1018

REVISED UPDATE
4-7-86

[redacted]

The Consortium of Alternate Energies

San Diego, California

Response to RFP
Including Project Summary

REVISON I

CHEMEHUEVI SOLAR ELECTRIC PGS PROJECT

The Consortium of Alternate Energies

P.O. Box 84450

San Diego, California 92138

(619) 464-3280

Telex: 3781829 CAE

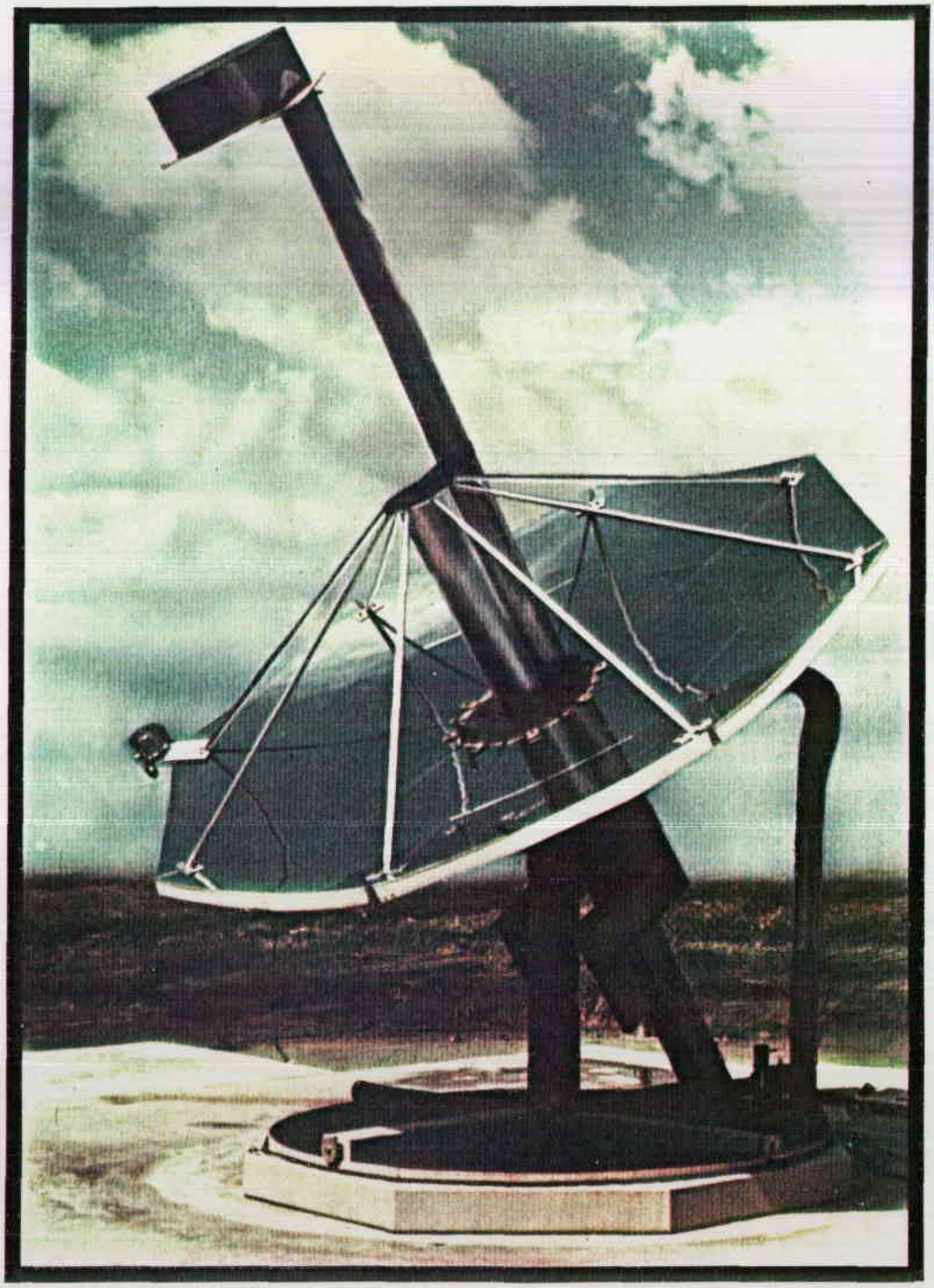
Preface

Solar parabolic dish concentrators have been developed to a high state of refinement by the scientists, engineers and members of the Consortium group. Years of development, sophisticated testing, evaluation and field experience have proven the equipment feasible, practical to construct and economically competitive with other power sources, especially when utilized in cogeneration applications. It is a market-ready resource with vast potential.

Accordingly, the Consortium of Alternate Energies (CAE) and its project partner Omnium-G of Anaheim, California have set a goal of providing this technology as a major energy alternative to conventional sources.

A corollary to this effort is our Economic Development, Training and Employment Program which has been specifically designed for economically disadvantaged areas and third world nations. Utilizing one megawatt or higher plants as nuclei, this program is a powerful tool for local economic stabilization, revenue generation and an ongoing source of jobs and training.

When exploited to full advantage, our advanced solar-electric technology will significantly impact people in ways that could not be imagined just a short time ago.



Heliodyne Model HTC-6000 3-meter parabolic dish collector

Earlier version of OMNIUM-G
3-Meter Dish.

Contents

PART A

EXECUTIVE SUMMARY

Executive Summary

I. INTRODUCTION

The Consortium of Alternate Energies (CAE) and The OMNIUM-G Company are pleased to provide this proposal for construction of a 30MWe solar-electric plant for the Chemehuevi Indian Tribe.

The above two companies have joined forces to propose what will be the world's largest and most advanced parabolic concentrator facility. As will be shown, this new plant concept when implemented will generate more overall revenue and job opportunities than any other total solar installation now available. Installed cost per kilowatt is low to begin with, but considering the plant's several income streams--from cogeneration and creative use of space--real cost becomes dramatically less.

This summary will present the plant concept, its cost and potential revenue sources, benefits to the Indian Tribe and development schedule. Details are provided in subsequent chapters.

II. PLANT CONCEPT AND SPECIFICATIONS (NO WEATHER CONDITIONS)

We propose a 30MWe power generating station, comprised of one megawatt modules that employ OMNIUM-G's advanced 3-meter automatic tracking point focusing parabolic collector.

Utilizing air as the energy transport medium, a conventional turbine steam-Rankine plant system would drive electric generators and charge thermal storage vaults to allow continued generation past sunset and minimize interruption due to weather transients. Our simplified and innovative design incorporates 480 concentrators per megawatt module, set in fixed array atop a revolving hexagonally-shaped platform which rotates to track the sun throughout its daily course. Each platform is raised off the ground almost thirty feet on a strong steel grid system. Power generating and thermal storage equipment is housed in the center of the structure, with space left underneath the platform for construction of storage, industrial, commercial or residential facilities as may be needed by the tribe's economic development plan.

Following is a summary of specifications:

1. Total land required: 2.64 acres per megawatt
   (80.8 acres required for 30 MWe plant)

2. Parabolic concentrators: 480 per MWe/14,100 for 30MWe

3. Total annual power output: 2,569,440 KWH/yr (1MWe module)
   (assuming no weather) 77.1 million KWH/yr (30MWe plant)

Council of Energy Resource Tribes

1580 Logan Street - Suite 400
Denver, Colorado 80203-1941
(303) 832-6600

VIA FEDERAL EXPRESS

May 28, 1986

James A. Leonard, Supervisor
Systems and Applications Development
Division 6227
Sandia National Laboratories
Albuquerque, New Mexico 87185

Dear Jim,

Enclosed is a copy of the proposal submitted by the Consortium of Alternate Energies for the proposed 20-30 Mwe Chemehuevi Solar Electric Power Generating Station project for review by your group as we discussed at our meeting on May 19, 1986.

As you will note, the system design entails a 1 Mwe module with a solar parabolic dish collector. I have also enclosed additional design details related to their unique thermal vault storage concept that I had previously requested.

Any comments that you and your staff might have on this proposal will be sincerely appreciated.

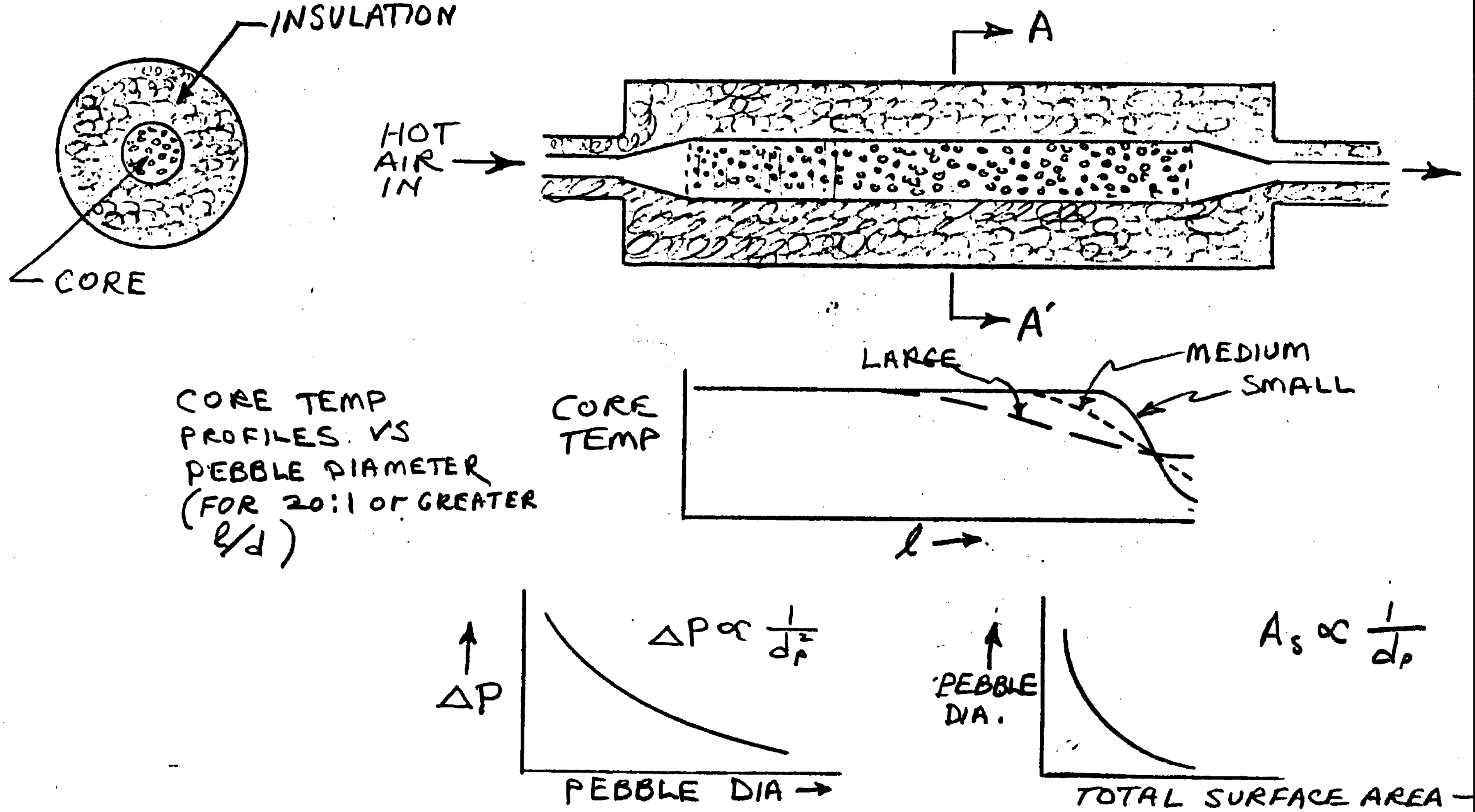
Sincerely,

Glen Lane

Glen Lane
Project Manager, Chemehuevi Solar
Electric Power Generating Station Project

GL:[illegible]
Enclosure

1975 - 1985
Celebrating a Decade of Achievement



ARW ASSOCIATES LOS ALAMITOS, CA 90720.	**PROJECT:** CENICOM		
	DRAWING: PEBBLE CORE TYPE THERMAL STORAGE VAULT - DESIGN CONSIDERATIONS		
	DESIGNER S.P. LAZZARA		**DWG. NO.** 10105-A
	DATE [illegible]	**SCALE**	**SIZE** A
			SHEET [illegible]

	TEMPERATURE RANGE	SPECIFIC HEAT AT HI TEMP	SHAPE	CHEMICAL STABILITY	CORROSIVE	COST	LIFE-CYCLE COST	COMPLEXITY		
PORCELIN-FIRED CERAMIC SPHERES	E	E	E	E	E	F	E	E		SELECTED - MEETS ALL REQTS ACQ COST IS HIGHER
FOUNDARY SLAG - COPPER SMELTING	F/U	F	F/U	E	E	E	E	E		TEMP RANGE IS CRUCIAL FACTOR
LIQUIDS	U	U		U	E	F	U	U		RULED OUT
PHASE-CHANGE MATERIALS	E	E		U	U	F	U	U		RULED OUT

E = EXCELLENT

F = FAIR

U = UNACCEPTABLE

ARW ASSOCIATES
LOS ALAMITOS, CA
90720.

PROJECT: CENICOM

DRAWING: CANDIDATE CORE MATERIALS FOR THERMAL ENERGY STORAGE

DESIGNER: S.P. LAZZARA

DWG. NO. 10105-P

DATE: 10OCT85 | SCALE: | SIZE: A | SHEET

REQUIREMENTS:

STORE 6.42×10^7 BTU *

DELIVER AT 1500°F

USE HOT AIR AS WORKING FLUID

DELIVERY RATE OF 1.25×10^7 BTU/HR

* ONE WINTER DAY OF COLLECTED ENERGY

USE PORCELIN SPHERES

STEATITE: 35 MgO, 60 SiO_2, 5 Al_2O

1.0 INCH DIAMETER (169 lbs/ft^3)

53% FILL FACTOR ⇒ 89 lbs/ft^3

SPECIFIC HEAT @ 1500°F = 0.26

THERMAL CONDUCTIVITY, $k = 1.693 \frac{BTU}{hr \cdot ft^2 \cdot °F/}$

FUSION TEMPERATURE = 2642°F

MAXIMUM SERVICE TEMPERATURE = 2192°

VOLUMETRIC STORAGE = 32,396 BTU/ft^3 (COR

VOLUME OF CORE = 1,982 ft^3

WEIGHT OF CORE = 176,374 lbs

CORE DIAMETER = 5.0 FT

CORE LENGTH = 101 ft

VAULT INSULATION OD = 15.0 ft

VAULT OVERALL OD = 15.5 ft

ARW ASSOCIATES
LOS ALAMITOS, CA
90720.

PROJECT: CENICOM

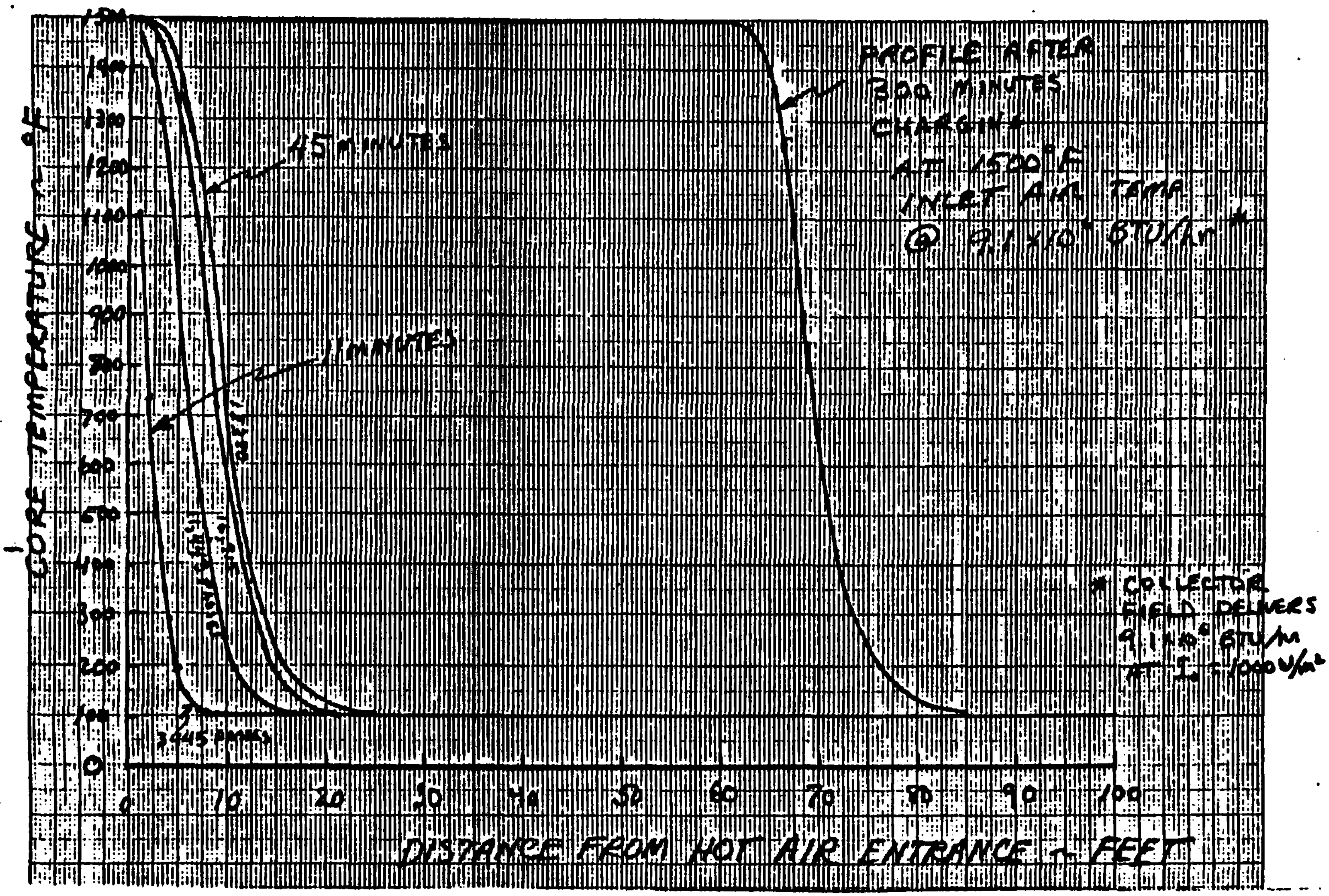
DRAWING: THERMAL VAULT SIZING

DESIGNER: S.P. LAZZARA

DWG. NO. 1106-P

DATE: 10 JAN 86 | SCALE: | SIZE: A

SHEET 1 of 1 | CHG LTR



VAULT CORE CHARACTERISTICS:

5.0 ft DIAMETER

PORCELIN SPHERES

1.0" DIAMETER

100 ft LONG

SPECIFIC HEAT = 0.26

THERMAL CONDUCTIVITY

$k = 1.693 \frac{BTU}{hr \cdot ft^2 \cdot °F/FT}$

53% FILL FACTOR

NO THERMAL LOSSES

ARW ASSOCIATES
LOS ALAMITOS, CA
90720.

THIS DRAWING CONTAINS DATA, INFORMATION, AND/OR DESIGNS WHICH ARE THE PROPERTY OF SAMUEL P. LAZZARA. THE RECIPIENT AND/OR HIS ORGANIZATION, BY ACCEPTING THIS DRAWING AGREES THAT THE DATA WILL NOT BE REPRODUCED, TRANSFERRED, USED FOR MANUFACTURE, OR PROCUREMENT WITHOUT THE EXPRESS WRITTEN PERMISSION OF SAMUEL P. LAZZARA.

PROJECT: CENICOM			
DRAWING: THERMAL STORAGE VAULT TEMPERATURE PROFILE GROWTH – CHARGE			
DESIGNER: S.P. LAZZARA			DWG. NO. 10045-P
DATE	SCALE	SIZE A	SHEET

① CHARGE VAULT FROM FIELD TO 100% OF CAPACITY BEFORE INITIATING TURBINE - START

② RUN TURBINE FROM FIELD + VAULT UNTIL SUNSET

③ CONTINUE TO RUN TURBINE AFTER SUNSET FROM VAULT ALONE UNTIL VAULT IS DEPLETED TO LEVEL REQUIRED FOR OVERNIGHT SUSTAINING (FROM EMERGENCY STEAM ENGINE GENERATOR IN THE EVENT OF GRID POWER LOSS.

NOTE:

ALTERNATES

ⓐ INITIATE TURBINE OPERATION BEFORE VAULT REACHES 100% SO THAT GENERATION CYCLE IS COMPLETED AT SUNSET

ⓑ COMPLETE TURBINE CYCLE BEFORE SUNSET AND CARRY OVER REMAINING COLLECTED ENERGY TO NEXT DAY (HIGHER LOSSES WILL RESULT)

ARW ASSOCIATES LOS ALAMITOS, CA 90720.	PROJECT: CENICOM			
	DRAWING: VAULT CYCLE RULES FOR OPERATION			
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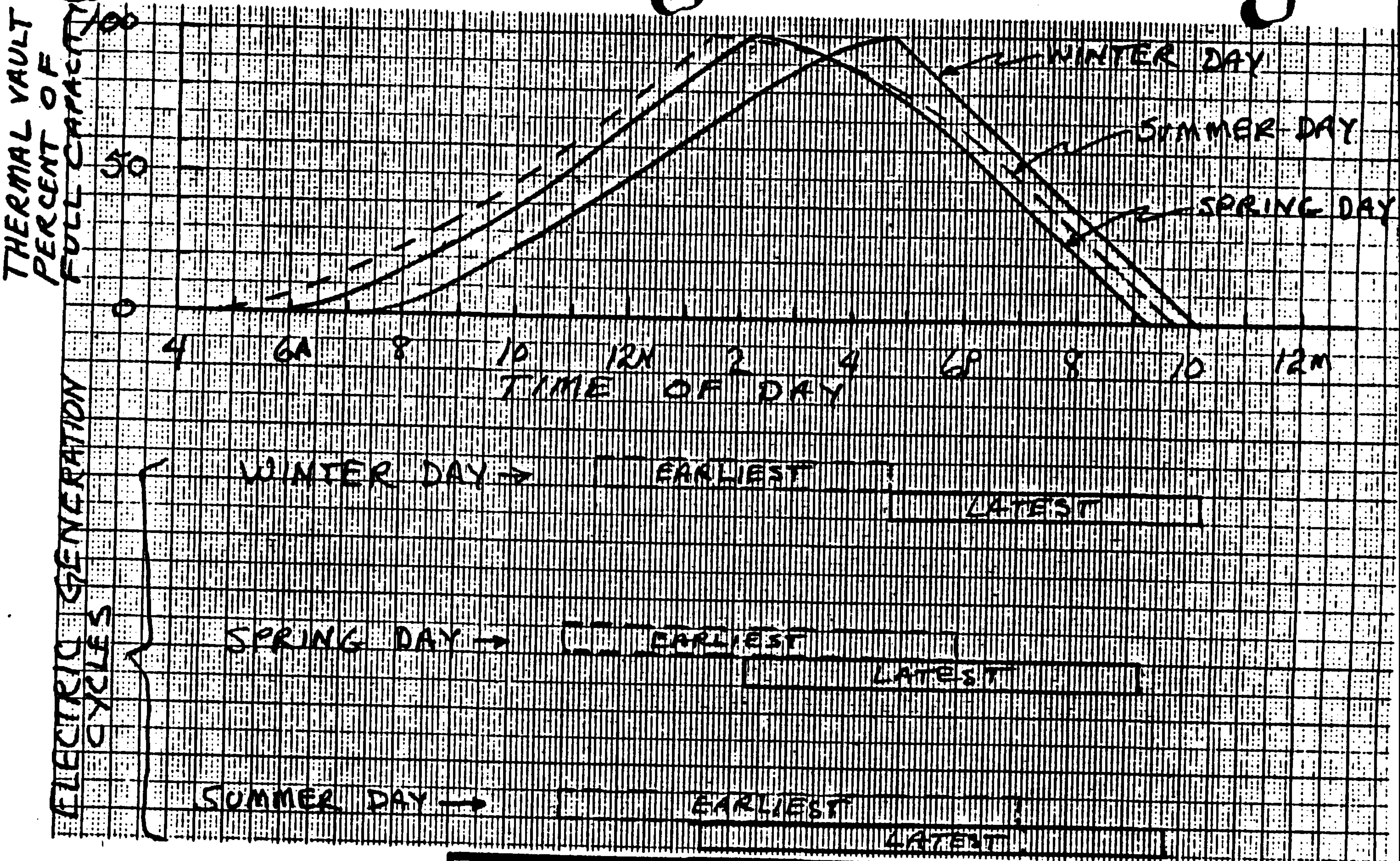
	DATE 19 APR 86	SCALE	SIZE	SHEET 1 OF 1 / CHG LTR



NOTES

(1) VAULT CAPACITY EQUALS ONE WINTER DAY OF COLLECTED ENERGY

ARW ASSOCIATES
LOS ALAMITOS, CA
90720.

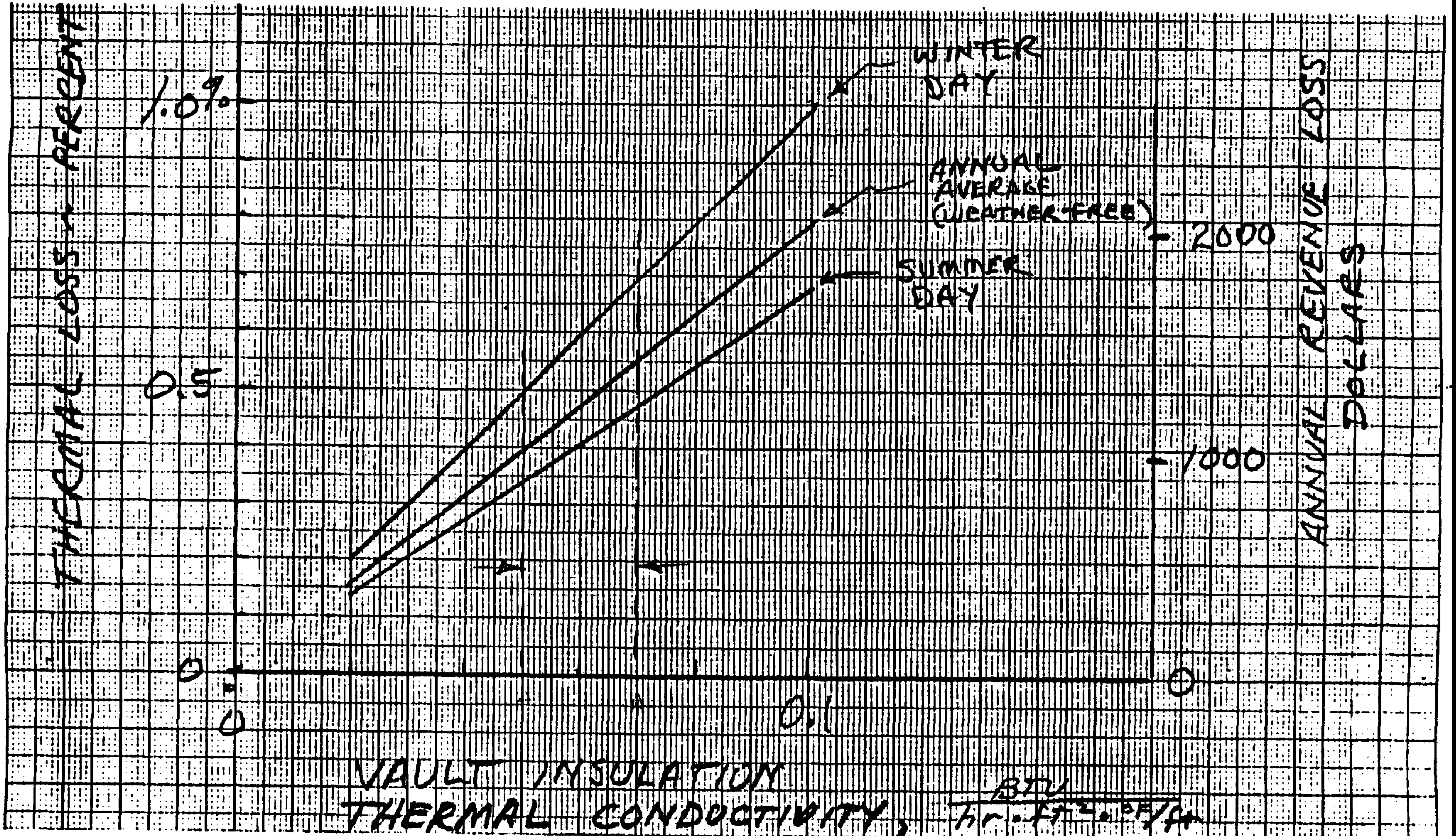
PROJECT: CENICOM

DRAWING: SOLAR-THERMAL-ELECTRI[C] COLLECTION-STORAGE-GENERATION CYCL[E]

DESIGNER S. P. LAZZARA

DWG. NO. 11195-A

DATE 3 NOV 85 | SCALE | SIZE



ARW ASSOCIATES
LOS ALAMITOS, CA
90720.

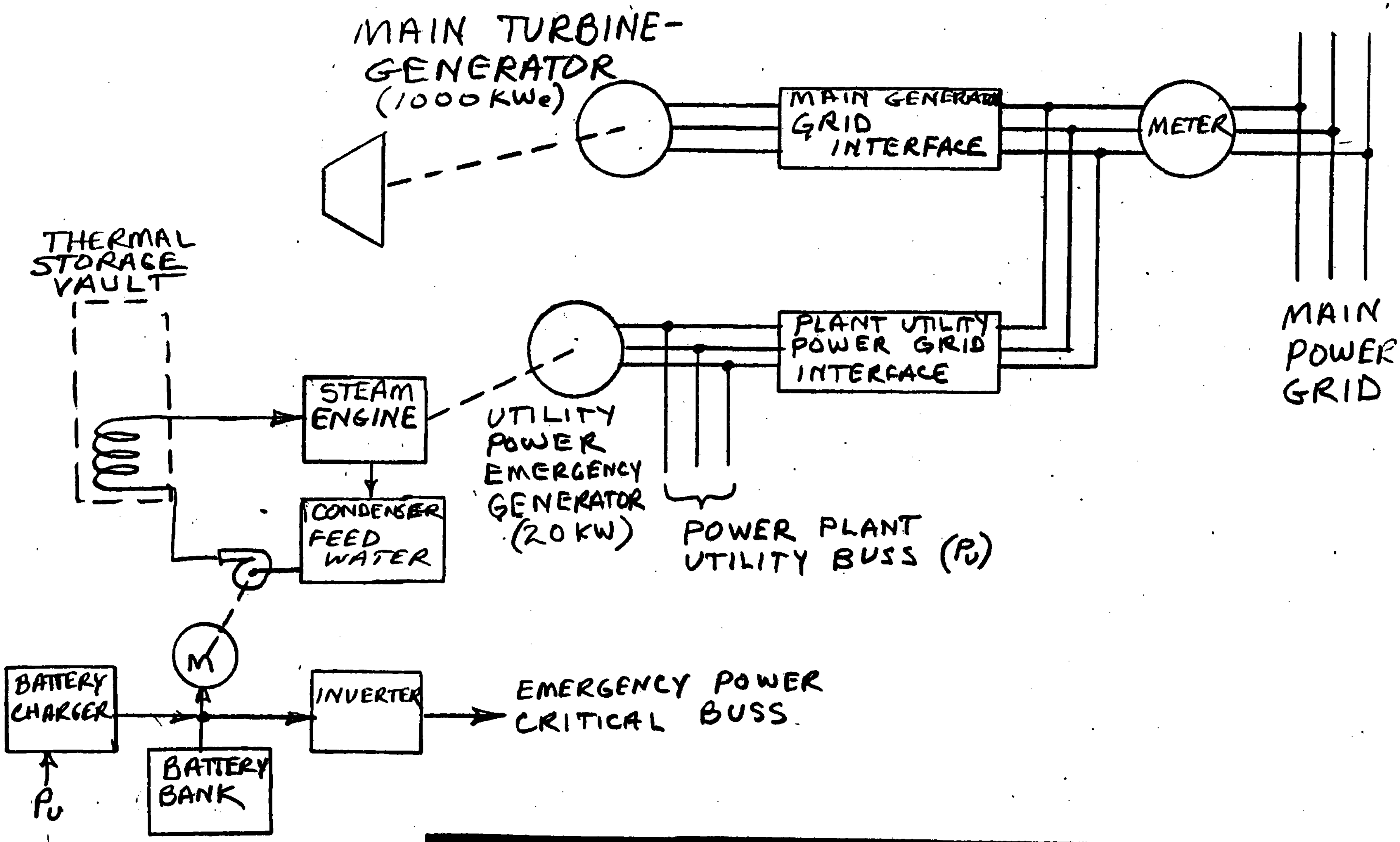
PROJECT: CENICOM

DRAWING: THERMAL STORAGE VAULT EFFECT OF INSULATION ON LOSSES

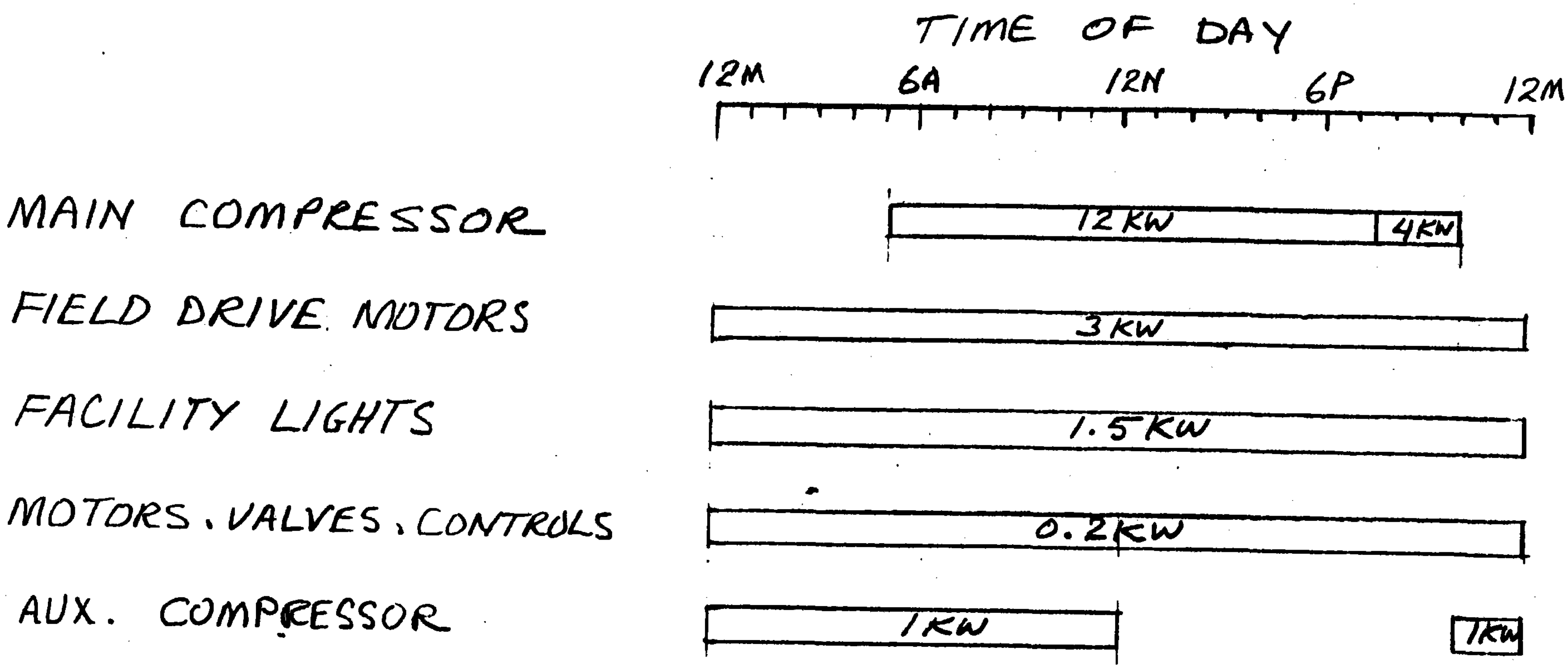
DESIGNER: S.P. LAZZARA

DWG. NO. 4066-A

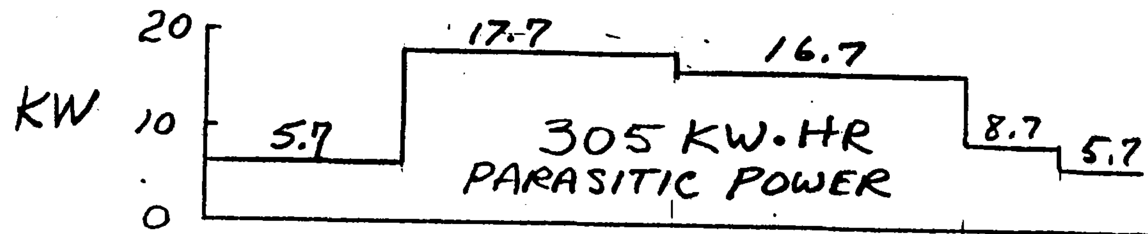
DATE | SCALE | SIZE A | SHEET



ARW ASSOCIATES LOS ALAMITOS, CA 90720.	PROJECT: CENICOM		
	DRAWING: POWER PLANT MAIN AND EMERGENCY POWER		
	DESIGNER S. P. LAZZARA		DWG. NO. 4166-P
	DATE 16 APR 86	SCALE	SIZE A
			SHEET	CHG LTR



PARASITIC POWER = 4.3% OF ANNUAL PRODUCTION



ARW ASSOCIATES
LOS ALAMITOS, CA
90720.

PROJECT: CENICOM

DRAWING: PLANT PARASITIC POWER (ELECT

DESIGNER S.P. LAZZARA

DWG. NO.

DATE 18 APR 8

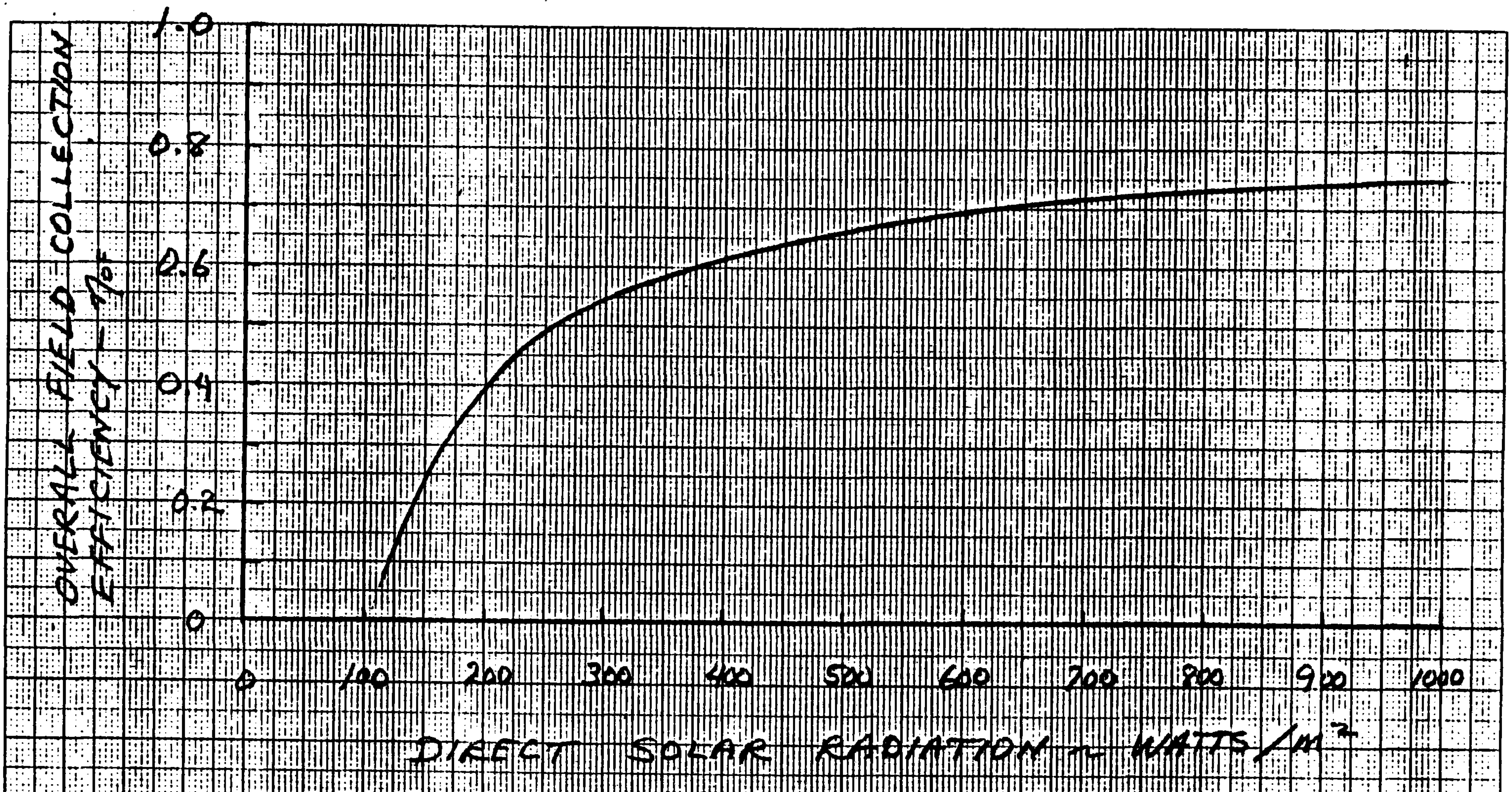
SCALE

SIZE A

SHEET

CHG. LTR

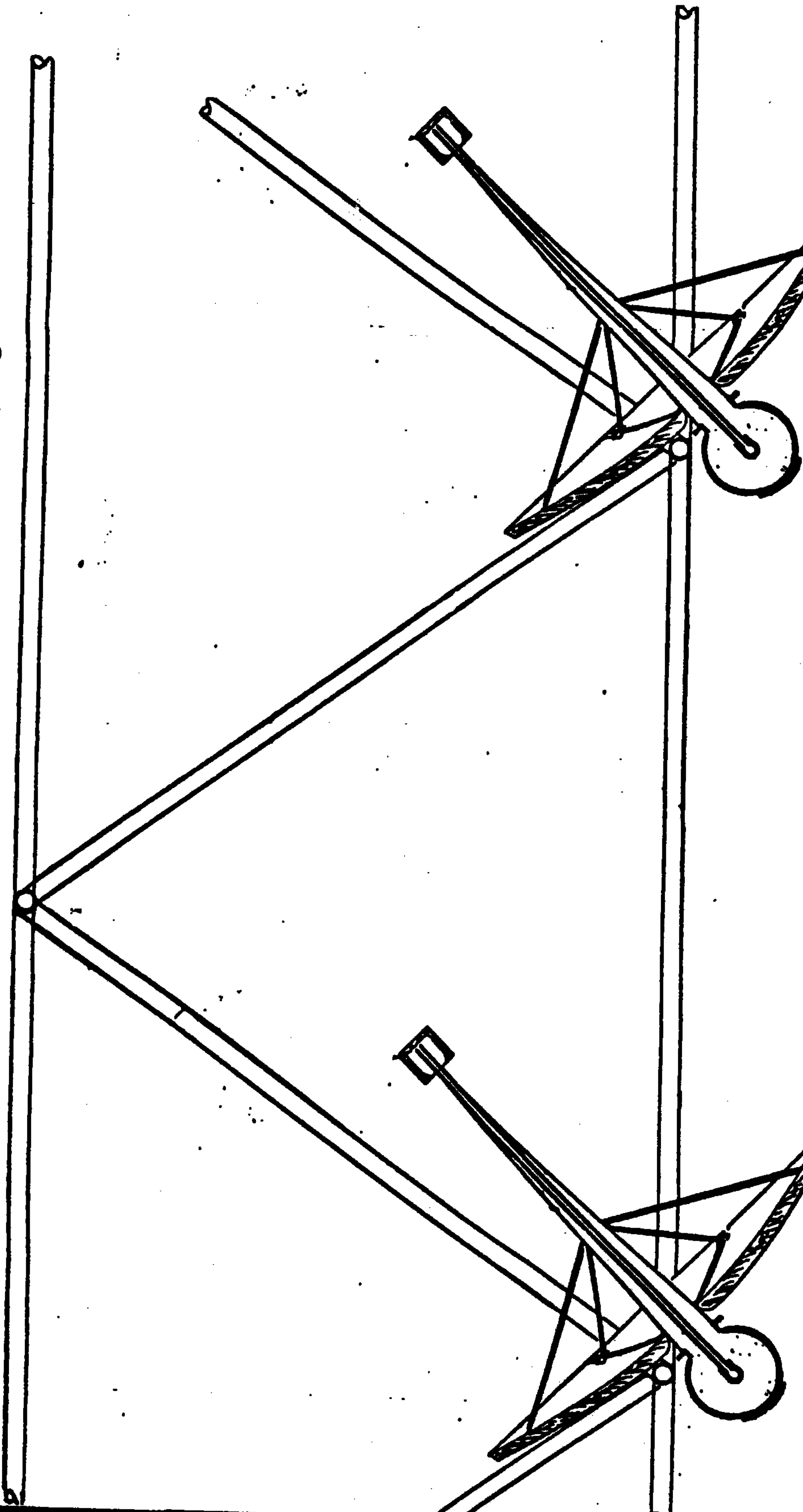
K•E 10 X 10 TO THE CENTIMETER 18 X 25 CM. KEUFFEL & ESSER CO. MADE IN U.S.A. 46 1510



ARW ASSOCIATES
LOS ALAMITOS, CA
90720.

PROJECT: CENICOM				
DRAWING: SOLAR - TO - THERMAL VAULT COLLECTOR FIELD EFFICIENCY				
DESIGNER S.P. LAZZARA			DWG. NO. 9005-A	
DATE SEPT85	SCALE	SIZE A	SHEET 1 OF 1	CHG LTR

COLLECTOR ROWS SHOWN IN ELEVATION STOW POSITION (-45°)



ARW ASSOCIATES
LOS ALAMITOS, CA
90720.

PROJECT:	CENICOM
DRAWING:	COLLECTOR STOW
DESIGNER	S. P. LAZZARA
DWG. NO.	4186-P
DATE	18 APR 86
SCALE	
SIZE	
SHEET	1 OF 1
CHG LTR	

4. Total thermal energy production (before electrical generation): 32 billion BTUs per year.

5. Total annual steam generation (before electrical generation): 25 million lbs. per year.

6. Plant capacity factor: 0.30 minimum

7. Total annual concurrent purified water output per 1MWe module, if needed: 10-20 million gallons (depending on purity level necessary)

8. Time required to construct 30MWe: 60 months.

9. Total estimated capital cost: $118,400,000 ($3,947 per KWe) (Includes water distillation unit in Module No. 1)

Detailed plant design data is incorporated in Section B.

III. POTENTIAL REVENUE SOURCES

Plant income can be derived from any combination of the following sources:

1. Electricity sold to Southern California Edison Company.

2. Electricity sold (at higher rates) to local consumers and/or enterprises housed under or proximate to the revolving solar platforms.

3. Sale of steam or process heat.

4. Sale of distilled water/purified product water.

5. Leasing of space under the concentrator arrays (residential, commercial, light industry).

6. Sale of condominium offices or residences under the arrays (based on a long term ground lease).

7. Profits from project on Indian-owned business activities on the plant site (examples: food, housing, retail sales, services).

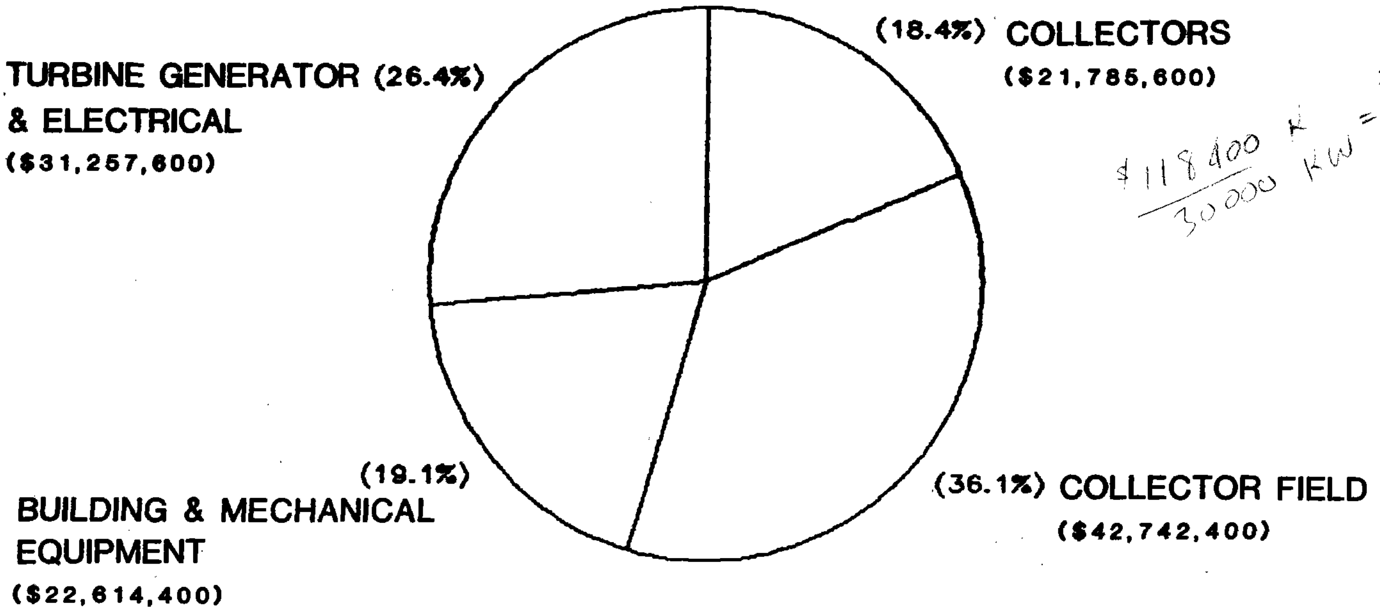
IV. PROPOSED ANNUAL GROSS INCOME FROM A SINGLE 1MWe MODULE:

1.	Sale of electricity to SCE @ $0.07/KWH:	$ 179,861
2.	Sale of product water, 20 million gallons @ $0.07/gallon:	$1,400,000
3.	Master lease of space, 50,000 SF @ $0.15 X 12 mos.:	$ 90,000
	Total annual Gross Income:	$1,669,861

CHEMEHUEVI SOLAR ELECTRIC PGS

30 MWe PLANT COST BREAKDOWN

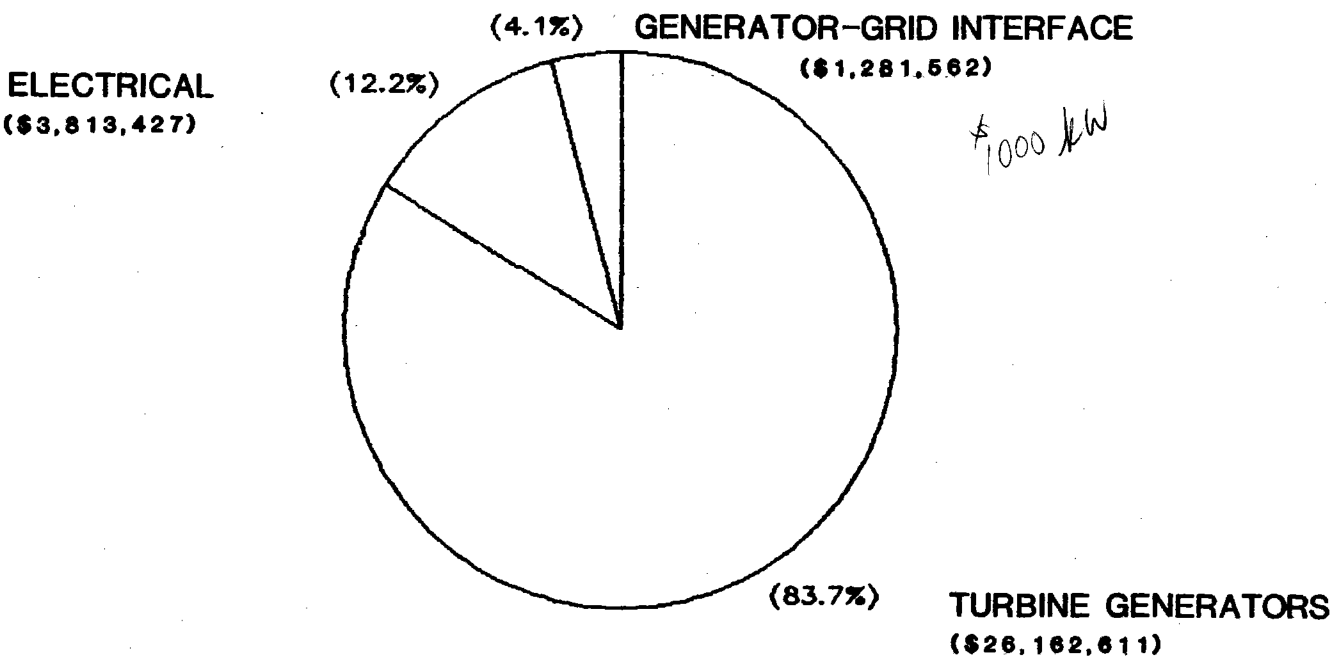
($118,400,000)



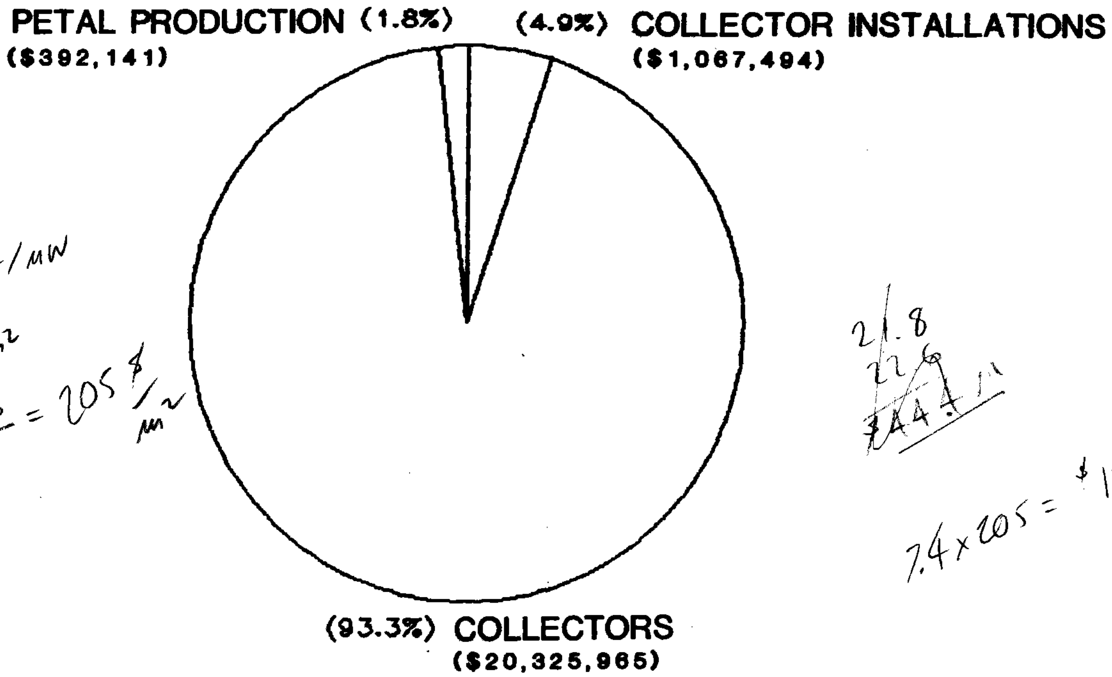
TURBINE GENERATOR AND ELECTRICAL

COST BREAKDOWN

($31,257,600)



COLLECTOR COST BREAKDOWN
($21,785,600)

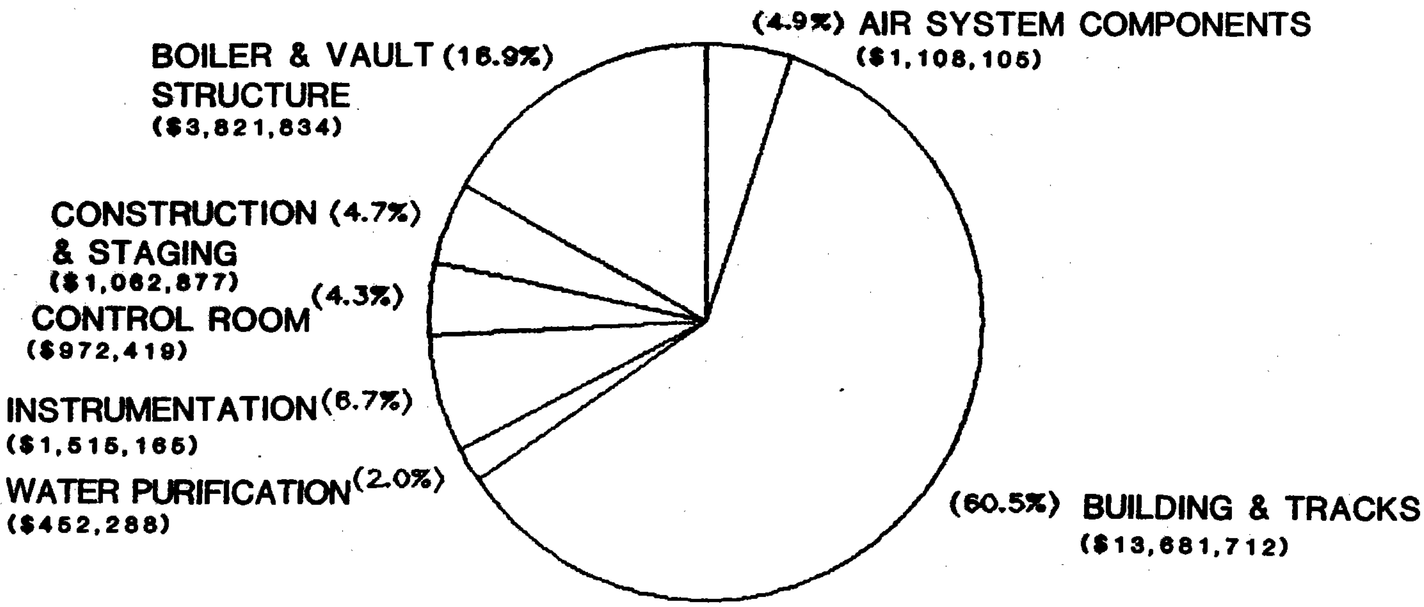


3549 m²/MW
30
106470 m²
21785600 / 106470 = 205 $/m²

21.8
22.6
$44.4 M

7.4 x 205 = $1517/collector

BUILDING & MECHANICAL EQUIPMENT
COST BREAKDOWN
($22,614,400)



Total plant income stream will derive from a combination of all seven sources described above in paragraph III. Combined revenues should be sufficient to retire conventional debt funding within a 20-year period or less, or to cover equipment lease payments, as appropriate. No attempt is made herein to structure an overall business plan.

V. PLANT FINANCING

The Consortium of Alternate Energies has received a strong statement of interest from the equipment leasing community to provide full capital funding (see Appendix for attached letter).

Other sources of financing include industrial development/revenue bonding or conventional debt/equity financing with the assistance of corporations needing tax credits/writeoffs inherent in this plant and equipment-intensive investment.

VI. INSURANCE AND BONDING

All aspects of plant development will be insured or performance bonded, as appropriate. In addition, equipment manufacturer's warranties will offer an additional level of safety; and in fact, their availability will be a criterion of equipment selection during the bid specification phase.

If needed to obtain capital financing, projec efficacy insurance may be available.

VII. OTHER BENEFITS

Plant development package assumes the following additional benefits will accrue to the Chemehuevi Tribe during and after construction:

1. Indian employment during construction: 380 (30% of total maximum required)

2. Permanent employment after startup: 25-30

3. Training services (provided by or arranged through project team). Will cover all trades necessary to support Indian employment programs.

4. Economic development planning and coordination--to maximize beneficial impact of plant on tribe and surrounding community. Includes business strategic planning and implementation services.

5. Permanent educational and employment program planning. Includes liaison with local, state and federal authorities.

   Resulting physical facilities may be housed onsite, with all power, heating, and cooling provided from the plant.

6. Technical consulting services as needed to apply plant output or technology to local needs.

VIII. CONSTRUCTOR AND DEVELOPMENT SCHEDULE

This plant will be constructed by a first-rate builder such as the Ralph M. Parsons Company or Bechtel. A letter of interest has already been received from the former (see Appendix for attached letter).

The chart shown on the next page illustrates the general work plan to be followed during construction. A more detailed analysis is available in Part C.

IX. SITING AND ENVIRONMENTAL ASPECTS

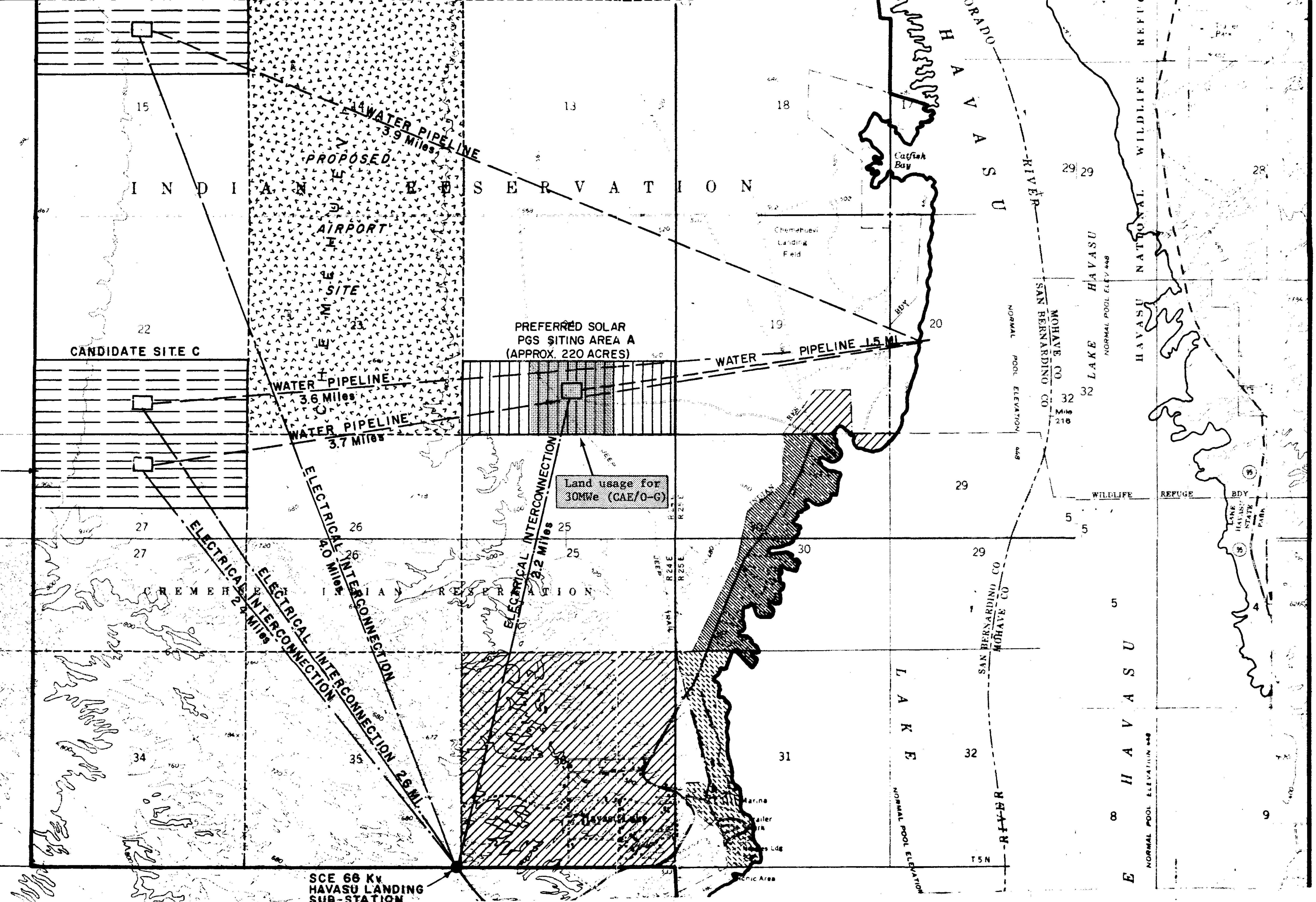
The proposed site on the Chemehuevi Reservation features slightly sloping terrain (2 degrees or less) and is ideally suited for solar energy purposes. It is fairly proximate to the Colorado River (1.5 miles) and is one mile from an existing paved road. Ground surface is of course, gravelly texture and is well drained.

At present, the land is not used for recreational, agricultural or commerical purposes, nor is it primary wildlife habitat. As far as can be determined, no rare flora grows thereon and there is an absence of archaeological relics.

The technology employed is exceedingly benign and is characterized by the almost complete absence of adverse environmental or safety impacts. Any negative effects should be limited to the construction phase and will principally include wind-borne particles and possibly sediment-laden runoff. This latter problem, however, will be greatly minimized by the coarse and porous nature of the ground.

Most equipment items will be elevated above grade; accordingly, disturbance to existing terrain will be minimal. The two most significant impacts will result from ground-shading under the collector platforms and by access roads. Subsequent economic development will logically affect the area as well; yet this must be evaluated on a case-by-case basis and it should be realized that really harmful or undesirable activities can be prohibited from the outset. Total impact can be assessed only when the Chemehuevi Indian Tribe's overall strategic plan is known.

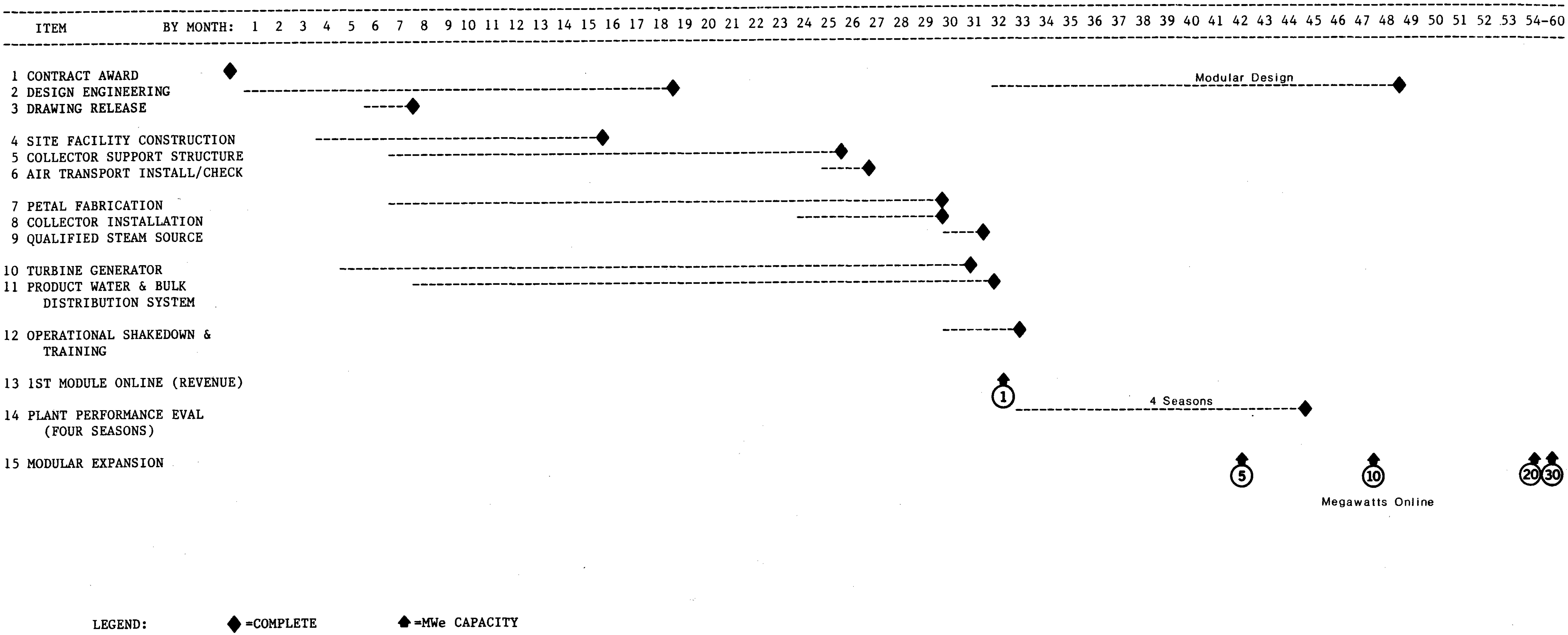
Upon project award, CAE and OMNIUM-G will review all major environmental issues involved. Throughout this effort, the services of a highly qualified and respected environmental engineering firm, Westec Services, will be utilized. A summary of this company is available in the appendix.



WATER PIPELINE
3.9 Miles
PROPOSED
AIRPORT
SITE
INDIAN RESERVATION
CHEMEHUEVI
PREFERRED SOLAR
PGS SITING AREA A
(APPROX. 220 ACRES)
CANDIDATE SITE C
WATER PIPELINE
3.6 Miles
WATER PIPELINE
3.7 Miles
WATER PIPELINE 1.5 MI.
Land usage for
30MWe (CAE/O-G)
ELECTRICAL INTERCONNECTION
4.0 Miles
ELECTRICAL INTERCONNECTION
2.2 Miles
ELECTRICAL INTERCONNECTION
2.4 Miles
ELECTRICAL INTERCONNECTION
2.6 MI.
CHEMEHUEVI INDIAN RESERVATION
SCE 66 Kv
HAVASU LANDING
SUB-STATION
Havasu Lake
Chemehuevi
Landing
Field
Catfish
Bay
HAVASU
RIVER
LAKE
LAKE HAVASU
SAN BERNARDINO CO
MOHAVE CO
HAVASU NATIONAL WILDLIFE REFUGE
WILDLIFE REFUGE BDY
NORMAL POOL ELEVATION 448
LAKE HAVASU STATE PARK
R 24 E
R 25 E
T 5 N
Marina
Picnic Area

Schedule A-1

PROGRAM PLAN SUMMARY--CHEMEHUEVI POWER PROJECT



X. PLANT OPERATIONS & MAINTENANCE CONTRACT

An operations and maintenance (O&M) team from CAE/OMNIUM-G will be pleased to operate and maintain the plant at top efficiency after startup, if desired by the Tribe. Maximum use of Indian personnel will be made in this effort.

XI. RETAINED EQUITY POSITION

CAE has great faith in this technology and particular plant. Accordingly, it wishes to maintain an equity position in the plant if such is possible. Part of CAE's normal compensation for plant development will be made available for this purpose.

TABLE 1

POWER PLANT MODULE CHARACTERISTICS

PLANT MODULE SIZE	1000 KWe	
PLANT TYPE	SOLAR-THERMAL STEAM ELECTRIC	
COLLECTOR TYPE	DISTRIBUTED POINT-FOCUS	
COLLECTOR AREA	3549 SQ. METER	= 7.4 m^2/coll
NUMBER OF COLLECTORS	480	
COLLECTOR ARRAY BASE CONFIGURATION	SINGLE COMMON HORIZONTAL WHEEL	
BASE DIAMETER	368 FT	
MODULE LAND AREA (TOTAL AREA FOR 30MWe PLANT)	2.64 ACRES (80.8 ACRES)	
ANNUAL COLLECTION EFFICIENCY (SOLAR-TO-THERMAL VAULT) includes 2000F sens heat x port ?	0.714	$\rho_{PETAL} \leq .7$
ANNUAL THERMAL TO MECHANICAL EFFICIENCY (STEAM-RANKINE TURBINE)	0.29	temp ?
GENERATOR EFFICIENCY	0.92	
ANNUAL SYSTEM EFFICIENCY (SOLAR-TO-BUSS BAR)	0.19	
ANNUAL PLANT CAPACITY FACTOR	0.30	

PART B

SYSTEM DESCRIPTION

PLANT SPECIFICATIONS

The solar-thermal steam electric generating plant described herein evolved as a part of project CENICOM (Concept for an Energy Neutral Industrial Complex) which uses OMNIUM-G's parabolic dish technology together with unique methods of assembling and controlling large numbers of collectors in a cluster. The result is a power plant featuring conversion and land use efficiency, and cost economies superior to all other available conventional forms of solar electric generation.

This standard power plant module has a capacity of 1,000KW of commercial electric power and realizes an annual production of 1,774,300KWH including the effects of weather and seasons assuming location in the California high desert. It is important to note that the plant is able to convert its daily production into electricity at any time of the day or night at the user's discretion. This is possible because of one of its unique design features. Sunlight collected by each of 480 OMNIUM-G point focus collectors (total of 38,201 square feet) is used to heat air to 1500 degrees F. where it is transferred to a centrally located thermal storage vault employing a unique high efficiency, low cost energy transport system.

The successful design of this transport system has provided the necessary breakthrough needed to render solar power generation competitive with conventional fossil fuel power plants.

The collected energy may be stored as heat at 1500 degrees F. for later use in generating steam to drive a modern high efficiency turbine generator at any time desired. To accomplish this and achieve overall annual system efficiencies of 19 percent (as measured from sunlight to power grid bus bar), the 480 collector cluster is supported on a common structure in such a manner that the structure--which resembles a large wheel and hub lying on its side 360 feet in diameter--is rotated as one unit to follow the sun. This permits the high temperature air transport lines to be very short and need significantly fewer energy losing joints than would be the case for conventional distributed collector designs. As a result, this 1,000KWe power plant occupies just 2.44 acres, a fraction of the nearly 7 acres demanded by conventional designs.

The versatility of this design is partly illustrated by the variety of available energy forms. The power plant can generate individually 1,774,300KWH of electricity (with weather), 17.3 million pounds of steam at 900 degrees F., and 900 psig, 22.1 billion BTUs of 1500 degree F. hot air per year and a nominal 20,000 gallons per day of bottled quality fresh water using only waste energy from the electric generation process.

The collector array base structure is a single rigid octagonal horizontally rotating structure constructed as a tubular space frame of four-sided pyramids with a cell size of 20 feet by 20 feet by 14.5 feet high. The 368 foot diameter structure rotates as a unit to follow the sun's azimuth position on a total of 14 trucks. Eight of these trucks ride on an outer track of 150 feet radius and 6 ride on an inner track with a radius of 50 feet. The outer track is located at grade level, and supports two-thirds of the 450,000 pound rotating load. The inner track is located on the outer wall of the central facility. The structure is shown in elevation and plan views in the accompanying drawings.

The structure is driven in asimuth by a single motor and gearbox and controlled by both sun-tracking sensor data and solar ephemeral data.

The collector array consists of 18 rows of contiguous point focus concentrators. Each row of collectors is rigidly mounted to a common tube and rotated as a unit to follow the sun's elevation position. The 18 rows are linked together by a common link arm drive mechanism thus permitting all 18 rows and 480 collectors to be driven in elevation by a single motor and gearbox controlled by the same data as the azimuth drive motor.

The row tube or elevation axle also serves as the outer jacket for the insulated hot air transport tubes running down its center and forming the branch lines of the air transport system. This design permits hot air from each collector to be combined at the row level without the need for expensive and lossy rotary joints at each collector. Please refer to the concentrator drawing for further detail. Air in the 18 branch lines is combined by the trunk line and brought to a common point into a rotary joint at the top entrance of the thermal storage vault.

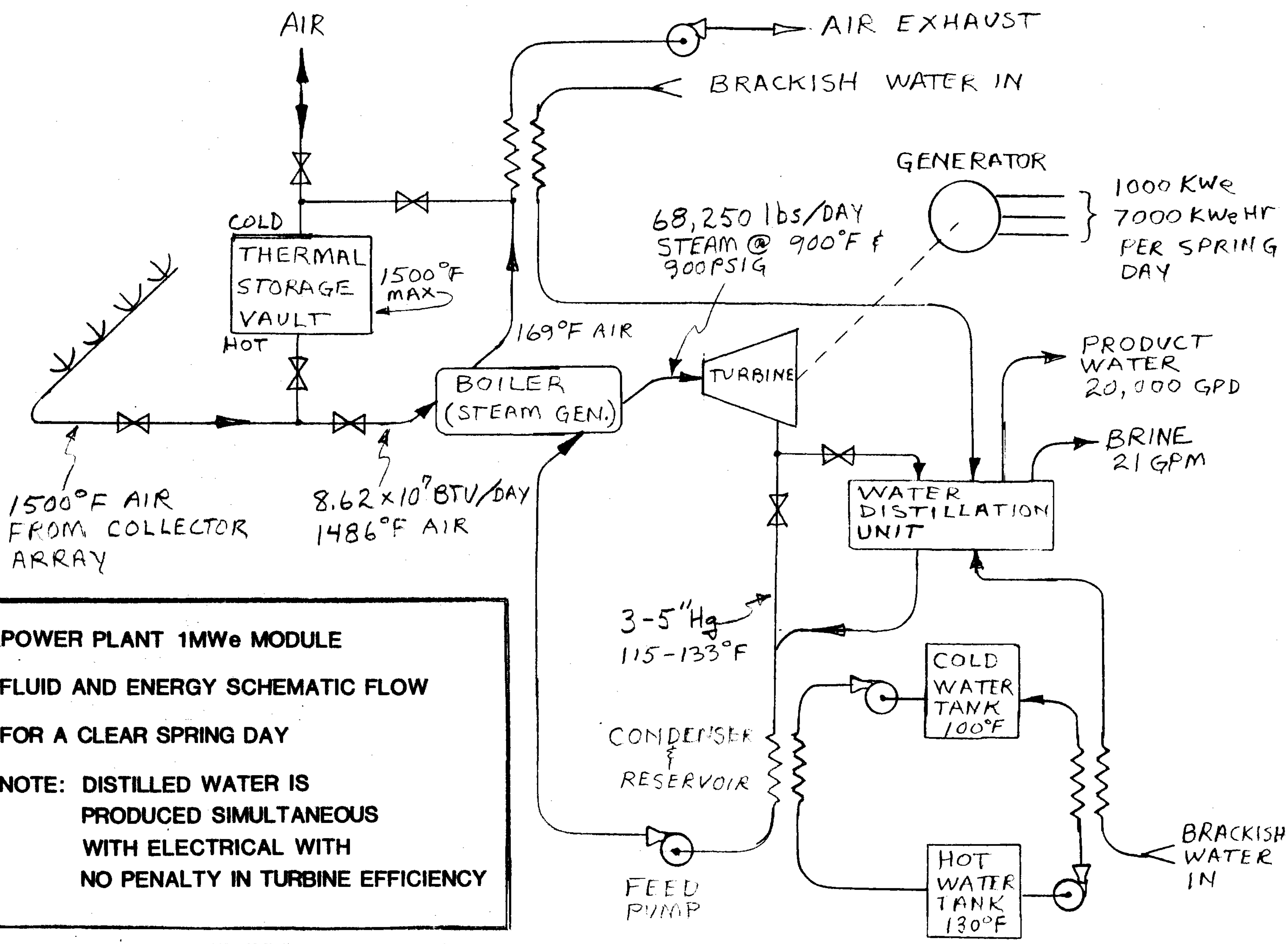
The concentrating collector used is an adaptation of a previously developed OMNIUM-G concentrator. Temperatures reaching 2,000 degrees F. may be generated at the focal plane. The system utilizes all ceramic components for high temperature service; in addition, it draws in ambient air at each converter entrance to provide complete fail-safe operation.

Three primary air flow cycles are used in this power plant (shown in the accompanying schematic). Air is drawn through the system via a 24 HP rotary screw compressor. The air at the compressor never exceeds 140 degrees F. The vault charge cycle reaches 1,500 degrees F. using air drawn from the collector field. Vault design incorporates a porcelain sphere core capable of storing one complete winter day of collected energy. When discharged from its full state it will deliver 5,160 KWH electric. It will also deliver 85 percent of its stored energy at a constant 1,500 degrees F. This feature permits the plant to deliver its daily output in one continuous run at full rated power (1,000 KWe) ranging between 5 hours on a winter day to about 8 1/4 hours on a summer day. The delivery interval may occur at any time of the day or night during winter and any time within the interval 3 hours prior to sunrise to 3 hours following sunset in summer.

The power plant fluid and energy flow schematic depicts the use of a conventional steam-Rankine turbine generator design. The only departures from convention are in the use of a water blow-down process for condenser cooling and inclusion of a 3-effect water distillation unit operating from turbine exhaust steam thus removing part of the condenser load. The use of the blow-down cooler permits the energy recovered during the 5 to 8 hours of turbine operation to be used for low-grade thermal energy needed for operation of the distillation unit on a continuous (around-the-clock) basis.

Plant characteristics and production data are summarized in the two tables provided herein.

Creative and efficient use of space is inherent in plant design. The collectors are closely spaced to reduce cost and losses. Importantly, most space beneath the rotating structure is available for construction of light industrial and other facilities. The walls for such a facility are shown in outline in the elevation drawing of the power plant.



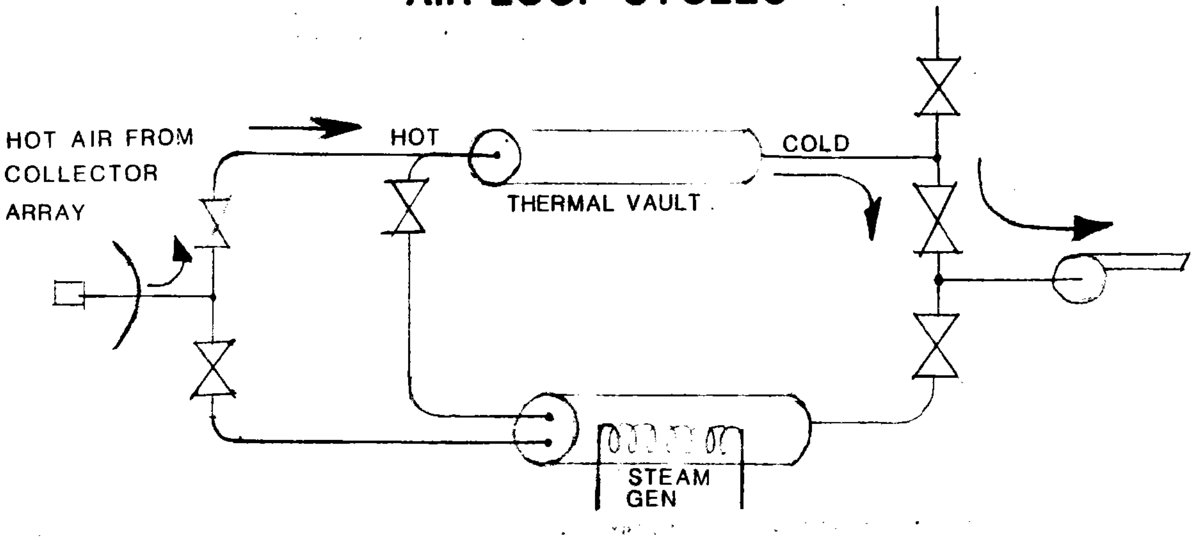
POWER PLANT 1MWe MODULE

FLUID AND ENERGY SCHEMATIC FLOW

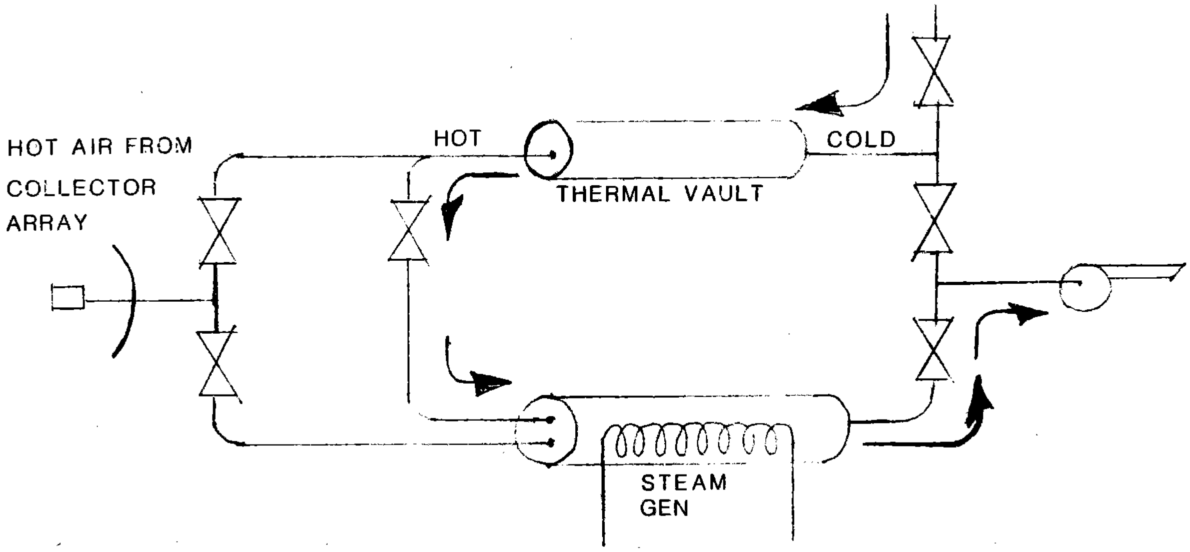
FOR A CLEAR SPRING DAY

NOTE: DISTILLED WATER IS PRODUCED SIMULTANEOUS WITH ELECTRICAL WITH NO PENALTY IN TURBINE EFFICIENCY

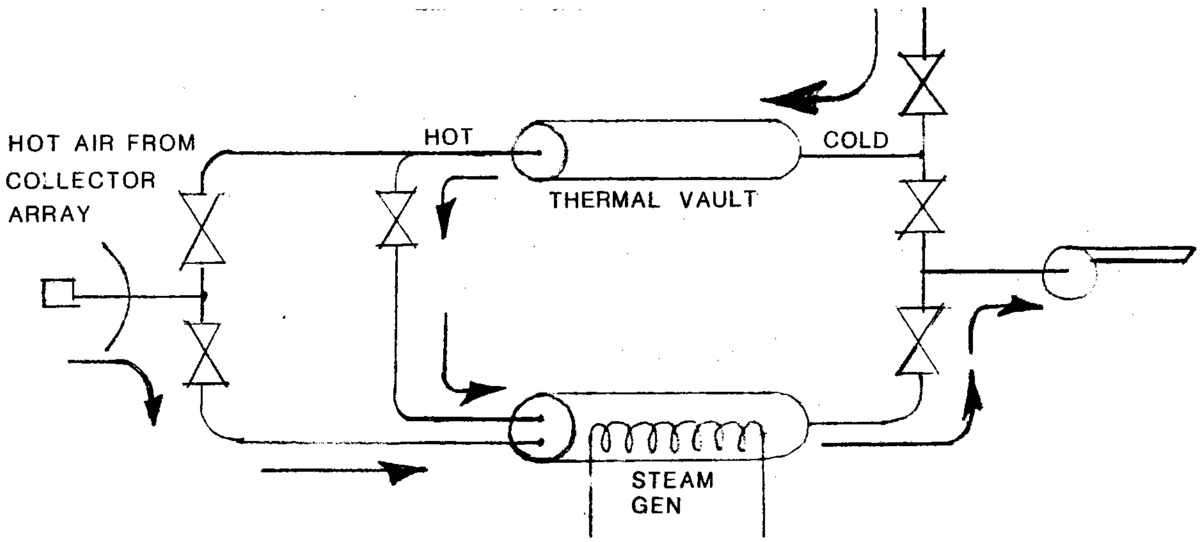
AIR LOOP CYCLES



THERMAL VAULT CHARGE CYCLE



STEAM-ELECTRIC GENERATION DURING NO-SUN

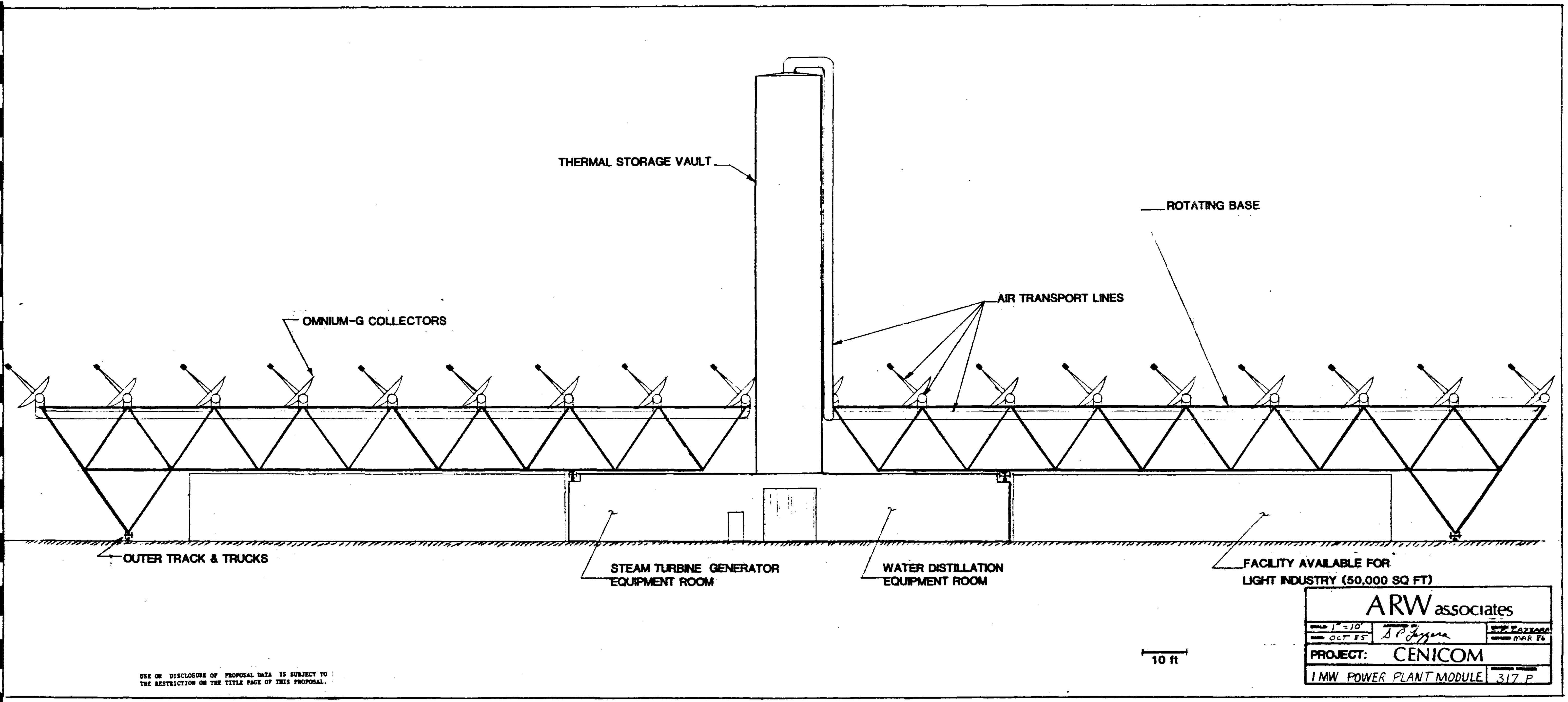


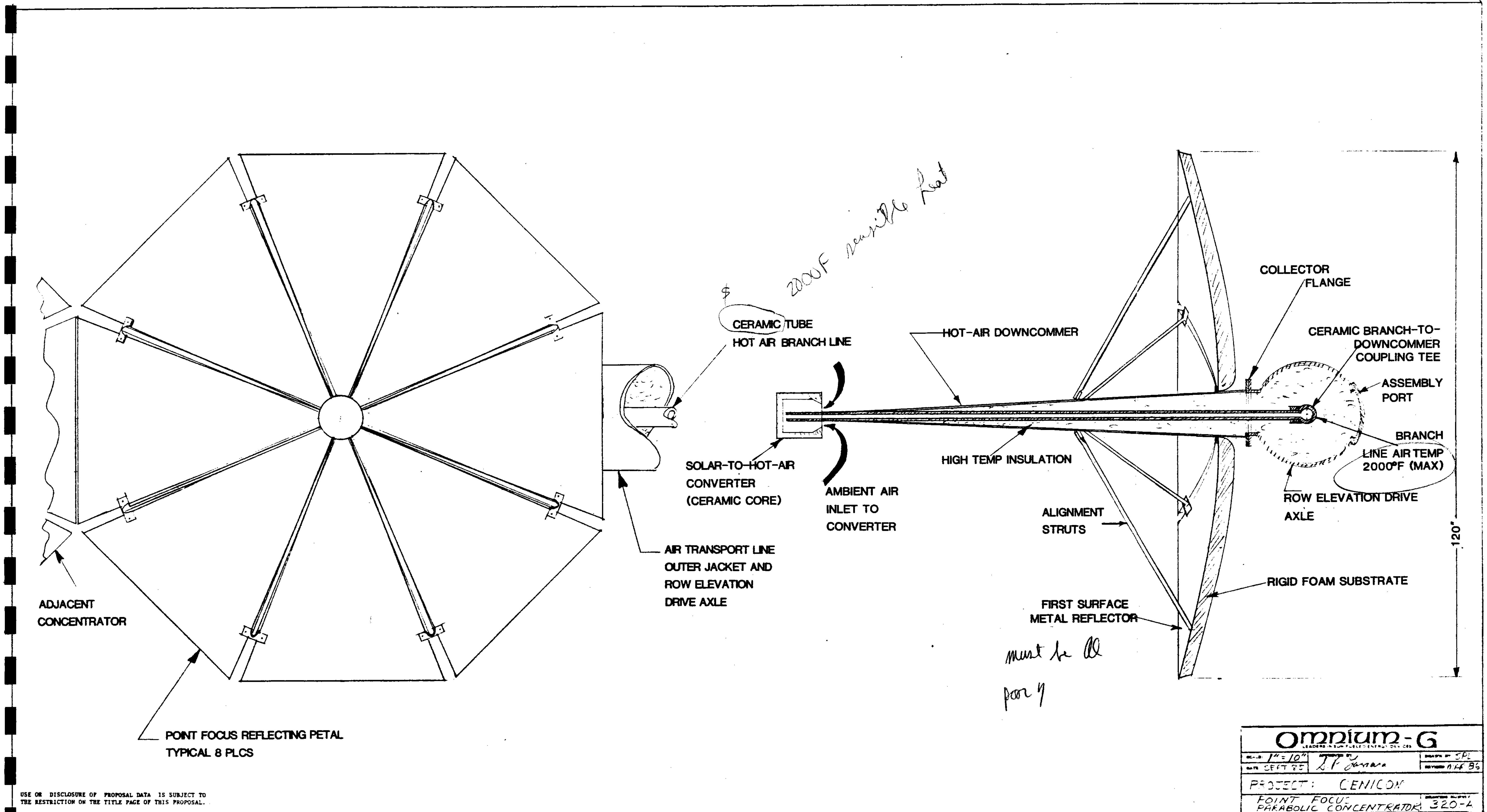
STEAM-ELECTRIC GENERATION DURING SUNLIGHT

POWER PLANT PRODUCTION

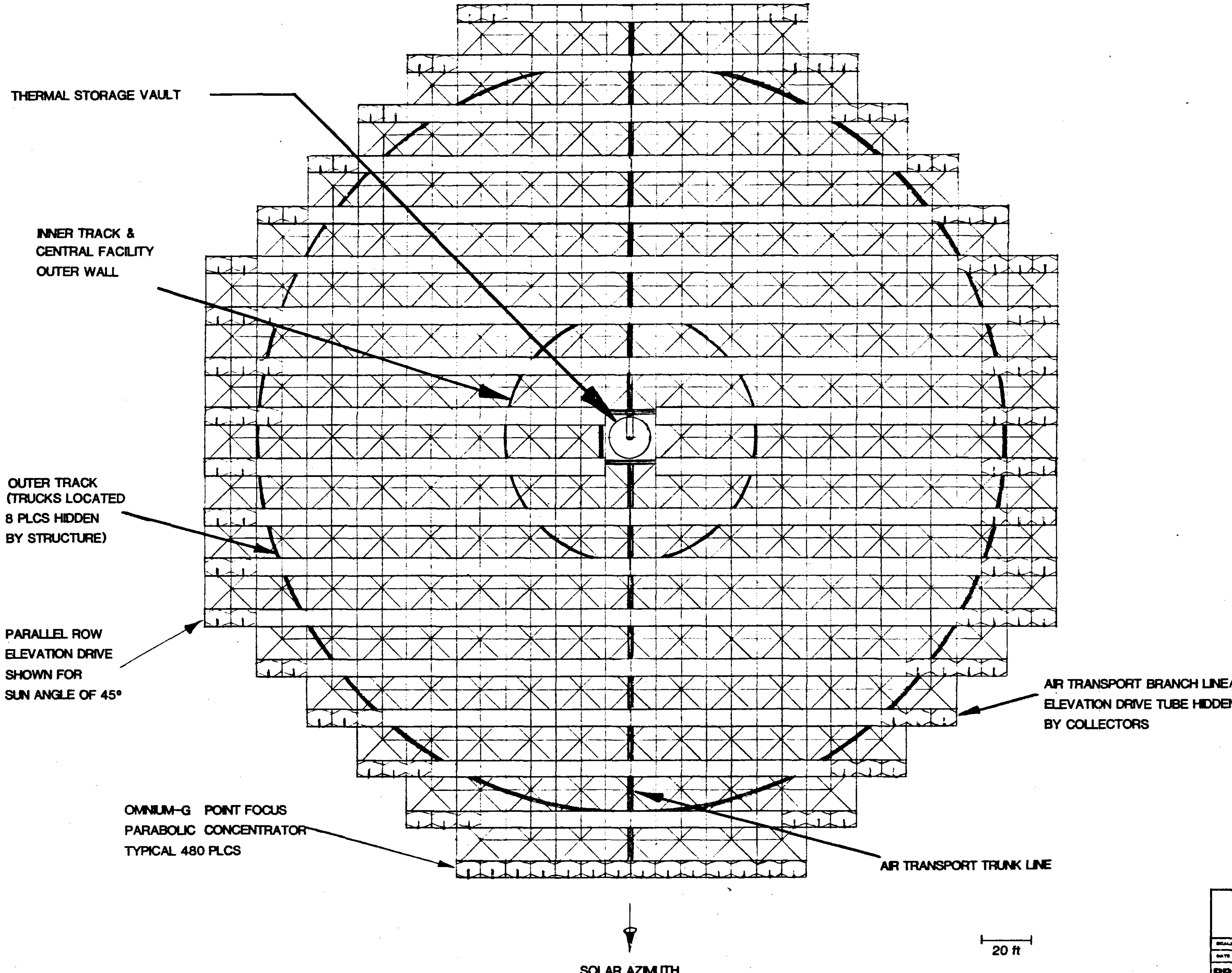
	ANNUAL WEATHER-FREE	ANNUAL INCLUDING WEATHER	SUMMER DAY	SPRING/ FALL DAY	WINTER DAY
SOLAR INPUT: $\frac{KWHr}{M^2}$	3,700/Yr 10.14/Day	2,555/Yr 7.0/Day	11.88	10.08	7.43
ELECTRICAL: (KWeHr)	2,569,440	1,774,300	8,250	7,000	5,160
STEAM: 900 Degrees F, 900 PSIG (in Lbs.)	2.5×10^7	1.73×10^7	80,437	68,250	50,310
THERMAL: 1,500 Degree F. air (BTUs)	3.2×10^{10}	2.21×10^{10}	1.026×10^8	8.71×10^7	6.24×10^7

PER 1MWe MODULE (OUTPUTS CAN BE EXCLUSIVE COMBINATIONS)


THERMAL STORAGE VAULT
ROTATING BASE
AIR TRANSPORT LINES
OMNIUM-G COLLECTORS
OUTER TRACK & TRUCKS
STEAM TURBINE GENERATOR EQUIPMENT ROOM
WATER DISTILLATION EQUIPMENT ROOM
FACILITY AVAILABLE FOR LIGHT INDUSTRY (50,000 SQ FT)
10 ft
ARW associates
1" = 10'
OCT 85
MAR 86
PROJECT: CENICOM
1 MW POWER PLANT MODULE
317 P



$
2000F sensible heat
CERAMIC TUBE
HOT AIR BRANCH LINE
HOT-AIR DOWNCOMMER
COLLECTOR FLANGE
CERAMIC BRANCH-TO-DOWNCOMMER COUPLING TEE
ASSEMBLY PORT
BRANCH LINE AIR TEMP 2000°F (MAX)
SOLAR-TO-HOT-AIR CONVERTER (CERAMIC CORE)
AMBIENT AIR INLET TO CONVERTER
HIGH TEMP INSULATION
ROW ELEVATION DRIVE AXLE
ALIGNMENT STRUTS
120"
AIR TRANSPORT LINE OUTER JACKET AND ROW ELEVATION DRIVE AXLE
RIGID FOAM SUBSTRATE
ADJACENT CONCENTRATOR
FIRST SURFACE METAL REFLECTOR
must be Al
POINT FOCUS REFLECTING PETAL TYPICAL 8 PLCS
OMNIUM-G
1" = 10'
SEPT 75
PROJECT: CENICON
POINT FOCUS PARABOLIC CONCENTRATOR
320-A



ARWassociates

SCALE 1" = 20'	S. F. Jassman	
DATE OCT 85		MAR 86

PROJECT: CENICOM

1 MW POWR PLANT MODULE - PLAN VIEW - 319-P

PART C

CONSTRUCTION SCHEDULE

Following is a detailed program development schedule for the Chemehuevi Project. The time line is fairly conservative, ensuring that all milestones may be comfortably achieved.

The reader will note that line item 2 does not have a completion date indicated. Owing to the continuous and developmental nature of the project/tribal needs assessment and feedback effort, we are assuming this function to be permanent. Even after plant startup, constant vigilance must be maintained to obtain the highest benefit from the plant complex.

Work Plan

SUMMARY

The Detailed Program Schedule shown in Figure C-1 identifies major milestones, and interrelationships based on sound engineering and management decisions to ensure the earliest possible plant operation and revenue generation. Technical services are provided to generate and coordinate engineering data to support the preparation of the environmental assessment, OSHA analysis and compliance during construction and operational phases, permits and licenses, building code compliance, production planning and subcontracting, long lead procurement, plant operation, training and maintenance.

Necessary management direction, planning, and control is provided to ensure the effectiveness of the technical effort, implementation of program plans, and timely completion of contract deliverables. The program plan includes effort to coordinate and expedite activities, prepare briefings, monitor travel expenses and other direct costs (computer time, reproduction, etc.) and prepare technical progress reports.

PLANT DESIGN ENGINEERING

The overall Plant Design effort will provide environmental data and assessment documentation, system performance specifications, and subsystem design criteria. System analysis is planned to establish baseline system designs, interface and subsystem specifications, system and subsystem performance, process flow diagram(s), and validation of proposed modularity expansion from a standard module to full plant capacity.

PRELIMINARY ENGINEERING DESIGN

Preliminary engineering design will be performed to prepare Top Level Drawings and Advanced Parts List (APL) for long lead procurement. This effort will identify, characterize and document all external interfaces in an Interface Control Document (ICD) specification format. These ICDs will be the governing specification for the detailed engineering design phases, including subcontractor evaluation and selections.

Effort during this period also includes the interface definition of the major critical path elements of the overall power plant project.

CRITICAL PATH ELEMENTS

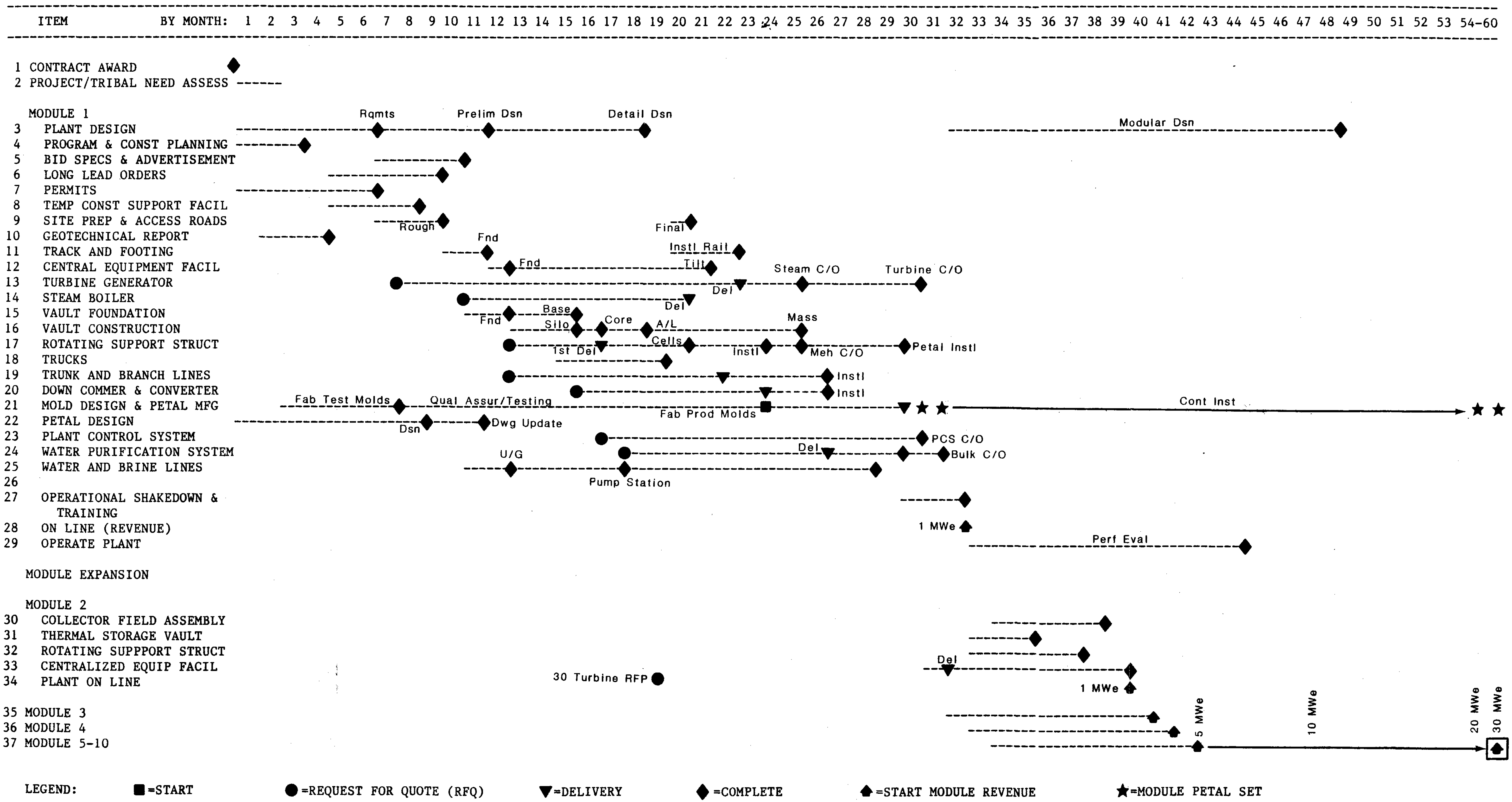
Three major critical path elements have been identified for the overall power plant project. They are:

(1) Turbine Generator Lead Time

(2) Petal Production

Schedule C-1

DETAILED PROGRAM SCHEDULE--CHEMEHUEVI POWER PROJECT



(3) Weather Contingency Factor

An independent Design Advisory Board will conduct engineering reviews, performance reviews, and readiness reviews to ensure that subsystems and their associated components are capable of meeting the required system performance specification. Control points will be defined for monitoring these critical path elements.

DETAILED ENGINEERING DESIGN

As preliminary engineering design is completed on each subsystem or element, detailed engineering design can proceed. Design engineering will prepare a complete Drawing Package for each element of the power plant, including test plans, procedures and processes. Drawing check will be performed by all participating disciplines before formal release. Completion of these drawing packages are staggered to support the start of fabrication and/or subcontractor request for quotation (RFQ) in a timely manner. Sequence of events for each element shown on the work plan schedule has been established commensurate with need dates, delivery dates, planned build-up and related activities.

PETAL MANUFACTURING

OMNIUM-G has already been successful in the breakthrough on the quality, weight, durability and cost of the basic mirror segments (called petals). Requiring years to develop, this process is completely owned by the general partners of OMNIUM-G and controlled as a trade secret.

Each parabolic collector is composed of eight separate, electro polished and anodized aluminum mirror segments mounted on foam substrates. Supplementary to engineering design of the petals, test fixtures and molds will be fabricated to produce some test petals. These test petals will validate drawings, manufacturing implementation, processes and planning. This petal testing period culminates in a subcontract for 3 casting and 12 precision molds to support the required production rate of one module of petals per month (3,840) for the full capacity power plant.

Incremental deliveries of these molds are arrranged to expedite earlier delivery of petals. These petals will be produced on site using local labor and automated processes. The petal manufacturing facility will be housed on site beneath the collector support structure of the first module and will continue to produce petals for all subsequent modules.

MODULAR EXPANSION APPROACH

The fundamental modular expansion approach to start generating revenue in the largest amount possible, commensurate with overall project risk assessment. Because of our extensive experience in solar thermal technology using point focusing parabolic dish concentrators, early revenue generation can be assured with a high degree of confidence. OMNIUM-G has always avoided using any aerospace technology, choosing to use commerical applicance-type technology. This resulted in being able to use standard factory techniques, using standard tools and materials for installation, standard personnel, and giving rise to a product that was not only in financial reach, but would last its 30 year life.

For further creditability, OMNIUM-G's Model OG-7500 Solar Powered Electrical Generating Plant was used as a baseline model for costing studies and manufactauring processes for production rates up to 100,000 units per year. This study was published in 1980 (JPL Publication 5105-23) and is included in the Appendix ~~to this~~ proposal. Also, the author and principal investigator, Mr. Cliff Blake, is now associated with OMNIUM-G. This background and expertise ~~strengthens~~ the role of OMNIUM-G in executing contract awards. Additionally, the structural design approach utilizes conventional bridge-building techniques, loose dimensional tolerances, and conventional materials and processes to construct the solar power plant.

To maximize revenue, maximum attention will be directed towards implementing "lessons-learned" from the first module and refining manufacturing methods and constructor activities. In other words, the first module is the test plant having essentially no risk. This first module will then act as a "breeder" facility for spawning the remaining modules, utilizing local labor and resources.

The first module will be operated over four seasons (one-year) so that detail technical and meteorological data can be analized to validate plant performance and cost effectivity. Seven months after the first module starts generating revenue, other modules start generating revenue at the rate of 1MWe per month for 15 months and then steps up to 2MWe per month for the remaining 7 months.

Also look up JPL and ERI performance test data.

Ask New England Telephone for theirs worked

ask how many were sold around the world and how many worked and for how long.

CONSTRUCTION APPROACH

The approach to work plan during the construction phase will include the acquisition of all necessary permits and the geotechnical report during the early stages of the plant design phase to ensure timely start dates of the site preparation activities.

The procurement, delivery and installation of the temporary construction support facilities will coincide with the access road installation and rough grading at the site. Site preparation will include trenching for underground piping and electrical as well foundation excavation. Foundation work will commence with the track footings and continue in parallel with the vault foundation and the central equipment building foundation.

The plan calls for an assembly yard for the rotating support structure. The support structure design was based on ease of installation on bridge building-type construction. All connections are slipon using pre-fabricated connectors or hubs (nodes) rather than a time consuming bolted or welded connection. A minimal tack welding or pinning will be required at the node connections.

The procurement of the rotating structure will include the pre-fabrication of single transportable two or three cell lengths. These single lengths will then be pre-assembled in the yard at the site into completed sections of two or three cells. These sections will then be lifted and placed into their final location.

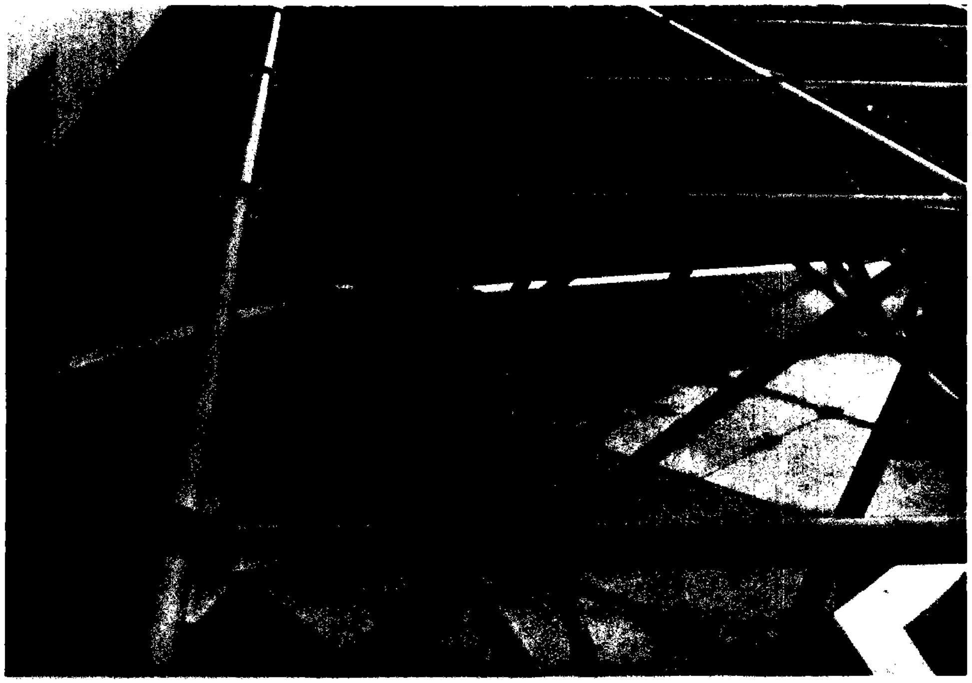
Prior to the erection of the rotating structure sections the vault support structure and silo housing will be installed together with the equipment building tilt-up wall and roof truss. All equipment has previously been installed in the building with the exception of the long lead turbine and auxiliaries. The plan allows for a section of the roof truss to remain open for the installation of the turbine through the permanent operation and maintenance overhead door.

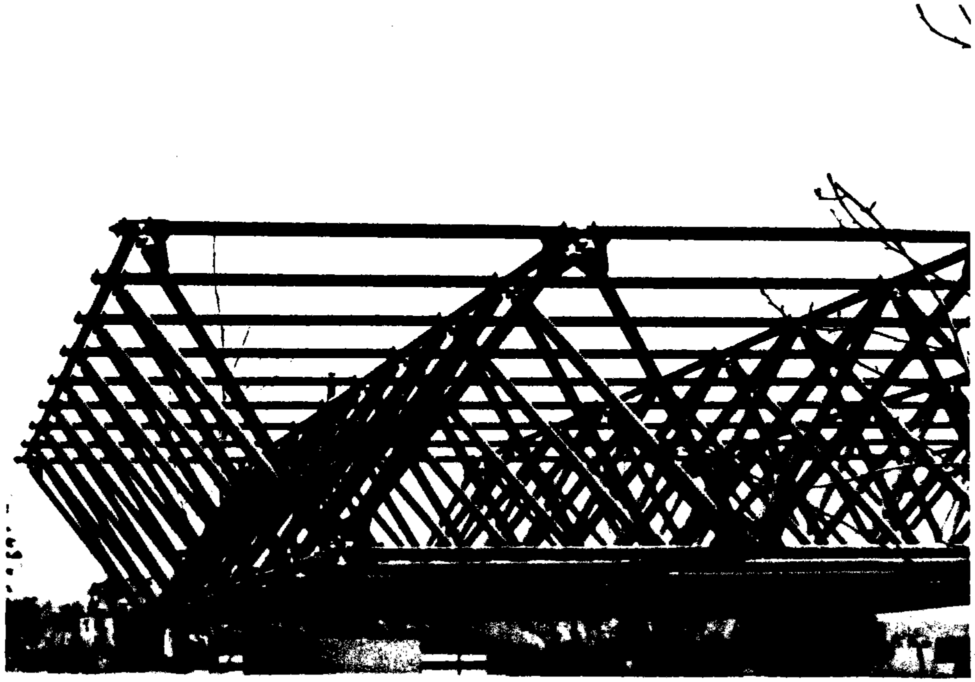
During the development of the detailed construction schedule the method of installation of the collector field trunk and branch lines will be selected from the listed options.

* Option A - Install trunk line and branch line pre-fabricated lengths in parallel with the installation of rotating structure cell sections.

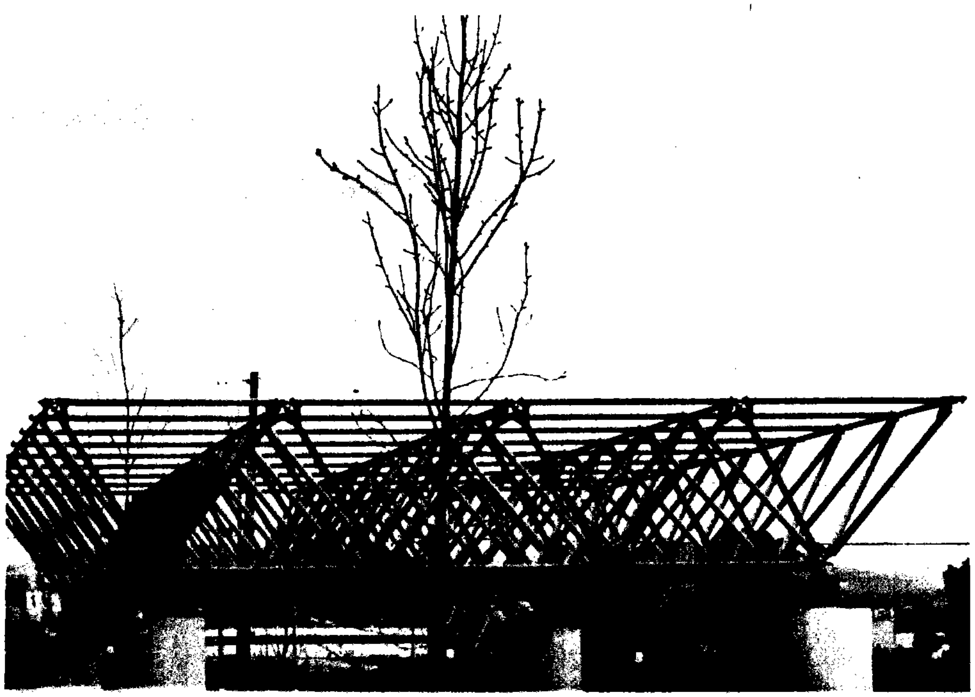
* Option B - Install trunk and branch lines from outside rotating structure diameter utilizing a P&H HC258 rubber tired truck crane or equal, with a capacity of 13,000 pounds at a radius of 185 feet and boom length of 190 feet.

Reflector segments (petals) will be individually attached to the down commer which has previously been installed as part of the branch line assembly on the rotating structure. Completion of this activity will coincide with the start of functional checkout of the system, run-in of the turbine and final collector assembly alignment and boresighting.





TYPICAL CONSTRUCTION TECHNIQUES



STANDARD MODULE
MAJOR EQUIPMENT LIST

INDENT	TITLE	QUANTITY
1	COLLECTOR FIELD ASSEMBLY	1
2	BRANCH ASSEMBLY NO. 1	1
3	CONVERTER	80
3	DOWN COMMER	80
3	ASSEMBLY HATCH	80
4	COUNTERWEIGHT	80
3	BRANCH SECTION, 2 FT OD X 20 FT	40
4	AIRLINE SEGMENTS, 3 IN OD X 20 FT	40
4	SPACER	TBD
4	INSULATION	TBD
3	BRANCH SECTION FLANGE CLAMP	40
3	YOKE ASSEMBLY	40
3	BRANCH TO TRUNK ROTARY COUPLER, ROTOR	3
4	SPROCKET	3
2	BRANCH ASSEMBLY NO. 2	1
3	CONVERTER	80
3	DOWN COMMER	80
3	ASSEMBLY HATCH	80
4	COUNTERWEIGHT	80
3	BRANCH SECTION, 2 FT OD X 20 FT	40
4	AIRLINE SEGMENTS, 3 IN OD X 20 FT	40
4	SPACERS	TBD
4	INSULATION	TBD
3	BRANCH SECTION FLANGE CLAMP	40
3	YOKE ASSEMBLY	40
3	BRANCH TO TRUNK ROTARY COUPLER, ROTOR	3
4	SPROCKET	3
2	BRANCH ASSEMBLY NO. 3	1
3	CONVERTER	80
3	DOWN COMMER	80
3	ASSEMBLY HATCH	80
4	COUNTERWIEGHT	80
3	BRANCH SECTION, 2 FT OD X 20 FT	40
4	AIRLINE SEGMENTS, 3 IN OD X 20 FT	40
4	SPACER	TBD
4	INSULATION	TBD
3	BRANCH SECTION FLANGE CLAMP	40
3	YOKE ASSEMBLY	40
3	BRANCH TO TRUNK ROTARY COUPLER, ROTOR	3
4	SPROCKET	3

2	BRANCH ASSEMBLY NO. 4	1
3	CONVERTER	80
3	DOWN COMMER	80
3	ASSEMBLY HATCH	80
4	COUNTERWEIGHT	80
3	BRANCH SECTION, 2 FT OD X 20 FT	40
4	AIRLINE SEGMENTS, 3 IN OD X 20 FT	40
4	SPACER	TBD
4	INSULATION	TBD
3	BRANCH SECTION FLANGE CLAMP	40
3	YOKE ASSEMBLY	40
3	BRANCH TO TRUNK ROTARY COUPLER, ROTOR	3
4	SPROCKET	3

2	BRANCH ASSEMBLY NO. 5	1
3	CONVERTER	80
3	DOWN COMMER	80
3	ASSEMBLY HATCH	80
4	COUNTERWEIGHT	80
3	BRANCH SECTION, 2 FT OD X 20 FT	40
4	AIRLINE SEGMENTS, 3 IN OD X 20 FT	40
4	SPACER	TBD
4	INSULATION	TBD
3	BRANCH SECTION FLANGE CLAMP	40
3	YOKE ASSEMBLY	40
3	BRANCH TO TRUNK ROTARY COUPLER, ROTOR	3
4	SPROCKET	3

2	BRANCH ASSEMBLY NO. 6	1
3	CONVERTER	80
3	DOWN COMMER	80
3	ASSEMBLY HATCH	80
4	COUNTERWEIGHT	80
3	BRANCH SECTION 2 FT OD X 20 FT	40
4	AIRLINE SEGMENTS, 3 IN OD X 20 FT	40
4	SPACER	TBD
4	INSULATION	TBD
3	BRANCH SECTION FLANGE CLAMP	40
3	YOKE ASSEMBLY	40
3	BRANCH TO TRUNK ROTARY COUPLER, ROTOR	3
4	SPROCKET	3
2	STATIC AIRLINES ASSEMBLY	1
3	SUNSIDE TRUNK LINE SECTION, 2 FT OD X 20 FT	8
4	BRANCH TO TRUNK ROTARY COUPLER, STATOR	9
4	AIRLINE SEGMENT, 12 IN OD X 20 FT	16
4	SPACERS	TBD
4	INSULATION	TBD
3	TRANSITION ASSEMBLY	1
3	IDLER SPROCKETS	36
3	DRIVE MOTOR	1
3	DRIVE CHAIN	680 FT
3	SHADE TRUNK LINE, 24 IN OD X 20 FT	8
4	BRANCH TO RUNK ROTARY COUPLER, STATOR	9

4	AIRLINE SEGMENT, 12 IN OD X 20 FT	16
4	SPACERS	TBD
4	INSULATION	TBD
3	VAULT RISER ASSEMBLY	1
4	AIRLINE SEGMENT, 12 IN OD X 80 FT	1
4	SPACERS	TBD
4	INSULATION	TBD
2	COLLECTOR SEGMENTS (PETALS)	7,680
3	NUTPLATES	11,520
2	COLLECTOR STRUCTS	3,840
1	THERMAL STORAGE VAULT	1
2	SILO HOUSING, 20 FT OD	1
3	SILO CAP	1
3	INSULATION	TBD
2	RISER TO CORE ROTARY JOINT, STATOR	1
2	CHARGE/DISCHARGE VALVE, 2-PORT	1
2	CHARGE/DISCHARGE VALVE, 1-PORT	1
2	CORE ASSEMBLY	1
3	CASE	1
3	AIR FEEDER LINE	1
3	THERMAL MASS	1
2	VAULT BASE, STEEL	1
1	ROTATING SUPPORT STRUCTURE	1
2	STRUCTS, 4 IN OD X .125 WALL X 20 FT	2,160
2	NODE FITTINGS	720
2	INNER TRUCKS	6
3	HORIZONTAL THRUST ROLLER	1
3	VERTICAL WHEEL, OD	12
2	OUTER TRUCKS	16
3	VERTICAL WHEEL, OD	32
3	AXLE	16
1	CENTRALIZED EQUIPMENT FACILITY	1
2	TURBINE GENERATOR, W/GEAR BOX	2
2	TURBINE CONTROL	1
2	STEAM BOILER	1
2	FIELD AIR PUMP	1
2	AIR FLOW CONTROL STATION	1
2	FACILITY POWER DISTRIBUTION	1
2	GENERATOR INTERFACE TO CONTROL GRID	1
2	POWER PLANT CONTROL ROOM	1
2	AZ/EL SENSOR	1
3	CONTROL LOGIC	1
2	COMMUNICATION/DATA INTERFACE CONSOLE	1
2	BUILDING, TILT UP CONSTRUCTION	2,853 FT2

1	BASE TRACK, 300 FT OD	1
2	CONCRETE BASE, 150 FT OD X 2.5 FT WIDE	1
2	RAIL	942 FT
1	WATER PURIFICATION SUBSYSTEM	1
2	PRODUCT WATER STORAGE TANK	1
2	BRACKISH WATER LINES	2
3	BRACKISH WATER INPUT LINE, 3 IN OD	7,920 FT
3	BRINE RETURN LINE, 3 IN OD	7,920 FT
2	WATER TRANSFER LINES (UNDERGROUND)	1
2	PUMP STATION	1
3	SUCTION PUMP	1
3	PUMP	1
1	SEWAGE TREATMENT	1
2	WATER/SEWAGE	1
1	MAINTENANCE SHOP	1

SUMMARY OF CONSTRUCTION SERVICES

FOR

CHEMEHUEVI SOLAR ELECTRIC

POWER GENERATING STATION

Parsons Corporation is one of several constructors under consideration to build the plant. A letter of interest is enclosed for information.

Other contenders at this time include Brown & Root, Fluor, Bechtel and a limited number of smaller firms. Selection will be based upon both ability to perform and compatability of goals.

CONSTRUCTOR RESPONSIBILITIES

The centralized CAE/OMNIUM-G Project Team will manage the overall project, while the Constructor will provide all services normally offered by a construction manager.

Constructor will assign the responsibility for managing the Chemehuevi Solar Project construction effort to a Project Manager who will be given authority commensurate with this responsibility. This manager will have access to extensive resources that can be rapidly mobilized with the assistance of Constructor's officers, managers, and engineers.

The Project Manager will have authority necessary to perform his duties, but he will report on his performance to the senior construction manager of the Power Group. In addition to providing guidance and support, this manager ensures that division procedures and policies are implemented and that performance and quality of work on the project are acceptable at all times.

The Project Construction Manager will direct the construction activities through a team consisting of:

* Construction Manager
* Project Construction Engineer
* Project Control Manager
* Administration Manager
* Personnel Services Manager
* Quality Assurance Manager
* Materials Manager

This overall project organization is illustrated on the attached Figure 1.

Construction Manager - The Construction Manager is responsible for production through a cadre of general and craft Superintendents. He is also responsible for quality, and therefore ensures inspection at every echelon from journeyman to the craft superintendent. Quality will be built into rather than inspected into the work, a comprehensive inspection program will be administered by the Project Construction Engineer and monitored by the Quality Assurance organization to further guarantee the work.

The key members of the Construction Manager's staff will consist of civil mechanical and electrical general superintendents and a contingent of craft superintendents as shown on Figure 1. While we refer to this approach as the "Discipline Management Concept," it offers the flexibility needed to control the project by area as well.

This discipline approach is particularly effective in the first half of the project during which bulk materials are being placed at a very rapid rate and there is little competition between crafts for a work area. This approach is flexible in that it permits a gradual transition to a more heavily oriented area concept as the structures are nearing completion and

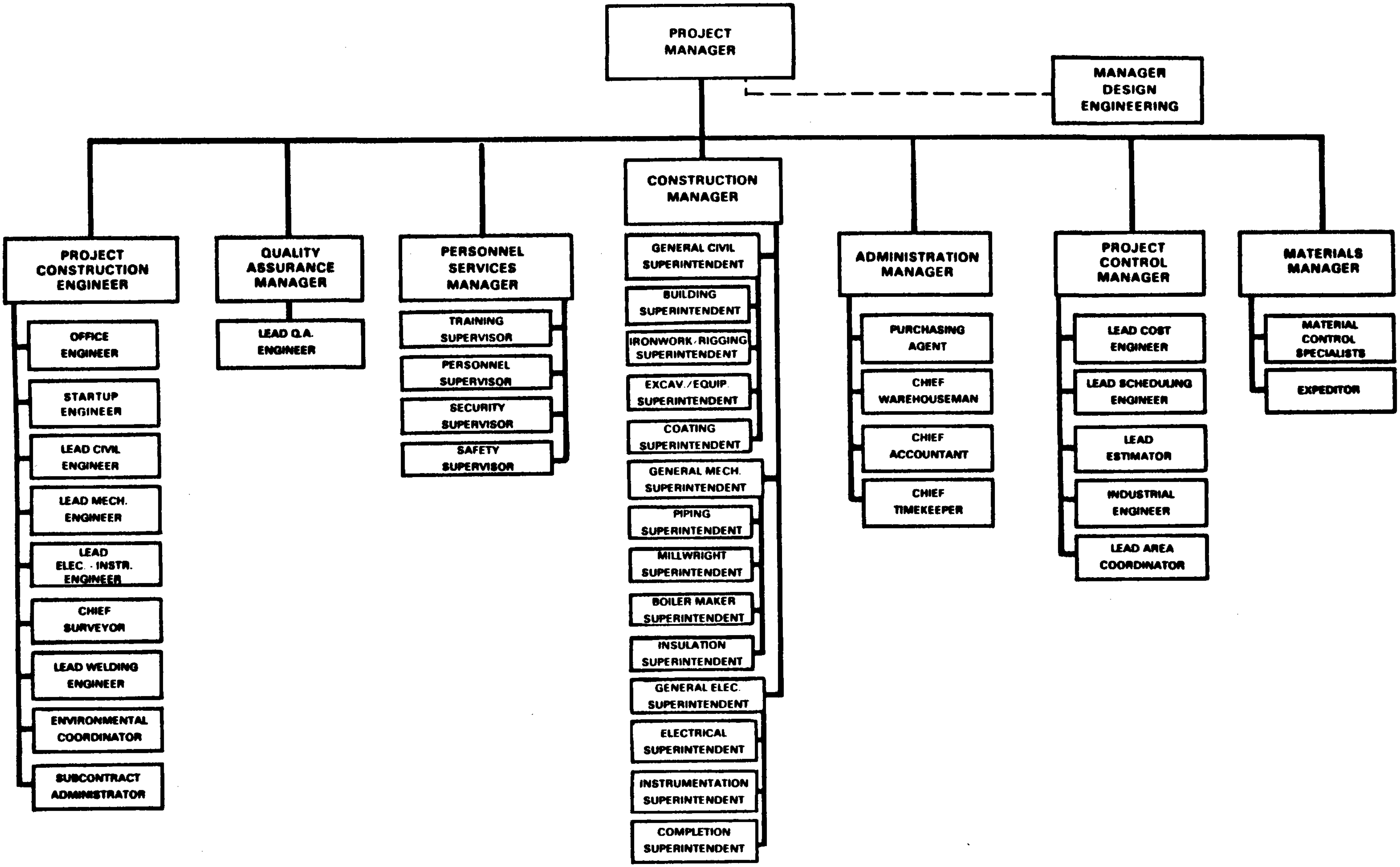

PROJECT MANAGER
MANAGER DESIGN ENGINEERING
PROJECT CONSTRUCTION ENGINEER
OFFICE ENGINEER
STARTUP ENGINEER
LEAD CIVIL ENGINEER
LEAD MECH. ENGINEER
LEAD ELEC. - INSTR. ENGINEER
CHIEF SURVEYOR
LEAD WELDING ENGINEER
ENVIRONMENTAL COORDINATOR
SUBCONTRACT ADMINISTRATOR
QUALITY ASSURANCE MANAGER
LEAD Q.A. ENGINEER
PERSONNEL SERVICES MANAGER
TRAINING SUPERVISOR
PERSONNEL SUPERVISOR
SECURITY SUPERVISOR
SAFETY SUPERVISOR
CONSTRUCTION MANAGER
GENERAL CIVIL SUPERINTENDENT
BUILDING SUPERINTENDENT
IRONWORK-RIGGING SUPERINTENDENT
EXCAV./EQUIP. SUPERINTENDENT
COATING SUPERINTENDENT
GENERAL MECH. SUPERINTENDENT
PIPING SUPERINTENDENT
MILLWRIGHT SUPERINTENDENT
BOILER MAKER SUPERINTENDENT
INSULATION SUPERINTENDENT
GENERAL ELEC. SUPERINTENDENT
ELECTRICAL SUPERINTENDENT
INSTRUMENTATION SUPERINTENDENT
COMPLETION SUPERINTENDENT
ADMINISTRATION MANAGER
PURCHASING AGENT
CHIEF WAREHOUSEMAN
CHIEF ACCOUNTANT
CHIEF TIMEKEEPER
PROJECT CONTROL MANAGER
LEAD COST ENGINEER
LEAD SCHEDULING ENGINEER
LEAD ESTIMATOR
INDUSTRIAL ENGINEER
LEAD AREA COORDINATOR
MATERIALS MANAGER
MATERIAL CONTROL SPECIALISTS
EXPEDITOR

Figure 1

the majority of piping, conduit, cable raceway and equipment is in place. This is possible by simply upgrading the area coordinators and increasing their authority.

Another advantage to the discipline approach is the effect it will have on training by having all personnel of a single craft reporting to a single manager. Improvements to the training effort result from the following.

* Resource utilization - Since the discipline General Superintendent has complete responsibility for a craft it is his duty to:

    - Know that the skilled craftsmen are being utilized properly throughout the job;

    - Assure that craftsmen are assigned to activities based on priorities set by the Project Manager;

    - Anticipate personnel requirements in his disciplines to assure that the hiring/training of personnel is done, or that the lay-offs of personnel are scheduled, to assure the most competent personnel remain on site.

* Student selection - By having all helpers of a particular craft work for the same manager the most deserving candidates for training are more likely to be selected.

* Instructor Selection and Monitoring - One of the responsibilities of the general superintendents is to select instructors for the training program and to monitor their effectiveness.

To assist the superintendents in craft-related problems and ensure that current construction techniques are used effectively, Constructor's Construction Division has senior staff level personnel available in the home office to monitor and assist the project as required.

<u>Project Construction Engineer</u> - This individual will have responsibility for all construction engineering and non-code Quality Control work. He will manage an organization of discipline engineers, specialists and technicians representing all pertinent engineering disciplines.

The primary objective of the construction engineering field organization is to provide the crafts with essential support, including:

* Inspection - The Project Construction Engineer will provide continuous inspection and advice throughout the duration of an activity and at the conclusion of the activity will provide inspection and approval. Inspection procedures will be developed before activities start.

* Material Take-Off and Requisitioning - The Project Construction Engineer is responsible for requisitioning all permanent materials that are to be ordered from the field.

He will monitor status of this material from procurement to installation.

* Project Control Support - Another major objective of construction engineering is to support the project control effort by ensuring accurate quantity reports, preparing periodic quantity reports and quantity forecasts, identifying out-of-scope work, and preparing backcharges.

* Surveying - Will provide all project survey control and line grade support to the crafts.

* Environmental Control - A trained environmental specialist will be responsible for assuring that all commitments of the project concerning environmental protection, hazardous waste, etc. are adhered to.

* Other Routine Duties - Routine duties include control of subcontractors' activities from initiation to completion, preparation of as-built drawings, interface with the designer, and construction studies.

Constructor's Power Group Chief Construction Engineer will support as well as monitor the Project Construction Engineer's efforts to assure the objectives of the construction engineering program are satisfied.

Project Control Manager - This position will be responsible for developing and implementing the project control program which will include:

* Project schedule development and implementation

* Budget development and maintenance, including quantity trending and forecasting

* Implementation of project quantity reporting methods and standards

* Construction estimating and cost control

* Area coordination

The Project Control Manager will perform these duties with a staff, the size and experience of which will be consistent with the needs of the project.

The Constructor Home Office Control Manager will monitor the Project Control Manager's efforts to ensure that the objectives of the project control program are satisfied.

Administration Manager - This position has the responsibility for implementing the administrative program for the project. Various duties include timekeeping and payroll, field purchasing, warehousing, accounting, and data processing. To assure that these activities are performed properly, the Constructor Power Group has existing procedures that are utilized. In addition to an onsite staff consisting of timekeepers, buyers, accountants and warehousemen, the Administration Manager has available, when required, a pool of administrative personnel working under the direction of the Home Office Administration Manager. This Manager also has responsibility for auditing all construction projects to assure they meet Constructor's standards.

Personnel Services Manager - This position has the responsibility for personnel training, safety and security. The Home Office Personnel Services Manager will provide backup assistance as needed.

Quality Assurance Manager - The Quality Assurance Manager, through a cadre of QA Engineers, will perform the required code-related inspection work and will monitor the inspection efforts of craft superintendents and engineers.

Materials Manager - The Materials Manager is responsible for developing procedures for and the monitoring of the purchasing, expediting and warehousing activities of the project.

SCOPE OF SERVICES

Constructor will provide all of the required construction management services. The following items are of particular importance and are described in detail.

* Preconstruction Planning
* Management Systems
* Training

PRECONSTRUCTION PLANNING

The preconstruction planning phase could very well be the most productive phase of the project; hence Constructor would begin immediately to assemble the key members of the project management team who will begin promptly to develop the Preconstruction Activities Plan. This plan will include a barchart preconstruction acitivity schedule; a worksheet describing each activity and identifying responsible parties, and an estimate of the cost of that activity including manhours, travel, etc. From this worksheet a cash flow and budget estimate for preconstruction activities will be developed. More specifically, this Preconstruction Activities Plan will provide for:

* Development of control tools.
* Constructability review.
* Procurement of construction resources.

* Development of Personnel Resource Plan.

* Site survey.

Control tools are the schedules, reports and procedures to assure that management is informed and that management goals, decisions, instructions, etc., are conveyed to all echelons of the project. Control tools to be developed include:

* The schedule, estimates and cash flow for preconstruction planning activities.

* The project schedule, estimate and cash flow.

* A Material Management Plan with special attention to identifying and resolving logistical problems and identifying procurement responsibilities.

* A Project Manual addressing pertinent procedures and interfaces. This will contain organization charts and define lines of communication between Constructor, CAE/OMNIUM-G, SCE, major consultants, subcontractors, and vendors. In addition, it will identify job procedures applicable to quality control, project administration, personnel training, security, safety, construction activities, estimating, scheduling, cost control, quantity take-off and reporting, and report formats.

* Project procedures governing construction, inspection, administration, etc.

Construction can have a positive effect on design if the opportunity is provided for a constructability review of drawings and specifications. The earlier in the design phase this is done the greater effect it will have. A design review will cover such factors as:

* Optimization of site layout to facilitate installation and handling of equipment and materials.

* Simplicity of concrete design in order to minimize forming cost. This would involve minimizing haunches, substitution of flat slab for beam and slab construction, repetitive column dimensions, and maximize the use of Q-decking.

* Reinforcing steel configuration and density.

* Anchor bolts with sleeves.

* Construction access to areas both inside and outside of the buildings to assure reasonable material and equipment handling opportunities.

* Standardization of items such as valves, fittings, attachments, hangers, and coatings.

* Interrelationships between HVAC, large pipe, small pipe, and cable tray in an effort to optimize erection sequencing.

* Design of the yard structures, underground pipe and conduit to allow simultaneous installation of all items at or near the same elevation as much as practical.

* Design of major building area foundations to hold a common bottom elevation as much as practical.

* Optimum use of large subassemblies to provide the maximum advantage of both shop and yard assembly. This will permit the efficient expenditure of the maximum number of manhours on the ground and in areas remote from the main plant congestion. This approach will require close coordination with the design engineers since it will be necessary for major vendors to design for yard and shop assembly; and the conceptual design of the plant could be affected if optimum placements of erection cranes and construction access are incorporated.

A Construction Resources Plan will be developed and the required resources will be obtained, including:

* Temporary facilities

* Construction equipment and tools

* Construction materials

* Communications systems

A Personnel Resource Plan will be developed to include:

* Extensive study and evaluation of skilled labor availability sufficient to determine if special housing will be required, such as an onsite camp and other incentives that will be needed to attract adequate numbers of qualified personnel.

* Training program for local (Indian) under-skilled personnel who want to work on the project. This activity will be incorporated into the project's overall Tribal Economic Development Employment and Training Program.

In addition, area and site trips will be conducted to survey transportation access to the site, specifically looking for potential problems in handling of heavy or large assemblies.

MANAGEMENT SYSTEMS

Constructor will develop a comprehensive plan for constructing the Chemehuevi Project. To assure the plan is followed and can be modified as required, proven management techniques will be employed. To be effective, these systems must answer the following questions:

* Is the plan being followed?

* Is production meeting project needs?

* Are we getting our money's worth?

* Are we spending our money as planned?

In the early stage of the project, Constructor will prepare a Key Item schedule showing major activities, interfaces and decision points. This schedule will essentially be a "standard logic network" for the type of plant to be built (i.e., coal, oil, nuclear, etc.), and will contain approximately 150 to 200 activities. Each schedule will be "fine tuned" to the requirements and idiosyncrasies of the individual project. This schedule is usually developed during the bid package preparation.

When the contract is awarded, a Key Item schedule will be written which integrates engineering, procurement, construction and startup activities. This schedule (Level I) will contain 150 to 200 activities--phased shown in a CPM format.

As the project becomes better defined, a Summary Level schedule (Level II) will be developed. This schedule will contain 600 to 1,000 activities and will reflect the engineering-procurement, procurement-construction and construction-startup constraints. This level and the Detail Level schedules will be, in most cases, computerized in order to easily incorporate and see the effects of the ever present changes common to any major project.

When the project nears the construction phase, we will produce a detailed construction schedule for the next 3 to 12 months. This Detail Schedule (Level III) will consist of 1,000+ activities, at any one time, constrained by engineering and/or procurement activities.

When construction begins, a Short-Interval schedule, a byproduct of the Level III schedule looking ahead three weeks, will be used for crew assignments and material and equipment staging.

The following measures are utilized by the Power Group to determine project status.

<u>Is the plan being followed?</u>

Schedule status reports are measures of the plan. Schedule (progress related to time) variance is usually expressed as weeks ahead or behind schedule based upon work units being completed in a predetermined sequence over a specified time period. These reports include a brief narrative of major contributors to schedule variance.

Schedule Table

Level	Name	Time Frame	Scope	Number of Activities	Remarks
I	Key Item	Project Duration	Project By Area & Discipline	150 - 200	Time Scaled Logic Manual or Computer Generated
II	Summary Level	Project Duration	Project By Area & Discipline	600 - 1,000	Computerized C.P.M.
III	Detail Level	A 3- to 12-Month Look-Ahead	Project By Area, Discipline, & % of Activity	1,000 +	Computerized CPM Tied to Summary Level
IV	Short Interval	3-Week Look-Ahead	Construction By Area, Discipline, & Itemized Activity	N/A	Manual Schedule Produced Weekly

Is production meeting project needs?

Production is measured by comparing work units completed to the work units required, as indicated by the schedule. As the work units are a mix of many things, such as installed quantities of materials and equipment, drawings, specifications, purchase orders and schedule activities, this can best be expressed as "percent complete." Percent complete is the ratio of work units completed to the total work units required which, when weighted by estimated manhours for each, provides a meaningful percent complete of the total project. This measure is calculated for a given period of time and compared to the estimate required to complete the project on time.

Are we getting our money's worth?

This is measured by comparing value to progress cost. Also, by examining the ratio of progress cost to earned value (in manhours), we have an expression of productivity.

Progress cost is the actual direct labor costs for the work completed. These actual costs, to be meaningful, must be compared to appropriate estimated values. For our purposes, the estimated (standard) value for comparison is earned value.

Earned value is the estimated costs for the actual work performed. The calculation to provide earned value is actual quantity x standard manhours per unit (Unit Rate) x standard labor rate.

Are we spending our money as planned?

Here we compare actual cost to budget. Budget is the estimated cost of the project as scheduled. To give a valid comparison with actual, this must be segregated into such categories as: (1) material, (2) craft labor, and (3) other. Project-to-date cost is the actual cost for the period of concern. For valid comparison purposes this must be segregated into the same categories as the budget.

We thus have four significant progress measures - estimated percent complete versus actual percent, ahead or behind schedule, progress cost versus earned value, and actual cost versus budget.

These measures are indicators of where the project is and where it has been. They provide the necessary data to support trend analysis.

TRAINING

As a supplement to traditional construction manpower acquisition practices, Constructor has developed a sytems approach to craft skills training which complements on-the-job training in assisting newly-hired craft personnel to become productive in a minimum acount of time. Our Power Training and Development section will work closely with the Construction Manager to assess individual and project needs for training in each craft area. When training is necessary, a project training program will be planned and implemented. The major objective of the system will be to develop effectively and utilize fully the potential and actual skills of the local workforce available to the project.

The training system will consist of a series of modular classroom and laboratory courses for each craft area which is sequenced to meet the project schedule. Training modules progress from entry-level through advanced and supervisory training and closely parallels the skill levels workers achieve as they progress from helper to craftsman, to foreman, and beyond. Each module places heavy emphasis on practical hands-on skills performance training. Training modules currently available in a wide range of construction craft areas include:

Concrete	Rigging
Rebar	Millwright
Pipefitting	Instrumentation
Electrical	Field Engineering
Welding	Insulation
Carpentry	

If necessary to meet a critical manpower shortage, Constructor may offer craft training programs during normal working hours. Workers who are to participate in such training are compensated and will be carefully screened by their supervisors and by the Training Supervisor. Training during normal working hours typically consists of one or more hours of classroom training and planning, followed by on-the-job training (closely supervised by the instructor) during which productive work is performed. Workers who particpate in such programs are carefully evaluated the the end of the program by the instructor for both successful completion and possible advancement.

A Training Supervisor will be assigned to the Chemehuevi Project by the Manager of Power Training and Development and will administratively report to that office. Functionally, the Training Supervisor is a member of the Project Management Team reporting directly to the Personnel Services Manager and working closely with the superintendents and craft supervisors to evaluate training needs and program effectiveness. The Training Supervisor is also responsible for maintaining complete and accurate training documentation including cost data, attendance records and lesson plans. He observes classes to assure that training is being conducted properly, that class presentations are effective and that lesson plans are being followed. He makes regular training status reports to project management and the home office on a weekly, quarterly, and annual basis. The Training Supervisor works with federal, state and local educational agencies and institutions as appropriate to secure what state/federal aid may be available to the project training program, including but not limited to instructor's wages, materials, supplies, and equipment.

For any training program to be of maximum effectiveness, the skilled craftsmen developed through such a program must be available when and where they are needed. Through Constructor's overall personnel management and records system each craftman's employment and training history is available for immediate review by supervisory personnel via access to the computerized corporate personnel data base. This program has been a very effective aid to the regular screening and referral process and also helps eliminate potential time lags inherent in standard hiring practices.

This approach to developing skilled construction labor is highly cost effective and sufficiently flexible to meet a wide range of project and employee training needs. It forms the basis of a systematic effort to meet project manpower requirements while at the same time offering workers a chance to improve themselves by acquiring marketable skills.

PART D

PROJECT PARTICIPANTS

As mentioned in the Executive Summary, CAE and OMNIUM-G are jointly producing this document and, if awarded the project, will formally merge into a new corporate entity that will be staffed by highly qualified management personnel--some hired from the outside and some obtained from within. All of the ten (10) CAE/OMNIUM-G personnel listed in the following biographical summaries will provide direction and support to the project.

The reader will note that this group has over 208 years combined experience in their fields.

THOMAS A. DAMBERGER, PROJECT DIRECTOR

Program Assignment: To provide overall management direction and coordination of resources to ensure implementation of project goals. He will ensure successful liaison is maintained with all project participants, including the Chemehuevi Tribe, BIA, DOE, FERC, SCE, PUC, and all other appropriate agencies and organizations.

Experience Related To Assignment: Ten years of administrative and management experience with seven as president of the The Consortium of Alternate Energies. In this role, he founded and guided the growth of a company that has pioneered in the development of solar-thermal systems ranging from residential to large central receiver plants. He formed the organizational and engineering nucleus that developed the conceptual design for the world's largest and most advanced central receiver plant, and assembled a prestigious international consortium fully capable of constructing the facility. Final development/construction will take place as soon as local political conditions permit.

Previous experience includes organizational development activities and research in and for a variety of private/public entities including local (San Diego) governments. These efforts have involved him in many projects resulting in innovative organizational/administrative designs and creative productivity enhancement programs. Other related experience includes teaching of college-level building construction technology and curriculum development related to high-rise construction techniques.

Education: B.A. Public Administration, San Diego State University (1975)
Master of Public Administration San Diego State University (1978)

DAVID R. BECK, ASSISTANT PROJECT DIRECTOR

Program Assignment: Assistant Project Director in overall management tasks, with particular emphasis in finance and strategic planning. Role will include development of and initial staffing of project team, followed by coordination of all functions to ensure efficient and effective use of resources. Will serve as principal advisor/manager on matters relating to real estate, secondary business enterprise planning and Indian training/employment programs. He will hold the position of Indian Placement & Liaison Officer until a suitable Indian candidate can be found for that duty.

Experience Related to Assignment: Twenty-four years of total experience in financial management, small business operation, public agency administration, and plant operations/maintenance supervision. Fourteen years as fiscal officer and plant manager within one of the largest college districts in the U.S.; seven years as vice president of a solar/alternate energy company, three years as a college placement officer, and four years as a U.S. Naval officer (operations, scheduling, and training for amphibious construction batallion, and amphibious group commander). Has also taught college level business courses for several years. Has been active in real estate/investment consulting, property management and organizational/legislative consulting. Has conducted research for U.S. senators and local legislators, and has headed a countywide employment task force for the disadvantaged.

Other related experience includes establishment and supervision of a state funded Equal Opportunity Programs & Services (E.O.P.S.) organization and many years with various affirmative systems design and productivity research.

Education: A.S. Electronic Technology, San Diego Community Colleges
Bachelor of Public Administration, San Diego State University (1968)
Master of Public Administration, San Diego State University (1977)
Master of Business Administration (Real Estate Management), National University (1978)
Graduate, U.S. Naval Officers Candidate School, Newport, Rhode Island
Various coursework in business, plant management, occupational safety, energy management, interviewing skills, and others at UCSD, University of Utah, San Diego State University, San Diego Community Colleges, Southwestern College.
College Teaching Credentials in Business and Industrial Management, Public Services and Administration, Real Estate; holds California State Credentials (CCC) authorizing service as Chief Administrative Officer and Community College Supervisor.
Certified Energy Auditor (State of California)

JOSEPH M. DAMBERGER, P.E., CONSULTING CIVIL ENGINEER

Program Assignment: To provide engineering and construction designs for road bed, foundations, structural supports, procedures, methods and processes. As Consulting Engineer, he will be responsible for providing detail management for design and construction activities.

Experience Related to Assignment: Thirty-six years of civil engineering experience with the California Division of Highways as District Design Engineer. Activities included major freeway design, plans and specifications, supervision and management of CAD team, aerial mapping, surveying group leader, highway economics and financing; characteristics and behavior of various kinds of materials used in highway foundation; methods, materials, and equipment used for highway construction; principles and techniques of personnel management and supervision; provided direction for team members.

Education: B.S. Civil Engineering, Marquette University (1934)

VIRGINIA W. PRUE, ADMINISTRATIVE SERVICES SUPERVISOR

Program Assignment: Under direction of president/project director, will provide/coordinate key financial, administrative, technical, and secretarial support services for entire project management team. Will provide a wide variety of direct and coordinative services to maximize effectiveness of support resources and minimize cost and redundancy. Will act as manager of corporate/project office and assist with special projects as needed.

Experience Related to Assignment: Nine years experience as controller, administrative assistant, and bookkeeper for solar energy and real estate development companies. Has performed accounting functions including payroll, accounts payable, accounts receivable, inventory, disbursements and receipts, financial statements, bank reconciliations, data entry, assisted with purchasing function and provided a wide range of reports and analyses. Also possesses necessary secretarial and reprographic skills.

Education:
University of Southern California, Business Major, emphasis on Business Administration (1965-67)
San Diego Community Colleges (1970-72)
Bookkeeping and Advanced Bookkeeping Certificates, San Diego Community College District, Clairemont Mesa Center (1978 and 1983)
Word Processing Certificate, San Diego Community College District, Clairemont Mesa Center (1983)
Quantel Computer Report Generator Course (1982)
Advanced Course, Lotus 1-2-3, Entre Computer Center (1985)

WILLIAM P. (BILL) DAMPIER, DIRECTOR OF OPERATIONS

Program Assignment: To provide necessary management direction, planning, and control to assure the effectiveness of the technical effort, implementation of program plans, and timely completion of the contract deliverables. As the program manager he will be responsible for the coordination of the technical and non-technical team to support the design, construction, and operation of the Solar Electric Generating Station.

Experience Related to Assignment: Thirty years engineering and management experience with development, manufacture, and operation of large sophisticated defense systems, satellite tracking systems, and data communications systems. Has directed the efforts to transition these engineering designs to production. For the past thirteen years he has been involved in design, development, and construction of OMNIUM-G point-focusing parabolic dish concentrator technology. Has planned and controlled the use of all resources and managed the daily business operation for the company.

Education: B.S. Electrical Engineering, University of Florida (1956)

SAMUEL P. (SAM) LAZZARA, DIRECTOR OF ENGINEERING

Program Assignment: To provide direction for all technical activities, with emphasis on design, analysis, and fabrication processes. As Technical Director, he will be responsible for the overall system definition, detail engineering design and achievement of the power plant characterization.

Experience Related to Assignment: Twenty-five years engineering design, analysis, and application of high energy laser systems, precision electro-optical system, and high temperature materials and processes. His experience in high precision and high resolution laser beam formation, projection, and tracking has paved the way for his patented breakthrough in coherent optical adaptive systems for laser beam phase error compensation. For the past thirteen years he has directed all OMNIUM-G technical activities and is responsible for the techniques developed in supplying the next generation commerical solar powered total energy system.

Education: B.S. Electrical Engineering, University of Illinois (1961)

STANLEY H. (STAN) ZELINGER, TECHNICAL ADVISOR

Program Assignment: To perform analysis, engineering studies, technical consultation, and reviews in suppport of the overall solar power plant design. As Technical Advisor, he will be responsible for directing the company's Design Advisory Board and establishing assignments for tasks that lead to presentation of all important information for the Engineering Reviews, Performance Reviews, and Readiness Reviews.

Experience Related to Assignment: Twenty-three years system analysis, design, mathematical modeling, computer simulation and evaluation of coded signal radars. His experience in high technology computer programming has led to automation technology software for Computer Integrated Manufacturing (CIM). He has provided national and international sales force with technical support, including preparation of proposals, field sales calls, and technical presentations. For thirteen years he has been involved with OMNIUM-G's solar thermal power systems, with emphasis on energy management, computer and tracking system. He has been involved in analysis and mathematical modeling of the collector system.

Education: B.S. Electrical Engineering, University of Colorado (1964)
M.S. Electrical Engineering, University of Southern California (1967)

RONALD C. (RON) DERBY, FINANCIAL ADVISOR

Program Assignment: To provide business management and financial analysis in support of the overall power plant design and operation. As Financial Advisor, he will be responsible for preparing all business reports, tax reports, special analyses and studies concerning the solar power plant.

Experience Related to Assignment: Twenty-nine years engineering, technical management, corporate organizations, product development, and financial planning. Has been responsible for corporate-wide long-range planning, product planning, and analysis of prospective acquisitions. Has directed activities relating to product management and planning, sales promotion, technical support, sales and product training, and sales administration. For the past thirteen years as Chief Financial Officer, he has been involved in the manufacture and sale of OMNIUM-G's thermal power systems.

Education: B.S. Mechanical Engineering, California State Polytechnic College, San Luis Obispo (1957)
M.S. Computer Science, University of Southern California (1967)
M.B.A. Marketing, California State University at Fullerton (1970)
UCLA Corporate Planning (1965-66)
Accounting, California State University at Fullerton, Passed CPA (1971)

PETER A. (PETE) HOLCOMBE, RESIDENT CONSTRUCTION MANAGER

Program Assignment: To provide engineering coordination, supervision, and subcontract management in development construction plans and logistics for modular power plant construction fabrication. As Resident Construction Manager, he will be responsible for design, preparation, procurement, and installation of the modularized facilities, including award and management of major subcontracts.

Experience Related to Assignment: Twenty-three years construction experience on major projects including field and office engineering from direct supervision level through contract management involving all phases of civil and mechanical construction activities. Has experience in all quality aspects through plant erection, installation, mechanical completion, and testing. He has directed shop fabrications and field installations in the field of solar powered electrical and steam generating plants.

Education: B.S. Civil Engineering, University Texas-El Paso (1963)

CLIFF A. BLAKE, JR., CHIEF MANUFACTURING ENGINEER

Program Assignment: To provide management of all manufacturing activities, including design and implementation of tooling, fixtures, procedures, methods, processes, and materials. As Chief Manufacturing Engineer, he will be responsible for developing all fabrication assembly and test processes for the modularized power plants.

Experience Related to Assignment: Twenty-eight years of engineering experience with manufacturing methods, material applications, design and development of new products, and plant management. Has redesigned product lines for mass production cost effectivity and developed manufacturing standards costs and methods. He has conducted studies and authored publications in the solar thermal field, including "Cost Study for Mass Production of OMNIUM-G Solar Powered Electrical Generating Device" (JPL 5105-23), "Cost Study of Brayton Solar Converter," "Cost Study of United

Sterling," "Manufacturing Facility for Mass Production of Point-Focusing Solar Receiver," and "Evaluation of McDonnell-Douglas Heliostat."

Education: B.S. Electrical Engineering, UCLA (1963)

PART E

APPENDIX

FINANCING SERVICES

Is there a letter from a bonding service?

San Diego Leasing

7969 Engineer Rd., Suite 201, San Diego, CA 92111-1922

25 March 1986

Mr. Tom Damburger
CONSORTIUM OF ALTERNATE ENERGIES
Post Office Box 84450
San Diego, California 92138

Re: Lease/Chemehuevi Indian Tribe

Dear Mr. Damburger:

Thank you for calling San Diego Leasing and giving us the opportunity to demonstrate why we have earned the reputation as San Diego's finest full service lease company.

We're very excited about handling this lease for you and have been in communication with our lending source, who have responded very positively.

You may be assured of the most efficient and professional handling of this transaction, excellent rates and personal attention to you and your customer.

Please feel free to call on me, if you have any questions, or if we may be of any further assistance. You may be assured of our continued interest in your business, and remember, we're here to serve you and your customer.

Sincerely,

SAN DIEGO LEASING

George Papas

GEORGE PAPAS
Owner

GP/kn

(619) 560-5400

DIVERSIFIED EQUIPMENT FUNDING
& MANAGEMENT SERVICES, INC.

March 18, 1986

Mr. Thomas Danberger
Consortium of Alternate Energies
P.O. Box 84450
San Diego, California 92138

Dear Mr. Danberger:

This is to inform you that Diversified Equipment Funding is interested in the Chemehuevi Solar Power Project.

Please keep us advised of the progress on the project so that at the time funds are required we will have them in place.

Sincerely,

Joseph Dau
President

JD/mf

4849 Ronson Court # 203, San Diego, CA 92111 • (619) 560-5905 CA (800) 258-4324

CONSTRUCTOR SERVICES

PARSONS CONSTRUCTORS INC.

POST OFFICE BOX 7036
PASADENA, CALIFORNIA 91109
(818) 440-3000
Telex WH: 675-336

March 17, 1986

Mr. Thomas A. Damberger
President
Consortium of Alternate Energies
Post Office Box 84450
San Diego, California 92138

Dear Mr. Damberger:

We are pleased to provide this letter as a statement of our interest in the development of solar thermal power technology.

Parsons Constructors Inc. (PCI) is one of 15 subsidiaries of The Parsons Corporation which together form one of the largest engineering and construction firms in the world. The Parsons Corporation 1985 annual review brochure is attached to give perspective to our diverse capabilities.

We have always maintained a keen interest in promising new technologies such as parabolic dish cogeneration facilities and are interested in proposing on these substantial projects as they become economically viable to build.

We understand your company may be involved in the development of such solar thermal power projects in the near future, and we would appreciate being kept informed as to their status.

Very truly yours,

PARSONS CONSTRUCTORS INC.

W. W. Cody

W. W. Cody
President

WWC:PAH:sr

Attachment

INSURANCE SERVICES

Project insurance needs will be handled by the brokerage firm of:

JOHNSON & HIGGINS
110 West A Street, Suite 1170
San Diego, CA 92101

(619) 231-1000

Johnson & Higgins
95 Wall Street
New York, NY 10005

(212) 701-7500

Johnson & Higgins
One Century Plaza
2029 Century Park East
Los Angeles, CA 90067

(213) 552-8700

Principal Contact: Mr. James C. J. Schober
Vice President
San Diego, CA

The company has assembled a special team of experts to study the specific needs of solar-thermal technology and the site-specific Ridgecrest Project. Appropriate insurance specifications and loss control procedures are being developed to cover project needs from beginning to end.

JOHNSON & HIGGINS ENERGY GROUP

George Kadri (Heads J&H Energy Group)	New York
Thomas Germani	New York
Willis King	Los Angeles
John Deitchman	Los Angeles
Robert Schill	San Diego

The following information is a summary of Johnson & Higgins experience and qualifications. Please feel free to contact J&H directly if you have questions.

FACILITIES AND SERVICES

HISTORY

Johnson & Higgins was the first insurance brokerage firm in the United States. We began in 1845 as a partnership handling Marine Insurance Brokerage and Average Adjusting. At the turn of the century, our company had branches in seven major cities coast to coast. By this time, our business included Property and Casualty Insurance. In 1927, we established the Employee Benefits Department. Today, we are one of the world's largest insurance brokerage/consulting firms with a staff of approximately 4,000 employees.

INVOLVEMENT

J&H is the only major insurance brokerage firm that is privately held. Since becoming a private corporation in 1899, the stockholders, called directors, have been active members of the firm. There are currently 32 directors; five of them are West Coast residents. At retirement age each director surrenders his stock, which is redistributed to include the new member. As ownership and top management are one and the same the most experienced, dedicated and talented personnel are continuing their efforts to design and innovate new programs, develop high level market contacts and, most importantly, assist our clients throughout the world on a direct and personal basis.

NATIONAL NETWORK

We are a leader in size as well as scope. With our head office in New York, we have 37 branch offices in the United States and seven in Canada. Overseas we have 14 in Europe (with principal offices in Milan, Paris and Zurich), 14 in South America, and one in Saudi Arabia. In the Pacific Basin, we have branches in Hong Kong, Taipei, Tokyo, and Singapore, and nine in Australia and New Zealand. We are represented in London by Willis, Faber and Dumas Ltd. We also have exclusive correspondents in Austria, Belgium, the Dominican Republic, Ecuador, Germany, Guatemala, Iran, Jamaica, Mexico, the Netherlands, Nicaragua, Norway, the Philippines, Portugal, Puerto Rico, Spain, and South Africa. Our branches can draw on our facilities anywhere in our international network and offer consistent top quality service wherever required throughout the world.

EXCLUSIVE CORRESPONDENT

We take pride in the consistent quality of our services. Our approach is to establish exclusive correspondent relationships with established brokerage firms in host countries. Where local brokerage firms are unsuitable for our needs, we open our own branch offices. All of these foreign technicians receive U. S. training and visit U. S. branches on a regular basis.

CLIENT EXPERIENCE

Johnson & Higgins works with 700 of the Fortune 1000 companies. Of the Fortune 500, Johnson & Higgins works for 350 of these firms.

RISK MANAGEMENT

Our aim is to provide our clients with effective Risk Management techniques which include the formation and management of "Captives", deductibles or retention and other funding mechanisms. Our private computer library coupled with the use of the latest computer technology enables us to provide guidance toward selecting the proper technique or combination of techniques to maintain a program of Risk Financing and Risk Transfer at the lowest net cost.

MARKET EVALUATION

When an insured program is selected, we use our experience in dealing with the worldwide markets, and evaluate them on our client's behalf, through an examination of the underwriter's service standards, the premium level and the extent of the coverage. Our specialists are continually in touch with the marketplace and are aware of the changes that can affect coverage, pricing and services offered by the insurance carriers. The same process of evaluation also applies to captive companies and service organizations.

MATRIX APPROACH TO ACCOUNT MANAGEMENT

Johnson & Higgins utilizes the team approach in account management. Our offices are organized into separate departments that are grouped according to operating and service facilities; each department head is responsible to top management. We appoint account managers who choose their account specialists from these departments. They coordinate the activities of the account team, communication with the client, and the smooth management of the entire account. A management team has been developed for The Consortium which is experienced, responsive, and large enough to provide for every need.

Because of the importance of your account to the San Diego Branch of J&H , James Altman, Branch Manager, will also be directly involved with the overall services that will be required. James Schober will function as the Account Manager.

RESOURCE GROUPS

Johnson & Higgins utilizes Resource Groups to assist various industries. We are active with such groups in Construction and Energy. Information on these groups is provided.

RESOURCE GROUPS

CONSTRUCTION INDUSTRY RESOURCE GROUP

A recent ENGINEERING NEWS RECORD survey on the 400 leading construction firms in the country indicated that 20 had annual billings of $1 billion or more. In this group, J&H has a client relationship with 11. Additionally, our position with contractors developing annual billings exceeding $100 million shows 18 more clients. Among the 137 largest contractors in the USA, J&H has client relationships with 29. Many are not clients for all lines of insurance, but taken together, they provide us with a large body of knowledge about construction business.

In an effort to better service existing construction industry clients and develop new ones, we have established a Construction Industry Resource Group made up of experienced construction insurance specialists from throughout our system. Representatives are stationed in all offices. They will assist all clients at the local level by providing all J&H services needed in coordination with the J&H office controlling the account, in this case San Diego.

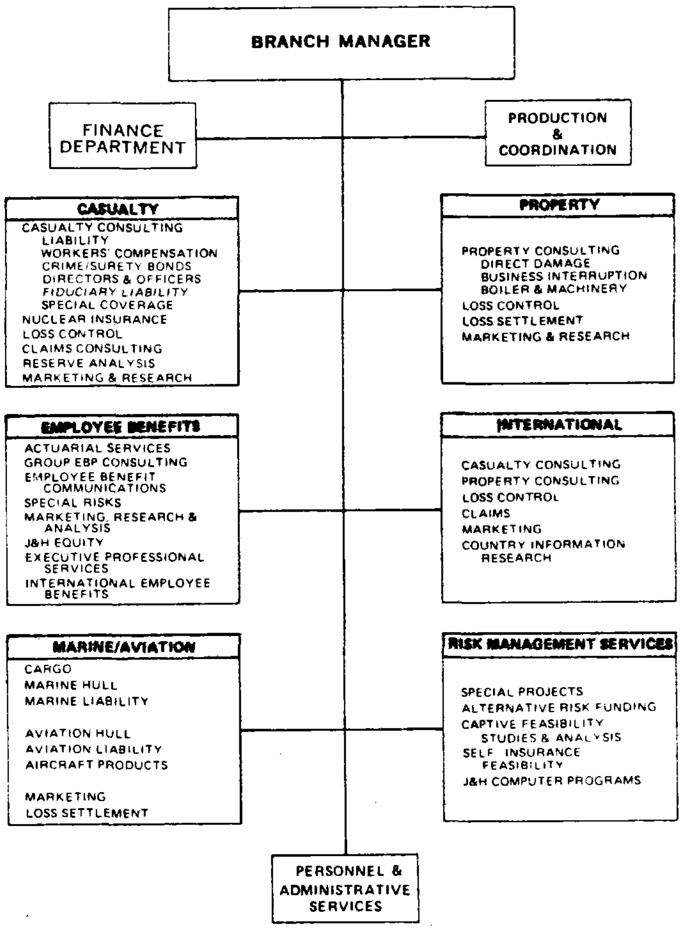
The Construction Industry Resource Group is coordinated by William Cullen. Mr. Cullen recently returned to our New York office after an eight-year assignment in Washington, D.C. where he was Director of Metro Insurance Administrators, the J&H subsidiary set up to manage the insurance and loss control programs for the construction and operation of the $10 billion Washington D.C. subway project.

ENERGY RESOURCE GROUP

Johnson & Higgins is deeply involved with major Alternative Energy Programs. The Group is headed by George Kadri in New York. Each of the 37 offices of J&H has a representative of the Energy Group for local client needs. Three major projects where we have been designated broker are:

- Solar One - Barstow
- Intermountain Power - Utah
- Palo Verde Power Project - Arizona
- Plus activity in two dozen other projects across the country.

JOHNSON & HIGGINS
SAN DIEGO
ORGANIZATION OF CLIENT SERVICES



ENVIRONMENTAL SERVICES

Environmental and other site services will be provided by:

WESTEC SERVICES, INC.
3211 Fifth Avenue
San Diego, CA 92105
(619) 294-9770

Principal contact:

Michael W. Wright, Vice President Environmental Design
Bob Tucker, Vice President Energy Business Development

This section provides a summary of corporate qualifications and experience and indicates some of the key environmental impact and water engineering services they provide.

SECTION 1

WESTEC SERVICES, INC. CORPORATE PROFILE

WESTEC Services was established in 1972 to meet the growing needs of government and industry for energy engineering and environmental services. Since that time, the firm has been involved in numerous public utility and energy-related projects, and has completed over 750 environmental and planning studies in California, Nevada, Arizona, Utah, Idaho, New Mexico, Colorado, Montana and Oregon.

WESTEC Services is staffed with a multi-disciplinary team of 165 full-time employees, and has current consulting revenues in excess of $7,000,000. Energy engineering and environmental services are provided out of the corporate headquarters in San Diego and from regional offices located in Santa Ana, Brawley and Sacramento, California; Phoenix, Arizona; and Philadelphia, Pennsylvania.

A two-fold philosophy has prevailed in developing WESTEC Services' consulting capabilities. First, the company is dedicated to building a staff of scientific and technical experts who, to the greatest extent possible, are long-term, full-time employees with post-graduate degrees. Second, the firm applies strict management controls in the areas of task assignment, scheduling, budget, and management participation/review in the final output. Evidence of the success of these policies is shown in the repeat business conducted with virtually all of our major clients.

The company has provided environmental studies for a broad range of projects including electrical generation plants, transmission, facilities, offshore oil platforms, natural gas storage facilities and other industrial and institutional projects. All of the projects have had a high degree of public visibility and interest, where carefully and professionally conducted environmental analysis and public presentations were essential to successful completion of the project.

SECTION 2

MAJOR ENERGY DEVELOPMENT AND TRANSMISSION CORRIDOR EXPERIENCE

WESTEC Services has provided environmental services for fossil, geothermal, solar and nuclear power plants and transmission corridors. WESTEC Services is capable of conducting both pre-development impact analyses and post-development monitoring programs. Environmental inventory or baseline planning data developed by WESTEC Services in numerous studies throughout the western United States have been utilized in subsequent project planning and design to avoid what would otherwise have resulted in significant impacts to environmental resources. WESTEC Services also offers the capability to monitor all aspects of the environment after development to detect or document adverse or beneficial impacts that may result, and to recommend mitigation measures where appropriate.

WESTEC Services has a full-time environmental consulting staff. The staff is capable of managing entire environmental documentation and permitting tasks for major energy developments as well as providing specialized fast turnaround services. The firm has demonstrated it can put large scientific teams in the field on very short notice and perform the assigned task. Specific services provided by the firm's environmental staff include:

- Environmental Impact Reports/Assessments
- Site Selection Tradeoff Studies
- Large-Scale Field Surveys and Monitoring
- Wildlife/Vegetation Studies
- Cultural Resource Management
- Air Quality Monitoring and Analysis
- Solid Waste Management
- Reclamation and Revegetation Programs
- Noise Monitoring and Analysis
- Groundwater/Surfacewater Analysis

WESTEC Services' Environmental Division has completed over 700 environmental impact assessment studies throughout the western United States.

Table 1 summarizes WESTEC's experience in major energy developments and transmission corridors.

Table 1

WESTEC SERVICES, INC.
MAJOR ENERGY STUDIES AND ELECTRIC
GENERATING/TRANSMISSION PROJECT EXPERIENCE

Project	Client
ENERGY DEVELOPMENT	
• Salton Sea 5 MW and 600 MW Solar Power Plant Environmental Feasibility Study	Jet Propulsion Laboratories
• Ivanpah Valley, California, Rare and Endangered Faunal Study	Southern California Edison
• Sundesert Nuclear Generating Station Site Screening Study	San Diego Gas & Electric Company
• Evaluation of Licensing Actions for Operating Nuclear Reactors	Franklin Research Center/U.S. Nuclear Regulatory Commission
• Encina Power Plant Stack Modification EIR	San Diego Gas & Electric Company
• North Brawley 10 MW Geothermal Power Plant	Union Geothermal Company/ Southern California Edison Company
• Salton Sea Anomaly Master EIR for Development of 1400 MW of Power	County of Imperial
• Baca Geothermal Demonstration Program	Public Service Company of New Mexico/Union Geothermal Company
• Superstition Hills Hazardous Waste Disposal Site	IT Corporation
• Shell OSC Beta Unit Development EIR	Shell Oil Company/U.S. Geological Survey/California State Lands Commission
• Shell OSC Molino Gas Field Development EIR and Emissions Offset Analysis	State Lands Commission/Shell Oil Company
• Point Conception OSC Exploratory Drilling Project EIR/EA	Union Oil Company/California State Lands Commission
• Point Conception OSC Project-Emissions Offset Analysis	Union Oil Company

Table 1 (Continued)

WESTEC SERVICES, INC.
MAJOR ENERGY STUDIES AND ELECTRIC
GENERATING/TRANSMISSION PROJECT EXPERIENCE

Project	Client
ENERGY DEVELOPMENT (Continued)	
• Point Conception Tank Farm NPDES Study	Union Oil Company
• Platform Eva, San Pedro Bay, Resumption of Drilling Environmental Report	Union Oil Company
• Phillips Petroleum Gas Field Development EIR	Philips Petroleum Company
• Hwasma Valley Oil Field EA	Phillips Petroleum Company
• Lucerne Valley Generating Station Biological Study	Southern California Edison Company
PIPELINE AND TRANSMISSION CORRIDOR STUDIES	
• Hualapai Valley (Arizona) Natural Gas Pipeline EA	Southwest Gas Corporation
• Lucerne Valley Generating Station Transmission Line, Fuel Line and Water Supply Line Environmental Studies	Southern California Edison Company
• San Onofre Nuclear Generating Station to Mission Substation 230 kV Transmission Line Environmental Data Statement	San Diego Gas & Electric Company
• San Onofre Nuclear Generating Station to Encina Substation 230 kV Transmission Line Environmental Data Statement	San Diego Gas & Electric Company
• Palo Verde Nuclear Generating Station (Arizona) to Devers Substation (California) Transmission Line Corridor Archaeological Assessment and Mitigation Program	Southern California Edison Company
• Imperial Valley Transmission Line Corridor Selection Study and EIS	California Energy Commission/County of Imperial
• Mexican Interchange Project - San Diego/Tijuana Interconnection Environmental Study Program	San Diego Gas & Electric Company

Table 1 (Continued)

WESTEC SERVICES, INC.
MAJOR ENERGY STUDIES AND ELECTRIC
GENERATING/TRANSMISSION PROJECT EXPERIENCE

Project	Client
PIPELINE AND TRANSMISSION CORRIDOR STUDIES (Continued)	
• Sundesert Nuclear Generating Station Transmission Line Corridors, Chiroptera and Carnivora Inventory Studies	U.S. Bureau of Land Management
• San Onofre Nuclear Generating Station to Black Star Canyon Substation Archaeological Salvage Program	Southern California Edison Company

SECTION 3
ARID LANDS EXPERIENCE

WESTEC Services is experienced in all environmental aspects of desert ecosystems and has recent experience in the vicinity of Ridgecrest. Table 2 describes several representative projects recently completed by the firm. These studies have included an environmental analysis of the Mojave "B" Ranges at the China Lake Naval Weapons Center, a dust storm abatement program at Owens Dry Lake, and an environmental study of the Second Community of California City. WESTEC Services is thoroughly familiar with the Mojave Desert-Lower Owens Valley ecosystem.

Table 2

WESTEC SERVICES, INC.
MOJAVE DESERT AND ARID LANDS EXPERIENCE

Project	Client	Description
EA for Mojave "B" Ranges	U.S. Navy China Lake Naval Weapons Center	Preparation of Environmental Assessment for continued withdrawal of the 325,000 acre weapons test range.
Owens Dry Lake Dust Storm Abatement Program	State of California, State Lands Commission	Prepare vegetative and non-vegetative test sites and conduct air quality monitoring and meteorological data collection for dust storm abatement determinations.
Relinquishment of Surface Entry Rights for Second Community of California City, EIR	State of California, State Lands Commission	Preparation of EIR for relinquishment of surface entry rights of 20,000 acres.
Lucerne Valley Generating Station Biological Impact Report	Southern California Edison	Biologic survey of 1,200 MW generating station site, 71 miles of transmission line and 56 miles of fuel and water lines.
Clark County Threatened and Endangered Plant Study	Bureau of Land Management - Las Vegas District	Survey of threatened and sensitive plants within the 3,000,000 acre Clark County area.
Survey of Sensitive Plants of the Algodones Dunes	Bureau of Land Management - Riverside District	Survey of threatened, endangered and sensitive plants of 250 square mile Algodones Sand Dunes.
MX Program Key Wildlife Habitat Analysis in Nevada and Utah	HDR Sciences, Inc.	Survey of 12 key areas in two major valley systems in Nevada and Utah for the MX Missile System.
Colorado River Resources Survey	U.S. Corps of Army Engineers, Los Angeles District	Biologic survey of 500 miles of the river to determine impact of small facilities development.
Pataya Natural Gas Storage Facility EA	Southwest Gas Co., Las Vegas, Nevada	Environmental Assessment of a natural gas storage project at Red Lake in Northwest Arizona.

Table 2 (Continued)

WESTEC SERVICES, INC.
MOJAVE DESERT AND ARID LANDS EXPERIENCE

Project	Client	Description
Holgate-Edwards-Kramer Transmission Corridor Study	Southern California Edison	Biological Assessment of a 7-mile electrical transmission line within Edwards Air Force Base.
Red Lake Reclamation Study	Southwest Gas Company, Las Vegas, Nevada	Survey of vegetation at and around Red Lake in northwest Arizona and formulation of revegetation methods for control of particulates emanating from the playa.
Nevada Highway Department Revegetation Study	Nevada Department of Highways	Determine feasibility of revegetation of revegetation of construction areas with native plants.
Mojave Desert ORV Air Quality Impact Study	Bureau of Land Management Desert Plan Staff	WESTEC Services determined air quality impacts associated with off-road vehicle races. This study included monitoring of particulate emissions during various types of ORV races.

SECTION 4
PERMIT PROCESSING

WESTEC Services possesses considerable experience in identifying, completing, and processing permits required for project implementation. WESTEC Services has provided permit processing and regulatory negotiation assistance in support of a variety of energy development projects. The regulatory environment is in constant flux, therefore this expertise in the current regulatory status is invaluable for facilitating project success. Specific project experience is described below.

- Outer Continental Shelf Oil Exploration, Support Services

  WESTEC Services has recently been retained by the Union Oil Company and Phillips Petroleum to provide support services for their oil exploration program on the Outer Continental Shelf. WESTEC Services is carefully monitoring federal and state legislative activities which might affect Union Oil's interests. In addition, WESTEC personnel will interact with licensing and regulatory authorities to assist Union Oil's permitting efforts and provide environmental documentation. In addition to offshore activity, WESTEC is handling all of Phillips' onshore development permits in San Luis Obispo and Monterey Counties.

- Pataya Gas Storage Facility

  WESTEC Services coordinated the Federal Energy Regulatory Commission (FERC) application for licensing of this gas storage and transmission facility in Arizona. This effort required coordination of several technical investigations and some 15 permitting requirements of both state and federal agencies.

- Rohr Marine Surface Effects Ship (SES) Shipbuilding Facility

  WESTEC Services submitted initial applications to the California Coastal Commission and the U.S. Army Corps of Engineers to secure permits for development in the coastal zone and dredging operations, respectively, to support development of a shipbuilding facility in San Diego Bay.

- Geothermal Utility Core Field Experiment

  WESTEC Services, Inc. processed the permits required for drilling geothermal wells, El Centro Thermal 1 and 2, which are part of the City of El Centro's geothermal energy utility core field experiment to demonstrate the engineering and economic feasibility of utilizing moderate temperature geothermal heat for space cooling, space heating and domestic hot water. This drilling required permits from the Imperial County Air Pollution Control District, California Division of Oil and Gas, and the Colorado Regional Water Quality Control Board.

- <u>Evaluation of Nuclear Licensing Submittals</u>

  Since October 1979, WESTEC Services, Inc. has been providing both managerial and technical services as principal subcontractor to the Franklin Research Center -- a division of the Franklin Institute, Philadelphia, Pennsylvania -- for the review and evaluation of licensing actions for operating reactors for the United States Nuclear Regulatory Commission (NRC). This contract marks the first time that the NRC has engaged a private organization for direct assistance in the review and evaluation of licensing matters.

- <u>Pine Creek Mine Project</u>

  As part of this comprehensive feasibility study for utilization of geothermal energy in the mining and processing of tungsten ore, WESTEC Services conducted an institutional barriers assessment. This involved a comparative analysis of regulatory constraints to geothermal development in Inyo and Mono Counties, California, and an evaluation of differing attitudes as to jurisdictional authority which federal and state governments have over geothermal development in those counties.

- <u>Baca Geothermal Demonstration Program</u>

  WESTEC Services conducted an institutional analysis including regulatory, permitting and environmental constraints to development of the geothermal resource and construction of a 50 MW geothermal power plant in New Mexico as part of this data gathering, reduction, evaluation and reporting services contract.

WESTEC Services, Inc.

WESTEC Services, Inc. is an engineering and technical services consulting firm which was established in 1972 to provide assistance to industry, public utilities, and governmental agencies. Operating from six offices located throughout the United States, WESTEC's technical expertise is focused on five areas of service:

☐ **Water Resources Planning and Engineering**

Surface/Groundwater Hydrology Engineering
Water Quality Assessment
Water Availability Studies
Water Rights Assessment

☐ **Environmental Planning/ Resource Management**

Impact Studies
Cultural Resource Studies
Biological Resource Studies
Air Quality Assessment
Emission Trade-off Programs
Site Selection/Constraint Studies

☐ **Power Systems Engineering**

Site Selection
Design Review
Licensing/Regulatory Compliance
Probabilistic Risk Assessment
Power Plant Operations/Maintenance
Process Hazards Analysis
Construction Management
Reliability Analysis

☐ **Communications Systems Engineering**

Telecommunications
Video Systems
Management Planning
Automated Message Processing
Shipboard Communications Systems
Integrated Logistic Support Planning
Medical Data Systems

☐ **Energy Systems Engineering**

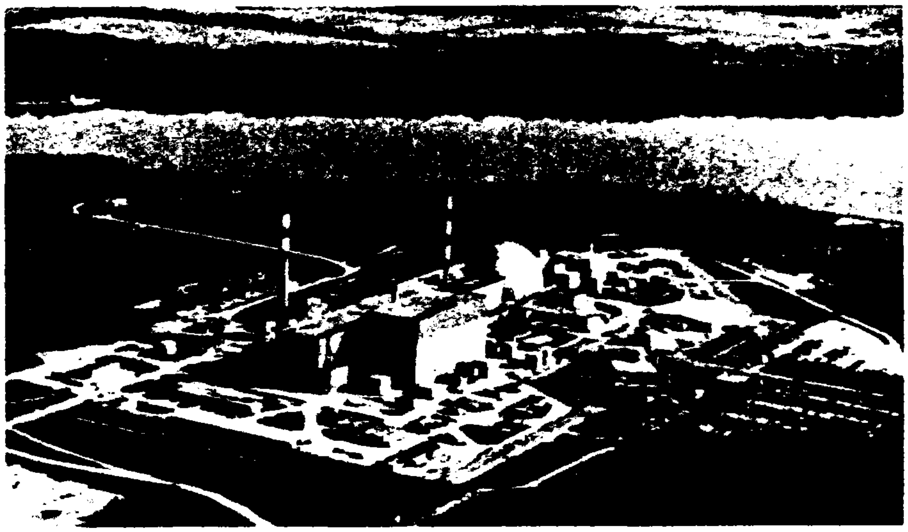
Facility Modifications
Rate Analysis
Energy Use Improvement Plans
Thermal Load Analysis
Energy Policy Review
Utility Load Studies
Energy Source Selection
Design Review of System Modifications
Mechanical Systems Design/Engineering
Life Cycle Cost Analysis

The company's professional staff represents a wide range of engineering, scientific, and technical knowledge in the fields of mechanical nuclear process and civil engineering, natural and social sciences, computer systems, telecommunications, and facilities operations.

Fifty percent of the WESTEC Services' staff have advanced degrees or professional engineering registration. The technical capability of the staff is enhanced by the company's substantial and diversified base of project experience. WESTEC Services is known for providing innovative and effective solutions to complex problems. This reputation is also based on a strong record of on-time and in-budget performance.

The company's business philosophy is to provide highly experienced professional and technical staff, supported by a management framework designed to our client's needs. The result has been a broad base of clientele who, on a continuing basis, rely on WESTEC Services for expert support.

When your project or business activities require the types of services our firm provides, call us to discuss your needs and explore ways in which we can serve you.



Dresden Station of Commonwealth Edison is one of several nuclear facilities being evaluated for flood hazards by WESTEC Services, Inc.

Power Systems Engineering Capabilities

WESTEC Services has been providing power systems engineering since 1974 in response to a growing demand for services in the areas of alternative, nuclear and fossil energy systems. With a staff comprised primarily of electrical, mechanical, and fluid systems engineers, the company provides both feasibility and plant/facility engineering services. The staff of experienced professionals is supported by a strong management team with a philosophy of providing close liaison and coordination with the client to ensure the most responsive product.

Power Systems Engineering Services

WESTEC Services has developed an engineering staff that is addressing the Nation's urgent need to achieve energy self-sufficiency. In certain energy development areas such as geothermal production, WESTEC Services has unique experience and is an industry leader in the field. In other, broader aspects of energy development, we have a proven track record of results in handling various types of engineering and analysis requirements. Our service capabilities include:

- ☐ Independent Design Review
- ☐ Power Plant Operation and Maintenance
- ☐ Start-Up/Operations Manuals
- ☐ Licensing/Regulatory Compliance Review
- ☐ Hazard Analysis
- ☐ Probabilistic Risk Assessment
- ☐ Site Selection/Feasibility Studies
- ☐ Heat Transfer System Component Analysis and Testing
- ☐ Mechanical Systems Design & Engineering
- ☐ Construction Management

The energy development and utilization needs of the nation are continually changing. This change requires an integration of conventional sources (coal, nuclear, hydro, oil/gas) and alternative sources (*geothermal, solar, wind*). WESTEC Services is a leader in the change process and is continually working on solutions for tomorrow's energy needs.

Project Experience

The need for energy self sufficiency *in the United States is well* defined. WESTEC Services is involved in developing both conventional and alternative solutions to the Nation's energy problem. Typical of our energy engineering services are the following projects:

- ☐ Operational Assessment Studies for a 10MW (e) Geothermal Power Plant
- ☐ Nuclear Power Plant Systems Design Review
- ☐ Operation/Maintenance of 10MW (e) Geothermal Power Plant
- ☐ Operation/Maintenance of Two Major Geothermal Test Facilities
- ☐ Interim Spent Fuel Storage Installation Risk Analysis
- ☐ Power Plant Safety and Regulatory Compliance Analysis
- ☐ Agricultural Product Processing Plant—Feasibility and Design Studies for Direct Geothermal Resources Use
- ☐ Ethanol Plant Feasibility Studies
- ☐ Agricultural Chemical Plant Energy Conservation Review and Geothermal Energy Utilization Analysis
- ☐ Direct Geothermal Energy Applications to a Mining Process Plant
- ☐ Operation/Maintenance of 5 MW(e) Binary Power Plan
- ☐ Fossil Steam Plant Component Material Deficiency Analysis
- ☐ Mechanical Engineering Design Services for Liquid Natural Gas Compressor
- ☐ Start-Up and Operations Safety Manual Preparation for a 10MW (e) Flash Steam and a 5 MW (e) Binary Geothermal Plant

WESTEC Services will be pleased to provide specific information concerning any of these projects or other completed work we have performed.

Staff/Facilities

WESTEC Services power systems engineering staff operates from two regional centers serving the western and eastern portions of the U.S. The staff consists of experienced power plant and process systems engineers, energy analysts, mechanical and electrical engineers, and other technical specialists necessary for power systems engineering. In addition to years of practical design and operational experience, many staff members hold master's degrees. Supporting the professional staff is a complete organization of drafting, contracts, and administration specialists. Our facilities include the most modern computational and engineering analysis tools.

Water Resources Planning and Engineering

WESTEC Services, Inc. Provides a Wide Range of Water Engineering Services

WESTEC Services and its subsidiary Water Resources Associates provide both surface and groundwater engineering capabilities for issues of water quantity/availability as well as water *quality*. The firm prides itself in its ability to provide state-of-the-art modeling including HEC, SCS and USGS programs for various open channel problems. Groundwater programs such as "The Trescott Model; Groundwater Level Program" by the USGS and "The Finite Element Solution of Steady State Flow" by the HEC of The Army Corps of Engineers, are used for analysis of water level and aquifer characteristics.

WESTEC Services has the inhouse staff capabilities for engineering and technical studies including:

Ground Water Engineering

- ☐ Aquifer Mapping
- ☐ Well Design and Testing
- ☐ Groundwater Quantity/ Quality Evaluations
- ☐ Pollution Control Systems
- ☐ Water Rights Determination
- ☐ Aquifer Pollution Studies in Support of Litigation Actions
- ☐ Groundwater Contouring
- ☐ Water Adequacy Reports
- ☐ Deep Soil Moisture Evaluations
- ☐ Lake Design/Seepage Control Studies

Surface Water Engineering

- ☐ Flood Control/Retention System Design
- ☐ Drainage and Storm Sewer Design
- ☐ Water Surface Profiles
- ☐ Water Transmission/Storage/ Distribution System Design
- ☐ Pump Station and Facilities Design
- ☐ Water Rights Investigation/ Consultation Litigation
- ☐ Regional Basin Modeling
- ☐ Natural & Designed Channel and Canal Systems
- ☐ Sanitary Sewerage Systems
- ☐ Reservoir and Dam Design

In addition to engineering services in the above areas, the company frequently provides expert testimony. Members of the firm have appeared on behalf of certain clients before the United States Supreme Court in three major water cases. Numerous appearances have been made before state courts and regulatory bodies throughout the Southwest.

Program Experience

WESTEC Services through its subsidiary Water Resources Associates, has served both the public and private sectors of the states of Arizona, Colorado, New Mexico, Nevada, Texas and California for the past 16 years. The firm has a successful history of achievement and experience in the planning and design of water, wastewater and flood control projects, and has consistently produced work of the highest quality and standards including the following:

Resource Development Industry/Utilities

Salt River Flood Plain Studies for Protections of the Arizona Public Service Power Plant

Water Rights and Water Acquisition Studies for the Arizona Public Service

Flood Control and Water Supply Development for Cyprus Bagdad Copper Company's Mill and Mine Expansion

Evaluation and Source Determination of Contamination of Fresh Ground Water in Eastern New Mexico for EXXON USA

Water Acquisition and Water Rights Study for Phelps Dodge Corporation's Smelting Operation Playa Basin and Grant County, New Mexico

Pollution Control Monitoring Engineering for Southwest Forest Industry's Paper Mill and Wood Treatment Plant, Snow Flake, Arizona

Municipal, State, Federal Government

The Indian Bend Wash Flood Control Project Including Open Channel Engineering and Design, Bridge Hydraulics and Flood Damage Studies for a 15 mile Floodway through the cities of Scottsdale, Paradise Valley, and Phoenix

Prepared for the State of Arizona—Hydrologic Modeling, Water Quality Study, and Water Rights Determinations for the Colorado River Basin

Bridge Hydraulics Design, Scour Analysis, River Channelization and Bank/Abutement Protection Design for the 16th Street Bridge at the Salt River, Tuthill Road Bridge on the Gila River and the Gilbert Road Bridge at the Salt River

Expert Testimony before the U.S. Supreme Court on Water Rights Issues between the States of Texas and New Mexico

Land Development

Water Acquisition and Engineering, Angel Fire Development, New Mexico

Hydraulic Studies and Flood Control Systems Engineering, Sun City

McCormick Ranch Hydrology Studies and Flood Control Systems Engineering. Coordination of City of Scottsdale development with contiguous U.S. Army Corps of Engineers Projects in Indian Bend Wash

Biological Resource Capabilities

WESTEC Services' Biological Resource Group was established in 1972 to respond to the growing need of government and industry for biological evaluation. The philosophy of this group of scientists and technicians is to provide high quality resource evaluation with an eye towards integrating the developmental requirements of our clients with the protection of the nation's limited and sensitive resources. In summary, it is a group of respected professionals seeking solutions to complex problems.

WESTEC Provides a Wide Range of Biological Services

WESTEC Services' staff specializes in the performance of comprehensive biological resource surveys throughout the United States. The firm prides itself on its past record of conducting biological surveys of the highest technical quality using state-of-the-art techniques within very constricted time frames. In addition, the Biological Resource Group regularly conducts resource management studies involving sensitive plant and wildlife species and riparian/marshland habitats.

The Biological Resource Group has in-house capabilities for highly specialized technical studies of various biological and ecological systems. These systems include:

- ☐ Mammalian populations in western ecosystems
- ☐ Rare, threatened, and endangered plant and animal species in the western United States
- ☐ Comprehensive botanical resource evaluations
- ☐ Bat populations and ecological requirements in the western United States
- ☐ Avian resources within riparian habitats
- ☐ Wetland ecosystems
- ☐ Amphibians and reptiles, particularly desert tortoise
- ☐ Specialized waterfowl and raptor studies
- ☐ Specialized revegetation studies
- ☐ Marine ecosystems

Further, the group has specialized impact analysis capabilities for energy-related projects including geothermal development, solar pond development, oil and gas development, fossil fuel power plant development, electrical transmission line construction, and military facilities.

Program Experience

The Biological Resource Group has completed biological resource studies ranging from simple habitat evaluation programs to comprehensive inventories requiring many man-months of field effort.

Major studies and field programs have been conducted within the States of California, Nevada, Utah, Arizona, and New Mexico, requiring close liaison and consultation with state and federal agencies. These studies include:

Military Installations

Riparian Habitat Assessment—MX missile sites in Utah and Nevada

Biological Impact Evaluation of Operational Bases—MX missile system, Utah, Nevada

Biological Impact Evaluation/Resource Management Plans—Naval Weapons Center, China Lake

Biological Resource Evaluation/Resource Management Plan—Pacific Missile Test Center

Least Tern Analysis—Mitigation Program, NAS North Island

Oil/Gas Development

Terrestrial/Marine Biological Studies for the Shell Oil Molino Gas Field Development

Terrestrial/Marine Biological Studies for Union Oil Company's Pt. Conception Oil Field Development, Santa Barbara Channel

Terrestrial Biological Studies for the Southwest Gas Company's Storage Complex, Kingman, Arizona

Energy Generation/Transmission

Terrestrial/Marine Biological Evaluation of the Southern California Edison Company's Salton Sea Solar Pond Generating Station

Biological Studies for the Southern California Edison Company's Lucerne Valley Generating Station and Transmission Corridors

Rare and Endangered Species Studies, Cal Coal Project, Ivanpah Valley

Biological Studies for the San Diego Gas & Electric Company's Mexican Interconnection Transmission Corridor

Staffing

WESTEC Services' Biological Resource Group consists of a staff of 15 full-time professional biologists with expertise in the fields of botany, mammalogy, herpetology, ornithology, aquatic/marine biology and environmental biology. All staff members have advanced degrees, with many at the doctoral level. Biologists are based in the major offices of WESTEC Services.

The Biological Resource Group maintains four-wheel-drive vehicles equipped for use in remote areas. In addition to field vehicles, the group maintains a small travel trailer as a field laboratory, as well as a full complement of specialized field equipment. WESTEC Services' in-house computer system has full capabilities for standard biometric analysis, as well as specialized wildlife and botanical analysis.

WESTEC Services has appropriate general collection permits for various states, as well as permits for collection of specific rare and endangered species.

Cultural Resource Capabilities

WESTEC's Consulting Approach Philosophy

WESTEC Services' Cultural Resource Group was established in 1972 to respond to the growing need of government and industry for cultural resource evaluation. The philosophy of this group of scientists and technicians is to provide high-quality resource evaluation aimed at integrating the developmental requirements of our clients with the protection of the nation's limited and sensitive resources.

WESTEC Provides a Wide Range of Cultural Resource Services

WESTEC Services' staff specializes in the performance of comprehensive cultural resource surveys throughout the western United States. The firm prides itself in its ability to conduct cultural resource surveys of the highest technical quality, using state-of-the-art techniques, within very constricted timeframes. In addition, the cultural resource staff regularly prepares research designs and resource management plans for sensitive resources and implements these plans through controlled testing and salvage programs.

The Cultural Resource Group has in-house capabilities for specialized technical studies. These studies include:

- ☐ Cultural Resource Overview Studies (Class I Inventory)
- ☐ Local and Regional Sampling Studies (Class II Inventory)
- ☐ Local and Regional Intensive Surveys and Testing Programs (Class III Inventory)
- ☐ National Register Assessment Programs
- ☐ Resource Management Planning and Mitigation Program Development
- ☐ Specialized Expertise in Archaeological and Historical Resources
  - Great Basin
  - Southwestern Deserts
  - Coastal
- ☐ Marine Archaeology Assessment

Program Experience

Over 700 cultural resource studies have been conducted by the Cultural Resource Group for federal, state, county, and city agencies. These studies have focused principally on Environmental Impact Statements and Reports prepared in accordance with the National Environmental Policy Act (NEPA) and similar legislation. In addition, the Cultural Resource Group has conducted numerous pre-development environmental inventory or baseline studies which have been used in project planning and design to avoid impacts to significant environmental resources. Major projects completed by the Cultural Resource Group include:

Federal

Class I Historical Land Use Study for the BLM California Desert Conservation Plan

Class II Cultural Resource Inventory of the Central Mojave and Colorado Deserts for the BLM California Desert Conservation Plan

Class I and II Cultural Resource Inventories for George Air Force Base

Oil/Gas Development

Class I and II Surveys for the Southwest Gas Company's Storage and Distribution Center, Kingman, Arizona

Class II Surveys for Shell Oil Company's Molino Gas Field Onshore Facilities and Transmission Systems

Resource Clearance Surveys for Petroleum Seismic Surveys Throughout Nevada and Arizona

Energy Generation/ Transmission

Class II and Class III Cultural Resource Inventory, National Register Assessment and Mitigation of Impacts for the Southern California Edison Company's Devers, California to Palo Verde, Arizona Transmission Corridor

Class III Cultural Resource and National Register Assessment for San Diego Gas & Electric's Black Star Canyon to San Onofre Generating Station Transmission Corridor

Class II Cultural Resource Inventory and Facility Siting Study for the Niland Known Geothermal Resource Area

Urban Development

Resource Management and Mitigation Implementation for the AVCO Corporation's Rancho Bernardo Development

Staffing

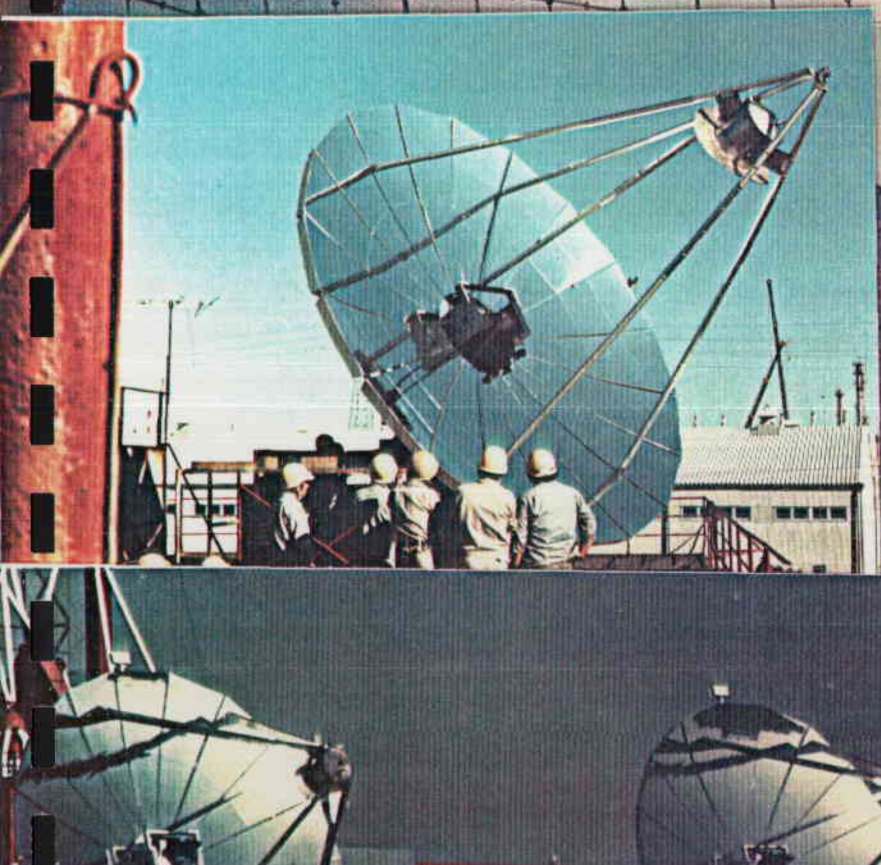
In all, WESTEC Services' Cultural Resource Group has over 25 full- or part-time archaeologists and historians. Principal Investigators all have Master's degrees either in anthropology/archaeology or history and are certified by the Society of Professional Archaeologists (SOPA). In addition, WESTEC has on its staff highly skilled field personnel with experience in survey and excavation in the Great Basin, southern deserts, and coastal regions. Consultants complement WESTEC's full-time employees for specialized radiocarbon and pottery analysis, as well as paleoenvironmental inquiries and Native American involvement.

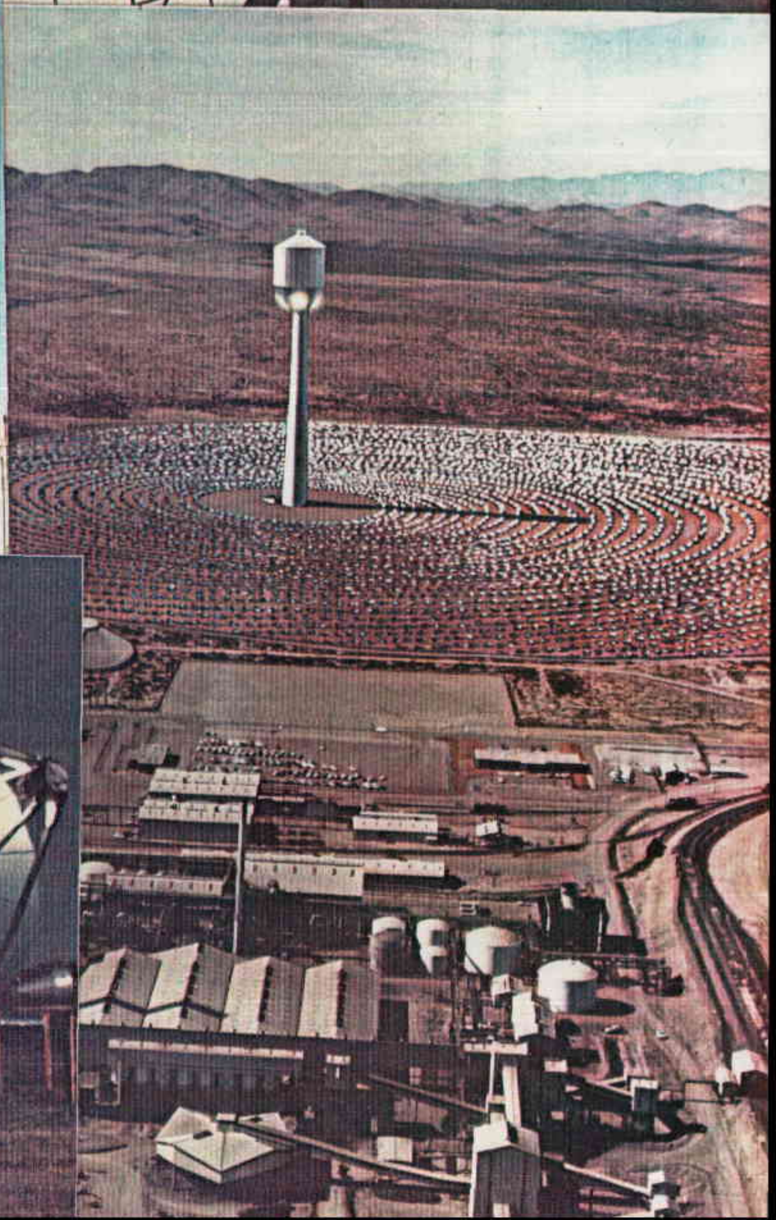
Permits

WESTEC Services possesses Antiquity Permits for California, Arizona, Nevada, and New Mexico. In addition, WESTEC has obtained, and will continue to obtain, Special Use Permits for those federally-administered lands not covered by Antiquity Permits. Investigations in states not specifically covered by WESTEC Antiquity Permits are directed by WESTEC consultants who possess the necessary permits.

WORLDWIDE INSTALLATIONS

Mirror on the Sun





WORLDWIDE SYSTEM INSTALLATIONS

SYSTEM CUSTOMER	LOCATION	USE
1. Dept. of Agriculture	El Marj, Libya	Water pumping for greenhouse
2. Solar Energy Research Institute (SERI)	Golden, Colorado	Carter Dedication; demonstration and evaluation
3. University of Houston	Houston, Texas	Development of chemical storage system
4. University of Washington	Seattle, Washington	Extra-terrestrial lasers and satellite-to-earth energy transmission
5. SERI	Golden, Colorado	Evaluation for industrial processes
6. Jet Propulsion Laboratory (JPL)	Edwards Air Force Base, California	Evaluation for small power systems
7. Government of Sri Lanka	Tangalle, Sri Lanka	United Nations Demonstration Village
8. Bharat Heavy Electricals, Ltd. (BHEL)	Hyderabod, India	Evaluation for Village Power System
9. Fiat	Brindisi, Italy	Power for employee food services facility
10. University of Queensland	Brisbane, Australia	Evaluation for rural use
11. Korean Institute of Science and Technology (KIST)	Kaeya Island, Korea	Evaluation for fishing village on small island
12. Omnium-G	Anaheim, California	Sales demonstration unit
13. Rocket Propulsion Laboratory (RPL)	Edwards Air Force Base, California	Evaluate rocket engine nozzle performance
14. Southern New England Telephone Co. (SNETCO)	Bethany, Connecticut	Power and heat for telephone switching building
15. Texas Tech University	Lubbock, Texas	Irrigation pumping
16. Texas Tech University	Lubbock, Texas	Irrigation pumping
17. Martin-Marrieta Co.	Orlando, Florida	Heat engine development

18. C. Itoh	Kawasaki, Japan	Heat for chemical processes
19. Omni-Sunergy, Inc.	Elgin, Illinois	High termerature processes
20. Omni-Sunergy, Inc.	Elgin, Illinois	Same--second facility
21. Omni-Sunergy, Inc.	Elgin, Illinois	Same--third facility
22. Omni-Sunergy, Inc.	Elgin, Illinois	Same--fourth facility
23. Omni-Sunergy, Inc.	Clementon, New Jersey	Same--fifth facility
24. Continental Energy, Corp.	Monument, Colorado	High temperature processes
25. Continental Energy Corp.	Colorado Springs, CO	High temperature processes
26. Orangethorpe Industrial Park	Anaheim, California	High temperature processes

CONCENTRATOR COST ANALYSIS (JPL)

5105-23
Solar Thermal Power Systems Project
Parabolic Dish Power Systems
Module Development

Cost Analysis of the Omnium-G System 7500 in Selected Annual Production Volumes

C. A. Blake

May 1980

Prepared for
U.S. Department of Energy
Through an agreement with
National Aeronautics and Space Administration
by
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Prepared by the Jet Propulsion Laboratory, California Institute of Technology, for the U.S. Department of Energy through an agreement with the National Aeronautics and Space Administration.

The JPL Solar Thermal Power Systems Project is sponsored by the U.S. Department of Energy and forms a part of the Solar Thermal Program to develop low-cost solar thermal and electric power plants.

ACKNOWLEDGMENT

The ability and talent of Virginia McAnulty and Sonja Dieters in producing the drawings and illustrations for this report were of immeasurable value. The authors wish to acknowledge this contribution and express their gratitude.

The JPL Parabolic Dish Test Site is now operating in the Mojave Desert at Edwards Test Station.

This site provides a testing ground for solar dish systems and their components. Designed as a user test facility, the site is equipped with precision instruments to measure concentrator performance, solar intensity (called insolation), and meteorological and environmental factors. A complete minicomputer and data system acquires, stores, and compares test data.

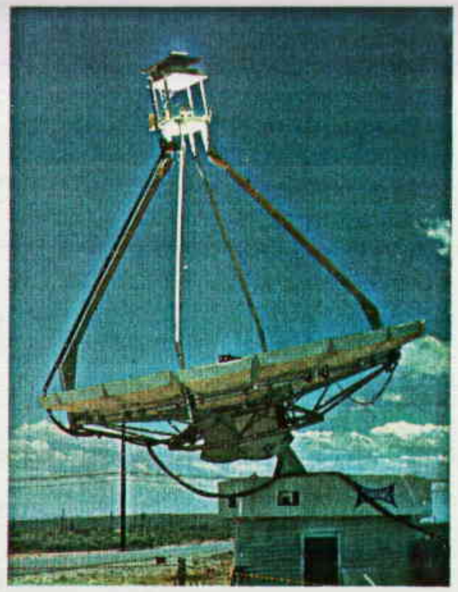
Currently there are four concentrators on site: the two recently completed Test Bed Concentrators that will be used in field tests of receiver and engine designs, the precursor concentrator used in calibrating equipment and early mirror testing, and an Omnium-G commercial concentrator used in early experiments and the development of test equipment.

Future plans call for the installation and testing of the General Electric Low-Cost Concentrator as well as for installation of other concentrators and their associated subsystems.

Precise measurement of concentrator performance is obtained with a Flux Mapper and a Cold-Water Calorimeter. The Flux Mapper directs an absolute energy-flow sensor through a programmed three-dimensional track to map the accuracy of solar concentration as well as the efficiency of the reflector surface. The Cold-Water Calorimeter measures the rise in temperature of a known water-flow rate to determine the total solar energy that the system concentrates.

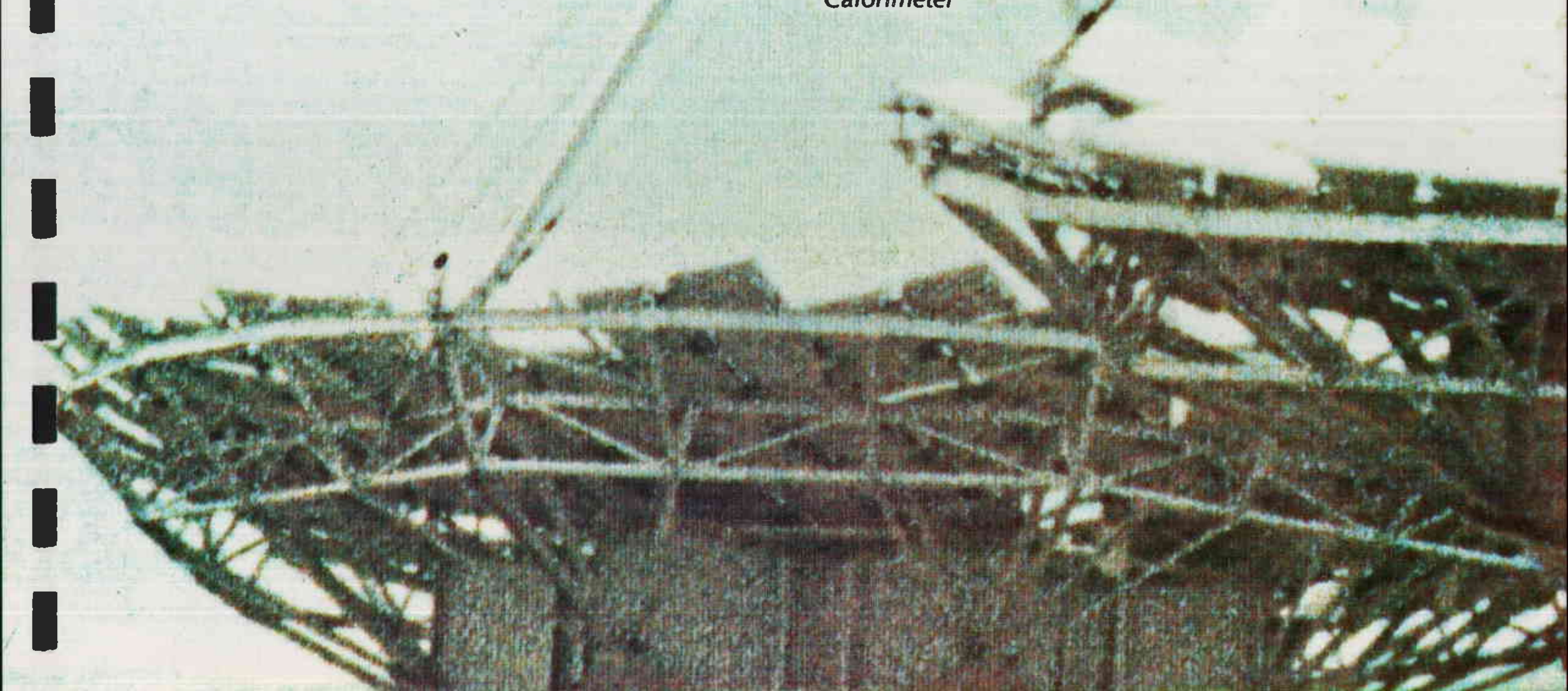
The Omnium-G, the first commercial point-focusing dish system, provided JPL test engineers with an opportunity for acquiring operational experience with a complete point-focus collector.

Flux Mapper



Omnium-G

Calorimeter



CONTENTS

Figures (Cont)

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SECTION I

INTRODUCTION

The objective of this study was to develop accurate cost numbers for the Omnium-G System 7500* in annual production quantities of 25, 100, 25,000 and 100,000 units. The results of the study are to serve as a "baseline" to which the cost of other point-focusing distributed receiver systems can be compared. All costs are expressed in 1979 dollars.

The information contained herein is for a complete Omnium-G System 7500 which is rated at 7.5 kW electrical and 30,000 BTU thermal (nominal). These performance figures were supplied by the Omnium-G Company.

The Omnium-G System 7500 concentrator** (Figure 1-1) is a parabolic dish, six meters in diameter, composed of 18 mirrored petal segments. This assembly is articulated in elevation and azimuth enabling it to track the sun from horizon to horizon. The mirrored segments are fabricated from electrochemically polished aluminum bonded to a polyurethane foam substrate.

The concentrator focuses the rays of the sun onto a receiver that is 3.9 meters in front of the center of the mirror. This receiver acts as a heat exchanger by boiling water contained within a helical tube thus producing steam. The steam ultimately powers a steam engine generator which produces electricity.

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* Solar-powered electrical plant manufactured by the Omnium-G Company, Anaheim, California.

**The term concentrator includes the reflector, supports, and foundation of the System 7500.

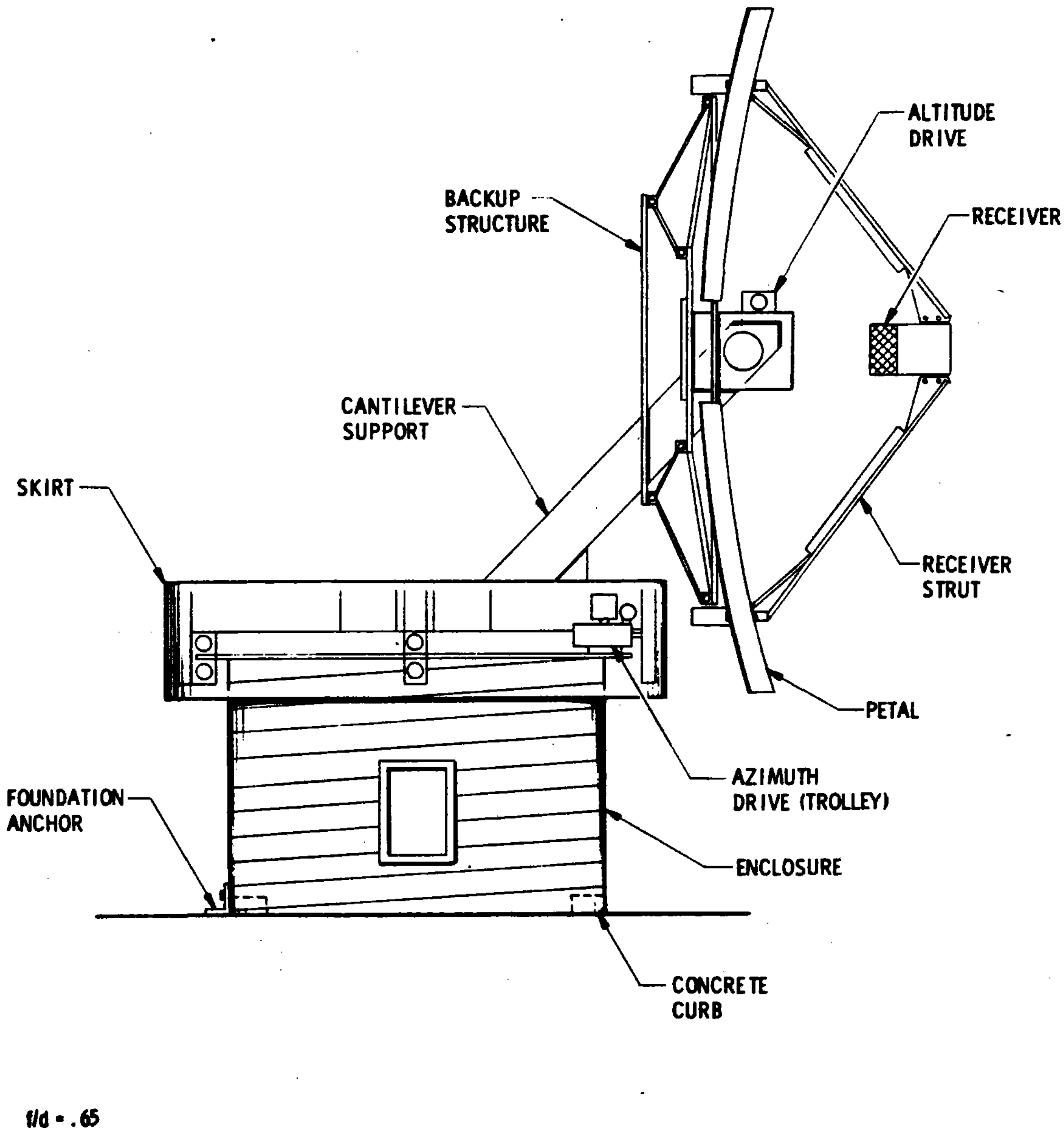


Figure 1-1. Omnium-G System 7500

SECTION II

SYSTEM COMPONENTS

The basic components and sub-units of the total system were classified as follows:

A. RECEIVER

B. REFLECTOR

1. Backup Structure

2. Reflective Surface (Petals)

C. BASE STRUCTURE

1. Support

2. Enclosure

3. Transport Line

4. Azimuth Control and Trolleys

5. Elevation Mechanism

D. SENSORS AND CONTROLS

E. STEAM ENGINE

F. PREHEATER

G. CONDENSER

H. HOTWELL

J. POWER CART

A description of each system component is provided in the corresponding subsection.

A. RECEIVER

The receiver (converter) consists of an outer body composed of #316 stainless steel, and an inner container of stainless steel and Inconel materials. The balance of the receiver is composed of insulation, #304 and #316 stainless steel tubing, a temperature probe, stainless steel fittings and 75 lbs. of pure aluminum.

At the present time the manufacturing is accomplished with standard machine shop equipment, power sheet metal shears, automatic cutting torches, small power tools and tungsten inert gas (T.I.G.) welding.

B. REFLECTOR

1. Backup Structure

The reflector is supported by a backup structure which is composed of polygonal supports, yoke assemblies and converter support legs. The entire backup structure is fabricated by using standard shop practices: electric hack saw, milling machine, T.I.G. welding, etc. Assembly is by heliarc welding and the use of standard fasteners.

a, Polygonal Supports. The three regular nine-sided polygons are composed of:

(1) An outer ring of: #6063 aluminum alloy tubing having a 3.00 in. outside diameter x .049 in. wall. Fabrication is by welding.

(2) An inner ring whose fabrication is similar to the outer ring.

(3) A truss ring whose fabrication is similar to the outer ring.

(4) Struts (27 required) of: #6063 aluminum alloy tubing having a 1.5 in. outside diameter x .049 in. wall. Fabrication is by welding.

b. Yoke Assembly. This is a heavy box assembly, welded and fabricated from heavy plate #6061 aluminum alloy, which is then welded to the inner ring. The entire backup structure pivots about a shaft which is connected to this assembly. More detail will be provided in discussion of the elevation mechanism.

c. Converter Support Leg. Four receiver support legs are clamped 90° apart around the outer ring of the backup structure. These hold the receiver at the focal point of the mirrors. The legs are a welded assembly, consisting of aluminum tubing, channel, plate and sheet metal. No special tooling or fixtures are required.

2. Reflective Surface (Petals)

Eighteen mirror segments or petals comprise the reflective surface of the concentrator.

Each petal consists of three mirror segments of electrochemically polished aluminum (Alzak) bonded to a polyurethane foam substrate. This is accomplished by placing the mirror segments face down in a mold, applying the polyurethane foam to the back surface of the mirrors and allowing it to foam in situ. When the foam substrate hardens, the mirror assembly is removed from the mold and is permitted to complete the cure cycle. Mounting cleats are installed and a conformal coating is applied to the cured foam substrate.

Two strut mounting assemblies are required per petal. These consist of a purchased tie rod end, a muffler clamp and a welded bracket.

C. BASE STRUCTURE

The base structure consists of a cantilever support with decking, and a base enclosure with an azimuth track.

1. Support

The cantilever support is made from standard structural steel channel, an "H" beam, heavy plates and sheet metal. No special tooling is required for fabrication other than a welding fixture. The support is a completely welded structure.

2. Enclosure

The base enclosure is made from a 10 foot section of Kaiser aluminum culvert stock and an azimuth track fabricated from heavy plate which is installed on the upper lip. No special tooling is required other than some simple fixtures.

3. Transport Line

The transport lines conduct the steam from the receiver to the engine and then return the spent steam, by way of a condenser, to the receiver for conversion into high energy steam. The transport lines are fabricated in four sections of #304 stainless steel. A feed and return line surrounded by insulation is contained in a stainless steel sleeve. The overall length is approximately 27 feet. No special tooling is required. The general construction is by welding and the use of standard fasteners.

4. Azimuth Control and Trolleys

Two trolley assemblies are situated on the front edge of the support structure with their flanged wheels resting on the azimuth track. They are driven by means of two D.C. motors connected by chains and sprockets to the wheels. The general assembly is fabricated from heavy steel plate with purchased parts augmenting the assembly. Fabrication is by means of welding and the use of standard fasteners.

5. Elevation Mechanism

The elevation mechanism is located between the yoke assemblies of the backup structure. It is connected to the yoke by means of two bearing end plates with bolt patterns that correspond to those on each side of the yoke. This complete assembly is pivoted by a tube within a tube; the outer tube being welded to the cantilevered support arm. The inside diameter of the outer tube and the outside diameter of the inner tube act as bearings allowing the entire structure to tilt up and down. The actuation is accomplished by means of a D.C. motor and a gear reduction box situated on a platform atop the cantilever arm. The output shaft of the gear box is connected to one side of the yoke by an adjustable drag link. The fabrication is accomplished with standard machine shop equipment. Assembly is welded and uses standard fasteners.

D. SENSORS AND CONTROLS

Electronic and electromechanical sensors and controls are used to accomplish the following:

(1) Elevation above and below sun

(2) Azimuth left and right of sun

(3) Heat exchanger temperature sensing

(4) Battery charging

(5) Speed servo controls

(6) Clock memory for sun tracking

(7) Photo cells for sun sensing

(8) Electronic circuitry operations

  (a) Amplifiers

  (b) Sensors

  (c) Drivers

(9) Miscellaneous electromechanical operations

(a) Relays

(b) Switches

(c) Indicators

The electronic circuitry is on printed circuit boards, held in caged racks with edge connecting receptacles accomplishing the functional wiring. The balance of the circuitry is contained in a National Electrical Manufacturers Association box, except for such items as limit switches, sensors, etc. that must be located at the source of their function.

E. STEAM ENGINE

The engine is a two-cylinder, sleeve-valve, actuated device driven by steam, which is produced by a point-focusing solar thermal source.

A six unit pilot run of the engine is currently being produced. These are 100% machined from aluminum raw stock, employing standard machine shop equipment and practices. Some rudimentary castings could be justified as the quantity approaches 100 per year. As production nears 25,000 per year, more sophisticated castings and second operations would be in order. At an annual rate of 100,000 units, a fully automated approach with complete foundry facility could be justified with a substantial product cost reduction.

F. PREHEATER

The preheater consists of a jacket through which spent steam flows prior to entering the condenser. A copper tube passes through this condenser carrying water pumped from the reservoir to the receiver.

G. CONDENSER

The condenser reduces spent steam to water which is deposited in a reservoir to be recycled to the receiver. It is a stainless steel construction consisting of an outer jacket and internal tubes supported by header plates.

The condenser is presently being fabricated by hand using standard shop tools and a welded construction. In larger quantities, a straightforward sheet metal shop approach adjusted to quantity requirements would be the best approach.

H. HOTWELL

A "hotwell" is provided to make hot water available. This consists of an 800-gallon corrugated, galvanized steel tank, externally coated with approximately four inches of polyurethane foam insulation. The water is heated by means of a copper tube heat exchanger connected to an engine exhaust steam line. The hotwell has a self-contained pump, solenoid valves and a radiator that can move water or dump heat as required.

At present the tank is purchased and the components and insulation are assembled in-house. For quantities up to 100,000/year, it would be a simple matter to create a total in-house capability by establishing a conventional sheet metal shop.

I. POWER CART

The power cart is a weldment consisting of a reservoir tank upon which is mounted the power generating components. This power cart includes the steam engine, preheater and condenser. Also included are the generator, D.C. sustainer motor, oiler, pump, magnetic clutch and miscellaneous controls.

The alternator is driven by the sustainer motor on battery power until sufficient pressure head is built up for the steam engine to take over. At this point, a magnetic clutch is engaged allowing the engine to drive the alternator. The sustainer motor then operates as a D.C. generator for battery charging and other functions.

Other required items are: a positive displacement pump to supply water to the receiver, an automatic oiler for engine lubrication, and miscellaneous plumbing and controls.

SECTION III

COSTING METHODOLOGY

Each part, assembly, and subassembly was identified and documented, as little information of this nature was available from the manufacturer. This necessitated visiting the facility and examining the various components, taking measurements, making pertinent notes and sketches, and then preparing the necessary dimensioned drawings. These drawings were used to prepare parts lists which identify the component parts, their basic breakdown and general sequence of assembly. The raw material and purchased parts were then identified and itemized. These were costed for a production run of 25 per year by examining the manufacturers' purchasing records and extracting the actual costs of the parts. This information was transferred to the parts lists. Appendixes A through E contain the detail drawings, costs and parts lists employed in this study's evaluation of the Omnium-G System 7500.

Capital equipment and tooling costs were not estimated. Labor costs were calculated based upon direct observation of parts manufacture. A figure of $10.00 per hour was applied as direct labor. The basic information provided by the Omnium-G Company reflects costs at a present production rate of approximately 25 units per year.

An in-depth investigation was undertaken to determine price reductions for annual quantities up to 100,000 units. Dramatic decreases can be realized with the greater quantities. For example, aluminum used at the present production rate (approximately 25 units per year) is purchased as needed through retail dealers. As the volume increases, quantity discounts are minimal from this source. At higher production levels, one may purchase wholesale lots at considerable savings. Again, as volume increases, it is more profitable to purchase directly from the mill. Although there is little difference between the price of tubing, plate, or sheet at this point, a price differential would exist for various alloys. For example, small quantities of tubing might cost over $3.00 per lb. from a dealer, but this price could decrease to less that $1.20 per lb. when purchased from a mill.

SECTION IV

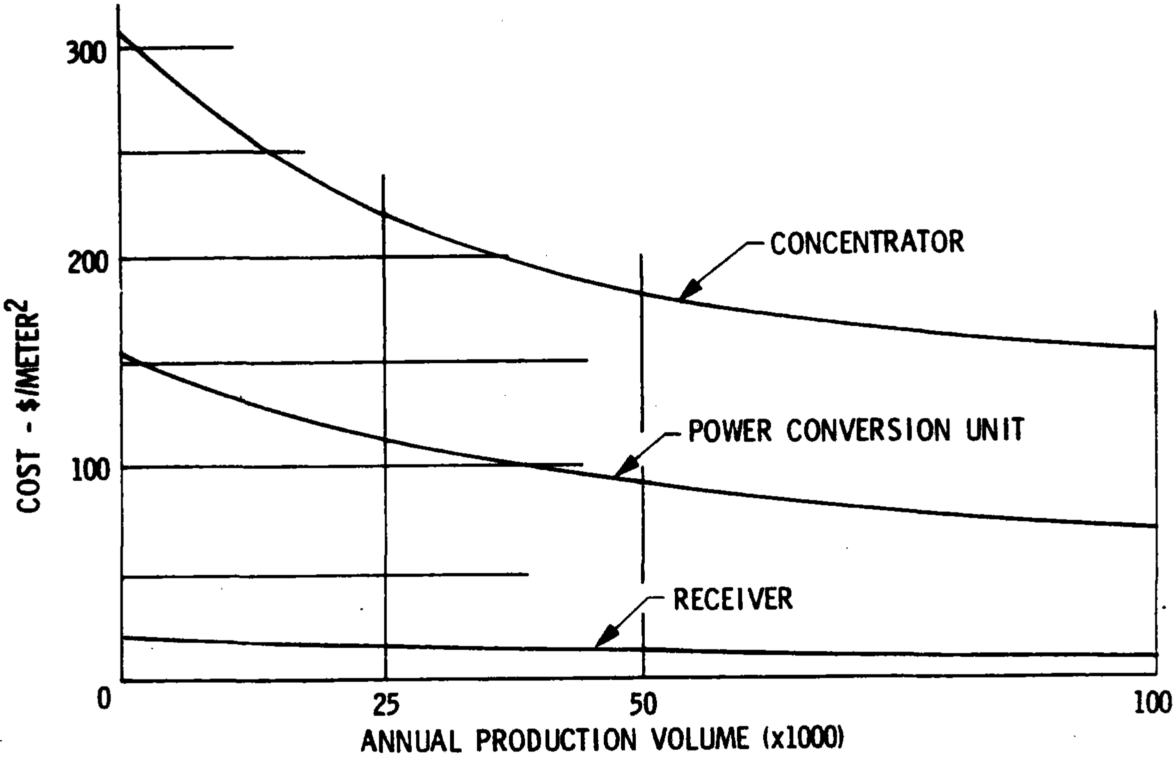
RESULTS

The cost results reported in this study reflect annual production quantities of 25, 100, 25,000 and 100,000 units. All costs are expressed in 1979 dollars.

Table 4-1 presents the cost of a complete Omnium-G System 7500 reduced to basic labor and material. The curves in Figure 4-1 represent the cost of each of the major components (concentrator, power conversion unit and receiver) of the Omnium-G System 7500 in dollars per square meter of concentrator area. The cost of a complete Omnium-G System 7500 in dollars per square meter of concentrator area is shown by the curve in Figure 4-2. Figure 4-3 is a bar chart illustrating the cost of a complete Omnium-G System 7500 as a function of production volume.

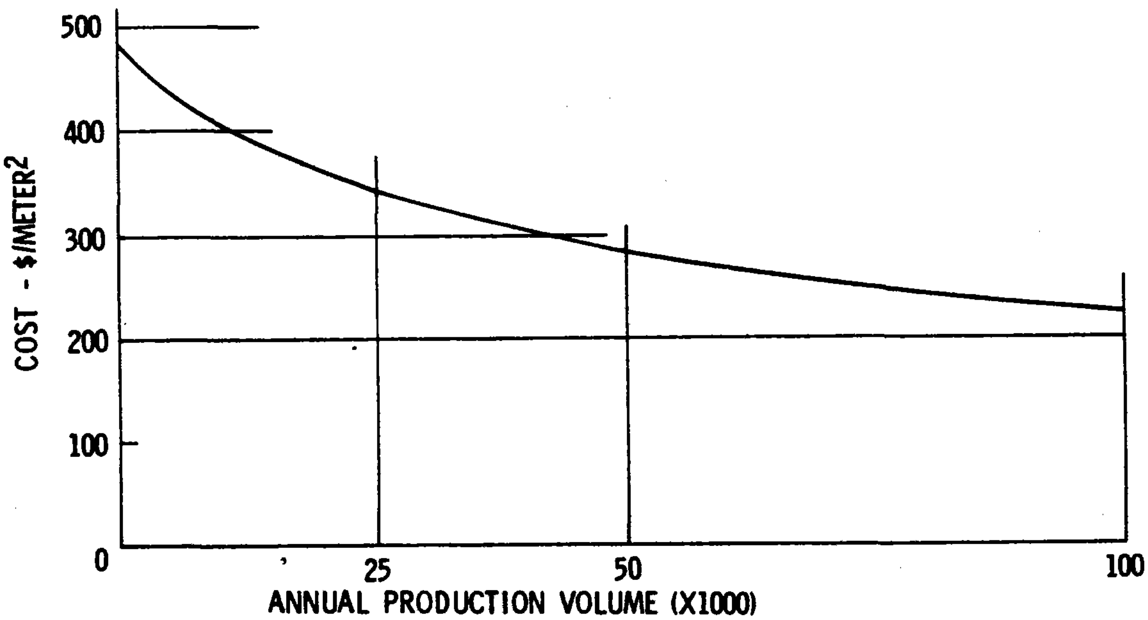
Table 4-1. Production Quantities and Costs Per Unit

SUB-ASSEMBLY	25 Units		100 Units		25,000 Units		100,000 Units	
	Material	Labor	Material	Labor	Material	Labor	Material	Labor
Receiver Assembly	391.27	120.50	378.57	114.50	291.20	80.15	213.55	45.80
Backup Structure	476.57	171.10	379.17	162.50	270.63	113.80	155.56	65.00
Petal Assembly	3,066.84	78.00	2,877.63	75.00	2,100.60	30.00	1,540.29	13.40
Receiver Strut	169.24	17.90	166.00	17.00	126.46	12.00	93.08	6.80
Cantilever Support	842.78	151.60	743.98	144.00	565.24	100.80	420.38	57.60
Elevator Mechanism	601.37	44.70	586.14	42.50	451.03	29.75	330.35	17.00
Azimuth & Trolley Assembly	746.18	93.20	642.96	88.50	494.69	62.00	362.70	35.40
Yoke Assembly	175.34	73.70	170.95	70.00	119.67	49.00	70.14	28.00
Base Assembly	336.61	82.60	326.29	78.50	252.46	55.00	198.89	31.40
Electrical	288.50	85.80	288.50	81.50	216.38	57.10	156.68	32.60
Foundation	550.05	766.20	550.05	727.85	385.04	673.25	220.02	545.89
Steam Engine	123.15	335.50	123.13	318.70	92.34	218.30	73.88	127.50
Condenser	41.85	23.00	41.85	21.80	31.39	15.26	25.11	8.70
Preheater	20.40	11.60	20.40	11.00	15.30	7.70	12.24	4.40
Hotwell	797.96	30.50	797.96	29.00	638.37	20.40	478.77	11.60
Power Cart	2,396.89	73.70	2,396.89	70.00	1,797.66	49.00	958.75	28.00
Transport	438.77	39.30	438.77	37.33	329.08	13.63	223.77	5.98
TOTALS	11,463.75	2,199.90	10,929.24	2,089.68	8,177.54	1,587.14	5,534.16	1,065.07
GRAND TOTALS (MATERIALS + LABOR)	$13,663.65		$13,018.92		$9,764.68		$6,599.23	



NOTE: COSTS ARE IN 1979 DOLLARS

Figure 4-1. Component Cost per Meter^2 of Concentrator Area



NOTE: COSTS ARE IN 1979 DOLLARS

Figure 4-2. System Cost per Meter^2 of Concentrator Area

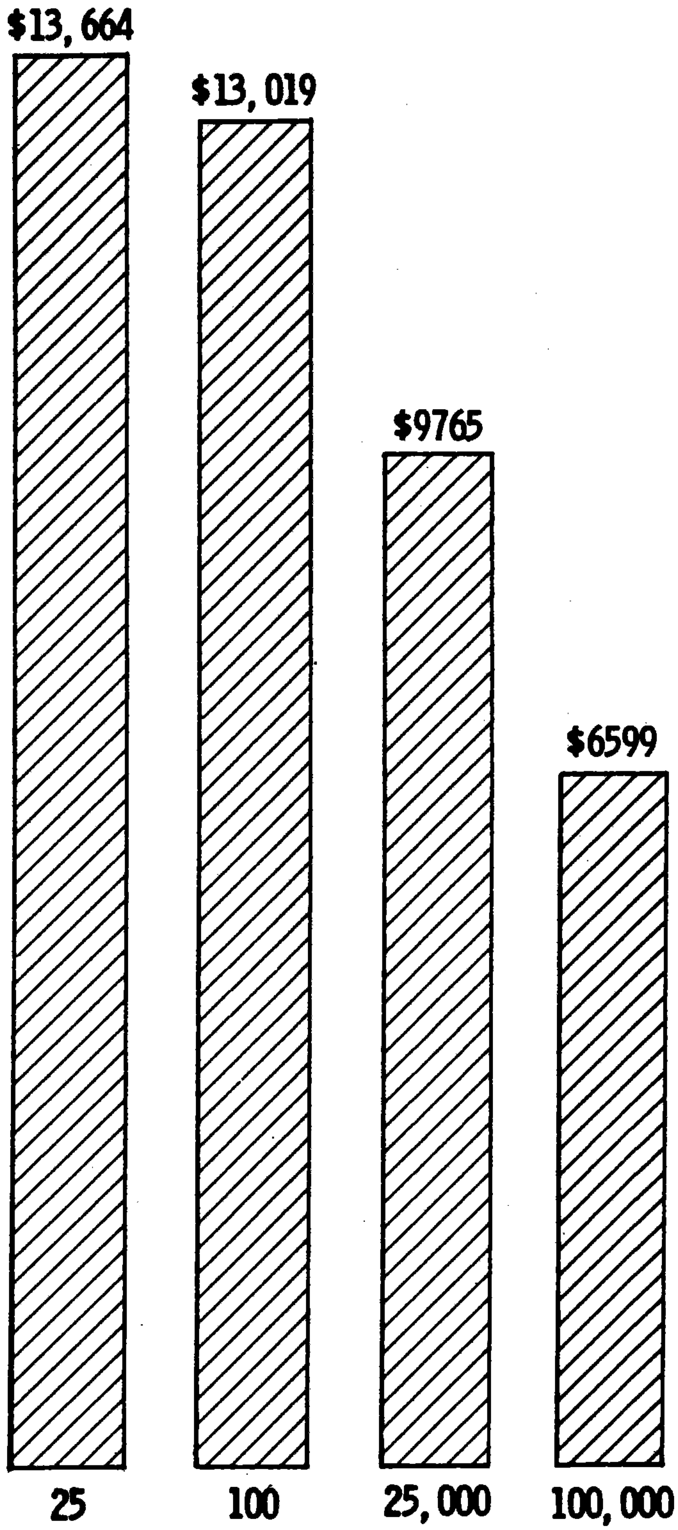


Figure 4-3. Cost as a Function of Annual Production Volume

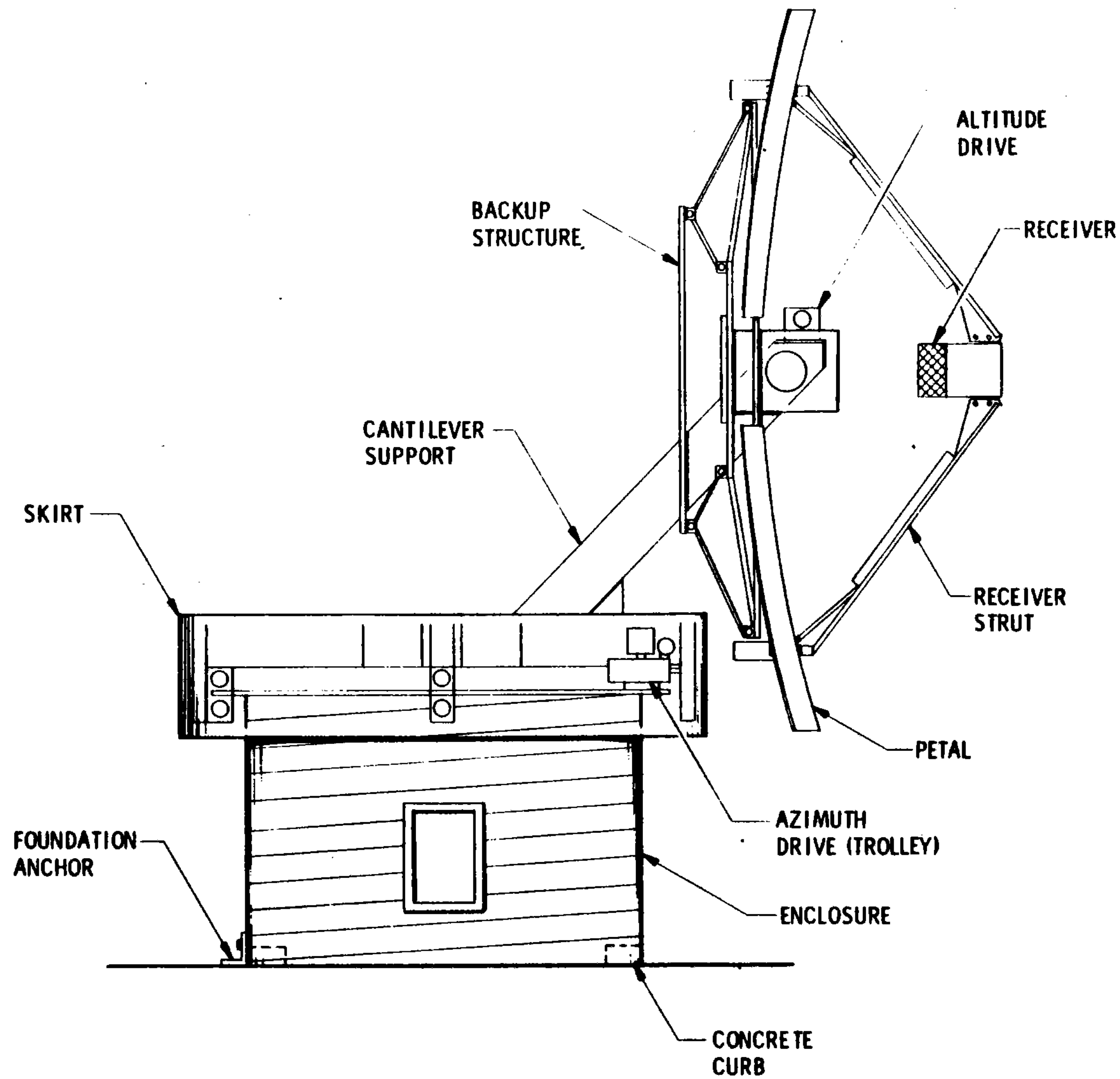


Figure A-1. Omnium-G System 7500

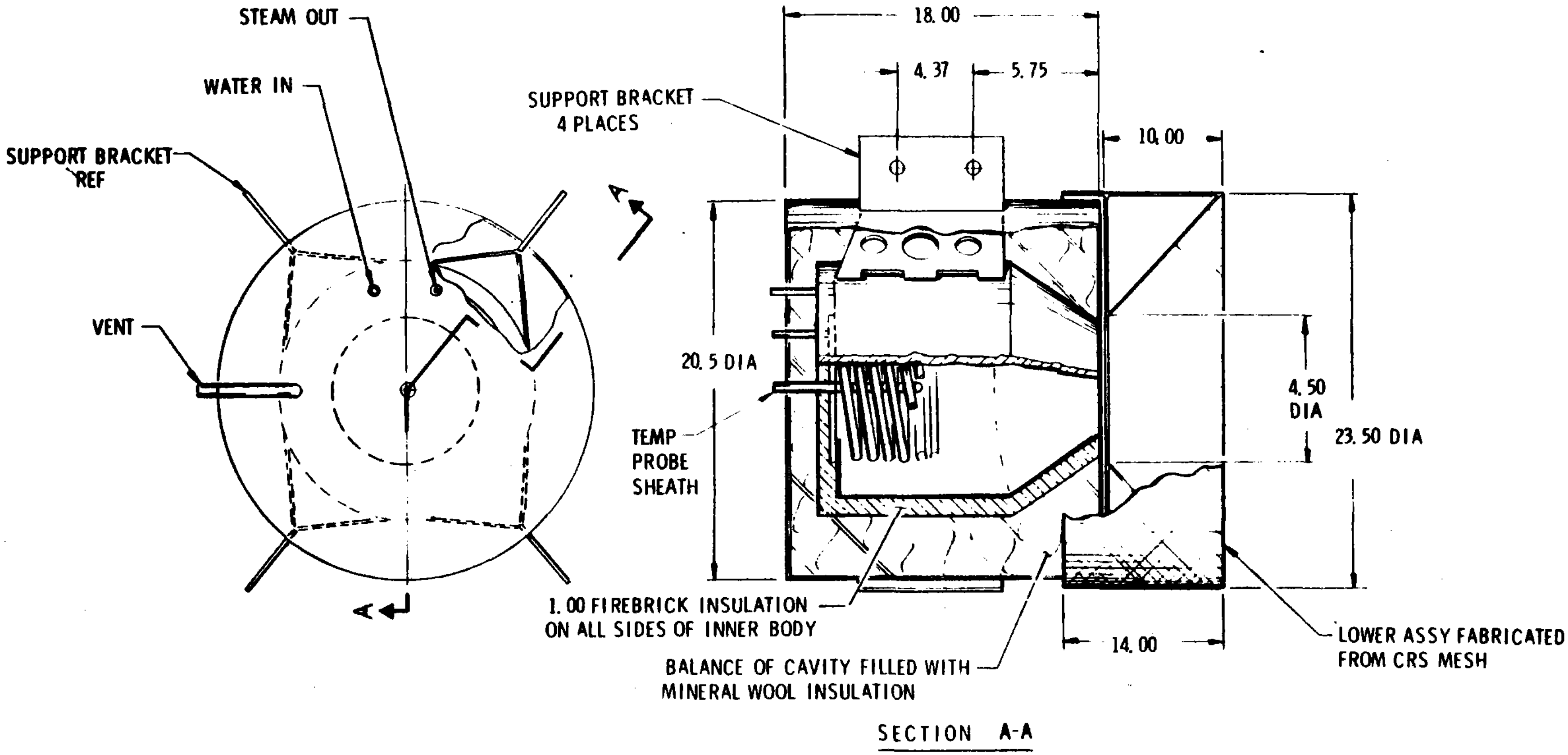


Figure A-2. Converter (Receiver) Assembly, Steam Engine

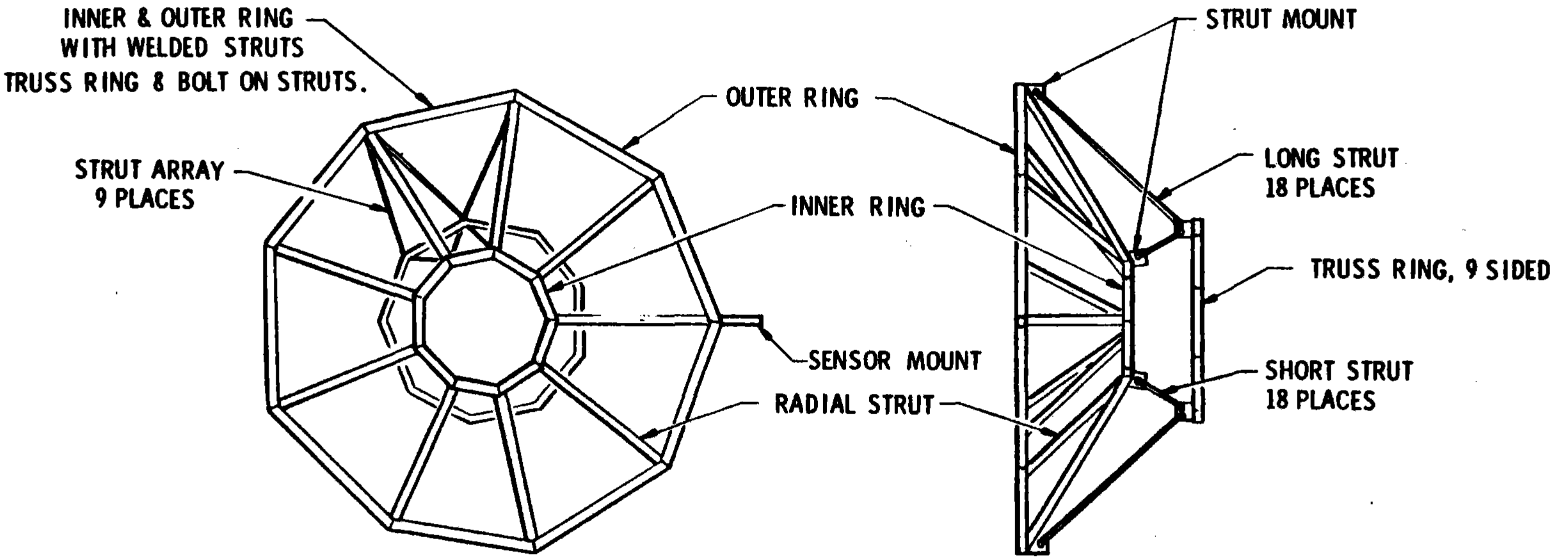


Figure A-3. Backup Structure

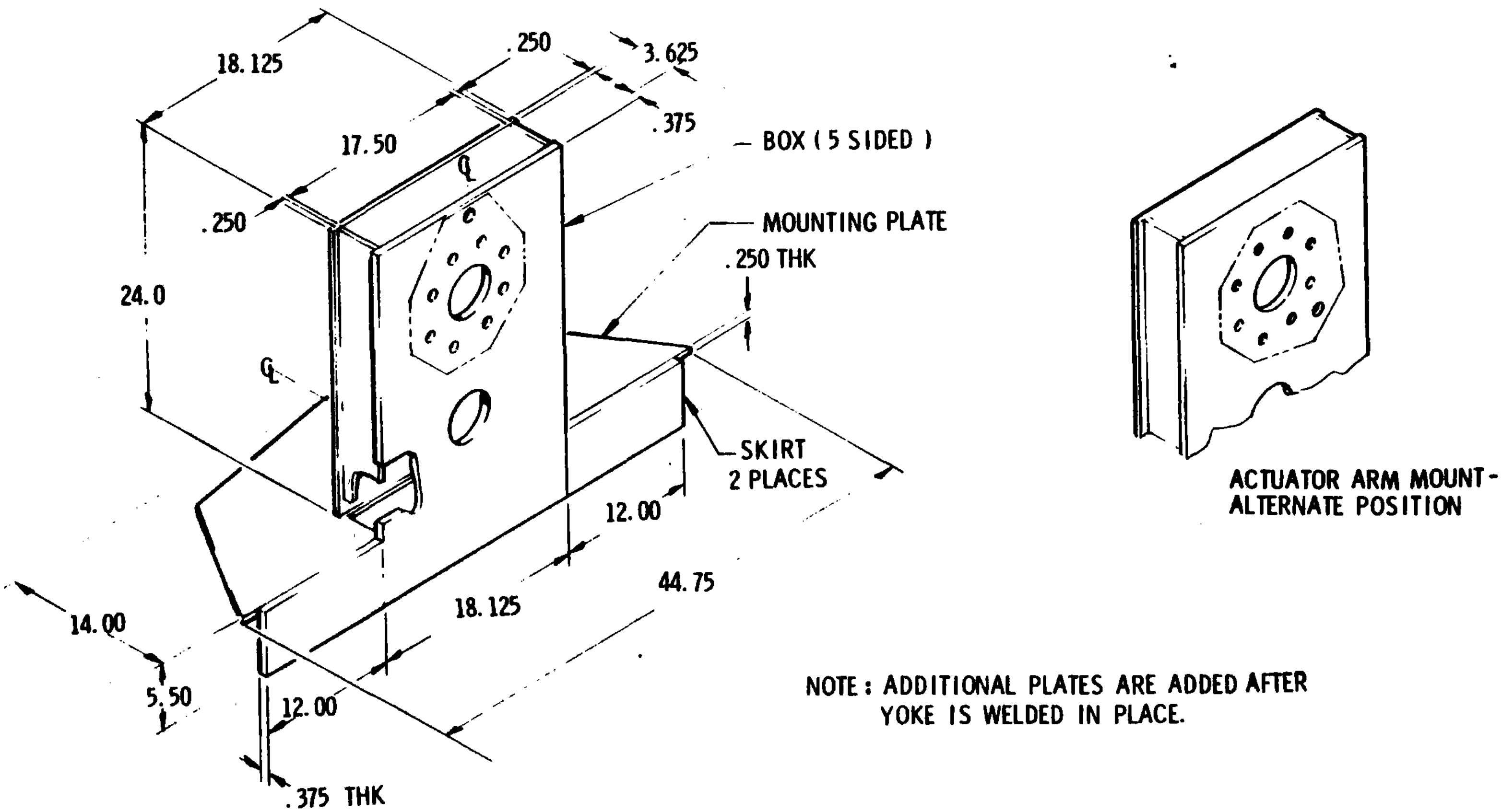


Figure A-4. Yoke Assembly

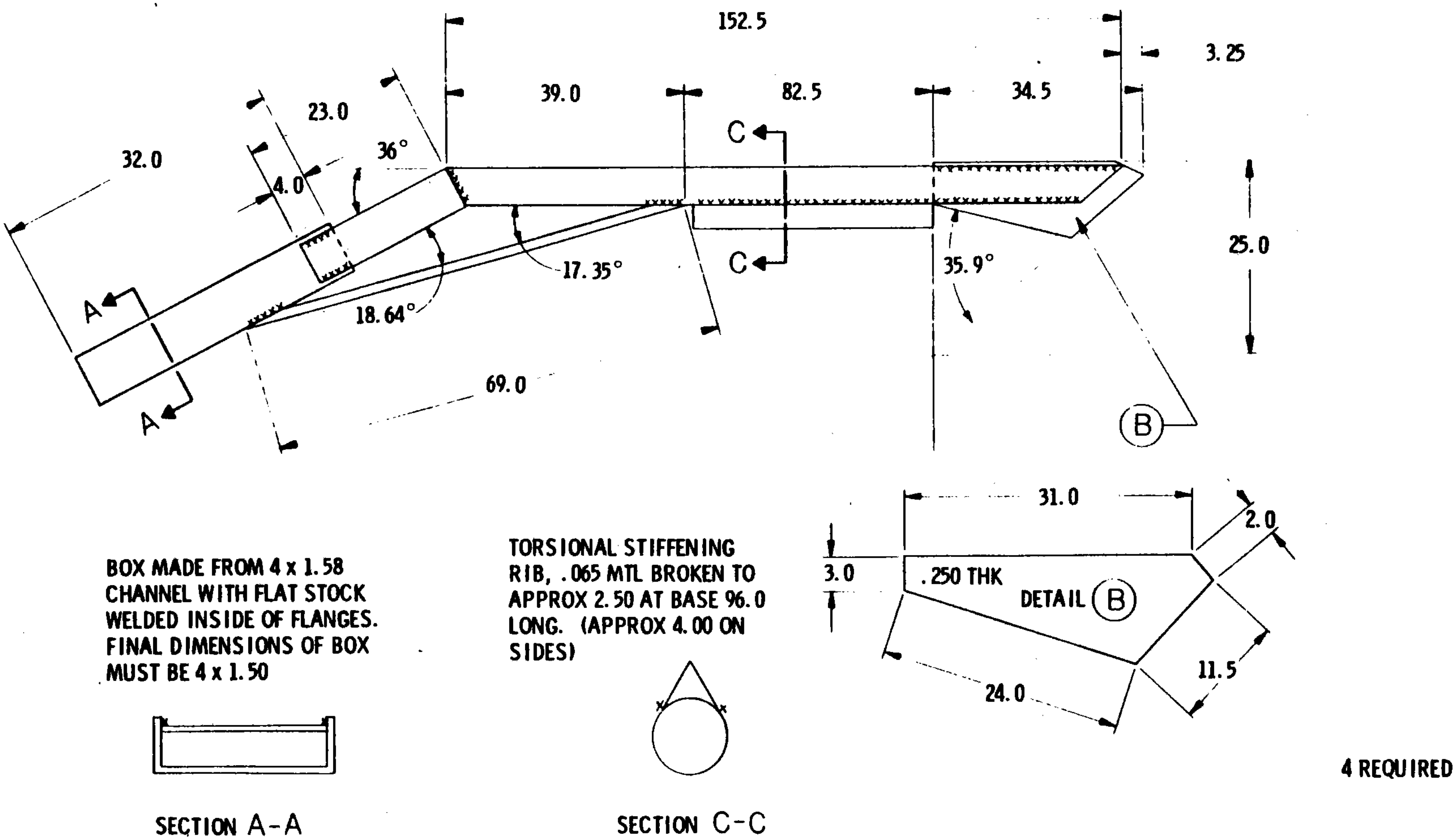


Figure A-5. Converter Support

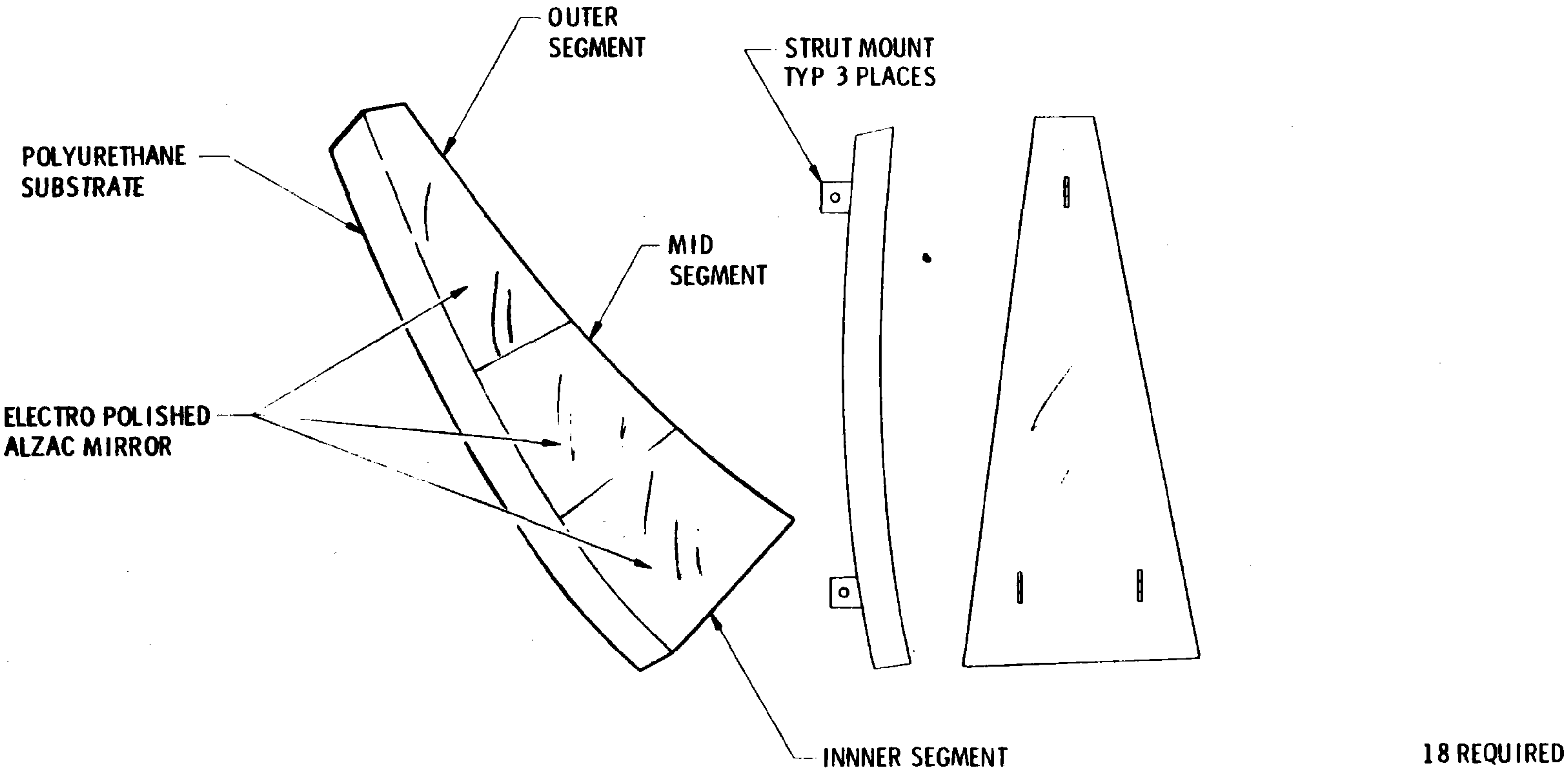


Figure A-6. Concentrator Segment Petal

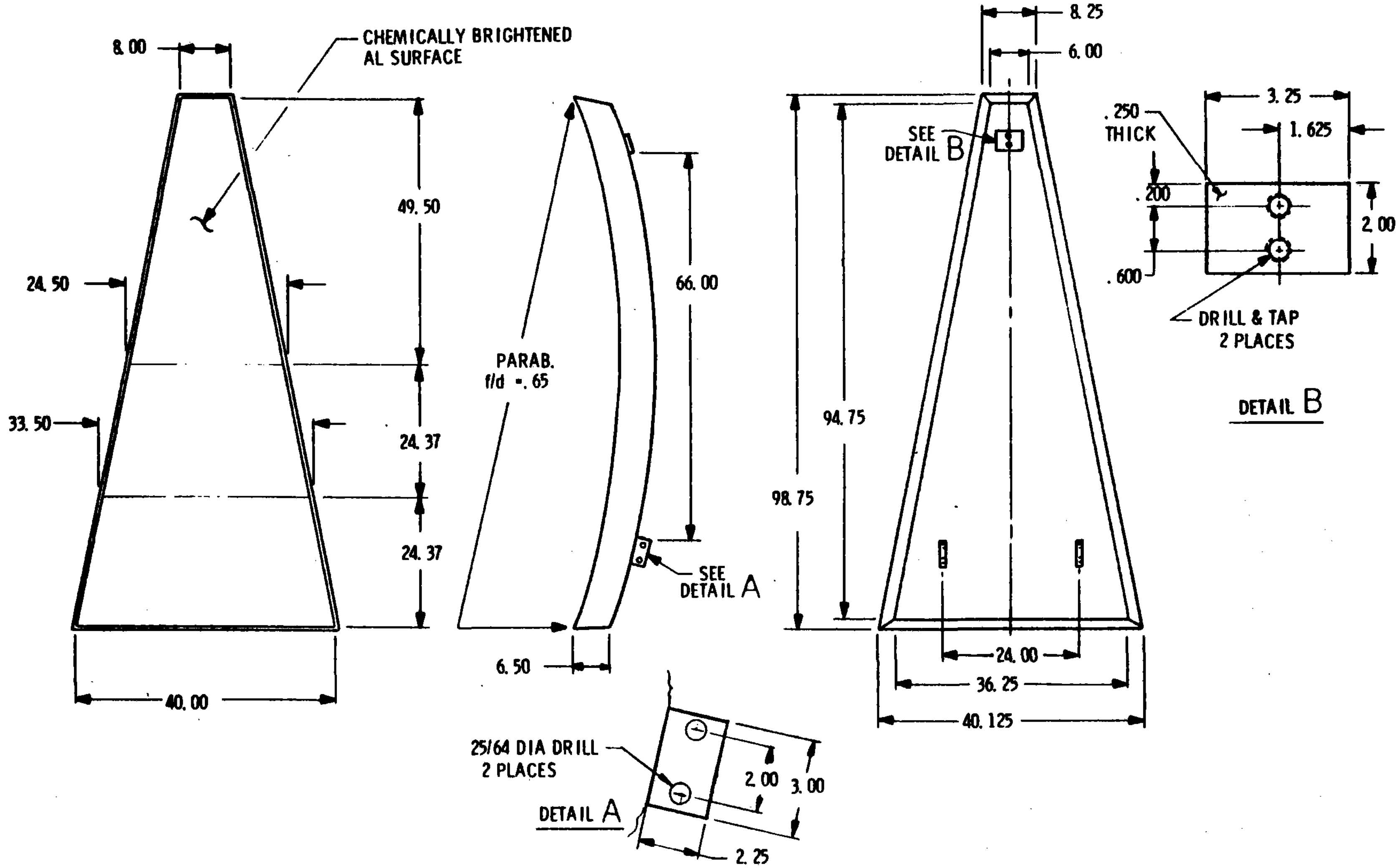
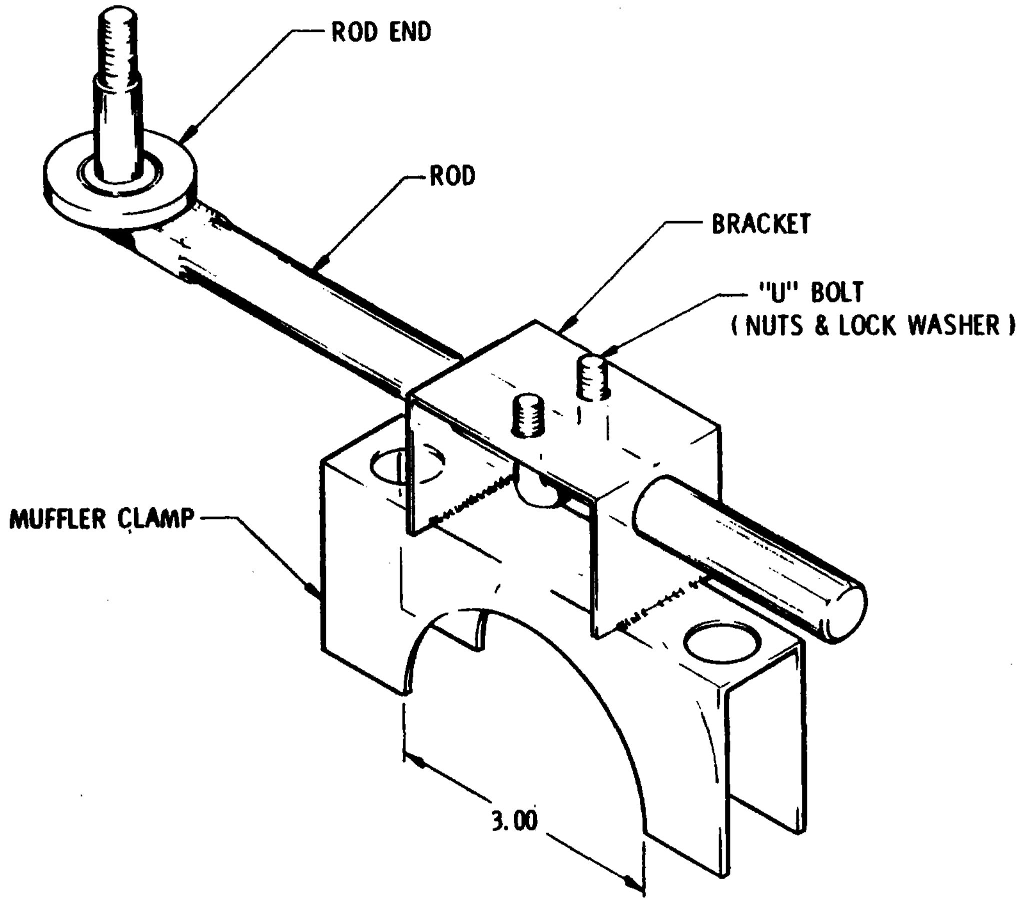


Figure A-7. Mirrored Petal Assembly



NOTE: ALL SEAMS WELDED

Figure A-8. Strut Assembly

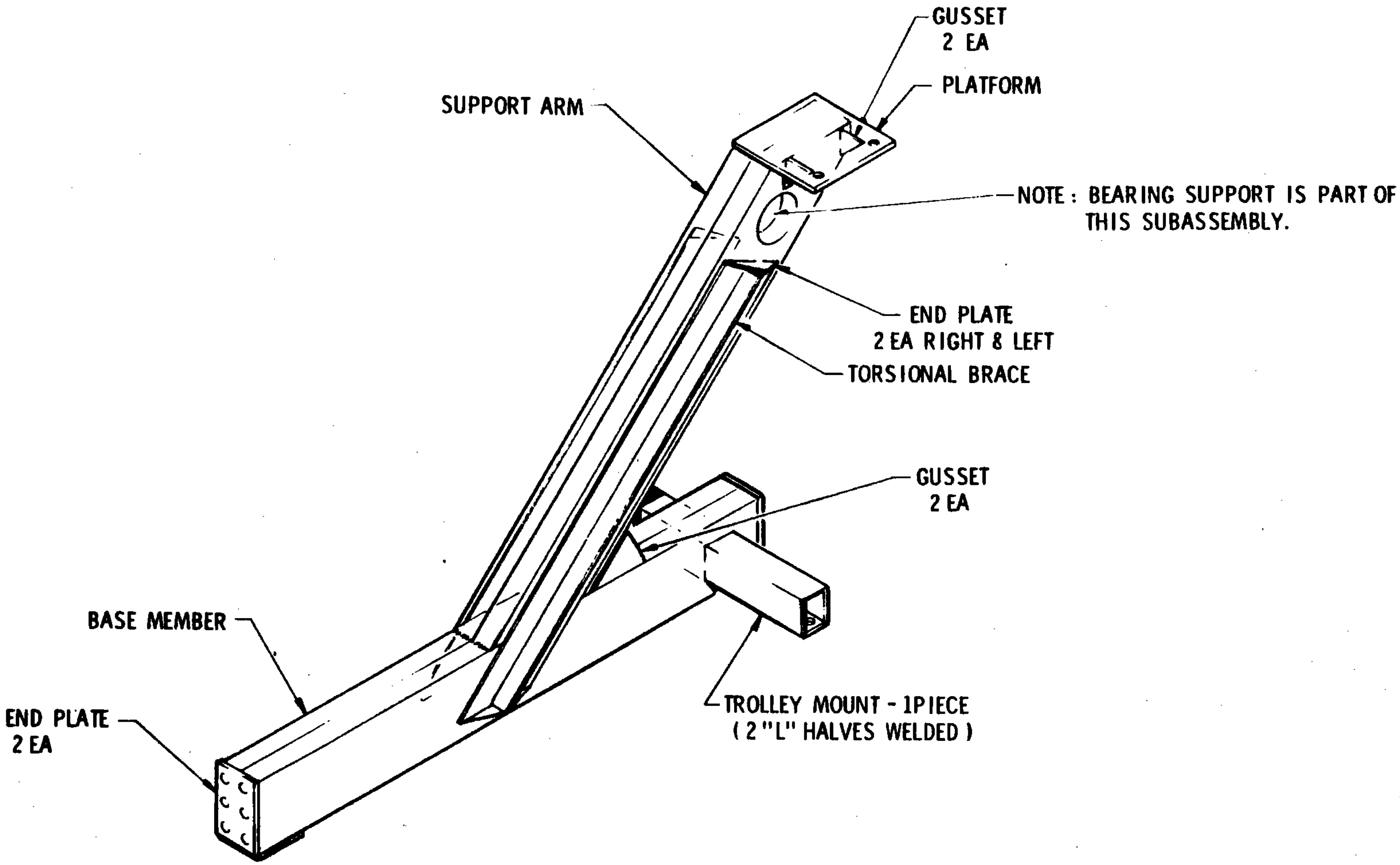
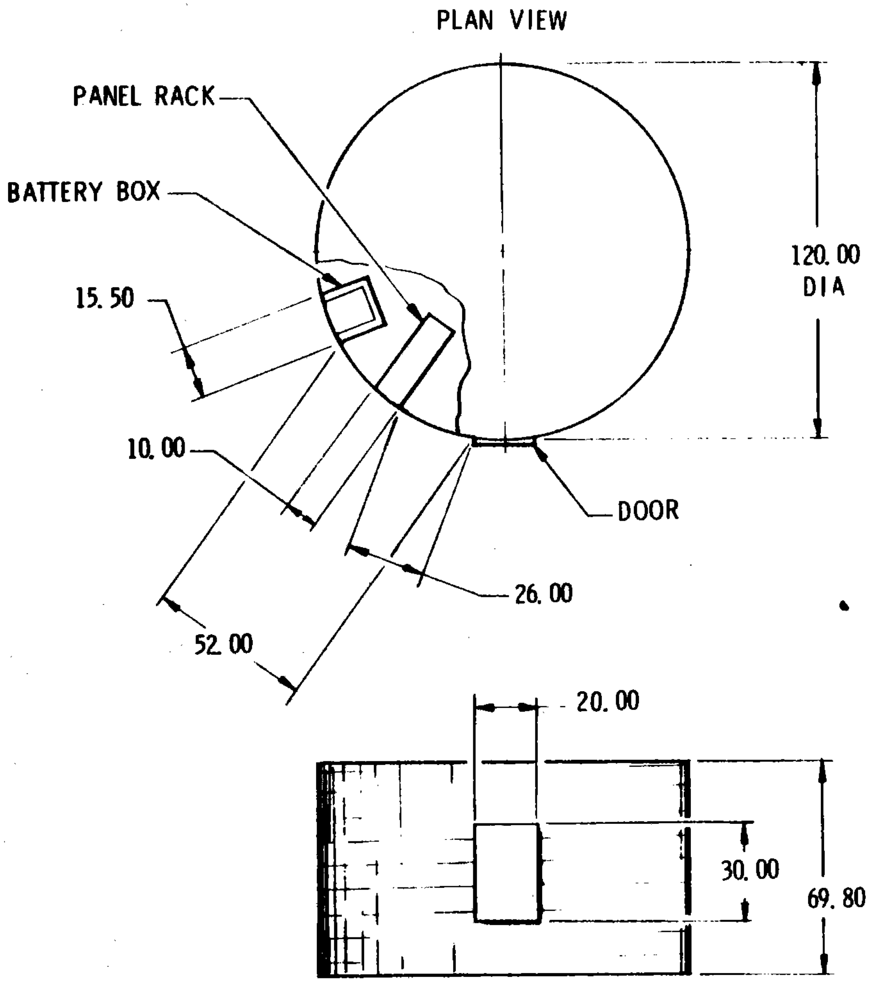


Figure A-9. Cantilever Support Structure



COPPER-STEEL CULVERT STOCK
12 GA, 1x3 CORRUGATION
2 OZ GALVANIZED COATED

Figure A-10. Base Enclosure

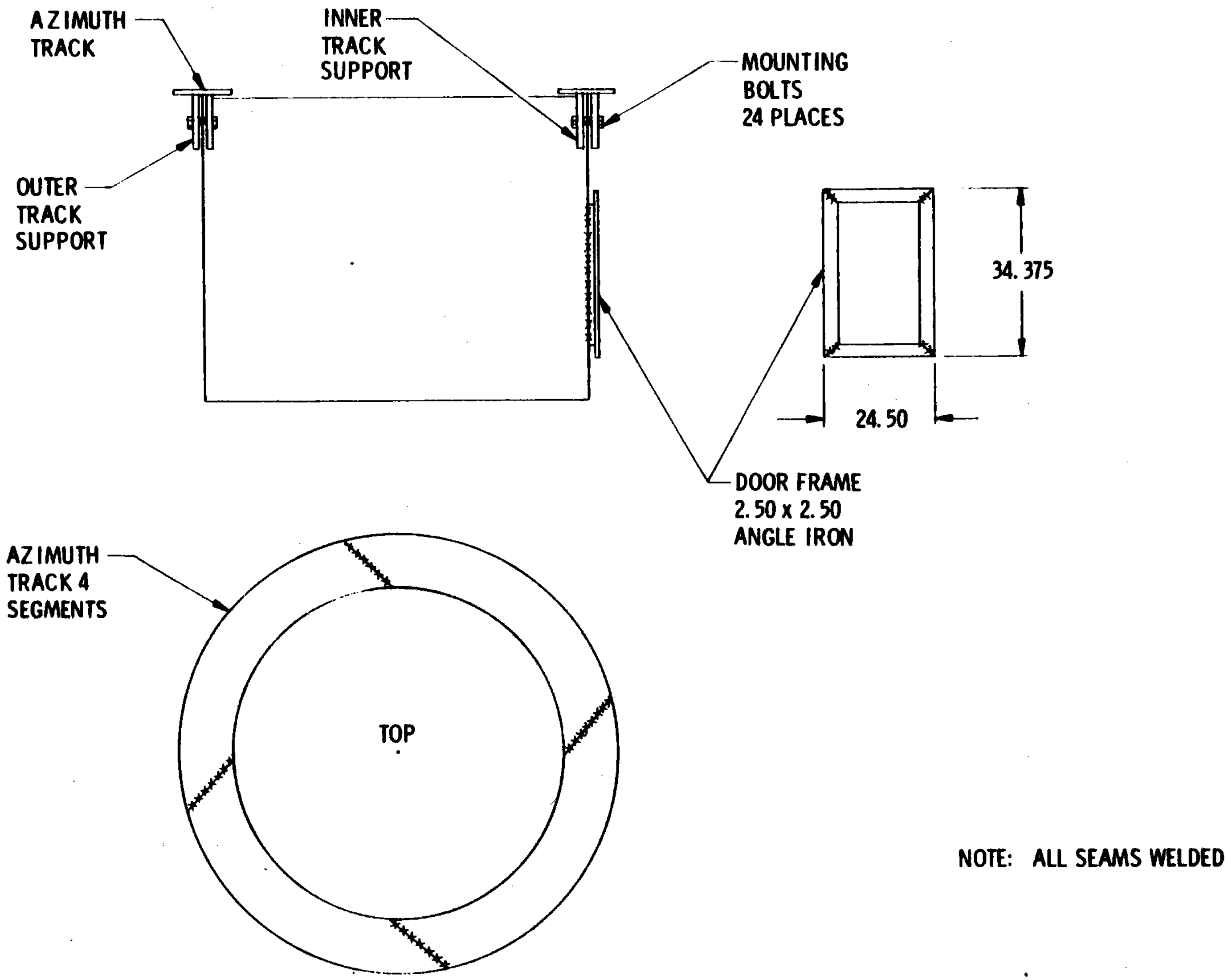
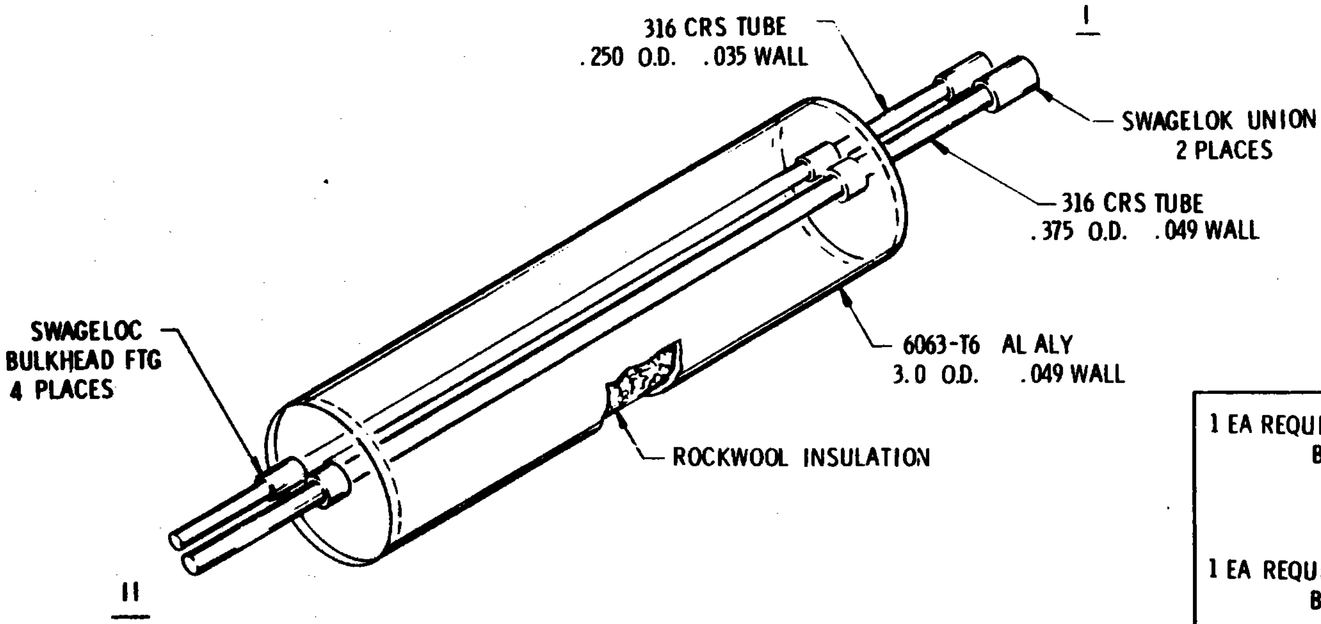


Figure A-11. Azimuth Ring, Door Frame



1 EA REQUIRED		102.0 OAL	
	BODY	90.0	TRUNION RUN
	I	6.0	
	II	6.0	
1 EA REQUIRED		57.0 OAL	
	BODY	30.0	CONVERTER TO LEG
	I	6.0	
	II	21.0	
1 EA REQUIRED		117.0 OAL	
	BODY	102.0	CENTER RISER STEAM LINE
	I	6.0	
	II	9.0	

Figure A-12. Transport Line Assemblies

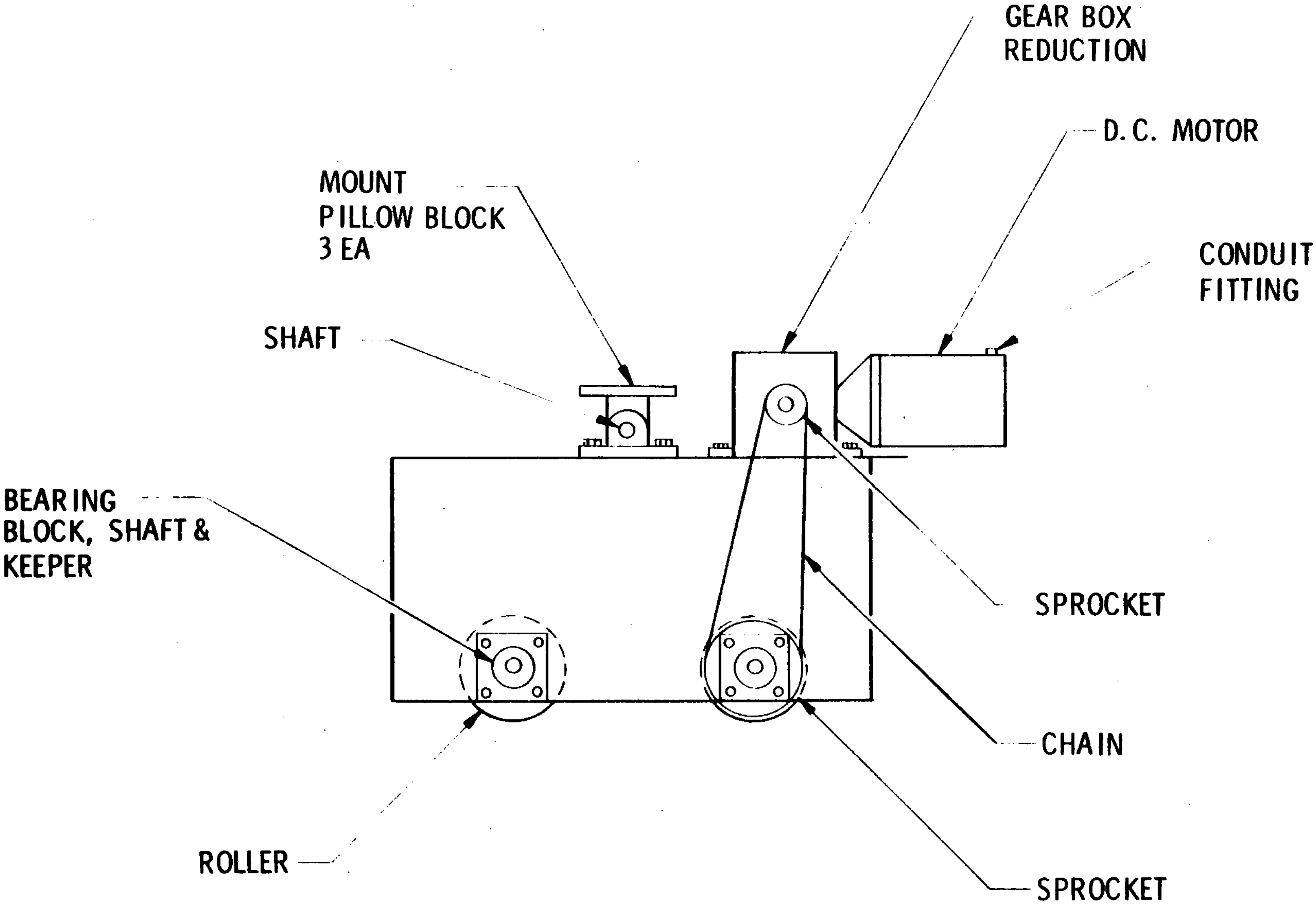


Figure A-13. Trolley Assembly

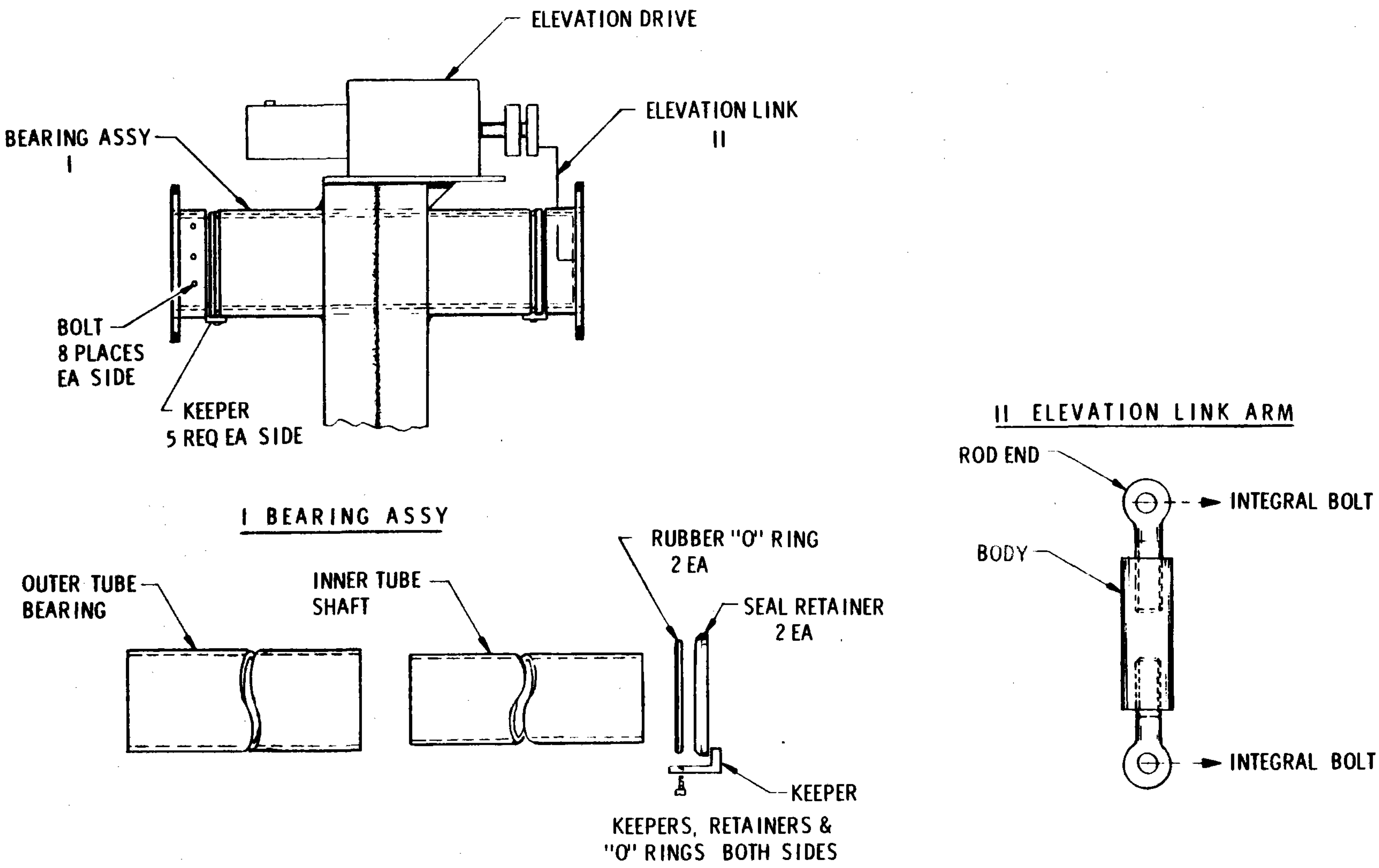


Figure A-14. Bearing Assembly and Elevation Drive

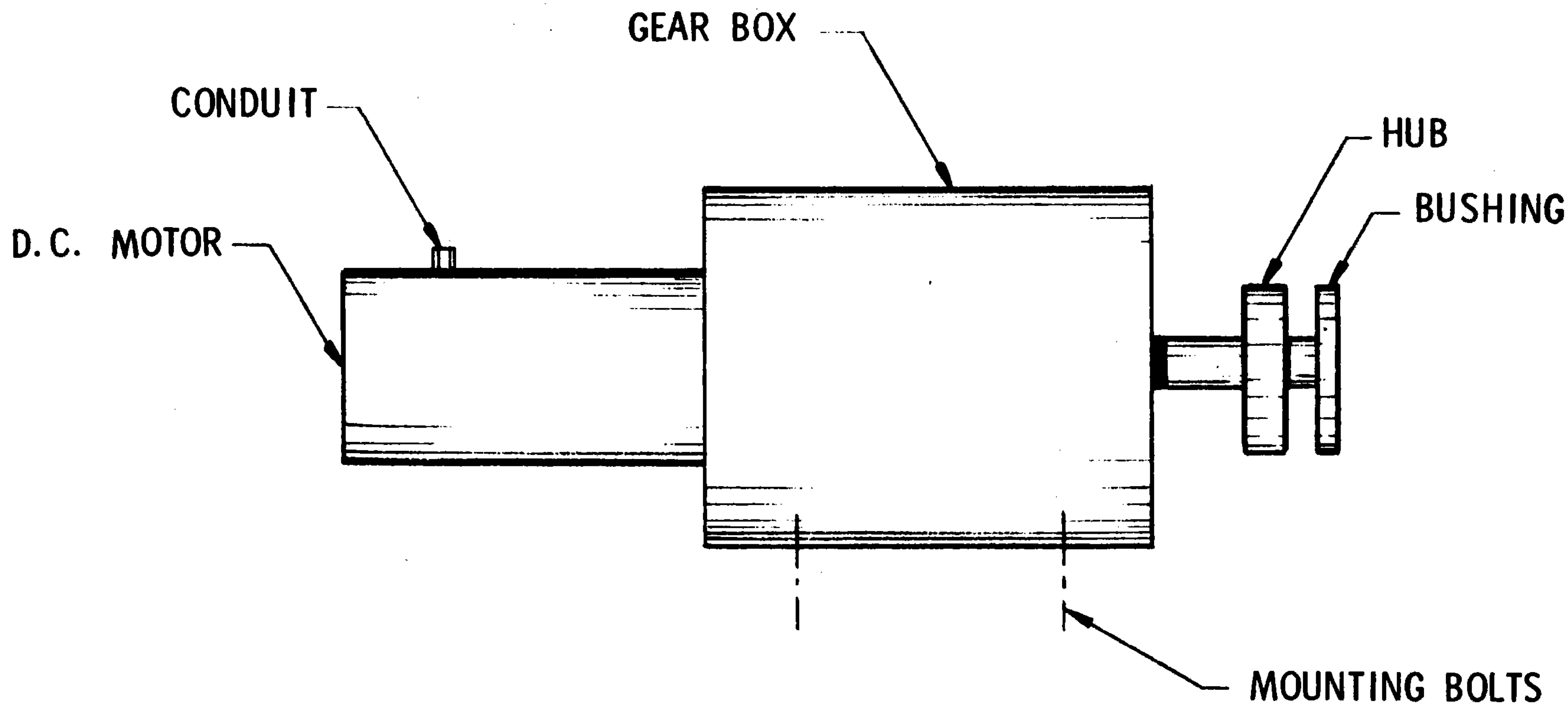


Figure A-15. Elevation Drive

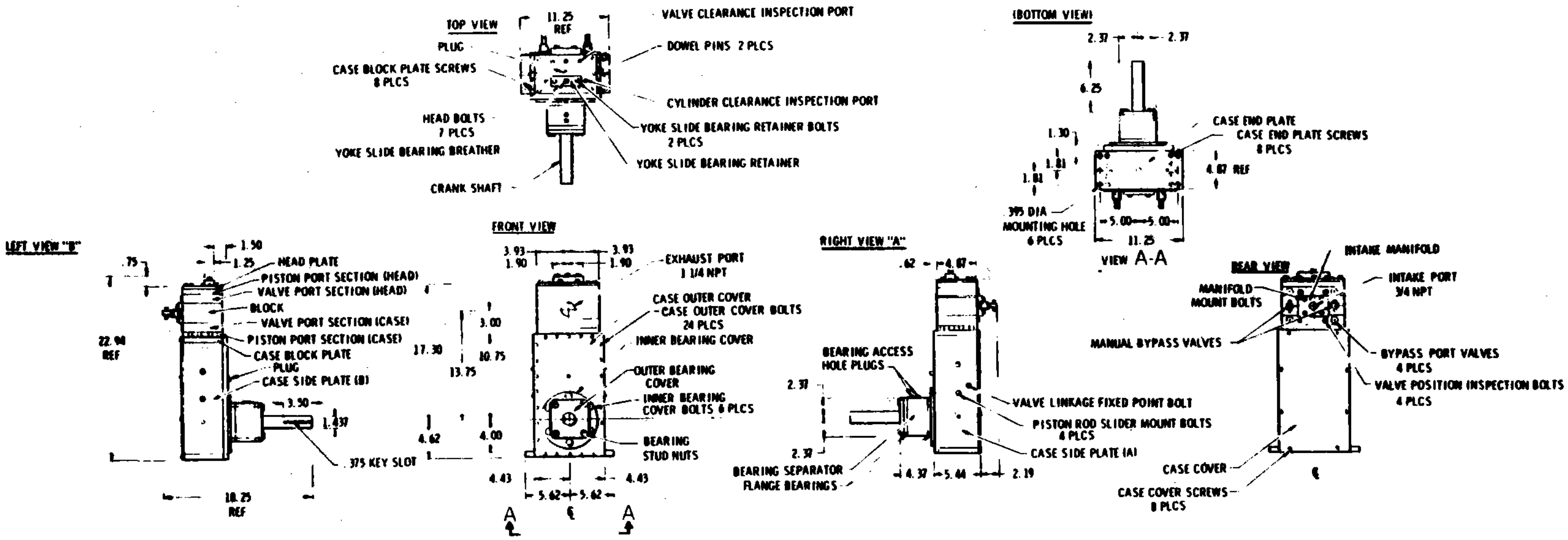


Figure A-16. Exterior Outline, Steam Engine

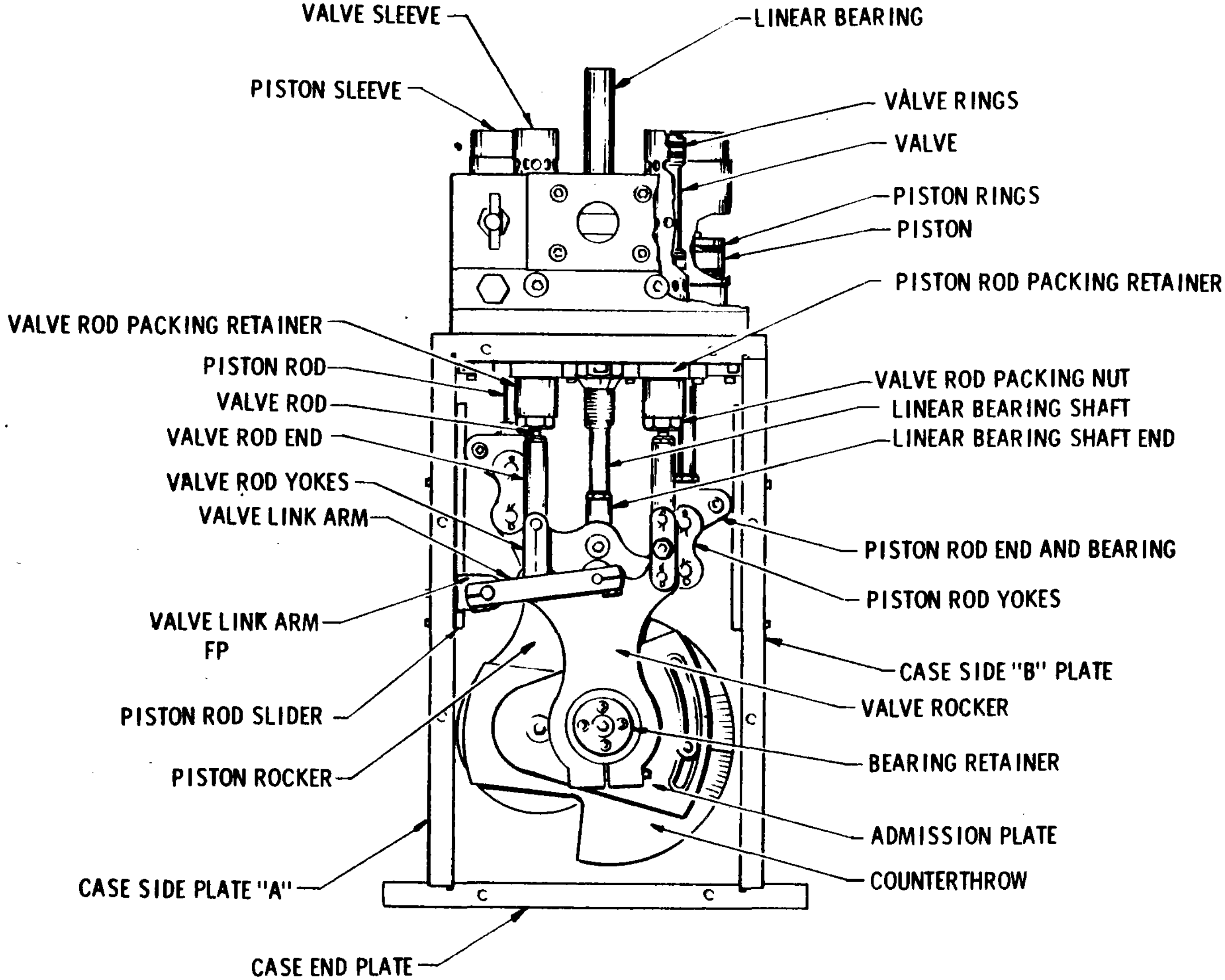


Figure A-17. Interior Outline, Steam Engine

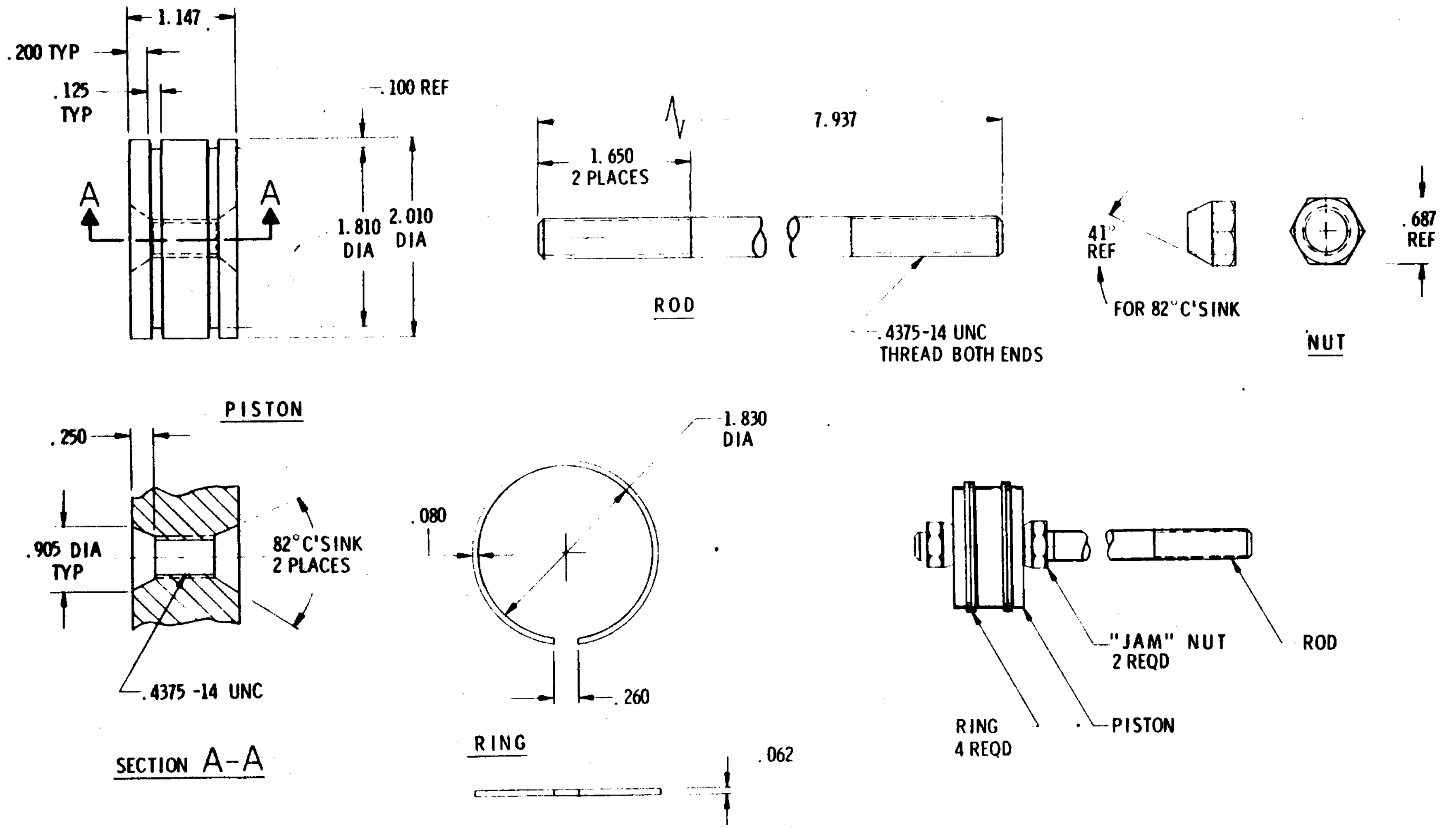


Figure A-18. Rod and Piston Assembly, Steam Engine

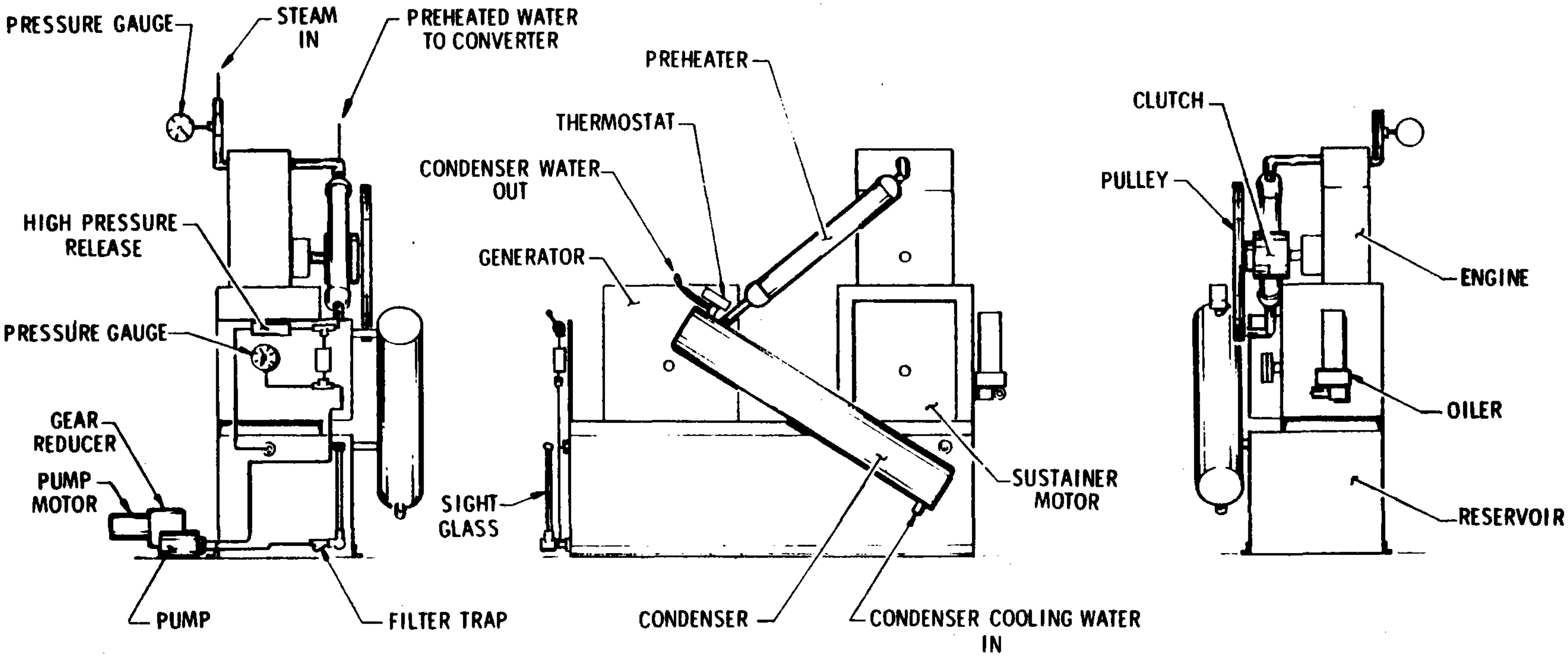


Figure A-19. Power Cart Assembly

APPENDIX B

COST AND PARTS LIST

25 UNITS/YEAR

SUMMARY SHEET

SUB-ASSEMBLY	MATERIAL COST	LABOR MANHOURS	LABOR DOLLARS	COST PER SUB-ASSY
Receiver Assembly	391.27	12.05	96.42	487.69
Backup Structure	476.57	17.11	136.84	613.41
Petal Assembly	3,066.84	7.80	63.16	3,130.00
Receiver Strut	169.24	1.79	14.32	183.56
Cantilever Support	842.78	15.16	121.26	964.04
Elevation Mechanism	601.37	4.47	35.79	637.16
Azimuth & Trolley Assembly	746.18	9.32	74.53	820.71
Yoke Assembly	175.34	7.37	58.95	234.29
Base Assembly	336.61	8.26	66.10	402.71
Electrical	288.50	8.58	68.63	357.13
Foundation	550.05	76.62	612.93	1,162.98
Steam Engine	123.13	33.55	268.38	391.51
Condenser	41.85	2.30	18.36	60.21
Preheater	20.40	1.16	9.26	29.66
Hotwell	797.96	3.05	24.42	822.38
Power Cart	2,396.89	7.37	58.95	2,455.84
Transport	438.77	3.93	31.43	470.20
TOTALS	$11,463.75	219.97	$1,759.73	$13,223.48

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Receiver (Converter) Assy.	1 ea.	391.27	O.G. Part #7531-100-A
2	Outer Body	1 ea.	138.55	
3	Outer Cover	1 ea.		Body, 316 CRS, 13.0 x 63.6 x .063
4	Outer Cover	1 ea.	87.30	Top, 316 CRS, 20.25 dia. x .063
5	Outer Cover	1 ea.		Bottom, 316 CRS, 20.25 dia. x .063
6	Protective Shroud	1 ea.	51.25	316 CRS, 12.50 x 63.60, wire cloth
7	Fire Brick	7 lbs.	15.55	1 in. layer (2400^{o}F max. wk. temp.) Apx. 603 in^3
8	Mineral Wool	2.32 ft^3	9.75	Mineral Wool Insulation
9	Inner Container	1 ea.	132.48	
10	Body	1 ea.		316 CRS, 7.25 x 35.72 x .125
10A	Support Bkt.	4 ea.	83.73	304 CRS, 5.5 x 6.0 x .250 (8 pcs.)
11	Top	1 ea.		316 CRS, 12.00 dia. x .125
12	Face Plate	1 ea.	48.75	Inconel, 12.25 dia x .157 x dished 1.50
13	Port Entry Cone	1 ea.		Inconel, 6.25 x 35.72 x .125 (Truncated cone)
14	Inlet Pipe	1 ea.	2.79	316 CRS, .25 tube x 12.0 long x .035 wall
15	Outlet Pipe	1 ea.	2.90	304 CRS, .375 tube x 15.0 long x .049 wall
16	Heat Exchang Mth.	75 lbs.	39.75	Aluminum
17	Helix	1 ea.	28.00	319 CRS, .250 tube x 8 ft. x .065 wall
18	Fitting	2 ea.	3.00	Swedgelock

ITEM		QTY	MAT'L COST	DESCRIPTION
	Receiver (Converter) Assy. (cont'd)			
19	Temp Probe	1 ea.	15.50	
20	Tube	1 ea.	8.00	316 CRS, .25 tube x 6.00 x .035 wall
21	Thermo Couple	1 ea.		Chromel-alumel x 10.0 long
22	Sending Unit	1 ea.	7.50	
23	Transport Line*	1 ea.	173.40**	26 ft. @ $6.67/ft.

*4 segments, see transport line P/L's

**Cost not included in total #1 above

	ITEM	QTY	MAT'L COST	DESCRIPTION	
1	Backup Structure	1 ea.	476.57		
2	Outer Ring	1 ea.	62.46		
3	Tube Segment	9 ea.	6.72	6063 T6 al.al.	3.00 OD x 70.75 x .049 wall (tube)
4	Strut Mount	9 ea.	.22	6061 T6 al.al.	2.0 x 3.0 x .250
5	Inner Ring	1 ea.	30.33		
6	Tube Segment	9 ea.	3.15	6063 T6 al.al.	3.00 OD x 33.125 x .049 wall (tube)
7	Strut Mount	9 ea.	.22	6061 T6 al.al.	2.0 x 3.0 x .250
8	Truss Ring	1 ea.	296.11		
9	Tube Segment	9 ea.	1.97	6063 T6 al.al.	3.0 x 20.75 x .049 wall (tube)
10	Strut Mount	9 ea.	.22	6061 T6 al.al.	2.0 x 3.0 x .250
11	Strut Radial	9 ea.	6.98	6063 T6 al.al.	3.0 x 73.50 x .049 wall (tube)(welded)
12	Strut Truss (long)	18 ea.	3.23	6063 T6 al.al.	1.50 x 57.0 x .049 wall (tube)
13	Strut End	36 ea.	1.61		1.375 x 12.0 x .125
14	Bolt	36 ea.	.14		1/2 - 10 x 1 1/2
15	Nut	36 ea.	.08		1/2 - 10
16	Washer	64 ea.	.04		1/2
17	Strut. Truss (short)	18 ea.	.96	6063 T6 al.al.	1.50 x 16.75 x .049 wall (tube)(bolted)
18	Strut End	36 ea.	1.61		1.375 x 10.0 x .125
19	Bolt	36 ea.	.14		1/2 - 10 x 1 1/2
20	Nut	36 ea.	.08		1/2 - 10
21	Washer	64 ea.	.04		1/2
22	Sensor Mount	1 ea.	1.28	6063 T6 al.al.	3.00 x 13.50 x .049 wall (tube)

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Yoke (2 required)	1 ea.	87.67	
2	Mounting Plate	2 ea.	17.68	
3	Box	1 ea.	44.61	
4	Top	1 ea.	1.34	6061 T6 al.al. 17.375 x 3.125 x .250
5	Side	2 ea.	1.89	6061 T6 al.al. 24.00 x 3.125 x .250
6	Outside	1 ea.	10.89	6061 T6 al.al. 24.00 x 18.00 x .250
7	Inside	1 ea.	28.60	6061 T6 al.al. 29.50 x 18.00 x .375
8	Skirt	2 ea.	3.85	6061 T6 al.al. 12.50 x 6.00 x .375

	ITEM	QTY	MAT'L COST	DESCRIPTION	
1	Receiver Strut	1 ea.	42.31		
2	Tube arm	1 ea.	14.94	6063 T6 al.al.	.049 wall x 3.00 dia. x 152.5 (tube)
3	Receiver mount	1 ea.	11.36	Stl.	31.0 x 15.0 x .250
4	Stiffening Rib	1 ea.	4.72	6063 T6 al.al.	.065 x 8.0 x 96.0
5	Short arm	1 ea.	2.28	6063 T6 al.al.	.049 wall x 3.00 dia. x 23.0
6	Base	1 ea.	9.01		
7	Channel	1 ea.	3.26	6063 T6 al.al.	channel 4.0 x 1.58 thick x 32.0 long
8	Box plate	1 ea.	1.80	6063 T6 al.al.	.250 x 3.50 x 32.0
9	Strut	1 ea.	3.95	6061 T6 al.al.	tube .049 wall x 1.50 dia. x 69.0

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Concentrator Mirror Assy.	1 ea.	3066.84	
2	Petal	18 ea.	170.38	
3	(Petal Unit)	1 ea.	170.38	
4	Inner Reflector	1 ea.		Electro Polished Alzac 24.0 x 60.0 x .032
5	Mid. Reflector	1 ea.	77.62	Electro Polished Alzac 30.0 x 24.0 x .032
6	Outer Reflector	1 ea.		Electro Polished Alzac 40.0 x 24.0 x .032
7	Substrate	45 lbs.	73.59	Polyurethane foam (2 densities)*
8	Moisture Coat	A/R	5.00	Latex Base Paint, apx. 2 qts (moisture & U.V. Barrier)
9	Strut Mount	3 ea.	.37	Al.al. 3.0 x 6.0 x .250
10	Strut Assy.	1 ea.	3.26	2 ea. Required
11	Rod	1 ea.	.13	
12	Rod End	1 ea.	1.88	Morse TF-GY
13	Nut	1 ea.	.04	Hex 3/8 - 24
14	Lock Washer	1 ea.	.04	Split Lock 3/8
15	Bracket	1 ea.	.05	Stl. 1.375 x 5.50 x 14 GA.
16	"U" Bolt	1 ea.	.26	9/16 x 1 1/4
17	Nut	2 ea.	.01	Hex 1/4 - 20
18	Washer	2 ea.	.03	Split Lock 1/4
19	Muffler Clamp	1 ea.	.79	

*Proprietary Information

	ITEM	QTY	MAT'L COST	DESCRIPTION
	Concentrator Mirror Assy. (cont'd)			
20	Strut Assy.	1 ea.	3.26	
21	Rod Threaded	1 ea.	.05	Al.al. 2.50 x .50 dia.
22	Rod Domed	1 ea.	.08	Al.al. 5.25 x .50 dia.
23	Rod End	1 ea.	1.88	Morse TF-GY
24	Nut	1 ea.	.04	Hex 3/4 - 24
25	Washer	1 ea.	.04	Split Lock 3/8
26	Bracket	1 ea.	.05	Stl. 1.345 x 5.50 x 14 GA.
27	"U" Bolt	1 ea.	.26	9/16 x 1 1/4
28	Nut	2 ea.	.01	Hex 1/4 - 20
29	Washer	2 ea.	.03	Split Lock 1/4
30	Muffler Clamp	1 ea.	.79	5/16 x 3

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Cantilever Support	1 ea.	842.78	
2	Support arm	2 ea.*	32.47	Stl. 97.625 x 10.00 x 2.50 channel
3	Platform	1 ea.	5.97	Stl. 14.687 x 11.937 x .250
3A	Bolt	4 ea.	.21	1/2 - 23 x 2 1/2
4	Gusset	2 ea.	.40	Stl. 6.0 x 6.0 x .250 (diag. cut to make two)
5	Tortional Brace	2 ea.	33.05	Stl. 6.0 x 6.0 x 5/16 x 98.25, angle iron**
6	End plate	2 ea.	.52	Stl. 8.0 x 8.0 x .250 (diag. cut to make two)
7	Conduit fitting	1 ea.	3.00	Pipe el., 45°, 3 1/2 in. (right side)
8	Cable clamp	2 ea.	.15	
8A	Screw	2 ea.	.05	Phms 8-32 x 1
8B	Nut	2 ea.	.05	Hex #8
8C	Lock washer	2 ea.	.03	#8
9	Base member	2 ea.*	44.15	Stl. 130.0 x 10.0 x 2.50 channel
10	End plate	2 ea.	1.09	Stl. 10.0 x 5.25 x .375
10A	Castor	1 ea.	20.49	Rapistan U-265R-FR
11	Trolley mount	1 ea.*	12.60	Stl. 4.0 x 4.0 x .250 x 36.0, angle iron
11A	Castor mount	1 ea.	1.38	
12	Gusset	2 ea.	3.75	Stl. 17.0 x 13.0 x .25

*(2 pc. box section)

**(left & right)

	ITEM	QTY	MAT'L COST	DESCRIPTION
	Cantilever Support (cont'd)			
13	"Y" Member	2 ea.	41.92	
14	Brace	4 ea.	5.84	Stl. 3.125 x 10.250 x 38.0, 10 Ga channel
15	Body	2 ea.*	5.84	Stl. 3.125 x 10.250 x 40.75, 10 Ga channel
15A	Castor mount	2 ea.	1.38	Stl.
16	Support channel	4 ea.	1.03	Stl. 1.25 x 2.0 x 84.0, 10 Ga channel
17	Deck	------	136.50	
18	Outer	4 ea.	28.35	Stl. 90.0 x 24.0, 10 Ga
19	Pop Rivet	128 ea.	.02	3/16 dia. x 3/8 long
20	Inner	1 ea.	14.78	Stl. 42.50 x 42.50, 10 Ga
20A	Pop Rivet	156 ea.	.24	
21	Skirt	4 ea.	37.87	Stl. 95.75 x 24.0, 10 Ga
22	Pop Rivet	156 ea.	.02	3/16 dia. z 3/8 long
23	Castor support	3 ea.	40.77	
24	Top plate	3 ea.	.12	Stl. 4.06 x 4.16 x .375
25	I-beam	3 ea.	11.86	Stl. 25.25 x 4.16 deep x 4.06 flange
26	Foot	3 ea.	1.23	Stl. 8.625 x 6.50 x .250
27	Slider	3 ea.**	.20	Stl. 2 x 2 x .186 x 2, angle iron
27A	Bolt	6 ea.	.05	3/8 - 16 x 1 GR5 cad.
27B	Lock washer	6 ea.	.04	3/8

*(2 pc. box section)

**fab from 2 pcs; 6 req

	ITEM	QTY	MAT'L COST	DESCRIPTION
	Cantilever Support (cont'd)			
28	Retainer leg	1 ea.	117.07	
29	Top plate	1 ea.	.12	Stl. 4.06 x 4.16 x .395
30	I-beam	1 ea.	11.86	Stl. 26.0 x 4.16 deep x 4.06 flange
31	Castor	3 ea.	34.15	Rapistan #U-265R-FR
32	Bolt	12 ea.	.08	3/8 - 16 x 1 1/2
33	Nut	12 ea.	.05	3/8 Hex
34	Washer	12 ea.	.03	3/8
35	Lock washer	12 ea.	.06	3/8

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Base Assembly (Enclosure)	1 ea.	336.61	
2	Base (stock)	1 ea.	92.00	(Kaiser Steel, Culver & Stock) 10.0 ft. dia. x 69.0 in., 203 Coating, Cu. stl, 109 Ga
3	Door frame	1 ea.	7.94	
4	Side	2 ea.	2.12	34.375 Long
5	Top	1 ea.	1.85	2.50 x 2.50 x .187 - 24.50 Long
6	Bottom	1 ea.	1.85	Angle iron 24.50 Long
7	Azimuth Ring Assy.	1 ea.	183.87	
8	Track	1 ea.	126.47	Stl. 6.00 x 92.00 x .375, 4 ea. Required
9	Outer support	1 ea.	22.10	Stl. 6.00 x 377.0 x .125, Fab. from 3 or 4 pieces
10	Inner support	1 ea.	22.10	Stl. 6.00 x 377.0 x .125, Fab. from 3 or 4 pieces
11	Mounting Bolt	24 ea.	.36	5/8 - 11 x 3
12	Nut	24 ea.	.19	Hex 5/8 - 11
13	Panel rack	1 ea.	8.64	
14	End	2 ea.	1.40	Stl. 12.50 x 24.0 x 16 Ga
15	Side	2 ea.	2.66	Stl. 15.0 x 36.0 x 16 Ga
16	Bolt	4 ea.	.07	1/4 - 20 x 2 1/2
17	Nut	4 ea.	.03	Hex 1/4 - 20
18	Washer	4 ea.	.03	Split lock, 1/4

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Base Assembly (Enclosure) (cont'd)			
19	Battery Box	1 ea.	5.52	
20	Frame	1 ea.	3.80	2 ea. 15.25 & 14.75*
21	Mounting leg	2 ea.	.62	2 ea. 10.0
22	Bolt	4 ea.	.08	3/8 - 16 x 2 1/2
23	Nut	4 ea.	.04	Hex 3/8 - 16
24	Foundation Anchor	1 ea.	38.64	
25	Clete	8 ea.	.74	Stl. 10.0 Long x 3 x 3 x .187 Angle Iron
26	Pad	8 ea.	.49	Stl. 4.5 x 4.0 x .250
27	Bolt	8 ea.	.46	3/4 - 10 x 1 1/2
28	Bolt	8 ea.	.62	3/4 - 10 x 2 1/2
29	Nut	16 ea.	.26	Hex 3/4 - 10
30	Washer	16 ea.	.10	Split lock 3/4
31	Anchor	8 ea.	1.80	Phillips Red Head 3/4

*(Fab. from 2.50 x 2.50 x .187 Angle Iron)

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Leg Transport Line Assy.	1 ea.	72.04	
2	Transport Tube	1 ea.	21.19	304 CRS 38.00 x 1.50 dia x 16 Ga Wall
3	Cross Tube	1 ea.	4.00	304 CRS 14.00x3.00 dia.x16 Ga Wall*
4	End Plate	2 ea.	.25	304 CRS 1.50 dia. x 16 Ga
5	Spacer	1 ea.	.25	304 CRS 1.50 dia. x 16 Ga
6	Steam Tube	1 ea.	9.67	304 CRS .375 Tubex .049 wall x 50.00 long
7	Bulkhead Ftg	2 ea.	3.50	3/8 Swedgelock bulkhead ftg. #SS-600-1-4
8	Union Ftg	1 ea.	6.70	3/8 Swedgelock bulkhead ftg. #SS-600-6
9	Return Water Tube	1 ea.	11.63	1/4 wall .035 x 50.00 316 CRS
10	Bulkhead Ftg	2 ea.	2.80	1/4 Swedgelock Bulkhead ftg. #SS-400-1-2
11	Union Ftg	1 ea.	4.60	1/4 Swedgelock Bulkhead ftg. #SS-400-6
12	Mineral Wool	.2 ft^3	.90	

*(Rolled from flat stock)

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Converter Transport Line	1 ea.	51.20	
2	Transport tube	1 ea.	2.23	Al.al. 6063 T6, 3.0 x 30.0 x .049 wall
3	End cap	2 ea.	.05	Al.al. 6063 T6, 2.875 dia. x .250
4	Spacer	1 ea.	.05	304 CRS, 2.75 dia. x 18 Ga
5	Feed water blkhd ftg	2 ea.	2.80	Swedgelock, 1/4 in. Bulkhead ftg. #SS-400-1-2
6	Steam line blkhd ftg	2 ea.	3.50	Swedgelock, 3/8 in. Bulkhead ftg. #SS-600-1-4
7	Steam line	1 ea.	9.67	304 CRS, .375 tube x .049 wall x 57.0 long
8	Union ftg	1 ea.	6.70	Swedgelock, 3/8 union, #SS-600-6
9	Feed water line	1 ea.	13.25	316 CRS, .250 tube x .035 wall x 57.0 long
10	Union ftg	1 ea.	4.60	Swedgelock, 1/4 union, #SS-400-6
11	Mineral wool	.5 ft^3	2.00	Mineral wool insulation
12	Center Riser	1 ea.	84.55	
13	Transport tube	1 ea.	7.58	Al.al. 6063 T6, 3.0 x 102.0 x .049 wall
14	End cap	2 ea.	.05	Al.al. 6063 T6, 2.875 dia. x .250
15	Spacer	3 ea.	.05	304 CRS, 2.75 dia. x 18 Ga
16	Feed water blkhd ftg	2 ea.	2.80	Swedgelock, 1/4 in. Bulkhead ftg. #SS-400-1-2
17	Steam line blkhd ftg	2 ea.	3.50	Swedgelock, 3/8 in. Bulkhead ftg. #SS-600-1-4
18	Steam line	1 ea.	22.62	304 CRS, .375 dia. x .049 wall x 117.0 long
19	Union ftg	1 ea.	6.70	Swedgelock, 3/8 union, #SS-600-6
20	Feed water line	1 ea.	27.20	316 CRS, .250 tube x .035 wall x 117.0 long
21	Union ftg	1 ea.	4.60	Swedgelock, 1/4 union, #SS-400-6
22	Mineral wool	.75 ft^3	3.00	Mineral wool insulation

	ITEM	QTY	MAT'L COST	DESCRIPTION
	Converter Transport Line (cont'd)			
23	Trunion Line	1 ea.	76.78	
24	Transport tube	1 ea.	6.69	Al.al. 6063 T6, 3.0 x 90.0 x .049 wall
25	End cap	2 ea.	.05	Al.al. 6063 T6, 2.875 dia. x .250
26	Spacer	3 ea.	.05	304 CRS, 2.875 dia. x 18 Ga
27	Feed water blkhd ftg	2 ea.	2.80	Swedgelock, 1/4 in. Bulkhead ftg. #SS-400-1-2
28	Steam line blkhd ftg	2 ea.	3.50	Swedgelock, 3/8 in. Bulkhead ftg. #SS-600-1-4
29	Steam line	1 ea.	19.72	304 CRS, .375 dia. x .049 wall x 102.00 long
30	Union ftg	1 ea.	6.70	Swedgelock, 3/8 union, #SS-600-6
31	Feed water line	1 ea.	23.72	316 CRS, .250 tube x .035 wall x 102.00 long
32	Union ftg	1 ea.	4.60	Swedgelock, 1/4 union, #SS-400-6
33	Mineral wool	.6 ft^3	2.50	Mineral wool insulation
34	Elevation Flex Line	1 ea.	70.60	Swedgelock #SS-6HO-L6, 3/8 union type 34 long
35	Azimuth Flex Line	1 ea.	70.60	Swedgelock #SS-6HO-L6, 3/8 union type 34 long
36	Elevation Flex Line	1 ea.	6.50	United Industrial #SAE-100-R2, Type A, 1/4, 30 long
37	Azimuth Flex Line	1 ea.	6.50	United Industrial #SAE-100-R2, Type A, 1/4, 30 long

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Trolley Assembly	1 ea.	373.09	2 ea. req/system, left & right, mirror images
2	Box	1 ea.	21.21	
3	Side	2 ea.	3.67	Stl. 19.625 x 6.625 x .375
4	Partition	3 ea.	2.15	Stl. 9.50 x 6.75 x .250
5	Lid	1 ea.	7.42	Stl. 22.125 x 12.125 x .375
6	Pillow Block	3 ea.	7.97	Seal master MP16 (1 in.)
7	Shaft	1 ea.	2.42	Stl. 1018 9.0 x 1.0 dia.
8	Bolt	4 ea.	.15	7/16 - 14 x 2
9	Lock washer	4 ea.	.04	Split 7/16
10	Flat washer	4 ea.	.04	7/16
11	Gear box	1 ea.	77.25	Dayton mod. 4Z008
11A	Mounting feet	1 pr.	5.52	Dayton 6 x 500
12	Sprocket	1 ea.	13.32	Morse TLB 319-2H
13	Bushing	1 ea.	3.82	Morse TL 1008
14	Bolt	4 ea.	.15	7/16 - 14 x 2
14A	Lock washer	6 ea.	.04	7/16
15	Nut	2 ea.	.06	7/16

	ITEM	QTY	MAT'L COST	DESCRIPTION
	Trolley Assembly (cont'd)			
16	D.C. Motor	1 ea.	91.59	Dayton mod 2M168 (1/2 HP)
17	Conduit fitting	1 ea.	1.45	T&B 2520 Streign relief
17A	Reducer	1 ea.	.30	T&B 610 (3/4 to 1/2)
18	Bolt	4 ea.	.05	3/8 - 16 x 1
19	Drive chain	1 ea.	5.75	Cullman #35-2, 3/8 pitch (5 ft. long)
20	Sprocket	1 ea.	20.00	Morse TLB 360-2 PT 117950
21	Bushing	1 ea.	4.63	Morse TL 1610
22	Bearing Block	4 ea.	7.98	Seal master SF-16C (1 in.)
23	Roller	2 ea.	61.20	
24	Shaft	2 ea.	2.85	Stl. 1018 1.0 dia. x 17.0
25	End	4 ea.	2.44	Stl. 7.75 dia. x .250
26	Body	2 ea.	9.25	Stl. tube 6.75 dia. x 7.75 x .50 wall

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Altitude Mechanism	1 ea.	601.37	
2	Bearing Assembly	1 ea.	111.93	
3	Outer tube	1 ea.	52.22	Stl. Const. tube 82.50 x 7.50 ± .023 I.D. x .375 wall
4	Grease fitting	2 ea.	.20	Zerks (straight)
5	Inner tube	1 ea.	48.33	Stl. Const. tube 26.50 x 7.48 ± .022 O.D. x .250 wall
6	"O" ring	2 ea.	1.07	.125 x 7.50 I.D. (Buna-n)
7	Retainer	2 ea.	.58	.250 x 7.50 I.D. x 8.25 O.D. (from .375 wall tube)
8	Screw	16 ea.	.26	6 - 32 x 1/2 Socket head
9	Bolt	16 ea.	.06	3/8 - 16 x 1
10	Bolt	16 ea.	.08	3/8 - 16 x 1 3/2
11	Lockwasher	16 ea.	.04	3/8
12	Nut	16 ea.	.04	3/8 - 16
13	Elevation Link	1 ea.	11.14	
14	Rod end	2 ea.	4.82	Morse TM-10Y, 5/8 - 18
15	Body	1 ea.	1.50	Stl. rod, 1.25 dia.
16	Elevation Drive	1 ea.	412.60	
17	D.C. motor	1 ea.	91.59	Dayton, D.C. Motor, 1/2 HP
18	Conduit fitting	1 ea.	1.70	

ITEM		QTY	MAT'L COST	DESCRIPTION
	Altitude Mechanism (cont'd)			
	Elevation Drive (cont'd)			
19	Gear box	1 ea.	278.13	Browning Reducer 300 DCR-LE1800
20	Hub	1 ea.	23.07	Browning HR-1
21	Bushing	1 ea.	14.05	Browning R-1 1 1/4 in. Bore, type 1
22	Mounting bolt	4 ea.	.21	1/2 - 13 x 2
23	Nut	4 ea.	.11	1/2 - 13
24	Lock washer	4 ea.	.10	1/2
25	Washer	4 ea.	.10	1/2
26	Drive plate	1 ea.	1.98	Stl. 5.50 x 10.875 x .625

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Bearing Collar Assembly (El.)	1 ea.	36.05	
2	Collar	1 ea.	5.80	Stl., 8.0 O.D. x 2.00 x .375 wall, Welded Drawn Tube
3	Gimbal end plate	1 ea.	29.29	H.R.C. Stl. 13.375 x 10.50 x 50
4	Bolt	8 ea.	.08	3/8 - 16 x 1 1/2
5	Nut	8 ea.	.04	Hex 3/8 - 16
6	Bearing Collar Assembly	1 ea.	29.65	
7	Collar	1 ea.	5.80	Stl., 8.0 O.D. x 2.00 x .375 wall, Welded Drawn Tube
8	Gimbal end plate	1 ea.	22.89	H.R.C. Stl. 10.50 x 10.50 x 50
9	Bolt	8 ea.	.08	3/8 - 16 x 1 1/2
10	Nut	8 ea.	.04	Hex 3/8 - 16

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Steam Engine OG-3	1 ea.	123.13	Total
2	Sleeve Valve Assy. (set)	1 ea.	3.75	
3	Rest Piston Assy. (set)	1 ea.	3.90	
4	Head Assy.	1 ea.	35.57	
5	Case (Housing) Assy.	1 ea.	57.50	
6	Crank Case Assy.	1 ea.	15.31	
7	Valve Rod Retainer	2 ea.	2.05	
8	Piston Rod Retainer	2 ea.	2.05	
9	Misc., Sealer, etc.	A/R	3.00	

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Sleeve Valve Assembly (set)	1 set	3.75	Subtotal
2	Valve sleeve	2 ea.	.25	Stl. seamless tube, 4.935 x 1.25 O.D. x .065 wall
3	Body	2 ea.	.30	Al.al. 7075, .995 dia. x 3.825
4	Ring	16 ea.	.12	Cast iron, .995 I.D. x .050 wall x .062 thick x .125 gap
5	Connecting rod	2 ea.	.25	Stl. .312 dia. x 6.81
6	Set screw	2 ea.	.06	Allen socket 1/4 - 28 x 1/4
7	Rod nut	2 ea.	.05	Hex 3/8 - 24

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Rod and Piston Assy.	2 ea set	3.90	Subtotal
2	Piston	2 ea.	.25	Stl. (1010 etc.) 2.010 dia. x 1.147
3	Connecting rod	2 ea.	.25	Stl. (1010 etc.) .437 dia. x 7.937
4	Piston "jam" nut	2 ea.	.15	Hex nut, 7/16 - 18 (tapered)
5	Ring	8 ea.	.20	Cast iron, 1.830 O.D. x .080 wall x .062 thick x .260 gap
6	Cylinder	2 ea.	.50	Stl. tube, seamless - 2.250 O.D. x 2.125 I.D. x 5.00 long

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Head Assembly	1 ea.	35.57	Subtotal
2	Yoke slide bearing rtr.	1 ea.	.40	Al.al. 7075-T651, 3.838 x 1.275 x .762
3	Breather	1 ea	.08	Pipe plug, 1.4 pipe sq. head
4	Retainer bolt	2 ea.	.10	Allen socket, cap screw 5/16 - 18 x 1
5	Heat plate	1 ea.	1.95	Al.al. 7075-T651, 7.875 x 4.890 x .500
6	Dowel pin	2 ea.	.02	Drill rod, .250 dia. x .750
7	Plug	1 ea.	.10	Allen socket, 1/4 pipe plug
8	Value clearance inspection plug	2 ea.	.08	Pipe plug, 1/4 sq. head
9	Cylinder clearance inspection plug	2 ea.	.10	Allen socket, 1/4 pipe plug
10	"O" ring	1 ea.	.05	1.00 O.D. x .125, rubber
11	Head bolt	7 ea.	.20	Allen socket, cap screw 5/16 - 18 x 7
12	Piston port sect. head	1 ea.	2.45	Al.al. 7075-T651, 7.875 x 4.890 x .635
13	Dowel pin	2 ea.	.02	Drill rod, .250 dia. x .750
14	"O" ring	2 ea.	.05	1.650 O.D. x .125, rubber
15	"O" ring	1 ea.	.10	3.00 O.D. x .125, rubber
16	"O" ring	1 ea.	.20	12.00 O.D. x .125, rubber

	ITEM	QTY	MAT'L COST	DESCRIPTION
	Head Assembly (cont'd)			
17	Valve port sect. head	1 ea.	4.43	Al.al. 7075-T651, 7.875 x 4.890 x 1.150
18	Bypass port plug	2 ea.	.12	Hex head, 3/8 pipe plug
19	Piston port plug	2 ea.	.10	Allen socket, cap screw 5/16 - 18 x 3/4
20	Dowel pin	2 ea.	.02	Drill rod, .250 dia. x .750
21	"O" ring	2 ea.	.10	2.5 O.D. x .125, rubber
22	"O" ring	2 ea.	.06	1.335 O.D. x .125, rubber
23	Block	1 ea.	9.63	Al.al. 7075-T651, 7.785 x 4.890 x 2.50
24	Bypass valve	2 ea.	1.85	Standard 1/4 brass needle valve, 3/8 pipe mounting
25	"O" ring	2 ea.	.10	3.00 O.D. x .125, rubber
26	"O" ring	2 ea.	.05	.718 O.D. x .125, rubber
27	Intake manifold	1 ea.	.62	Al.al. 7075-T651, 3.820 x 2.610 x .620
28	"O" ring	1 ea.	.10	3.00 O.D. x .125
29	Mounting bolt	4 ea.	.10	Allen socket, cap screw 5/16 - 18 x 1

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Valveport sect case	1 ea.	4.43	Al.al. 7075-T651, 7.875 x 4.890 x 1.150*
2	Bypass port plug	2 ea.	.12	Hex head, 3/8 pipe plug
3	Piston port plug	2 ea.	.10	Allen socket, cap screw 5/16 - 18 x 3/4
4	Dowel pin	2 ea.	.02	Drill rod, .250 dia. x .750
5	"O" ring	2 ea.	.10	2.5 O.D.
6	"O" ring	2 ea.	.06	1.335 O.D. x .125, rubber
7	Piston port sect case	1 ea.	2.45	Al.al. 7075-T651, 7.875 x 4.890 x .635*
8	Dowel pin	2 ea.	.02	Drill rod, .250 dia. x .750
9	"O" ring	2 ea.	.05	1.650 x .125, rubber
10	"O" ring	1 ea.	.10	3.00 x .125, rubber
11	"O" ring	1 ea.	.20	12.00 x .125, rubber

*(same as head sect)

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Case (Housing) Assy.	1 ea.	57.50	Subtotal
2	Case Outer Cover	1 ea.	14.04	Al.al. 7075-T651, 22.60 x 10.02 x .620
3	Screw	24 ea.	.04	FH.CSK. Slot, 5/16 - 18 x 1 Machine Screw
4	Plug	1 ea.	.08	1/4 Pipe plug Sq. Ho.
5	Inner bearing cover	1 ea.	2.14	Al.al. 7075-T651, 7.5 x 7.5 x .38
6	Cover screw	6 ea.	.04	FH.CSK. Slot M.S. 3/8 - 16 x .75
7	Flange bearing	2 ea.	2.87	Seal Master, #SF-23C (Mod. per Dwg.)
8	Bearing separater	1 ea.	5.62	Al.al. 7075-T651, 4.74 x 4.74 x 2.50
9	Access hole plug	2 ea.	.08	1/4 pipe plug, Sq. No.
10	Outer bearing cover	1 ea.	1.12	Al.al. 7075-T651, 4.74 x 4.74 x .50
11	Bearing stud	4 ea.	.15	Stl., threaded rod, 1/2 - 13 x 5.25
12	Nut	4 ea.	.06	Hex, Stl., 1/2 - 13
13	Crank Shaft	1 ea.	3.68	Stl. Drill Rod (Shafting) 1.437 dia. x 11.62
14	Case Side Plate "A"	1 ea.	7.52	Al.al. 7075-T651, 22.06 x 5.50 x .620
15	Slider mount bolt	2 ea.	.04	Allen socket, 5/16 - 18 x 3/4
16	Fixt point bolt	1 ea.	.04	Allen socket, 5/16 - 18 x 3/4
17	Case Side Plate "B"	1 ea.	7.52	Al.al. 7075-T651, 22.06 x 5.50 x .620
18	Slider mount bolt	2 ea.	.04	Allen socket, 5/16 - 18 x 3/4
19	Case End Plate	1 ea.	3.83	Al.al. 7075-T651, 11.24 x 5.50 x .62
20	Dowel pin	2 ea.	.02	Drill rod, .250 dia. x .750
21	Screw	8 ea.	.04	FH.CSK. Slot M.S., 3/8 - 16 x 1 1/2

ITEM		QTY	MAT'L COST	DESCRIPTION
	Case (Housing) Assy. (cont'd)			
22	Case Cover	1 ea.	2.53	Al.al. 7075-T651, 15.375 x 8.812 x .187
23	Screw	8 ea.	.04	FH.CSK. Phil. M.S., 5/16 - 18 x .50
24	Piston Rod Slider	2 ea.	.30	Al.al. 7075-T651, 6.00 x 2.00 x .250

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Crankcase Assy. (Internal)	1 ea.	15.31	Subtotal
2	Piston Rod End	2 ea.	.50	Al.al. 7075-TL51, 2.0 x 2.0 x 1.25
3	Screw "	2 ea.	.05	Allen socket cap screw 5/16 - 24 x .250
4	Valve Rod End	2 ea.	.11	Al.al. 7075-T651, .625 x .625 x 2.70
5	Piston Rod Yoke	2 ea.	.60	Std. Heavy Duty Sprocket Chain Master Link (1.25)
6	Valve Rod Yoke	2 ea.	.60	Std. Heavy Duty Sprocket Chain Master Link (1.50)
7	Linear Bearing Shaft	1 ea.	.45	Brass tube, .750 O.D. x .500 I.D. x 9.562
8	Shaft End	1 ea.	.46	Morse Shaft End
9	Valve Link Arm	1 ea.	.16	Al.al. 7075-T651, 4.20 x .62 x .62
10	Valve Lnk Arm Fxer Pnt	1 ea.	.10	Al.al. 7075-T651, .87 x .87 x 1.25
11	Valve Rocker	1 ea.	1.28	Al.al. 7075-T651, 6.00 x 4.25 x .500
12	Bearing retainer	1 ea.	.10	Al.al. 7075-T651, 1.875 dia. x .500
13	Bolt	4 ea.	.06	Mod per Dwg. 4200047
14	Piston Rocker	1 ea.	6.73	Al.al. 7075-T651, 8.125 x 5.75 x 1.44
15	Counterthrow Inner	1 ea.	.55	Stl. (1010 etc.), 3.6 x 3.6 x .62
16	Bolt	4 ea.	.06	Mod. per Dwg. 4200048
17	Counterthrow Outer	1 ea.	.55	Stl. (1010 etc.), 3.6 x 3.6 x .62
18	Throwbushing "B"	1 ea.	.25	Al.al. 7075-T651, 2.68 dia. x 1.25
19	Bolt	8 ea.	.06	Mod. per Dwg. 4200047

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Valve Rod Packing Retainer	2 ea.	2.05	Subtotal
2	Body	2 ea.	.45	Al.al. 7075, 3.00 dia. x 1.690
3	Packing Nut	2 ea.	.25	Stl (1010 etc.), 7.150 dia. x 1.00
4	Packing	A/R	.25	
5	Mounting Bolt	4 ea.	.10	Hex, Cap 5/16 - 24 x 1.00
6	Piston Rod Packing Retainer	2 ea.	2.05	Subtotal
7	Body	2 ea.	.45	Al.al. 7075, 3.00 dia. x 1.690
8	Packing Nut	2 ea.	.25	Stl (1010 etc.), 1.150 dia. x 1.00
9	Packing	A/R	.25	
10	Mounting Bolt	4 ea.	.10	Hex, Cap 5/16 - 24 x 1.00

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Condenser Assembly	1 ea.	41.85	
2	Body	1 ea.	15.00	CRS 36.00 x 28.25 x .060
3	Header plate	2 ea.	1.00	CRS 6.00 dia. x .060
4	Tubes	19 ea.	.80	CRS Tube 31.25 x .500 dia. x .035 wall
5	End plate	2 ea.	1.00	CRS 6.00 dia. x .060
6	Water jacket cplng	2 ea.	.90	CRS 1/2 in. pipe coupling
7	Inlet coupling	1 ea.	1.25	CRS 1 in. pipe coupling
8	Outlet coupling	1 ea.	1.60	CRS 1- 1/4 in. pipe coupling
9	Welding rod, etc.	A/R	3.00	--

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Preheater Assembly	1 ea.	20.40	
2	Body	1 ea.	6.00	Tube Cu. 2.625 O.D. x 15.50 x .060 wall
3	Coil	1 ea.	4.00	CRS tube, .250 dia. 28 turns wound on 1.8 dia. mandrill (approx. 100 in.)
4	Reducer	2 ea.	2.40	Cu. fitting, 2.5 to 1.5, end cap reducer
5	Elbow	2 ea.	1.80	Cu. fitting, 1.625
6	Welding rod, etc.	A/R	2.00	

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Hotwell	1 ea.	797.96	
2	Tank	1 ea.	450.00	Corrugated Stl. (16 Ga) Galvanized includes lid & fittings (850 gal)
3	Insulation	A/R	25.00	4.5 in. coat of polyurethane foam
4	Heat exchanger	1 ea.	12.00	Cu tube 1/2 in.-15 ft long (circulated around inside)
5	Cooler	1 ea.	72.00	"Finn Tube" 16 ft. (4.50/ft)
6	Shield	1 ea.	9.35	Stl. (13.0 dia. x 3.20 high) 41.0 x 32.0 x 16 Ga
7	Output pump	1 ea.	49.66	Teel #1P798
8	Motor	1 ea.	109.34	Dayton #2M168
9	Jaw Coupling	1 ea.	4.56	Gerbing-Elgin #G-100 5/8
10	Mount	1 ea.	2.35	Stl. 24 x 14 x 14 Ga
11	Solenoid valves	2 ea.	13.43	Skinner Electric #LC20B41
12	Thermostat	1 ea.	19.66	Dayton #7738
13	Misc. Plastic Tube	A/R	2.00	
14	Misc. Fittings	A/R	3.50	3/4 pipe
15	Coupling	4 ea.	2.72	3/4 pipe
16	"T" Fitting	1 ea.	.80	3/4 pipe

	ITEM	QTY	MAT'L COST	DESCRIPTION
1	Power Cart Assembly	1	2,396.89	
2	Reservoir	1	240.20	
3	Side	2	37.50	CRS (304) 11 Ga, 10.0 x 36.0
4	Top	1	60.00	CRS (304) 11 Ga, 16.0 x 36.0
5	Bottom	1	60.00	CRS (304) 11 Ga, 16.0 x 36.0
6	End	2	20.00	CRS (304) 11 Ga, 12.0 x 16.0
7	Rail	2	1.50	Stl. angle, 2.0 x 2.0 x 25 x 36.0
8	Coupling	3	1.25	CRS, 3/4 pipe
9	Equipment Mount	1	15.64	
10	Base	1	7.83	Stl. channel 3.0 x 10.0 x 36.0
11	Channel frame	2	2.60	Stl. channel 2.0 x 2.0 x .25 x 47.0
12	Enclosure	1	2.61	Stl. 10.0 x 47.0 x 10 Ga
13	Sight Glass	1	2.32	Teel #6X343
14	"T" Fitting	1	.80	3/4 pipe
15	Nipple	1	.27	3/4 pipe
16	Pump	1	68.19	Giant, #PB42K
17	Pump motor	1	122.60	Dayton, #2M168
18	Gear Reducer	1	94.36	Dayton, #47006
19	Generator	1	850.00	Fidelity #F15-36-534
20	Pully	2	13.23	Browning 3X532
21	Sustainer Motor	1	500.00	Morse #15764
22	Pully	1	13.23	Browning 3X532

	ITEM	QTY	MAT'L COST	DESCRIPTION
	Power Cart Assembly (cont'd)			
23	Oiler	1	56.83	Lincoln Centroiler #1812
24	Engine	1	--	See Engine Section
25	Clutch	1	245.00	Magnetic Clutch, Rockwell #45138 (90 V.D.C.)
26	Pully	1	39.13	Browning 3X571
27	Condenser	1	--	See Condenser Section
28	Thermostat	1	19.66	Dayton #7738
29	Preheater	1	--	See Preheater Section
30	Pressure gauge	1	4.78	0-.3000 PSIG - Teel #4X790
31	Pressure gauge	1	2.76	0.400 PSIG - Teel #5X938
32	High Pressure Release	1	9.86	Para-plate #BR5-3
33	Filter trap	1	12.50	Dayton 2Z925
34	Check Valve	1	8.37	Pneu-trol #CP2055
35	Tube	A/R	8.50	5/16 CRS Tube (Approx. 8 ft)
36	Tube Fittings	A/R	30.00	Stainless
37	"V" Belt	3	7.96	Grates B-43209

APPENDIX C

COST & PARTS LISTS

100 UNITS/YEAR

SUMMARY SHEET

SUB-ASSEMBLY	MATERIAL COST	LABOR MANHOURS	LABOR DOLLARS	COST PER SUB-ASSY
Receiver Assembly	378.57	11.45	91.60	470.17
Back Structure	379.17	16.25	130.00	509.17
Petal Assembly	2,877.63	7.50	60.00	2,937.63
Receiver Strut	166.00	1.70	13.60	179.60
Cantilever Support	743.98	14.40	115.20	859.18
Elevation Mechanism	586.14	4.25	34.00	620.14
Azimuth & Trolley Assembly	642.96	8.85	70.80	713.76
Yoke Assembly	170.95	7.00	56.00	226.95
Base Assembly	326.29	7.85	62.80	389.09
Electrical	288.50	8.15	65.20	353.70
Foundation	550.05	72.79	582.28	1,132.33
Stem Engine	123.13	31.87	254.96	378.09
Condenser	41.85	2.18	17.44	59.29
Preheater	20.40	1.10	8.80	29.20
Hotwell	797.96	2.90	23.20	821.16
Power Cart	2,396.89	7.00	56.00	2,452.89
Transport	438.77	3.73	29.86	468.63
TOTALS	$10,929.24	208.97	$1,671.74	$12,600.98

APPENDIX D

COST & PARTS LISTS

25,000 UNITS/YEAR

SUMMARY SHEET

SUB-ASSEMBLY	MATERIAL COST	LABOR MANHOURS	LABOR DOLLARS	COST PER SUB-ASSY
Receiver Assembly	291.20	8.02	64.12	355.32
Backup Structure	270.63	11.38	91.04	361.67
Petal Assembly	2,100.60	3.00	24.00	2,124.60
Receiver Strut	126.46	1.20	9.60	136.06
Cantilever Support	565.24	10.08	80.64	645.88
Elevation Mechanism	451.03	2.98	23.80	474.83
Azimuth & Trolley Assembly	494.69	6.20	49.60	544.29
Yoke Assembly	119.67	4.90	39.20	158.87
Base Assembly	252.46	5.50	44.00	296.46
Electrical	216.38	5.71	45.68	262.06
Foundation	385.04	67.33	538.60	920.64
Steam Engine	92.34	21.83	174.64	266.98
Condenser	31.39	1.53	12.21	43.60
Preheater	15.30	.77	6.16	21.46
Hotwell	638.37	2.04	16.32	654.69
Power Cart	1,797.66	4.90	39.20	1,836.86
Transport	329.03	1.36	10.91	339.99
TOTALS	8,177.54	158.73	1,269.72	9,447.26

APPENDIX E

COST & PARTS LISTS

100,000 UNITS/YEAR

SUMMARY SHEET

SUB-ASSEMBLY	MATERIAL COST	LABOR MANHOURS	LABOR DOLLARS	COST PER SUB-ASSY
Receiver Assembly	213.55	4.58	36.64	250.19
Backup Structure	155.56	6.50	52.00	207.56
Petal Assembly	1,540.29	1.34	10.72	1,551.01
Receiver Strut	93.08	.68	5.44	98.52
Cantilever Support	420.38	5.76	46.08	466.46
Elevation Mechanism	330.35	1.70	13.60	344.35
Azimuth & Trolley Assembly	362.70	3.54	28.32	391.02
Yoke Assembly	70.14	2.80	22.40	92.54
Base Assembly	198.89	3.14	25.12	224.01
Electrical	158.68	3.26	26.08	184.76
Foundation	220.02	54.59	436.71	656.73
Steam Engine	73.88	12.75	102.00	175.88
Condenser	25.11	.87	6.96	32.07
Preheater	12.24	.44	3.52	15.76
Hotwell	478.77	1.16	9.28	488.05
Power Cart	958.75	2.80	22.40	981.15
Transport	223.77	.60	4.78	228.55
TOTALS	5,536.56	106.51	852.05	6,388.61