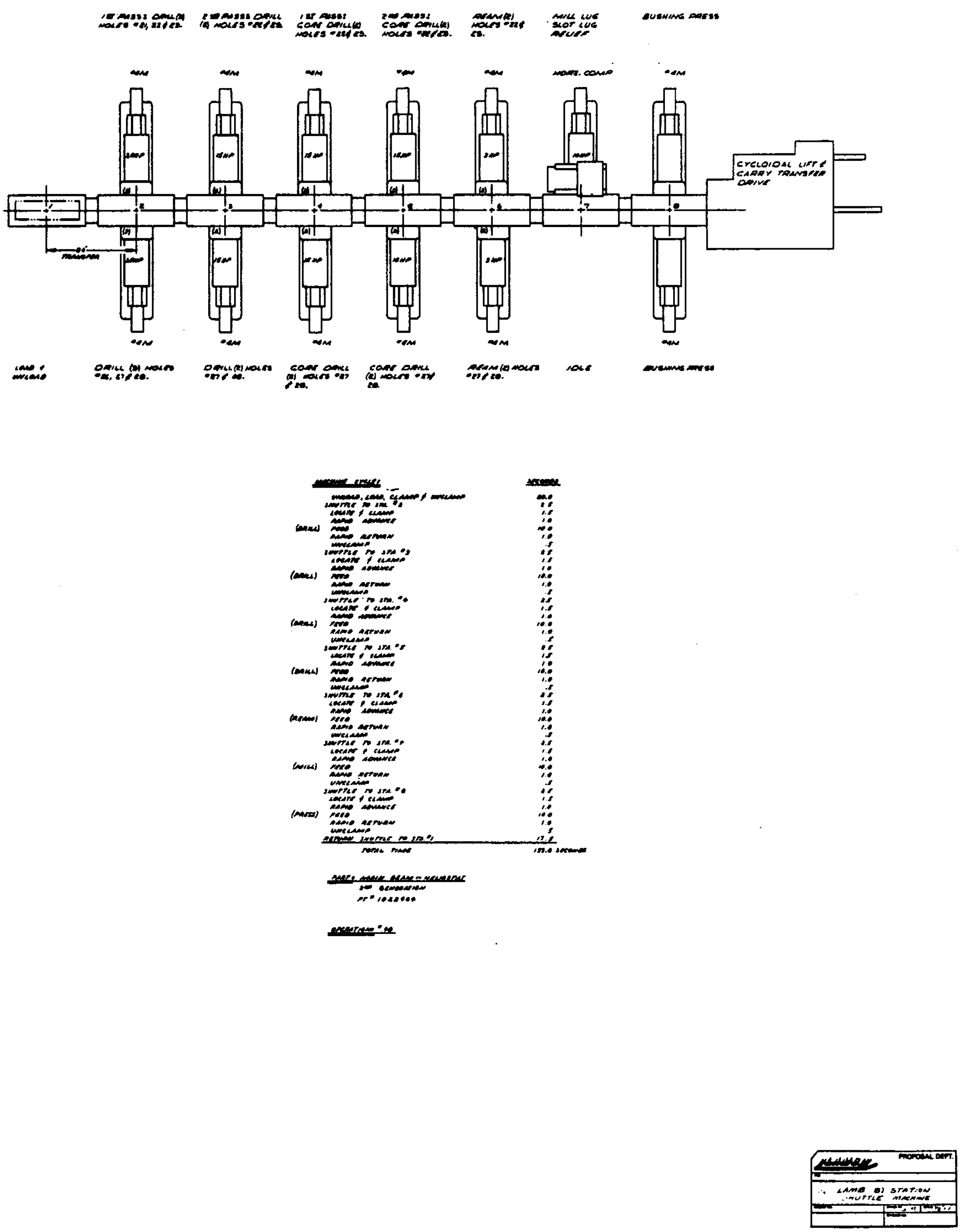


FIGURE B-7. LAMB EIGHT STATION SHUTTLE MACHINE

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	ELEVATION DRIVE SUPPORT (Machine)	1	50,000/YR		1 OF 2
CUSTOMER MDC	DRAWING NUMBER 1D22439-1				

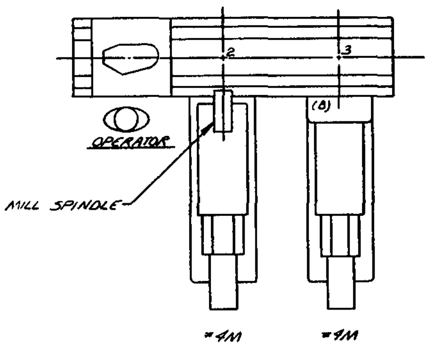
OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
10	Purchase Casting							
11	Mat'l. Hand. - Pallets		1.000					
15	Qualify Mtg. Surface &			Lamb 3 Sta. Spec. Machine (Figure B-8)	1	20		
	2 Locating Holes - 86.5 Cycle	34	2.942	Installation			1	48,000
	1/2 Oper./Mach.			Machine Capital Cost			1	310,000
				Special Tooling			1	212,000
				Durable Tooling			1	8,000
				Non-Durable Tooling			1	3,200
16	Mat'l. Hand. - Mono.		1.000	Monorail Conveyor				
				Trolleys & Hooks				
17	Hoist - Monorail			Hoist			1	15,000
20	Mill Lugs & Rib, Tap	16	6.250	Lamb 7-Sta. Shuttle (Figure B-9)	1			
	Drill (7) & Tap (7)			Mach. Dbl. End				
	186.0 Mach. Cycle Time			Installation				138,600
	1 Mach./Operator			Mach. Capital Cost				924,000
				Special Tooling			1	565,000
				Durable Tooling			1	97,000
				Non-Durable Tooling		350	1	6,500
21	Part Wash		-				1	3,850
22	In Process Gage		-				1	13,200
23	Hoist - Monorail		-				1	15,000
24	Mat'l. Hand. - Mono.		1.000	Monorail Conveyor 75 ft.				56,250
				Trolleys & Hooks 26			26	19,500
25	Hoist - Monorail		-				1	15,000
30	Drill (6) & Tap (4), Ream (2)	16	6.250	Lamb 6-Sta. Shuttle (Figure B-10)	1			
	Bushing Press			Machine Dbl. End				
	186.0 Mach. Cycle Time			Installation				126,225
	1 Mach./Operator			Mach. Capital Cost				841,500
				Special Tooling			1	561,000

REMARKS

Wt. 175# Approx.

LAMB STANDARD WAY TYPE UNIT				
J.I.C. NO	WIDTH ACROSS [illegible]	STROKE		CROSS SECTION OF WAYS
2	9.25		18	[illegible]
3	14.5	18	20	1.5"X[illegible]2"
4	[illegible]	[illegible]	[illegible]	2.25"X4.75"
5	27.0	24	[illegible]	3"X7"
SPEC.				

MACHINE CYCLE	SEC.
UNLOAD, LOAD CLAMP & UNCLAMP PART	45.0
RAPID ADVANCE	1.0
FEED	20.0
SHUTTLE	1.5
RAPID ADVANCE CROSS SLIDE	1.0
FEED CROSS SLIDE	14.0
RAPID RETURN CROSS SLIDE	1.0
RETURN SHUTTLE	3.0
TOTAL SECONDS	86.5



STA #2	STA #3
MILL FACE	DRILL (8) HOLES

PART - ELEVATION DRIVE SUPPORT
#1022439

OPERATION - #15

APPROXIMATE FLOOR AREA
16'-0" x 15'-0"

DO NOT SCALE

TITLE LAMB (3) STATION SHUTTLE MACHINE

FIGURE B-8. LAMB THREE STATION SHUTTLE MACHINE

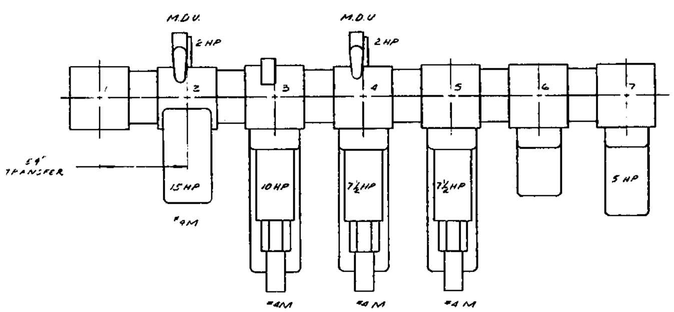
GM ENERGY SYSTEMS

STA # 3LV	STA # 5L	STA # 7L
PROBE HOLE # 29	IDLE	IDLE

STA # 2LV	STA #4LV	STA # 6L
DRILL & CHAMFER HOLE # 29.	TAP HOLE # 29.	IDLE

LAMB STANDARD WAY TYPE UNIT				
JIC NO	WIDTH ACROSS WAYS	STROKE		CROSS SECTION OF WAYS
		SHORT	LONG	
2	925		18	1"X2"
3	14 5	18	30	15"X362"
4	195	18	28	2 25"X4 75"
5	270	24	33	3"X7"
SPEC				

MACHINE CYCLE :	SECONDS
UNLOAD, LOAD, CLAMP & UNCLAMP PART	60.0
SHUTTLE TO STA.#2	2 5
LOCATE & CLAMP	1 5
RAPID ADVANCE	2 0
FEED	9 5
RAPID RETURN	2 0
UNCLAMP	1 0
SHUTTLE TO STA. #3	2.5
LOCATE & CLAMP	1 5
RAPID ADVANCE	2 0
FEED	9 5
RAPID RETURN	2 0
UNCLAMP	1 0
SHUTTLE TO STA. #4	2 5
LOCATE & CLAMP	1 5
RAPID ADVANCE	2 0
FEED	9.5
RAPID RETURN	2.0
UNCLAMP	1 0
SHUTTLE TO STA #5	2 5
LOCATE & CLAMP	1 5
RAPID ADVANCE	2.0
FEED	8 7
RAPID RETURN	2 0
UNCLAMP	1 0
SHUTTLE TO STA. #6	2 5
LOCATE & CLAMP	1 5
RAPID ADVANCE	2 0
PROBE IN, PROBE OUT	4 0
RAPID RETURN	2 0
UNCLAMP	1.0
SHUTTLE TO STA. #7	2.5
LOCATE & CLAMP	1.5
RAPID ADVANCE	2 0
TAP IN TAP OUT	5 0
RAPID RETURN	2 0
UNCLAMP	1.0
RETURN SHUTTLE TO STA #1	15 0
TOTAL SECONDS	175 2



STA # 1	STA # 3 RH	STA #5 RH	STA # 7
	FINISH LUG INSIDE.	DRILL & CHAMFER HOLES # 23 THRU 28.	TAP HOLES # 23 THRU 28.

STA #2 RV	STA #4 RH	STA #6 RH
FINISH MOUNTING RIB.	FINISH LUG OUTSIDE.	PROBE HOLES # 23 THRU 28

PART: SUPPORT ASSEMBLY ~ ELEVATION DRIVE
PT. # 1022439

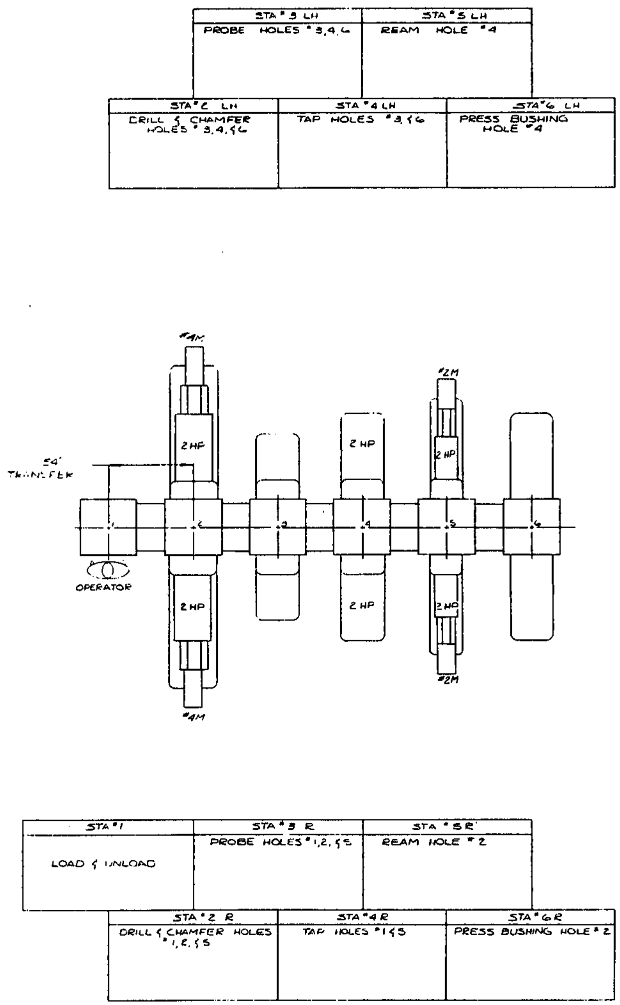
OPERATION # 20

APPROXIMATE FLOOR AREA: 34'-0" · 17'-6"

PROPOSAL DEPT
LAMB (7) STATION SHUTTLE MACHINE
DRAWN BY S M SCALE ½"=1'

ENERGY SYSTEMS

FIGURE B-9. LAMB SEVEN STATION SHUTTLE MACHINE



LAMB STANDARD WAY TYPE UNIT				
SIZE NO	WIDTH ACROSS WAYS	STROKE SHORT	STROKE LONG	CROSS SECTION OF WAYS
2	9.25		18	1" X 2"
3	14.5	18	30	1.5" X 3.62"
4	19.5	18	28	2.25" X 4.75"
6	27.0	24	33	3" X 7"
SPEC				

MACHINE CYCLE	SECONDS
UNLOAD, LOAD CLAMP & UNCLAMP PART	[illegible]
SHUTTLE TO STA #2	2.5
LOCATE & CLAMP	2.0
RAPID ADVANCE	2.0
FEED	23.5
RAPID RETURN	2.0
UNCLAMP	1.5
SHUTTLE TO STA #3	2.5
LOCATE & CLAMP	[illegible]
RAPID ADVANCE	[illegible]
PROBE IN - PROBE OUT	[illegible]
RAPID RETURN	[illegible]
UNCLAMP	1.5
SHUTTLE TO STA #4	2.5
LOCATE & CLAMP	[illegible]
RAPID ADVANCE	[illegible]
TAP-IN TAP OUT	12.5
RAPID ADVANCE	[illegible]
UNCLAMP	[illegible]
SHUTTLE TO STA #5	[illegible]
LOCATE & CLAMP	[illegible]
RAPID ADVANCE	[illegible]
FEED	[illegible]
RAPID ADVANCE	[illegible]
UNCLAMP	[illegible]
SHUTTLE TO STA #6	[illegible]
LOCATE & CLAMP	[illegible]
RAPID ADVANCE	[illegible]
FEED	[illegible]
RAPID RETURN	[illegible]
UNCLAMP	[illegible]
RETURN SHUTTLE TO STA #1	[illegible]
TOTAL SECONDS	[illegible]

PART SUPPORT ASSEMBLY ELEVATION DRIVE PT# [illegible]

OPERATION #30

APPROXIMATE FLOOR AREA
30'-0" x 23'-0

PROPOSAL DEPT.

LAMB (6) STATION SHUTTLE MACHINE

GM ENERGY SYSTEMS

FIGURE B-10. LAMB SIX STATION SHUTTLE MACHINE

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	ELEVATION DRIVE SUPPORT (Machine)	1	50,000/YR	2 OF 2
CUSTOMER	**DRAWING NUMBER**			
MDC	1D22439-1			

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
30				Durable Tooling			1	21,100
				Non-Durable Tooling		360	1	7,100
31	Part Wash		-				1	3,850
32	In Process Gage		-				1	13,200
33	Hoist - Monorail		-				1	15,000
34	Mat'l. Hand. - Mono.		1 000	Monorail Conveyor 75 ft.				56,250
				Trolleys & Hooks 26			26	19,500
35	Hoist - Monorail		-				1	15,000
40	Spotface, Drill, & Tap	16	6 250	Lamb 6-Sta. Shuttle (Figure B-11)	1			
	(16)			Mach. Dbl. End				
	186.0 Mach. Cycle Time			Installation				126,225
	1 Mach./Operator			Mach. Capital Cost				841,500
				Special Tooling			1	561,000
				Durable Tooling			1	21,100
				Non-Durable Tooling		300	1	7,100
42	Hoist - Monorail		-				1	15,000
43	Inspection - Floor Inspector		1 000					
44	Part Wash		-				1	3,850
45	Master Gage &		2 500				1	38,500
	Hand Gage							
46	Mat'l. Hand. to Drive		2 500	Hoist - Monorail			1	15,000
	Ass'y. Line			Monorail Conveyor 144 ft.			1	36,000
				Trolleys & Hooks 36			1	9,000
	Scrap @ 1%		247					
	Rework @ 5% (4 x Labor)		4 939					
	Mach. Downtime @ 5%		1 235					

REMARKS

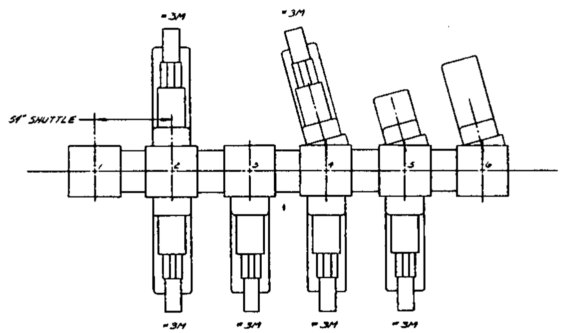
Total Labor 38.113

STA #2LH	STA #3L	STA #4LH	STA #5LH	STA #6LH
SPOT FACE (4) HOLES #12, 13, 14 & 15	IDLE	TAP DRILL & CHAMFER (5) HOLES #7, 8, 9, 10 & 11	PROBE (5) HOLES #7, 8, 9, 10 & 11	TAP (5) HOLES #7, 8, 9, 10 & 11

LAMB STANDARD WAY TYPE UNIT

[illegible] NO	WIDTH ACROSS WAYS	STROKE SHORT	STROKE [illegible]	[illegible] SECTION [illegible]
2	9 25		18	[illegible]
3	14 5	18	30	[illegible] X 362
4	195	[illegible]	[illegible]	[illegible] X 475
6	270	24	35	3 X 7"
SPEC				

MACHINE CYCLE	SEC
UNLOAD, LOAD CLAMP & UNCLAMP PART	60
SHUTTLE TO STA #2	25
LOCATE & CLAMP	20
RAPID ADVANCE	20
FEED	125
RAPID RETURN	20
UNCLAMP	15
SHUTTLE TO STA #3	25
LOCATE & CLAMP	20
RAPID ADVANCE	20
FEED	110
RAPID RETURN	20
UNCLAMP	15
SHUTTLE TO STA #4	25
LOCATE & CLAMP	20
RAPID ADVANCE	[illegible]
FEED	75
RAPID RETURN	[illegible]
UNCLAMP	15
SHUTTLE TO STA #5	25
LOCATE & CLAMP	[illegible]
RAPID ADVANCE	[illegible]
FEED	50
RAPID RETURN	[illegible]
UNCLAMP	15
SHUTTLE TO STA #6	[illegible]
LOCATE & CLAMP	20
RAPID ADVANCE	20
TAP IN	25
TAP OUT	25
RAPID RETURN	20
UNCLAMP	15
RETURN SHUTTLE TO STA #1	125
TOTAL SECONDS	1063



ESTIMATED PRODUCTION
21.6 PARTS/HOUR @ 100% EFFICIENCY

STA #1	STA #2RH	STA #3RH	STA #4RH	STA #5RH	STA #6
LOAD & UNLOAD	SPOT DRILL (4) HOLES #12, THRU #15	DRILL (4) HOLES #12 THRU #15	SPOT DRILL (7) HOLES #16, THRU #22	CORE DRILL (7) HOLES #16 THRU 22	IDLE

PART - SUPPORT ASS'Y ELEVATION DRIVE
#1022439

APPROXIMATE FLOOR AREA
30'0" X [illegible]

ENERGY SYSTEMS

PROPOSAL DEPT
LAMB (6) STATION SHUTTLE MACHINE

FIGURE B-11. LAMB SIX STATION SHUTTLE MACHINE

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	FLEX SPLINE		50,000/YR		1 OF 2
CUSTOMER	**DRAWING NUMBER**				
MDC	1D22499-1				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
	Receive							
10	Purchased Doubler Stamping		-					
	& Deep Drawn, Punched, Annealed Shell							
15	Material Handling - Gon.		.500	Gondolas			3	450
				Tote Pans for Doublers			3	105
				Installation				25,245
40	Hone I.D.	45	2.223	Micromatic Hone	5	10	1	168,300
	1/3 Oper./Mach.			1 Spindle, Mod. 10 VH				
	60 Sec. Mach. Cycle			Tooling: Special			1	18,700
				Durable			1	7,700
				Non-Durable			1	3,300

REMARKS Wt. 17.48#/Piece

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET 2 OF 2
HELIOSTAT	FLEX SPLINE		50,000/YR		
CUSTOMER: MDC	DRAWING NUMBER: 1D22499-1				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
45	Material Handling		.500	Lt. Conveyor 30 ft.			1	1,800
50	Broach Flex Spline Teeth	40	2.500	Apex Broach Mach. Cap.	1		1	143,595
	1/2 Oper./Mach.			Tooling: Special			1	28,000
	70 Sec. Mach. Cycle			Non-Durable			1	84,620
				3500 Pc/Sharpening		0		
				Installation				21,550
55	Material Handling		.500	Lt. Conveyor 30 ft.			1	1,800
60	Part Wash		1.500	Spray Booth	-	-	1	2,200
				(Manually Loaded)				
65	Heat Treat - Tuff Tride		-	Purchase - Vendor	-	-		
66	Master Gage - Inspection		1.000		-	-	1	5,000
70	Material Handling		1.000	Gondolas 4' x 5'			4	600
	to Drive Ass'y. Line							
	Scrap @ 5%		.111					
	@ 1%		.025					
	Rework @ 5% (4 x Labor)		.945					
	Machine Downtime @ 5%		.236					

REMARKS
Wt. 17.48#/Piece Total Labor 11.040

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET 1 OF 3
HELIOSTAT	CIRCULAR SPLINE	1	50,000/YR	

CUSTOMER	DRAWING NUMBER
MDC	1D22499-1

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
	Receive							
5	Purchased Rolled Ring		-	Vendor				
10	Material Handling		1 500	Gondolas 4' x 5'			4	600
11	Job Hoist		-				1	15,000
15	Turn, Face, Bore, Chamf.	20	5 000	Bullard Templa Turn	3		2	946,000
	1 Oper./2 Machs.			Vert. Turret Lathe				
	200 Sec. Mach. Cycle			Tooling: Special			2	17,600
				Durable			2	13,200
				Non-Durable			2	6,600
				Installation				142,000
20	Material Handling		1 500	Lt. Conveyor 20 ft.			1	1,200
21	Job Hoist		-				1	15,000

REMARKS

Wt. 80.45#/Piece

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	CIRCULAR SPLINE	1	50,000/YR	2 OF 3
CUSTOMER	**DRAWING NUMBER**			
MDC	1D22499-1			

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
				Installation				20,000
25	Blanchard Grind to	16	6.250	Blanchard Grinder	2	25	1	133,100
	Thickness			Model 26HD - 48" Dia. Table				
	1 Oper./Mach.			Tooling: Special				
	900 Sec. Mach. Cycle			Durable			1	2,200
	5 Parts/Cycle			Non-Durable			1	1,100
	Relief - Oper. #25 @ 16.7%		1.044					
30	Material Handling		1.500	Lt. Conveyor 20 ft.			1	1,200
31	Job Hoist		-				1	15,000
				Installation				16,200
35	Grind O.D. Bearing Race	30	3.334	Landis Model 4R Grinder	3	15	1	108,020
	Contour			Tooling: Special			1	6,600
	1/2 Oper./Mach.			Durable				
	90 Sec. Mach. Cycle			Non-Durable			1	2,200
40	Material Handling		1.500	Lt. Conveyor 20 ft.			1	1,200
41	Jib Hoist		-				1	15,000
				Installation				57,750
45	Drill & Tap Two Sets of	7.5	13.333	Buhr N.C. Mach.	3	30	2	385,000
	8 Holes 5/8-11 & 1/4-20			Tooling: Special			2	44,000
	3/4 Oper./Mach.			Durable			2	7,700
	390 Sec. Mach. Cycle			Non-Durable			2	1,100
	Relief - Oper. #45 @ 16.7%		2.227					
50	Material Handling		1.500	Lt. Conveyor 20 ft.			1	1,200
51	Jib Hoist		-				1	15,000

REMARKS Wt. 80.45#/Piece

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	CIRCULAR SPLINE	1	50,000/YR	3 OF 3

CUSTOMER	DRAWING NUMBER
MDC	1D22499-1

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
				Installation				22,850
55	Broach Spline Teeth *		–	Apex Broach Mach. Cap.	1		1	152,320
*	1/3 Oper./Mach.			Tooling: Special			1	13,000
	60 Sec. Mach. Cycle			Non-Durable			1	39,450
				3500 Pc/Sharpening				
57	Master Gage		2.000				1	6,500
60	Material Handling		1.500	Gondolas 4' x 5'			4	600
	to Drive Ass'y. Line							
56	Jib Hoist		–				1	15,000
	Scrap							
	Oper. #25 @ 2%		.146					
	Oper. #15, 35 & 45 @ 3%		.717					
	Rework @ 5% (4 x Labor)		7.438					
	Mach. Downtime @ 5%		1.560					
	Floor Inspector		1.000					
*	Oper. #55 Broach Mach. to be							
	positioned adjacent to Oper. #45							
	N.C. Mach's.(2) - #55 Operation							
	then performed during internal							
	operation time of N.C. Machs.							

REMARKS Wt. 80.45#/Piece Total Labor 53.049

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	WAVE GENERATOR	1	50,000/YR		1 OF 2
CUSTOMER	**DRAWING NUMBER**				
MDC	1D22499-1				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
	Receive							
10	Purchased Tube Stock		–					
	20' Lgt.							
15	Material Handling		.500	Tote 1' x 1.5'			4	140
				Installation				156,750
20	Turn, Face, Bore, Chamf.	28	3.572	National Acme Model	3	20	2	1,045,000
	& Cut Off			SST-10-5/8 Lathe				
	1/2 Mach./Oper.			Tooling: Special			2	44,000
	192 Sec. Cycle Time			Durable			2	8,250
				Non-Durable			2	2,750
25	Material Handling		.500	Lt. Conveyor 20 ft.			1	1,200
				Installation				20,000
30	Blanchard Grind Both	16	6.250	Blanchard Grinder	2	25	1	133,100
	Sides			Model 26 HD 48" Dia. Table				
	1 Oper./Mach.			Tooling: Special				
	900 Sec. Mach. Cycle			Durable			1	2,200
	5 Parts/Cycle			Non-Durable			1	1,100
	Relief - Oper. #30 @ 16.7%		1.044					
35	Material Handling		.500	Lt. Conveyor 20 ft.			1	1,200

REMARKS

Wt. 13.08#/Piece

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	WAVE GENERATOR	1	50,000/YR	2 OF 2
CUSTOMER: MDC	DRAWING NUMBER: 1D22499-1			

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
				Installation				3,600
40	Broach Keyway		-	Mitts & Merril	-	5	1	24,200
	1/4 Oper./Mach.			Keyseater				
	35 Sec. Mach. Cycle			Tooling: Special				
	(Labor Included w/Oper. #30)			Durable			1	2,200
				Non-Durable			1	1,100
45	Material Handling		.500	Lt. Conveyor 20 ft.			1	1,200
				Installation				35,000
50	Profile Grind O.D.	17	5.883	Landis Polygon Grinder	3	20	1	233,200
	1 Oper./Mach.			Tooling: Special			1	6,600
	180 Sec. Mach. Cycle			Durable				
				Non-Durable			1	1,100
57	Master Gage		1.000				1	7,200
55	Material Handling		.500	Tote 1' x 1.5'			4	140
	to Drive Ass'y. Line							
	Scrap							
	Oper. #30 @ 2%		.125					
	Oper. #20 & 50 @ 3%		.284					
	Rework @ 5% (4 x Labor)		3.650					
	Mach. Downtime @ 5%		.838					
	Floor Inspector		1.000					

REMARKS

Wt. 13.08#/Piece Total Labor 26.146

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	DRIVE SHAFT	1	50,000/YR		1 OF 2
CUSTOMER MDC	**DRAWING NUMBER** 1D22495-1				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
5	Receive Purchased Bar Stock		--					
10	Material Handling		1.000	Tote Pans			4	140
20	Cut Stock Into Slugs	100	1.000	Marvel 9A Hack Saw	1	(Inst'n)		1,700
	1/3 Oper./Mach.			Mach. Capital Cost			1	11,240
	150 Sec. Mach. Cycle			Spec. Tooling			1	1,405
	(5 pc/Cycle)			Durable Tooling			1	983
25	Material Handling		.500	Tote 1' x 1.5'			4	140
30	Mach. Ends, Turn &	120	.834	Miles Four Station	5	55	1	214,500
	Thread Slugs			Trunnion Machine	(Install'n)			32,175
	1/7 Oper./Mach.			Tooling: Special			1	27,500
	25 Sec Mach. Cycle			Durable			1	30,800
				Non-Durable			1	6,600
35	Material Handling		.500	Lt. Conveyor 26'			1	1,560
40	Grind Bearing & Wave Gen.	37.5	2.667	Landis #2R Grinder (Installation)	3	15	1	82,500
	Pilot Diameters			Tooling: Special			1	35,000
	1/2 Oper./Mach.			Durable			1	6,000
	80 Sec. Mach. Cycle			Non-Durable			1	1,000
45	Material Handling		.500	Lt. Conveyor 26'			1	1,560

REMARKS

Wgt. = 6.79#/Piece

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	DRIVE SHAFT	1	50,000/YR		2 OF 2
CUSTOMER MDC	**DRAWING NUMBER** 1D22495-1				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
50	Mill 4 Keyways	56	1 786	Installation				24,750
	1/3 Oper./Mach.			Miles Single Purpose	3	20	1	165,000
	54 Sec. Mach. Cycle			Double End Machine				
				Tooling: Special			1	38,500
				Durable			1	11,000
				Nondurable			1	5,500
57	Master Gage		1 000				1	4,800
55	Material Handling		500	Tote 1' x 1.5'			4	140
	To Drive Assy Line							
	Scrap							
	Oper #20 @ 1%		010					
	Oper #40 & 50 @ 3%		134					
	Oper #30 @ 5%		042					
	Rework @ 5% (4xLabor)		1 658					
	Mach. Downtime @5%		315					
	Floor Inspector		1 000					

REMARKS

Wgt. = 6.79#/Piece

Total Labor 13.346

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	AZIMUTH DRIVE, BEARING RETAINER	1	50,000/YR	1 OF 2

CUSTOMER	DRAWING NUMBER
MDC	1D22489-1

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
5	Receive Purchased Rolled Ring		--					
10	Material Handling		2.000	Gondolas 4' x 5'			4	600
11	Jib Hoist		--				1	15,000
15	Abrasive Machine Sides of Ring	54	1.852	Blanchard	2	50	1	137,500
	Parallel & Flat			Tooling: Special			-	---
	1/3 Oper./Mach.			Durable			1	2,200
	55 Sec Mach. Cycle			Nondurable			1	1,100
				Installation				20,625
20	Material Handling		1.000	Lt. Conveyor 10'			1	600
21	Jib Hoist		--				1	15,000

REMARKS

Wgt. = 49.25#/Piece

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	AZIMUTH DRIVE, BEARING RETAINER	1	50,000/YR		2 OF 2
CUSTOMER	**DRAWING NUMBER**				
MDC	1D22489-1				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
				Installation				70,350
25	Turn I.D. Bearing Race	14	7 143	Bullard Templa Turn	3	90	1	473,000
	Contour & 'O' Ring Grooves			Vert. Turret Lathe				
	2/3 Oper./Mach.			Tooling: Special			1	8,800
	215 Mach. Cycle			Durable			1	6,600
				Nondurable			1	3,300
30	Material Handling		1 000	Lt. Conveyor 10'			1	600
31	Jib Hoist		--				1	15,000
				Installation				46,200
35	Drill (16) .40 Dia. Holes	54	1 852	Lamb 4 Sta. Dial Mach. (Figure B-12)	1	30	1	308,000
	1/4 Oper./Mach.			Tooling: Special			1	181,500
	55 Sec. Mach. Cycle			Durable			1	68,200
				Nondurable			1	8,800
37	Master Gage		1 500				1	6,800
40	Material Handling		1 500	Gondolas 4' x 5'			4	600
	To Drive Ass'y Line							
36	Jib Hoist		--				1	15,000
	Scrap Allowance							
	Oper #35 @ 1%		019					
	Oper #15 @ 2%		037					
	Oper #25 @ 3%		215					
	Rework @ 5% (4xLabor)		2 670					
	Mach. Downtime @ 5%		643					
	Floor Inspector		1 500					

REMARKS Wgt.= 49.25#/Piece Total Labor 22.831 (Note: On Oper #25 the Machine Capacity is sufficient for actual build resets. At stipulated 67.5% Mach. Capac. Rating for planning it would require a 2nd Mach. due to investment cost (very high) recommend initial bank of extra parts, thus keeping investment cost down to requiring only (1) mach.)

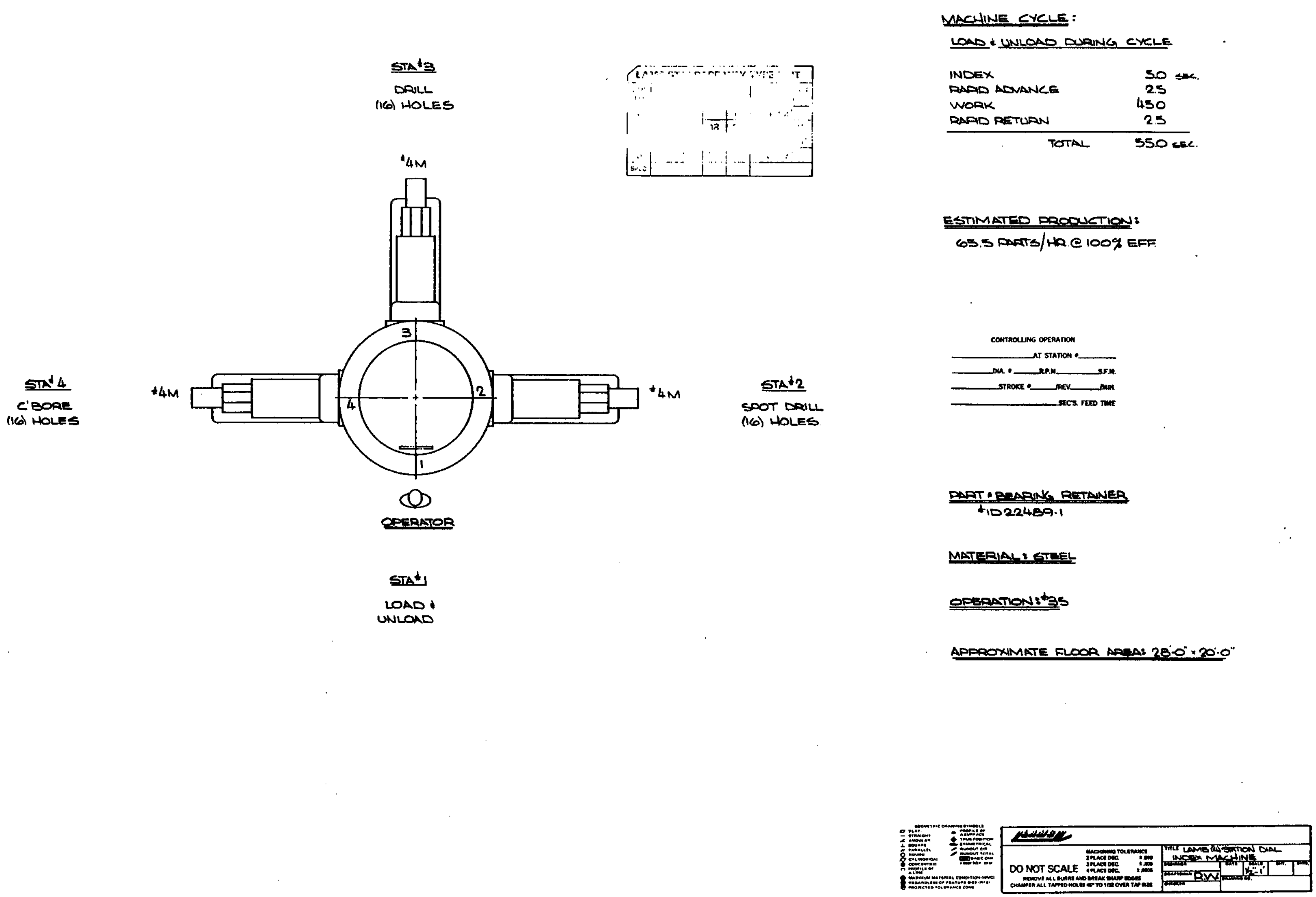


FIGURE B-12. LAMB FOUR STATION DIAL MACHINE

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	AZIMUTH DRIVE		50,000/YR		1 OF 1
CUSTOMER: MDC	DRAWING NUMBER: 1D22489-1				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
5	Mat'l. Handling From		1.500	Lt. Overhead Monorail 600 ft.			1	150,000
	Receiving & Machining			Trolleys & Hooks 500			1	125,000
	Bay			Monorail Hoist			1	15,000
20	Spray Tectyl Inside Cover	16	6.250	Binks Spindle Machine	1	--		
	Outside Retainer			Capital			1	24,990
	1 Operator 18GSec. Cycle			Installation			1	3,750
25	Mat'l Handling to		1.500	Lt. Overhead Monorail			1	75,000
	Drive Ass'y Line			300'				
	Floor Inspector		2.000					
	Scrap @ 1%		.063					
	Rework 1% (4xLabor)		.250					

REMARKS Total Labor 11.563

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	AZIMUTH/ELEVATION DR. ASSY.	1	50,000/YR	1 OF 1
CUSTOMER MDC	**DRAWING NUMBER**			

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
4	Receive Az Dr. Housing							
	& Elevation Support Cast.		--					
5	Mat'l. Handling		4.000	Monorail 180 ft.			1	135,000
7	Supply & Assist W/Sub-Ass'y.		8.000					
	For Oper #5 (on Ass'y. Line)							
10	Assemble Azimuth Drive			25 Sta. Transfer				
	Housing & Support, Jack & Main Beam	(16)	75.000	Ass'y Machine	1%		1	1800,000
	Elevation Drive			Jib Hoists			1	15,000
	12 Oper./Mach.			Pneumatic Wrenches			8	3,000
	185 Sec. Mach. Cycle			Automatic Gage and			2	60,000
				Shim Selection				
	Relief of (12) Operators @ 16.7%		12.525	Bearing Press			2	12,000
				Bowl Feeders			8	29,000
	Repair @ 5% (4xLabor)		15.000	Bulk Oil Feed			1	11,000
				Bulk Grease Feed			1	2,500
	Scrap @ 1%		.750	Tooling: Special			30	129,000
				Durable				35,000
	Inspection		8.000	Nondurable				10,000
				Installation				300,000
15	Material Handling		4.000	Monorail 16 ft.			1	15,00[illegible]
	to Paint Line							

REMARKS

Wgt = 1100#/Ass'y (Approx. Total Labor 127.275 (Note: Ass'y. Line Oper. #182 combined was too tight. Supply [illegible]r. to assist w/#5 sub-ass'y. so that some of #1 & [illegible]ork can be diverted to #4 & 5 stations)

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	AZ-EL DRIVE (PAINT)	1	50,000/YR	1 OF 1
CUSTOMER: MDC	DRAWING NUMBER:			

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
5	Mat'l. Handling From		--	Overhead				
	Drive Ass'y Line			Monorail 12 ft.			1	9,000
10	Load/Unload Paint Line	16	6.250	Monorail Hoist			1	15,000
	1 Operator							
20	Spray Prime, Paint & Cure	(16)	12.500	Binks Prime & Paint	1%	---		
	Drive Ass'y			Spray Line - Special				
	186 Sec Cycle Time			Capital			1	185,000
	2 Oper Per Mach.			Installation			1	
25	Mat'l Handling to Electrical		2.000	Overhead Monorail 10 ft.			1	7,500
	Installation Line							
	Scrap @ 1%		.188					
	Rework 1% (4xLabor)		.750					
	Floor Inspector		4.000					

REMARKS

Total Labor 25.688

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	INCREMENTAL ENCODER (2)		50,000/YR	1 OF 3

CUSTOMER	DRAWING NUMBER
MDC	Azimuth 1D25573-1 Elevation 1D25573-501

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
5	Issue Fabricated Connectors, Printed Circuit Board, Plugs, Washers, Screws, Vanes, Covers and Components in Kits, and Component Tubes, in Batches of 100.	260	.385	Four Storage Racks 5' x 8' x 3'				1,600
				Fifteen Tote Boxes 1' x 1' x 1'				300
	9 Time for Each Batch							
	1 Material Handler							
10	Manually Assemble Plug to Encoder Cover and Thread Six (6) Leads of Terminated J11 (Azimuth) or J21 (Elevation) Connector Wires Through Plug.	144	.695	Holding Fixture				100
	20 Assembly Cycle Time							
	1 "B" Assembler							
20	Automatically Insert Two Hall Sensors 2-5.1K Resistors, 1 Line Driver, 1-0.1 wt capacitor on a two sided board.	190	.527	Fifty Board Fixtures				10,000
				Universal Instruments Corp. Insertion Machine, Semi-Automatic				15,000
				Installation				2,250
	15 Assembly Cycle Time							
	1 "B" Assembler							

REMARKS

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	INCREMENTAL ENCODER		50,000/YR		2 OF 3
CUSTOMER	**DRAWING NUMBER**				
MDC	Azimuth-1D25573-1 Elevation-1D25573-501				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
30	Manually Assemble J11 (or J21)	120	834	Holding Fixture with Wire				500
	Connector Wires to Board			Identification				
	24 Cycle Time							
	1 "B" Assembler							
40	Automatically Trim and Crimp Wires,	190	527	(Board Fixtures Same as Operation 20)				
	Flow Solder and Clean Assemblies			Hollis Flow Solder Machine			1	20,000
	15 Cycle Time							
	"1" "B" Assembler							
45	Automatic Inspection for Presence	144	695	Hughes Industrial Products Scanner				4,000
	of Parts, Sample 5% for Workmanship			Installation				600
	20 Average Cycle Time							
	1 Inspector							
55	Conduct Automatic Continuity	72	1 389	Ditmico Tester				12,500
	Test Between Pins and Terminals			Installation				1,900
	of Printed Boards, Conduct			Test Adaptors (2) for Connectors				2,000
	Automatic Tests of Voltage							
	Connector Pins to Ground			Test Fixtures (2) for Boards				1,000
	40 Cycle Time							
	1 Inspector							

REMARKS

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	INCREMENTAL ENCODER		50,000/YR		3 OF 3

CUSTOMER	DRAWING NUMBER
MDC	Azimuth-1D25573-1 Elevation-1D25573-501

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
60	Snap Printed Circuit Board to Cover	190	.527					
	15 Cycle Time							
	1 "B" Assembler							
70	Press Vane to Motor Shaft	190	.527					
	15 Cycle Time							
	1 "B" Assembler							
75	Conduct Vane Inserted Test	48	2.084	(Use Ditmico Tester -				
	With Voltage Across Selected Pins			Same as Operation 55)				
	60 Cycle Time			Two Test Fixtures				2,000
	1 Inspector							
80	Screw Encoder Cover to Motor, with	72	1.389					
	Four (4) Set Screws and Lock Washers							
	40 Cycle Time							
	1 "B" Assembler							
90	Plug Three Lead Connector of J11	190	.527					
	(or J21) Harness to Motor, Driver							
	Motor - Encoder to Next Assembly							
	15 Cycle Time							
	1 "B" Assembler							
	Supply All Operations		2.000					
	Floor Inspector		2.000					

REMARKS Total Labor 14.106

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	SENSOR-CONTROLLER CABLES (5)		50,000/YR		1 OF 1
CUSTOMER	**DRAWING NUMBER**				
MDC	1D22514				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
	Elevation Hel. Sensor - Cont.(P24-P5)							
	Elevation Ref. Sensor - Cont.(P22-P5)							
	Elevation Limit Sensor-Cont.(P23-P5)							
	Azim.Helicon Sensor - Cont.(P13-P5)							
	Azim.Ref. Sensor - Controller(P12-P3)							
	Supply All Parts		1.500					
5	Issue Color Coded Wires (18 AWC)	240	.417					
	Pins, Sockets, Connectors, Sealing							
	Plugs, and Color Bands							
	10 for Each Unit							
	1 Material Handler							
10	Automatically Cut Wires to Length,	190	.527	Artos (Same as That for Encoder				
	Strip and Terminate			Cable)			5	1,000
	15 for each unit			Fixtures				
	1 "B" Assembler							
20	Manually Assemble Wires to Plugs,	48	2.084					
	on P3 and P5 Plugs Insert Sealing			Fixtures			5	1,000
	Plug, Apply Shrink Tubing and Color							
	Band							
	60 Average for each unit							
	1 "B" Assembler							
25	Automatically Test Continuity of	100	1.000	Ditmico (Same as that for Encoder				
	Conductors, Insulation Resistance,			Cable)				
	Sample Test Tensile Strength			Fixtures			5	1,000
	Termination - 25 Average Test Time							
	1 Inspector							

REMARKS

Total Labor 5.528

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	MOTOR - CONTROLLER CABLE (2)		50,000/YR		1 OF 1
CUSTOMER MDC	**DRAWING NUMBER** 1D22514				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
	Azimuth Motor-Controller ID22514-501							
	Elevation Motor-Controller ID22514-1							
5	Issue Color Coded Wires (18AWG), Pins	240	417					
	Connectors, Sockets, Sealing Plugs							
	and Color Bands							
	10 for each unit							
	1 Material Handler							
10	Automatically Cut Wires to Length,	190	527	Artos (Same as that for Encoder				
	Strip and Terminate			Cable)				
	15 for each unit			Fixtures			2	400
	1 "B" Assembler							
20	Manually Assemble Wires to Plugs	48	2 084	Fixtures			2	400
	on P1 insert Sealing Plug, Apply							
	Shrink Tubing and Color Band							
	60 Average for each unit							
	1 "B" Assembler							
25	Automatically Test Continuity of	100	1 000	Ditmico (Same as that for Encoder				
	Conductors, Insulation resistance,			Cable)				
	Sample Test Tensile Strength of			Fixtures			2	400
	Termination.							
	25 Average test time							
	1 Inspector							
	Supply All Parts		1 500					

REMARKS

Total Labor 5.528

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	ENCODER CABLE (2)		50,000/YR		1 OF 1

CUSTOMER	DRAWING NUMBER
MDC	Azimuth 1D 22573-1 (A3-J11) Elevation 1D 22573-501 (A10-J21)

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
5	Issue Color Coded 18 AWG Wire, Pins,	240	.417					
	Sockets and Connectors							
	10 for each unit							
	1 Material Handler							
10	Automatically Cut Wires to Length,	190	.527	Artos Wire Cutter, Stripper, and			2	24,800
	Strip and Terminate			Terminator CS-9-AT				
	15 for each unit			Installation				3,700
	1 "B" Assembler							
20	Manually Assemble One End of Six	72	1.389	Fixtures			2	400
	Wires to Connector, Add Grommet for							
	J11, Add Shrink Tubing for J11							
	40 for each unit							
	1 "B" Assembler							
				Installation				1,900
25	Automatically Test Continuity	144	.695	Ditmico Tester			1	12,500
	Conductors to Shield and Insulation			Fixtures			2	400
	Resistance							
	20 Test time per unit							
	1 Inspector							
35	Sample Test Tensile Strength		.200	ITT Cannon Tool CCT-SS			2	600
	Termination							
	2 Average test time							
	1 Inspector							
	Supply All Parts		1.000					

REMARKS Total Labor 4.228

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	SENSOR CABLES (5)		50,000/YR		1 OF 1
CUSTOMER	**DRAWING NUMBER**				
MDC					

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
	Azimuth Ref.Sensor 1D22414-1(A5-J12)							
	Azimuth Helicon Sensor 1D22414-1(A4-J13)							
	Elevation Ref. Sensor 1D22414-501(A6-J22)							
	Elevation Limit Sensor 1D22414-501(A7-J23)							
	Elevation Helicon Sensor 1D22414-501(A8-J24)							
5	Purchase Unit with Terminated Leads	240	417					
	Assembled to Sensors, Issue Sensors							
	10 for each unit							
	1 material handler							
10	Manually Assemble Leads to Jacks,	96	1 042	Fixtures			5	1,000
	Apply Grommet to Azimuth Helicon							
	Sensor, and Shrink Tubing to Azimuth							
	Helicon Sensor and Az. Ref. Sensor							
	30 Average unit time							
	1 "B" Assembler							
	Floor Inspector		500					
	Supply All Parts		500					

REMARKS

Total Labor 2.459

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	MOTOR CABLE (2)		50,000/YR		1 OF 1
CUSTOMER	DRAWING NUMBER				
MDC					

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
	Elev. Motor Cable 1D22487-1(A9-J21)							
	Azim.Motor Cable 1D22487-501(A2-J11)							
5	Purchase, Store and Issue Motors with Terminated Three Wire Leads, Issue Jacks	144	695					
	20 for each unit							
	1 Material Handler							
10	Manually Assemble Motor Leads to Jacks (J11 or J21)	190	527	Fixtures			2	400
	15 for each unit							
	1 "B" Assembler							
	Floor Inspector		500					
	Supply All Parts		500					

REMARKS

Total Labor 2.222

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	ENCODER - CONTROLLER CABLE (2)		50,000/YR	1 OF 1
CUSTOMER	**DRAWING NUMBER**			
MDC	1D22514			

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
	Azim.Incr.Encoder-Controller(J11-P3)							
	Elev.Incr.Encoder-Controller(J21-P4)							
5	Issue Color Coded Wires (18AWG), Pins,	240	.417					
	Sockets, Connectors, Sealing Plugs							
	and Color Bands							
	10 for each unit							
	1 Material Handler							
10	Automatically Cut Wires to Length,	190	.527	Artos (Same as that for Encoder				
	Strip and Terminate			Cable)				
	15 for each unit			Fixtures			2	400
	1 "B" Assembler							
20	Manually Assemble Wires to Jacks and	57	1.756	Fixtures			2	400
	Plugs, on P4 Plug Insert Sealing							
	Plug, Apply Shrink Tubing and							
	Color Band							
	50 Average for each unit							
	1 "B" Assembler							
25	Automatically Test Continuity of	100	1.000	Ditmico (Same as that for Encoder				
	Conductors, Insulation Resistance,			Cable)				
	Sample Test Tensile Strength of			Fixtures			2	400
	Termination							
	25 Average unit test time							
	1 Inspector							
	Supply All Parts		1.500					

REMARKS

Total Labor 5.200

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME		SHEET
HELIOSTAT	ELEC. INSTALL - DR. ASS'y.		50,000/YR		1 OF 1
CUSTOMER: MDC	DRAWING NUMBER				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
5	Material Handling from Paint Booth		1.500	Overhead Monorail Conveyor 16 ft.			1	13,500
				Installation				12,000
10	Install Electrical Hardware	(16)	25.000	9 Station Monorail Assembly Machine			1	78,750
	4 Oper./Mach.			26 ft. (Indexing Monorail Only				
	175 Sec. Mach. Cycle			Oper's Done by Hand)				
				Parts Bins			4	2,000
15	Material Handline		2.000	Overhead Monorail Conveyor 16 ft.			1	13,500
	to Final (Pedestal) Ass'y.							
	Supply All Parts		2.750					
	Inspection		6.250					

REMARKS

Total Labor 37.500

TOOL AND LABOR ROUTING

MODEL	PART NAME	PCS/MOD.	VOLUME	SHEET
HELIOSTAT	FINAL (PEDESTAL) ASS'Y.		50,000/YR	1 OF 1
CUSTOMER	**DRAWING NUMBER**			
MDC				

OP. NO.	OPERATION DESCRIPTION	PROD. STD. P.P.H. (Avg.)	HOURS PER 100 PCS.	MACHINE NAME AND NUMBER TOOLS AND GAUGES	SCRAP %	TOOLS $/HR.	EQUIPMENT QTY.	EQUIPMENT EST. COST
10	Load Elevation/Azimuth Drives from	10	10 000	Overhead Crane				
	Ass'y Area with Overhead Crane			Bridge Crane 2 ton Capac.			1	5,500
				Installation				825
20	Load Pedestal Tube From Capweld	13	7 700	Overhead Crane				
	Area with Overhead Crane			Bridge Crane 1 Ton			1	3,300
				Installation				495
30	Final Assemble Pedestal to Drive	(16)	12 500	Single Sta. Ass'y Bench				
	Unit, Run (16) Bolts & Make Final			Mach. Capital Cost			1	8,250
	Electrical Connections			Installation				1,238
	175 Sec. Cycle Time			Machine Consists of the Following				
	2 Operators/Mach.			Major Elements				
35	Tackweld Control Box to Pedestal			Portable MIG Welder			1	5,000
				90^o Roller/bed "V" Blk Fixture			1	7,920
				Air Wrench			1	330
40	Unload Final Heliostat Ass'y. with	13	7 700	Overhead Crane			1	5,500
	Overhead Crane to Palletize &			Installation				825
	Shipping Area							
41	Inspection		4 000					
50	Load Shipping Rack			Overhead Crane				5,500
	(2) Operators	20	10 000	Installation				825

REMARKS All equipment is Capital Exc. Ass'y. Bench. Total Labor 51.900
Replace Wrenches 2x/yr. Wgt. = 1,556.3#/ 'y.

APPENDIX C

PRODUCT COST ESTIMATE

PRODUCT COST ESTIMATE

Date 4N080 | SUPPORT ASSEMBLY, ELEVATION DRIVE | Sheet 1 of 1

PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
Name	Number	Quan.	Spec.	Wgt/BM	Price	Cost	Dept	Hrs/C/BM	Rate	Cost	Rate	Cost	
Supp't Assy El Dr.													
Casting		1	P			175.0000		-					
Bearing	M521230-1b	1	P			8.7900		-					
Bearing-TFC Lines	1D22415-501	1	P			9.1700							
Supt. Assy., El.Drive	1D22439-1	1				-		38.113		Mach.			
Total						192.9600		38.113	9.09	3.4656	661	22.9076	219.3332

PRODUCT COST ESTIMATE

Date 4N080 — Pedestal — Sheet 1 of 1

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
	Name	Number	Quan.	Spec.	Wgt/BM	Price	Cost	Dept	Hrs/C/BM	Rate	Cost	Rate	Cost	
1	Nut	1.00-8	4	P		.24	1.1600		-					
2	Ring	1D22461-11	1	P			7.3000		-					
3	Cone	-9	1	P			21.5800		-					
4	Plate	-5	1	P			48.2800		-					
5	Tube	-3	1	P			62.1500		-					
6	Pedestal	-1	1				-		30.478		Weld			
7									19.125		Paint			
8	Total						140.4700		49.603	9.09	4.5089	661	29.8038	174.7827
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PRODUCT COST ESTIMATE

Date 4N080

Reflector Assembly 1D22456-1

Sheet 1 of 2

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
	Name	Number	Quan.	Spec.	Wgt/BM	Price	Cost	Dept	Hrs/C/BM	Rate	Cost	Rate	Cost	
1	Angle	1D22470-12	2	P		1.11	2.2200		--					
2	Angle	-11	2	P		1.11	2.2200		--					
3	Angle	- 5	2	P		1.11	2.2200		--					
4	Angle	- 3	2	P		1.11	2.2200		--					
5	Braces	- 1	2						(Incl in Reflector Supp. St. Asm.)					
6														
7	Bar	1D22463-9	4	P		3.47	13.8800		--					
8	Plate	-7	4	P		3.52	14.0800		--					
9	Gusset	-5	4				--		(Incl in Reflector Supp. St. Asm.)					
10														
11	Doubler	1D22463-3	4	P		2.69	10.7600		--					
12	Outboard Cross Beam	1D22467-1	2	P		59.25	118.5000		--					
13	Diagonal Beam	1D22466-2	2	P		38.92	77.8400		--					
14	Diagonal Beam	-1	2	P		38.92	77.8400		--					
15	Doubler Angle	1D22465	28	P		.41	11.4800		--					
16		-003-5												
17	Inboard Cross Beam	ID22465-1	2	P		66.49	132.9800		--					
18	Reflector Supp. St.													
19	Asm.	1D22463-1	2				--		34.576		(4412 Mirror Supt. Struc.)			
20														
21	Hexnut	312-18	56	P		.0568	3.1808		--					
22	Flange Nut	21SFF51618	56	P		.03	1.6808		--					
23	Shoulder Washer	1D22591-503	28	P		.07	1.9600		--					
24	Shoulder Washer	-501	28	P		.08	2.2400		--					
25	Stud	1D22778-501	56	P		.5411	30.3016		--					
26	Mirror Attach. Kit													
27	(4 Point)	1D22471-501	2				--		(Incl in Reflector Assy)					
28														
29	Adhesive (Single Sheet) PVB		14	P		10.56	147.8400		--					
30	Back Lite	1D22428-5	14	P		15.40	215.6000		--					
31	Paint Mirror						--		--					
32	Copper Ref ID22430	1D22428-3	14	P		33.00	462.000		--					
33	Silver Mirror Spec.						--		--					
34	Glass						--		--					
35	Laminated Mirror	1D22428-1	14				--		(Incl Mirror Module Assy)					
36														
37	Edge Sealant-11 & 13	SC51202		P	182oz.	.0631/oz.	11.4842		--					
38	Edge Sealant-17 & 3													
39	Bond Lines	SC51202		P	238oz.	.0631/oz.	15.0178		--					

PRODUCT COST ESTIMATE

Date 4N080 — Reflector Assembly 1D22456-1

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
	Name	Number	Quan.	Spec.	Wgt/BM	Price	Cost	Dept	Hrs/C/BM	Rate	Cost	Rate	Cost	
1	Adhesive - 17 to 13	EC3532		P	10.50#	4.3067/lb	45.2204		--					
2	Adhesive-Glass to	STABOND												
3	-17 Shim	1897		P	7#	1.88/lb	13.1600		--					
4	Steel Primer	COROGARD 9		P	28 oz	.12/oz	3.3600		--					
5	Glass Primer	PR1506		P	14 oz	.02/oz	.2800		--					
6	Clinch Fastener	S-0518-1-Z	56	P		.02	1.1200		--					
7	Shim	1D22462-7	28	P		1.48	41.4400		--					
8	Edge Member	1D22462-13	28	P					--					
9	Edge Member	-11	28	P		.935	26.1800		--					
10	Stiffener	- 3	28	P		5.235	146.5800		--					
11	Mirror Module Assy.	1D22462-1	14						105.308		(4411 Refl. Surf.)			
12														
13	Reflector Assy	1D22456-1	2						47.516		(4413 Refl. Panel Assy.)			
14				PACK					26.666					
15														
16	Total						1634.8848		214.066	9.09	19.4586	661	128.6213	1782.9647
17														
18														
19														
20														
21														
22														
23														
24														
25														
26														
27														
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29														
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31														
32														
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34														
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36														
37														
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39														

PRODUCT COST ESTIMATE

Date 4N080 Main Beam **Sheet** 1 **of** 1

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
	Name	Number	Quan.	Spec.	Wgt/BM	Price	Cost	Dept	Hrs/C/BM	Rate	Cost	Rate	Cost	
1	Pin (Same 1D22475-3)	1D22464-19	4	P		1.50	6.0000		-					
2	Bearing TFE Lined	1D22415-1	2	P		4.50	9.0000		-					
3	Stiffener	1D22464-33	1	P			.3000		-					
4	Channel	1D22464-31	2	P		1.20	2.4000		-					
5	Stiffener	1D22464-29	1	P			.5200		-					
6	Stiffener	1D22464-27	1	P			1.0000		-					
7	Pad	1D22464-25	2	P		2.20	4.4000		-					
8	Bar	1D22464-17	4	P		2.39	9.5600		-					
9	Gusset	1D22464-15	2	P		.94	1.8800		-					
10	Lug	-11	2	P		3.03	6.0600		-					
11	Lug	-9	2	P		2.68	5.3600		-					
12	Lug	-7	2	P		4.84	9.6800		-					
13	Web	-5	2	P		2.93	5.8600		-					
14	Body	-3	2			21.69	43.3800		-					
15	Main Beam	-1	1				-		128.078		Weld			
16									34.126		Mach			
17														
18	Total						105.4000		162.204	9.09	14.7443	661	97.4598	217.6041
19														
20														
21														
22														
23														
24														
25														
26														
27														
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32														
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37														
38														
39														

PRODUCT COST ESTIMATE

Date 4N080 Drive/Pedestal/Main Beam Final Assembly Sheet 1 of 3

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
	Name	Number	Quan.	Spec.	Wgt/BM	Price	Cost	Dept	Hrs/C/BM	Rate	Cost	Rate	Cost	
1	1" Black Shrink Tubing	STM0069-							--					
2		13-A6-02		P	4"	.09/in	.36		--					
3	½" " " "	DPM2617-15		P	4"	.05/in	.20		--					
4	#222 SJ Wire	8451		P	6'	.0950/ft	.5700		--					
5	#18 AWG Wire	8918		P	30'	.1070/ft	3.2100		--					
6	Splice	A1A	1	P			.0600		--					
7	Plug, Filler	225-0072-000	2	P		.015	.0300		--					
8	Contact, Socket	110238-0085	5	P		.07	.35		--					
9	" Pin	110238-0040	3	P		.04	.12		--					
10	Connector	120-1869-000	1	P			.3700		--					
11	Cable, Assy. Pedestal	1D22514-501	1				--							
12														
13														
14	Split Lock Washer	.190	1	P			.0100		--					
15	Roundhead Screw	190-32UNF												
16		-2AX.50	1	P			.0100							
17	Jumper	ST263-1666	1	P			.6500							
18	Clamp	ST253C6	1	P			.1000							
19	Electrical Inst,													
20	Pedestal	1D22445-1	1				--							
21														
22	Promixity Switch	4C2P-1839												
23		1A-60	1	P			.6900		--					
24	1/8" Dia Black Shrink													
25	Tubing	DPM2617-15		P	1"		.0225		--					
26	1" " " "	STM0069												
27		-13-A6-02		P	4"	.09	.36		--					
28	Contact, Socket	110238-0085	1	P			.1400		--					
29	Contact, Pin	-0040	1	P			.0400		--					
30	Connector	120-1807-000	1	P			.3700		--					
31	Sensor, Elec. Assy.	1D22414-501	1						5.528					
32									2.459					
33	Proximity Switch	LC2P-1839												
34		-1A-60	6	P		.69	4.1400		--					
35	1/8" Dia Black													
36	Shrink Tubing	DPM2617-15		P	4½"	.06	.2700		--					
37	1" " "	STM0069-13												
38		B6-02		P	12	.0225	.2700		--					
39	Contact, Socket	110278-0085	6	P		.07	.4200		--					

PRODUCT COST ESTIMATE

Date 4N080 Drive/Pedestal/Main Beam Final Assembly Sheet 2 of3

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
	Name	Number	Quan.	Spec.	Wgt/BM	Price	Cost	Dept	Hrs/C/BM	Rate	Cost	Rate	Cost	
1	Contact, Pin	110238-0040	6	P		.04	.2400		--					
2	Connector	120-1809-000	3	P		.37	1.1100		--					
3	Sensor, Elec. Assy.	1D22414-1	3				--		16.584					
4									7.377					
5	Jumper	ST268-09CC	1	P			.6500		--					
6	Hex Cap Screw	.250-28UNF												
7		-.2AX.50	1	P			.0100		--					
8	Cotter Pin	.062X.50	1	P			.0100		--					
9	Nut	AN130-15	1	P			.0800		--					
10	Washer	An960-1616	1	P			.0900		--					
11	Split Lock Washer	.875	4	P		.07	.2800		--					
12	" " "	.500	8	P		.02	.1600		--					
13	Hexnut	.250-20UNC												
14		-2B	8	P		.005	.0400		--					
15	Split Lock Washer	.250	26	P		.003	.0780		--					
16	Hex Cap Screw	.250-20UNC												
17		-2A x.88	8	P		.012	.0960		--					
18	" " "	.250-20UNC												
19		-2A x .75	2	P		.011	.0220		--					
20	" " "	.250-20UNC												
21		-2A x .50	16	P		.009	.1440		--					
22	Hexnut	.190-32UNF												
23		-2B	2	P		.003	.0060		--					
24	Split Lock Washer	.190	2	P		.016	.0320		--					
25	Flat Head Brass Scr.	.190-32UNF												
26		-2A x .75	2	P		.02	.0400		--					
27	Shaft	A3-17	2	P		.195	.3900		--					
28	Washer	5710-245-90	2	P		.02	.0400		--					
29	"	5710-67-10	30	P		.02	.6000							
30	Magnet	M2	2	P		.1650	.3300							
31	Set Screw	NAS1081				.02	.0400							
32		-6A10P	2	P			.400							
33	Set Screw	NAS1081												
34		-4A12P	1	P			.0200							
35	Bolt	NAS1308-15	8	P		.99	7.9200							
36	"	NAS1316-420	1	P		1.30	1.3000							
37	"	NAS1314-16	4	P		.98	3.9200							
38	Cotter Pin	MS24665-377	2	P		.04	.0800							
39	" "	MS24665-374	1	P			.0300							

PRODUCT COST ESTIMATE

Drive/Pedestal/Main Beam Final Assembly

Date 4N080 | Sheet 3 of 3

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
	Name	Number	Quan.	Spec.	Wgt/BM	Price	Cost	Dept	Hrs/C/BM	Rate	Cost	Rate	Cost	
1	Hinge, Half Assy.	1D22405-503	1	P			.1300		--					
2	Pin	-9	1	P			.0300		--					
3	Angle	-3	1	P			.1300		--					
4	Hinge, Half Assy.	-501	1	P			.1300		--					
5	Pin	-7	1	P			.0300		--					
6	Angle	-3	1	P			.1300		--					
7	Hinge, Half Assembly	-1	1	P			.1300		--					
8	Cover Elevation Dr.	1D22594-1	1	P			.1600		--					
9	Pin, Rod End	1D22478-1	1	P			.1500		--					
10	Pin, Hinge	1D22455-1	1	P			3.0000		--					
11	Cap, Rod End Pin	1D22438-1	2	P		.08	.1600		--					
12	Mount, Sensor Output	1D22433-1	1	P			.1200		--					
13	Pin, Trunnion	1D22432-1	2	P		2.52	5.0400		--					
14	Base	1D22419-5	1	P			--		--					
15	Plate	-3	1	P			--		--					
16	Bracket, Elev. Sensor	-1	1	P			.4100		--					
17	Bracket, Magnet, Elev	1D22418-1	1	P			.1000		--					
18	Mount, Elevation Sen	1D22417-1	2	P		.1600	.3200		--					
19	Cover, Elevation Sen	1D22416-1	1	P			.6200		--					
20	Dr/Pedestal/Main Beam													
21	Assembly	1D 22475-1	1						41.900					
22														
23				PACK			--		10.000					
24														
25	Total						42.6605		83.848	9.09	7.6218	661	50.3801	100.6624
26														
27														
28														
29														
30														
31														
32														
33														
34														
35														
36														
37														
38														
39														

PRODUCT COST ESTIMATE

Azimuth Drive

Date 4N080

PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
Name	Number	Quan.	Spec.	Wgt/BM	Price	Cost	Dept	Hrs/C/BM	Rate	Cost	Rate	Cost	
1½ Orange Shrink													
Tubing	DPM2617-15		P	¼"	.24/in	.06		--					
1" Black Shrink	STM0069-												
Tubing	-13-A6-02		P	28"	.09/in	2.52		--					
½" " " "	DPM2617-15		P	4"	.05/in	.20		--					
1/8" " " "	"		P	9"	.0225/in	.2025		--					
1½" White " "	"		P	¼"	.24/in	.06		--					
1½" Yellow "	"		P	¼"	.24/in	.06		--					
1½" Red	"		P	¼"	.24/in	.06		--					
Wire #22-2SJ	8451		P	145'	.095/ft	13.775		--					
Wire #18 AWG	8918		P	100'	.1070/ft	10.7000		--					
Splice	AIA	4	P		.03	.1200		--					
Grommet	351-1634-												
	000	2	P		.4450	.8900		--					
Plug, Filler	225-0072-												
	000	4	P		.0125	.0500		--					
Contact, Socket	110238-0085	27	P		.07	1.89		--					
Contact, Pin	110238-0040	31	P		.04	1.24							
Connector	120-1870-												
	000	1	P			.3300		--					
"	120-1804-												
	000	2	P		.2900	.5800		--					
"	120-1865-												
	000	1	P			.4400		--					
"	120-1893-												
	000	1	P			.3700		--					
"	120-1869-												
	000	2	P		.3600	.7200		--					
Wire Harness	1D22514-1	1						5.528					
								2.222					
Clamp	M321919												
	WDG-6	1	P			.0500							
1" Shrink Tubing Blk	STM0069												
	13-A6-02	1	P	4"	.09	.36		--					
Receptacle	120-1805-												
	000	1	P			.3700		--					
Grommet	351-1634-												
	000	1	P			.4500		--					
Grommet	351-1641-000	2	P		.4400	.8800		--					

PRODUCT COST ESTIMATE

Azimuth Drive

Date 4N080

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
	Name	Number	Quan.	Spec.	Wgt/BM	Price	Cost	Dept	Hrs/C/BM	Rate	Cost	Rate	Cost	
1	Receptacle	120-1870-												
2		000	1	P			.3300		--					
3	"	120-1806-												
4		000	1	P			.3700		--					
5	Washer	M5353338-43	1	P			.0020		--					
6	Nut	NAS671-10	1	P			.0800		--					
7	Washer	NAS620-10L	2	P		.01	.0200		--					
8	Screw	NAS601-6P	1	P			.0200		--					
9	Electrical Install.	1D22596-1	1						5.528					
10									2.222					
11	Proximity Switch	LC2A1839												
12		-1A-60	1	P			.69		--					
13	1/8" Blk Shrink Tubing	DPM2617-15		P	1"	.0225	.0225		--					
14	1" " " "	STM0069-												
15		13-A6-02		P	4"	.09	.36		--					
16	Contact, Socket	110238-0085	1	P			.07		--					
17	Contact, Pin	110238-0040	1	P			.04		--					
18	Connector	120-1807-												
19		000	1	P			.3700		--					
20	Sensor, Electronic													
21	Assy.	1022414-503	1						5.528					
22									2.459					
23	1" Black Shrink	STM0069												
24	Tubing	-13A6-02		P	4"	.09	.36		--					
25	Connector		1	P			.3700		--					
26	Strap	PLT8H-LP0	1	P			.1800		--					
27	Washer	NAS620-6	8	P		.0050	.0400		--					
28	Lock Washer	NAS5338-41	8	P		.0020	.0160		--					
29	Screw	NAS601-5P	6	P		.0170	.1020		--					
30	Cover, Incremental													
31	Encoder		1	P			.1700		--					
32	Vane		1	P			2.8200		--					
33	Screw	M524693-C28	2	P		.03	.0600		--					
34	Washer	NAS620-6	1	P			.0100		--					
35	Screw	NAS601-10P	1	P			.0200		--					
36	Clamp	NAS1715-DST	1	P			.0500		--					
37	Spacer	NAS4300-3-												
38		20	1	P			.0100		--					
39	Socket Contacts	110238-0085	5	P		.07	.35		--					

PRODUCT COST ESTIMATE

Azimuth Drive

Date 4N080

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
	Name	Number	Quan.	Spec.	Wgt/BM	Price	Cost	Dept	Hrs/C/BM	Rate	Cost	Rate	Cost	
1	Pin Contacts	110238-0040	2	P		.04	.08		--					
2	Grommet	M535489-122	1	P			.0500		--					
3	1/8" Black Shrink													
4	Tubing	DPM2217-15		P	3"	.0225	.0675		--					
5	Splice	A1A	1	P			.0600		--					
6	Wire	A22-2SJ		P	6'	.095	.59		--					
7	Ink	CMP3627												
8		-37875		P			.0100		--					
9	Solder	DPM3891		P			.0300		--					
10	Micro Switch	4A VIC-T1	2	P		.7650	1.5300		--					
11	I.C.	DM7830-JB	1	P			4.9800		--					
12	Resistor	RCR056512JS	2	P		.05	.1000		--					
13	Capacitor	M39014-101												
14		1513	1	P			.3400		--					
15	PWB Incremental													
16	Encoder	1022574-1	1	P			.1200		--					
17	CCA " "	1022573-1	1	P			3.0000		--					
18	Incremental Encoder													
19	Electrical Assembly		1						14.106					
20									8.456		Encoder Cables (2)			
21	Motor	1022487-501	1	P			60.9300		10.400		Encoder Controller Cable (2)			
22	Azimuth Motor/Incremental													
23	Encoder Elec. Assy.		1				--							
24														
25	Grease	Alundia Epl		P	4#	.40/lb	1.600		--					
26	Gear Oil	Mobile 626		P	4 qt	.25/qt	1.000		--					
27	Adhesive(1P20025-Chass 1)	DPM3279		P			.1200		--					
28	Plastic Gasket Product 749-xx	DPM5793		P			.2500		--					
29	Tape ½" wide Antiseize													
30	mil T-2773D	DPM2766		P	1'	.05/ft	.0500		--					
31	Clamp	ST253C6	1	P			.1000		--					
32	Plug	3/8-18NAPT	2	P		.0650	.1300		--					
33	Plug	1/8-27ANPT	1	P			.0500		--					
34	Bracket	TA4064E0610	1	P			.0700		--					
35	Split Lock Washer	.375	16	P		.007	.1120		--					
36	Hex Cap Screw	.375-24 UNF												
37		-2Ax1.75	16	P		.039	.6240		--					
38	Split Lock Washer	.250	12	P		.003	.0360		--					
39	Hex Cap Screw	.250-20UNC -2A x .75	4	P		.011	.0440		--					

PRODUCT COST ESTIMATE

Date 4N080 Azimuth Drive

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
	Name	Number	Quan.	Spec.	Wgt/BM	Price	Cost	Dept	Hrs/C/BM	Rate	Cost	Rate	Cost	
1	Hex Cap Screw	.250-20UNC												
2		-2Ax.63	8	P		.010	.0800		--					
3	Hexnut	.190-32UNF-												
4		28	2	P		.003	.0060		--					
5	Split Lock Washer	.190	20	P		.016	.3200		--					
6	Flat Head Brass Screw	.190-32UNF												
7		-2Ax.88	1	P			.0220		--					
8	Round Head Screw	.190-32UNF												
9		-2Ax.50	15	P		.004	.0600		--					
10	" " "	.190-32UNF												
11		-2Ax.38	4	P		.004	.0160		--					
12	Washer	AN970-3	3	P		.016	.0480		--					
13	Magnet	M2	1	P			.1600		--					
14	Expansion Chamber	1010-104000	2	P		2.605	5.2100		--					
15	Key	NA5558-1212												
16		-15	1	P			.0500		--					
17	Key	NAS558-606												
18		-24	1	P			.0500		--					
19	Washer	N-08	1	P			.2300		--					
20	Washer	W-06	1	P			.2300		--					
21	Nut	N-08	1	P			.6700		--					
22	Nut	N-06	1	P			.6700		--					
23	Vitron Seal	9651	1	P			.9800		--					
24	Seal	506-325G	2	P		.98	1.9600		--					
25	"	2-459V747-												
26		75	1	P			.4900		--					
27	"	2-386V747-												
28		75	1	P			.4900		--					
29	"	2-275V747-												
30		75	1	P			.6500		--					
31	"	2-133V747-												
32		75	1	P			.2600		--					
33	Bearing	106-KS22	1	P			.8100		--					
34	Bracket, Elec. Azimuth	1022411-1	1	P			.1000							
35	Azimuth Drive Cover		1	P			6.7600		--					
36	Mount		1	P			1.4600		--					
37	Tube - Brg.		1	P			2.9900							
38	Tube		1	P			8.5000		--					
39	Shell		1	P			7.4200		--					

PRODUCT COST ESTIMATE

Date 4NOV80

Azimuth Drive

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
	Name	Number	Quan.	Spec.	Wgt/BM	Price	Cost	Dept	Hrs/C/BM	Rate	Cost	Rate	Cost	
1	Retainer		1	P			12.75		{29.210		Mach			
2	Weld Assy., Housings	1D22474-1	1						}22.892		Weld			
3	Bracket, Elec Azimuth	1D22411-501	1	P			.1000		--					
4	Washer	1D22593-5	1	P					--					
5	Tube	1D22593-3	1	P			4.9800		--					
6	Tube Assembly	1D22593-1	1	P										
7														
8	Bass	1D22442-7	1	P					--					
9	Tube	1D22442-5	1	P					--					
10	Pan	1D22442-3	1	P			4.1500		--					
11	Lube Pan Assy.	1D22442-1	1	P										
12														
13	Filler Block Flex													
14	Spline	1D22422-1	1	P			5.4500		--					
15	Bushing, Guide Dr.													
16	Shaft	1D22481-1	1	P			.5000		--					
17	Spacer, Shaft Seal	1D22449-1	1	P			.6900		--					
18	Brkt, Magnet, Azimuth													
19		1D22424-1	1	P			1.1000		--					
20	Retainer, Turret													
21	Bearing	1D22489-1	1	P			19.9000		22.831					
22	Shaft, Harmodic Dr.													
23	Input	1D22495-1	1				4.8700		13.346					
24	Plate Bearing Ret.	1D22482-1	1	P			.5200		11.563	Paint	Cover &	Retainer		
25	Shim Helicon Gear	1D22485-1	4	P		.045	.1800							
26	Shim Turret Bearing	1D22443-1	1	P			1.6000		--					
27	Gear-Helicon Output	1D22486-1	1	P			15.0000		--					
28	Wire Race - Outer		2	P										
29	Wire Race - Inner		2	P										
30	Balls		52	P			22.8600							
31	Bearing Kit - Turret	1D22490-1	1	P										
32	Diaphram Hub (Collar)		1				.7900							
33	Circular Spline		1				36.4600		53.049					
34	Flex Spline		1				10.7700		11.040					
35	Wave Generator Brg.		1	P			83.1800		--					
36	Wave Generator Plug		1				6.6600		26.146					
37	Harmonic Drive Kit	1D22499-1	1				--							
38														
39														

PRODUCT COST ESTIMATE

Date 4NOV80 | Azimuth Drive |

PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
Name	Number	Quan.	Spec.	Wgt/BM	Price	Cost	Dept	Hrs/C/BM	Rate	Cost	Rate	Cost	
Azimuth Drive	1D22494-1	1				--		127.275		Assy			
								25.688		Paint			
								37.500					
Total						392.8155		436.989	9.09	39.7223	661	262.5644	695.1022

PRODUCT COST ESTIMATE

Date 4N080 — Actuator Assembly - Elevation — Sheet 1 of 2

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
	Name	Number	Quan.	Spec.	Wgt/BM	Price	Cost	Dept	Hrs/C/BM	Rate	Cost	Rate	Cost	
1	Shroud	1D22595-501	1	P			.8900		--					
2	Shroud	1D22595-1	1	P			1.1000		--					
3	Sleeving, Black	STM0069												
4	Shrink Tubing	-12-A6-02		P	4"	.09	.36		--					
5	Socket	110-238-0085	7	P		.07	.49		--					
6	Pin	110-238-0040	6	P		.04	.24		--					
7	Plug	120-1869-000	1	P			.3700		--					
8	Plug	120-1808-000	1	P			.3700		--					
9	Clamp	S0985C600	2	P		.0650	.1300		--					
10	Clamp	S09856500	3	P		.0633	.1900		--					
11	Clamp	ST253C6	1	P			.1000		--					
12	Clamp	ST253C2	2	P		.2500	.5000		--					
13	Washer	NAS620-10L	3	P		.0070	.0210		--					
14	Washer	NAS620-6	6	P		.0050	.0300		--					
15	Washer	MS35338-41	2	P		.0020	.0040		--					
16	Screw	NAS610-5P	6	P		.0015	.0090		--					
17	Washer	MS35338-43	3	P		.0020	.0060		--					
18	Screw	NAS610-6P	3	P		.0300	.0900		--					
19	Cover-Incremental													
20	Encoder			P			.1600		--					
21	Vane			P			1.0000		--					
22	Screw	MS24693-628	2	P		.0300	.0600		--					
23	Tubing	RJ102-3/8		P	8"	.0213/in.	.1700		--					
24	Washer	NAS620-6	1	P			.0050		--					
25	Screw	NAS601-10P	1	P			.0200		--					
26	Clamp	NAS1715-05T	1	P			.0800		--					
27	Spacer	NAS4300-3-20	1	P			.0500		--					
28	Socket Contacts	110238-0085	5	P		.07	.35		--					
29	Pin Contacts	110238-0040	2	P		.04	.08		--					
30	Grommet	M535489-122	1	P			.0500		--					
31	1/8" Black Shrink													
32	Turbine	DPM2617-15		P	3"	.0225	.0675		--					
33	Splice	AIA	1	P			.0600		--					
34	Wire, #22 - 28J	8451		P	21'	.095	1.995		--					
35	Ink	DPM3627-												
36		37875		P			.0100		--					
37	Solder	DPM3891		P			.0300		--					
38	Microswitch	4AVIC-TI	2	P		.7650	1.5300		--					
39	I.C.	DMT830JB	1	P			4.9800		--					

PRODUCT COST ESTIMATE

Date 4N080

Actuator Assembly - Elevation

	PART			MATERIAL				LABOR				BURDEN		TOTAL MFG COST
	Name	Number	Quan.	Spec.	Wgt/BM	Price	Cost	Dept	Hrs/C/BM	Rate	Cost	Rate	Cost	
1	Resistor	RCR05G												
2		J12JS	2	P		.05	.1000		--					
3	Capacitor	M39014101												
4		1513	1	P			.3400		--					
5	PWB Incremental													
6	Encoder	1D22574-1	1	P			.1200		--					
7	CCA Incremental													
8	Encoder	1D22573-501	1	P			3.000		--					
9	Incremental Encoder													
10	Electrical Assy.						--		14.106					
11														
12	Motor	1D22487-1	1	P			60.9300		--					
13	Jack - Elevation	1D22497-1	1	P			332.0800		--					
14	Actuator Assy.-Elev.	1D22496-1	1				--							
15														
16														
17	Total						412.1675		14.106	9.09	1.2822	661	8.4753	421.9250
18														
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APPENDIX D

TYPICAL LABOR DEVELOPMENT

This appendix has been extracted from the Heliostat Production and Cost Evaluation - Final Report, SERI TR-8052-1, December 1979. It 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.

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

SUMMARY DATA

Oper.#	Equip't.	Shift @100%	Day @100%	Day Less Downtime	Day Less Scrap @3%	Relief
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 PCS/Shift x 2 Shifts	= 160.30 PCS/2 Shifts
Less: 5% Machine Downtime	= 152.29
3% 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 PCS/Shift x 2 Shifts		= 143.38 PCS/2 Shifts
Less:	10%* Machine Downtime	= 129.04
	3% 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 PCS/Shift x 2 Shifts	= 151.34 PCS/2 Shifts
Less: 10%* Machine Downtime	= 136.20
3% Scrap Loss	= 132.11

*In-Line Machines Projected Machine Downtime @ 10%

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 PCS/Shift x 2 Shifts	= 177.06 PCS/2 Shifts
Less: 10%* Machine Downtime	= 159.35
3% 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.

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

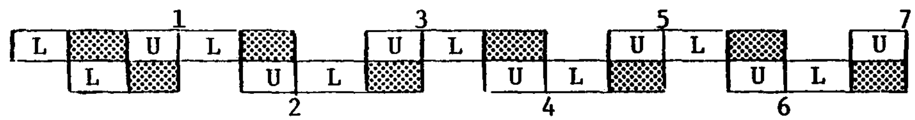
(480 Mins./Shift - 348 Mins. Relief Time = 132 Mins. Available for "other" work)

SUPPORT STRUCTURE - PEDESTAL - TAPERED END

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

MULTIPLE MACHINE (2) SETUP

Secs.
0 40 80 120 160 260 240 280 320 360 400 440 480 520 560 600



L = Load U = Unload ▒ = Mach. Oper. Time

1 & 2 = #1 - 2 mins.
7 PCS/ #2 } $1\frac{1}{3}$ mins. each
(Figure at $1\frac{1}{2}$ Mins.)

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

* 30 Mins. (Rel'd. Personal)

2 Mach. x 480 Mins. (8 Hr. Shift) = 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.)

$\frac{\text{90 secs/cycle}}{\text{60 secs/min.}}$

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: $\frac{\text{155 PPH x 8 Hrs/Shift}}{\text{3 Oper. x 8 Hrs/Shift}}$ = 51.67 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.)	56.390	16.238
(Azim. Hsg.-Galv.)	-	3.200
(Bearing Retainer)	31.590	39.238
(Circular Spline)	58.182	28.775
(Drive Shaft)	(Purch)	7.787
(Flex Spline)	45.058	48.151
(Housing-Azim. Dr.)	82.832	18.364
(Housing-Azim. Dr.-Weld)	(Purch)	40.527
(Wave Generator)	27.435	29.240
(Sub-total)	(301.487)	(231.520)
4422 Elevation (Drag Link-Elev. Dr.)	16.750	2.576
(Elev.-Dr. Ass'y.)	59.000	40.000
(Drag Link-Weld)	(Purch)	4.924
(Drag Link-Galv.)	-	3.200
(Main Beam Ass'y.)	(Purch)	5.100
(Torque Tube-Elev. Dr.)	35.167	2.788
(Torque Tube-Galv.)	-	6.400
(Sub-total)	(110.917)	(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.)	(Purch)	18.741
(Pedestal & Taper Pipe-Galv.)	-	6.400
(Support Structure-Final)	41.900	41.100
(Sub-total)	(41.900)	(66.241)
TOTAL (Std. Hrs./100 Units)	798.923	629.634

BY: EGW DATE: 11/12/79 SUBJECT: Summary Data - Standard Hours/100 Units (SH/100) & Operators Earned by Clasif. SHEET NO: 1 OF: 1
CHKD. BY: DATE: JOB NO:

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)						7.787		6.687 9	.600 1	.500 ½	
-Flex Spline	45.058		41.758	1.800	.500	1.000	48.151		45.051 59	1.800 2	.300 ½	1.000 1½
-Housing-Azim Dr	82.832		63.689	8.000	11.143		18.364		6.364 8	8.000 10½	4.000 5	
-Housing-Azim Dr-Wld	(Purch)						40.527		38.227 50	.800 1	1.500 2	
-Wave Generator	27.435		25.035	2.000	.400		29.240		26.840 35	.400 ½	2.000 2½	
(Sub-total)	(301.487)						(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	-						6.400					6.400 8½
(Sub-total)	(110.917)						(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%)

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