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TEXTILE DRYING USING SOLARIZED CAN DRYERS TO DEMONSTRATE THE APPLICATION OF SOLAR ENERGY TO INDUSTRIAL DRYING OR DEHYDRATION PROCESSES

Phase II Final Report

By
P. D. Mitchell
M. E. Beesing
G. L. Bessler

December 1979
Date Published

Work Performed Under Contract No. EY-76-C-05-5124

Honeywell Inc.
Technology Strategy Center
Minneapolis, Minnesota

U.S. Department of Energy

Solar Energy

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Prepared for the United States
Department of Energy
Division of Solar Energy

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ABSTRACT

This Phase II DOE program has resulted in the installation of a solar energy collection system for providing process heat to a textile drying process. The solar collection subsystem uses 700 square meters (7500 square feet) of parabolic trough, single-axis tracking, concentrating collectors to heat water in a high temperature water (HTW) loop. The solar collectors nominally generate 193°C (380°F) water with the HTW loop at 1.9×10^6 Pa (275 psi). A steam generator is fueled with the HTW and produces 450 kg/hour (1000 pounds per hour) of process steam at the nominal design point conditions. The solar-generated process steam is at 0.5×10^6 Pa (75 psi) and 160°C (321°F). It is predicted that the solar energy system will provide 1.2×10^6 MJ/year (1.1×10^9 Btu/year) to the process. This is 46 percent of the direct isolation available to the collector field during the operational hours (300 days/year) of the Fairfax mill.

The process being solarized is textile drying using can dryers. The can dryers are part of a "slashing" operation in a WestPoint Pepperell mill in Fairfax, Alabama. Over 50 percent of all woven goods are processed through slashers and dried on can dryers.

The collectors were fabricated by Honeywell at a pilot production facility in Minneapolis, Minnesota, under a 3000-square-meter (32,000-square-foot) production run. The collectors and other system components were installed at the site by the Bahnson Service Company and their subcontractors, acting as the project general contractor. System checkout and start-up was conducted. Preliminary system performance was determined from data collected during start-up.

ACKNOWLEDGEMENT

This document reports the activity of Honeywell Inc. and WestPoint Pepperell during Phase II of the subject program. The overall program was under the direction of P.D. Mitchell of Honeywell. WestPoint Pepperell support was provided by R.I. Uhl and C. Summers.

Support provided to this program by the Agricultural and Industrial Process Heat Branch, Division of Solar Energy, U.S. Energy Research and Development Administration, and the help provided by William W. Auer, Technical Project Officer, and the Program Consultants, G. Greyerbiehl, A. Clark, D.E. Randall, W.C. Dickenson, J. Mills and C.W. Treadwell, is acknowledged with sincere thanks.

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SECTION 1.0
SYSTEM DESIGN

1.1 INTRODUCTION

1.1.1 Program Objective

The overall objective of the Application of Solar Energy to Industrial Drying or Dehydration Processes program, under which this Textile Drying project is funded, is to stimulate and give impetus to the growth of industry in areas capable of supplying significant amounts of industrial process heat through the use of solar energy.

The specific objectives of the Textile Drying project are to design, build, install, and evaluate the application of solar energy to textile drying and to provide an analysis of the economic benefits to be gained by such application.

1.1.2 Phases of the Program

This document is the Final Report for Phase II of the Textile Drying project.

Phase I included the process definition, detailed design of the solar energy system, development of specifications and installation blueprints for the system, and an economic analysis of the solar application.

Phase II included the procurement and assembly of the system components and subsystems, the installation of the system at the MARTEX* towel mill of WestPoint Pepperell at Fairfax, Alabama, the system start-up and checkout, and the development of a plan for tests to be conducted in Phase III.

Phase III will include operation of the system for a 12-month period of supplying process heat to the drying application, collection of system operating data during that period, and evaluation of system performance and system economics based on the data collected.

1.1.3 Design Status

The Phase I Final Report, "Textile Drying Using Solarized Cylindrical Can Dryers," documented the detailed design of the solar process steam system at the conclusion of Phase I. Since that time, improvements of that design have been realized, both prior to and during construction. The following subsection describes in general the detailed design "as built." Section 5.0 contains the specification and drawing package that defines the detailed design of the system.

1.2 DETAILED DESIGN

The solar system designed to provide process steam for textile drying consists of five major subsystems:

- The collector field,
- The high temperature water (HTW) pipe loop,
- The steam generator,
- The steam pipe loop,
- The process.

Figure 1-1 is an illustration of this system combining a simplified system schematic and photographs of the subsystems.

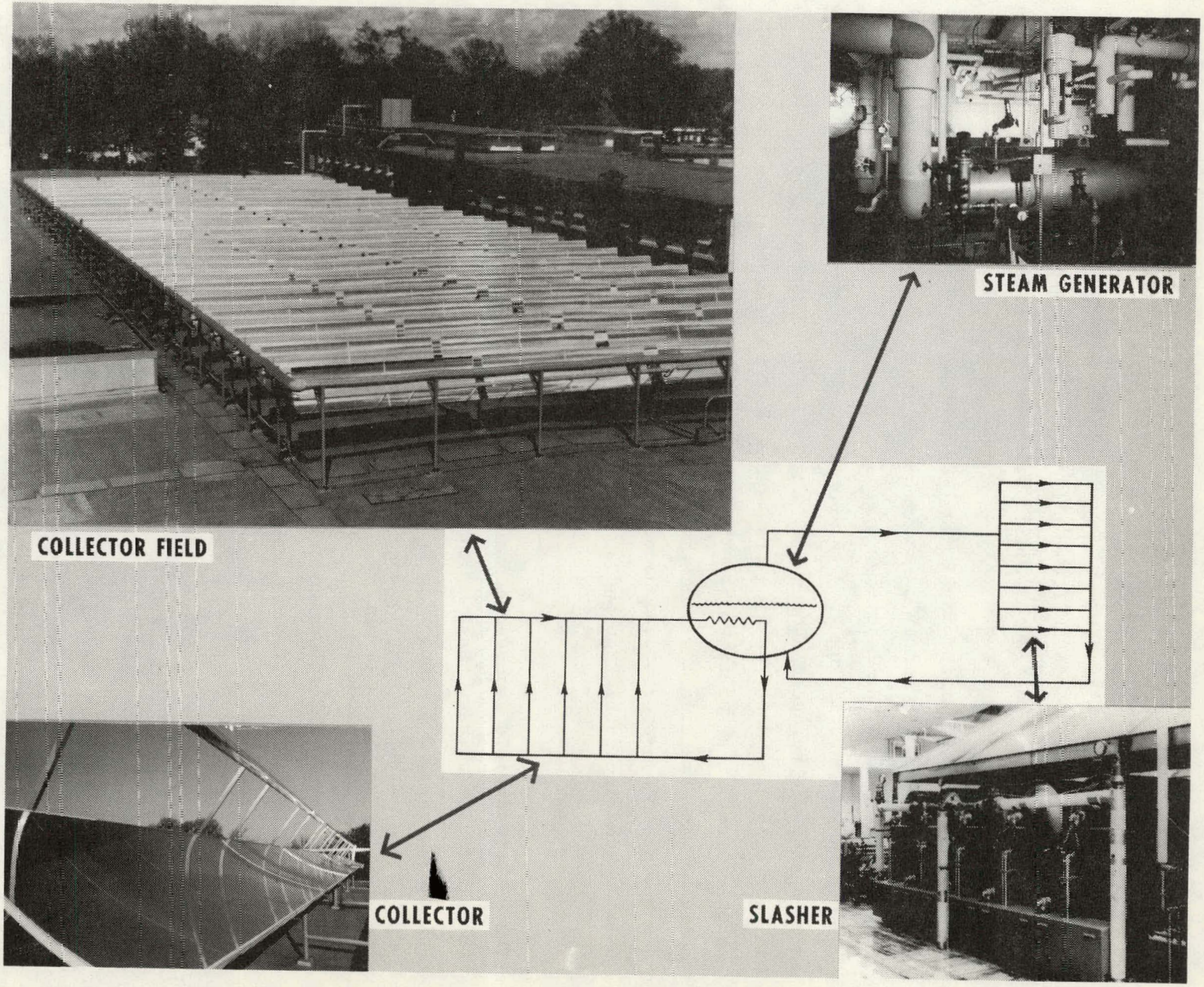


Figure 1-1. Process Steam System

The collector field consists of 24 concentrating trough collectors arranged on the weave room roof to provide 7500 square feet of collector aperture. The collector field is aligned along the building coordinates, and spacing between collector axes is 10 feet 8 inches, which eliminates shadowing from adjacent collectors unless the sun is below 22° elevation.

The collector, illustrated in Figure 1-2, uses a half-parabola mirror concentrator to focus solar energy on an insulated tube receiver. The mirror is constructed of aluminum honeycomb with a reflective surface applied. Four 20-foot by 4.3-foot mirrors per collector result in 313 square feet of active mirror aperture per collector unit. The collector rotates through 270° to allow stowing. A motor/gearbox drives the mirror assembly via a torque tube under control of a sun tracker. The pivot axis is at the middle of the mirror chord to minimize wind loads on the drive system. The receiver/absorber is attached to the mirror drive and rotates with the unit. The receiver uses calcium silicate insulation and an etched soda glass window to reduce thermal losses.

The collector field is under control of the system controller and individual collector controllers. System start-up is initiated by a preset minimum insolation level and maximum wind level. At start-up each collector acquires the sun (points at the sun) and initiates tracking. The collectors track individually throughout the day. High wind or low light level will cause the system controller to command the collectors to stow. In the stowed position the mirrors look downward to protect the surface from the weather and reduce wind loads on the collector support structure.

The high temperature water (HTW) loop transports the thermal energy to a steam generator and includes the solar receivers. The loop is a closed system pressurized to 275 psi to allow for HTW transport without the formation of vapor (boiling). A supply header feeds the collectors from one edge of the field and a return header runs down the other edge of the field to form a "C" loop

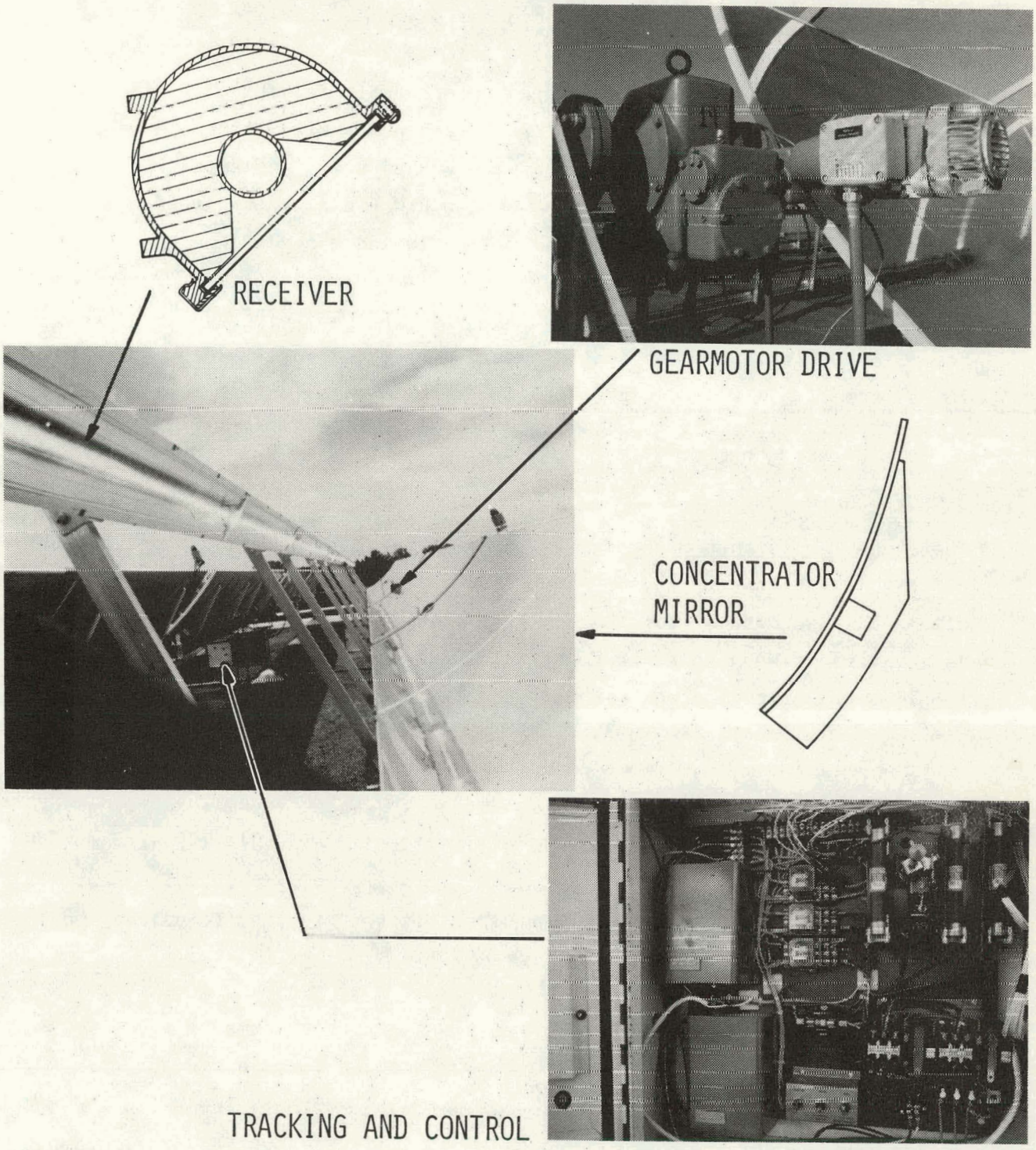


Figure 1-2. Collector

flow pattern. Valves at the collectors are used to balance the flows in the collectors and isolation. Design flow is 2 gpm in each collector (48 gpm system flow). The HTW loop is sloped to enhance elimination of air bubbles and contains manual air vents, an air trap, and an air eliminator. A 5-hp pump provides the 48-gpm field flow against a 22-psi head. An expansion tank allows for daily expansion and contraction of the HTW fluid. A water-to-steam package boiler (steam generator) is fueled by the HTW and provides the process steam.

The steam generator is the interface between the HTW loop and the process steam loop. It is a commercially available package boiler that generates 76 psi steam when fueled with 380°F water. Feedwater for the steam generator is taken from a steam condensate tank. The steam generator is located on the weave room roof near the collector field.

The steam loop transports the solar steam from the steam generator into the building and to the process. Steam flow is controlled by a check valve that allows displacement of fossil-fuel-generated steam when solar-generated steam is available. When solar steam is not generated, the existing steam system supplies the process steam. Completing the steam loop is the feedwater line pumped from a condensate receiver.

The slasher steam manifold is maintained at 70 psi by a pressure regulator off the main high pressure steam line. The drying cans are set at some pressure (less than 60 psi) to maintain a proper drying rate. The slashers operate 24 hours a day, 6 days a week, except for stoppage to unload and load.

1.3 DESIGN CHANGE RECOMMENDATIONS

Although formally a Phase III task, several design change recommendations are documented herein because they were developed during the installation.

1.3.1 Collector Support Adjustments

Construction and installation tradesmen are not experienced at working to the fractions of an inch specifications required for installation of concentrating collectors. Therefore, two problems arise: 1) they bid the job high because achieving the specifications will be difficult; 2) they do not achieve the accuracy required to meet the specifications. Therefore, the collector support mechanism must have freedom for adjustment in all directions, and this adjustment should be at least $\pm$ 1 inch.

1.3.2 Penthouse Piping

Due to constraints in the penthouse and convenience in piping, the HTW pipe in the penthouse was not routed on a continuous sloping pitch as designed. Therefore, special measures were taken to allow vapor to be eliminated at high points in the system. On similar systems in the future, alternative HTW equipment locations and pipe routings should be considered for simplicity of design.

1.3.3 Photographic Instrumentation

A desirable addition to the instrumentation package would be time-lapse photography, either tracking the sun or an "all sky" type of camera. Subjective interpretation of the "type of day" cannot be obtained from the insolation sensors alone, and unknown events which appear in the data leave the analyst with the desire to have a weather observer at the site at all times. A time-lapse photographic record could provide this visual information.

SECTION 2.0
PHASE II ACTIVITIES

2.1 INTRODUCTION

Phase II was initiated on 18 July 1977. Based on the bids received during Phase I, the Bahnson Service Company, a Division of Envirotech, Winston-Salem, North Carolina, was selected as the general contractor for installation of the system at the site.

At a preconstruction meeting with DOE on 27 July, Honeywell suggested the collector field be comprised of 24 80-foot-long collectors rather than the 48 40-foot-long collectors originally specified. This modification was approved and the specification package was modified accordingly.

Collector parts procurement was conducted by Honeywell. System parts procurement was conducted by Bahnson. System installation was scheduled in two parts: 1) collector support installation; 2) completion of system installation, to allow WestPoint Pepperell to reroof the weave room roof (at their cost) after the supports were installed and before winter weather.

2.2 COLLECTOR FABRICATION

Honeywell initiated parts procurement for the 24 concentrating collectors in August 1977. This procurement was done in concert with procurement of parts for collectors for other projects. In all, parts for 3000 square meters (32,000 square feet) of collector were procured (77 collector rows of various lengths).

In October 1977, the pilot production line for the concentrating collectors was set up in Minneapolis. This line produced collectors through the months of November and December 1977 and January and February 1978. Once established, the facility produced collectors at the rate of 900 square meters per month (10,000 square feet per month). The collectors were shipped to the site in several truckloads during February and early March 1978.

Figure 2-1 is a photograph taken at the pilot production site showing (from the left) a 20-foot mirror assembly being fabricated on a fixture, a stack of painted torque tubes, a second 20-foot mirror assembly being fabricated on a fixture (partly hidden by torque tubes), a receiver assembly table, completed mirror assemblies awaiting shipment, and crates of mirror panels. This facility produced 128 of the 20-foot mirror assemblies (and an associated 128 20-foot receivers) per month, representing 32 collectors (80-foot-long) per month.

The mirror assemblies are fabricated by placing two prefabricated 10-foot mirror panels (aluminum honeycomb) on an alignment fixture and attaching a 20-foot torque tube with aluminum honeycomb ribs, as shown in Figure 2-2. All interfaces on the aluminum honeycomb are bonded with adhesive. Sheet metal screws hold the components in place until the adhesive has set. The torque tubes are premanufactured with flanges and shafts for attachment to the gear-box, other mirrors, and bearings.

The receiver assembly being fabricated in Figure 2-3 consists of an aluminum extrusion (shown) in which is placed calcium silicate insulation and the selectively coated absorber tube. An etched glass window completes the assembly. Like the mirror assemblies, the receivers are fabricated in 20-foot lengths and joined at the site into an 80-foot-long collector.

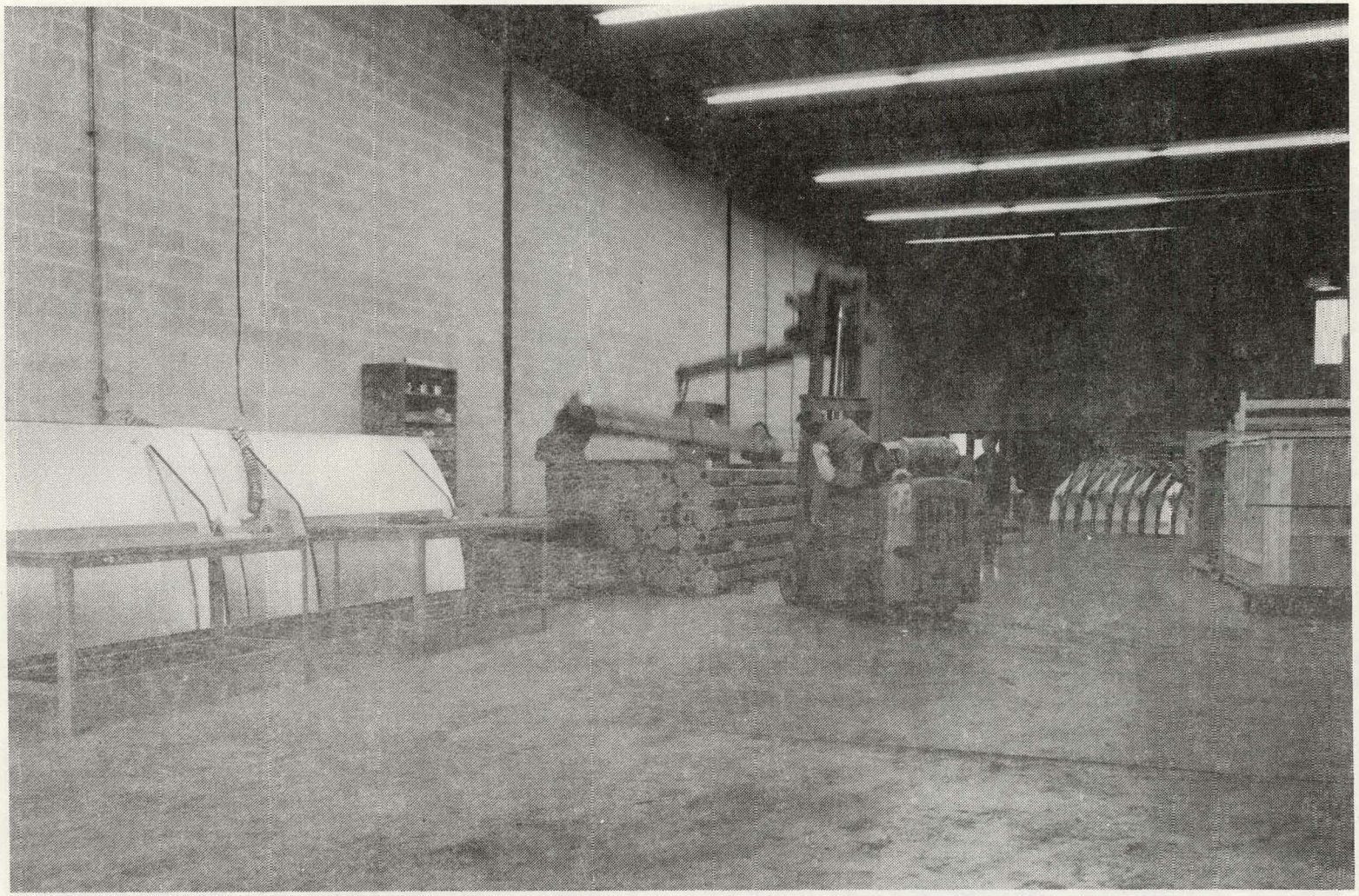


Figure 2-1. Pilot Production Facility

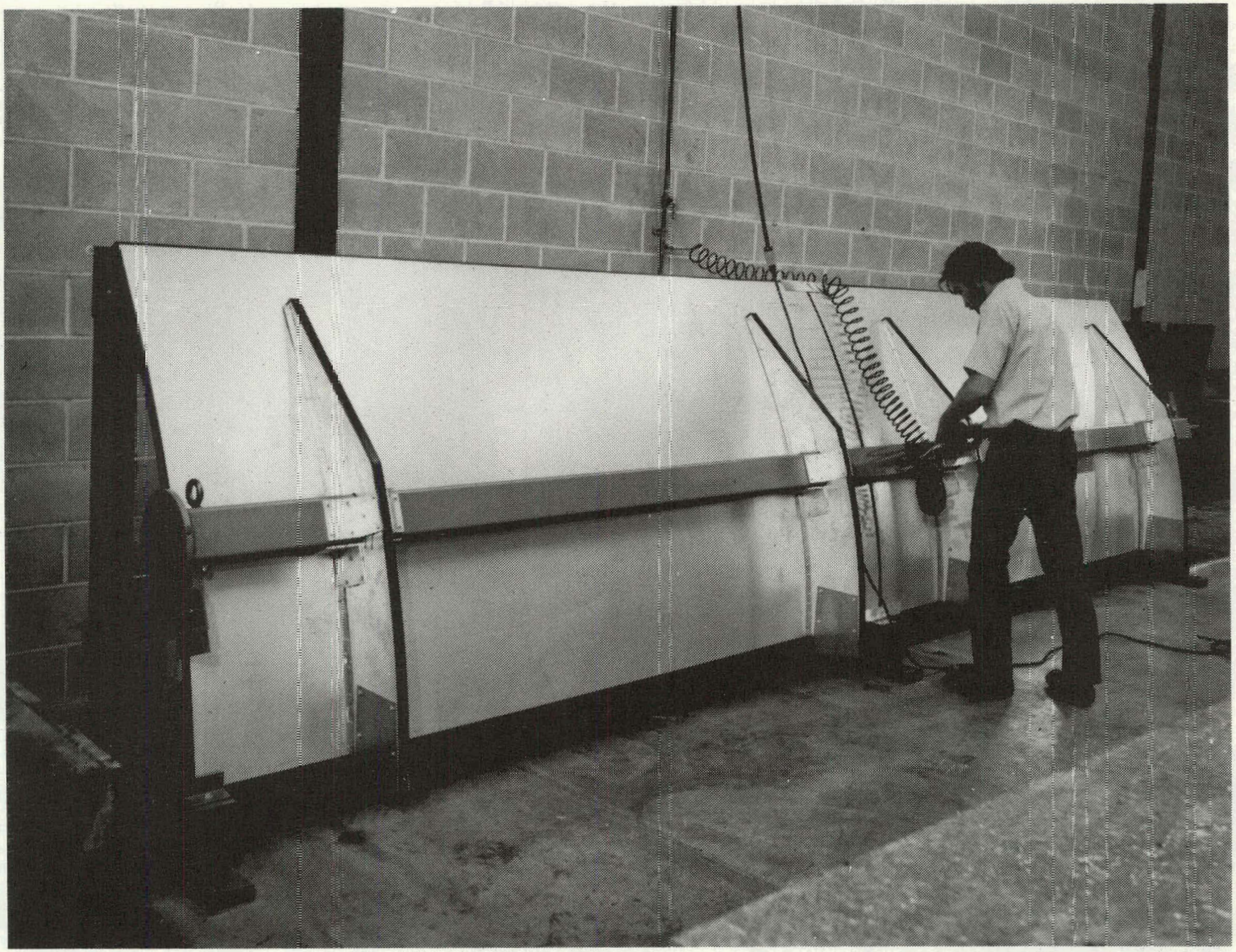


Figure 2-2. Mirror Assembly

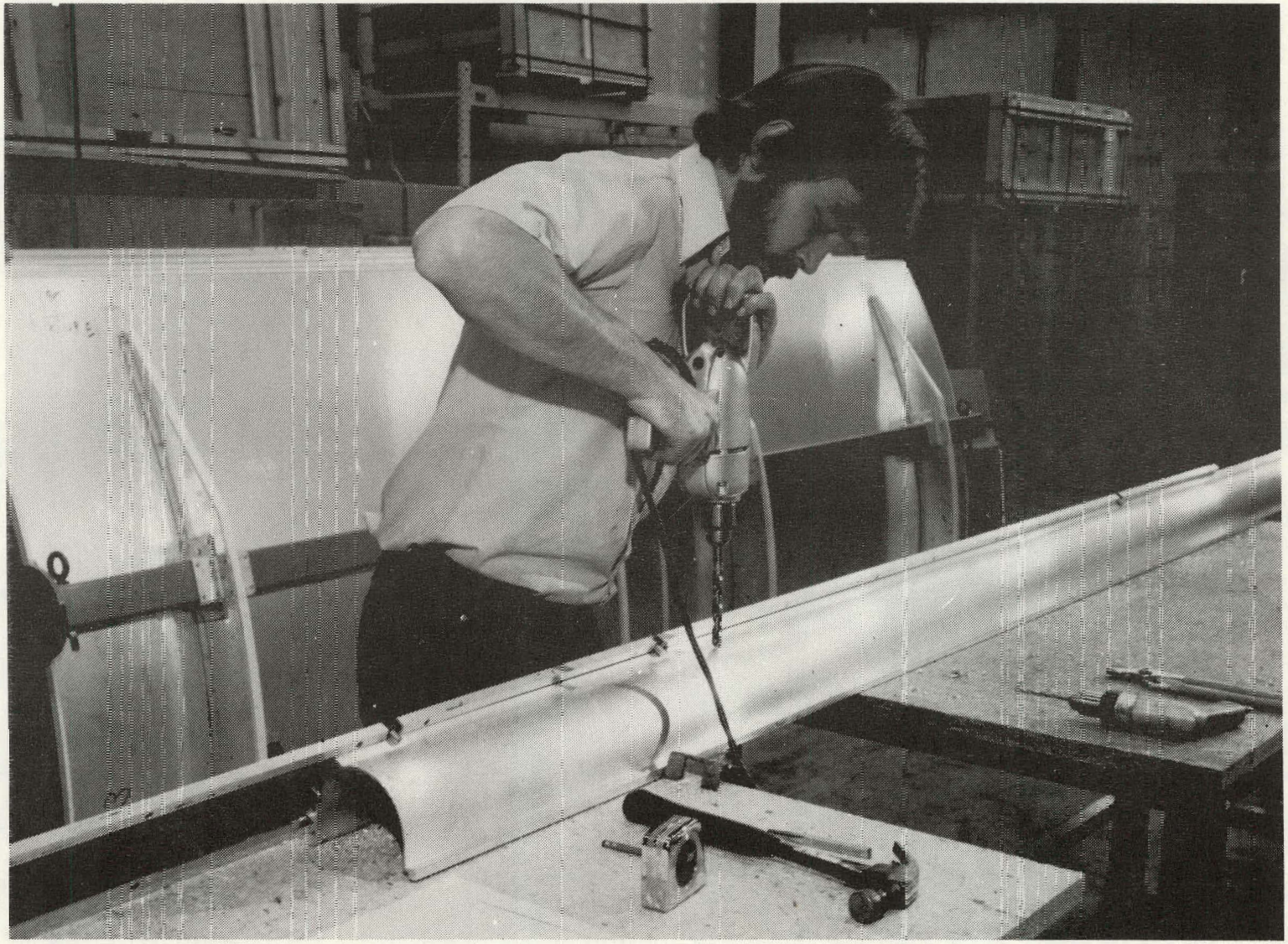


Figure 2-3. Receiver Assembly

2.3 INSTALLATION DETAILS

2.3.1 Collector Supports

The building atop which the collector field is installed was built in 1916 and is of wood construction. Although the collectors are relatively light and pose no static load problem, the dynamic loads from winds were a major consideration in designing the support structure and the structure/roof interface. Because towels are woven in the room below the collectors, leaks in the roof could not be tolerated.

The collectors themselves are designed to withstand 30 mph winds when operating and 100 mph winds in the stowed position. The structure supporting the collectors was designed for worst-case loads resulting from these winds. To reduce the rotational forces at the steel structure/wood roof beam interface, the collectors were paired and supported by an H-shaped structure (sketched in Figure 2-4). The long (10 foot 8 inch) lever arm converts the drag forces to lift forces (both upward and downward) rather than rotational forces, thereby minimizing the loads on the collector support structure/roof interface. Each post is constructed in a pitch pan, as shown in Figure 2-5. The complete roof was covered with a new urethane roof to assure that no leaks would occur at the posts. The H-shaped support structures were shop fabricated to the drawings to reduce field construction costs.

Figure 2-6 shows the collector supports as delivered to the site in October 1977. The center post is fabricated from 5-inch schedule 40 pipe to support the motor/gearbox unit and withstand the torque moments imposed by wind loads. The outer posts (four per collector) are fabricated from 3 1/2-inch schedule 40 pipe to support the collector bearings. The posts were fabricated over-sized (in length) so that they could be sized and leveled in the field to adjust for uneveness in the wood beam roof.

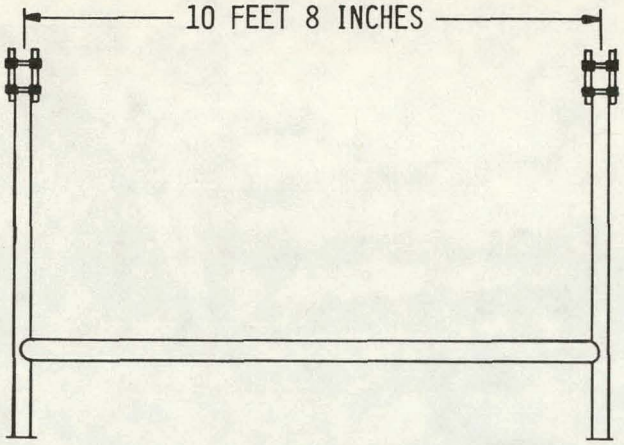


Figure 2-4. H-Shaped Collector Support

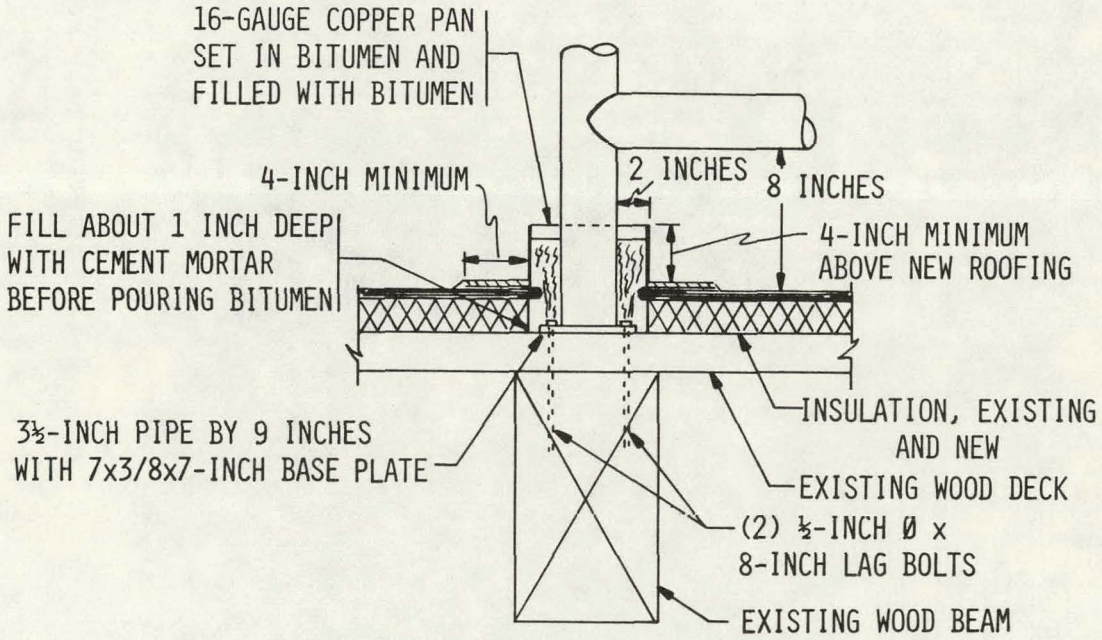


Figure 2-5. Pitch Pan Drawing

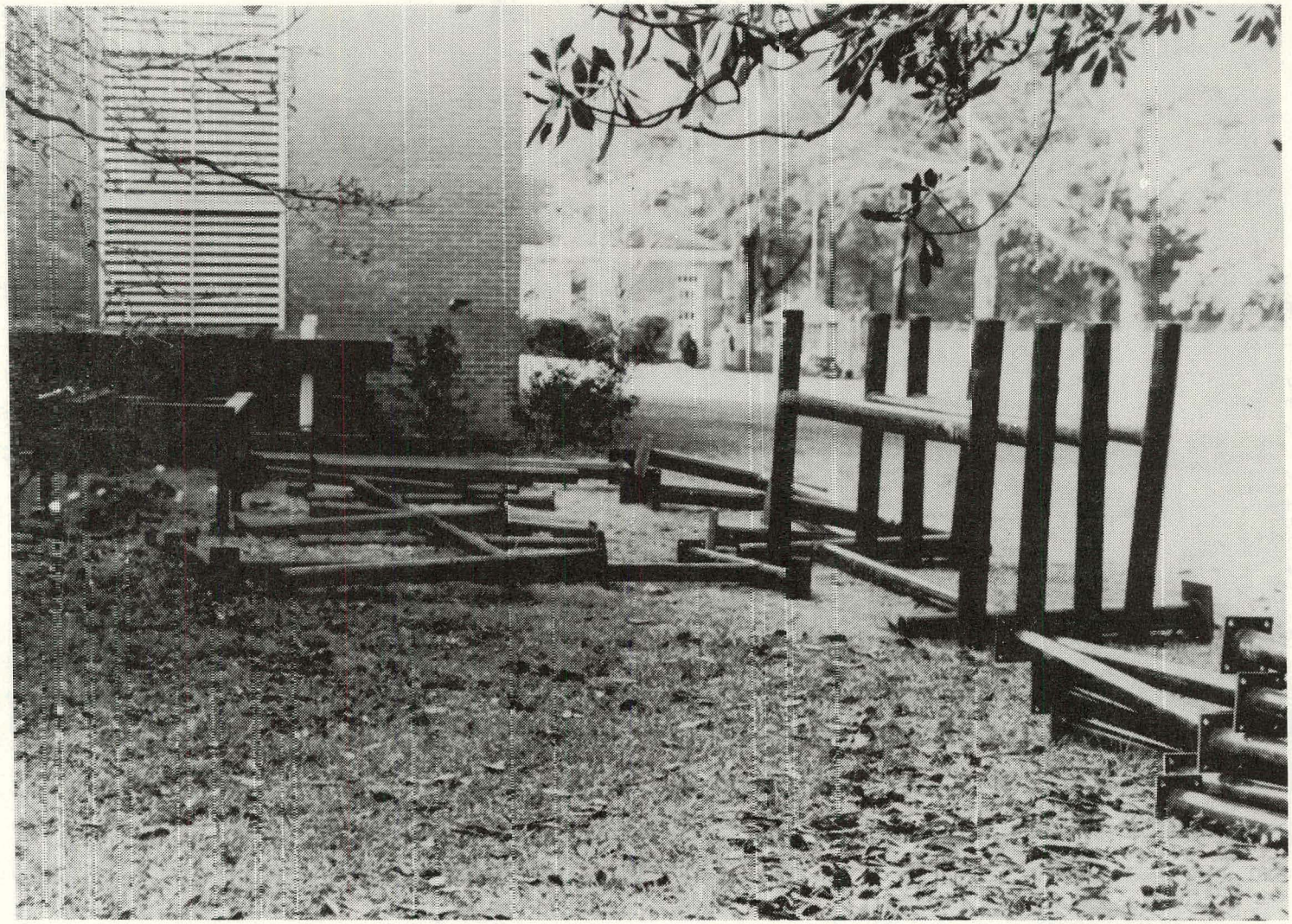


Figure 2-6. Collector Supports at Site, October 1977

The early status of the support installation is shown in Figure 2-7, a photograph taken in November 1977. Supports for eight collector rows are installed (six shown). Pitch pans for the remaining 16 collector rows are evident on the roof.

Installation of the collector supports was completed in November, allowing WestPoint Pepperell to reroof the weave room roof (at their cost) during December. The completed supports and the reroofing activity are shown in Figure 2-8. The dark areas are the old roof and the light areas are the polyurethane foam roof being applied. Note that the foam is sprayed up and over the support post pitch pans to assure a watertight roof. The polyurethane foam was then covered with a silicone foam for protection. Figure 2-9 shows the roof in December with all supports installed and the reroofing nearly complete.

2.3.2 Collector Installation

Installation of the collectors on the support posts was initiated in April 1978, and the mechanical installation was completed in May. Bahnson elected to assemble the collectors on the posts first, then build the high temperature water loop around them to allow easy access to the collector field during this critical installation. Figure 2-10 shows the collector bearing plates installed and leveled prior to mirror installation. The penthouse steel structure can be seen in the background. Figure 2-11 shows the gearboxes installed on the center posts and leveled.

Mirror assemblies were lifted from the shipping crates to the roof with a crane, as shown in Figures 2-12 and 2-13, and hand-carried to the supports for assembly, as shown in Figures 2-14 and 2-15. Support arms and receivers were installed using a template for proper spacing (Figure 2-16). A completed unit was rotated (under manual control) to focus the sunlight as a demonstration for site personnel (Figure 2-17).

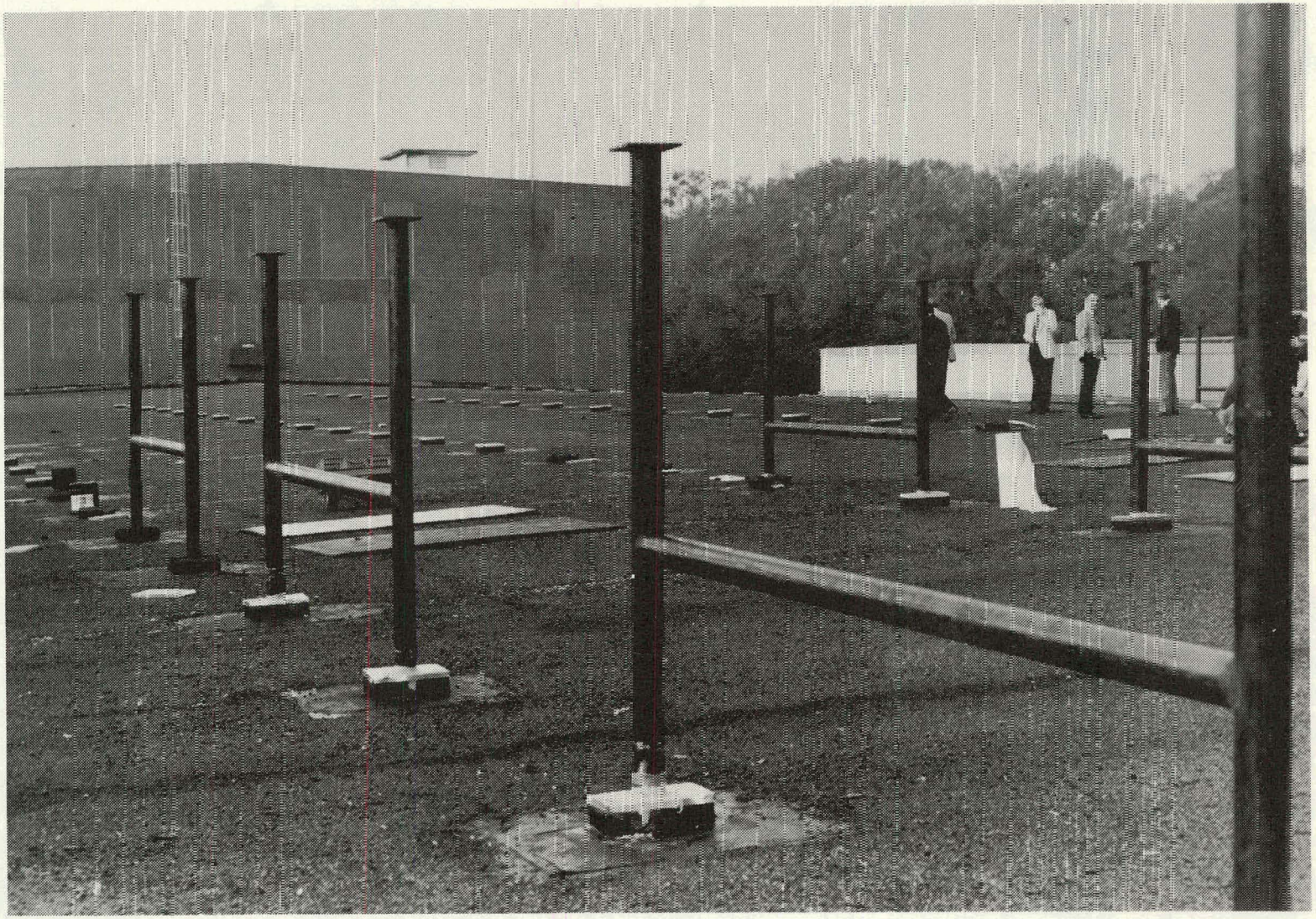


Figure 2-7. Collector Support Installation, November 1977

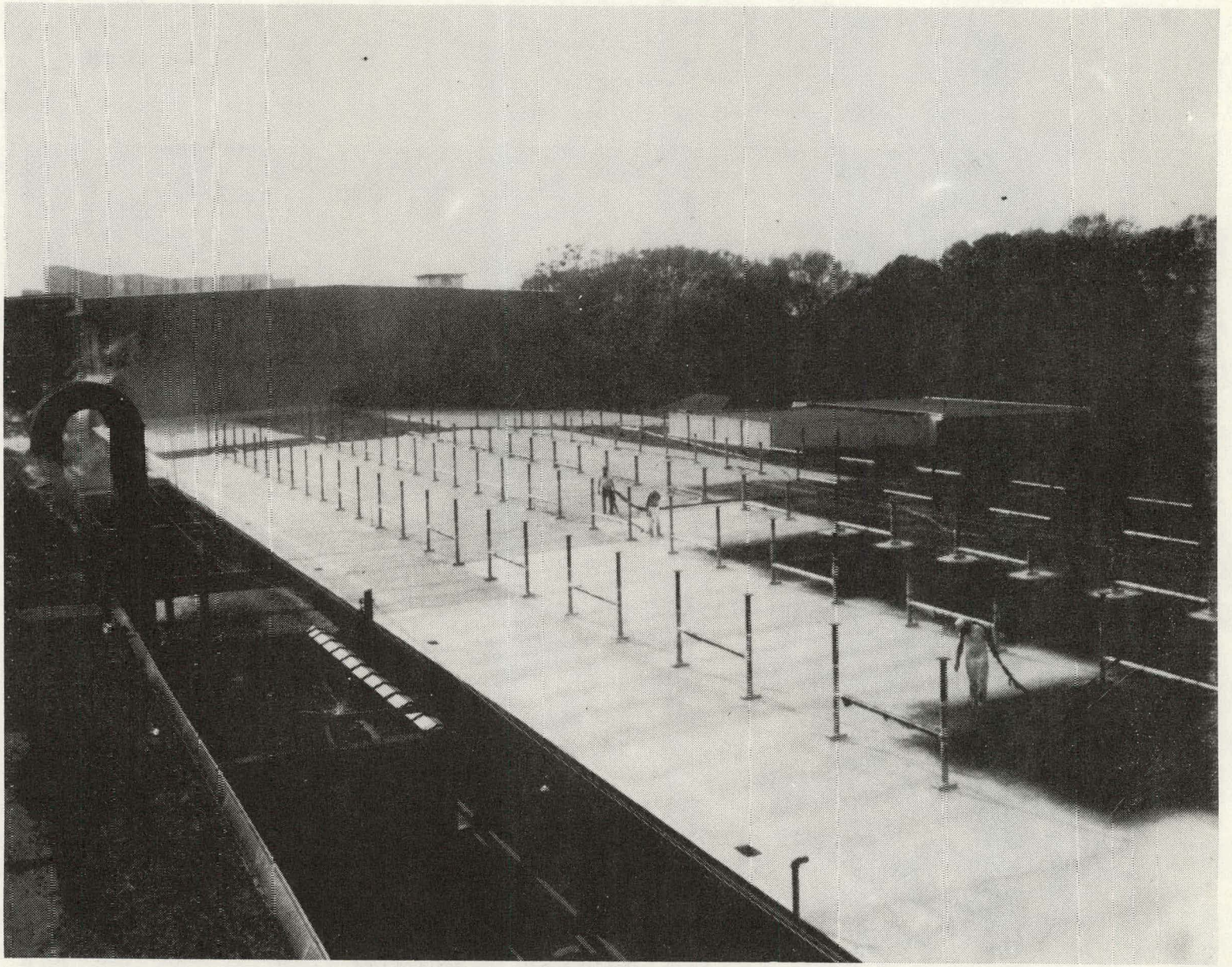


Figure 2-8. Collector Support Installation Complete--Reroofing in Progress, November 1977

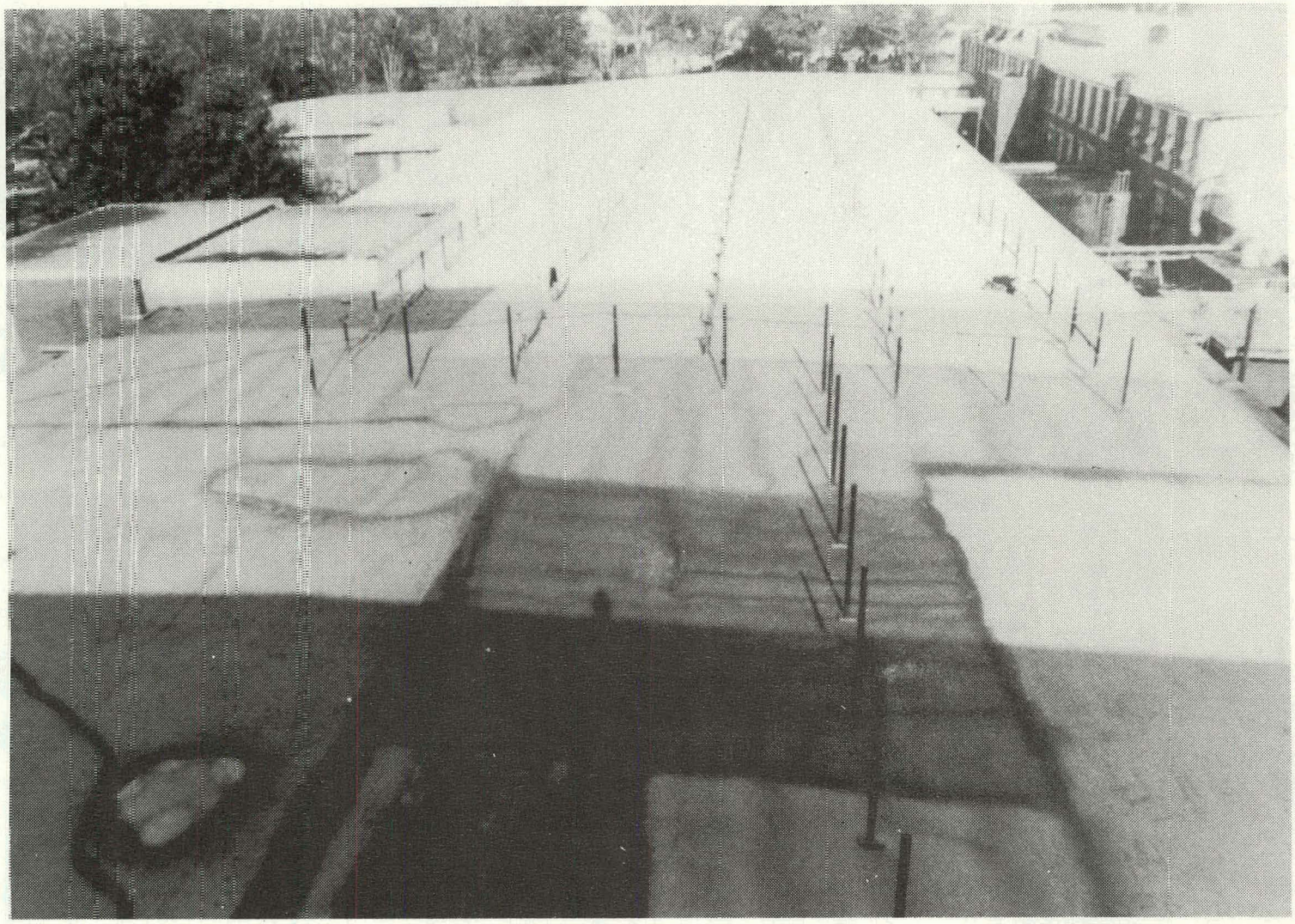


Figure 2-9. Collector Supports Installed--Reroofing Nearly Complete, December 1977

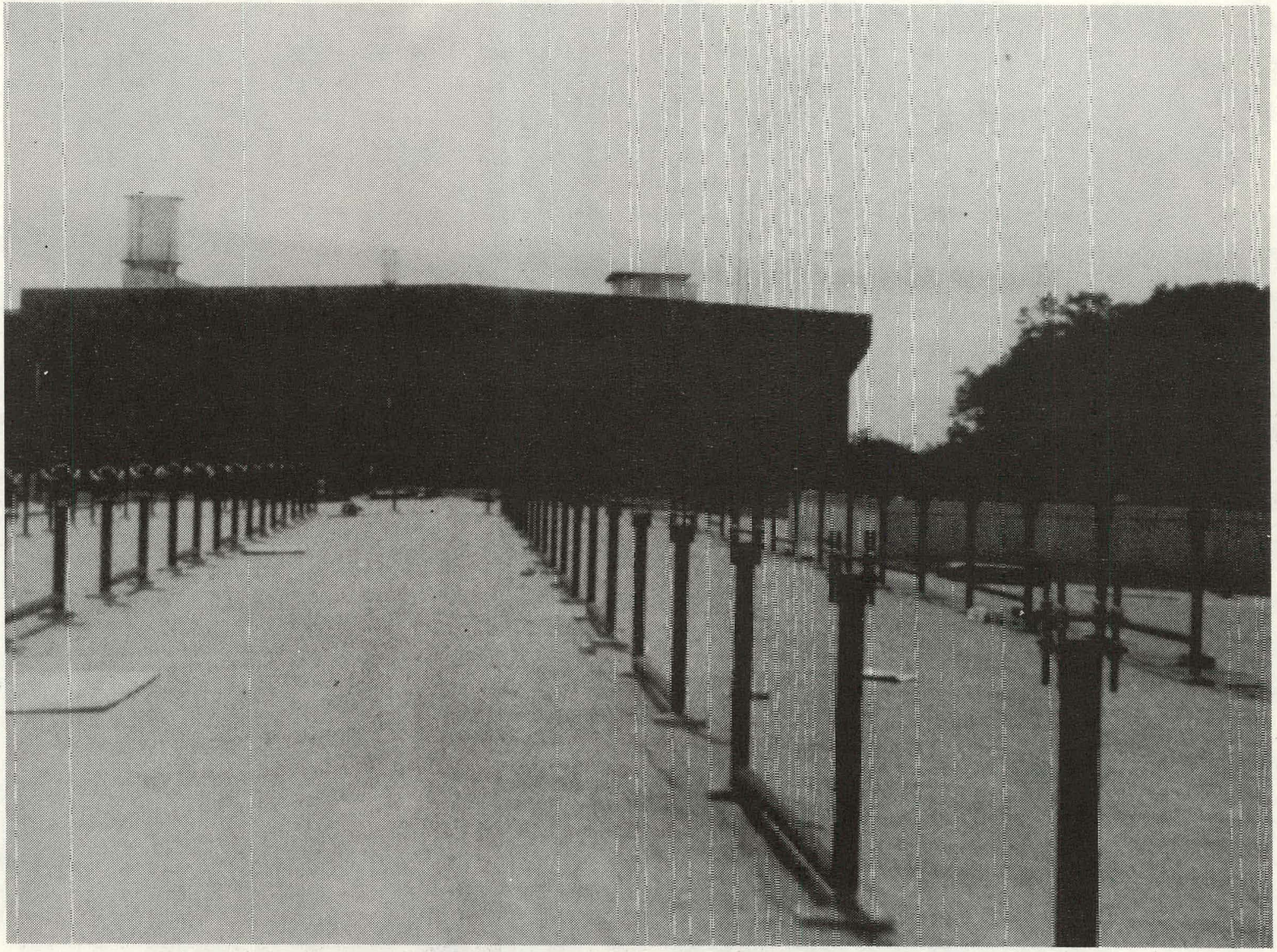


Figure 2-10. Collector Bearing Plates Installed Atop Support Posts, April 1978

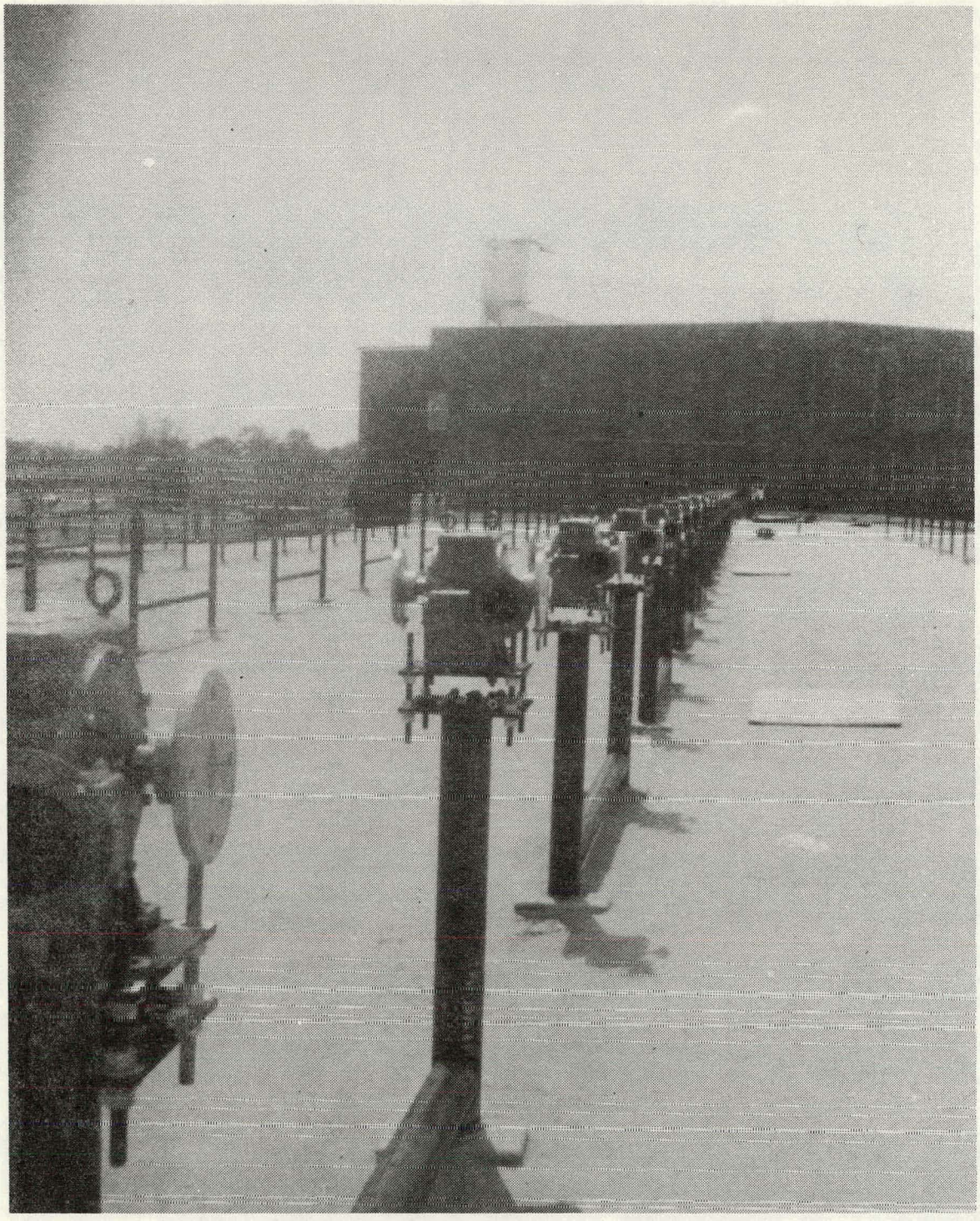


Figure 2-11. Gearboxes Installed Atop Support Posts, April 1978

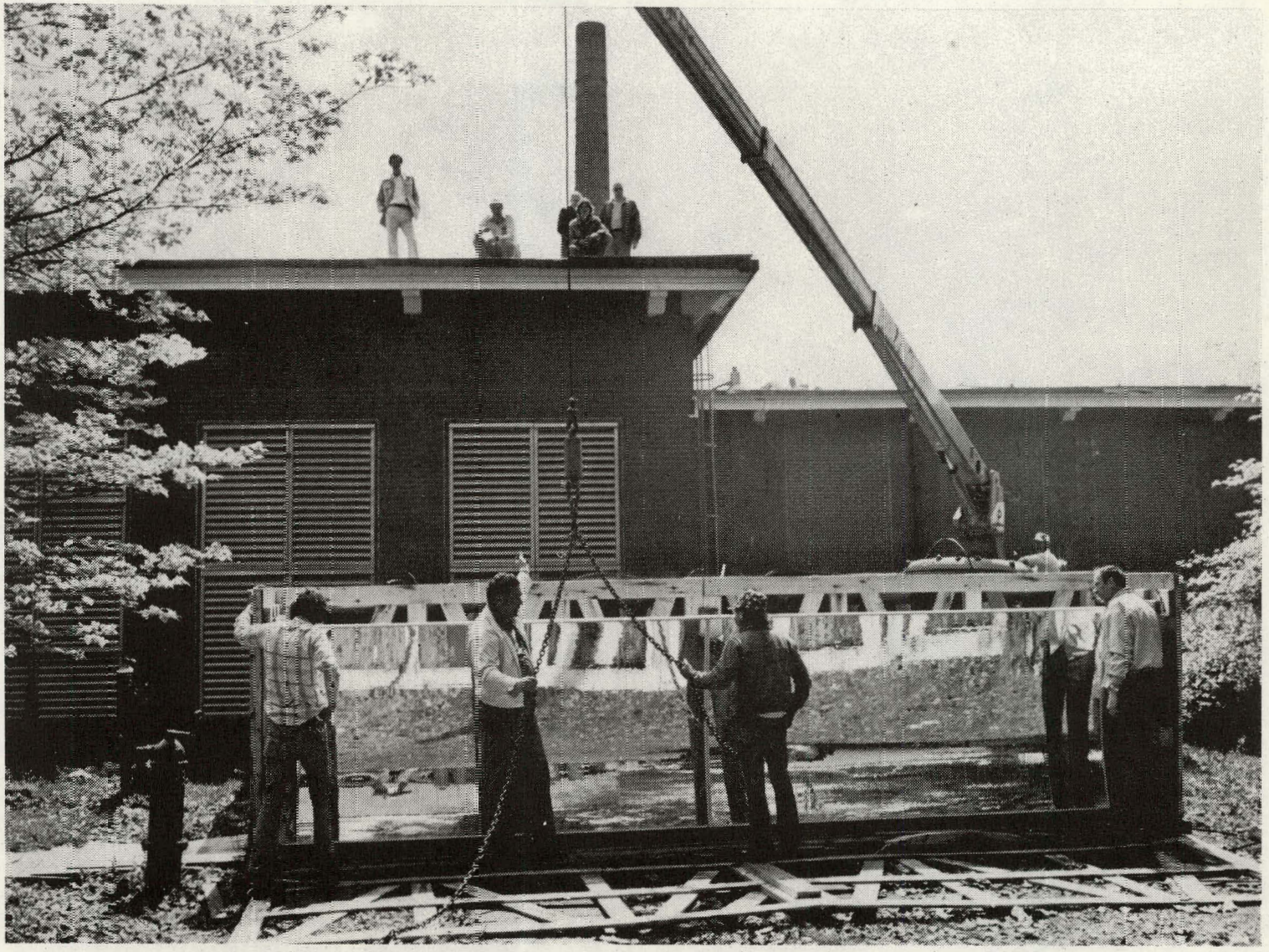


Figure 2-12. Collector Mirror Assembly Being Lifted from Shipping Crate, April 1978

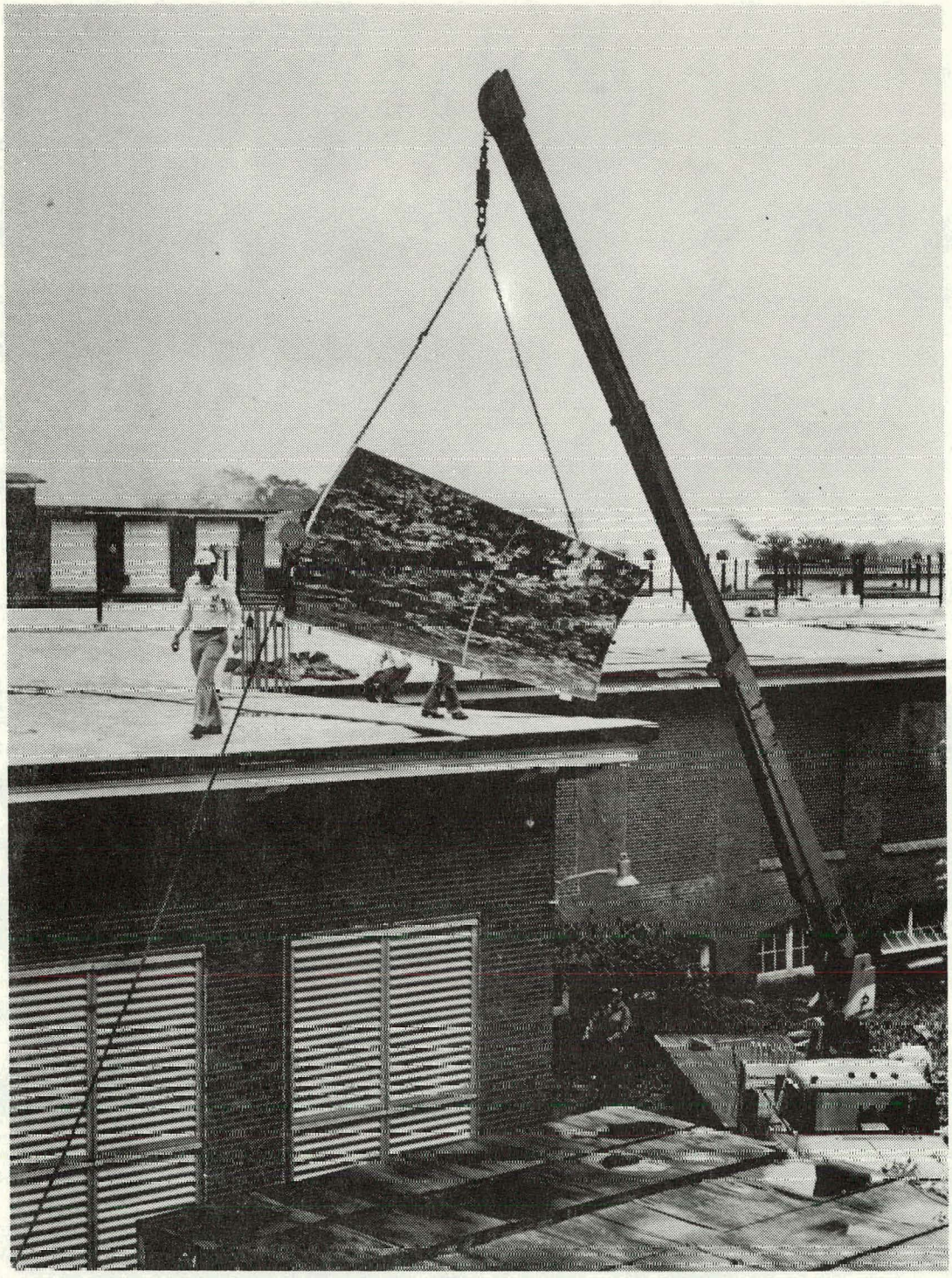


Figure 2-13. Collector Mirror Assembly Being Lifted onto Roof. April 1978

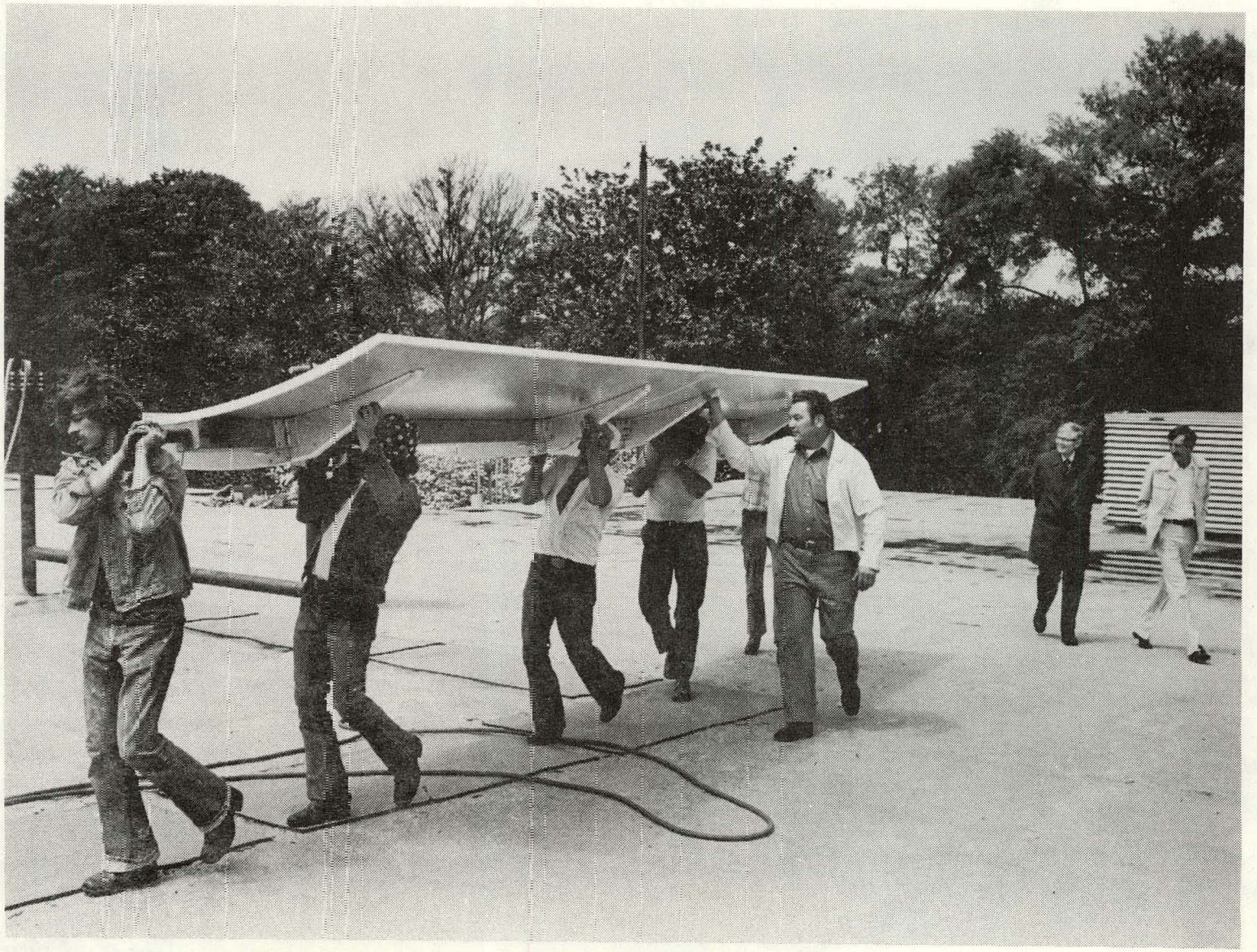


Figure 2-14. Collector Mirror Assembly Being Hand-Carried to Supports, April 1978

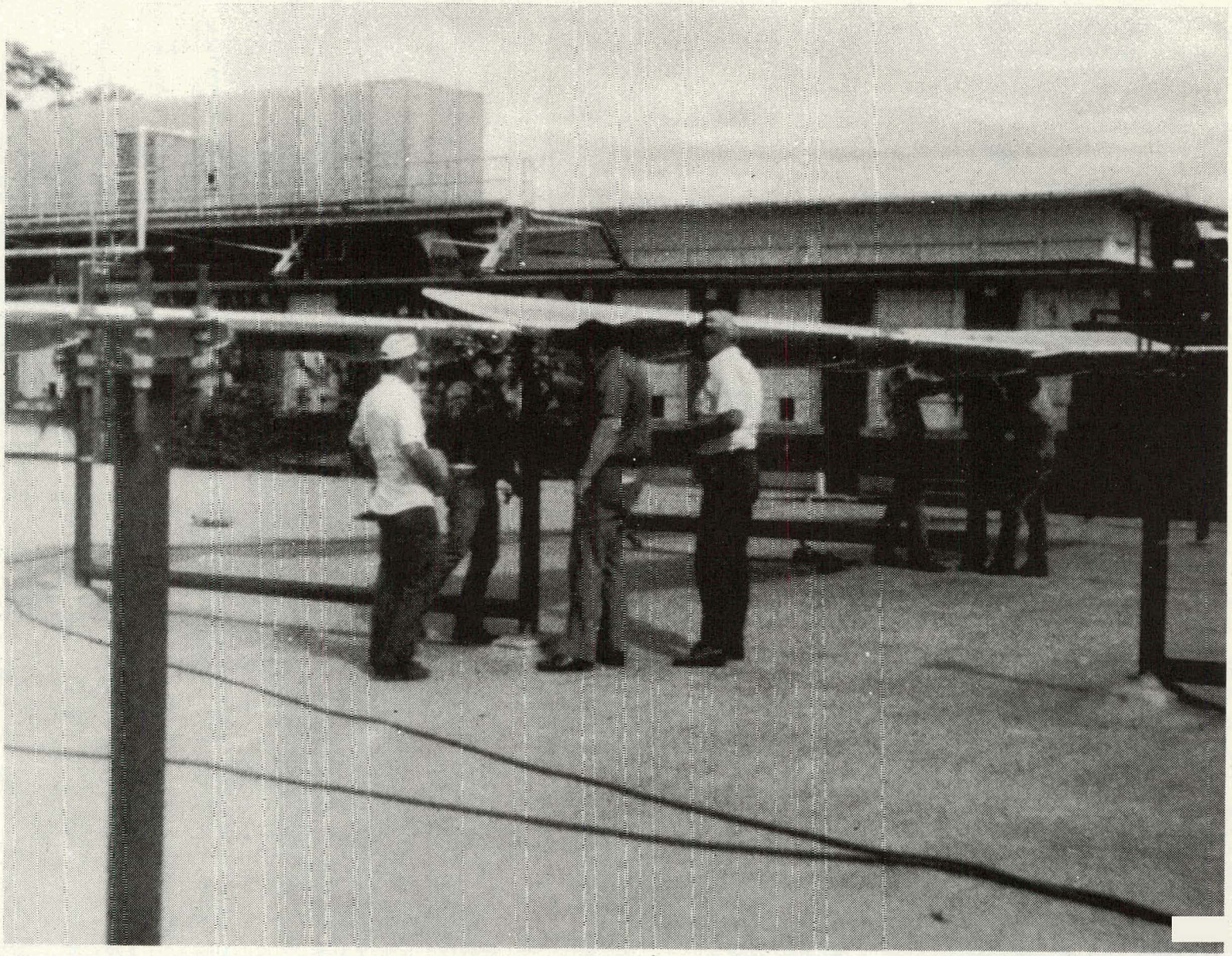


Figure 2-15. Mounting of Mirror Assembly onto Supports, April 1978

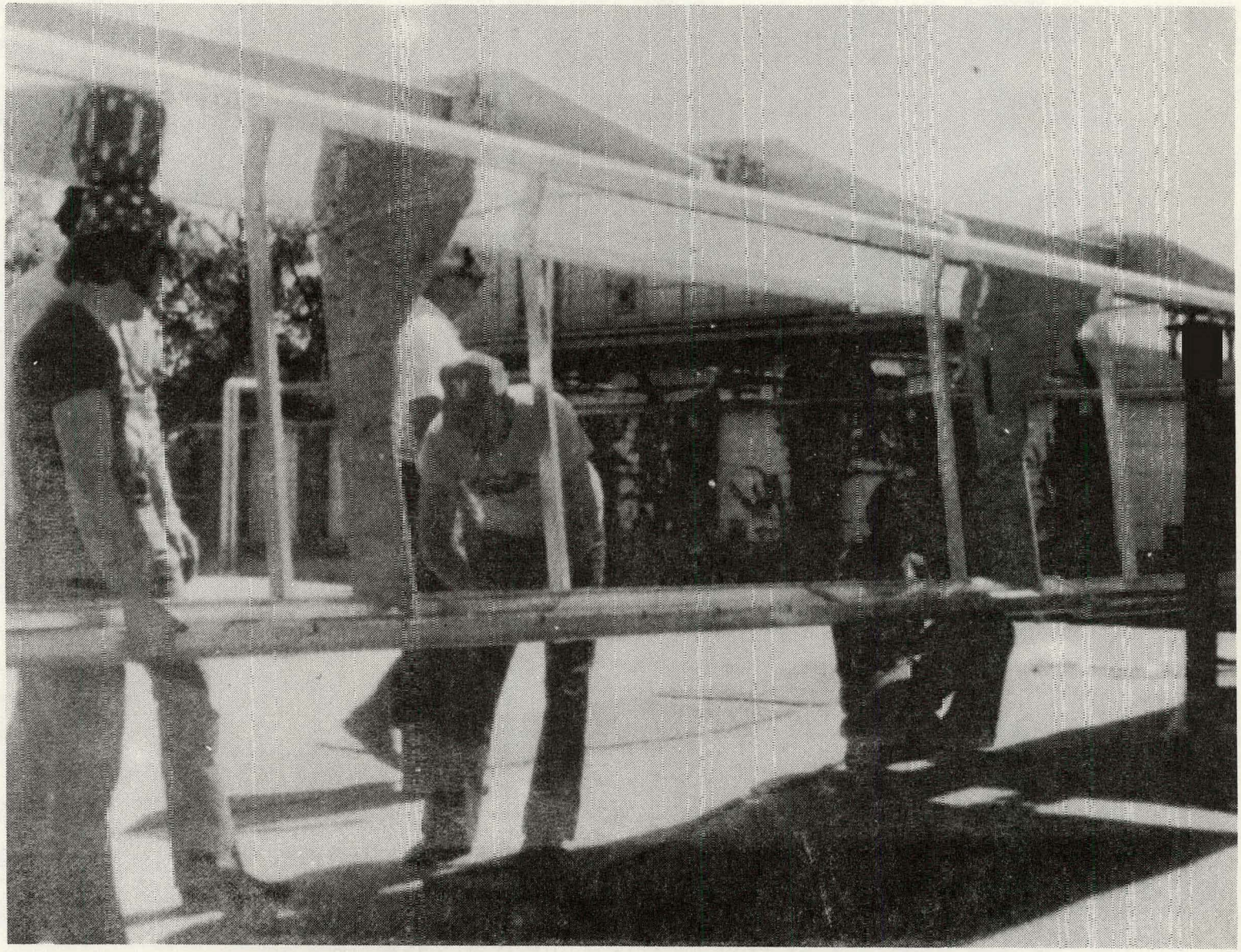


Figure 2-16. Installation of Receiver Using Template for Location, April 1978

Figure 2-17. Solar Concentration Demonstration

Collector leveling, mirror alignment, receiver alignment and tracker alignment were conducted in June, July and August as weather and other site activities permitted.

Installation of the electrical components of the collector began in May 1978 and continued until September 1978. This activity is discussed below in Subsection 2.3.7.

2.3.3 High Temperature Water (HTW) Piping

The HTW piping was built around the collector field at the conclusion of collector installation. It consists of two 2-1/2-inch headers, a collector supply and a collector return. Figure 2-18 illustrates the HTW loop outside the penthouse. Detail at each collector interface consists of a valve (balance and/or isolation), a flex hose, and a swivel joint.

Pipe brackets were fabricated and hangers were installed as part of the HTW piping installation. The pipe is anchored at two locations--the penthouse and the center of the field. Pipe expansion under heating is accomodated by "Z" ball joints at the penthouse end of the field and by the freedom to expand outward at the far end of the field.

The HTW piping in the penthouse is shown as a schematic in Figure 2-19. The HTW piping forms a pressurized closed loop with a nitrogen blanket to eliminate oxygen from the system. Upon completion of the HTW loop, a pressure test at 300 psi was conducted to demonstrate the integrity of the welds and joints.

2.3.4 Penthouse

The penthouse is a three-sided, prefabricated metal building that is set against a brick wall of the textile mill to form the fourth wall. It contains the vast majority of the process steam equipment, including HTW loop accessories,

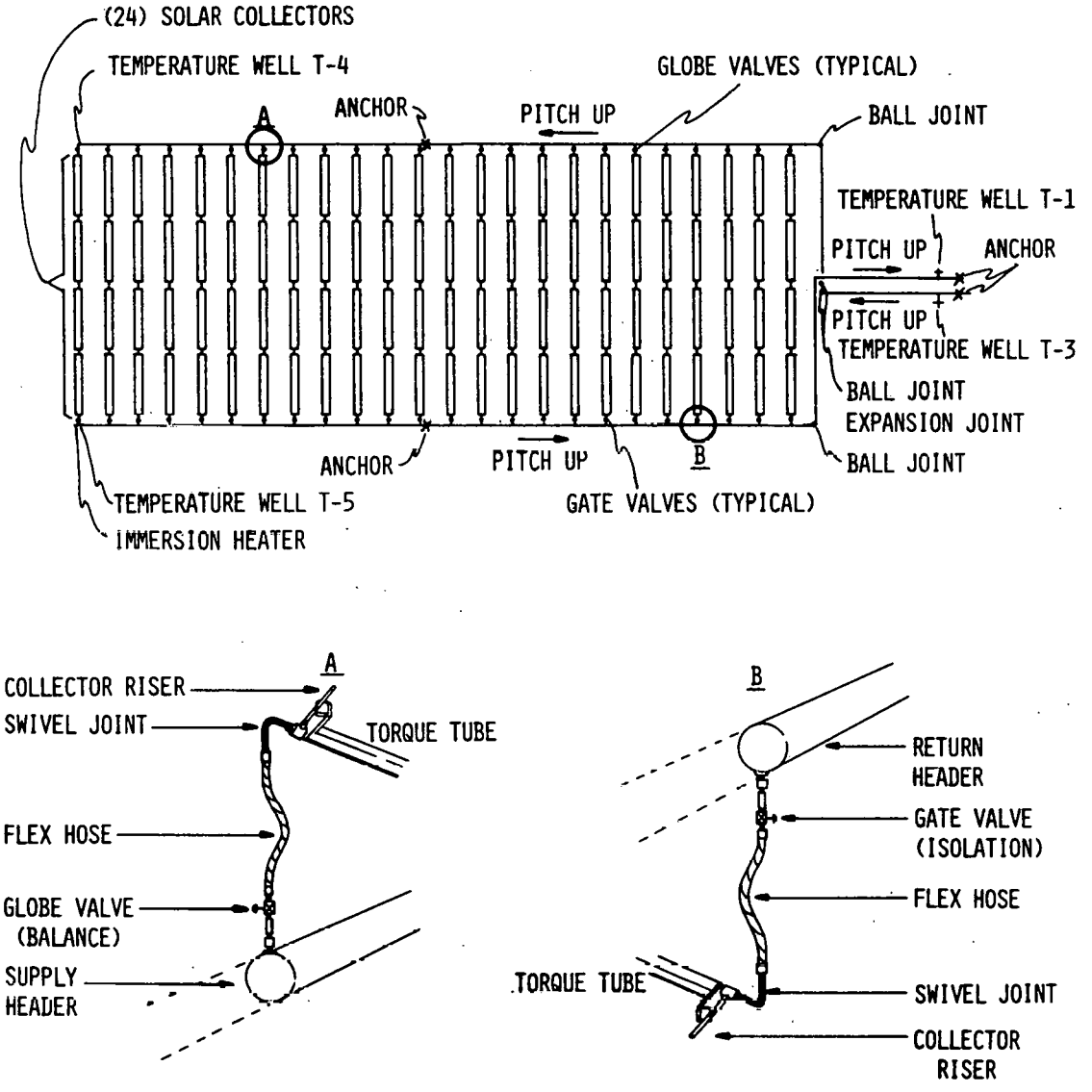


Figure 2-18. HTW Loop Schematic Plus Collector Interface Details

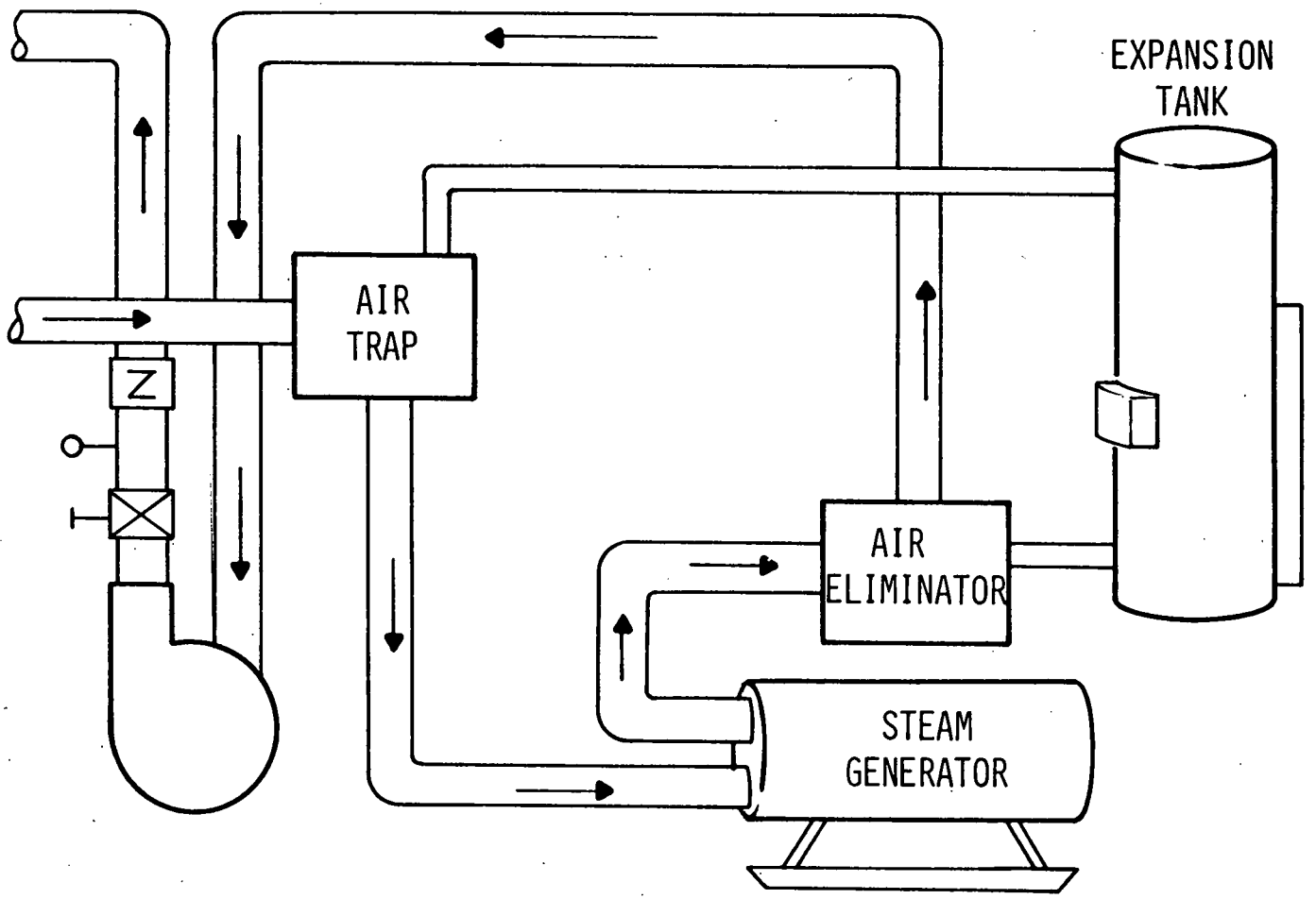


Figure 2-19. Schematic of HTW Piping in Penthouse

steam loop accessories, electrical equipment, and data collection equipment. Figure 2-20 is a layout of the equipment in the building.

Figure 2-21 is a photograph of the outside of the completed penthouse. It has a service door, an overhead door facing the collector field, and ventilation. The building's steel structure and wood floor are supported above the weave room roof to allow normal drainage of the roof as well as access to the roof.

2.3.5 Equipment in Penthouse

The equipment in the penthouse falls into five categories:

- HTW equipment,
- Steam equipment,
- Electrical equipment,
- Data collection equipment,
- Other accessories.

HTW Equipment--Figure 2-22 is a set of photographs taken in the penthouse showing most of the HTW equipment. Starting at the termination of the collector return header, A, high temperature water at 193°C (380°F) enters the penthouse, passes through an air trap, B, and drops to the inlet side of the steam generator, C. The air trap is connected to the expansion tank, D, to bleed vapors out of the fluid and into the expansion tank, E.

The steam generator is a Patterson-Kelley Series 380, Model 307 Package Boiler. The heat transfer surface is a six-pass stainless steel tubing bundle. Fluid exits the steam generator, F, at 167°C (333°F) and passes to an air eliminator, G. Vapors extracted from the fluid stream are carried to the expansion tank, E, while the fluid progresses to the suction side of the recirculation pump, H. Between the air eliminator and the pump are a gate valve, capped tee, and strainer.

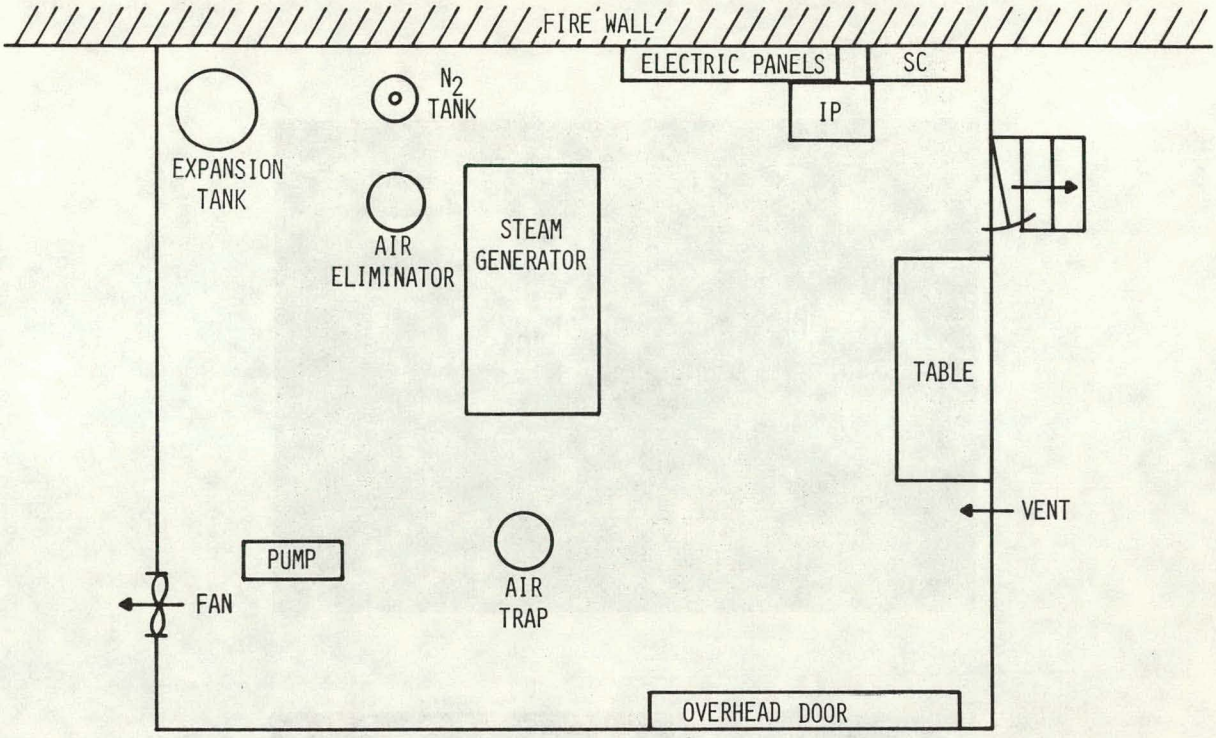


Figure 2-20. Layout of Equipment in Penthouse

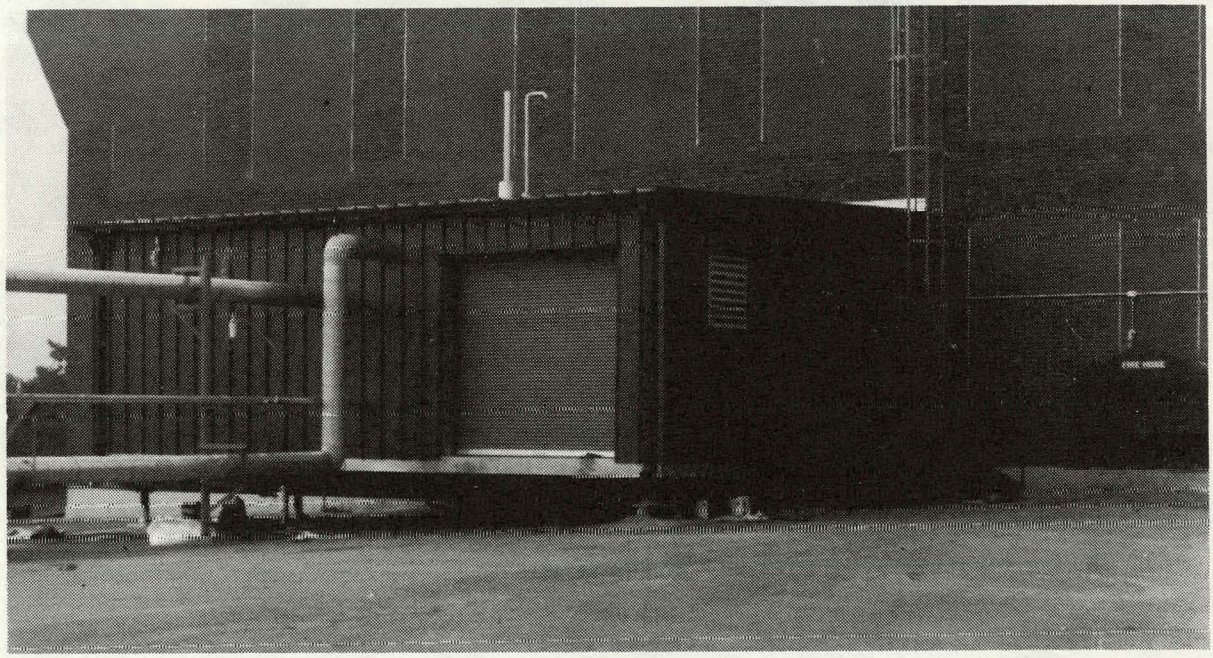


Figure 2-21. Photo of Penthouse

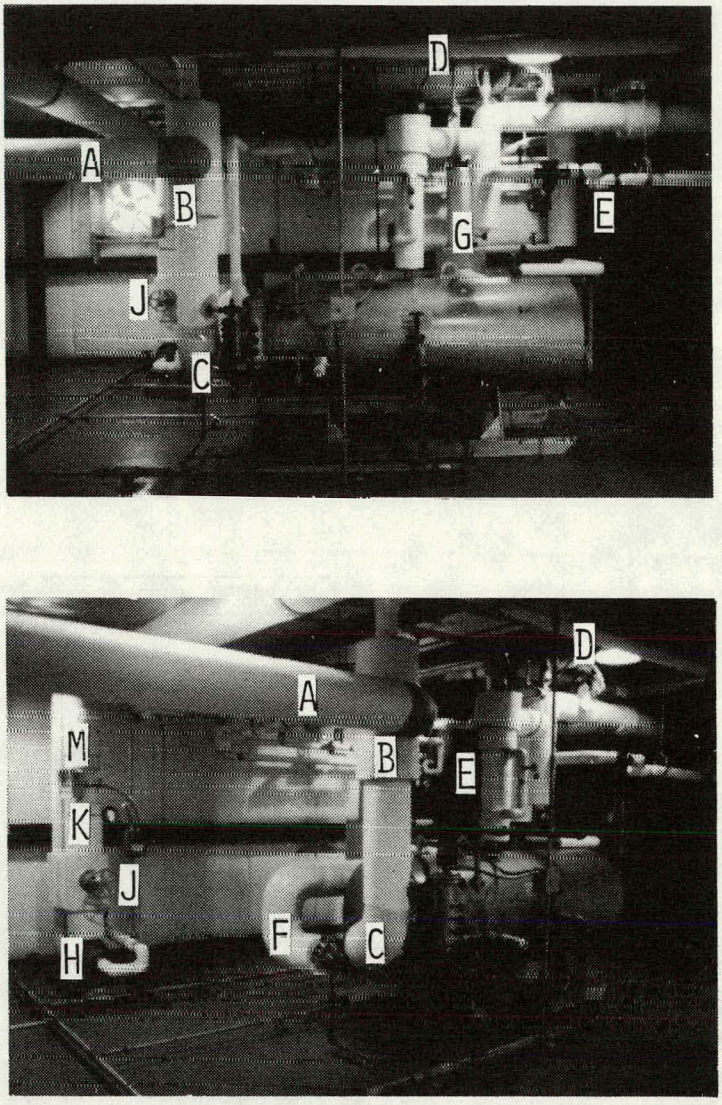


Figure 2-22. Photos of HTW Equipment in Penthouse

On the pump outlet is another capped tee, the HTW loop balance valve, J, a pressure relief valve, K, and a fluid flow meter, M. Drains are included at low points in the HTW loop piping. Manual relief valves are included at high points in the system to bleed out entrapped vapors.

The recirculation pump is a Buffalo Can-O-Matic Model HCR-H66058 pump with a 5-hp, 600-volt, three-phase motor. This pump will deliver 60 gpm against the system pressure drop (balance valve open). In operation the balance valve is adjusted to maintain the fluid flow at 48 gpm.

The expansion tank is a 400-psig, 100-gallon unit with sight glass, liquid level control, and pressure sensor. A nitrogen charge system provides a nitrogen blanket for the closed HTW loop expansion tank.

Steam Equipment--Figure 2-23 is an illustration of the steam loop, including a photograph that highlights the steam equipment in the penthouse. The Patterson-Kelley Package Boiler is the source of the steam. This steam exits the boiler at N. Equipment in this steam line includes pressure sensor, stop and check valve, temperature sensor, steam flow meter and associated gate valves, strainers, steam traps, and condensate lines. Feedwater enters the boiler under control of a liquid level sensor in the boiler.

Electrical Equipment--The electrical panels are mounted on the brick wall of the penthouse, as shown in Figure 2-24. These panels are:

- HC - Heating Contactor Panel
- IP - Instrumentation Panel
- SC - System Controller
- DC - DC Power Supply Panel
- ELL - 208-volt Panel
- EHL - 480-volt Panel
- LL - Lighting, Receptacle Panel
- RP - Recirculation Pump Panel

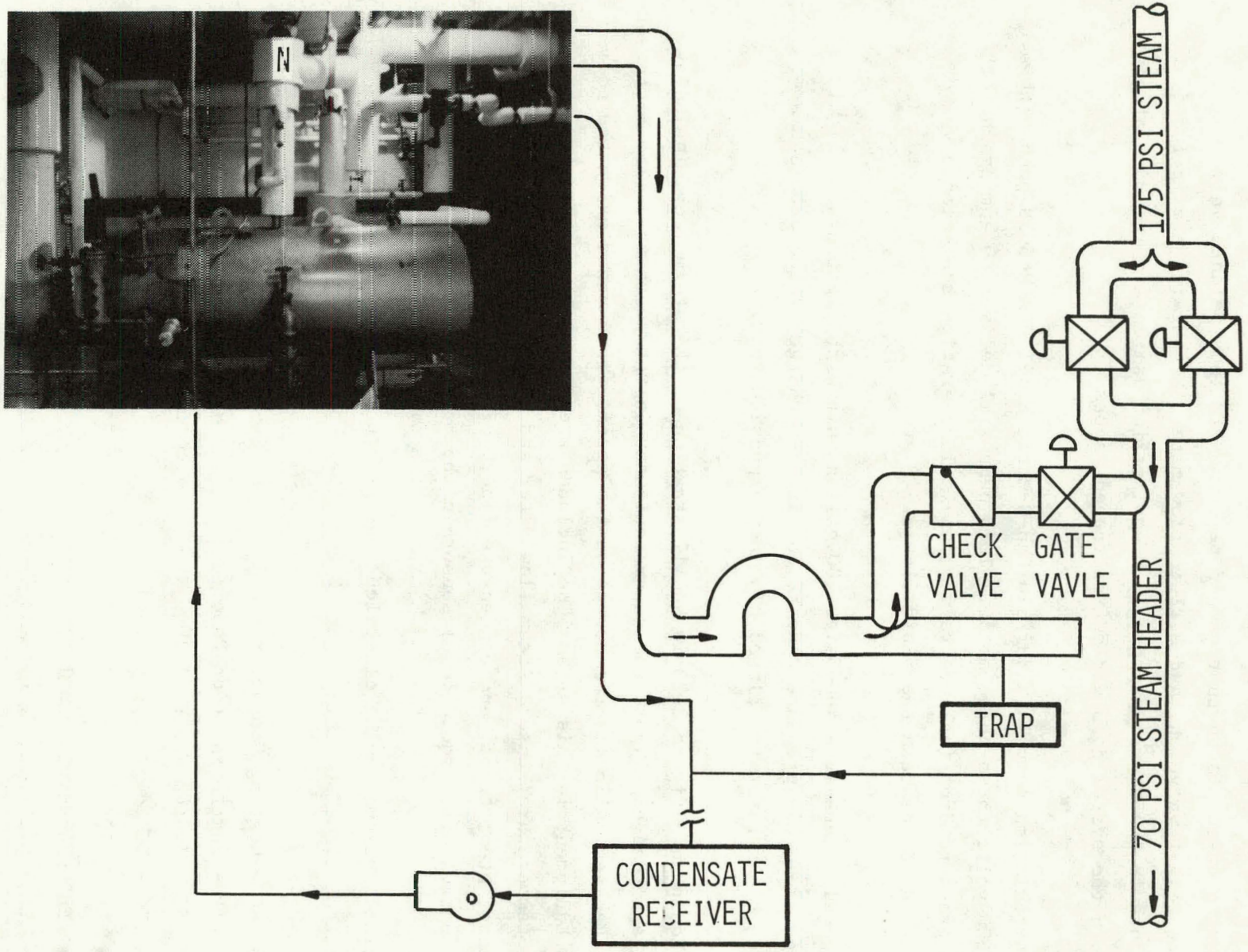


Figure 2-23. Illustration of Steam Loop

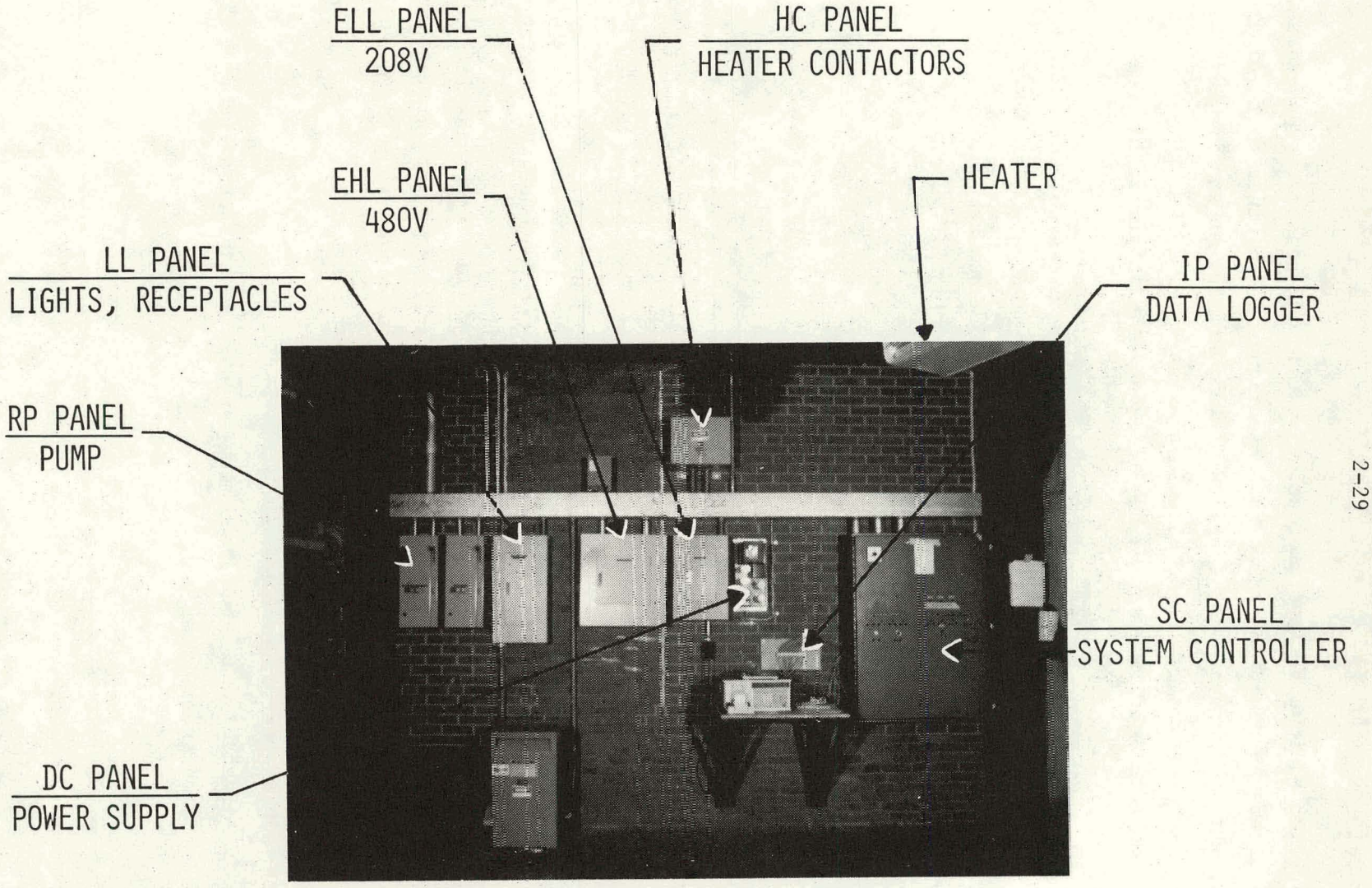


Figure 2-24. Electrical Panels in Penthouse

Data Collection Equipment--Instrumentation in terms of sensors, transducers, and transmitters is described below in Subsection 2.3.8. Other data collection equipment in the penthouse consists of the data logger and its peripheral equipment. The data logger is an Esterline-Angus model 2064. It outputs paper tape containing all sensor values (15 channels) at preset intervals.

Other Equipment--Other equipment in the penthouse includes collector field lighting switches, ventilating fan, and a space heating unit. Figure 2-22 shows the fan and louvers in the wall. Figure 2-20 shows the location on the fan, exhaust, and fresh air vents on the floor plan. Figure 2-24 shows the heater hung from the ceiling.

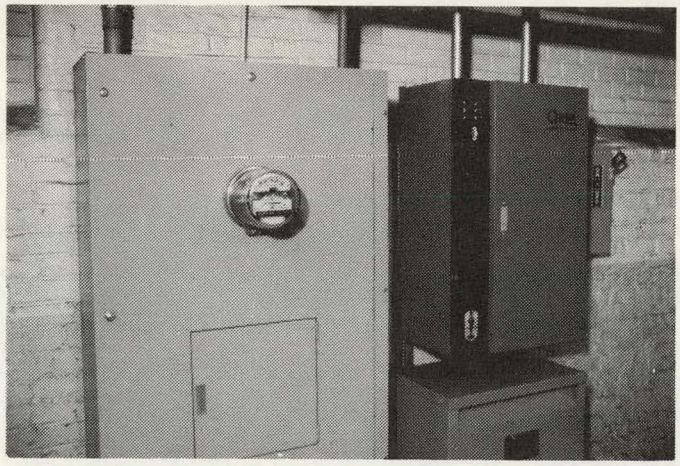
2.3.6 Equipment in Mill

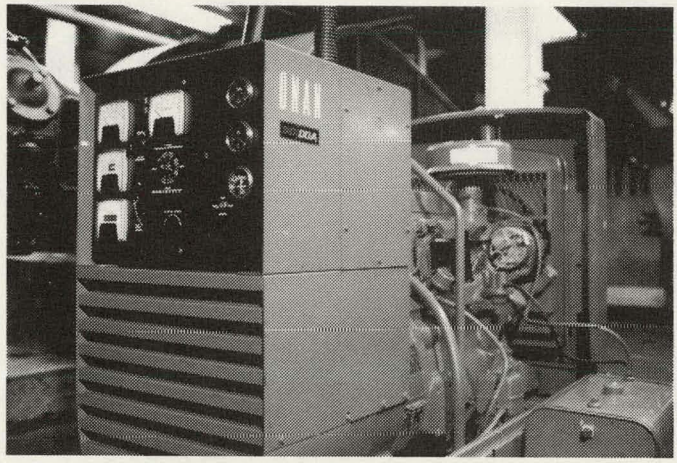
The equipment in the mill consists of four types:

- Electrical service,
- Feedwater pump,
- Annunciator panel,
- Steam tie-in.

Electrical Service--The electrical service panels are located on the first floor of the mill in the compressor room. Figure 2-25 shows the service panels and the standby generator, and illustrates the location with respect to the solar collector field. The panels are:

- MDP - Main Distribution Panel,
- ONAN - Standby Generator Panel with automatic transfer switch,
- T1 - Transformer.





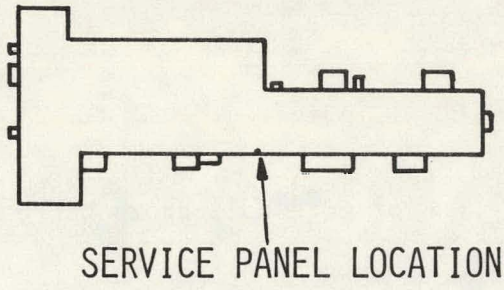


Figure 2-25. Photo of Electrical Service Panels and Standby Generator

The standby generator is an Onan 30-kw, 480-volt, three-phase diesel fuel powered unit with a 60-amp automatic transfer switch. This unit powers the system controls and automatically stows the collectors when service power is interrupted.

Feedwater Pump--The feedwater pump is an Aurora E5T pump with a 3-hp, 600-volt, three-phase motor. Figure 2-26 is a photograph of the pump motor and includes an illustration of the location of the unit with respect to the solar collector field. The pump takes water from a condensate receiver and pumps it to the steam generator as feedwater on command from the boiler liquid level sensor.

Annunciator Panel--Figure 2-27 shows the annunciator panel, which is located in the Machine Room. This panel displays system operational data and alarms to a portion of the building that is continuously occupied. The meter on the face of the panel shows HTW loop temperature (hot side); the recorder under the panel records solar steam flow. The switches and lights on the panel perform the following functions:

- ERROR LIGHT - indicates one of the following three problems
  - Low loop pressure,
  - High inlet temperature,
  - High outlet temperature;
- FEEDWATER PUMP FAILURE - indicates fluid in steam generator is low;
- WIND AND NO STOW - one or more collectors has not stowed and wind is above preset level;
- SYSTEM ON - system power is on;

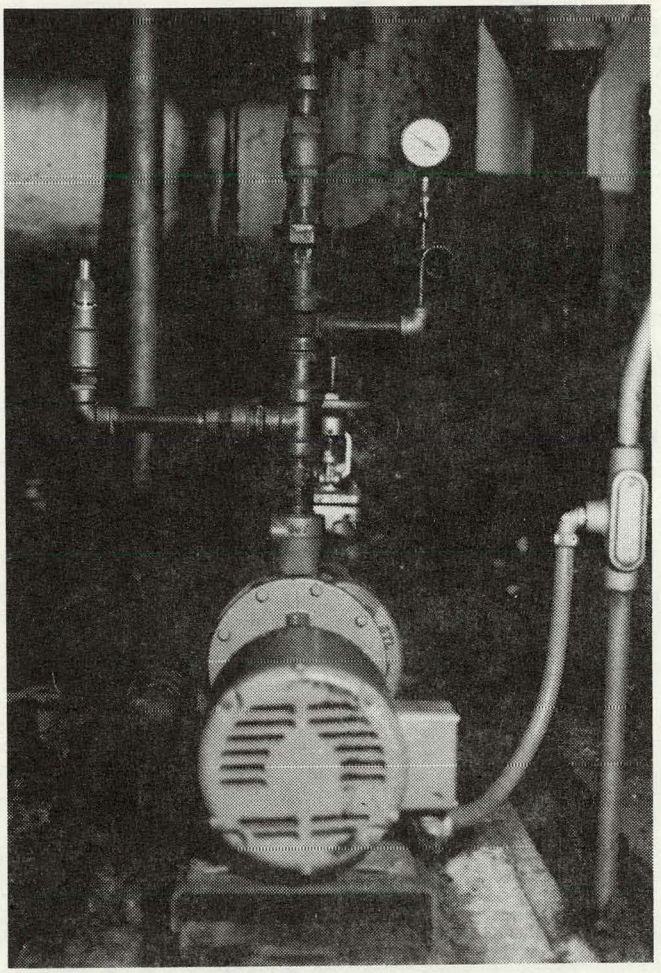


Figure 2-26. Photo of Feedwater Pump

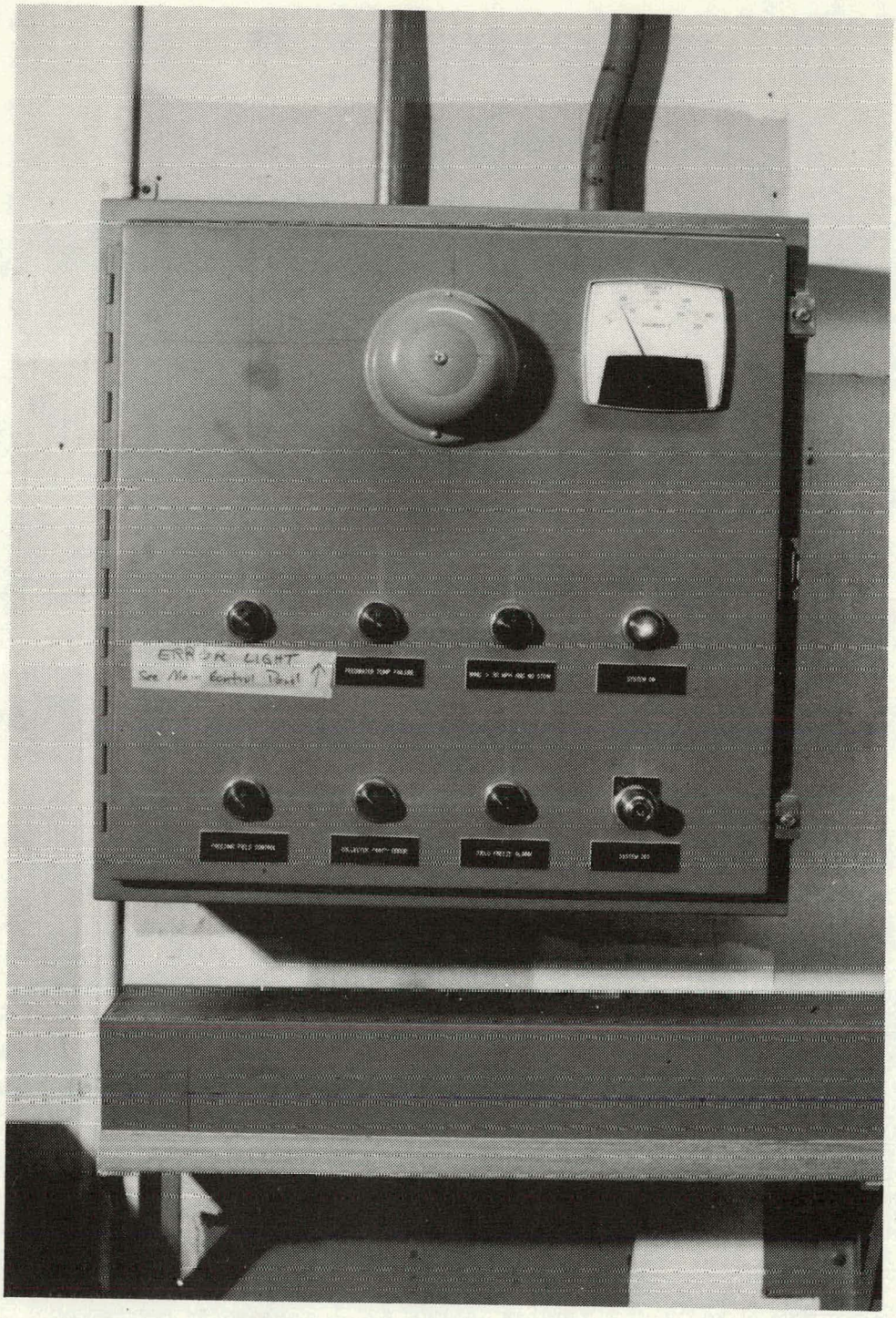


Figure 2-27. Annunciator Panel

- FREEZING FIELD CONTROL - recirculation pump and immersion heaters are on;

- COLLECTOR PARITY ERROR - one or more collectors are stowed while others are tracking, OR one or more collectors are unstowed while others are stowed;

- FIELD FREEZE ALARM - Freezing Field Control is on and temperature in loop continues to fall;

- SYSTEM OFF - key reset for ON/OFF.

Steam Tie-In--Figure 2-23 shows schematically how the steam line is tied into the existing steam header in the mill. This header is directly below the slashing process equipment. A gate valve allows isolation of the solar process steam system from the conventional system. A check valve controls the flow of the solar steam into the header. Steam traps and condensate return complete the tie-in.

2.3.7 Electrical

Electrical installation at the site was conducted in June, July, August and September 1978. Late delivery of electrical panels and other components delayed this construction.

Figure 2-28 shows the electrical components schematically. The electrical service panels tie into a plant 600-volt, three-phase line and include a watthour meter for monitoring solar steam system electrical power requirements.

Pump motors are supplied with 600 volt power for consistency with plant standards. The solar collector motors use 440 volt power. Electrical service outlets at 110 volts are provided alongside the collector field.

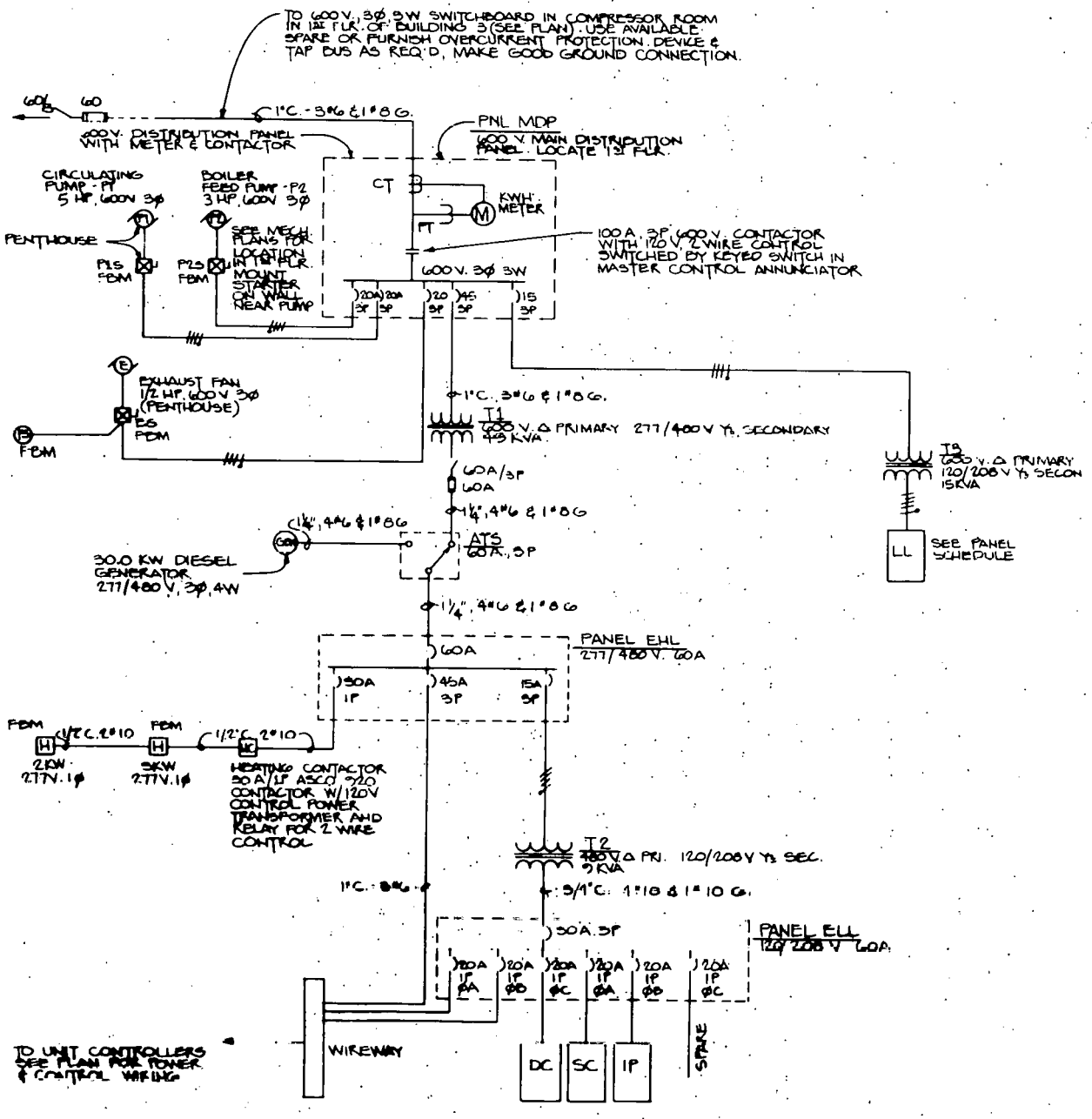


Figure 2-28. Electrical Schematic

2.3.8 Instrumentation

Instrumentation in the form of sensors is used on this project for data collection and system control. Some sensors serve both purposes. This subsection describes both the data collection instrumentation and the control sensors.

Data Collection Instrumentation--Instrumentation is provided for collection of data during the Phase II checkout and the Phase III operation and test. Figure 2-29 is a schematic of this instrumentation. Table 2-1 lists data collection instrumentation and summarizes the purpose of each sensor. This data is being collected on a multichannel data logger for analysis and determination of system performance. All sensor inputs are compatible with the Solar Data Acquisition System (SDAS). The data analysis methodology is described in Section 3.0.

Control Instrumentation--The solar energy system is controlled by a system controller that performs logic functions based on control sensor inputs. Unit controllers at each collector control the individual collectors when the system controller permits. Figure 2-29 shows the system controller, the control sensors, and the control outputs schematically. Table 2-2 lists the control sensors and the control functions each sensor commands. The primary sensors in normal operation are I-1, the illumination sensor, and W-1, the wind sensor. The illumination sensor turns the system on and off each day as a function of the light level, and the wind sensor serves to protect the tracking collectors by stowing the system if winds are above 30 mph. The other sensors protect the system from damage due to component failures or temperature extremes. The flow switch and pressure sensor are standard control sensors that serve to inhibit system operation if either the HTW loop flow or pressure is too low. The temperature sensors monitor various locations for overtemperature protection and freeze protection.

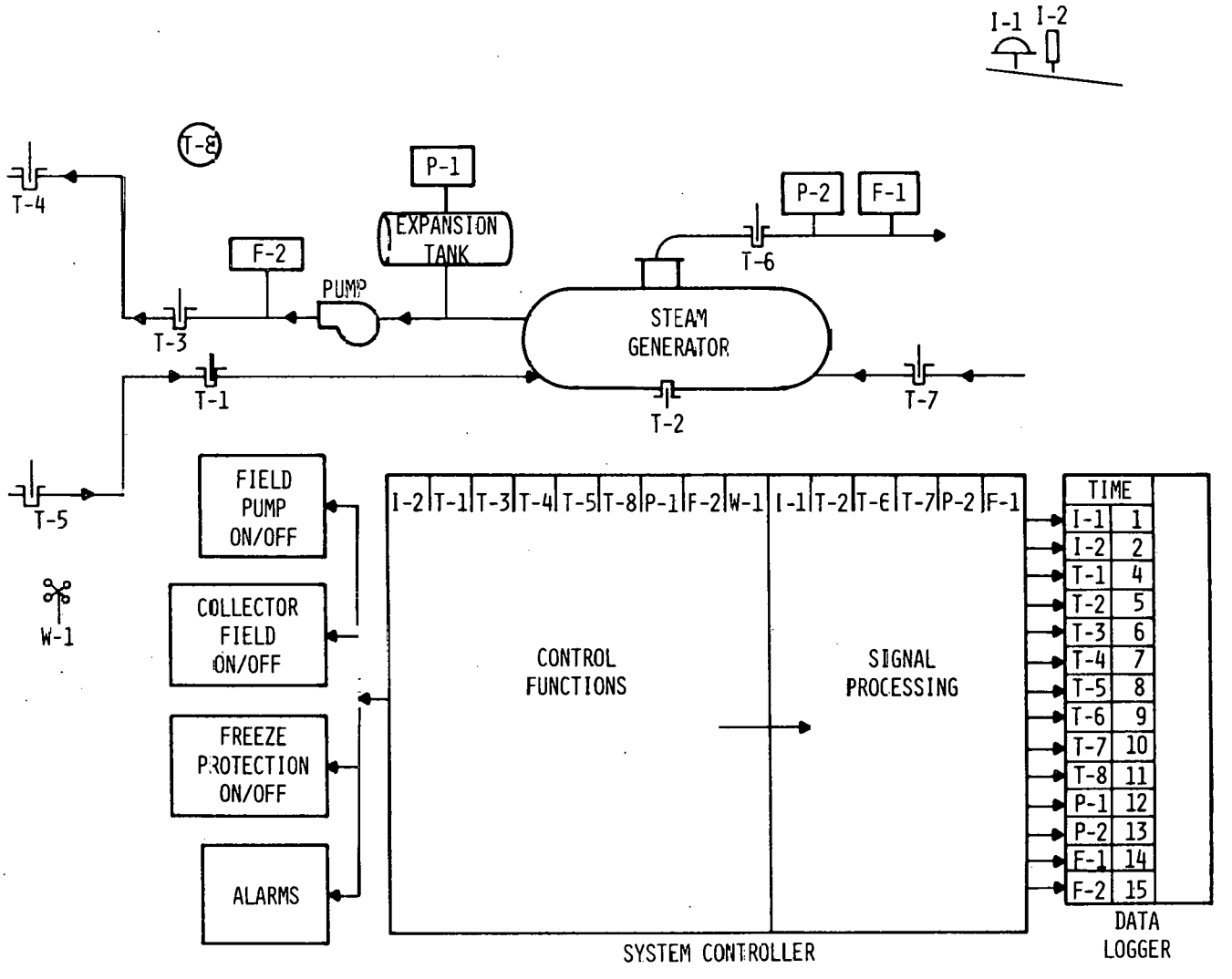


Figure 2-29. System Instrumentation--Control and Data Collection

Table 2-1. Data Collection Instrumentation

ABBREVIATION	SENSOR	MANUFACTURER	FUNCTION
T-1* T-2 T-3* T-4* T-5* T-6 T-7 T-8*	STEAM GENERATOR INLET TEMPERATURE STEAM GENERATOR FLUID TEMPERATURE STEAM GENERATOR OUTLET TEMPERATURE HTW FLUID TEMPERATURE IN FIELD HTW FLUID TEMPERATURE IN FIELD PROCESS STEAM TEMERATURE FEEDWATER TEMPERATURE AMBIENT TEMPERATURE	HONEYWELL HONEYWELL HONEYWELL HONEYWELL HONEYWELL HONEYWELL HONEYWELL MINCO	• MONITOR SYSTEM CHARACTERISTICS AS A FUNCTION OF TIME • CALCULATE SYSTEM PERFORMANCE
P-1* P-2	HTW LOOP PRESSURE PROCESS STEAM PRESSURE	HONEYWELL MODEL 41222-0001-03-08-U1C2 HONEYWELL MODEL 41221-0001-03-08-U1C2	• MONITOR SYSTEM CHARACTERISTICS • CALCULATE SYSTEM PERFORMANCE
F-1 F-2*	PROCESS STEAM FLOW FIELD RECIRCULATION PUMP FLOW	HONEYWELL MODEL 411 WALLACE & TIERNAN	• CALCULATE SYSTEM PERFORMANCE
I-1 I-2	PYRANOMETER PYRHELIOMETER (TRACKING)	EPPLEY MODEL NO. 2 EPPLEY MODEL PIN	• MONITOR TOTAL RADIATION LEVEL • MONITOR DIRECT RADIATION LEVEL • CALCULATE SYSTEM PERFORMANCE
E-1	WATTHOUR METER	WESTINGHOUSE	• MONITOR ELECTRICAL POWER USAGE

* ALSO USED FOR CONTROL (SEE FIGURE 2-29 AND TABLE 2-2)

Table 2-2. Control Sensors

ABBREVIATION	SENSOR	MANUFACTURER	FUNCTION
I-2	PYRHELIOMETER/TRACKING	EPPLY	SENSE ILLUMINATION LEVEL TO TURN SYSTEM ON AND OFF.*
T-1	STEAM GENERATOR INLET TEMPERATURE	HONEYWELL	SENSES OVERTEMPERATURE* AND FREEZE THREAT.
T-3	STEAM GENERATOR OUTLET TEMPERATURE	HONEYWELL	SENSES OVERTEMPERATURE,* FEEDWATER FAILURE, AND FREEZE THREAT.
T-4, T-5	TEMPERATURE OF FLUID IN FIELD	HONEYWELL	SENSES FREEZE THREAT.*
P-1	PRESSURE SENSOR	HONEYWELL	SENSES PRESSURE IN HTW LOOP.* HIGH PRESSURE SHUTS SYSTEM OFF; LOW PRESSURE INDICATES FLUID LOSS AND INHIBITS SYSTEM OPERATION.
F-2	FLOWMETER	WALLACE & TIERNAN	SENSES FLOW/NO FLOW IN FIELD HTW LOOP (NO FLOW STOWS COLLECTORS).*
W-1	ANEMOMETER	WEATHER MEASURE	SENSE WIND TO PROTECT COLLECTORS (STOW IN HIGH WINDS).

*SENSOR ALSO USED FOR DATA COLLECTION.

2.4 START-UP AND CHECKOUT

Solar energy system checkout was initiated in September 1978. This activity consisted of checking all mechanical and electrical components and operating modes prior to start-up, as listed below:

Mechanical

- Collector torque tube alignment,
- Mirror alignment,
- Receiver alignment,
- Swivel joint alignment,
- Check flex hoses,
- Check all valves,
- Piping pressure test,
- Check location of all sensors,
- Check HTW pipe routing,
- Check steam piping, condensate piping,
- Check penthouse,
- Review general contractor "Punch List."

Electrical

- Check service connections,
- Check pump motor power (2),
- Check collector motor power (24),
- Check unit controllers,
- Check sensors,
- Check wiring,
- Check system controller,
- Check annunciator panel,
- Check standby generator,
- Operate collectors in manual model,
- Operate collectors in automatic mode,

- Exercise all protection/control modes,
- Operate system automatic.

Upon completion of checkout, with the assurance that all self-protection control modes were operational, the field was operated manually. On 22 September 1978, during the initial week of operation, 18 of the 24 collectors tracked the sun satisfactorily. The other six collectors would not operate due to various unit controller and/or tracker problems. Under partially cloudy skies, the system temperature reached 115°C (239°F), and low pressure steam was generated and dumped to the atmosphere.

Over the next 3 weeks, WestPoint Pepperell personnel operated the solar process steam system manually as weather permitted. System temperature reached 113°C (235°F), and low pressure steam was generated and dumped to the atmosphere. Problems with the data logger restricted the amount of data collected.

Weather and problems with the feedwater pump inhibited system operation during the third week of October. In the last week of October, after 6 days of regular sunshine weather operation, the feedwater pump failed, shutting down the system until a replacement could be obtained and installed.

Start-up and checkout was re-initiated in late November after receipt and installation of a new feedwater pump. WestPoint Pepperell personnel operated the system initially to check out the new pump operation. Honeywell engineers continued the start-up and checkout in late November and early December, culminating in a Construction Review Meeting at the site on 5 December. This meeting represented the formal conclusion of Phase II and the initiation of Phase III.

2.5 DATA COLLECTION

Data collection during Phase II was by data logger recording on printed paper tape. During system start-up, when project engineers were at the site, data was taken at 1-minute intervals for detailed analysis. At other times the data logger printed at 15-minute intervals.

Fifteen channels were recorded. Table 2-3 lists the variables recorded on each channel. Data collection was sometimes interrupted by problems with the data logger, which included loss of program, reluctance to print out automatically, and printing of bad data.

Data collected during start-up was affected by several factors--the field was only partically insulated, at times not all collectors were tracking, and operation usually was restricted to temperatures below design temperature. Table 2-4 summarizes the data collected during start-up and checkout. Analysis of that data is described in Section 3.0.

2.6 PROBLEM IDENTIFICATION

Although this is formally a Phase III task, several problems are identified herein because they occured during start-up and checkout.

2.6.1 Existing Steam Flow Data

The system design included addition of a transducer on the existing steam flowmeter to allow recording of the existing steam flow on the solar energy data collection system. This data will be used to define slasher steam demand. However, the existing steam flowmeter and its sensor are very old pneumatic-mechanical units that do not lend themselves to modification to an electronic signal. Therefore, data on existing steam flow will be taken from WestPoint Pepperell records.

Table 2-3. Data Collector Sensors

CHANNEL	ABBREVIATION	SENSOR
1	I-1	PYRANOMETER--TOTAL INSOLATION
2	I-2	PYRHELIOMETER--DIRECT NORMAL
3	---	---
4	T-1	STEAM GENERATOR INLET TEMPERATURE
5	T-2	STEAM GENERATOR FLUID TEMPERATURE
6	T-3	STEAM GENERATOR OUTLET TEMPERATURE
7	T-4	HOT WATER FLUID TEMPERATURE IN FIELD
8	T-5	HOT WATER FLUID TEMPERATURE IN FIELD
9	I-6	PROCESS STEAM TEMPERATURE
10	T-7	FEEDWATER TEMPERATURE
11	T-8	AMBIENT TEMPERATURE
12	P-1	HOT WATER LOOP PRESSURE
13	P-2	PROCESS STEAM PRESSURE
14	F-1	PROCESS STEAM FLOW
15	F-2	HOT WATER LOOP FLOW

2.6.2 Collector Ball Valves

Ball valves to allow flow balance and isolation of individual collectors were specified and installed. These valves leaked under system operating pressure, and substitute valves were specified, purchased, and installed. These valves are gate valves (for isolation) and globe valves (for flow balance and isolation).

2.6.3 Mirror Wrinkles

Under the high humidity conditions experienced at Fairfax, Alabama, the reflective surface of the mirrors formed "wrinkles" or "tunnels" at many of the panel corners. These wrinkles were caused by the acrylic reflective film expanding over the expanse of the aperture and being constrained at the edges.

Figure 2-4. Westpoint Pepperell Data Collection, Phase II Start-Up

DATE	DAY	PERSONNEL AT SITE	DATA COLLECTION PERIOD	COMMENTS
SEPT. 12	T	GLB/WH	15:25 — 15:57	TOTAL RADIOMETER
13	W	GLB/WH	07:30 — 12:06	BOTH RADIOMETERS
14	TH	GLB/WH	13:36 — 15:30	BOTH RADIOMETERS
15	F	GLB/WH	08:38 — 12:19	FIRST DAY ALL CHANNELS
16	S			
17	SU			
18	M			
19	T	GLB/WH	12:02 — 16:21	TOTAL RADIOMETER
20	W	GLB/WH	08:43 — 17:02	TOTAL RADIOMETER
21	TH	GLB/WH	08:31 — MIDNIGHT	OPERATION, LITTLE STEAM
22	F	GLB/WH	08:37 — 17:30	FIRST DAY OF GOOD STEAM
		WPP	DATA THROUGH FRI. NIGHT	COOL DOWN
23	S	WPP	MIDNIGHT — 04:38	
			10:48 — 13:00	FLOW, NO SUM
24	SU			
25	M	WPP	13:00 — 17:13	SOME DATA
26	T	WPP	08:30 — 15:02	SOME DATA
27	W	WPP	09:35 — 15:30	SOME DATA
28	TH	WPP	08:51 — 17:00	SOME DATA
29	F			BAD DATA
30	S	WPP	08:15 — 14:26	SOME DATA
OCT. 1	SU	WPP	13:42 — 13:58	SOME DATA
2	M			BAD DATA
3	T	WPP	12:21 — 14:11	SOME DATA (TNS NOTES)
4	W			
5	TH	WPP	06:00 — 16:03	SOME DATA
6	F	WPP	10:59 — 16:09	SOME STEAM (NOTES)
7	S			
8	SU			
9	M			
10	T	WPP	14:04 — MIDNIGHT	RADIOMETER ONLY
11	W	WPP	MIDNIGHT — 21:17	RADIOMETER ONLY
12	TH	WPP	13:51	ONE DATA POINT
OCT. 13-22	F-SU			BAD WEATHER AND FEEDWATER PUMP PROBLEMS
23	M	WPP	08:35 — 14:07	DATA
24	T	GLB/RK	08:42 — MIDNIGHT	DATA
25	W	GLB/RK	24 HOURS	DATA
26	TH	GLB/RK	24 HOURS	DATA
27	F	GLB/RK	MIDNIGHT — 19:32	DATA
28	S	GLB/RK	08:24 — 15:11	DATA
29	SU			
30	M	GLB/RK		FEEDWATER PUMP FAILED
31	T	GLB/RK		
NOV. 1-27	W-M			SYSTEM DOWN DUE TO FEEDWATER PUMP FAILURE
28	T	GLB/JW	14:47 — 15:40	SOME DATA
29	W	GLB/JW	08:37 — 13:15	SOME DATA
30	TH	GLB/JW	08:57 — MIDNIGHT	SOME DATA
DEC. 1	F	GLB/JW	MIDNIGHT — 13:36	SOME DATA; OPERATED SYSTEM
2	S	GLB	08:09 — MIDNIGHT	SOME DATA
3	SU		24 HOURS	DATA LOGGER BAD
4	M	GLB	24 HOURS	DATA LOGGER BAD UNTIL 14:37
5	T	GLB	MIDNIGHT — NOON	DEMONSTRATED SYSTEM: GENERATED STEAM; PIPE LEAK

The wrinkles were removed by a patching technique developed by the material manufacturer. In future applications, 1/8-inch gaps should be left at the edges and between pieces of film to accommodate this humidity-induced expansion.

SECTION 3.0
DATA ANALYSIS

3.1 INTRODUCTION

This section describes the analysis techniques developed to determine the solar process steam heat balance and the system performance and documents the results from system operation during start-up and checkout. The Phase III Test Plan is included under Subsection 3.2, Analysis Techniques. Details of the system instrumentation, sensors, and data collection equipment are described in Subsection 2.3.8, Instrumentation.

3.2 ANALYSIS TECHNIQUES

3.2.1 Phase II, Start-Up and Checkout

During the Phase II start-up and checkout task, data was gathered to monitor system performance in the field. System temperatures, pressures and flow rates were observed and recorded as the system was adjusted and brought into full operation. The primary use for this data was real-time checkout and adjustment of the system components.

Subsection 3.2.2, Test Plan, includes descriptions of the relationships and equations to be used in the data analysis. Subsection 3.3, Results, describes the Phase II results in terms of graphs of temperature, pressures, flows and radiation.

3.2.2 Test Plan

The Phase III operation and evaluation will be directed toward two objectives:

- Provide solar-produced steam to the process,
- Monitor performance of the system.

Performance of the system will be monitored through 15 sensors as listed in Table 2-3. The sensor data will be used to calculate system performance and will supply a record of system parameters in case of malfunction. Data will be recorded continuously at 15-minute intervals all day, every day. Data will be collected at the site and mailed to Honeywell weekly to be reduced, and the outputs will be used for reporting purposes and detailed analysis of the system.

The function of each sensor in the test plan and data analysis is described in the following paragraphs.

Temperature Sensors--The temperature sensor data will be plotted versus time (eight sensors, eight curves) for representative days of operation to allow visual inspection of the system warm-up, operation, and cooldown, and for comparison with similar plots of illumination versus time.

The solar collector field input and output temperatures (T1 and T3) and the collector field flow (F2) will be used in calculating the performance of the solar collector field subsystem. The rate of energy collection by the field, Q_c, will be determined as a function of time using the following relationship:

$$Q_c = \dot{M}(C_p)\Delta T_c$$

where

Q_c = rate of energy collection by the collector field (MJ/hr)

$\dot{M}$ = HTW flow rate (kg/hr)
= F2 x (units conversion constant)

C_p = the specific heat of the fluid

ΔT_c = temperature differential (°C)
= T1 - T3

The solar steam line temperature (T6), the feedwater temperature (T7), and the steam flow (F1) will be used in calculating the overall performance of the system in terms of the rate of energy delivered to the process:

$$Q_p = \dot{m}(C_p \Delta T_p + h_{f_g})$$

where

Q_p = rate of energy delivery to the process (MJ/hr)

$\dot{m}$ = steam flow to process (kg/hr)
= F1 x (units conversion constant)

ΔT_p = the temperature differential (°C)
= T7 - T6

h_{f_g} = heat of vaporization (MJ/kg)
= function of T7

The value ΔT_p will be relatively constant, and the flow rate, $\dot{m}$, will be integrated to determine the total amount of energy, E_p, delivered per day:

$$E_p = m(C_p \Delta T_p + h_{f_g})$$

where

m = the amount of steam delivered to the process per day (kg) as determined by the flowmeter integrator.

These performance values will be plotted versus time, Q_c and Q_p on an hourly basis and E_p on a daily scale.

Pressure Sensors--The pressure sensor data will be plotted versus time (two sensors, two curves) for representative days of operation to allow visual inspection of the system changes in pressure with temperature change and time. The solar steam pressure, P2, will also be used in determining the performance of the system through validation of the value of the heat of vaporization, h_{f_g}.

Flow Sensors--Data from the HTW loop flow sensor (F2) will be used primarily to determine the rate of energy collection by the field, Q_c. Flow rate data for representative days will also be graphed to illustrate the relationship between flow rate, time, and fluid temperature.

Data from the process steam flow (F1) will be used primarily to determine the rate of energy delivered to the process, Q_p. Flow rate data for representative days of operation will allow visual inspection of the system performance in terms of steam flow provided to the process. The flow in the existing steam line, taken from the existing sensor, F2, will be recorded on its existing recorder at the mill. These data will be used to define the steam demand and the percentage of that demand supplied by solar steam.

Radiation Sensors--The radiation sensor data will be plotted versus time (two sensors, two curves) for representative days of operation to allow visual inspection of the illumination levels and comparison with other data. These data will provide a data base of total and direct normal incident radiation not currently available for the Alabama-Georgia locality.

The solar collector field efficiency at given points in time will be calculated from

$$\eta_c = \frac{Q_c}{A_c I_d}$$

where

η_c = the efficiency

Q_c = the rate of energy collected as calculated above (MJ/hr)

A_c = the area of the collector field (m^2)
= 700 m^2

I_d = the direct normal solar insolation (MJ/hr • m^2)
= I2

These values of efficiency will be plotted versus time for representative days of operation.

The total solar process steam system efficiency at given points in time, η_{syst}, will be calculated from

$$\eta_{syst} = \frac{Q_p}{A_c I_d}$$

where

η_{syst} = the energy-available-to-energy-provided-to-the-process ratio

Q_p = the rate of energy delivered to the process as calculated (MJ/hr)

These values of efficiency will be plotted versus time for representative days of operation.

Using data from the pyrheliometer integrator and the process steam integrator, average values of efficiency over a day's time will also be calculated.

Solar system efficiency as a function of the total incident radiation may also be calculated using the data from sensor I1.

Graphs of solar system peak efficiency versus the operating parameter OP will be generated where

$$OP = \frac{\left(\frac{T1 - T3}{2}\right) - T8}{I_d}$$

and T8 is the ambient temperature. The system peak efficiency will be calculated from the measured efficiencies and the cosine α factors associated with the sun angle. This plot is expected to be a family of curves forming a band of expected performance.

3.3 RESULTS

Data taken during start-up and checkout (see Table 2-4) were used primarily for on-the-spot diagnosis and to monitor the operational readiness of the system. Factors that make this data preliminary and unrepresentative include:

- System only partially insulated,
- Control setpoints set low for initial tests,
- Sensor calibration incomplete,
- Data logger operation problems,
- Noise in sensor signals,

- Collector alignments in progress,
- System operated at low temperatures,
- System exercised in all weather conditions.

Data taken on 2 days is analyzed and documented in the following subsections.

3.3.1 Friday, 22 September 1978

On Friday, 22 September 1978, the WestPoint Pepperell system was operated for several hours and produced steam. Figure 3-1 is a graph of total radiation, direct normal insolation, and ambient temperature. The day dawned clear with a great deal of promise, but sky conditions became extremely variable in the afternoon. The data show direct normal readings up to 212 Btu/hr/ft^2, and total radiation went to 280 Btu/hr/ft^2.

After start-up at 8:30 AM, the system had to be shut down at 9:00 AM to conduct feedwater pump and relief valve repairs. These repairs extended over the best 3 hours of the day. At 11:30 AM the feedwater pump was turned on to refill the HTW loop. The system was turned on at 12:20 PM. Seventeen (of 24) collectors were tracing automatically, six were tracking manually, and one was stowed.

Figure 3-2 shows several system temperatures and the associated direct normal insolation data. Note the warm-up of sensor T3 when feedwater (near 200°F) is added to the HTW loop (refilling after relief valve fix). Condensate pump turn-on is shown as an event. Under the existing conditions (high system flow, low system temperature, hot day), the system has a great deal of inertia and responds very slowly to insolation changes. The data show poor calibration of the temperature sensors since the value shown for T1 (temperature out of field) is lower than the value shown for T3 (temperature into field).

Figure 3-3 shows system pressure and steam flow and the associated insolation and temperatures. The first segment of the pressure curve shows nitrogen

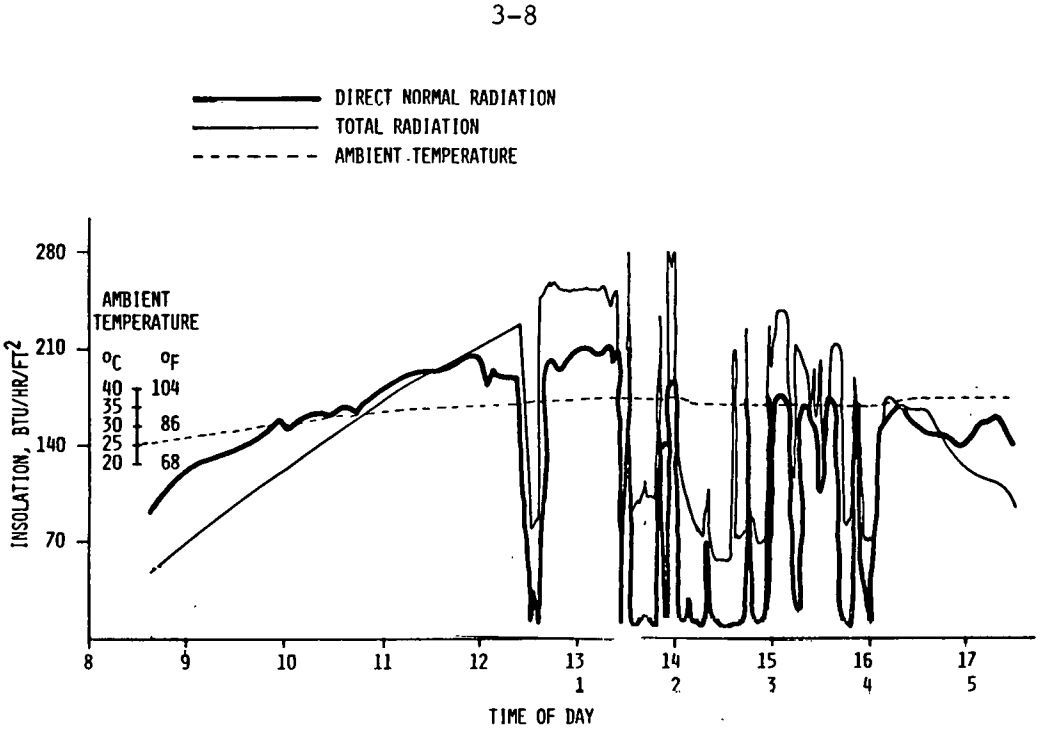


Figure 3-1. Insolation (Direct and Total) and Ambient Temperature

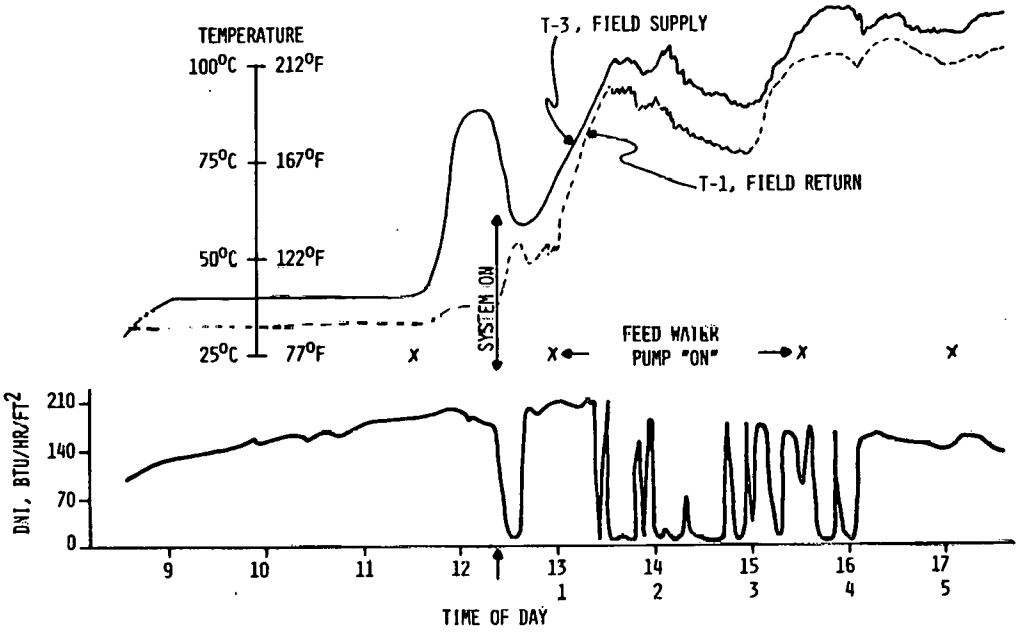


Figure 3-2. System Temperatures

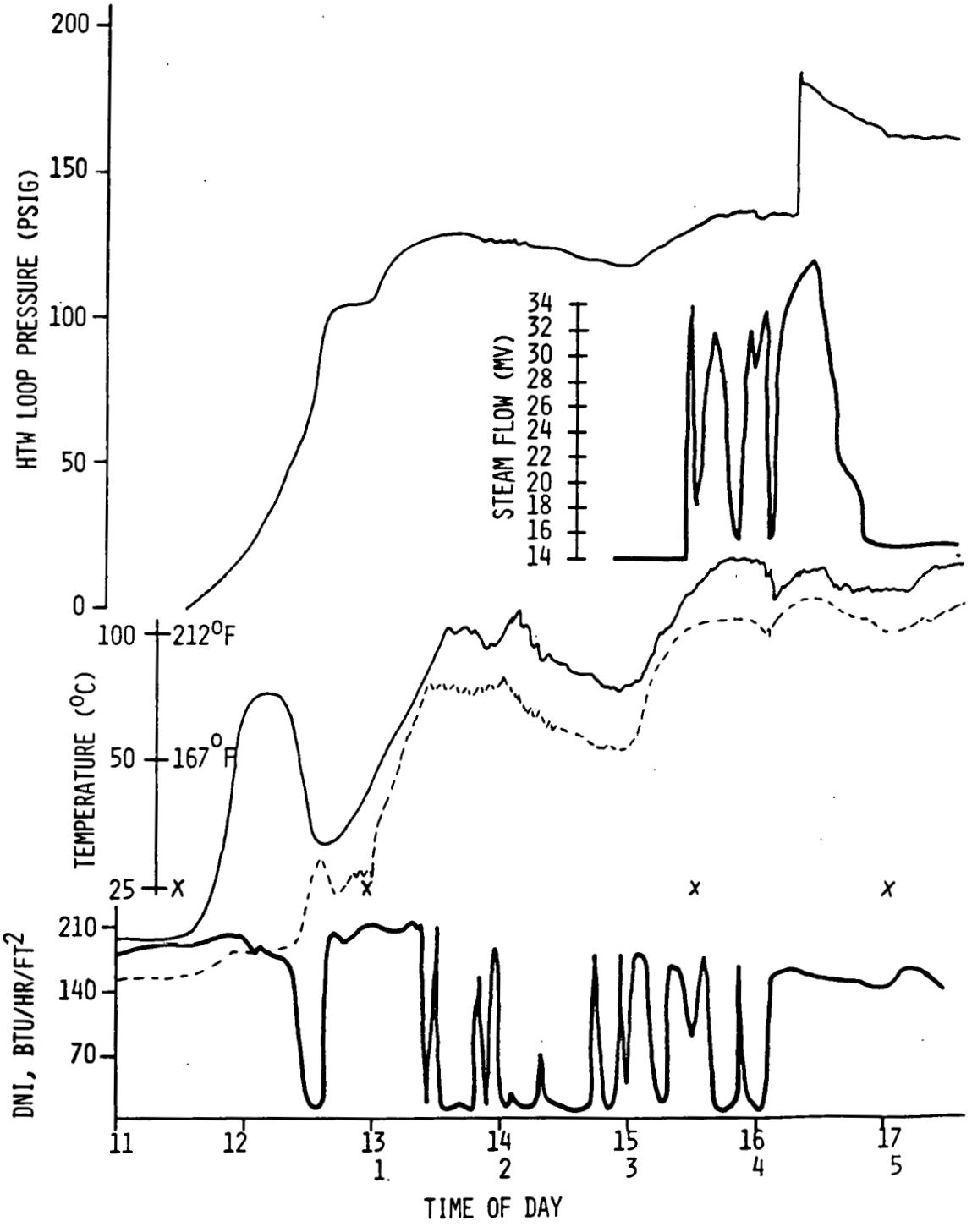


Figure 3-3. Steam Flow and System Pressure

charging to 100 psig. Similarly at 4:20 PM, another 50 psig was added with the nitrogen bottle to assure adequate system pressure to inhibit boiling. Other pressure variations are associated with the system temperature changes, i.e., expansion of the water into the expansion tank.

Steam flow into the atmosphere occured from 3:30 until 5:00 PM. Steam pressures ranged from 3 to 5 psig. The flow calibration is not yet available so the data is shown in millivolts.

3.3.2 Tuesday, 5 December 1978

On Tuesday, 5 December 1978, the WPP system was operated in connection with the DOE Construction Review Meeting (informal "dedication"). Insolation over the time of interest was high. Direct normal readings were consistently near 1000 W/m^2 (317 $Btu/hr/ft^2$). Total radiation on a horizontal plane was typically less than 540 W/m^2 (172 $Btu/hr/ft^2$).

Data collection began at 00:00:00 (midnight) on 5 December and continued until 11:58:06 when the system was abruptly shut down due to a pipe leak. Shutdown was initiated at the "panic switch," which turned off the data logger (and turned on the standby generator to stow the field).

During the 12 hours recorded, 132 timepoints were logged on 13 channels of data. The logged data were reviewed to exclude obviously "bad" data points. Thus, the data analyzed herein should be considered selected data and therefore possibly somewhat biased.

Prior to sunrise (00:00 to 06:30), the data logger cycled every 30 minutes, providing 14 data points while the system was dormant (stowed). The sun came up between the 6:30 AM reading and the 7:00 reading. At 7:30, the system was turned ON (the HTW loop pump showed flow) and data was logged every 2 minutes. The system pressure (HTW loop) increased 26.5 psi when the pump turned on.

The system showed continual cooling through the night until it switched ON. Accompanying this cooling was a reduction in the HTW loop pressure. Figure 3-4 is a graph of the temperature data from 00:00 (midnight) until 08:46. Ambient temperature (T-8) decreases slowly until 6:30, whereupon it begins to rise near dawn. The temperature in the steam generator (T-2) is maintained at 21°C (70°F) by the penthouse heater. The trend of the other temperature sensors seems reasonable, but the values do not. This suggests that the sensors are not zeroed properly.

Upon turning the system ON (07:30) the steam generator temperature (T-2) dropped quickly (see Figure 3-4) as its energy was transferred to the cold fluid in the HTW loop. System temperature rose, both from the energy stored in the steam generator and the solar energy from the collectors, which began operation. System temperatures did not "come together" as one would expect from this "mixing" of the HTW loop fluid, but this could be due to the two heat sources (steam generator plus collectors). The steep rise of the temperature at T-5 (steeper than the system as a whole) implies that collector number 24 was collecting solar energy.

System dynamics were evaluated analytically to determine the expected "time constant" of the HTW loop. Based on a fluid hold volume of 300 gallons pumping at 48 gpm, the average time to complete one pass around the HTW loop is 6 minutes. Fluid going through collector number 1 (shortest time) makes one pass in 4 minutes. Fluid going through collector number 24 (longest time) makes one pass in 9 minutes.

Figure 3-5 is a plot of the direct normal insolation and temperature data from 8:30 AM to 12:00 noon. a definite warming trend is indicated. However, many anomalies occur in the data; T-3 greater than T-1, T-2 greater than T-1, etc. Once the field temperature rises above 70°F, T-1 should be higher than T-2 or T-3. These anomalies apparently are due to errors in the zero reading of the sensors. The slope of the data points in Figure 3-5 shows the warm-up to occur at the rate of 100°F per hour.

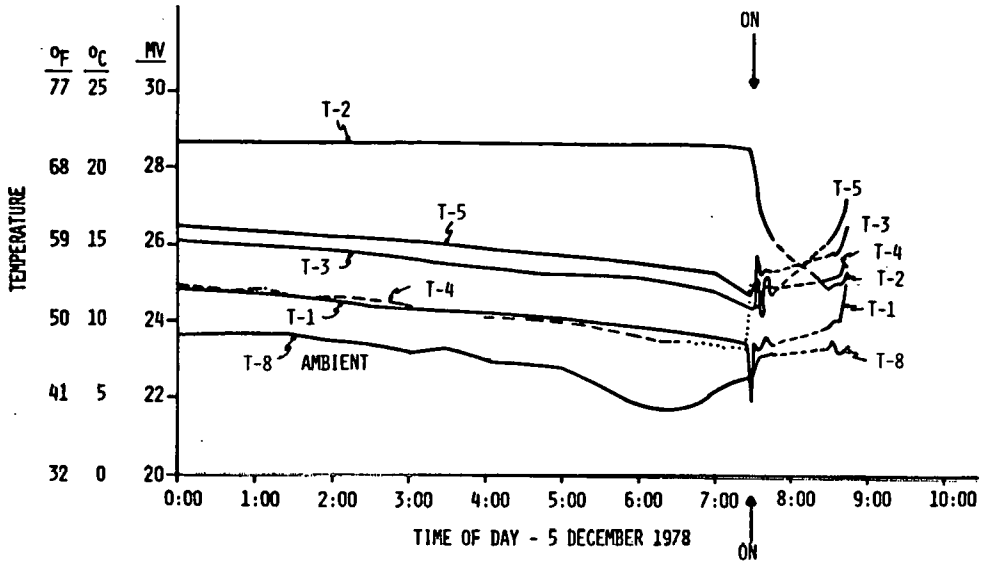


Figure 3-4. Temperature Versus Time

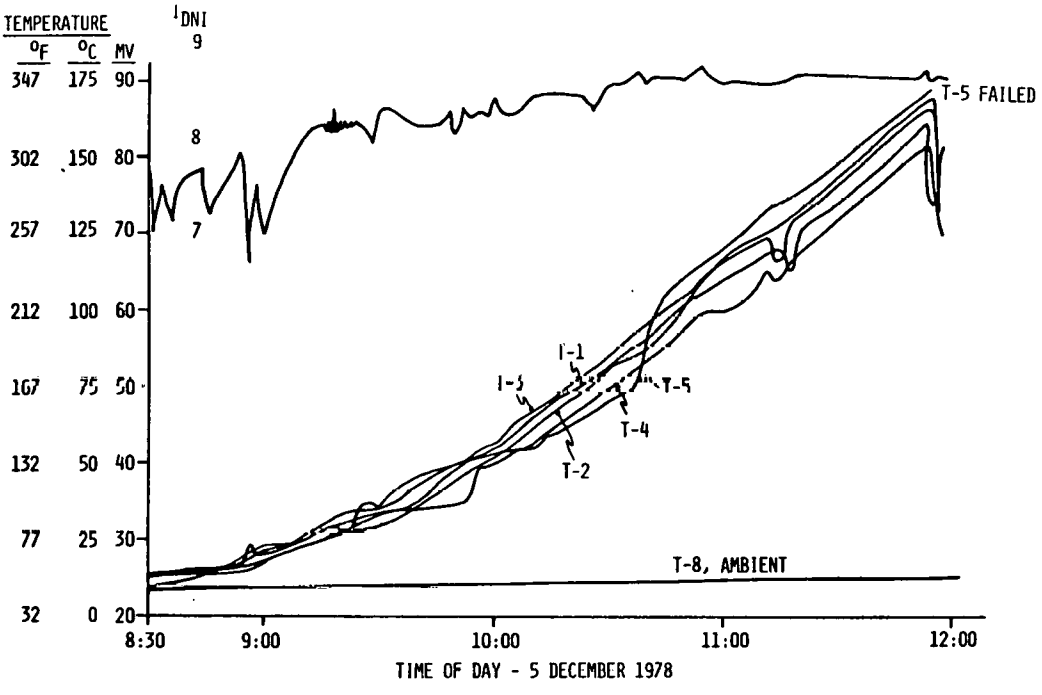


Figure 3-5. Temperature Versus Time (Plus Insolation)

The system reached 300°F before being shut down due to a pipe leak. The slope of the data (warm-up rate) is still constant at that temperature.

Figure 3-6 plots steam generator pressure (P-2) versus time from 10:00 AM until 12:00 noon. Only one good data point was acquired between 10:20 and 11:52, so an estimated curve is graphed consistent with steam valving during warm-up. Steam flow during this valving and after shutdown was into the atmosphere.

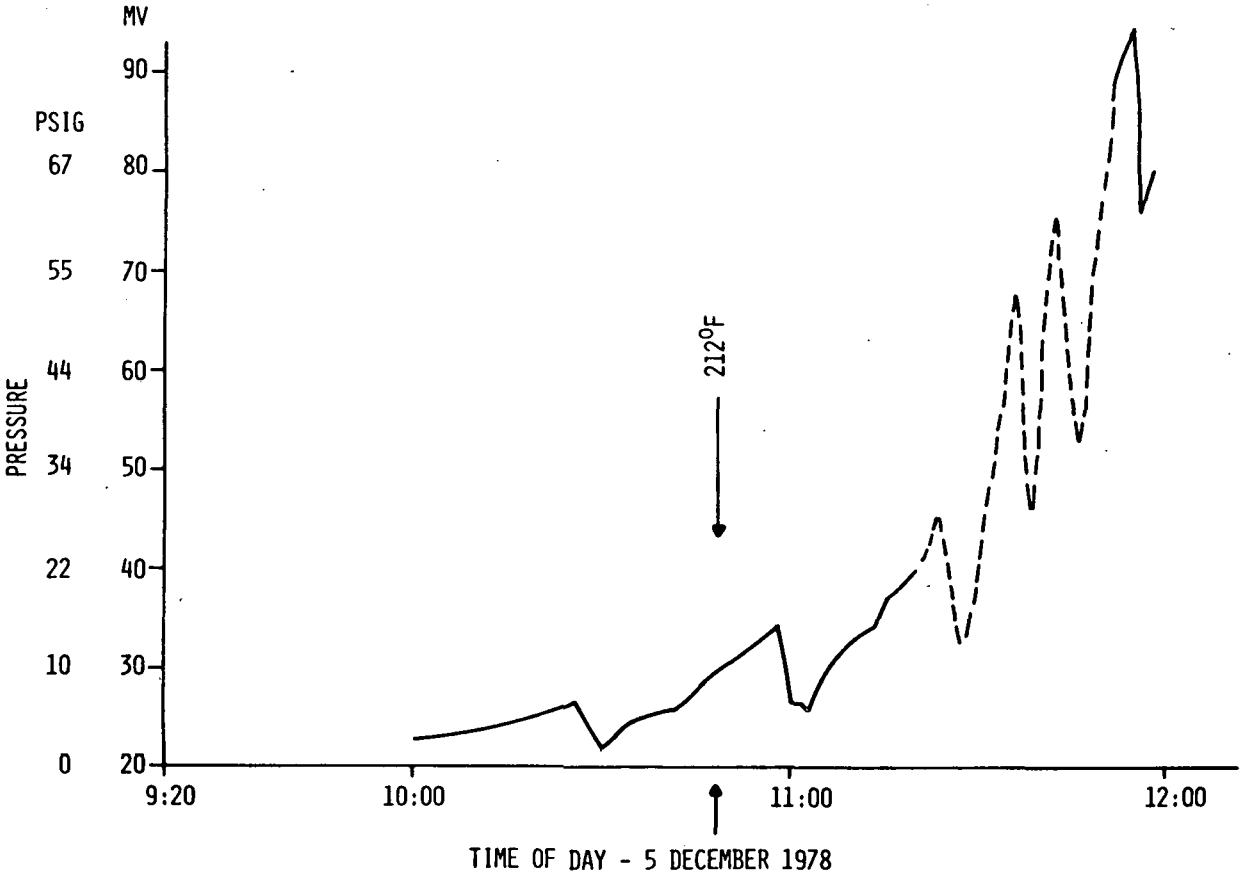


Figure 3-6. Steam Generator Pressure Versus Time of Day

SECTION 4.0
OPERATION AND MAINTENANCE PROCEDURES

4.1 INTRODUCTION

Operation and maintenance procedures have been developed as a basis for 1) the Phase III system operation and 2) the publishing of an Operation and Maintenance (O&M) Manual. These procedures are based on operation and maintenance of prototype collectors in Minneapolis, Minnesota, and experiences with installing and operating concentrating collector systems in Columbus, Ohio; Minneapolis, Minnesota; and Fairfax, Alabama.

4.2 OPERATION

4.2.1 System Operation

The solar process steam system designed for and installed at the WestPoint Pepperell textile mill in Fairfax, Alabama, is an automatic unit that operates on a daily basis with no manual control. Under normal operating conditions the system will "wakeup" in the morning, warm up to operating temperature, provide solar steam to the process, and shut down at night. Data on this operation is taken automatically on a data logger 24 hours per day. Table 4-1 summarizes the operational sequence of the system.

Consistent with the experimental nature of the first year of operation, and in support of the data collection activities, the following operating procedures will be conducted, most on an ever-decreasing frequency as operational experience is gained:

- Adjust tracking pyrheliometer in declination;

Table 4-1. System Operational Sequence

MODE	FUNCTIONS
A. NIGHTTIME STATUS	CONTROL IN AUTOMATIC. COLLECTORS STOWED. PUMPS OFF. 110-VOLT SUPPLY ON. 28-VOLT CONTROL SUPPLY ON. SENSORS ACTIVE FOR CONTROL AND DATA COLLECTION.
B. SUNUP	WHEN ILLUMINATION IS ABOVE PRESET LEVEL, WIND IS BELOW PRESET LEVEL, SYSTEM TEMPERATURE AND PRESSURE ARE WITHIN LIMITS, AND STEAM GENERATOR HAS FLUID; TURN ON FIELD PUMP. WHEN FIELD FLOW IS VERIFIED; TURN ON COLLECTOR FIELD
C. UNSTOW (ACQUIRE)	COLLECTOR CONTROL TRANSFERRED TO UNIT CONTROLLERS. COLLECTORS ROTATE TO UNSTOW. TRACKING SENSOR MONITORS SUN POSITION. UNSTOW CEASES WHEN TRACKING SENSOR NULLS.
D. TRACKING	COLLECTOR TRACKS FORWARD AND/OR IN REVERSE WITH CONTROL FROM TRACKER. FLUID IN HTW LOOP IS HEATED IN RECEIVER TUBE. FIELD FLOW PUMP TRANSFERS WATER AROUND COLLECTOR LOOP AND TO STEAM GENERATOR. HEAT IS TRANSFERRED TO WATER IN STEAM GENERATOR. STEAM IS GENERATED AT PROCESS CONDITIONS AND PIPED TO SLASHER MANIFOLD. FEEDWATER PUMP MAINTAINS LIQUID LEVEL WITH FEEDWATER. OPERATION CONTINUES THROUGHOUT DAY, WITH HTW LOOP COLLECTING SOLAR ENERGY AND TRANSPORTING IT TO STEAM GENERATOR FOR PRODUCTION OF PROCESS STEAM.
E. STOW (SUNDOWN)	ILLUMINATION DROPS BELOW PRESET LEVEL. STOW COMMAND SENT FROM SYSTEM CONTROLLER. COLLECTORS STOW. FIELD FLOW PUMP TURNS OFF. SYSTEM IS IN NIGHTTIME STATUS (A).

- Monitor daily operation--temperatures;
- Monitor daily operation--pressures;
- Monitor daily operation--flows;
- Monitor collector parity error;
- Monitor data logger operation, mail data;
- Monitor daily operation--collector field;
- Monitor fluid level--HTW loop.

The following paragraphs describe nonautomatic operation functions (i.e., start-up and recovery from automatic shutdown). Nonautomatic operation should be documented in the system log book.

Start-up--Figure 4-1 is a schematic of the system control panel located in the Penthouse on the weave room roof. Figure 4-2 is a schematic of the annunciator panel located in the mill machine room. Starting the system consists of switching the keyed SYSTEM OFF switch on the annunciator panel to the ON position. In this state, the system controller awaits appropriate signal levels from the protection sensors before automatically initiating the "wakeup" sequence.

During the collector "wakeup" unstow and during stow, the RED Collector Parity Error light will come on momentarily as some collectors leave or reach stow before the others. This is normal during the "wakeup" and stow transition.

System High Temperature Stow--If the fluid in the HTW loop exceeds 392°F, the system controller will automatically stow the collector field and shut down the system. Simultaneously, the RED System High Temperature Stow light will come on and an alarm will sound at the annunciator. In this state the system will not "wakeup" automatically upon cooling down. Recovery from this condition requires reset at the System Controller.

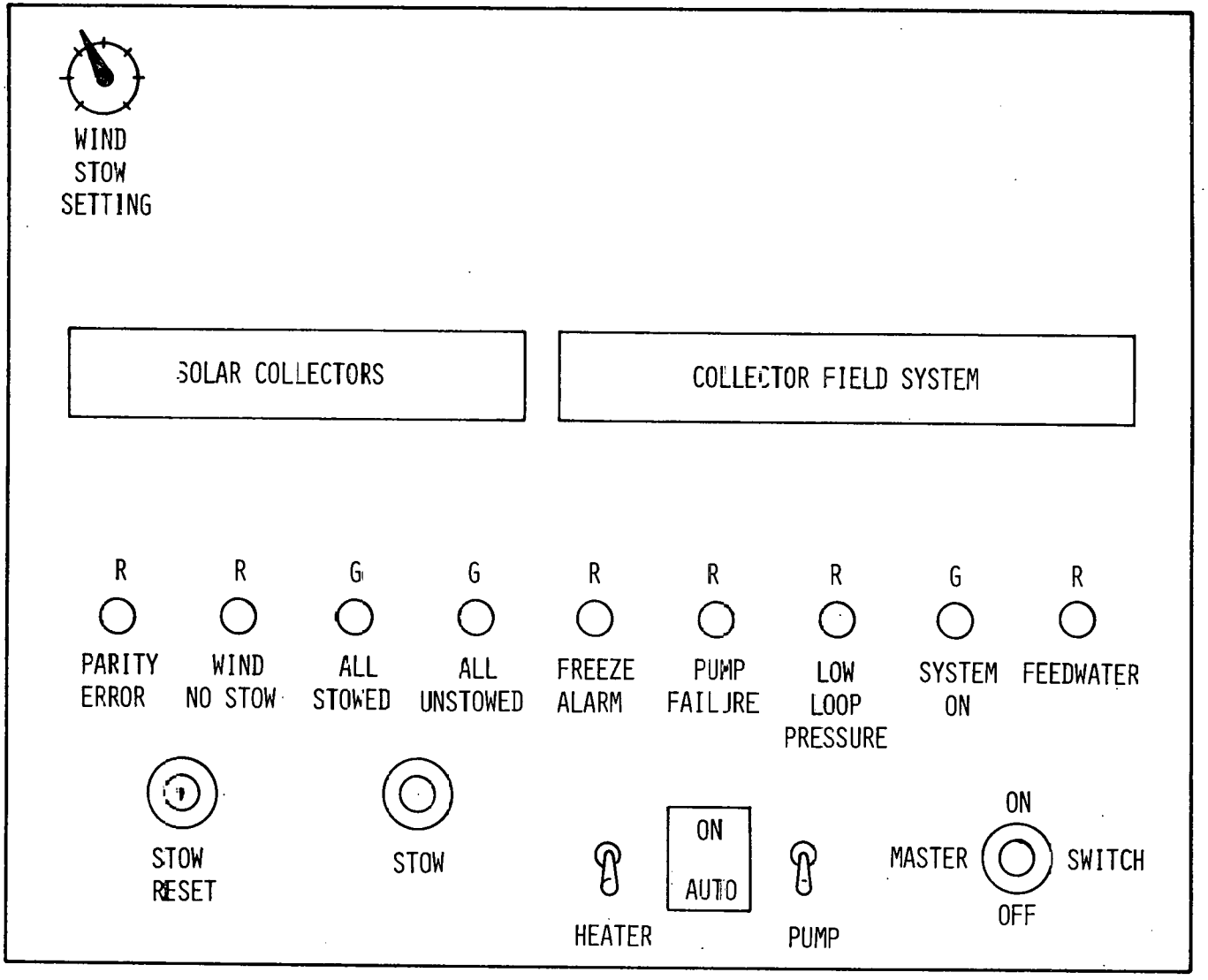


Figure 4-1. Schematic of System Control Panel

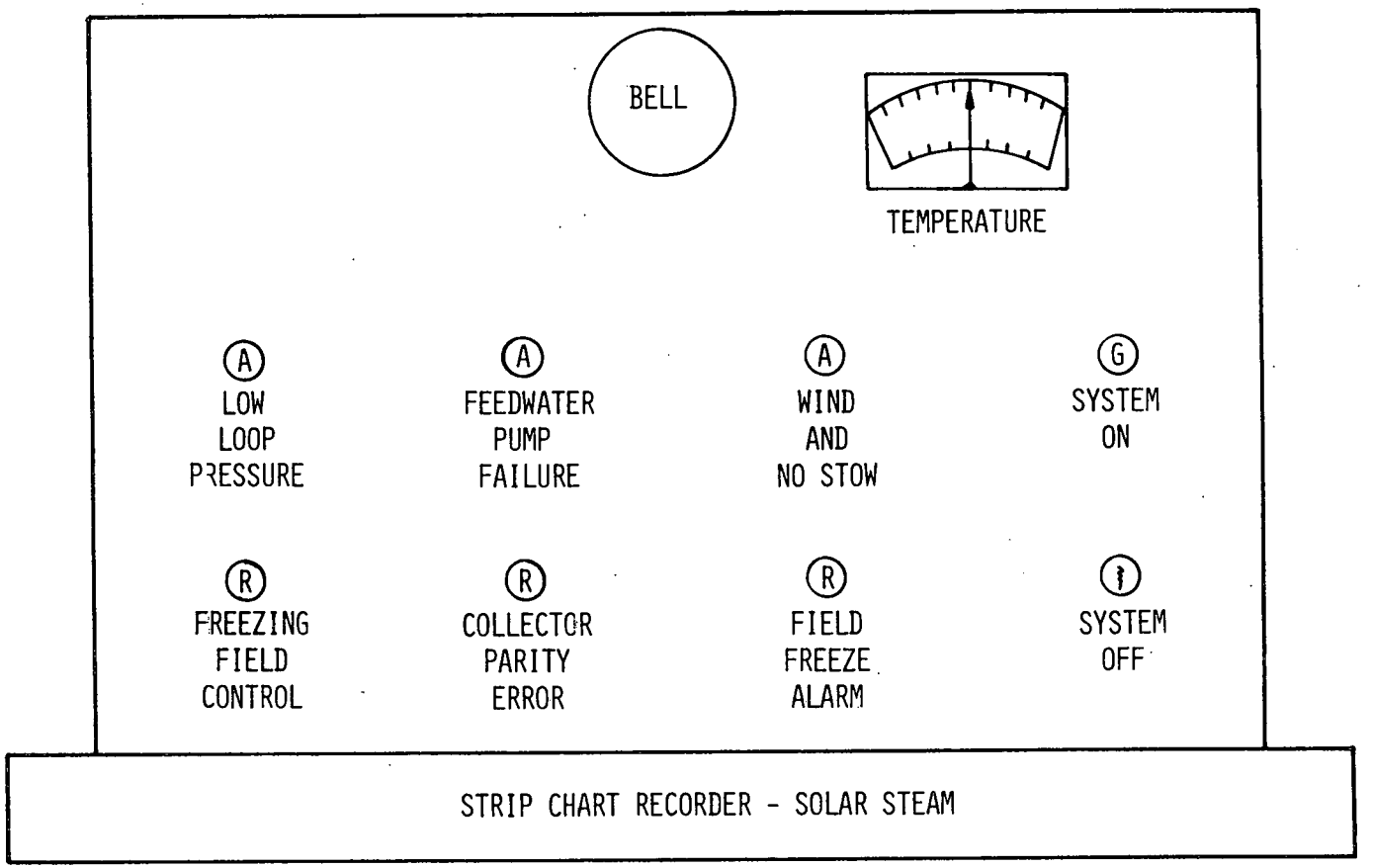


Figure 4-2. Schematic of Annunciator Panel

THE OPERATOR IS CAUTIONED TO DETERMINE WHY THE SYSTEM REACHED THE HIGH TEMPERATURE SETPOINT. Causes could include electrical faults, low system flow, abnormal steam generator operation, or no steam demand.

High System Pressure--If the HTW loop pressure rises above 275 psi, the system controller will automatically stow the collector field and shut down the system. Simultaneously, the RED High System Pressure light will come on and an alarm will sound at the annunciator. In this state the system will not "wakeup" automatically upon cooling down. Recovery from this condition requires reset at the System Controller.

THE OPERATOR IS CAUTIONED TO DETERMINE WHY THE SYSTEM REACHED THE HIGH PRESSURE SETPOINT. Causes could include electrical faults, excessive fluid in HTW loop, or excessive N_2 pressure in expansion tank.

Low System Pressure--If the HTW loop pressure drops below a predetermined level, the system controller will prohibit system "wakeup" or, if already operating, will automatically stow the collector field and shut down the system. Simultaneously, the RED Low System Pressure light will come on and an alarm will sound at the annunciator.

The predetermined level is a pressure/temperature relationship which assures that the system will have adequate pressure to prohibit the formation of vapor at the system operating temperature. Figure 4-3 is a graph of this relationship.

Recovery from this condition requires re-establishment in the HTW loop of the proper pressure/temperature relationship, plus reset at the System Controller.

THE OPERATOR IS CAUTIONED TO DETERMINE WHY THE SYSTEM REACHED THE LOW PRESSURE SETPOINT. Causes could include, electrical faults, loss of HTW loop fluid, or loss of N_2.

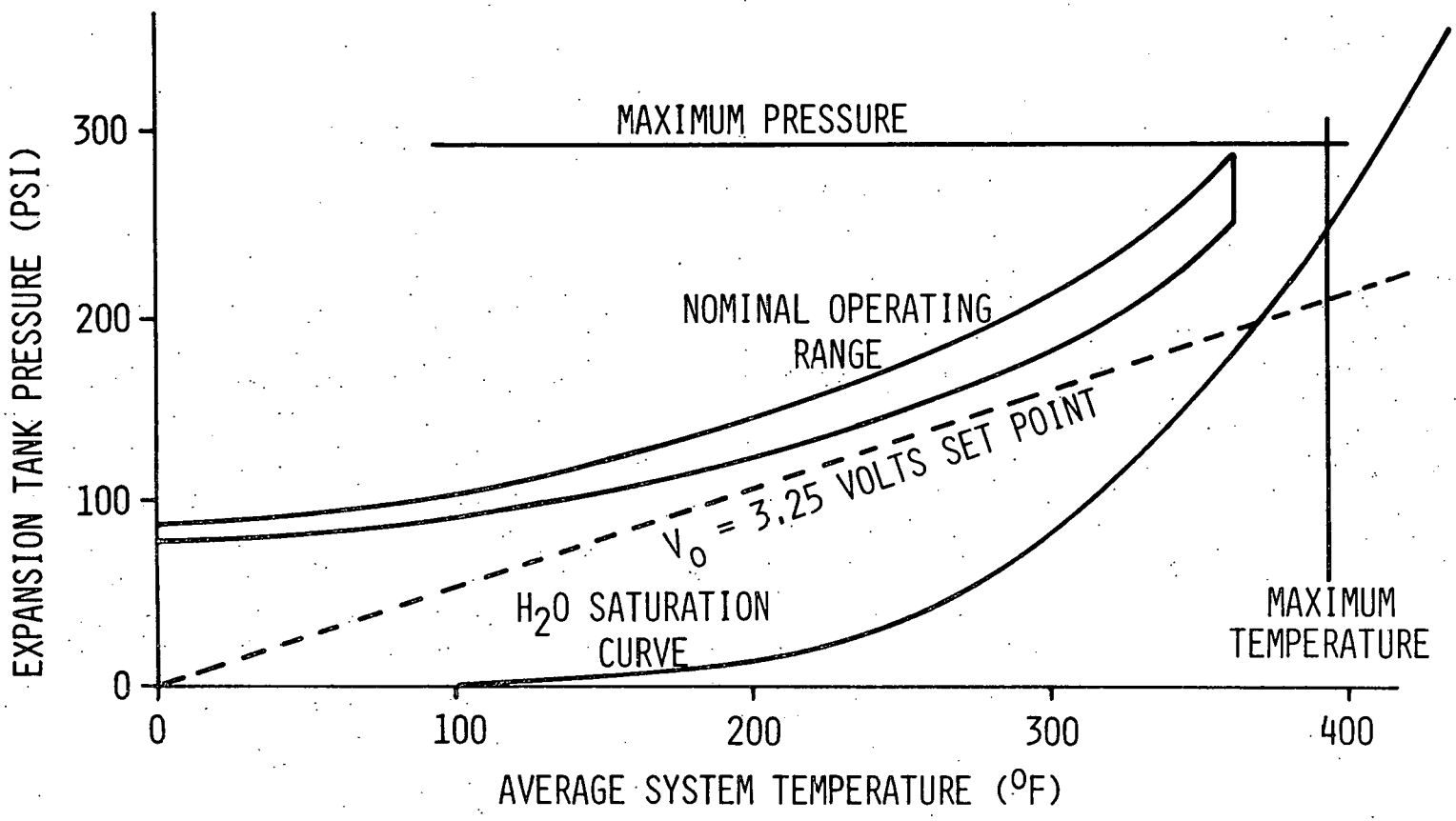


Figure 4-3. Pressure/Temperature Relationship for V_o = 3.25 Volts

Freeze Protection Failure--If the freeze protection system is unable to supply sufficient heat to the collector field, the RED Freeze Protection Failure light will come on and an alarm will sound at the annunciator. This alarm implies that 1) fluid temperature in the HTW loop has fallen below 2°C and 2) the freeze protection system (pump motor on, immersion heaters on) has failed to raise the temperature. Under these conditions, manual intervention may be required to avoid freezing of the HTW loop fluid and damage to the pipes and solar collectors.

Unless the operator is convinced that (due to weather conditions, time of day) freezing will not occur, the manual procedure is as follows:

- Open the steam generator drain valves (blowdown valve and gate valve) and drain off water. This will turn on the feedwater pump and supply hot condensate to the steam generator. The hot condensate will exchange heat with the tube bundle and heat the HTW fluid as it circulates.

- Initially, adjust valves for flow consistent with feedwater pump flow (3 gpm) for maximum heating.

- As system temperature rises above 5°C, reduce drainage flow to keep collector field around 4 to 6°C without dumping excessive hot water.

- When weather warms, shut off valves; system will return to ready status.

- If condensate feedwater is not available, all system fluids must be dumped (drained) to protect pipes and collectors:

  - Open HTW loop drain valves,
  - Shut down system,

- Open N_2 valve to purge system,
- Open steam generator drain valves,
- Manually rotate collectors (24) to drain.

High Wind Conditions--If the wind speed exceeds 25 mph during operation, the system controller will stow the collector field. When the winds drop below 25 mph, the system will again "wakeup" and operate automatically if the illumination, temperature, pressure, and flow signals are affirmative. This condition is completely automatic and requires no operator intervention. The COLLECTOR PARITY ERROR light will come on momentarily as some collectors reach stow before others. This is normal during the "wakeup" and stow transition.

Cloudy Conditions--If clouds obscure the illumination sensor for 15 minutes, the system controller will stow the collector field. Once stowed, if the illumination increases again to the set point, the system will "wakeup" and operate automatically if the wind, temperature, pressure, and flow signals are affirmative. This condition is completely automatic and requires no operator intervention.

High Wind and Parity Error--If a parity error exists (one or more collectors not stowed) after the system stows the field due to high winds (greater than 25 mph), the RED High Wind and Parity Error light will come on and an alarm will sound at the annunciator. To protect the collector field from potential damage, the operator must go to the collector field and manually stow collectors that have not gone into stow. Once stowed, the parity error will be eliminated.

Standby Generator--If electrical power to the solar energy system service panel is interrupted, standby power will be supplied automatically by a diesel generator. The system controller will command the field to stow. The standby generator will provide the power to stow the collectors and power the controller.

Pump Failure--Failure of the HTW recirculation pump will cause the RED Pump Failure light to come on, shutting down the system. Recovery from this situation requires repair of the pump.

4.2.2 Collector Operation

The concentrating collectors installed at the WestPoint Pepperell textile mill in Fairfax, Alabama, operate automatically on a daily basis under control of a system controller. When given a "wakeup" signal from the system controller, each collector individually unstows, acquires the sun, and tracks the sun until a stow signal is received from the system controller.

The following paragraphs describe nonautomatic functions. These operations should be documented in the system log book.

Manual Mode--Each collector has a unit controller that may be switched to AUTO or MANUAL. In the automatic mode the collector is under control of the system controller ("wakeup" or stow). In the manual mode an operator may rotate the collector forward or in reverse. The collector will track the sun only in the automatic mode.

Collector Overtemperature Stow--Individual collectors may stow due to an overtemperature condition while the rest of the collector field continues to track. This condition occurs at 400°F fluid temperature. The individual unit controller resets this stow switch after the collector has cooled to 350°F. In the absence of the "wakeup" signal, this collector probably will remain stowed and the COLLECTOR PARITY ERROR lights will come on on the control and annunciator panels.

Observation of a collector parity error necessitates maintenance on the collector to determine the cause of the overtemperature. This signal can be caused by electrical faults (fail safe design), low flow, or system temperature

anomalies. If maintenance is not performed, the subject collector (when cool) will unstow the next operating day and operate normally until overtemperature occurs again. To prohibit this operation, the collector unit controller can be switched into MANUAL.

Overtravel Switches--Whisker switches protect the collector from overtravel, which would damage the unit. Normally, cam switches perform the function of switching from forward to reverse (at extreme forward position) and from reverse to off (at the stowed position). If the collector travels beyond either of these cam switches, the receiver unit will contact a whisker switch that will perform these functions (redundancy).

4.3 MAINTENANCE

Operation of the solar process steam system, as described above, will be accompanied by maintanence functions to assure proper performance and lifetime of the components. The following maintenance schedules are subject to change based on the first year of operation. All maintenance should be documented in the collector log book.

4.3.1 Collector Maintenance

Motor--The collector motor is a DEMAG brake motor utilizing an integral electrically actuated brake mechanism. This brake mechanism should be inspected quarterly to detect excessive wear or improper adjustment.

Gearbox--The collector gearbox is a Winsmith 5000:1 triple reduction unit. It should be inspected quarterly to detect fluid leaks or low fluid level.

Bearings--The collector bearings are hard maple impregnated with lubricant. They should be inspected quarterly to detect any excessive wear.

Electronics--The unit controllers should be inspected quarterly to determine if degradation of the box or components is occurring. The operating modes should be checked out, and relay contacts should be inspected.

Optical Surfaces--The collector mirrors and receiver glass windows should be inspected monthly to determine the need for maintenance. Such maintenance may include cleaning, replacing glass, or patching mirrors.

4.3.2 HTW Loop Maintenance

On a quarterly basis, the HTW loop should be inspected for leaks and insulation damage. This check should be conducted both with the system operating (at nominal temperatures and extremes of expansion) and with the system cooled to ambient. A small quantity of fluid should be drained to check for corrosion in the HTW pipes.

As needed, based on experience (daily at first, then once a week, etc.), vapors should be bled from the manual vents to avoid vapor traps forming in the HTW loop.

4.3.3 Steam Generator Maintenance

The steam generator should be drained quarterly to eliminate buildup of contaminants in the boiler shell. Operation of the liquid level sensor should be checked at that time.

SECTION 5.0
SPECIFICATIONS AND DRAWINGS

5.1 INTRODUCTION

This section documents the Specifications and Drawings (S&Ds) developed during Phase I and used to install the system in Phase II. The S&Ds were used initially to solicit bids for installation of the process steam system. Eight firms showed interest in responding to the solicitation, and four firms responded with bids to conduct the work. Bahnson Service Corporation, a Division of Environtech, Winston-Salem, North Carolina, was the low bidder and was selected to perform the installation.

The S&Ds in the following subsections are not identical to those originally bid. Addendums, corrections, and changes to the S&Ds have been incorporated into the text for clarity. The drawings are reproduced undersized as illustrations rather than including scale drawings. Furthermore, the Terms and Conditions of the S&Ds, 50 pages of contractual requirements that flow down to the subcontractor, have been eliminated from this report for brevity.

5.2 SPECIFICATIONS

The conformed specifications, minus the Terms and Conditions (General Conditions), can be found on the following pages:

5.3 DRAWINGS

The following construction drawings, which have been reduced to illustrations, are included in a pocket inside the back cover of this document:

- Partial Plan, Buildings No. 2 and No. 3;
- Collector Field Layout, Partial Roof Plan--Building No. 3;
- Piping Schematic--Support, Hanger and Connection Details;
- Structural Roof Plan, Building No. 3;
- Penthouse Details and Elevation;
- Electrical;
- Solar Collector.

SECTION 1A

INSTRUCTIONS TO BIDDERS

.1 GENERAL. Proposals are requested by Honeywell, Inc., hereinafter referred to as the "Owner", for the construction work set forth in the attached specifications. All proposals shall be prepared and submitted in accordance with these instructions. and the invitation to bid letter transmitting these specifications and documents.

.2 INTERPRETATION OF SPECIFICATIONS. If bidder is in doubt, as to the true meaning of any part of the proposed contract documents, he may submit a written request to the Engineer for an interpretation. The person submitting the request will be responsible for its prompt delivery.

Any interpretation of the proposed documents will be made only by addendum mailed or delivered to each person receiving a set of such documents. The Owner will not be responsible for any oral or other explanations or interpretations of the proposed documents.

It shall be the bidder's responsibility to advise the Engineer, before the bid opening date, of conflicting requirements or missing information which required clarification. Those questions not resolved by addenda shall be listed in the space provided in the proposal form, together with statements of the basis on which the proposal is made as affected by each question.

.3 LOCAL CONDITIONS. The bidder shall visit the site of the work and throughly inform himself of all conditions and factors which would affect the work and the cost thereof, including the arrangement and conditions of existing or proposed structures affecting or affected by the proposed work, the procedure necessary for maintenance of uninterrupted operation, the availability and cost of labor, and facilities for transportation, handling, and storage of materials and equipment.

Visits to the site shall be scheduled and arranged through the Owner.

It must be understood and agreed that all such factors have been investigated and considered in the preparation of every proposal submitted. No claims for fiancial adjustment to any contract awarded for the work under these specifications and documents will be permitted by the Owner which are based on lack of such prior information or its effect on the cost of the work.

.4 TIME OF COMPLETION. The time of completion of the work is a basic consideration of the contract. The proposal shall be based upon completion of the work in accordance with the specified schedule in DIVISION 1. It will be necessary that the bidder satisfy the Owner of his ability to complete the work within the stipulated time.

In this connection, attention is called to the provisions of the GENERAL CONDITIONS relative to delays and extentions of time.

.5 PROPOSALS. Proposals which are not perpared and submitted in accordance with these instructions will imply that the bidder does not intend to comply with all of the contract conditions and such proposals will be considered irregular.

If the bidder declines to bid, he shall return all bidding documents and give written notice to the Owner not later than the date bids are due.

.5.1 PREPARATION. Each proposal shall be carefully prepared using the proposal and data forms bound herewith. Entries on the proposal and data forms shall be typed, using dark black ribbon, or legibly written in black ink. All prices shall be stated in words and figures except where the forms provide for figures only.

The proposal shall be based on new equipment and materials which comply with specifications in every respect unless the bidder takes specific exception as provided herein. If alternate equipment or materials are indicated in the proposal, it shall be understood that the Owner will have the option of selecting any one of the alternates so indicated and such selection shall not be a cause for extra compensation or extension of time.

The bidder shall not alter any part of these specifications in any way, except by stating his exceptions in the space provided on the proposal form.

The bidder shall list in the space provided on the proposal from all exceptions or conflicts between his proposal and these specifications. If more space is required for this listing, additional pages may be added. If the bidder takes no exceptions, he shall write "None" in the space provided. Proposals which do not comply with this requirement will be considered irregular. In case of conflicts not stated as directed, these specifications shall govern.

The bidder shall staple or otherwise bind, with each copy of Bidders Proposal submitted, copy of each addendum issued for these contract documents during the bidding period.

.5.2 SIGNATURES. Each bidder shall sign the proposal with his usual signature and shall give his full business address.

Bids by partnership shall be signed with the partnership name followed by the signature and designation of one of the partners or other authorized representative. A complete list of partners shall be included with the proposal.

Bids by a corporation shall be signed in the official corporate name of the corporation, followed by the signature and designation of the president, secretary, or other person authorized to bind the corporation. The names of all persons signing should also be typed or printed below the signature.

A bid by a person who affixes to his signature the word "president", "secretary", "agent", or other designation, without disclosing his principal, will be rejected. Satisfactory evidence of the authority of the officer signing in behalf of the corporation shall be furnished. Bidding corporations shall designate the state in which they are incorporated and the address of their principal office.

The bidder's name stated on the proposal shall be the exact legal name of the firm.

.5.3 SUBMITTAL. Proposals shall be submitted not later than the date and time stipulated in the letter transmitting these documents to the bidder.

.5.4 WITHDRAWAL/ALTERATION. Proposals may be withdrawn, altered, and resubmitted at any time before the time set for opening the bids. Proposals may not be withdrawn, altered, or resubmitted within 60 days thereafter.

.6 INFORMATION TO BE SUBMITTED WITH PROPOSAL.

.6.1 CONTRACTOR"S FIELD ORGANIZATION. Each bidder shall submit with his proposal an organization chart showing the names of field management, supervisory, and technical personnel, and the details of the management, supervisory, and the technical organization which he proposes to use for this project. The successful bidder's organization will be subject to the review and acceptance of the Owner. The experience record of the Contractor's field superintendent shall be submitted with the bid.

.7 SURETY BOND. The contractor to whom the work is awarded may, at the option of the Owner, be required to furnish a Performance and Payment Bond to the Owner in an amount equal to 100 per cent of the contract amount. The bond, if required, shall be signed by a surety company authorized to do business in the State of Alabama and acceptable as surety to the Owner. Copies of "Power of Attorney", certified to include the date of the bond, shall be filed with the bond.

.8 BID SECURITY. The bid shall be accompanied with a bid security of 5%. The required security must be in the form of a certified or bank cashier's check made payable to Owner or a bid bond issued by a surety licensed to conduct business in the state where the Project is located and named in the current list of "Surety Companies Acceptable on Federal Bonds" as published in the Federal Register by the Audit Staff Bureau of Accounts, U.S. Treasury Department. The Bid Security of the successful Bidder will be retained until he has executed the Agreement and furnished the required Contract Security, whereupon it will be returned. If he fails to execute and deliver the Agreement and furnish the required Contract Security within 15 days of the Notice of Award, Owner may annul the Notice of Award and the Bid Security of that Bidder will be forfeited.

.9 ACCEPTANCE AND REJECTION OF BIDS. The Owner reserves the right to reject any and all bids and to waive irregularities and informalities in any bid that is submitted.

All proposals shall become the property of the Owner.

.10 CERTIFICATES. The successful bidder will be required to submit, prior to contract award, the following certifications:

1. Equal Employment Opportunity Certification - Form HE-200. REV. 8/76 (copy attached).

2. Clean Air and Water Certificate - Form PNC-25 (02/76). (copy attached)

3. Certificate of Current Cost or Pricing Data (04/69)-Form PNC-27 (12/76)

Failure to provide the certificates will result in bid rejection.

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SECTION 1B

PROPOSAL

TO: Honeywell, Inc.
2600 Ridgway Parkway
Minneapolis, Minnesota 55413

Attention: R. E. Eagle
Procurement Department
Mail Station MN19-T101

PROPOSAL FOR GENERAL CONSTRUCTION
SOLAR ENERGY COLLECTION SYSTEM
WESTPOINT PEPPERELL MILL
FAIRFAX, ALABAMA

Gentlemen,

The undersigned bidder having read and examined the specification and associated contract documents for General Construction which will be incorporated at the Fairfax, Alabama plant of Westpoint Pepperell Inc. does hereby propose to perform the construction and provide the services set forth in this proposal at the prices stated herein.

B.1 LUMP SUM PRICE. The undersigned bidder hereby proposes to furnish equipment and materials; labor; labor supervision; construction tools and equipment; construction services and utilities; as required to perform the general construction work complete in accordance with the contract documents as defined in Article 1 of the General Conditions, for the firm lump sum price of:

_____

_____ ($)
(Price in Words)

In support of this firm lump sum price an OPTIONAL FORM 60 is attached hereto.

B.1.1 LUMP SUM PRICE BREAKDOWN. The above lump sum price represents the aggregate of the following work element prices:

1. Install high temperature hot water loop
   Materials $_____
   Labor $_____

2. Structural supports for collectors and piping on roof
   Material $_____
   Labor $_____

3. Steam Generator
   Material $_____
   Labor $_____

4. Expansion tank, process water piping, steam piping and accessories, floor drains and piping, HTHW accessories

	Material	$_____
	Labor	$_____

5. HTHW field pump

	Material	$_____
	Labor	$_____

6. Penthouse

	Material	$_____
	Labor	$_____

7. Emergency generator

	Material	$_____
	Labor	$_____

8. Sensor Cost

T1 thru T8	Material	$_____
P-1 and P-2		$_____
F-1		$_____
FS-1	Material	$_____
I-1	Material	$_____
I-2	Material	$_____
I-3	Material	$_____
E-1	Material	$_____
W-1	Material	$_____
Labor to install above		$_____

9. Electrical

	Material	$_____
	Labor	$_____

10. Fence and other General Construction Work

Material $_____

Labor $_____

11. Collectors Erection and Installation Costs

Material $_____

Labor $_____

B.2 UNIT LABOR COSTS. The undersigned bidder hereby proposes to furnish for any additional work deemed necessary by the Owner in accordance with the following unit labor costs which shall include Contractors overhead and profit:

CATEGORY *	Dollars per Hour	
	Straight Time	Overtime
Supervision	_____	_____
Pipe Fitters	_____	_____
Electricians	_____	_____
Roofers	_____	_____
Labors	_____	_____
Carpenters	_____	_____
Sheet Metal Worker	_____	_____
Welder	_____	_____

* LIST ALL REQUIRED IF NOT SHOWN

B.3 UNIT MATERIAL COSTS. The undersigned bidder hereby proposes to furnish any additional materials deemed necessary by the Owner at the actual cost plus a mark-up of _____per cent for overhead and profit.

The undersigned proposes that he will perform the majority of the work with his own forces and that specific portions of the construction work not performed by the undersigned will be subcontracted by the following subcontractors:

WORK SUBCONTRACTED	NAME OF SUBCONTRACTOR
_____	_____
_____	_____
_____	_____
_____	_____

The undersigned hereby certifies that the following list states any and all variations from, and exceptions, to the requirements of the contract documents and that, otherwise, it is the intent of this Proposal that the work will be performed in strict accordance with the contract documents.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

The undersigned agrees to complete the work in _____ calendar days from the date of notification to proceed, but no later than April 30, 1978.

The undersigned hereby certifies that he has visited the site of the proposed work and has familizaried himself with the conditions affecting the work.

The undersigned hereby declares that only the persons or firms interested in the Proposal as principal or principals are named herein, and that no other persons or firms than herein mentioned have any interest in this Proposal or in the contract to be entered into; that this Proposal is made without connection with any other person, company, or parties likewise submitting a bid or proposal; and that it is in all respects for and in good faith, without collusion or fraud.

The following Addendums, copy Attached, are hereby receipted and are considered a part of this proposal:

ADDENDUM NO. _____ DATED_____

ADDENDUM NO. _____ DATED_____

ADDENDUM NO. _____ DATED_____

DATED AT _____ THIS _____ DAY OF _____, 19___.

BIDDER _____

BY _____

_____
(Typed)

TITLE _____

ATTEST:

_____

BUSINESS ADDRESS OF BIDDER _____

_____

STATE OF INCORPORATION _____

ADDRESS OF PRINCIPAL OFFICE _____

_____

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SECTION 1C

AGREEMENT BETWEEN OWNER AND CONTRACTOR

This agreement, made this_____day of_____ by and between Honeywell Inc., a Delaware Corporation, acting through its ENERGY RESOURCES CENTER, hereinafter called Owner and_____ a_____Corporation, hereinafter called Contractor.

ARTICLE 1

This agreement covers the construction by Contractor of various modifications to the plant facilities of West Point Pepperell Inc. located Fairfax, Alabama, to install a solar energy collection system for textile drying as a subcontract under the Owner's prime contract with the U.S. Government (ERDA) E(40-1)-5124.

ARTICLE 2

The Contract Documents, which constitute the entire Agreement between Owner and Contractor, are listed as follows:

1. Purchase Order
2. This Agreement
3. Special Conditions
4. Plans and Specifications
5. General Conditions
6. Letter of Scope Inclusions and Exclusions
7. Construction Schedule
8. List of Subcontractors and Materialmen, the selection of which shall be subject to the Owner's approval.

In case of inconsistency between the above documents, precedence shall follow the order of listing unless specifically covered by a lower priority document.

ARTICLE 3

The Contractor accepts the relationship of trust and confidence established between him and the Owner by this Agreement. He covenants with the Owner to furnish his best skill and judgement and to cooperate with the Owner and Engineer in furthering the interests of the Owner. He agrees to furnish efficient business administration and superintendence and to use his best efforts to furnish at all times an adequate supply of workmen and materials, to perform the work in the best and soundest way in the most expenditious and economical manner consistent with the interest of the Owner.

ARTICLE 4

The Engineer for this project is the firm of Orr-Schelen-Mayeron & Associates, Inc. 2021 East Hennepin Avenue, Minneapolis, Minnesota 55413.

ARTICLE 5 - TIME OF COMMENCEMENT AND COMPLETION

The Work to be performed under this Contract shall be commenced on a date which is the earliest possible date after the issuance of the building permit, and shall be completed within _____ after the issuance of the building permit.

ARTICLE 6 - CONTRACT PRICE

The Owner agrees to pay the Contractor for the full, faithful and prompt performance of this Contract, subject to all of the Terms and Conditions hereof, the sum of _____ dollars ($).

ARTICLE 7 - CHANGES IN THE WORK

The Owner may make changes in the work in accordance with Article 15 of the General Conditions.

Unless specifically directed otherwise by the Owner, the Contractor shall promptly submit his itemized prices for additions, alterations or deductions within ten days after receipt of the change, and in any event prior to proceeding with such work. If agreed to by the Owner in writing, such prices shall be added to or deducted from the Contract Price.

When so directed, the Contractor shall submit separate unit prices on work for both additions to and deductions from the Contract price.

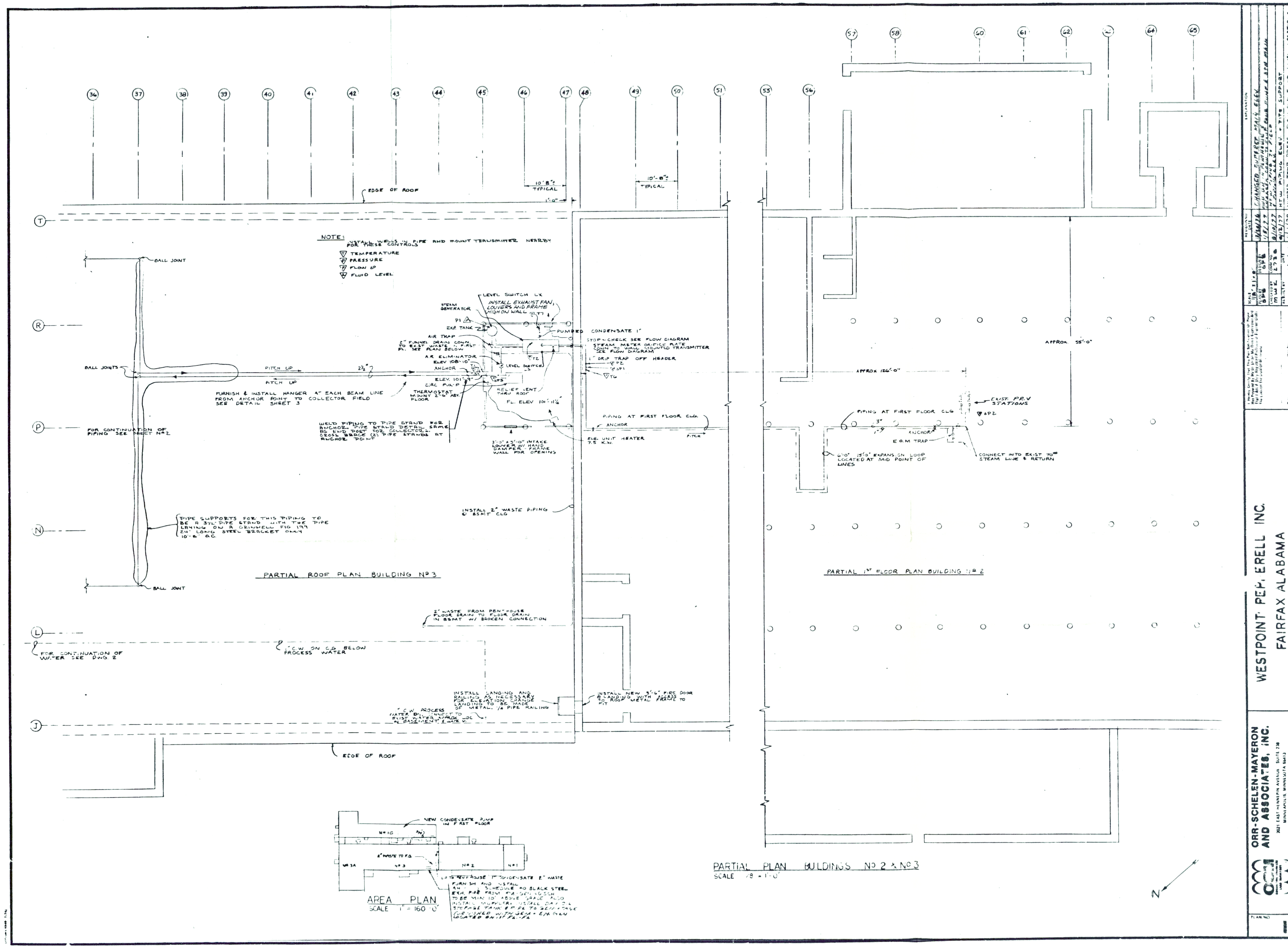
Adjustment, if any, in the amounts to be paid to the Contractor, at the discretion of the Owner, determined by one or more of the following methods:

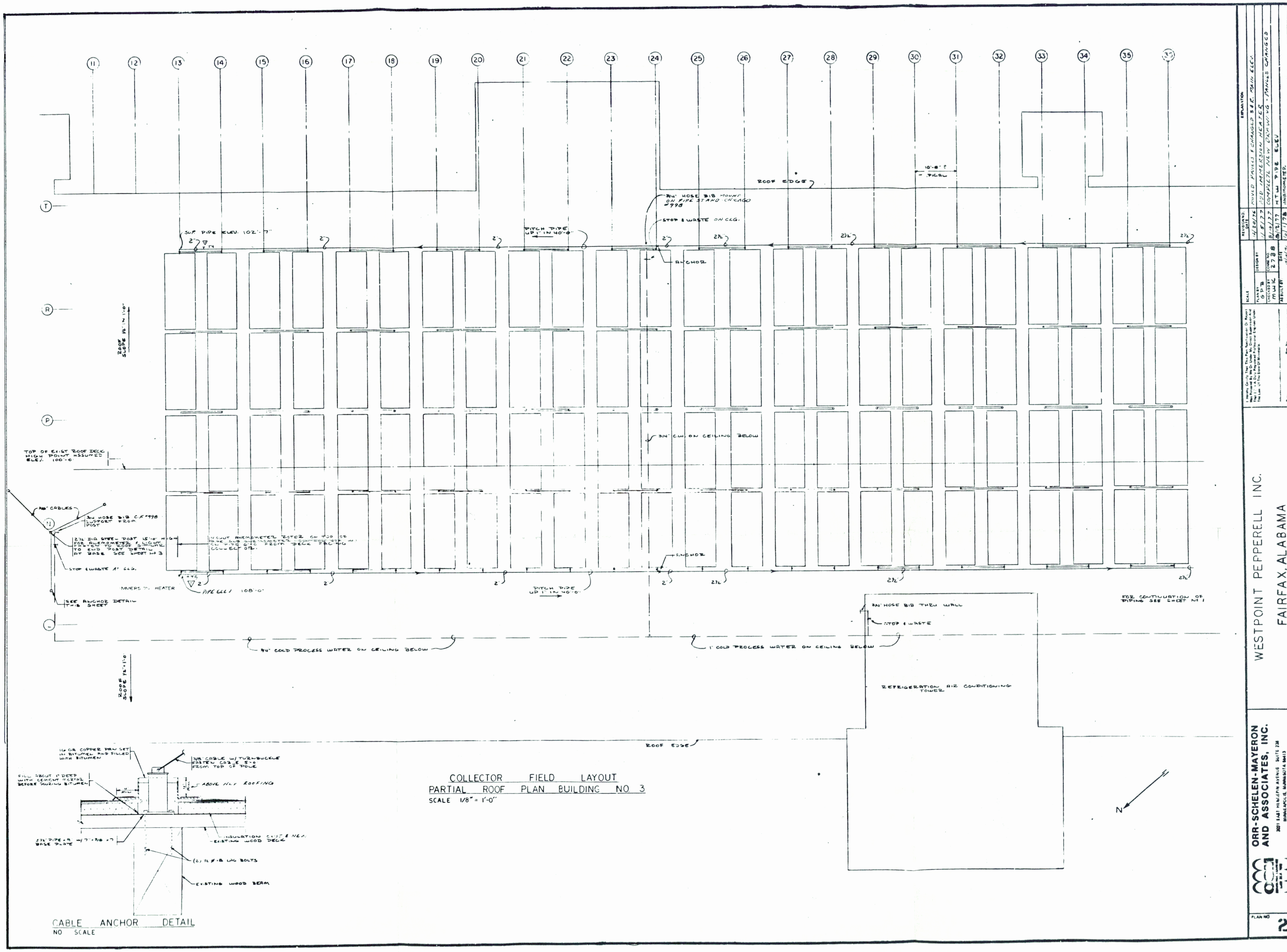
A. By unit prices as contained in the Contractor's Proposal, which unit prices shall be deemed to include all charges. For changes in quantity only, the appropriate unit price shall be applied to the change in quantity. For substitution of materials when quantities are equal, the difference between unit prices shall be applied to determine additions and deductions. For substitution of materials when quantities are unequal, the unit prices for deductions shall be used for both materials in case of a net reduction in quantity, and the unit prices for additions shall be used for both materials in case of a net increase in quantity.

B. By reasonable estimate of net cost of: Contractor's or Subcontractor's labor and material, plus an agreed upon markup of the foregoing for overhead and profit.

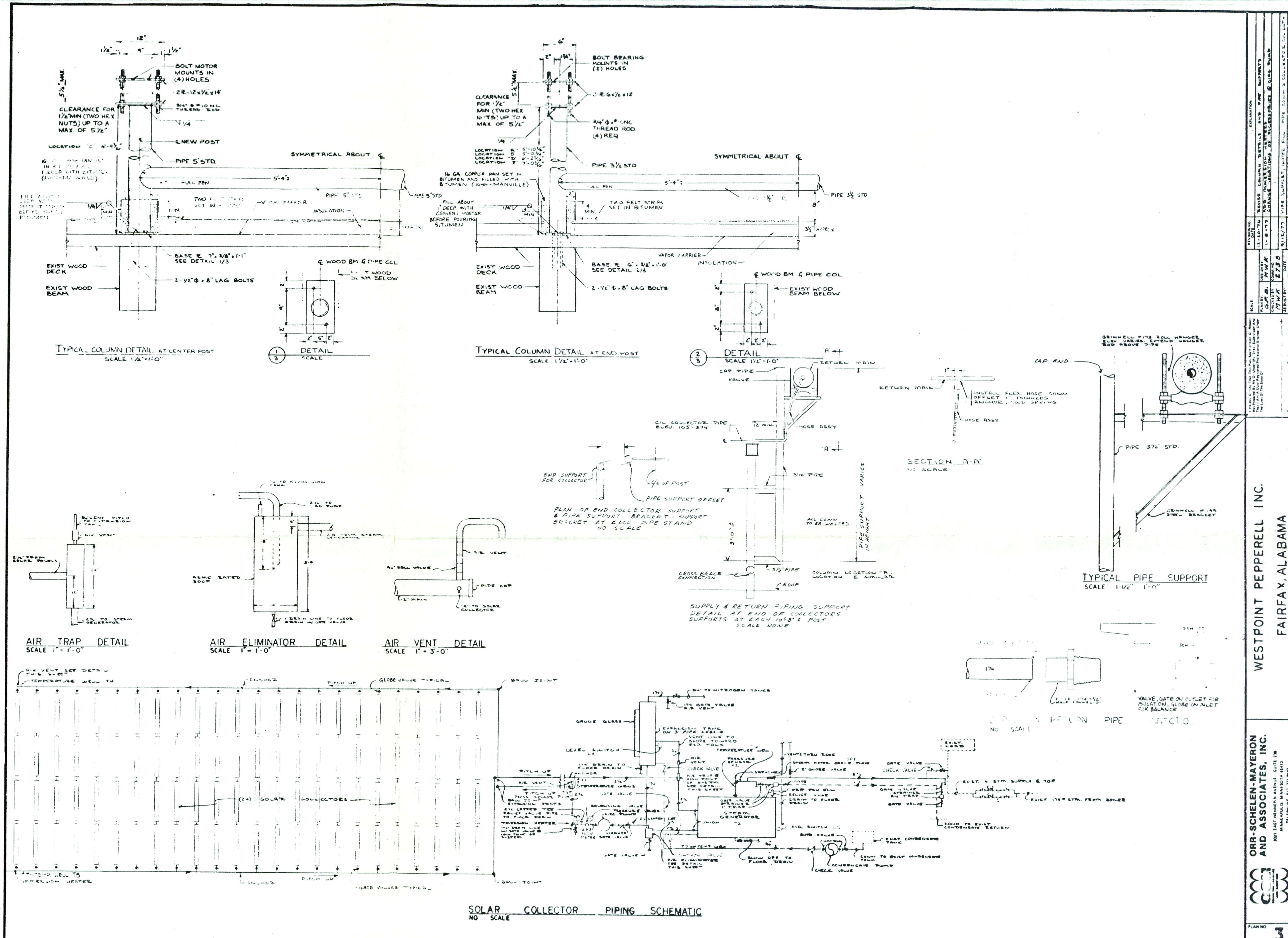
C. By an acceptable lump sum proposal from the Contractor.

D. By accumulation of actual labor and material costs, plus an agreed upon markup of the foregoing for overhead and profit.

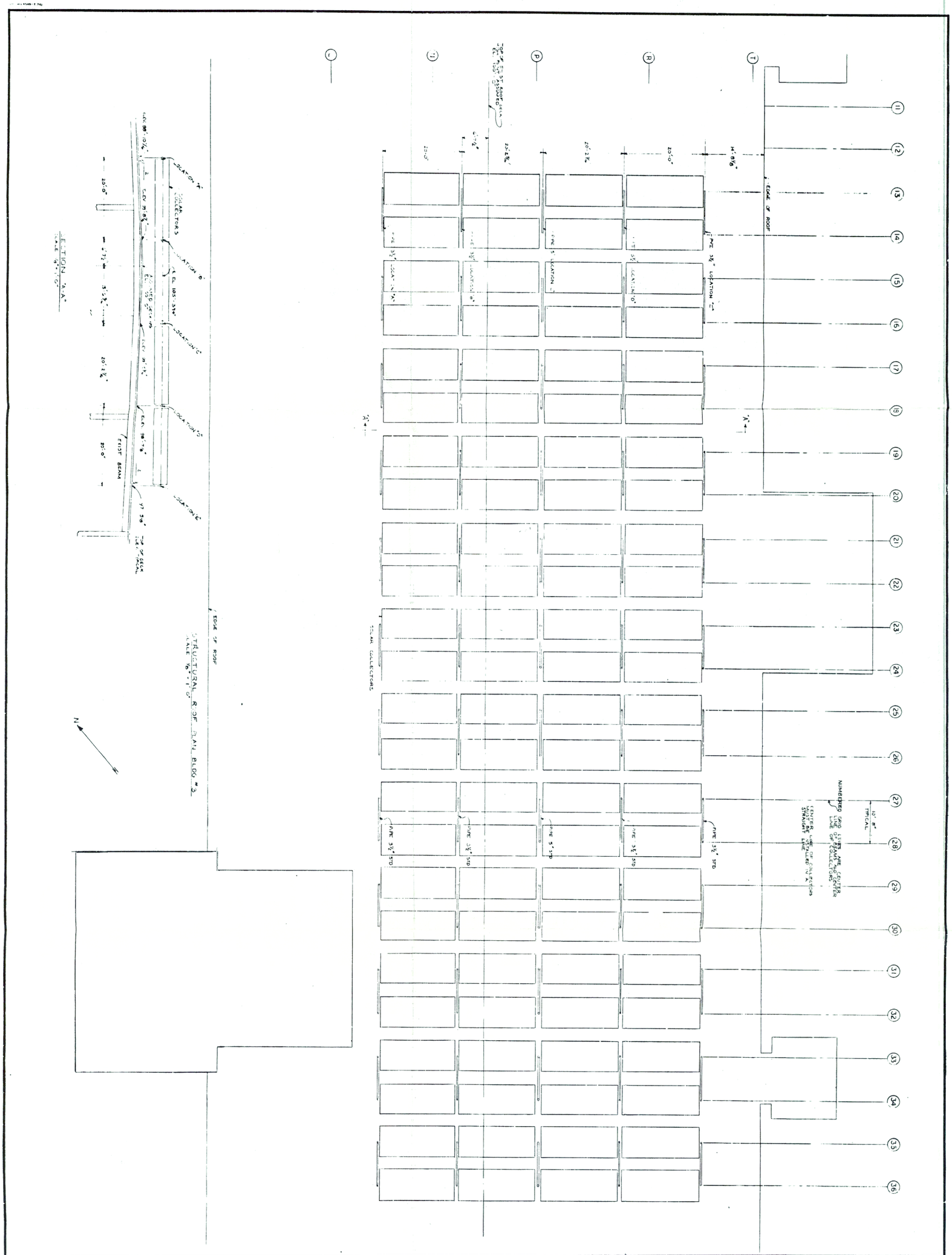

PARTIAL ROOF PLAN BUILDING No 3
PARTIAL 1ST FLOOR PLAN BUILDING No 2
PARTIAL PLAN BUILDINGS No 2 & No 3
AREA PLAN
SCALE 1" = 160'-0"
EDGE OF ROOF
10'-8" TYPICAL
BALL JOINT
BALL JOINTS
PITCH UP
FURNISH & INSTALL HANGER AT EACH BEAM LINE FROM ANCHOR POINT TO COLLECTOR FIELD SEE DETAIL SHEET 3
FOR CONTINUATION OF PIPING SEE SHEET No 2
INSTALL 2" WASTE PIPING @ BSMT CLG
PIPING AT FIRST FLOOR CLG
ANCHOR
APPROX 126'-0"
APPROX 58'-0"
EXIST. PRV STATIONS
E.O.M. TRAP
CONNECT INTO EXIST 10" STEAM LINE & RETURN
FOR CONTINUATION OF WATER SEE DWG 2
PROCESS WATER
NEW CONDENSATE PUMP IN FIRST FLOOR
N
WESTPOINT PEPPERELL INC.
FAIRFAX ALABAMA
ORR-SCHELEN-MAYERON AND ASSOCIATES, INC.
AS BUILT REVISION



COLLECTOR FIELD LAYOUT
PARTIAL ROOF PLAN BUILDING NO 3
SCALE 1/8" = 1'-0"
CABLE ANCHOR DETAIL
NO SCALE
ROOF EDGE
REFRIGERATION AIR CONDITIONING TOWER
WESTPOINT PEPPERELL INC.
FAIRFAX, ALABAMA
ORR-SCHELEN-MAYERON AND ASSOCIATES, INC.
PLAN NO 2

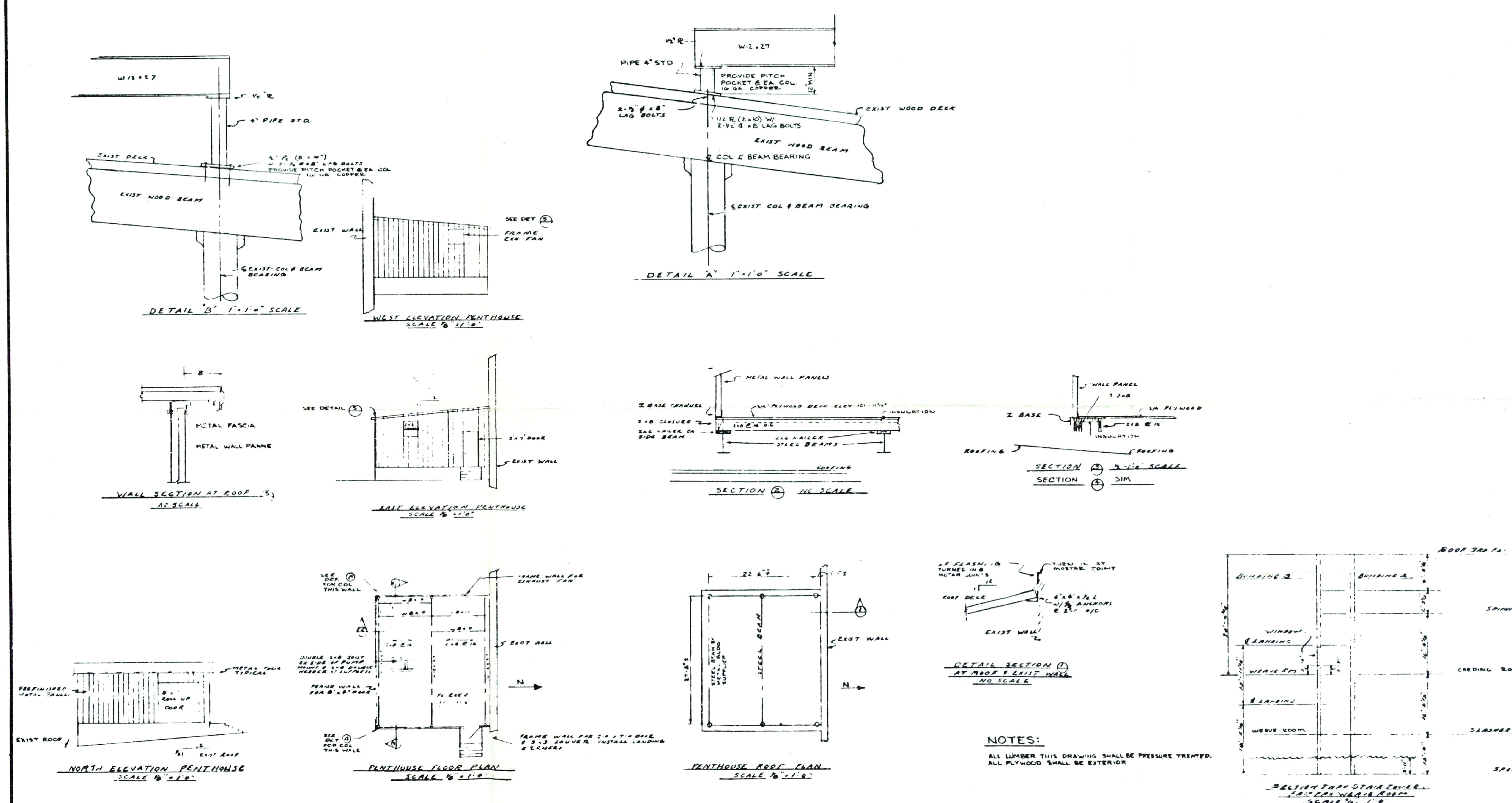


TYPICAL COLUMN DETAIL AT CENTER POST
SCALE 1½" = 1'-0"
DETAIL
TYPICAL COLUMN DETAIL AT END POST
SCALE 1½" = 1'-0"
DETAIL
BOLT MOTOR MOUNTS IN (4) HOLES
BOLT BEARING MOUNTS IN (2) HOLES
SYMMETRICAL ABOUT ℄
PIPE 5" STD.
PIPE 3½ STD
INSULATION
VAPOR BARRIER
EXIST WOOD DECK
EXIST WOOD BEAM
2 - ½"⌀ x 8" LAG BOLTS
℄ WOOD BM & PIPE COL
EXIST WOOD BEAM BELOW
AIR TRAP DETAIL
SCALE 1" = 1'-0"
AIR ELIMINATOR DETAIL
SCALE 1" = 1'-0"
AIR VENT DETAIL
SCALE 1" = 3'-0"
PLAN OF END COLLECTOR SUPPORT & PIPE SUPPORT BRACKET - SUPPORT BRACKET AT EACH PIPE STAND
NO SCALE
SUPPLY & RETURN PIPING SUPPORT DETAIL AT END OF COLLECTORS SUPPORTS AT EACH 10'-8" POST
SCALE NONE
SECTION A-A
NO SCALE
TYPICAL PIPE SUPPORT
SCALE 1 1/2" = 1'-0"
VALVE: GATE ON OUTLET FOR ISOLATION, GLOBE ON INLET FOR BALANCE
SOLAR COLLECTOR PIPING SCHEMATIC
NO SCALE
(24) SOLAR COLLECTORS
STEAM GENERATOR
WESTPOINT PEPPERELL INC.
FAIRFAX, ALABAMA
ORR-SCHELEN-MAYERON AND ASSOCIATES, INC.
PLAN NO 3



ORR-SCHELEN-MAYERON AND ASSOCIATES, INC.	WESTPOINT PEPPERELL INC.	
CONSULTING ENGINEERS LAND SURVEYORS	FAIRFAX, ALABAMA	
2021 EAST HENNEPIN AVENUE SUITE 230 MINNEAPOLIS, MINNESOTA 55413 TELEPHONE 612 331 8600	I Hereby Certify That This Plan Specification Or Report Was Prepared By Me Or Under My Direct Supervision And That I Am A Duly Registered Professional Engineer Under The Laws Of The State Of Minnesota. Date ____ Reg. No. ____	SCALE: PLAN BY MWK; DESIGN BY LB; CHECKED BY MWK; DRAWING NO Z738; AS BUILT BY ____; DATE 11/11/74

REVISIONS DATE	EXPLANATION
12-23-74	REVISE COLLECTOR LOCATION
8-10-77	COMPLETELY NEW DRAWING - PANELS CHANGED
8-12-77	PANEL CENTER LINE ELEV
2/6/79	AS BUILT REVISION

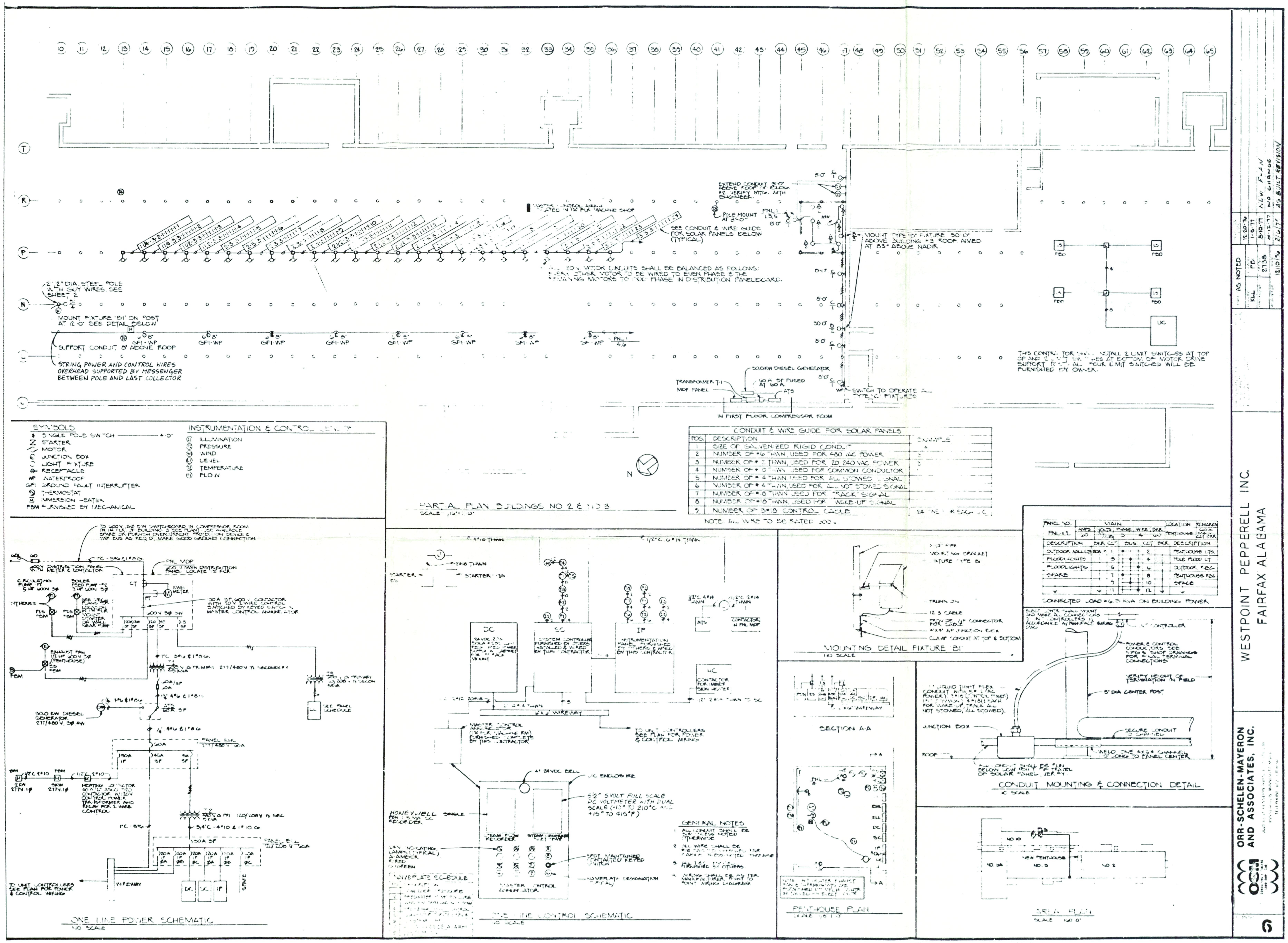


NOTES:
ALL LUMBER THIS DRAWING SHALL BE PRESSURE TREATED.
ALL PLYWOOD SHALL BE EXTERIOR

WESTPOINT PEPPERELL INC.
FAIRFAX, ALABAMA

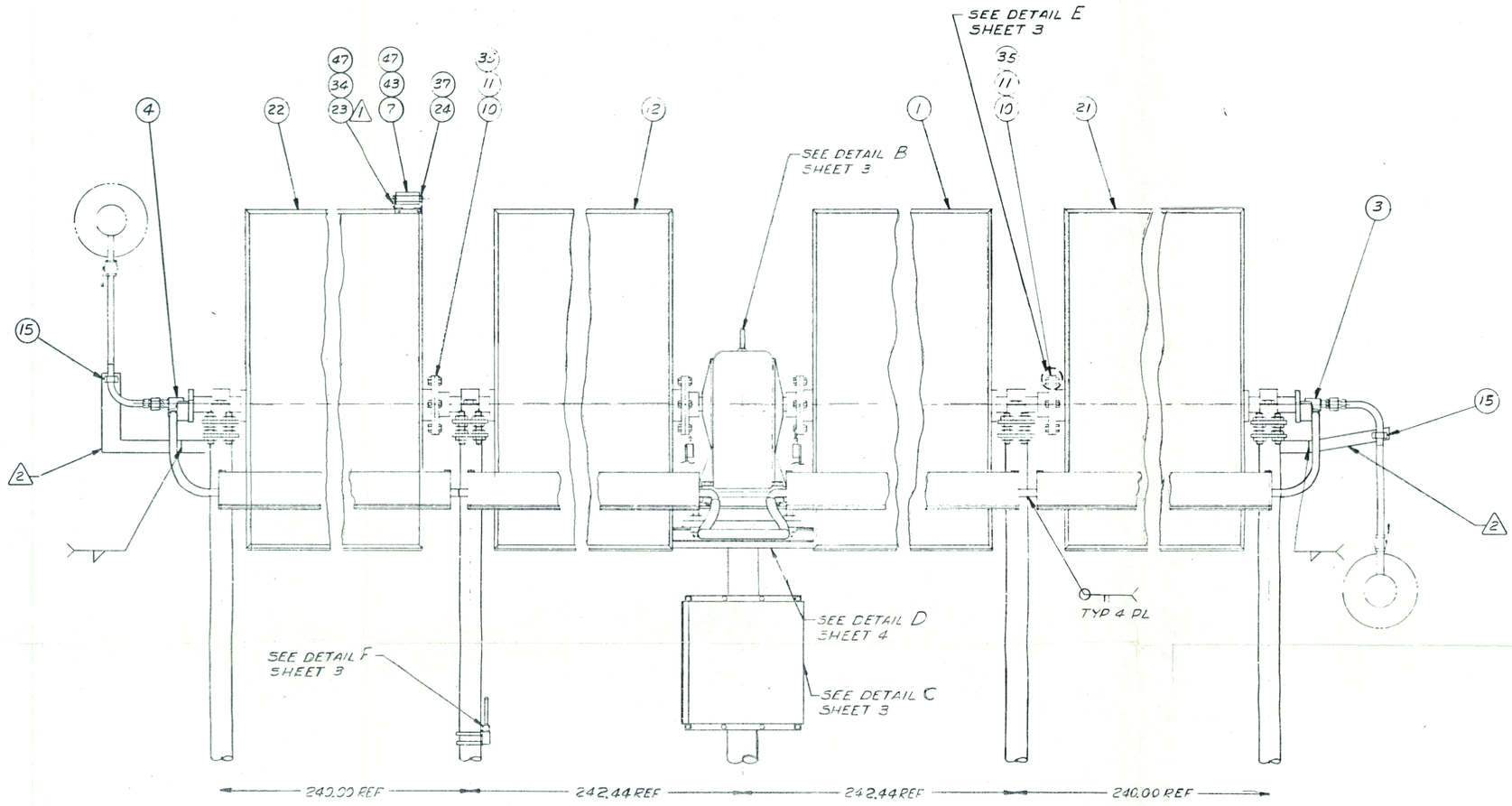
ORR-SCHELEN-MAYERON AND ASSOCIATES, INC.

PLAN NO. 5


PARTIAL PLAN BUILDINGS NO 2 & NO 3
SYMBOLS
INSTRUMENTATION & CONTROL LEGEND
SINGLE POLE SWITCH
STARTER
MOTOR
JUNCTION BOX
LIGHT FIXTURE
RECEPTACLE
WATERPROOF
GROUND FAULT INTERRUPTER
THERMOSTAT
IMMERSION HEATER
FURNISHED BY MECHANICAL
ILLUMINATION
PRESSURE
WIND
LEVEL
TEMPERATURE
FLOW
SEE CONDUIT & WIRE GUIDE FOR SOLAR PANELS BELOW (TYPICAL)
300KW DIESEL GENERATOR
TRANSFORMER T-1
MDP PANEL
60 A 3P FUSED AT 60 A
ATS
IN FIRST FLOOR COMPRESSOR ROOM
SWITCH TO OPERATE ALL TYPE 'C' FIXTURES
STRING POWER AND CONTROL WIRES OVERHEAD SUPPORTED BY MESSENGER BETWEEN POLE AND LAST COLLECTOR
SUPPORT CONDUIT 8' ABOVE ROOF
ONE LINE POWER SCHEMATIC
NO SCALE
ONE LINE CONTROL SCHEMATIC
NO SCALE
GENERAL NOTES
MOUNTING DETAIL FIXTURE B1
NO SCALE
SECTION A-A
PENTHOUSE PLAN
CONDUIT MOUNTING & CONNECTION DETAIL
AREA PLAN
CONNECTED LOAD = 6.5 KVA ON BUILDING POWER
AS NOTED
KLL
PD
2738
12/10/76
12-20-76
1-5-77
8-10-77
6-12-77
2/6/78
NEW PLAN
NO CHANGE
AS BUILT REVISION
WESTPOINT PEPPERELL INC.
FAIRFAX ALABAMA
ORR-SCHELEN-MAYERON AND ASSOCIATES, INC.
6

CONDUIT & WIRE GUIDE FOR SOLAR PANELS		
POS.	DESCRIPTION	EXAMPLE
1	SIZE OF GALVENIZED RIGID CONDUIT	4
2	NUMBER OF #6 THWN, USED FOR 480 VAC POWER	[illegible]
3	NUMBER OF #2 THWN, USED FOR 120/240 VAC POWER	3
4	NUMBER OF #10 THWN USED FOR COMMON CONDUCTOR	[illegible]
5	NUMBER OF #14 THWN USED FOR ALL STOWED SIGNAL	[illegible]
6	NUMBER OF #14 THWN, USED FOR ALL NOT STOWED SIGNAL	
7	NUMBER OF #18 THWN USED FOR 'TRACK' SIGNAL	
8	NUMBER OF #18 THWN, USED FOR 'WAKE-UP' SIGNAL	
9	NUMBER OF 3#18 CONTROL CABLE	24 [illegible]

NOTE: ALL WIRE TO BE RATED 600 V.



QTY	ITEM	PART NO.	DESCRIPTION	REMARKS
	32			
	31			
	30			
	29			
	28			
4	27	SK142203-101	BAR, SPACER	
2	26	IT-11	OUTLET BOX-WEATHERPROOF	3
2	25	BRR1-2RN1B-RH	SWITCH, FLEXIBLE ACTUATOR	HONEYWELL INC. P/N (MICROSWITCH)
1	24	SK142110-101	BRACKET, PIVOT	
1	23	SK142103-101	BRKT, MTG-SUNTRACKER	
1	22	SK142113-104	COLLECTOR ASSY	
1	21	SK142113-103	COLLECTOR ASSY	
1	20	2EEA9-6	SWITCH, ENCLOSED	HONEYWELL INC. P/N (MICROSWITCH)
1	19	2IEN9-6	SWITCH, ENCLOSED	HONEYWELL INC. P/N (MICROSWITCH)
1	18	SK142274-101	HOSE, FLEXIBLE	
1	17	SK142278-101	PLATE, HOSE RETAINER	
2	16	SK142272-101	ANGLE, MTG	
2	15	SK142103-102	CLAMP	1.0" TUBE
2	14	SK142282-102	U BOLT	
1	13	SK142271-101	PLATE, MTG-LIMIT SWITCH	
1	12	SK142113-102	COLLECTOR ASSY	
2	11	SK142113-101	KEY, SPLINE	
2	10	SK142114-101	SPLINE	
2	9	SK142164-101	ANGLE, MTG-SWITCH BOX	
2	8	SK142165-101	COVER, SWITCH BOX	
1	7		SUNTRACKER	
48	6	SK142283-101	WASHER, BELLEVILLE	
1	5	SK142116-101	DRIVE ASSY	
1	4	SK142282-104	SWIVEL JOINT ASSY	
1	3	SK142282-103	SWIVEL JOINT ASSY	
4	2	SK142153-101	BEARING ASSY-1.5"	
1	1	SK142113-101	COLLECTOR ASSY	

LIST OF MATERIALS

QTY	ITEM	PART NO.	DESCRIPTION	REMARKS
4	51		HEX NUT - SELF LOCK	3/4-10 UNC
6	50			5/8-11 UNC
26	49			3/8-16 UNC
26	48			1/4-20 UNC
5	47		HEX NUT - SELF LOCK	10-32 UNF
4	46		SPLIT-LOCK WASHER	1/4
16	45		FLAT WASHER	5/8
10	44		FLAT WASHER	1/4
2	43		FLAT WASHER	NO. 10
16	42		HEX HD CAP SCREW	3/4-10 UNC-2A x 2.25 LG
16	41			5/8-11 UNC-2A x 2.75 LG
10	40			3/8-16 UNC-2A x 3.00 LG
2	39			1-20 UNC-2A x 2.50 LG
14	38			1/4-20 UNC-2A x 1.125 LG
14	37			1/4-20 UNC-2A x .75 LG
2	36		HEX HD CAP SCREW	1/4-20 UNC-2A x .62 LG
2	35		SOCKET SET SCREW-SELF LOK	3/8-16 UNC-2A x .75 LG
2	34		SOCKET HD CAP SCREW	10-32 UNF-2A x .50 LG
2	33	SC-2632-EA-08	SPOOL WASHER-TEFLON	1.5" I.D. x 2.0" O.D. RELEASE P/N
QTY	ITEM	PART NO.	DESCRIPTION	REMARKS

SHEET	1	2	3	4
REV	2	2	2	-

-PERFECT LINE MFG. CORP. P/N
LINDENHURST, N.Y.
SUGGESTED SOURCE OF SUPPLY:- WARNERS HOWE

-TO BE FURNISHED BY OTHERS

-LOCATE APPROX AS SHOWN-DRILL .303 DIA HOLES 2 PL AT ASSY

TOLERANCES UNLESS NOTED OTHERWISE	DRAFTSMAN
MATERIAL	CONTRACT NO
NEXT ASSY / APPLICATION	USED ON

HONEYWELL INC. ENERGY RESOURCES CENTER
MINNEAPOLIS MINN. 55413

COLLECTOR AND DRIVE ASSEMBLY - 5 STATION FIELD

SIZE E | FSCM NO. 55513 | SHEET NO. SK 142121

CONTROL

ARTICLE 8 - ACCOUNTING RECORDS

The Contractor shall check all materials, equipment and labor entering into the work and shall keep such full and detailed accounts as many be necessary for proper financial management under this Agreement, and the system shall be satisfactory to the Owner. The Owner shall be afforded access to all the Contractor's records books, correspondence, instructions, drawings, receipts vouchers, memoranda, and similar data relating to this Contract and the Contractor shall preserve all such records for a period of three years after the final payment.

ARTICLE 9 - PAYMENTS

All payments shall be made as set forth in Article 37 of the General Conditions.

ARTICLE 10 - ASSIGNMENT

This Agreement shall not be assignable by either party without the written consent of the other except that Owner may assign its interest to and wholly owned subsidiary of Honeywell Inc. without such consent.

ARTICLE 11 - TITLE TO THE WORK

Title of all work completed and in course of construction and of all materials on account of which payment has been made, shall be in the Owner, and in the U.S. Government.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement as of the day and year first above written.

HONEYWELL INC.

ATTEST: BY _____

_____ TITLE _____

ATTEST: BY _____

_____ TITLE _____

This agreement shall not become effective until incorporated into and issuance of Honeywell Purchase Order No. _____.

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SECTION 1D

GENERAL CONDITIONS

(INDEX ONLY)

The Work under the Contract shall be subject to all provisions set forth in the following Articles of these General Conditions except as specifically mentioned otherwise in the Purchase Order.

SECTION 1D

INDEX - PAGE TWO

NOTE:

Fifty-one (51) pages of General Conditions, GC-1 to GC-51, have been deleted for brevity.

These Terms and Conditions are government requirements which flow down to project sub-contractors.

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SECTION 1E

SPECIAL CONDITIONS

The following provisions shall be supplementary to and amendatory of the General Conditions of the Construction Contract and shall be included within the definitions of Contract Documents. In any case, where these provisions are in conflict with the provisions of the General Conditions of the Construction Contracts, these provisions shall govern.

CONDITION 1

WORKING HOURS: It is intended that as much work as possible be conducted during normal working hours. All work can be performed during the Contractor's normal daily work hours. Work within the Building shall be scheduled in coordination with the Company.

CONDITION 2

CONTRACTOR PARKING: Provision for Contractor Parking will be provided in areas as designated by the Company.

CONDITION 3

TEMPORARY WATER AND ELECTRIC FOR CONSTRUCTION: The Contractor shall arrange with the Company for the source, payment and method of extending temporary water and electric service to construction areas. Contractor to run all temporary water and electric lines.

CONDITION 4

CONSTRUCTION SCHEDULE: The Contractor, before commencing his work, shall prepare a construction schedule which he shall review with and be approved by the Owner so that the interior construction work will provide the least interference with the facility.

CONDITION 5

LIABILITY: The Contractor agrees to limit the Engineer's liability to the Client, the Owner, and to all construction contractors and subcontractor's, their agents and employees, on the project, due to the Engineer's negligent acts, errors, or omissions such that the total aggregate liability of the Engineer to all those named shall not exceed $50,000, or the Engineer's fee, whichever is greater.

CONDITION 6

COST DISCLOSURES: The Contractor is to furnish the Owner with take-off forms, wage rates, equipment estimates, etc., prior to award of contract. The Owner intends to use this information for projections of cost on future projects.

CONDITION 7

SPECIAL WORKING CONDITIONS: During the second installation period (after the new roof has been installed) the Contractor will observe the following conditions to prevent damage to the roof:

a) All workmen when on the roof will wear rubber soled shoes such as tennis shoes.

b) There will be no dragging or sliding of materials across the roof.

c) Storage of materials on the roof will be kept to a minimum in all cases; where materials or tools are held on the roof prior to installation, they shall be placed on plywood (1/2" minimum) rather than directly on the roof.

   Plywood sheets shall also be used to protect areas of the roof requiring a high degree of activity or traffic.

d) The designated walkways shall be utilized to the maximum extent possible.

e) In the event of any damage to the roof during installation of the solar equipment, the Owner shall have said damage repaired by a qualified roofer and shall bill the contractor for the cost of said repairs.

DIVISION 1

GENERAL REQUIREMENTS

TABLE OF CONTENTS

DIVISION 1
GENERAL REQUIREMENTS

.01 GENERAL DESCRIPTION AND SCOPE OF THE WORK

A. General

This section covers the general project description of the Solar Energy System and the general requirements for the work under these specifications designated General Construction.

The design of this solar energy collection system for textile drying was done in Phase I of a program funded by ERDA under the title, "Application of Solar Energy to Industrial Drying or Dehydration Processes". Honeywell Inc. and WestPoint Pepperell are teamed in this study. The work to be performed includes modification of the WestPoint Pepperell, Fairfax, Alabama, Mill in support of demonstration of a solar energy collection system for textile drying and includes high temperature water (HTW), steam, feedwater, and electrical power. Installation of all piping, instrumentation, and electrical power. Installation of all piping, instrumentation, and electrical hardware necessary for inter-connection of the system to the plat process shall be performed by the Contractor.

B. Work Included Under These Specifications.

The work under these specifications shall include all materials and services to perform the General Construction work for the processs heat demonstration complete in accordance with the specifications, drawings, and other contract documents, except as specifically excluded herein under "Owner-furnished Equipment and Materials" and Work Not Included Under These Specifications.

Work shall include submittal of drawings and data for all Contractor furnished equipment and materials.

Major components of the work under these General Construction specifications are:

DIVISION 1	GENERAL REQUIREMENTS
DIVISION 4	MASONRY
DIVISION 5	METALS
DIVISION 6	CARPENTRY
DIVISION 8	DOORS
DIVISION 13	PREFABRICATED METAL BUILDING
DIVISION 15	MECHANICAL
DIVISION 16	ELECTRICAL

The above explanations and listings are intended to give a general definition of the scope of the work under these specifications, and shall not be construed to be an itemized listing of each element of work reported. The Contractor shall be responsible for construction of complete facilities, conforming in all respects to the details and requirements of the specifications, drawings and other contract documents.

(1) Contractor Furnished Materials, Manpower and Services. The contractor shall provide all materials and equipment which will be permanently incorporated in the work and which are not specifically designated to be furnished by the Owner; all labor, supervision, technical direction, administration and management; and all construction plant and services.

(2) Owner Furnished Equipment Materials. The Owner will furnish the following equipment and materials which shall be installed under these specifications:

- Solar Collectors (24) with Motor/drive and unit Controller
- System Controller

The owner furnished equipment and materials will be delivered to Fairfax, Alabama, where the Contractor shall receive them into his custody until final acceptance of the work

C. Work Not Included Under These Specifications.
In addition to the terms under these General Construction specifications, the Company has awarded or will award separate contracts for the following work which will be directly associated with the work under these specifications:

Reroofing of the Company weave room roof.

Part of the work listed above will be in progress concurrently with the work under these specifications. The Contractor shall coordinate his activities and cooperate with the other contractors and the Company in the best interest of the project.

.02 DRAWING SCHEDULE

A. General
This section lists the drawings and schedules which have been prepared for the work covered by these specifications and which shall be a part of the contract documents.

B. Drawings
The contract drawings are dated August 12, 1977.

Drawing No.	Title
1	Partial plan, buildings No. 2 & No. 3
2	Collector field layout, partial roof plan building No. 3
3	Piping Schematic; support, hanger & connection details
4	Structural roof plan, building No. 3
5	Penthouse details and elevation
6	Electrical
7	Solar Collector

.03 JOINT OWNER/CONTRACTOR RESPONSIBILITIES

A. General

Owner shall supply the solar collectors as defined in the drawings. The collector includes the mirrors, the receiver, the motor drive, the unit controller risers, swivel joints, and associated assembly hardware. The contractor shall be responsible for:

(1) Scheduling delivery of the collectors.
(2) Unloading and storing the collector subassemblies at the site.
(3) Hoisting the collector subassemblies into the roof according to manufacturers recommendations.
(4) Assembling the collector.
(5) Installing the collectors into the system.

Owner shall supply the system controller at field. The contractor shall be responsible for installing the system controller and connecting it to the system as defined by Owner and shown in the drawings.

All other equipment required for the proper operation of the system shall be the responsibility of the General Contractor.

B. Schedule

The program schedule is shown on page Div. 1-6. It includes two time periods for installation. The first period consists of the month of September. During October and November the company weave room roof will be reroofed by another contractor. Completion of the installation is scheduled for 20 Februrary 1978 to 14 April 1978. System start-up and check-out will follow immediately after completion of installation.

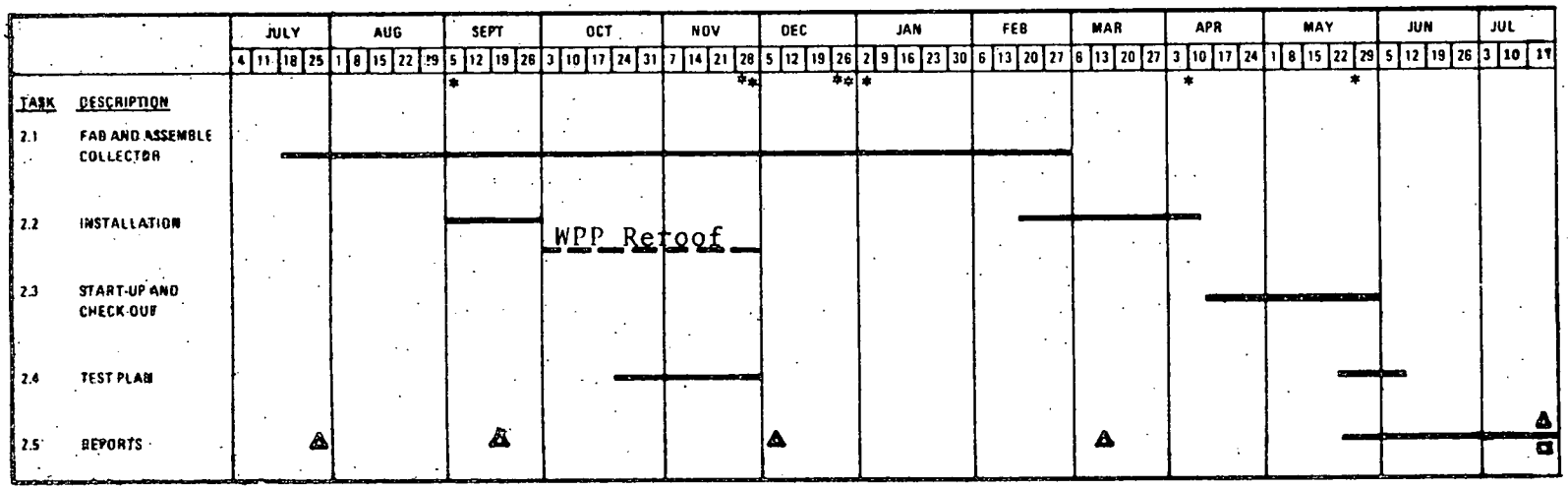
C. Sequence of Erection

Other construction activity at the site constrains the sequence of erection to the following two time periods.

(1) All penetrations of the roof and the associated installation of pitch pans and support structures shall be conducted during the 1 September 1977 to 30 September 1977 time period. This work shall be completed by 1 October 1978 to allow the Company to reroof over the modifications associated with this project.

(2) The fabrication schedule for the 24 collectors for this job includes January and February 1978. Twelve of the collectors are scheduled to be shipped on 6 February and can be expected on-site on 13 February 1978. The remaining twelve collectors will be shipped 6 March for arrival of site on 13 March 1978.

03.3.4 WPP SCHEDULE BY TASK



(3) The remainder of the Installation shall be conducted between 20 February and 14 April 1978. Order of assembly of the collectors, HTW loop, Penthouse, etc. shall be mutually agreed upon by Contractor and Owner prior to February 1978.

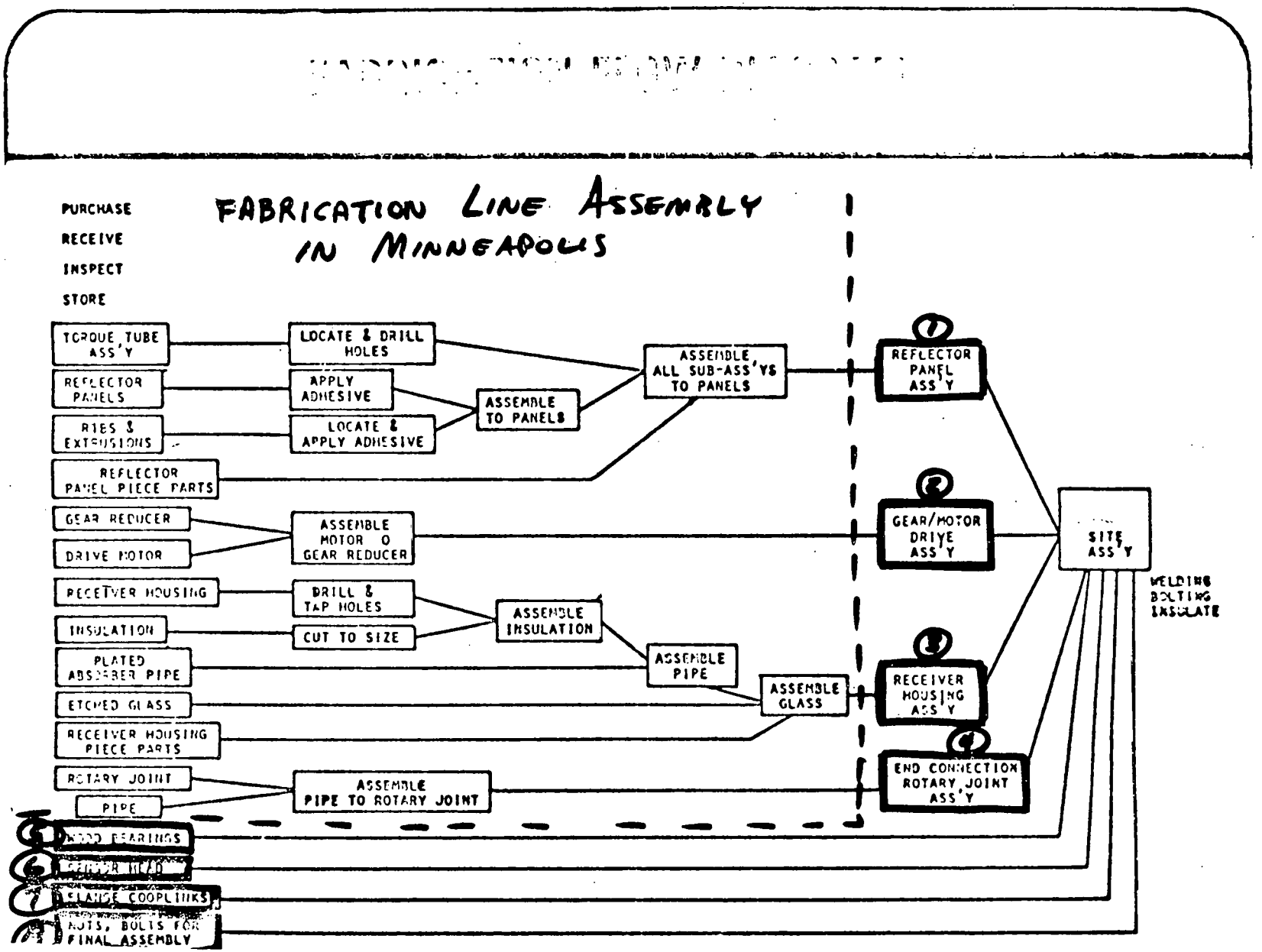
D. Tolerances On Support Posts

Critical tolerances in installing the collector support posts are associated with the straightness of the collector. The five posts supporting a collector must be straight and level with +1/4 inch, as measured from the center of the bottom plate in the leveling mechanism atop the post. The distance between collectors (nominally 10'8") is not critical, however, the straightness of the row is important to proper collector operation.

E. Collector Installation Procedure

The chart on page Div. 1-7 shows the components, subassemblies, and assemblies that make up the owner furnished collector. Four (4) major assemblies, (numbered 1 through 4), three (3) components, (numbered 5 through 7), and hardware, (numbered 8), will be delivered. These items will be assembled into solar collectors on the support posts by the contractor as defined in the following statements and the drawings.

(1) Procedure:
- (a) Remove parts from transportation.
- (b) Store parts until needed.
- (c) Install Gear Reducing Drive Units on Roof.
  - (i) Lift gear reducing assembly units up onto roof and set on support plates.
  - (ii) Place unit on mounting bolts and tighten nuts down finger tight.
- (d) Install Mirror Panels on Roof.
  - (i) Slip a bearing onto shaft that protrudes from torque tube on panel assembly. Place a key into the keyway in shaft and slip a flange onto shaft. This flange mates with the flange on the next panel assembly.
  - (ii) Lift mirror panel assembly up onto roof.
  - (iii) Lower mirror panel assembly and position bearing mounting bolt holes and tighten bolts finger tight.
  - (iv) Align flange on drive unit with flange on end of torque tube, install four bolts with bellville washers in between flanges. Tight up bolts until flanges clamp onto "flange spacer" provided, then back-off nut until spacer can just be removed.
  - (v) Continue with 4a)b)c), & d; except that next panel flange will bolt to flange on end of shaft mounted on the panel; until all four panels are in position on the roof.


FABRICATION LINE ASSEMBLY IN MINNEAPOLIS
PURCHASE
RECEIVE
INSPECT
STORE
TORQUE TUBE ASS'Y
REFLECTOR PANELS
RIBS & EXTRUSIONS
REFLECTOR PANEL PIECE PARTS
GEAR REDUCER
DRIVE MOTOR
RECEIVER HOUSING
INSULATION
PLATED ABSORBER PIPE
ETCHED GLASS
RECEIVER HOUSING PIECE PARTS
ROTARY JOINT
PIPE
HEAD BEARINGS
GEARED HEAD
FLEXIBLE COUPLINGS
NUTS, BOLTS FOR FINAL ASSEMBLY
LOCATE & DRILL HOLES
APPLY ADHESIVE
LOCATE & APPLY ADHESIVE
ASSEMBLE TO PANELS
ASSEMBLE ALL SUB-ASS'YS TO PANELS
ASSEMBLE MOTOR & GEAR REDUCER
DRILL & TAP HOLES
CUT TO SIZE
ASSEMBLE INSULATION
ASSEMBLE PIPE
ASSEMBLE GLASS
ASSEMBLE PIPE TO ROTARY JOINT
1 REFLECTOR PANEL ASS'Y
2 GEAR/MOTOR DRIVE ASS'Y
3 RECEIVER HOUSING ASS'Y
4 END CONNECTION ROTARY JOINT ASS'Y
SITE ASS'Y
WELDING
BOLTING
INSULATE

(vi) Align mirror panel assembly for straightness with alignment gauge. Then tighten down mounting bolts on drive unit, and proceed to tighten down bearing mounting bolts, beginning with bearings nearest center of each row, continuing outward to end of each row.

(vii) Recheck alignment for level and straightness.

(e) Install Receiver Tube Assembly.

(i) Install receiver tube support arms to ribs on panels and bolt into place.

(ii) Lift 20 foot section of receiver tube assembly up onto roof, position on support arms position with alignment gauge and bolt into place.

(iii) After bolting next 20 foot receiver tube section into place, position absorber tubes together and weld tubing. Continue bolting and welding until all four sections are in place.

(iv) Position central spacer and weld into place.

(v) Install rotary joint assembly, by slipping clamp onto end of 2 1/2" shaft and bolting into place. Install tubing from rotary joint to receiver tube, by measuring from end of tube, on rotary joint assembly to receiver tube, cutting pre-bent tube to fit and welding into place. Clamp tubing into pipe clamp on bearing support post, measure from end of tubing to flex. Joint, cut tube and weld into place. Test tubing for leaks, after test is approved insulate all open tubing and rap joints along receiver tube assembly with aluminum tape.

(f) Install Electrical Power Controls.

(i) Mount "dead man" limit switch mounting brackets on support post and clamp into position. Mount limit switch on bracket and screw into position.

(ii) Mount control box on support column, and clamp to column.

(iii) Place "sun sensor" mounting bracket on end of first panel and screw into place. Mount "sun sensor" on mounting bracket and screw into position.

(iv) Run wire from "sun sensor" along panel, attach with wire clips to control box.

(v) Run wire in waterproof conduit, from four limit switches to control box.

(vi) Run wire in waterproof conduit from control box to drive motor.

(2) Other

Owner will be responsible for performing the following tasks during installation:

(a) Fine adjustments to the collector focus.
(b) Balancing the field water flow.

F. List of Materials

All material schedules, material lists, locations, etc. listed herein are for the convenience of the contractor and are not necessarily complete or all-inclusive. It is the responsibility of the various contractors to make their own material take-offs.

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DIVISION 4

MASONRY

.01 CONDITIONS OF THE CONTRACT

A. The Conditions of the Contract (General Sections, Supplementary Sections and all other Conditions) and the General Requirements (All Sections of Division 1) are hereby made a part of this Section.

.02 SCOPE

A. Provide opening in existing masonry wall for new 3'-6" x 7'-0" door at location noted on drawings.

.03 MATERIAL

A. New concrete block shall conform to ASTM C90 Type 1.

B. Mortar shall conform to ASTM C270 type M or S.

C. Lintel shall be concrete block to match wall thickness reinforced with 2 #4 bars for each 8 inches of width. Brick to be supported with 3 1/2" x 3 1/2" x 1/4" to each brick width. Lintel to have 8 inch minimum bearing each end.

.04 CONSTRUCTION

A. Opening shall be 3'-10" wide x 7'-2" high plus an additional 8 inch to allow for placement of frame anchors.

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DIVISION 5

METALS

.01 CONDITIONS OF THE CONTRACT

A. The Conditions of the Contract (General Sections, Supplementary Sections and all other Conditions) and the General Requirements (All Sections of Division 1) are hereby made a part of this Section.

.02 SCOPE

A. Provide all labor, materials, accessories, and related items for metals and complete installation in accordance with applicable references noted herein.

B. This section includes all structural, miscellaneous and ornamental metal work.

C. Refer to drawings for sizes and locations of all metal items.

D. Submit shop drawings to engineer and owner prior to fabrication.

.03 MATERIAL

A. Structural Steel - ASTM A36-70

B. Steel Pipe - ASTM A53-69 Grade B

C. Bolts - ASTM A307

D. Welding - American Welding Society (AWS) Publication D1.1-72.

.04 FABRICATION

A. American Institute of Steel Construction (AISC) latest publication.

.05 FINISH

A. All metals, including the inside of the Butler and Company buildings shall receive 2 coats of paint after fabrication. Color to be selected later.

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DIVISION 6

0610 CARPENTRY

.01 CONDITIONS OF THE CONTRACT

A. The Conditions of the Contract (General Sections, Supplementary Sections and all other Conditions) and the General Requirements (All Sections of Division 1) are hereby made a part of this Section.

.02 SCOPE

A. Furnish and install all carpentry indicated on the drawings and herein specified.

B. Work required under this section shall include, but not be limited to the following items:

Scaffolding
Temporary Enclosures
Temporary Protection of Construction
Roof Cants and Curbs
Furring and Blocking
Installation of Finish Hardware
Rough Hardware
Rough Carpentry

C. All lumber shall be so delivered, piled and handled as to protect it from damage. Lumber shall not be delivered unduly long before it is required in the normal progress of the work and shall be stored off the ground and under water-proof cover until it is used.

.03 LUMBER GRADES

A. Lumber herein referred to shall conform to American Lumber Standard, Simplified Practice Recommendation R 16. Grades shall conform to the grading rules of the manufacturer's association under whose rules the lumber is produced and lumber shall bear the grade and trade mark of this association. If certain specified lumber is not grade marked as a trade practice, it shall be accompanied by a Certificate of Inspection listing material quantities and grades. Defects or blemishes prohibited by this specification, even though permissible in the specified grades, will not be accepted in any material used.

B. Lumber shall be sound, thoroughly seasoned and well manufactured. Material shall be free of warp that cannot be corrected in the normal process of bridging or nailing. Lumber shall be air driled or kiln dried and average moisture content shall not exceed 19 per cent, surfaced four sides (S4S).

.04 MATERIALS

A. All lumber for cants, curbs, plates, blocking, nailers, fascias, and similar items concerned with roofing, roof insulation or roof flashings, shall be pressure preservative treated. Preservative shall be salt treated.

B. All nominal 2 inch lumber for bucks, blocking, nailers, grounds or furring shall be Standard Grade Douglas Fir or West Coast Hemlock. All nominal 1 inch lumber for such uses shall be No. 3 Ponderosa Pine, Douglas Fir or West Coast Hemlock per WPA grading rules.

C. All plywood shall be Douglas Fir conforming to Product Standard for outside use.

D. All plywood shall carry the DFPA hallmark and grade stamp. See drawings for thickness.

E. Furnish all rough hardware for entire project. Shall include such items as nails, screws, bolts, anchors, devices, shot anchors and similar devices. Common nails shall be all hot-dipped galvanized.

F. Rough hardware shall be of the proper type and size for use intended and shall be of adequate design to achieve substantial and positive anchorage.

.05 INSTALLATION PROCEDURES

A. Protect all masonry, carpentry, metal work and other materials from damage of any character during the progress of the work.

B. Furnish and install all wood plates, nailing blocks, furring strips, and all other grounds and framing detailed or required for the securing of all finished work.

C. Install all rough hardware which is furnished under this Section as well as anchorage items which are furnished under other sections. All nailing shall be in conformance with requirements established by the publication "Technique of House Nailing" by the United States Forest Products Laboratory".

DIVISION 8

DOOR

.01 CONDITIONS OF THE CONTRACT

A. The Conditions of the Contract (General Sections, Supplementary Sections and all other Conditions) and the General Requirements (All Sections of Division 1) are hereby made a part of this Section.

.02 SCOPE

A. Furnish and install one 3'-6" x 7'-0" metal 2 hour fire rated door and frame at location shown on the drawings. Material to be Trussbilt, Ceco or approved equal.

.03 MATERIAL

A. Doors shall be 1 3/4 inches thick with hardware and paint, color as selected later.

B. Frames shall be 14 gauge steel 2 inches by 5 3/4 inches with three anchors per jamb. Paint to match door and caulk both sides. Fire assembly to be fire rated.

.04 INSTALLATION

A. Installation shall be complete with the threshold and weather stripping.

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DIVISION 13

1365 PREFABRICATED METAL BUILDING

.01 CONDITIONS OF THE CONTRACT

A. The Conditions of the Contract (General Sections, Supplementary Sections and all other Conditions) and the General Requirements (All Sections of Division 1) are hereby made a part of this Section.

.02 GENERAL

A. DESCRIPTION OF BUILDING

(1) The contractor shall furnish and install on existing roof one prefabricated metal building, located as shown on the drawings.

(2) The overall building dimensions shall be as shown on the drawings.

(3) The roof shall have a single slope from back to front of one inch in 12 inches or 1/4" per foot. All sides of the building shall have eave trim and fascia.

(4) The building shall be clear span with no interior columns. All wall panels and framing shall be rigidly attached to existing steel. The base channel shall be continuous rolled formed galvanized steel Z - base flashing.

B. QUALITY CRITERIA

(1) The following standards shall be used where applicable in the structural design of this building:

(a) Metal Building Manufacturers Association "Recommended Design Practice Manual".

(b) AISC "Steel Construction Manual".

(c) AISC "Cold-Formed Steel Design Manual".

(d) The American Welding Society "Code Welding in Building Construction".

C. DESIGN LOADS

(1) Vertical live loads shall be 20 psf applied to the horizontal projection of the roof, in addition to the applicable dead loads.

(2) The wind load on the structure shall be 25 psf velocity pressure proportioned and applied as horizontal and uplift forces according to the U. S. Navy Technical Publication "NAVFAC DM-2" and as recommended by the MBMA "Design Practices Manual".

D. DEFLECTIONS
(1) The maximum deflection of any structural member or panel shall be 1/240 of its span under full design load.

E. SHOP DRAWINGS
(1) Shop drawings shall be submitted to the owner and engineer prior to fabrication.

.03 PRODUCTS
A. BASIC MATERIALS
(1) All materials shall be new, unused, and free from defects and imperfections.

B. ROOF AND WALL PANELS
(1) All roof and wall panels shall be roll formed from zinc coated sheet steel conforming to ASTM A-446, Grade B, with a 1.25 oz. zinc coating. All panels shall have at least 2 inch deep interlocking ribs.

(2) Panels shall be at least 26 gage thickness.

(3) Panels shall have factory applied acrylic enamel finish. Color shall be chosen in consultation with the owner with the exact color being selected from one of suppliers standard colors.

C. STRUCTURAL FRAMING MEMBERS
(1) All structural framing members shall be ASTM A36 steel, and shall be given a shop prime coat of red oxide paint.

(2) The base channel shall receive a 1.25 oz. zinc coating.

D. MISCELLANEOUS METALS
(1) All eave trim, fascia, and base flashing shall be fabricated from cold formed sheet steel conforming to ASTM A-446, Grade B, with 1.25 oz. of zinc coating. Eave trim and fascia to have factory applied acrylic enamel finish to match building color.

(2) All sheet metal screws shall be Class #410 stainless steel, and shall have neoprene washers conforming to ASTM D735.

E. ATTACHMENT BOLTS, NUTS, AND FITTINGS
(1) Attachment bolts, nuts, and fittings shall be in accordance with ASTM A307 and shall be electro-galvanized conforming to ASTM A164. Fittings shall be electro-galvanized conforming to ASTM A123.

F. CAULKING

(1) Caulking shall be "Tremco Monolastomeric".

G. DOORS

(1) The door shall be sized and positioned as shown on the drawings. The door shall be 1 3/4" thick flush type with face sheets of 18 gage steel sheets, stiffened with honeycomb type stiffeners. Reinforcing channels shall be 14 gage zinc coated steel.

(2) Door frames shall be of 16 gauge zinc coated steel. Threshhold shall be extruded aluminum with vinyl seal, continuous across width of opening. Door shall have weatherstripping at head and jambs and shall be Pemko #303A or approved equal.

(3) Door shall be fitted with standard passage latch hardware of approved design and manufacturer.

(4) Service door to be minimum of 8'-0" x 7'-0", push-up operation, Kinnear Type FM-10 or equal. Furnish and install complete with curtain, guides, counter balance, brackets, hoods and painted with rust resistant primer. Jambs and head girt to be 14 gauge steel.

H. INSULATION

(1) All exterior walls, floor and roof shall receive insulation. Insulation shall be of the rolled, fiber glass, blanket type foil faced vinyl reinforced vapor barrier. The insulation shall be of the required thickness and density to provide "U" factor not exceeding .22 BTU/HR/SQ. FT/°F.

.04 INSTALLATION

A. FOUNDATION

(1) The foundation will be the steel columns mounted on the existing wood deck and beams.

B. BUILDING SHELL

(1) A continuous bead of caulking shall be applied to the inside edge of the base channel.

(2) Wall panels shall be fastened to supports with self tapping sheet metal screws. All wall panels shall be continuous from base to eave.

(3) Roof panels shall be attached to framing with stainless steel weather sealed screws. The roof panels shall overhang the exterior wall line by approximately 6 inches on all sides.

(4) Fascia shall be applied to all sides of the roof and eave trim shall be applied to the intersection of the wall and roof panels.

(5) Base channel at top of curb shall be anchored with 3/8" diameter anchor bolts at 16" O/C.

(6) Weatherproof seals shall be provided around all panel penetrations of frame work or piping.

DIVISION 1500

MECHANICAL WORK

SECTION 1501

GENERAL PROVISIONS

INDEX

SECTION 1501

GENERAL PROVISIONS

.01 CONDITIONS OF THE CONTRACT

A. The Conditions of the Contract (General Sections, Supplementary Sections and all other Conditions) and the General Requirements (All Sections of Division I) are hereby made a part of this Section.

.02 REGULATIONS AND CODES

A. The work, materials and equipment covered by these specifications shall comply in all respects with the requirements of State, County, and City applicable ordinances, regulations and codes. In addition, the following published standards shall be adhered to:

American Institute of Steel Construction
Institute of Electrical and Electronic Engineers
American Society of Mechanical Engineers
American Society for Testing Materials
American Standards Association
American Welding Society
National Bureau of Standards
National Electric Code
American Standard Mechanical Engineers Rules for Pressure Tanks
State Codes which apply to Plumbing and Heating Work
All local codes which apply to Heating Work
State Industrial Commission
American Society of Heating, Refrigeration and Air Conditioning Engineers
Institute of Boiler and Radiator Manufacturers (I.B.R.)
National Insulating Manufacturer's Association (N.I.M.A.)

B. This shall not permit a lower grade of construction when plans or specifications call for workmanship or materials in excess of code requirements.

.03 SUMMARY OF SYSTEMS

A. The following systems will be incorporated into the building with specific equipment and labor related thereto as described in this Division 15.

(1) Sanitary sewers and drains with connections to building sewer as shown on plans.

(2) Steam and condensate piping system and equipment

(3) Hot water heating system, including piping, connections to boiler, pump, etc.

(4) Process Water System

(5) Associated electrical temperature control systems.

(6) Solar collectors.

.04 GENERAL

A. These plans and specifications form a guide for a complete installation and where an item is not specifically mentioned and is reasonably necessary for a complete installation, the Contractor shall furnish such items under his contract without additional cost to the Owner.

B. The Contractor shall familiarize himself with the existing conditions of the proposed project. In no case will extra charges be allowed because of failure of the Contractor to acquaint himself with all existing conditions.

C. These drawings shall not be scaled to obtain exact dimension.

D. Where connections are made to equipment furnished by others, the Contractor shall obtain exact location of connections from persons furnishing said equipment.

E. The major piping, and equipment are shown on the drawings and called for in these specifications. Any detail not clear to the Contractor shall be referred to the Engineer for clarification before bids are submitted. If no question is raised prior to the opening of bids or award of contract, the Contractor will be obliged to install the work in question without additional cost, as directed by the Owner whose decision shall be final.

F. All work shall be performed in a neat and workmanlike manner by men skilled in the trade.

G. This Section (1501) applies to all the work under the Mechanical Contract and includes furnishing all materials, equipment, and labor to make a complete mechanical installation

as specified under Division #15 including Plumbing, Heating, Temperature Controls, Insulation, etc.

.05 SUBSTITUTION OF MATERIALS

A. Manufacturer's names and catalog numbers mentioned in these specifications have been used to designate the type and quality of materials or equipment desired. Products by other manufacturers equal to those specified may be used subject to the provisions of the General Conditions, and Supplementary General Conditions.

.06 MATERIALS AND EQUIPMENT

A. All equipment and materials used for the work in this contract shall be new and of the makes and types as let and contracted for. This Contractor is positively prohibited from using secondhand or used materials and equipment.

.07 GUARANTEE

A. This Contractor shall be responsible for the proper installation and working of everything in this contract and shall guarantee to remedy free of charge any defects in workmanship and materials that gives rise to trouble of any kind for a period of 12 months from the time of final acceptance of his work.

B. This Contractor shall place all systems in operation and make all adjustments required to insure proper operation and to obtain the results desired.

.08 SHOP DRAWINGS

A. The related sections of the General and Special Conditions of the General Specifications regarding Shop Drawings shall be amended by this section of the specifications.

B. This Contractor must submit shop drawings on all the major items of equipment specified hereinafter. Shop drawings must be supplied in at least seven (7) copies and must be complete and similar to all the components of the specified and design equipment.

C. All shop drawings must be accompanied by a letter, on the Contractor's letterhead, stating that these drawings have been checked by the Contractor as to capacities, physical dimensions, space requirements and limitations, appurtenances, workmanship, appearance and any and all other necessary details as specified.

D. Letter must itemize each shop drawing for each piece of equipment submitted.

E. Contractor shall not enter into any written or oral agreement until manufacturers and their equipment have been submitted to and approved by the Engineers

F. Failure to check this equipment and submittal of a letter with the shop drawings will result in return of same to the Contractor. Submittals will not be processed until return of the shop drawings in compliance with above paragraph.

G. Approval of shop drawings by the Engineer shall in no way relieve the Contractor of his responsibility for correct performance of the equipment, or for furnishing all the materials and equipment specified or noted on the plans, although not specifically shown on the shop drawings.

.09 PERMITS, LICENSES, FEES AND SERVICE CHARGES

A. All permits, licenses, fees and service charges required in connection with this work shall be secured and paid for by the installation contractor and upon completion of the work he shall furnish the Owner with proof of acceptance of all work from the proper local or State Department having jurisdiction.

.10 CLEANING

A. This Contractor shall be responsible for the rough cleaning of all scrap materials left on the job by men working under this contract. This shall be meant to include preliminary cleaning of all equipment and piping installed under this contract and the removal of pieces of pipe, pipe cuttings, insulation, etc.

B. This Contractor shall leave his work and work area broom clean so that the finish cleaning by the company is a light cleanup.

C. This Contractor shall place plywood, Visqueen or other suitable material on the floor of his work area to prevent oil and grease from staining the floor.

D. After the new HTW and steam systems are completed this Contractor shall thoroughly flush the entire system to a drain until the system runs clean and clear.

E. Systems will not be accepted until tight and clean.

F. Special care shall be taken to ream and clean all new piping before installation and connection to insure minimum dirt in the new installation.

G. Contractor shall thoroughly clean the HTW and steam heating system. During the cleaning out process of steam system he shall by-pass return mains, remove bellows on traps and waste condensate to sewer. The HTW system shall be thoroughly flushed using only the water designated by the company.

The Contractor shall "boil" out hot water lines with a chemical as recommended by a local chemical supplier that is familiar with the building water conditions, before he puts the system into operation, consult with the company.

.11 START-UP AND CHECKOUT

A. Upon completion of the installation of this system, and after the testing of each individual element, component, and sensor, the contractor shall participate in the start-up and checkout of the system which will be directed by the owner and monitored by the company.

B. Start-up will consist of filling the HTW loop with condensate, charging the HTW loop with N_2, setting the HTW loop flow, and operating the field flow pump with the collectors stowed.

C. Checkout will consist of cycling the solar collectors and tracking the sun to heat the water in the HTW loop. Checkout will include adjusting and tuning the system until process steam is generated.

.12 MODIFICATIONS TO PLANS AND SPECIFICATIONS

A. Throughout the course of the work, minor changes and adjustments to the plans and specifications may be requested by the owner. The Contractor shall make such adjustments without additional cost to the Owner, where such adjustments are necessary to the proper installation and operation and within the intent of the Contract Documents.

.13 CONNECTIONS AND LAYOUT

A. It shall be the responsibility of this Contractor to make connections at terminal points of contact. The piping, ducting and equipment, etc., may be shown with excess clearances for clarity. However, the Contractor shall group pipe and arrange all ducts and equipment to present a neat and workmanlike appearance and to avoid blocking of passageways.

B. The Contractor shall store his materials and equipment in such a place and in such a manner, that a minimum of congestion will result. The placing of such materials and equipment shall be subject to the approval of the Owner.

C. Should the drawings disagree in themselves, or with the specifications, the better quality or greater quantity of work or materials shall be provided and unless noted otherwise the specifications shall govern. All items specified whether shown on plans or not shall be installed as if shown on plans and specified.

.14 INSPECTION OF SITE

A. Before submitting a proposal on the work contemplated, each bidder shall examine the site and familiarize himself with all existing conditions and limitations. No extras will be allowed because of the Contractor's misunderstanding as to the amount of work involved or his lack of knowledge of any existing conditions.

SECTION 1510

BASIC MATERIALS AND METHODS

INDEX

SECTION 1510

BASIC MATERIALS AND METHODS

.01 CONDITIONS OF THE CONTRACT

A. The Conditions of the Contract (General, Supplementary and other Conditions), General Requirements (Sections of Division 1) and the General Provisions, Section 1501 are hereby made a part of this Section.

.02 SCOPE

A. This Section applies to all the work under the Mechanical Contract and Division 15 and includes all materials, equipment and labor required to make a complete and acceptable mechanical installation of plumbing, heating, ventilating, refrigeration, insulation and temperature control systems, steam heating, etc.

.03 ELECTRIC WIRING

A. All motor starters, pushbuttons and H.O.A. switches will be supplied under Division 1500 and all wiring to starter will be furnished and installed under Division 16, unless herein specified otherwise.

All motor starters that are required with electrically operated equipment specified herein shall be furnished by this Contractor, and delivered to the site.

It shall be the responsibility of this Contractor to caution his supplier of motors to check carefully the motor characteristics and to supply the starter to meet the specifications.

Furnish nameplates with starters, designating service in 3/8" letters.

All miscellaneous wiring required for complete installation under this Division will be done by this Contractor. All wiring to meet rules of the National Electrical Code. All wiring diagrams required shall be furnished by this Contractor.

Power for motors 1 h.p. and over shall be 600 volts, 60 cycle, and 3 phase. Power for motors less than 1 h.p. shall be 440 volts, 3 phase, 60 cycle. Starters are required for all motors 1/2 h.p. and over, starter to contain a 110 volt transformer and a set of N.C. and a set of N.O. contacts and be equipped with a H.O.A. switch in cover unless noted otherwise.

.04 TESTS

A. Test all new steam and condensate return heating systems piping with a cold hydrostatic test of not less than 100 pounds per square inch. Hot water piping to be tested at 300 PSIG.

All of the above tests shall be made by the Contractor installing the work at his expense and he must furnish to the Engineer and Owner a certificate of satisfactory test.

.05 PIPE SLEEVES

A. Sleeves shall be provided in place for all pipes passing through brick, concrete or masonry floors, walls and roofs and shall be 1/2" greater in inside diameter than the external diameter of the pipe and insulation (if required) passing through.

B. All sleeves shall be fabricated of new material, cut square and reamed.

C. Sleeves through exterior building walls above grade shall be Schedule 40 steel pipe installed flush with the finished surfaces and caulked between sleeves and pipe with oakum and lead to provide a weathertight joint.

D. Sleeves through partition walls and floor slabs in exposed areas shall be 22 gauge galvanized iron extending through the full thickness of the wall or floor and shall be flush with the finished surfaces.

E. Pack the space between all sleeves and pipes with heat resistant packing and install 1" depth of plastic caulking compound flush with the top of the sleeve.

F. Plastic caulking coumpound shall be Prestite or Dura-gum.

G. Sleeves shall be set and maintained in place by this Contractor during the progress of the work and during the pouring of the floor slabs or walls.

.06 FLOOR, WALL AND CEILING PLATES

A. Furnish and install on all pipes passing through ceilings, walls, or partitions in exposed areas, Crane No. 13 BC wall or ceiling plate with set screw to fasten to pipe. All plates shall be chrome plated and shall be a t least 1/32" thick. No floor plates will be required where sleeves extend above the floor.

.07 ROOF JACKETS

A. Vent stacks from sewer, soil, waste and rain pipes shall be extended at least 12 inches above the roof and shall be encased in galvanized iron frost proof jackets, Moore #1, having an air space of at least 1" between the outside surface of the pipe and the inside surface of the frost jacket. The top of the frost jacket shall be designed to permit the insertion therin of a testing plug of such form that it can be readily seen until removed and said plug shall be removed at once after a final inspection has been made and approved. The vent pipes shall be cast iron where they pass through the roof and the minimum size of any vent where it passes through the roof shall be 2 inches.

.08 UNIONS

A. Steam and condensate unions for screwed pipes 3" and smaller shall be Grinnell Figure 463 bronze to iron ground joint, 150 pound w.s.p. with hexagonal nut.

B. Unions on hot water system to be Grinnell Figure 459 for 300 lb. working pressure.

.09 VALVES

A. Furnish and install all valves indicated on the drawings or required for the proper sectionalizing or operation of the different piping systems. Install gate valves on all individual equipment.

B. All valves shall bear the manufacturer's name and pressure rating shall be stamped or inscribed on each valve. The following is a schedule of the valves using Powell valve numbers unless noted otherwise. Valves of Crane, Lunkenheimer manufacture, fully complying with the specifications, will be accepted as equal.

C. Install valves on all piping to tanks, pumps, and all locations shown on plans and all other locations necessary for removal of equipment and where reasonably can be expected for maintenance.

D. Hot Water Heating

1. Collector inlet valves shall be ½" globe type valves for modulation (Powell 2612 or equivalent). Collector outlet valves shall be ½" gate type valves for isolation (Powell 2377 or equivalent).

2. All ball valves to be Worcester model #466-300 with poly filled seal and have complete shut off at 300 PSIG and 400°F.

F. Check Valves
Furnish and install check valve in the discharge line of condensate pump. Check valves shall be installed close to pump.

G. Steam and Condensate and High Temperature Hot Water
Valves not readily accessible from the floor of equipment room shall be furnished with chain wheel and chains.

Valves with hand wheels which cause installation difficulties shall be provided with ratchet handle.

The following types of valves shall be used:

VALVE SCHEDULE

	Gate		Globe		Check	
Line	1 1/2" and Smaller	2" Larger	1 1/2" and Smaller	2" Larger	1 1/2" and Smaller	2" Larger
MP stm	375	1503	2608	1531	560	1561
Conden-sate	3714	1793	2600	241	500	559
HTHW	2377	3003N	2612	3031	1239 Y	1239 Y

.10 VALVE TAGS

A. Brass or plastic valve tags shall be provided for all new valves. Tags shall be stamped with valve purpose or service and shall be attached to the valve handles with brass wire.

B. Valves adjacent to equipment they serve need not be tagged provided that their function is obvious and provided that this Contractor has the approval of the Owner to delete the tags.

C. A list of all valves shall be left with the company along with a marked up set of drawings showing locations of all valves.

.11 ANCHORS AND GUIDES

A. Furnish and install all necessary anchors and guides in connection with the various piping systems. Anchors shall be securely fastened to the building structure and shall be

sufficiently strong to overcome the forces set up by the expansion. Guides shall be constructed to properly guide the pipe in proper direction.

.12 PIPE HANGERS AND SUPPORTS

A. Contractor shall furnish and install pipe hangers and supports required for his work and of various types specified herein and detailed on the drawings together with all inserts, beam clamps, sockets, bolts, clips, or rods to complete all hangers and supports. No chain, wire, strap, or perforated strap shall be used. Hangers of Grinnell manufacture are specified but hangers of Fee and Mason, Elsen or Crawford, which comply to the specifications, will be accepted.

B. All hangers for pipes 1/2" and smaller shall be Grinnell split ring hanger Figure 104, complete with sockets, turnbuckle and rod.

C. Hangers for pipes 3/4" up through 4" shall be Grinnell wrought clevis hanger Figure 260 or 65 complete with rod and nuts.

D. Hangers on all piping shall be large enough to encompass piping and insulation.

E. The following support intervals shall be the maximum permissible, but shall be closer if necessary for proper support.

Distance Between Supports

Pipe Size, Inches	Spacing of Hangers
1/2"	6'-0" Centers
3/4" to 1"	8'-0" Centers
1 1/4" to 5"	10'-0" Centers Unless Noted Otherwise On Plans

The following rod sizes shall be the minimum permissible for pipe hangers.

Hanger Rod Sizes

Pipe Size, Inches	Hanger Rod Dia., Inches
up to 2"	3/8"
2 1/2" to 3 1/2"	1/2"

F. This Contractor shall furnish and install all cross members, channels, brackets, spring nuts and bolts and all incidentals necessary to support all piping.

G. Groups of pipes at the same elevation may be supported on trapeze hangers using Unistrut P-1001 channels or Kindorff with threaded rod connected to inserts. Furnish pipe clamps to control spacing to span the outer surface of the installation.

H. Install pipe saddles to keep from crushing insulation between pipe and hangers on all piping 2" or greater in pipe size. All piping less than 2" shall have an insert of rigid, 7 1/2 lb. density installed at each hanger point.

I. Saddles for 2" and larger piping shall be fabricated of 16 gauge galvanized iron. Saddles shall encompass the lower one half of the covering. Saddles shall have a minimum length of 6".

Provide riser clamps for support of vertical risers at every floor.

J. Furnish and install pipe covering protection saddles where insulated piping is installed on rollers and where insulated piping rests on trapeze hangers and at all locations where pipes are installed over beams.

.13 PIPING IN GENERAL

A. All pipes shall be run with adequate grades to provide for proper draining. They must be thoroughly reamed and cleaned before installation. Pipes run overhead shall be placed as close to the ceilings as possible to maintain proper headroom and to present a neat appearance, all consistent with the correct pitching of pipes. The Contractor shall consult the Owner before installing any pipe lines which will reduce the proper headroom in any way. Piping shall be run as shown on the drawings, but the Owner reserves the right to make minor changes, without extra charge, to avoid interference with other work or unforeseen structural interference.

B. All hot water piping shall be pitched to drain points, and up from mains or risers 1" in 40' wherever possible. Provide a drain valve on each low point. Drains shall be located in accessible locations.

C. Heating piping, except runouts, must be pitched in the direction of steam or water flow to drain points and shall be so installed as to prevent vibration and water hammer.

Eccentric reducers or eccentric fittings must be used at all points where pipe sizes changes and particular care shall be taken to eliminate all pockets for lodgement of condensate or air.

D. Proper swing joints shall be provided in the spring pieces to allow for expansion in the main, the runouts and the risers.

E. All screw threads must be tapered and proportioned in accordance with the regulations formally adopted by the manufacturers of wrought iron pipe and boiler fittings. All threads must be cut true and sharp and threaded joints shall be put together and made tight with graphite only as a lubricant. No caulking will be allowed. All pipes must be well reamed. Particular care must be taken toward keeping the piping system clean during the installation. Each length of pipe, fittings, etc. must be thoroughly cleaned of all dirt, filings, etc., before assembling.

F. Mechanical Contractor will check each length of pipe before it is welded in place to make certain there is no foreign material (stones, sand, etc.) in the heating system.

.14 PIPE AND FITTINGS

A. Contractor shall furnish and install all pipes and fittings required for a complete installation of all piping systems required and specified under this Division 15, Mechanical Work. All material shall be best grade of established and reputable manufacturers. Types and weights of pipe and fittings shall conform to the following or approved equal.

B. Process Water, Waste and Vent Piping: Galvanized Steel

All process water, rainwater, waste and vent piping above ground shall be Schedule 40 weight galvanized mild steel pipe, National Tube Company manufacture, scaleless type.

The fittings for the galvanized, waste shall be cast iron recessed screwed drainage fittings, tar coated inside and outside. Long sweep fittings shall be used unless space conditions prevent.

Fittings for process water to be malleable galv-iron.

Contractor may use in lieu of galvanized steel pipe for waste and vent piping above ground the following: Hubless cast iron soil pipe (ClSPpFT-HBLS) ClSPl 301-75, provided fittings comply with requirements of the applicable code and ClSPl Standards HSN-75.

C. Medium Pressure Steam Piping: Black Steel - All piping for medium pressure steam shall be Schedule 40, black steel as specified above. Fittings shall be same as above suitable for 250 psi working pressure.

D. Standard Weight Yoloy Pipe shall be used for the following:

(1) All steam condensate return & pumped return lines.

E. Steam, Condensate Return, Hot Heating Supply and Return Pipe Connections - Piping shall be welded for pipe 2" and above. Piping less than 2" shall be screwed.

(1) Hot water supply and return branch lines shall be connected to mains, using a welding fitting. Connectors from that point to all solar panel shall be made by a flexible coupling furnished with solar panel and this contractor to leave a 37° flare fitting.

(2) All HTW piping to be schedule 40 black steel seamless tubing. Welding fittings to be schedule 40 and screwed fittings schedule 80.

G. Lubrication - All valves, cleanouts and such items will be lubricated before being installed.

.15 WELDING

A. All welding fittings, slip-on flanges, etc., shall be Tube-Turn welding fittings. The welding shall apply to straight runs of piping such as mains, etc., and to weld-o-lets for branch connections to the mains. Branch or runout piping and risers beyond the weld-o-lets shall be fabricated with screwed connections to provide greater flexibility to the piping arrangement. Any deviation from this specification shall be done only on authorization of the Engineer and Owner.

B. All welding shall be done by a proven welding procedure with certified and tested operators and, in general, be in accordance with the latest edition of the ASME Boiler Code and American Standard Code for Pressure Piping. Inside of pipe diameter must be free from obstruction resulting from improper welding operation. Samples of each welder's work shall be submitted for testing and approval if requested by the Owner.

C. All piping over 1 1/2" in size to be arc welded joints, a minimum of two (2) passes must be made. Use stainless steel welding rod when welding wrought iron pipe.

.16 PRESSURE GAUGES - WATER & STEAM

A. Furnish and install U.S. Gauge or Ashcroft pressure gauges at all points of pressure change in the systems. Pressure gauges shall have a range equal to 1 1/2 times the highest operating pressure. Gauges shall have 4 1/2" dial face and be lettered to indicate the units of measurement.

B. Gauges on water systems shall be Ashcroft #1010 without pigtails and provided with Ashcroft #1106 Series pulsation dampener and #1092 gauge cock.

C. Gauges on steam system shall have pigtail and cock.

D. Gauges of Crosby, Konkle, and Trerice will be accepted provided that they fully comply with the specifications.

.17 PIPING SPECIALTIES

A. Strainers Steam - Provide "Y" type strainers with monel screens ahead of all traps (other than radiator traps) and pressure reducing valves and control valves. Strainer shall be designed for line pressure and shall be complete with valve, and plug on blow-off. Equal to Armstrong 125# design. Illinois, Hoffman acceptable.

B. Relief Valves - Size as required for equipment capacities.

C. Drip Traps - F & T - Furnish and install float and and the Thermostatic traps at the ends of all med. pressure steam mains and at all major drip points and on steam fed equipment where indicated on the drawings. Ahead of each float and thermostatic trap, furnish and install a gate valve, an offset type strainer and a union. Place all drip traps in approved accessible locations to facilitate service and repairs. Drip traps shall be of Armstrong Manufacture.

.18 EXPANSION JOINTS AND COMPENSATORS

A. Where expansion joints are required they are shown on the drawings, details or riser diagrams.

B. Ball joints shall be Chiksan or Barco ball joints as shown on plans. Ball joint working pressures shall be a minimum of 300 PSIG at 400°F water temperature. Installation of ball joints shall be in accordance with the manufacture recommendations.

.19 FOUNDATIONS, BASES & SUPPORTS

A. Concrete bases required for mechanical equipment will be the responsibility of the Contractor. (Unless specifically specificed otherwise).

B. All steel supports either to wall or floor for tanks, convertors, heat exchangers, and other miscellaneous mechanical equipment shall be furnished and installed by the Mechanical Contractor, all as required or as detailed on the drawings or called for in the specifications.

.20 CUTTING & PATCHING

A. The Mechanical Contractor shall endeavor to provide sleeves, pipes, chases and other openings throughout the structure of the new building, and he shall install all equipment, piping and other parts of his work at such time as will reduce to a minimum the amount of cutting to be done.

B. Each contractor shall do all cutting and patching necessary for the proper execution of his work in a manner approved by the Owner. Where new work is removed or altered, all work affected shall be properly patched and filled out to match adjacent surfaces.

C. Contractors shall not endanger any work by cutting, digging or otherwise, and shall not cut or alter the work of any other Contractor without the consent in writing of the Owner. Any shoring material or labor required to properly support the portion of this structure where cutting is being done shall be furnished by this Contractor. Any damage to building structures caused by this Contractor's work shall be repaired at his expense.

D. Each Contractor shall be responsible for giving the General Contractor all necessary roughing-in dimensions and recess openings for all equipment under his contract requiring smae. Failure to coordinate these recess openings or roughing-in dimensions for equipment to be used shall result in this Contractor paying any and all charges for any revision of recess openings or roughing-in dimensions to accommodate equipment.

.21 PAINTING

A. Painting of all mechanical equipment and materials shall be the responsibility of this contractor.

B. This Contractor to paint all ducts, all pipe, and pipe hangers, all insulation that is exposed to weather with sufficient sizing and two (2) coats of paint, color as selected by Owner.

.22 MATERIALS & EQUIPMENT

A. All materials and equipment shall be new and of best quality, conform to requirements of local and state codes governing the work involved, and be made by nationally recognized and substantially established manufacturers. The type and weight of material used for each purpose shall be as hereinafter specified and all material shall conform to the requirements of the latest standard specifications of the ASTM for that particular material.

B. Within seven (7) days after the awarding of the contract, this Contractor shall submit for the approval of the Engineer, a complete list of the makes of all the material and equipment that he contemplates using in the construction of the work, which, after approval has been given, shall be final.

C. All material and equipment shall be by a reputable firm and shall have been used in similar installations previously.

SECTION 1516

MECHANICAL SYSTEMS

INSULATION

INDEX

SECTION 1516

MECHANICAL SYSTEMS

INSULATION

.01 CONDITIONS OF THE CONTRACT

A. The Conditions of the Contract (General, Supplementary and Other Conditions), General Requirements (Sections of Division 1), General Provisions (Section 1501), and Basic Materials and Methods (Section 1510), are hereby made a part of this Section.

.02 SCOPE

A. Work under this Section of the specifications includes the furnishing of all labor and materials necessary to complete the insulation installation, all in accordance with the drawings and as further specified herein.

B. Work shall include thermal pipe insulation, and equipment insulation, all as specified hereinafter. All of the major piping, and equipment to be insulated are shown on the drawings and called for in these specifications. Any detail not clear to the Contractor shall be referred to the Engineer for clarification before bids are submitted. If no question is raised prior to the opening of bids or award of contract, this Contractor will be obliged to install the work in question without additional cost, as directed by the Owner, whose decision shall be final.

C. All insulation shall have composite (insulation, jacket, or facing, and adhesive used to adhere to the facing or jacket to the insulation) fire and smoke hazard ratings as tested by procedure ASTM E-84, NFPA 255 and UL 723 not exceeding:

Flame Spread	25
Smoke Developed	50

D. Accessories, such as adhesives, mastics, cements, tapes, glass fabric and asbestos cloth for fittings shall have the same component ratings as listed above.

E. All products or their shipping cartons or packages shall bear a label indicating that flame and smoke ratings do not exceed above requirements.

F. Insulation on all cold surfaces where vapor barrier jackets are used will be applied with a continuous, unbroken vapor seal. Hangers, supports, anchors, etc., that are secured directly to cold surfaces must be adequately insulated and vapor-sealed to prevent condensation.

G. General

(1) Insulation shall be applied on clean, dry surfaces, and after inspection and release for insulation application.

(2) All insulation shall be continuous through wall and ceiling openings and sleeves.

.03 MATERIALS

A. Insulation on all cold surfaces where vapor barrier jackets are used will be applied with a continuous unbroken vapor seal. Hangers, supports, anchors, etc. that are secured directly to cold surfaces must be adequately insulated and vapor sealed to prevent condensation.

B. Material Approval Code

Code I Fiber Glass Pipe Insulation

A. Johns-Manville Flame Safe Pipe Insulation
1. All purpose jacket - AP 4 1/2 pound density and 650°F.

Code II One piece PVC Insulated Fitting Covers

A. JM Uni-Fit
B. Zeston
C. Speed-Line

Code III Fittings and Valves

A. Insulate with molded fiber glass fittings; segments of pipe covering; or with compressed Universal Fiber Glass Blanket secured in place with corrosion resistant wire. Pipe sizes under 4" may be insulated with hydraulic setting insulating cement. All thicknesses to be equal to that of adjoining pipe covering. Apply a smoothing coat of finishing cement where necessary and cover with canvas or fiber glass tape embedded into a wet coat of fire retardant lagging adhesive and overlapping all seams 2".

.04 STEAM HEATING SUPPLY AND CONDENSATE PIPING AND PUMPED CONDENSATE

A. All piping in concealed and exposed areas shall be insulated with fiber glass insulation with all service jacket of grades mentioned in paragraph .03 "B", Code I.

ECONOMIC THICKNESS TO 450° F. 80° AMBIENT

Operating Temperature (F)

Pipe Size	200	250	300	350	400
0.50	1.0	1.0	1.5	2	2
0.75	1.0	1.0	1.5	2	2
1.00	1.0	1.5	1.5	2	2
1.25	1.0	1.5	2.0	2	2
1.50	1.5	1.5	2.0	2	2
2.00	1.5	2.0	2.0	2	2
2.50	1.5	2.0	2.5	2.5	2.5
3.00	1.5	2.0	2.5	2.5	2.5

B. The contractor to use Code III insulated fitting covers as outlined in .03 "B".

.05 HOT WATER SUPPLY AND RETURN

A. All piping in concealed and exposed areas shall be insulated with fiber glass pipe insulation with all service jacket of grades mentioned in paragraph .03 "B", Code I. Thickness shall conform to the following schedule.

Pipe Size	Thickness
Through 1"	3"
1 1/4" through 3"	4"

B. Jackets inside of building to be all purpose type and fittings to be .03 "B" Code III.

C. Jackets exposed to weather to be .016" thick aluminum with chillers CP 11 mastic and fiber glass minimum of two coats. Fitting to be covered same as end seals.

D. The Contractor to insulate all piping from end of collector pipe. This shall include pipe from collector to swivel joint, shut off valve, balancing valve, flexible pipe, rigid pipe and main.

E. The swivel joint at each end of the collector shall be insulated and jacketed.

.06 PROCESS WATER PIPING

A. All piping in concealed and exposed areas shall be insulated with fiber glass pipe insulation with all service jacket of grades mentioned in paragraph .03 "B", Code I. Thickness shall conform to the following schedule:

Pipe Size	Hot	Cold
Through 3"	1"	1"

B. Jackets and End Laps shall be sealed with Chicago mastic 17-465 or equal applied to two surfaces.

C. Valve Bodies, Fittings and Flanges. The Contractor to use PVC insulated fitting covers as mentioned in paragraph .03 "B", Code II.

SECTION 1520

WATER SUPPLY SYSTEM

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SECTION 1520

WATER SUPPLY SYSTEM

.01 CONDITIONS OF THE CONTRACT

A. The Conditions of the Contract (General, Supplementary and other Conditions), General Requirements (Sections of Division 1), General Provisions (Section 1501), and Basic Materials and Methods (Section 1510) are hereby made a part of this Section.

.02 SCOPE

A. This Section includes all labor, materials, equipment, skills and tools necessary to furnish and install the new process water supply system.

B. Work in this Section includes, but is not limited to:

(1) Piping, valves, hangers, supports, insulation specialties, etc.

C. Following related materials as specified elsewhere:

(1)	Piping, fittings, valves, etc.	SECTION 1510
(2)	Tests	SECTION 1510
(3)	Insulation	SECTION 1516

.03 WALL HYDRANTS & HOSE BIBS

A. Wall hydrants shall be furnished and installed in location shown on the drawings. The exterior wall hydrants shall be set as directed and shall be on concealed nozzle wall hydrant with a nickel bronze face and galvanized casing. All internal part subject to wear shall be renewable from the front face of the hydrant. Hydrant to be Wade W8625 with integral V.B. non-freeze nickel brass box, key operated cover. Extend shut off valve to the inside of wall insulation in all cases.

B. Install gate valves inside of building on all supplies to hydrants at an accessible location as shown or directed. All hydrants are to be equipped with vacuum breakers.

.04 VACUUM BREAKERS & AIR CAPS

A. Water supply connection to fixtures or equipment which have submerged inlets, or inlets which are below the spill line of the fixture or equipment, or fixtures which have hose end connections shall be provided with an approved vacuum breaker device or air gap arrangement whether mentioned specifically herein or not.

SECTION 1525

SOIL AND WASTE SYSTEM

INDEX

SECTION 1525

SOIL AND WASTE SYSTEM

.01 CONDITIONS OF THE CONTRACT

A. The Conditions of the Contract (General, Supplementary and other Conditions). General Requirements (Section of Division 1), the General Provisions, Section 1501 and Basic Materials and Methods, Section 1510, are hereby made a part of this Section.

.02 SCOPE

A. This section includes all labor, materials, equipment, skills and tools necessary to furnish and install the sanitary sewer and vent system including connections to all such equipment in the building.

B. The work of this section includes, but is not limited to the following:

(1) Pipe, fittings, valves, hangers, supports, covering and appurtenances required for a complete system as specified in this Division 15.

(2) Sanitary services in the building to existing lines.

(3) Floor drains, cleanouts, etc. as specified.

(4) Soil, waste and drain connections to all equipment furnished under Division 15 and that furnished under Sections pertaining to general contract work.

C. The following related materials are specified elsewhere:

(1) Piping, Valves, etc. - Section 1510

.03 CLEANOUTS

A. Full sized brass, screw plug cleanouts shall be furnished and installed according to Alabama Code, at all points where shown on the drawings and where necessary to permit the entire drainage systems to be rodded out easily.

B. All C.O.'s shall be placed in accessible locations.

.04 FLOOR DRAINS

A. General: All floor drains shall be W2500 8 x 3 Wade size as noted on plans.

SECTION 1560

STEAM HEATING SYSTEMS

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SECTION 1560

STEAM HEATING SYSTEMS

.01 CONDITIONS OF THE CONTRACT

A. The Conditions of the Contract (General, Supplementary and Other Conditions), General Requirements (Sections of Division 1) and the General Provisions, Division 1501 and Basic Materials and Methods, Division 1510 are hereby made a part of this Division.

.02 SCOPE

A. The scope of this division includes, but is not limited to, the furnishing and installation of boiler unit, condensate pumping unit, steam traps, steam, condensate water piping and all accessories indicated or required to provide a complete, efficient quiet operating steam supply system.

B. The following shall be included:

(1) Boiler

(2) Steam Traps

(3) Connections

(4) Condensate Pumps

C. The following material will be specified elsewhere:

(1) Piping and Piping Accessories - See Division 1510

(2) Insulation - See Division 1516

.03 BOILER

A. Furnish and install where shown on drawing one (1) boiler with all required accessories on steel skids carefully grouted to the floor and make all final feed and make-up water connections; feed water valve and pump, operating and safety control all as required to provide a fully automatic efficient operating boiler system.

B. Supply and install, where shown on the plans, one (1) P-K Series 380 Unfired Steam Generator, Model H 307 as manufactured by the Patterson-Kelley Co., Inc.

C. Generator shall generate a minimum of 1000 lb/hr of saturated steam at a pressure of 765 PSIG from Feedwater at 200°F, when supplied with 48 GPM of HTW at 389°F., fouling factor .0005, H.T.W. leaving temperature to be 333°F or a 56°F drop through tube bundle. Water pressure drop not to exceed 4.6 Feet of Head (2 psi).

D. The generator shall be a complete factory assembled package consisting of the following components:

Series 380, Model H 307 Generator constructed and stamped in accordance with the ASME Code and with FM Insurance Company certification. The shell and tube circuit shall be flange grade steel and the tubes shall be 3/4" black steel pipe on a 1" square pitch. The U-tube bundle shall be supported on heavy steel tracks and shall be removeable.

The shell shall be constructed of SA285 Grade C steel or SA515 Grade 70 steel.

Shell shall be fully x-rayed and stress-relieved according to Section VIII-UW-2(c) of ASME Code and ASME stamped for a design pressure of 150 PSIG at 400°F.

The tubeside shall be designed for a pressure of 400 PSIG at 450°F. and ASME Stamped. The HTW bonnet shall be a one piece solid steel billet with 300# USAS flanged nozzles elbowed into the radical position. The bolting between the HTW bonnet, tubesheet and shell flange shall be independent on each gasket to allow inspection and replacement of either gasket without disturbing the other gasket. The HTW bonnet gasket shall be the spiral wound metal-asbestos type. The shellside gasket shall be compressed asbestos.

2. Steel lifting lugs.

3. Steam-moisture separator.

4. Full length steel skid foundation to support the generator 18" above the floor.

5. Steam pressure gauge 6" dial with shut-off cock and syphon. (Ashcroft 1379A Duragauge or equal.)

6. Sheelside, ASME Section I steam safety valve.

7. Combination water column and pump controller, magnetrol W126 and 2 extra sets of contacts.

8. ASME (reflex) gauge glass and trycocks.

9. Two (2) HTW Blow-down valves in series. Yarway (1 1/4") #3482R.

10. Fibre-type high density insulation 2" thich with heavy gauge anodized zinc coated steel jacket.

11. One (1) fluid temperature well.

See list of points in Section 1565.

E. Fully descriptive certified scale drawings shall be submitted for approval showing all instrumentation, controls and design details as herewith specified. Schematic or non-scale representation will not be accepted.

F. Insurance certificates of inspection and test shall be sent to the designated people after completion.

G. The generator manufacturer shall assume operational responsibility for all components and shall furnish written operating and maintenance instructions with data on all components. The manufacturer shall also perform a simulated operating test to prove all controls operational before shipment.

H. Furnish and install on nozzle outlet of boiler one Powell No. 2475 stop and check valve designed for 1,200 lbs of steam maximum to 100 lbs minimum flow with out chatter and maximum pressure drop of 4 1/2 PSIG.

.04 CONDENSATE RECEIVER AND PUMP UNITS

A. Furnish and install from the existing condensate receiver, a new pump unit as listed below. Furnish necessary controls and magnetic starter. Pump shall be quiet in operation. Furnish and install a check valve and gate valve in discharge line of pump;. Motor shall be 600 volts, 3 phase, 60 cycle. Also furnish magnetic starters with H.O.A. switch in cover and an extra set of N.O. and N.C. contacts.

B. Condesnate pump to be Aurora E5T, 2 stage turbine pump with 3 h.p., 600 volt, 3 phase, 60 cycle motor that will deliver 3 GPM at 125 PSIG when supplied with 210°F inlet water at approximately 2 feet suction pressure.

C. Condensate pump starter to be pulled in by 115 VRMS-60Hz isolated coil.

D. Two control valves at discharge side of condensate pump are to be Honeywell No. 1407, ½" size, 300 PSIG carbon steel body valve, single seated and designed to close bubble tight against 360 PSIG differential with a 10 second operator. Both valves to be 110V. Valves to be furnished and installed by Contractor.

E. Condensate control valve operators are to be Honeywell M 630B with Q607 auxiliary switch (2-SPDT), furnished and installed by Contractor.

F. The control valve in the boiler feed line is to operate from the liquid level controller on the steam generator. On call for condensate valve to open and condensate pump to start, and reverse control on shut down.

G. The control valve that feeds water into the HTW system to operate from Magnetrol Model TF-62-F with a DPDT switch placed approximately 1/3 of the way up from bottom of the expansion tank. The above liquid level switch is to be so wired that on a call for liquid, and pressure in HTW line is below 100 psi, it will open control valve and start pump. Reverse shall happen when there is a rise in water level. Also furnish and install 3-valve bypass line around this HTW control valve (for manual operation).

.05 STEAM TRAPS

A. Steam Traps and main drips shall be Armstrong F & T trap or inverted bucket traps with integral strainer and thermostatic vents, sized at not over 1/2 lb. drop and at least three times the condensing rate of the equipment being serviced. See plans for locations. Also furnish all steam main drips.

B. Traps to be installed in the following order: Starting at steam main, install in the following order: gate valve, strainer, union, trap, and gate valve.

.06 CONNECTIONS

A. This Contractor shall furnish all steam and condensate return piping for all units shown, furnishing and installing all valves, strainers and traps and installing valves furnished by Owner.

.07 STEAM FLOW METER

A. Install a 1/8" thick stainless steel orifice plate in the 3" steam line and run a copper line from orifice plate to a Honeywell 411 transmitter, transmitter to be complete with blow down valves and 110 volt inlet, transmitter to be furnished by Contractor.

B. The recorder shall be a Honeywell 4" strip chart recorder.

SECTION 1565

HIGH TEMPERATURE HOT WATER SYSTEM

INDEX

SECTION 1565

HIGH TEMPERATURE HOT WATER SYSTEM

.01 CONDITIONS OF THE CONTRACT

A. The Conditions of the Contract (General, Supplementary and other conditions), General Requirements (Sections of Division 1) and the General Provisions, Section 1501 and Basic Materials and Methods, Section 1510, are hereby made a part of this Section.

.02 SCOPE

A. The scope of this section includes, but is not limited to, the furnishing and installation of all pumps and solar collectors. System accessories and connections indicated or required to provide a complete, efficient, quiet operating heating system. System is designed to operate at 275 PSIG when in operation and shall not exceed 300 PSIG at any time.

B. The following shall be included:

(1) Pumps
(2) System Accessories
(3) Connections

C. The following related material will be specified elsewhere:

(1) Pipe, fittings, valves and specialities - Section 1510.
(2) Pipe hangers, vibration isolators - Section 1510.
(3) Insulation - Section 1516
(4) Steam Heating System - Section 1560

.03 PIPING

A. Furnish and install all indicated or required piping to provide a complete circulating hot water heating system using Schedule 40 black iron pipe with hangers per Section 1510. Piping shall be run concealed where possible and with maximum head room, pitched to drain properly vented and of size shown on drawings or indicated in pipe sizing schedule or required.

.04 PUMP

A. Furnish and install on a base a Buffalo can-o-matic "HCR" H66058 ductile iron pump. Pump to have seals good for 430°F, 300 PSIG pressure when driven with a 1750 RPM, maximum of 5 H.P. 600 volt, 3 phase motor. Pump to deliver 48 GPM at 50 feet of head. Furnish starter with pump and H.O.A. switch in cover and an extra set of N.O. and N.C. contacts.

.05 SYSTEM ACCESSORIES

A. Furnish and install in the piping system where shown and/or required accessories required for proper, efficient, quiet operation of the hot water heating system.

B. Air eliminator unit shall be as detailed on plans unit located where shown having capacity of 60 gpm.

C. Expansion tank shall be ASME construction 100 gallons and rated at 400 PSIG. Provide all required rods and angles or channels to support from structure on floor. Expansion tank and level switch as installed shall be rated for 400 PSIG.

D. Furnish on tank a drain valve and a nitrogen charge valve. Install an airtrol non convective valve where connected to main piping to prevent convection losses.

E. Air vents, shall be provided at high points and where shown in equipment rooms. Manual vents shall be provided.

F. HTW make up water system shall be automatic in operation with a manual valve and check valve as a by-pass.

G. Furnish for installation in hot water line a pressure relief valve with outlet piped to near the floor. See Section 1510. Valve to be set to release at 295 PSIG.

H. Provide thermometers. See Section 1510.

I. Provide pressure gauges at pump as shown. See Section 1510.

J. Furnish and install one - 300 cu. ft. nitrogren tank.

K. Automatic air vent on air chamber to be Armstrong # 11AV stainless steel construction 400 PSIG at 500°.

L. Provide fittings for second HTW field flow pump in parallel with specified pump.

M. Provide Globe valve in HTW line as shown on drawing, with range of 35 gpm to 60 gpm.

N. Furnish and install a flow meter in the high temperature hot water line, a Wallace and Tiernan metal - tube vanea - meter with indicator which shall include a 316 S.S. 2" meter tube with indicator (calibrated in GPM), vertical in - vertical out 300# carbon steel flanged connections, 316 S.S. float and a 4 wire electronic transmitter. Tube #WT-2-39-M-5 and float no. 2-M-6V1-1020.

O. Furnish and install on inlet and outlet side of each solar collector a Flexamics stainless steel flexible connector Model 401 - 1¼" diameter and 20" long with welded end connections.

.06 INSTRUMENTATION

A. Equipment

Abbreviation	Senscr	Manufacturer	Address
T-1 T-2 T-3 T-4 T-5 T-6 T-7 T-8	steam generator inlet temperature steam generator fluid temperature steam generator outlet temperature HTW fluid temperature in field HTW fluid temperature in field process steam temperature feedwater temperature ambient temperature	Honeywell 30672953-002 with Honeywell transmitters 39102-8060-0911- 00-55-72	Honeywell Inc. Process Control Division Fort Washington, PA
P-1	HTW loop pressure	Honeywell Model 41222-0001-03- 08-U1C2	Honeywell Inc. Process Control Division Fort Washington, PA
P-2	process steam pressure	Honeywell Model 41221-0001-03- 08-U1C2	Honeywell Inc. Process Control Division Fort Washington, PA
F-1	process steam flow	Honeywell 411	Honeywell Inc. Process Control Division Fort Washington, PA
F-2	HTW flow meter	Wallace & Tiernan	Belleville, N.J.
I-1	pyronometer	Eppley Model No.2	EPPLEY New Port, RI 15238 (401) 847-1020
I-2	pyrheliometer (tracking)	Eppley Model NIP with standard tracker and inte- grator	
E-1	wattmeter	Westinghouse	WESTINGHOUSE Instrument Division Pittsburgh, PA 15238 (412) 782-1730
W-1	anenometer	Weather measure Sky Vane W161	WEATHER MEASURE P.O.Box 41257 Sacramento, Calif. 95841 (916) 481-7565

B. TESTS

1. Temperature Sensors: Upon completion of the wiring, each temperature sensor shall be tested to assure a) calibration for data collection, and b) proper operation for control. Each sensor shall be tested over its expected range of operation - in general, 30° to 400° F.

2. Pressure Sensors: Same as 1 above except for the HTW loop pressure sensor shall be tested at its set point. The steam line pressure shall be tested and calibrated over the range 60 psig to 90 psig.

3. HTW Flow Meter: Upon completion of the wiring, the flow meter shall be tested to assume proper operation for control.

4. Wind Sensor: Same as 1 above.

5. Illumination Sensor: Same as 1 above.

.07 IMMERSION HEATER

A. Furnish and install two Tempco immersion heaters. One heater to be located in the return line to be 2000 watts and the one in supply line in penthouse to be 3000 watts. Each heater to be supplied with 277 volt one phase power. Control furnished by Owner.

SECTION 1580

AIR TEMPERING SYSTEM

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SECTION 1580

AIR TEMPERING SYSTEM

.01 CONDITIONS OF THE CONTRACT

A. The Conditons of the Contract (General Supplementary and other Conditions), General Requirements (Sections of Division 1) and the General Provisions, Section 1501 and Basic Materials and Methods, Section 1510 are hereby made a part of this Section.

.02 SCOPE

A. The scope of this Section includes but is not limited to the furnishing and installation of all fans and accessories.

B. The following shall be included:

(1) Propeller Fan Unit

(2) Louvers

C. The following related material will be specified elsewhere:

(1) Steam Piping - Section 1560

(2) Heating Water Piping - Section 1565

(3) Waste Piping - Section 1525

(4) Controls - Section 1595

.03 SERVICE CONNECTIONS

A. All steam, heating water, waste and electrical connections will be made under other sections of these and other specifications but all equipment furnished under this Section requiring said connections shall be provided with proper opening and connecting facilities.

.04 PROPELLER FANS

Furnish and install where shown on plans wall mounted propeller type exhaust fans. Fans to be Greenheck or approved having following capacities and shall be thermostically operated.

Fan No.	Area Served	Model No.	CFM	s.p.	H.P.	Notes
E-1	Equip. Room	SPx24.5	2552	.38"	1/2	with inlet guard

.05 ADJUSTMENTS

A. The Sheet Metal Contractor shall be responsible to make changes in pulleys, belts and dampers where necessary to obtain the required air volume.

B. All fans shall be initially started, lubricated and balanced to eliminate noise and vibration.

.06 DUCT ACCESSORIES FOR LOW PRESSURE DUCTWORK

A. Where dampers are shown in ductwork, regulators or operators shall be installed to position them.

.07 GRAVITY BACKDRAFT DAMPERS

A. Furnish and install gravity backdraft dampers at all locations as noted or shown. Dampers shall be for either horizontal or vertical air flow as required.

.08 LOUVERS

A. Fresh air intake louvers for all units shall be furnished by this Contractor and turned over to be installed by the General Contractor.

B. Wall Louvers - This Contractor (Ventilating) shall furnish and install all louvers shown on drawings for air intakes, air exhausts, and ventilating systems. Each louver shall be built and ready for installation at the time the stone, tile or brick work is laid up. Exact locations of louvers shall be checked by this Contractor so ducts can be properly connected.

(1) Louvers shall be Titus Manufacturing Corporation, with air balance and American Warming as equal.

(2) Louvers shall be Model OXL-02 extruded aluminum stationary with blade #355 and aluminum bird screen on inside of louver. Screen shall be 1/2" mesh and .063 aluminum.

(3) Louver shall be extruded aluminum 12 gauge thickness, 6063-T5 alloy. Aluminum collar to be furnished on each louver for connecting ductwork. All louvers shall have bracing strips on minimum of 48". Louvers shall be continuous heli-arc Welding method. Louver shall be anodized.

.09 CONNECTIONS TO MISCELLANEOUS EQUIPMENT

A. Make connections to all equipment as shown on plans including connections to fan mounting of fans and fan connections.

B. Bird Screens - All outlets and intakes that terminate outside of building shall have 1/2" mesh bird screens.

.10 AUTOMATIC TEMPERATURE CONTROL

A. Equipment Room Penthouse: Contractor shall furnish and install reverse acting Honeywell thermostat connected through starter to stop and start fan for this Penthouse. Sequence will be such that on rising temperature, electric switch will start exhaust fan and fall in temperature the Honeywell thermostat shall stop fan. Do all necessary wiring.

.11 UNIT HEATER THERMOSTAT

A. The unit heater to be controlled by a direct acting Honeywell thermostat to turn heater on, on a drop in temperatures range 35° to 70°. Furnish and install all necessary wiring.

.12 ELECTRIC UNIT HEATER

A. Furnish and install in penthouse one chromalox LUH-75 - 7.5 KW forced flow heater. Heater to be 208 volt, 3 phase, and come complete with contractor, and over load protection devices.

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DIVISION 1600

ELECTRICAL WORK

SECTION	DESCRIPTION
1601	General Provisions
1610	Basic Materials and Methods
1620	Electric Service
1630	Electrical Distribution System
1640	Lighting Fixtures
1670	Electrical Power Equipment
1680	Standby Generator

SECTION 1601

GENERAL PROVISIONS

INDEX

DIVISION 1600

ELECTRICAL WORK

SECTION 1601 - GENERAL PROVISIONS

.01 GENERAL

The General Conditions, Supplemental General Conditions and Special Conditions apply to all work of this Division.

.02 SCOPE

The Contractor shall furnish all labor, equipment, materials, tools, transportation, permits, etc., necessary for or incidental to the installation of new systems and/or the modification of existing systems to provide complete lighting, power and other systems in accordance with these specifications and the accompanying plans. Electrical work shall be complete from the location designated by the electric utility company as the point of electric service connection to the final connection of motors, fixtures, devices, apparatus, etc., as herein specified and as indicated. Electrical work shall be in accordance to the requirements of all governing local, state and national code regulations.

.03 INSPECTION OF SITE

Before submitting a proposal on the work specified herein and indicated on the contract drawings, each bidder shall examine the site and familiarize himself with all existing conditions and limitations. No extra compensation will be allowed because of the Contractor's misunderstanding as to the amount of work involved or because of his lack of knowledge of any existing conditions.

.04 DRAWINGS AND COORDINATION

The Contractor shall refer to the structural and mechanical drawings for dimensions, furred spaces, suspended ceilings, locations of equipment, etc. Any discrepancies between the electrical, structural and mechanical drawings shall be reported to the engineer.

For exact locations of partitions and walls the Contractor shall refer to the structural drawings, which are dimensioned. Structural drawings, however, shall not take precedence over field measurements.

The swings of all doors shall be verified before switch outlets are installed.

Outlet heights are in general indicated on the drawings.

The heights are from the center of the outlet to the finished floor; however, in exposed masonry, construction height shall be adjusted so that one box edge is on masonry joint. Outlets indicated back to back in adjoining rooms shall be offset 1'-0" from each other.

Mechanical space lighting fixtures shall be located after all mechanical equipment is in place.

It shall be the responsibility of the Electrical Contractor to consult with the Mechanical Contractor before installing conduits or pull boxes for electrical feeders, so that any conflicts between the locations of conduit runs, piping and ductwork will be adjusted before installation. In general, large pipe mains and air ducts shall be given priority in available space. Conduit runs shall be installed so as to maintain, wherever practical, a minimum separation of 3" from water and waste piping, and 12" from steam piping. All conduit runs shall be parallel or perpendicular to building lines.

It shall be this Contractor's responsibility to see that all roughing-in work for concealed electrical devices is done within required tolerances.

All equipment shall be installed with ample space allowed for removal, repair or changes to the equipment. Ready accessibility to removable parts or equipment and to all wiring shall be provided without moving equipment which is installed or which is already in place.

Electrical equipment, outlet boxes, conduit, etc., shall not be attached or otherwise fastened to duct work or other mechanical equipment except where indicated on the drawings or approved by the engineer.

.05 MATERIALS AND WORKMANSHIP

All materials and equipment furnished under this contract shall be new and shall be listed by the Underwriter's Laboratories, Inc., as conforming to its standards in every case where such a standard has been established for that particular type of material.

All workmanship shall be performed in a workmanlike manner by workmen skilled in the trade and shall present a neat appearance.

.06 CODES, STANDARDS, PERMITS, FEES AND LICENSES

All work shall meet all requirements of the latest edition of the National Electrical Code (NFPA 70) and all national, state and local regulations that may apply. Standards of the following associations or organizations shall be followed where applicable as minimum requirements:

UL	Underwriters Laboratories
IEEE	Institute of Electrical and Electronic Engineers
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NBFU	National Board of Fire Underwriters
EEI	Edison Electric Institute
IPCEA	Insulated Power Cable Engineers Association
ASTM	American Society for Testing Materials

Where requirements indicated on the drawings or specified herein are in excess of the applicable codes and standards, the requirements of the drawings and these specifications shall govern.

The rules and regulations of the local utility companies providing service shall be checked and complied with where applicable.

All fees, permits, licenses, etc., necessary for this work shall be obtained and paid for by this Contractor.

.07 BROCHURE OF EQUIPMENT
Prior to final acceptance of the work, the Electrical Contractor shall furnish two (2) copies of the complete portfolio covering all electrical systems and equipment furnished by him under these specifications. The complete portfolio shall include approved shop drawings, operating and maintenance instructions and replacement parts listed for such equipment, with all material carefully segregated and identified. Information shall be printed or typewritten, neatly folded and bound in a 8 1/2" x 11" expansion post binder.

Such information shall be provided for all fixtures (identified by type), panelboards, wiring devices, receptacles, bus duct, primary cable high potential test report, and auxiliary systems included in these specifications.

.08 SHOP DRAWINGS
Shop drawings on equipment furnished under paragraph 1630.01, 1630.02, 1630.03, 1640.03, and 1680 of these specifications shall be submitted to the Architect before such material is ordered. Shop drawings shall include size, dimensions, capacity rough-in, accessories, descriptive information, installation information, etc. and other information as specified. Six (6) copies will be distributed as follows: Engineer (2); Contractor (2); and (2) for the Owner's "Brochure of Equipment".

.09 AS-BUILT DRAWINGS This Contractor shall maintain
This Contractor shall maintain a complete set of electrical drawings at the job site at all times, to be marked up as "as built" drawings. This set shall be kept up to date and include

all changes and/or additions to the electrical work. At the completion of the project this set of drawings shall be submitted to the Architect before final payment will be approved.

.10 CUTTING AND PATCHING

Where cutting is required to facilitate construction, this contractor shall patch and repair all such openings to the original state. However, structural elements shall not be cut without the written approval of the engineer or his representative.

.11 EXISTING WIRING AND EQUIPMENT

Necessary modifications and adjustments to all electrical items and equipment, both new and existing, shall be made as may be required by these alterations and additions. Careful inspection of the plans and site is required as the plans do not indicate all such electrical items and equipment.

Existing electrical materials and equipment, including but not limited to lighting fixtures, wiring devices, signal equipment, conduit and wires, and all other electrical items which are rendered obsolete by these alterations and additions, shall be disconnected at source and removed.

Existing electrical materials and equipment, including but not limited to lighting fixtures, wiring devices, signal equipment, conduit and wires and all other electrical items which interfere or are interfered with, obstruct or are obstructed by these alterations and additions, shall be disconnected, removed, and relocated. Such items shall be permanently installed in new locations as directed. New outlets, conduit, wiring, etc., shall be provided as required to extend wiring to new locations. Such items shall be reconnected to proper operating condition in new locations.

Uninterrupted services shall be maintained to all areas during these alterations and additions.

.12 EXISTING MATERIAL AND EQUIPMENT

All existing material and equipment removed under this contract shall remain the property of the Owner and, unless reused, shall be stored or disposed of as directed by the Owner. This Contractor shall be responsible for damage to equipment removed under this contract and shall repair or replace such damaged items without cost to the Owner.

.13 IDENTIFICATION

All switchboard equipment, panelboards, disconnect switches, motor starters, contactors, remote control and indication devices, and other indicated equipment shall be furnished with

identification labels. All main switchboard device labels and panelboard designation labels shall be made of laminated type bakelite and shall be sized relative to the apparatus to which they are attached.

Unless otherwise noted or specified, engraving shall be white letters on black background for normal power distribution utilization equipment, and white letters on red background for equipment connected to the emergency electrical system. Lettering shall be as shown, or shall indicate equipment function where specific engraving is not indicated.

Labels shall be fastened to the equipment with bolts, sheet metal screws or epoxy cement.

.14 SLEEVES AND INSERTS

All sleeves, inserts, forms, etc., required for openings shall be furnished by this Contractor. The Electrical Contractor shall be responsible for their size, fabrication and location and installation. When construction is completed previous to the installation of sleeves, inserts, forms, etc., necessary cutting and patching shall be at the expense of this Contractor.

Inserts shall be installed for hanging or bracketing all conduits to construction, wherever any work included in this contract is attached to new concrete work.

Inserts shall be set during the construction of the building and shall be set only in locations approved by the engineer.

Inserts shall be Crawford Company, Fig. 50 and 51, Trucson, or Grabler Manufacturing Company's adjustable concrete inserts, or approved equal.

Where inserts have been improperly located, or where it is necessary to support conduits from present masonry construction, the Contractor shall anchor conduit hangers and supports with Philips, or approved equal, expansion bolts. Location of expansion bolts must have approval of engineer.

Sleeves shall be provided for 1" conduit and larger, and shall be packed with Dura-Gum.

.15 ACCESS PANELS

Conduit and wiring shall be so arranged that remote electrical controls can be operated and/or properly maintained through access panels. Access panels shall be provided as required

for this part of the work. The Contractor shall cooperate with the Architect on the location of the panels so that they will be least obtrusive and will work best into the architectural treatment of the respective rooms.

.16 MANUFACTURER'S NAMEPLATES

Each major component of the equipment shall have the manufacturer's name, address, model number and rating on a plate securely affixed in a conspicuous place. The nameplate of a distributing agent is not acceptable. ASME code ratings, or other data which is die-stamped into the surface of the equipment, shall be stamped in easily visible locations.

Manufacturer's nameplate, identification or symbol shall not be permitted on equipment, apparatus or material in finished or habitable spaces, located so as to be visible or exposed to view. For equipment, apparatus or material in finished or habitable spaces, nameplates and/or identifications shall be concealed in accessible locations. Deviations from the above shall not be permitted except by specific written permission from the Architect. This paragraph does not apply to Underwriter's Laboratories labels or other labels required in these specifications.

.17 PAINTING

All shop-fabricated and factory-built equipment not galvanized or protected by painting shall be cleaned and given one (1) shop coat of red lead or zinc chromate primer before delivery to the site. Any portions of the shop coat damaged in delivery or during construction shall be recoated. All finish painting will be done according to the "Painting" section of the General Work.

Nameplates, labels, tags, stainless steel or chromium plated items such as shafts, levels, handles, trim, strips, etc., shall not be painted.

.18 PROTECTION OF WORK

The Contractor shall protect his work done under this Contract from injury by keeping all conduit capped or plugged, drained, or otherwise protected from injury, including damage done by freezing, flooding and/or stoppage from building materials or dirt.

The Contractor shall protect all equipment and fixtures furnished under this Contract from damage during the construction of the building and he shall provide all tarpaulins, drop cloths, barricades, temporary heaters and/or auxiliary equipment as may be required.

Any materials or equipment that are injured or damaged shall be removed immediately and replaced with new materials or equipment to the satisfaction of the Architect.

.20 SUBSTITUTIONS AND MATERIALS APPROVAL

All materials and equipment shall be new and shall be listed by the Underwriters Laboratories, Inc. as conforming to its standards in every case where such a standard has been established for the particular type of material in question.

The materials for which a manufacturer is not specified shall be high quality products made by nationally recognized and substantially established manufacturers.

The manufacturers and/or proprietary names specified are not limiting but do indicate the desirable quality, size, appearance and performance. It is the responsibility of the successful bidder to request approval of any material or equipment he wishes to substitute for specified material or equipment prior to his signing a contract. Request must be submitted in triplicate with supporting data, and should follow in sequence the articles of the specifications.

Any changes in the work necessitated by the Contractor's choice of equipment shall be the responsibility of the Contractor and shall be accomplished at no additional cost to the Owner.

In the event this list of substituted equipment and/or materials is not received by the Engineer before Contracts are signed, this Contractor shall therefore be bound to furnish all the items as specified.

The Engineer reserves the right to require the removal and replacement of any material or equipment which does not meet the specifications and does not have the written approval of the Engineer as a substitute item. This requirement may be enforced at any time of discovery regardless of the degree of completion of the installation.

.21 TEMPORARY LIGHTING AND POWER

This Contractor shall provide any and all temporary lighting and power required for the performance of this Contract and as needed by other contractors on this project.

.22 CLEAN-UP

This Contractor shall cooperate with other workmen and with the General Contractor in the daily removal of debris from the work site.

This Contractor shall leave "broom clean" all areas where he has interrupted or completed his work.

He shall cooperate with the General Contractor in good housekeeping procedures.

At the completion of his work, prior to the final inspection, this Contractor shall clean all devices, plates, fixtures, glassware, switches, cabinets, exposed conduits and fittings and shall leave the premises in a thoroughly clean condition.

.23 SUBMITTALS

Certain submittals are required under the Electrical Contract. It is essential that these items be transmitted in a timely manner so as not to delay any facet of the project.

The following items are representative of the above submittals:

(1) request for substitutions
(2) certificate of insurance
(3) performance bond
(4) cost breakdown
(5) requests for payment
(6) shop drawings
(7) balancing report
(8) ground verification letter
(9) brochure of equipment
(10) "as built" drawings

All submissions shall be sent with a transmittal form which explains the reason for and the extent of the transmittal. It shall be dated and signed.

.24 INSTRUCTION OF OWNERS PERSONNEL

The Electrical Contractor shall ensure that personnel designated by the Owner shall be instructed, to the Owner's satisfaction, in the use of equipment and systems listed below:

(1) emergency power system
(2) control system

.25 INSPECTION
Regular electrical inspection shall be requested of duly authorized electrical inspectors. All charges for such inspection shall be paid for by this Contractor as part of this Contract.

.26 GUARANTEE
This Contractor shall guarantee all material and workmanship supplied under this Contract to the extent of replacing without additional cost any work or material which is found to be defective within a period of one (1) year from the date of final acceptance by the Owner.

.27 COST BREAKDOWN
The Electrical Contractor shall furnish for Engineer's approval a cost breakdown, for the purpose of determining progress payments during construction. The breakdown and subsequent payment requests shall be submitted in a format similar to that on the following pages.

Request for payments will not be certified until a satisfactory cost breakdown has been received by the Engineer.

COST BREAKDOWN

Item No.	Item	Material	Labor	Total
1.	Administration, Overhead, Taxes Permits, Insurance, Fees			
2.	Building Wiring Including Boxes, Conduit, and Wire (Rough-in)			
3.	Device and Device Plates			
4	Fixtures and Fixture Wiring			
5.	Temporary Wiring			
6.	Branch Circuit Panelboards & Feeders			
7.	Power Panels & Feeders			
8.	Control Panels & Wiring			
9.	Electrical Equipment Wiring			
10.	Emergency Generator			
11.	Miscellaneous			
	TOTALS	_____	_____	_____

SECTION 1610

BASIC MATERIALS AND METHODS

INDEX

SECTION 1610

BASIC MATERIALS AND METHODS

.01 WIRING SYSTEM

All wiring shall be installed in a continuously grounded metallic conduit system. The number of wires in branch circuit conduits is indicated by the number of cross lines appearing across conduit runs between outlets as shown on the plans; conduits not marked contain only two wires. All wiring shall be color-coded. Numerals generally shown in the righthand quadrant, at branch circuit outlets, indicate circuit numbers.

.02 CONDUCTORS

All wire shall be copper and shall be type THW, THWN or XHHW, unless otherwise indicated or required. All branch circuit wire shall be #12, or larger. All wire shall be color coded.

Wire shall be any one or all of the following manufacturers: General Cable, Rome, Triangle, or approved equal.

.03 WIRING DEVICES

Switches shall be Arrow-Hart 1990 series, gray, quiet mechanical-type, 20 ampere, AC rated or approved equal.

Duplex receptacles sahll be Arrow-Hart #5735-S-GRY, three (3) wire grounding type rated at 20 amperes, or approved equal.

Duplex receptacles indicated as weatherproof G.F.I. shall be surface mounted horizontally and shall be equipped with duplex plate, complete with gasketed spring door covers.

Combination switch and pilot lights shall be Sierra #5029R neon type with red lighted toggle, or approved equal.

Pilot lights shall be Arrow-Hart #1720 complete with red plastic jewel and 1/25 watt neon lamp, or approved equal. This unit fits a single gang switch plate with opening of the type required for the specified switches.

Device plates for concealed wiring shall be Sierra satin finished #302 stainless steel, or approved equal. Plates shall be engraved where noted on the plans. Engraving shall consist of 1/8" block letters with black filler. Device plates for exposed

wiring shall be the pressed steel type. Device plates for outlets on emergency power shall be stainless steel painted #13655 yellow.

Standard mounting heights of devices shall be as shown on the plans and shall be to the center line of the device, unless otherwise specified or noted.

Hubbell, Pass & Seymour, or Sierra switches and receptacles, with published comparative catalog numbers, will be accepted as substitutes for the devices specified.

.04 CONDUITS AND WIREWAYS

Galvanized rigid metal conduit shall be used for wiring installed in the earth below slabs, for wiring installed in slabs laid directly on earth, for wiring in outside walls below grade, and for exposed exterior wiring, including conduits exposed on roof.

Flexible metal conduit or electrical metallic tubing may be used at all other locations as permitted by code.

Where indicated on the drawings or required by the building construction, the Contractor shall furnish and install conduit expansion fittings made by O.Z., or approved equal.

All devices (LB's, hubs, couplings, etc.) for steel conduit shall be galvanized malleable iron or steel.

Flexible metal conduit (18" maximum length) shall be used for final connections to motors and other equipment with flexible mounting in dry locations. Liquid-tight flexible metal conduit shall be used for final connections to motors and other equipment with flexible mounting in wet locations.

Couplings and connectors for electrical metallic tubing shall be the rain-tight steel compression type or the concrete-tight steel set screw type.

Rigid conduit connections at boxes outdoors, or where subjected to moisture, shall be made with threaded hubs and bushings. Rigid conduit connections to NEMA 1 enclosures where not subject to moisture shall be made with double-lock nuts and O.Z. type B insulated steel bushings, or approved equal.

Flexible metal conduit shall not be coupled to flexible metal conduit. Connectors for flexible metal conduit shall be the angled wedge, or set screw type.

All conduit installed in earth shall be thoroughly coated with Bitumastic #50, or approved equal, before being covered with back-fill.

Aluminum conduit may be used. When using it, the Contractor must comply with the following requirements:

a. Local codes governing the use of aluminum conduit must be observed.
b. Aluminum conduit shall not be embedded in concrete or underground.
c. Aluminum conduit shall be limited to feeder conduits two (2) inches and larger.
d. Bending, cutting and threading operations shall conform to manufacturer's recommendations, and approved aluminum lubricant shall be used on threaded connections.

Conduit shall be produced by any one or all of the following manufacturers: Republic, Rome, Triangle, or approved equal.

O.J. Type R cable supports shall be provided for vertical risers at 30' minimum intervals.

Wireways shall be provided where shown on the drawings and as specified hereinafter. Wireways for panelboards shall be sized as shown on the drawings and shall have screw covers. Closure plates shall be provided at the ends of the wireways, and wireways shall be secured to the panelboard and pull box by means of a 2-1/2" chase nipple, lock nut and insulated bushing. Wireways for the motor equipment shall be as sized on the drawings and shall be equipped with hinged covers and closure plates.

Where conduit passes through spaces where it may be subject to mechanical abuse, this contractor shall furnish and install adequate conduit protection and shall route conduit to minimize mechanical damage.

OUTLET BOXES

Each switch, light and wall receptacle outlet shall be equipped with an approved type outlet box of steel or malleable iron, heavily galvanized to prevent rusting, as manufactured by any one or all of the following manufacturers: Nation Electric Products Corporation, Appleton, Steel City, Raco, All Steel Equipment, Inc., or approved equal.

The heights of bracket outlets, switch outlets, clock outlets, etc., shall be as indicated on the drawings, or shall be obtained from the Architect. The Contractor shall particularly note spaces where ceilings are furred down or suspended and in all such spaces he shall extend conduits and install the outlets to conform with requirements therefor.

All ceiling and bracket outlets for supporting lighting fixtures shall be equipped with a 3/8" malleable iron fixture stud. Studs shall be No-bolt type as manufactured by Steel City Electric Company.

Outlet boxes for single or two-gang switches in plastered walls shall be 4" x 4" x 2-1/8" with plaster rings of the same thickness as the depth of plaster. Where three or more switches are installed in one location, suitable gang-boxes shall be used. The gang-boxes shall not be less than 2" deep and shall be complete with plaster rings.

Outlet boxes for switches installed in unfinished concrete walls and columns or concrete block walls shall be 4" x 4" x 1-1/2" boxes with tile covers, installed flush with surface of the concrete or concrete block. Deeper boxes shall be installed where conditions and locations require same. Steel barrier plates shall be provided in all ganged 277 volt switch outlet boxes.

Outlet boxes for glazed tile, brick and concrete block walls shall be 4" x 4" x 1-1/2" boxes with tile covers. Opening in wall shall be cut carefully and true by sawing.

Outlet boxes for wall receptacles shall be as specified for switches above. Where multiple installation of receptacles is indicated or required, multi-gang boxes shall be installed.

Outlet boxes for exterior waterproof lighting fixture shall be an integral part of the fixture as provided by the fixture manufacturer, and shall be installed flush in the exterior walls except as indicated otherwise on the drawings.

Outlets for weatherproof locations and all devices and outlets in all surface-run conduit installations, except where indicated otherwise, shall be type FS or FD conduit boxes with threaded hubs and mounting lugs as manufactured by any one or all of the following manufacturers: Pyle National, Appleton or Crouse-Hinds. Boxes in weather-proof locations shall be equipped with cover plates complete with gaskets, suitable for the device installed as hereafter specified or as indicated.

All ceiling outlets shall be located with due consideration given to clearance from ventilating ducts and mechanical piping. Where numerous ducts occur, conduits and outlets may be installed after ventilating ducts are in place.

Where outlets occur in plastered or concrete finish ceilings, outlet boxes shall be installed to finish flush with the finished

ceiling line. Where ceiling outlets occur on acoustically treated ceilings, they shall be equipped with extension rings finishing flush with acoustical ceiling lines.

Outlet boxes installed in concrete slab for ceiling lights shall be concrete boxes with back plate and fixture stud. At time of box installation and prior to concrete pouring, plug conduits and fill boxes with sand to prevent concrete entrance.

.06 FUSES

Cartridge fuses for motor branch circuits 60 amperes or less shall be Buss, FRN, FRS (or type as indicated) or approved equal.

Cartridge fuses for all other applications shall be Buss, LPN, LFS, (or types as indicated) or approved equal, for 600 amperes or below and Buss Hi Cap, or approved equal, for above 600 amperes. Plug fuses shall be Buss Fustats or approved equal. Fuses shall all be of one make. Feeders and other equipment shall be fused to conform to the requirements of the National Electrical Code. One (1) set of three (3) spare fuses of each type and size used shall be provided.

.07 PULL BOXES

Pull boxes shall be installed as required in long runs, or when more than the equivalent of four quarter bends occurs in any conduit runs. All pull boxes shall be sized to conform to the requirements of Section 370-18 of the National Electrical Code.

.08 EQUIPMENT FURNISHED BY OTHERS

This Contractor shall install feeders for all equipment indicated as furnished by others. These feeders shall terminate in safety switches, J-boxes, receptacles, or capped outlets, as indicated or required, from which point all wiring for these items will be installed by others.

.09 GROUNDING

The electrical system and equipment shall be grounded in accordance with the National Electrical Code, as shown on the drawings and as specified hereinafter.

All metal, non-current carrying parts of transformers, primary disconnect switch, cubicle framework, ground bus in cubicles, motor control centers, primary cable, cable supports, conduits, switches, panelboards and other electrical equipment shall be securely grounded to the system ground.

The Contractor shall furnish and install an O.Z. type building grounding bushing on all conduit stubs from the floor to floor-mounted equipment.

The Contractor shall furnish and install a grounding conductor in each feeder circuit and branch circuit exceeding 20 ampere rating and in each motor branch circuit. Grounding conductor shall be sized as shown on the drawings. Grounding conductor is indicated by suffix "G".

.10 WIRE AND CABLE SPLICES AND TERMINATIONS

Unless specified otherwise, all wire and cable splices shall be insulated with Scotch #33 plus electrical tape. A uniform layering of the tape, covering the complete splice, shall be of such a thickness as to provide 600 volt insulation over the splice. All branch circuit wire and cable splices in conductors up to and including No. 10 gauge shall be connected by means of twist nut connectors. Connectors shall be Ideal Wing-Nut, 3M Scotch-Lok, or approved equal.

All wire and cable splices in conductors of larger sizes than No. 10 gauge shall be made with clamps or bolted type connectors. Where clamp-type lugs or any bolting connection is used, all contact surfaces shall be cleaned to ensure maximum conductivity.

SECTION 1620

ELECTRIC SERVICE

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SECTION 1620

ELECTRIC SERVICE

.01 SERVICE

Service shall be obtained from an available 600 volt, 3 phase, 3 wire source within the plant. This contractor shall verify the location of service connection and routing of feeders with the owner.

This contractor shall furnish and install fused safety switches as shown on the plans and the tap main bus at the building main distribution switchboard, or shall make connections to available spare over current protection devices as directed by the owner.

.02 GROUNDING

Grounding shall conform to the requirements of the National Electrical Code.

SECTION 1630

ELECTRICAL DISTRIBUTION SYSTEM

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SECTION 1630

ELECTRICAL DISTRIBUTION SYSTEM

.01 LIGHTING PANELBOARDS

This Contractor shall furnish, install and connect all lighting and branch circuit panelboards as shown on the drawings and as specified hereinafter. Panelboards shall be equipped with circuit breakers and shall be furnished with copper ground bus and neutral bus and shall be as manufactured by Cutler Hammer, Federal Pacific, General Electric, ITE, Square D, Westinghouse or equal, approved by the Architect. Nomenclature used is that of the Westinghouse Electric Corporation.

Bus bar connections to the branch circuit breakers shall be the "distributed phase" or "phase sequence" type. Bussing shall be such that any adjacent single pole breakers will be on different phases or polarities and that two or three pole breakers can be installed on any location. Bus structure shall be copper and be braced for 25,000 RMS amps minimum. All copper parts shall be plated to prevent corrosion.

Panelboard numbering shall be such that, starting at the top, odd numbers shall be used in sequence down the left-hand side and even numbers shall be used in sequence down the right-hand side.

Cabinets shall be fabricated of code gauge galvanized steel. Top and bottom wiring gutter shall be a minimum of 4" wide. Side gutters shall also be a minimum of 4" wide, except where feeders 250 MCM and larger pass through, in which case gutters shall be increased as required by code. Front shall have doors in matching one-piece trim, be code gauge and be finished with rust-inhibiting primer and baked enamel. Fronts shall have adjustable indicating trim clamps, which shall be completely concealed when the doors are closed. A circuit directory frame and card with a clear plastic covering shall be provided on the inside of the door. The directory shall be typed to identify the load fed by each circuit using the final room numbers provided by the Owner. Fronts shall have flush locks with two (2) keys. All locks shall be keyed alike.

Circuit breakers shall be quick-make, quick-break, thermal-magnetic, trip-indicating and have common trip on all multi-pole breakers. Branch circuit breakers feeding convenience outlets shall have sensitive instantaneous trip settings of not more than ten (10) times the trip rating of the breaker. Connections to the bus shall be bolt-on. Ratings shall be as shown on the panelboard schedules. Where indicated, breaker shall be furnished with ground fault interrupter (GFI).

This Contractor shall furnish panelboards with ASCO-920 contactor where indicated. Contactor shall be complete with auxiliary relay for 2 wire control, and shall be switched by dry contacts in the system controller.

208/120 volt lighting panelboards shall be rated for use on a 208/120 volt, four-wire, three-phase system. Circuit breakers shall be type "BA" 100 A frame having a minimum short circuit current rating of 10,000 RMS amperes asymmetrical at 120/240 volts. Panelboards shall be type "BIOB".

Shop drawings shall provide all information required to verify compliance with these specifications.

.02 DISTRIBUTION PANELBOARD (600V)

The 600 V distribution panelboard shall be a Westinghouse Type CDP or equal, 600 volt, 3 phase, 3 wire, 100 amp, complete with circuit breakers, 100 amp, 3 pole, contactor, current transformers, potential transformers, and kilowatthour meter for owner metering as shown on the drawings.

The contactor shall be Asco 9204 TR9 100 amp, 3 pole, 600 volt with auxiliary relay for 2 wire control. Control power shall be 120 volt and shall be obtained from a fused control power transformer connected to the line side of the contactor.

Circuit breakers shall be Westinghouse Type JB or equal, 22,000 amp interrupting capacity (symmetrical). Panelboard shall be rated to withstand the forces associated with a 22,000 a symmetrical fault. The contractor shall furnish a copper ground bus.

Box shall be constructed of code gauge steel, painted blue-gray. Front shall be without doors and shall have fully concealed self-aligning trim clamps.

Shop drawings shall provide all information required to verify compliance with these specifications.

.03 DRY TYPE TRANSFORMERS (T-xx)

Dry type transformers shall be furnished as herein specified and as indicated.

Transformers shall be of the non-explosive and fire-resistant type and shall be cooled by natural circulation of air through and around the windings. The transformer shall be capable of continuous operation at rated load, voltage and frequency, with a maximum temperature rise of 150 degrees C above an ambient temperature of 40 degrees C.

Single-phase transformers rated at 10 KVA or less shall be furnished with a minimum of two (2) 5% full capacity taps below

rated voltage. Single-phase transformers rated at 15 KVA and above shall be furnished with a minimum of four (4) 2-1/2% full capacity taps below rated voltage.

Three-phase transformers rated less than 30 KVA shall be furnished with a minimum of two (2) 5% full capacity taps below rated voltage. Three-phase transformers rated 30 KVA and larger shall be furnished with a minimum of six (6) 2-1/2% full capacity taps, two above rated voltage and four below rated voltage.

Transformers shall be enclosed in a sheet metal housing with required ventilation openings and provision for conduit in the sides, top or rear. Construction and testing shall be in accordance with NEMA and ASA standards, and the transformers shall be UL listed.

Transformers shall have the core and coil assembly isolated with neoprene rubber isolation pads and sleeves and the transformer shall be set on Isomode, Keldur or Korfund isolation pads of proper size and thickness to reduce noise transmission to the building structure.

Transformer electrical connections shall be made with 18" minimum length of flexible conduit. This Contractor shall furnish all mounting devices and material required for the type of installation indicated.

Shop drawing information shall include impedance values, weight, dimensions and sound rating.

Transformers shall be Sorgel, General Electric, Hevi Duty or Westinghouse.

SECTION 1640

LIGHTING FIXTURES

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SECTION 1640

LIGHTING FIXTURES

.01 LIGHTING FIXTURES

The following listed fixtures, or approved equals, shall be furnished and installed complete with all lamps, ballasts and necessary hardware, mounting devices, plaster frames, etc., required for a complete operational unit. Each fixture shall be UL labeled as installed. Lens must be glass, virgin acrylic or lexan as indicated.

Capital letters adjacent to outlets indicate the fixture type; small letters indicate the manner of switching.

All fixtures shall be adequately supported by approved methods and shall be thoroughly cleaned before acceptance by the Owner.

The Contractor shall provide lock-offs on constant circuits where panelboards are used for switching lights, as indicated on the panelboard schedule.

All fixture mounting heights indicated on the plans are to the bottom of fixture for stem-suspended fixtures and to the center line of the outlet box for bracket-mounted fixtures.

.02 LAMPS AND BALLASTS

Incandescent lamps shall be 120 volt inside-frosted, unless otherwise indicated, and have the indicated shape.

Fluorescent lamps shall be as scheduled herein. Mercury vapor lamps shall be deluxe white. All lamps shall be General Electric, Sylvania, Westinghouse or approved equal.

Fluorescent ballasts shall be high power factor type, certified by ETL and have the CBM label where applicable. Ballasts shall have the following minimum sound rating: 430 ma, "A" rating; 800 ma, "B" rating and 1500 ma, "D" rating.

The temperature rating of all ballasts shall be such as to provide the design service and life under the installed conditions.

High intensity discharge lamp ballasts shall be externally in-line fused, constant wattage, high power factor, and designed for minus 20 degrees F starting and operation in the indicated ambient temperature. Ballasts shall be listed by UL and shall have the lowest sound rating consistent with the requirement of the application.

.03 FIXTURE SCHEDULE

Type	Description	Lamp
A	Benjamin #V7642. Pendant mounted, industrial standard vented dome incandescent fixture, 120 volt.	1-200 WIF A-23
B	GE #C537G114. Heavy duty weatherproof metal halide floodlight with galvanized steel trunnion bracket with seal for No. 12 3-conductor cable and 120 volt ballasts. Provide wall mounted angle bracket, GE #25-110728-06, and mount fixture on bracket as required.	1-MH1000W (Phosphor Coated)
B1	GE #C539G038. Pole mounted, heavy-duty weatherproof metal halide floodlight with galvanized steel trunnion bracket with seal for No. 12 3-conductor cable and 120 volt ballasts. Provide G.E. cat. no. 35-110728-05, 2 1/2" vertical pipe clamp.	1-MH400W (Phosphor Coated)
C	Appleton #VGAT1050. Wall mounted vaporproof incandescent fixture with 1/2" hubs, horizontal feed through integral junction box and with a 30° angle tilt reflector, Appleton #URW-2AN, 120 volts.	1-100WIF A21

SECTION 1670

ELECTRICAL POWER EQUIPMENT

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SECTION 1670

ELECTRICAL POWER EQUIPMENT

.01 GENERAL

The Electrical Contractor shall provide all power wiring as indicated and as shown on the motor and equipment schedule. Unless otherwise noted or specified, this shall include all power wiring from the switchboard, panelboards, or other indicated power source to the power outlet or safety switch; from the power outlet to the starter; and from the starter to the motor for all motors and equipment. Electrical Contractor shall furnish and install all interlock and control wiring between equipment and control devices as indicated.

The Mechanical Contractor and other Contractors will install equipment furnished by them except as otherwise specified or indicated.

Final connections to motors and controllers shall be made with flexible metal conduit. Each fusible device shall be labeled to indicate fuse size and type.

Wiring connections to motors shall be made with pressure one hole terminal lugs and bolts with washers, a double wrap of varnished cambric and taped with friction tape and final taped with Scotch 33 Plus. Insulate the motor leads from the motor frame opening with a double wrap of varnished cambric. Secure the cambric by taping to the motor leads. The varnished cambric may encompass all motor leads.

.02 SAFETY SWITCHES

The Electrical Contractor shall furnish and install enclosed safety switches where shown on the drawings or otherwise required by these specifications or by code. A non-fused safety switch or other disconnect shall be provided adjacent to each motor, except in locations where power distribution center is not over 50' distant and within sight of the motor.

Safety switches shall be the required voltage and current rating, shall have quick-make, quick-break operating mechanism, and shall, where indicated on the plans or required by code, be equipped with cartridge-type fuses.

Double-throw switches shall be designed for transfer under full load conditions, as manufactured by Federal Pacific.

Safety switches shall be the heavy duty horsepower rated type with cover interlock to prevent opening of cover with switch on. Interlock shall be equipped with a defeating mechanism to permit authorized personnel to open the switch cover with the switch in the closed position. Switch enclosure shall be as indicated or required by the installation.

Safety switches shall be as manufactured by Cutler Hammer, Federal Pacific, General Electric, ITE, Square D, Westinghouse, or approved equal, and shall be one make. All safety switches shall be labeled to identify equipment served. In all instances where safety switches serve equipment furnished by others, this contractor shall secure correct descriptions of equipment before preparing and installing labels.

SECTION 1680

STANDBY GENERATOR

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SECTION 1680

STANDBY GENERATOR

.01 GENERAL

The Electrical Contractor shall furnish and install complete a 30.0 KW, 277/480 volt, 3 phase, 4 wire, diesel fuel powered, standby generator set with a 60A, 3P automatic transfer switch.

The installation of a standby electric power system shall include an Onan 30.ODEH series or approved equal electric generating set rated for continuous standby service at 30KW, 37.50KVA at 0.8-PF. The system shall be a package of new and current equipment consisting of:

1. A diesel engine driven electric generating set to provide standby power.
2. An engine start-stop control system mounted on the generating set.
3. An automatic load transfer control to provide automatic starting and stopping of the engine and switching of the load.
4. Mounted accessories as specified.

This system shall be built, tested and shipped by the manufacturer of the alternator so there is one source of supply and responsibility. The performance of this generating set series shall be certified by an independent testing laboratory as to the set's full power rating, stability and voltage and frequency regulation.

.02 ENGINE

The engine shall be diesel-fueled, four-cycle, water-cooled with mounted radiator, fan and water pump. It shall have 4-cylinders and a minimum displacement of 254 cubic inches, with a minimum rating of 63-bhp at its operating speed of 1800-rpm. Intake and exhaust valves shall be heat resisting alloy steel, free rotating exhaust valves. Exhaust valve seat inserts shall be provided. Full pressure lubrication shall be supplied by a positive displacement lube oil pump. The engine shall have air cleaner, fuel and oil filters with replaceable elements; and a fuel transfer pump. Engine speed shall be governed by a mechanical governor to maintain alternator frequency within 5 percent from no-load to full-load alternator output. The engine shall have a 12-volt battery charging DC, alternator with a transistorized voltage regulator. Remote, 2-wire, starting shall be by a 12-volt, solenoid shift, electric starter.

.03 ENGINE INSTRUMENTS
The engine instrument panel shall contain an oil pressure gauge, coolant temperature gauge, and battery charge rate ammeter.

.04 ENGINE CONTROLS
The generating set shall contian a complete engine start-stop control which starts engine on closing contact and stops engine on opening contact. A cranking limiter shall be provided to open the starting circuit in approximately 45 to 90 seconds if the engine is not started within that time. The engine controls shall also include a 3-position selector switch with the following positions: RUN-STOP-REMOTE. High engine temperature, low oil pressure, and overspeed shutdown with signal light and alarm terminals shall also be provided.

.05 ALTERNATOR
The alternator shall be a 4-pole, revolving field design with temperature compensated solid state voltage regulator and brushless rotating rectifier exciter system. No brushes shall be allowed. The stator shall be directly connected to the engine flywheel housing, and the rotor shall be driven through a semiflexible driving flange to insure permanent alignment. The insulation system shall be Class F as defined by NEMA MG1-1.65. The three phase, broad range alternator shall be 12-lead, reconnectible.

The alternator shall be connected for 277/480 volts, 3-phase, 4-wire.

.06 UNIT PERFORMANCE
Frequency regulation shall not exceed 3-hertz from no load to rated load. Voltage regulation shall be within plus or minus 2 percent of rated voltage, from no load to full rated load. The instantaneous voltage dip shall be less than 18 percent of rated voltage when full, 3-phase, load and rated power factor is applied to the alternator. Recovery to stable operation shall occur within 2 seconds. Stable or steady state operation is defined as operation with terminal voltage remaining constant within plus or minus 1 percent of rated voltage. A rheostat shall provide a minimum of plus or minus 5 percent voltage adjustment from rated value. Temperature rise shall be within NEMA MG1-22.40 definition.

.07 ALTERNATOR INSTRUMENT PANEL
The alternator instrument panel shall be wired, tested and shock mounted on the generating set by the manufacturer of the alternator. It shall contain panel lighting; manual reset circuit breaker; frequency meter; running time meter; voltage adjusting rheostat; AC voltmeter (dual range, indicates all voltages); AC ammeter (dual range, indicates current each phase); meter switch, voltmeter-ammeter phase selector with OFF position. Single phase instrumentation includes voltmeter, two ammeters and no selector switch.

.08 GENERATOR SET MOUNTING

The electric generating set shall be equipped with vibration isolators and mounted on a welded steel base which shall provide suitable mounting to any level surface.

.09 ACCESSORIES

All accessories needed for the proper operation of the generating set shall be furnished. These shall include a muffler, flexible exhaust connection, starting batteries, battery cables, battery rack, fuel tank and lines, and detailed operation and maintenance manuals with parts list.

The fuel tank shall have a capacity of eight (8) U.S. gallons and shall not require a float switch.

.10 AUTOMATIC LOAD TRANSFER SWITCH

A 60A, 3P, automatic transfer switch shall be furnished and installed as part of the generator package. The complete control shall be designed, built and tested by the manufacturer of the alternator. It shall include the necessary relays and component parts, together with U.L. listed and tested electrically or mechanically interlocked contactor and shall be field interlocked with the system controller to function as follows:

1. Upon failure of the normal source and if auxiliary contacts of 45 AMP breaker in main distribution panel are closed, the plant shall start, and when up to voltage, the switch shall disconnect the load circuits from the normal source and transfer them to the standby plant's output. One set of normally open and one set of normally closed contacts shall be furnished in the ATS control to indicate standby or normal source.

2. Upon return of normal power the load circuits shall transfer back to normal source.

3. Automatic operation, stopping, checking or providing manual cranking of the plant by means of a 4-position, manual control selector switch.

4. A cranking limiter shall be provided to protect the batteries and starting circuit. It will open the starting circuit in approximately 45 seconds if the plant has not started within that time.

Each contact pole of the main transfer device shall be double break design, with solid silver cadmium contacts, capable of handling both noninductive and inductive loads and allow for inrush currents of 20 times the continuous rating. Contact pressure shall be maintained by a coil spring, not a part of the current carrying path. The ampere rating of the transfer switch shall be sufficient to handle the capacity of the loads being transferred.

The control shall contain a 12 volt, fused, battery trickles charging circut with a rheostat and ammeter, to maintain starting batteries fully charge.

.11 WARRANTY

This standby electric power system, furnished completely by the manufacturer, shall be warranted for a period of five years from the date of installation.

.12 SHOP DRAWINGS

Shop drawings shall be furnished to verify compliance with these specifications.