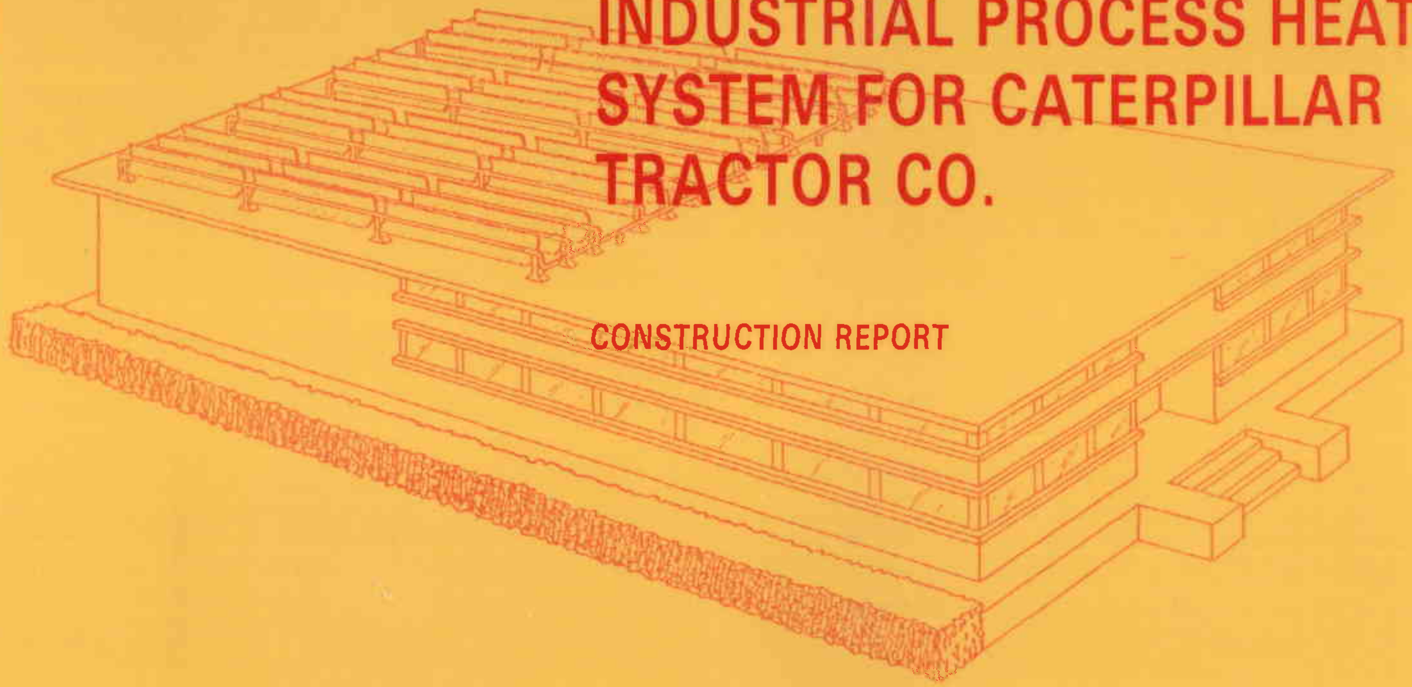
A LARGE-SCALE SOLAR INDUSTRIAL PROCESS HEAT SYSTEM FOR CATERPILLAR TRACTOR CO.



CONSTRUCTION REPORT

PREPARED FOR:
DEPARTMENT OF ENERGY

SEPTEMBER 30, 1982

SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO HOUSTON

SOUTHWEST RESEARCH INSTITUTE
Post Office Drawer 28510, 6220 Culebra Road
San Antonio, Texas 78284

A LARGE-SCALE SOLAR INDUSTRIAL PROCESS HEAT SYSTEM FOR CATERPILLAR TRACTOR CO.: CONSTRUCTION REPORT

Prepared by:
D. M. Deffenbaugh

Project No. 02-5821

Prepared for:
DEPARTMENT OF ENERGY

September 30, 1982

Approved:
Robert L. Bass

Robert L. Bass, Director
Department of Mechanical Sciences

EXECUTIVE SUMMARY

The objective of this phase of the project was to construct the solar process heating system previously designed for the Caterpillar Tractor Company's San Leandro plant. This phase of the project was completed on time and within 1% of the construction budget.

The San Leandro plant's predominate energy load is its parts washing activity. This activity requires 836 gpm of 235°F pressurized hot water, and is ideally suited to integrate with a simple solar hot water system. The climate at San Leandro is, also, ideally suited for a solar thermal system. Located on the east shore of the San Francisco Bay, San Leandro enjoys a relatively mild climate with an average solar radiation of 1536 Btu/ft^2/day. The collector performance, therefore, is estimated to provide 12 billion Btu/yr with a peak output of 9 million Btu/hr and a best day output of 83 million Btu/day.

The solar thermal system consists of 50,400 ft^2 of parabolic trough collectors. These collectors are assembled in a simple open loop hot water heating system that provides 450 gpm of heated hot water at 235°F. The overall quality of construction is excellent and is illustrated by the photographs documenting construction.

The thermal performance of this system will be determined during the operational phase and recorded by the computer based automatic data acquisition system provided.

As with any construction project, especially an experimental system such as this, a number of construction problems were encountered. Since the majority of these problems were resolved during construction only a few recommended modifications are presented, and most of these have to do with the collector hardware itself. In summary, this phase of the project was highly successful and a relatively trouble-free operating phase is anticipated.

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INTRODUCTION

I. INTRODUCTION

This document is a phase report for the construction activities on DOE Project No. DE-FC03-79CS30309 (SwRI Project No. 02-5821). This program was conducted as a cooperative agreement between the U. S. Department of Energy (DOE) and Southwest Research Institute (SwRI) with Caterpillar Tractor Co. (CTCo.) acting as the industrial partner.

From a financial point of view the project was cost-shared between DOE and CTCo. The financial arrangements were somewhat unique with DOE funding 75% of construction and CTCo. funding 25%, but CTCo. would finance 100% of any overruns. The original construction phase (DOE Phase II) was budgeted in design as $2.8 million. After the design package went out for bid, the total bid came in at $2.832 million which is within 1.2% of the design estimate. As will be detailed under the construction problems and the cost comparison sections of this report, the construction field orders issued to solve construction problems pushed the construction budget to $2.938 million. This additional $138,000 cost growth was authorized and funds were provided by CTCo. The construction budget was eventually underrun by $110,000 so that the final construction cost was $2.828 million. This $110,000 underrun was a tribute to the excellent construction management provided by Rudolph and Sletten, Inc., the project general contractor. The net result was that the project was completed on time (considering the original 2-year construction phase) and within the construction bid price of $2.832 million. It was also within 1% of the original design estimate.

The solar industrial process heating (SIPH) system is a very simple open loop hot water system that takes 195°F water and heats it to 235°F under clear sky conditions. This system consists of 50,400 ft^2 of Solar Kinetics, Inc. T-700 parabolic trough solar collectors. The collector array is composed of 60 drive rows each 120 ft long by 7 ft wide. This array is divided into two fields, a north field of 16 rows (13,440 ft^2) and a south field of 44 rows (36,960 ft^2). Within each field these rows are assembled with two rows in series so that 30 delt-T strings are configured in parallel.

The remainder of this report is organized to provide a detailed description of the plant process interface, details of construction, outline of problems encountered, construction cost comparison, recommended system changes, assessment of performance, and as-built drawings.

INDUSTRIAL PLANT

II. INDUSTRIAL PLANT

A. Plant Site

The facility at which this solar industrial heat system is installed is the Caterpillar Tractor Company's San Leandro Plant. This plant produces a variety of fuel injection components for use on Caterpillar diesel engines. In this manufacturing operation the major portion of energy consumed is for industrial parts washing. These washers are required to clean parts after critical machining operations so that inspection can be performed for quality control. The impact of energy consumption of these parts washers has necessitated a major effort to investigate ways of reducing the total energy required. A major effort has been underway to replace a large number of high-temperature washers with medium- to low-temperature washers and, wherever possible, with room temperature washers. This investigation has centered on testing the effectiveness of lower temperature detergents. Unfortunately, some of the final machining operations prior to priming the end product still require the high-temperature washers. The process water temperature of 235°F is, therefore, the minimum possible.

A drawing of the process heat supply system at the San Leandro plant is shown in Figure 1. Basically, hot water is generated in the hot water "boilers" and is then pumped through a hot water supply header that encircles the building. Every 40 feet there is a 2-inch valved outlet for connection to process equipment and an accompanying 2-inch valved inlet to the hot water return header. The cooled process water is then returned to the "boilers" via boiler feed pumps. The building circulation pump system consists of four hot water pumps piped in parallel; likewise, the boiler feed pump system also consists of four hot water pumps piped in parallel. The maximum required flow rate is 1672 gpm for 20°F temperature difference through the process equipment and 836 gpm for a 40°F temperature difference. The process hot water generating system is comprised of two natural gas fired hot water heaters (or "boilers") rated at 500 boiler horsepower which is equal to 16,738 MBH (10^3 Btu/hr). A list of the process heating loads is shown in Table I. The maximum total load is 32,528 MBH with a 10% (3000 MBH) reserve. Since most of the process equipment is intermittent service, past plant experience indicates a 14,000 MBH design criteria for the manufacturing process.

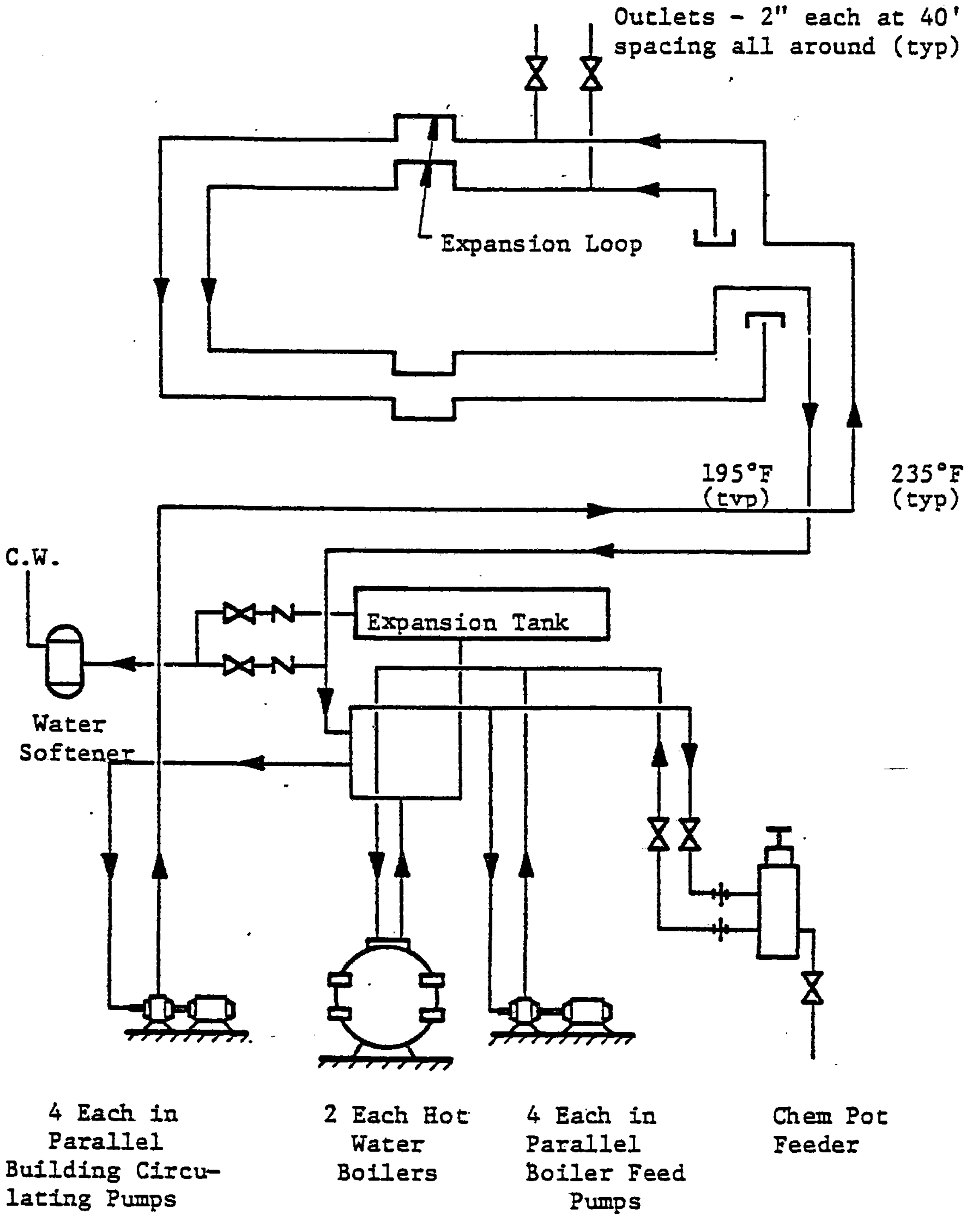


FIGURE 1. PROCESS HOT WATER FLOW DIAGRAM

TABLE I. PROCESS HEATING HOT WATER LOAD

	Connected Load*				
Description	Quantity	Flow Duration	System Type	Heating (MBH)	Water Flow (gpm)
Process washer	1 each	Intermittent	Closed	10,508	525
Process washer	6 each	Intermittent	Closed	8,407	420
Office heating	52,000	Intermittent	Closed	7,800	390
Tumbling area	2 each	Intermittent	Closed	1,201	60
Tacco H.T. unit	4 each	Intermittent	Closed	1,201	60
Wash and test - Met Lab	1 lot	Intermittent	Closed	300	15
Insulation line loss	1 lot	Continuous	N.A.	111	0
Reserve	10%			3,000	150
Total				32,528	1,620
Caterpillar Tractor Co. design criteria (including diversity) manufacturing process				14,000	

---

* Process heating hot water boiler ratings. Each boiler (500 boiler horsepower) equals 16,737.5 MBH, 1672 gpm flow rate for 20°F temperature difference, or 836 gpm flow rate for 40°F temperature difference.

This manufacturing operation is located in a two-story factory with a flat roof of 360 ft by 1092 ft (393,120 ft^2). The support structure for this roof consists of a truss structure between support columns spaced on 40-ft centers with steel 10-inch I-beam purlins on 6-2/3 ft centers. These purlins are oriented in the north/south direction so that the installation of the collector field is oriented with the collector axis of rotation in the north/south direction.

Since the collector field is proposed to be installed on the second story roof top of the industrial plant, factors pertaining to topography, geologic stability, hydrologic conditions, adequate open land area, and land use restrictions are not relevant. As with any other application in a large metropolitan area, however, the collector field will be visible to air traffic, but since the type of collector chosen will either be facing the factory roof or pointing directly at the sun focusing all the rays from the sun onto an absorber tube, there is no danger of glare from the collectors causing a hazard to aircraft or vehicular traffic. The only potential problem with the location selected is the severe seismic zone that the plant is located in. The type of collector selected has a much larger horizontal wind load design requirement than the maximum expected seismic load, therefore, no problem is anticipated.

B. Climatological Summary

The climatological characteristics of this site have three outstanding features: mild year-round temperatures; low overcast, clearing by noon with almost no rain during the summer; and copious rains during the winter.

Located on the east shore of San Francisco Bay, San Leandro enjoys a climate more equable than would be expected if only latitude were considered. Because of the prevailing westerly winds from the Pacific, where temperature varies very little between winter and summer, winters are mild and summers are cool. On an average of about 4 days a year, when northeasterly winds have overcome the prevailing westerly wind, daytime temperatures may reach into the nineties, and on rare occasions (6 times since 1928) temperatures of 100° or higher have been recorded. Although during the winter about 6 days with minimum temperatures of 32° or below can be expected, some flowers are usually in bloom, and hardy shrubs seldom are damaged due to any prolonged hard freezing. The average date of the last freeze in the spring is February 3, but freezing temperatures have been reported as late as April 6. The average date of the first freeze in the fall is December 12, although temperatures of 32° or lower have been observed as early as November 4.

Since 1928 the total annual rainfall has ranged from a low of 8.34 inches in 1929 to a high of 29.54 inches in 1941. About 90% of the annual total rainfall is received in the six months, November through April. During the 100-day period, June 15-September 22, the normal rainfall is only 0.07 inch. In spite of the almost rainless summers, however, cooling sea breezes, morning overcast and rather high relative humidity prevent any semblance of a desert climate.

Separating San Leandro both geographically and climatically from its neighboring communities to the north and east, is a range of hills 700 to 1900 feet in height, roughly paralleling the Bay shore and lying about 4 miles inland. East of these hills, summers are normally free of fog, have low humidities, and afternoon temperatures 15° to 25° higher than San Leandro. In winter, local variations in temperature are not so apparent, with the entire East Bay area registering daily high and low temperatures comparable to those of San Leandro.

The long-term climatological data for San Leandro is shown in Table II. Since long-term solar radiation has not been measured at San Leandro, the SOLMET weather table for Oakland was used for determining the estimated solar radiation. A summary of the total solar radiation on a horizontal surface is shown in Table III.

TABLE II. CLIMATOLOGICAL DATA FOR SAN LEANDRO

Latitude: 37°44' Longitude: 122°12' Elevation: 6'

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
TEMPERATURE(°F)													
average monthly	48.6	51.9	53.7	56.1	58.9	61.9	63.1	63.5	64.5	61.1	55.3	49.9	57.4
average daily max/min	55/43	58/46	60/47	63/49	65/52	69/55	70/56	70/57	72/57	69/53	62/49	56/44	64/51
extreme max/min	74/32	74/37	82/35	88/39	98/43	94/50	99/52	89/50	96/49	89/42	78/37	73/26	99/26
DEGREE DAYS													
heating (base 65°F)	508	367	350	270	193	114	80	74	59	135	291	468	2909
cooling (base 65°F)	0	0	0	0	0	21	21	28	44	14	0	0	128
WIND													
Mean speed (mph)	6.7	7.3	9.0	9.5	10.0	10.0	9.3	9.0	7.8	6.8	6.3	6.5	8.2
Max. speed* (mph)	46	49	45	35	38	42	28	29	33	43	46	48	49
Prevailing direction	SE	W	W	W	W	W	WNW	WNW	WNW	WNW	WNW	E	W
FREEZE DAYS PER MONTH	<0.5	0	0	0	0	0	0	0	0	0	0	1	1
PRECIPITATION (in. water)													
average	4.03	2.83	2.32	1.58	0.55	0.14	0.01	0.03	0.18	1.08	2.37	3.57	18.69
max/min	8.90/0.65	8.85/0.02	5.69/0.04	4.60/T	3.42/T	1.21/0.00	0.80/0.00	0.34/0.00	3.27/0.00	8.56/T	7.42/0.00	11.3/0.28	11.3/0.00
RELATIVE HUMIDITY(%)													
4 AM	83	81	80	80	83	85	87	87	83	80	82	82	83
10 AM	77	75	72	68	71	74	76	76	73	72	75	75	74
4 PM	72	69	66	63	65	68	68	68	64	64	69	71	67
10 PM	80	79	76	76	79	82	84	84	80	77	78	80	79

*"fastest mile"; speed is fastest observed 1-minute value.

Source of climatological data: NWS climatic summary.

TABLE III. SOLAR RADIATION DATA FOR SAN LEANDRO

Month	Radiation, KBTU/ft^{2}*
Jan	26.2
Feb	25.3
Mar	44.7
Apr	61.2
May	70.4
Jun	71.8
Jul	71.5
Aug	64.7
Sep	47.4
Oct	33.7
Nov	25.3
Dec	18.3
Yearly	560.7 KBTU/ft^{2}yr
Average	1536.0 BTU/ft^{2}day

*Total solar radiation on a horizontal surface based on Standard Year Solmet Data for Oakland California (1962)

THERMAL SYSTEM

III. THERMAL SYSTEM

A. System Description

The solar process heating system is a simple open loop hot water preheat system. A schematic of this system is shown in Figure 2. Water is pumped from the plant hot water water return header (HHWR) through the collector array and returned to the HHWR at an elevated temperature. Under clear sky conditions and at the plant design load, the collector array inlet temperature is typically 195°F and the outlet temperature is typically 235°F. Since the HHWR temperature is a function of process load this temperature fluctuates between 195°F at design load to 235°F at minimum load. With the constant flow system utilized in this design, the temperature difference across the collector system is primarily dependent on solar input. So for a peak solar condition the system delta-T is approximately 40°F, therefore, the maximum collector outlet temperature is 275°F, which brought about some unforeseen control problems. These problems are discussed in a separate section.

Figure 3 shows the system Piping and Instrumentation Diagram (P&ID). As can be seen from this drawing, water at a rate of 450 gpm is pumped from the HHWR split between the system north field at 120 gpm and the south field at 330 gpm. This water then passes through each system delt-T string via a reverse return piping system. Each delt-T string consists of two 125 ft long collector drive rows piped in series. The flow rate through each delt-T string is 15 gpm. After exiting the delt-T string the solar heated water is then returned to the HHWR.

The pumping system consists of two parallel pumps that alternately operate to provide full flow from a single pump. The control logic for this pump operation will be discussed later in this section. Operational instrumentation consists of mercury thermometers, and pressure gauges at the system inlet and outlet of each bank with a Venturi flow meter on the inlet to each bank, outfitted with pressure gauges marked in units of gpm to give a direct indication of flow.

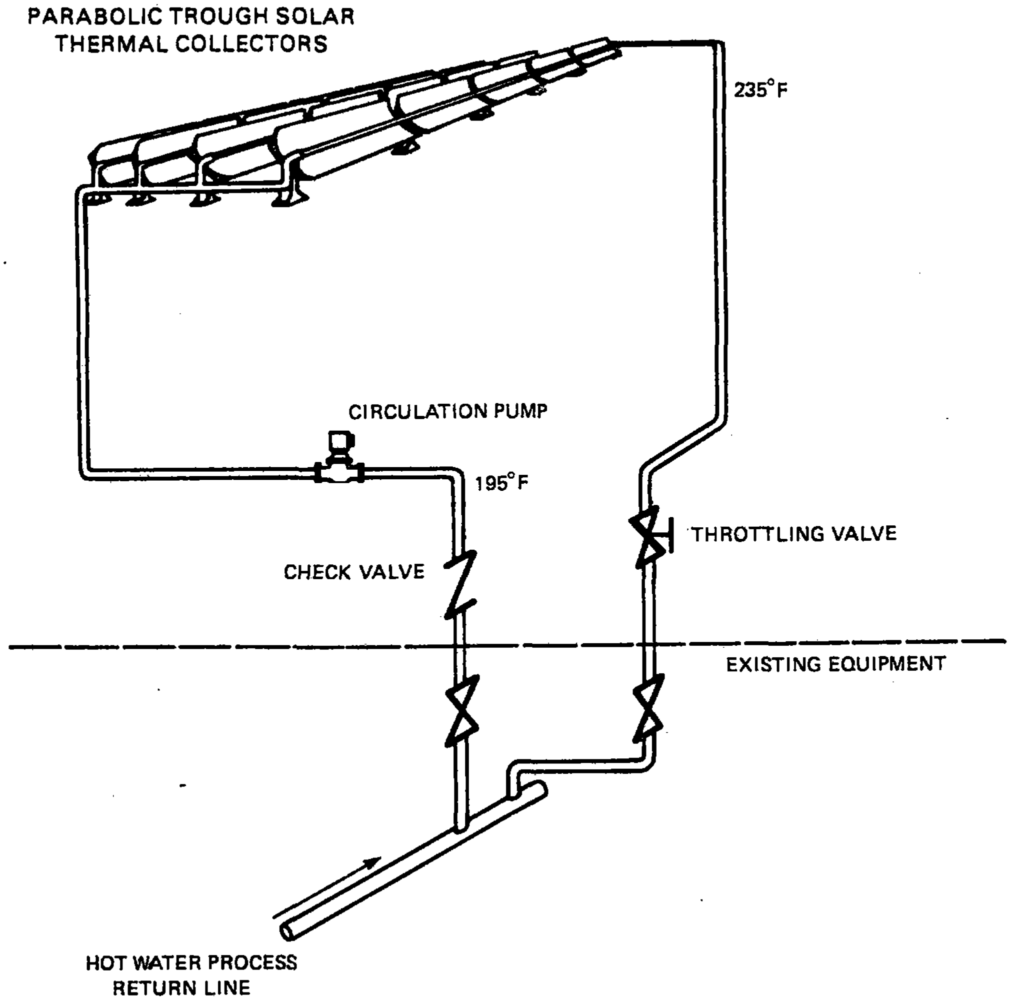
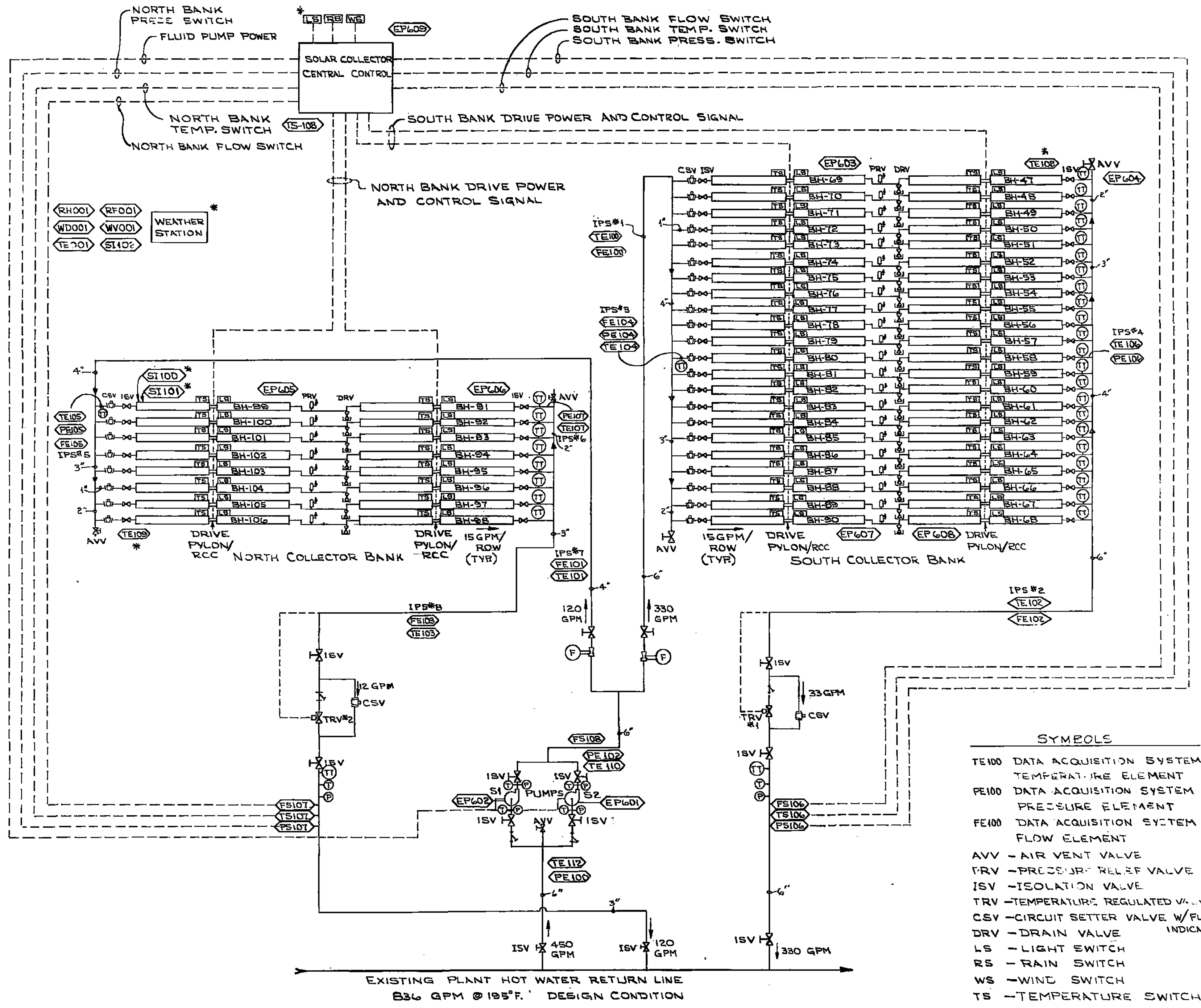


FIGURE 2. SYSTEM SCHEMATIC



FE202 FE200
BOILER ROOM BLDG N-N

* MOUNTED ON ROOF

SYMBOLS

TE100 DATA ACQUISITION SYSTEM TEMPERATURE ELEMENT
PE100 DATA ACQUISITION SYSTEM PRESSURE ELEMENT
FE100 DATA ACQUISITION SYSTEM FLOW ELEMENT
AVV - AIR VENT VALVE
PRV - PRESSURE RELIEF VALVE
ISV - ISOLATION VALVE
TRV - TEMPERATURE REGULATED VALVE
CSV - CIRCUIT SETTER VALVE W/FLOW INDICATOR
DRV - DRAIN VALVE
LS - LIGHT SWITCH
RS - RAIN SWITCH
WS - WIND SWITCH
TS - TEMPERATURE SWITCH
FS - FLOW SWITCH
PS - PRESSURE SWITCH
Ⓣ - DIAL THERMOMETER
Ⓟ - PRESSURE GAGE
Ⓕ - VENTURI FLOWMETER WITH PRESSURE GAGE.
(TT) - TEMPERATURE TAP
—— HOT WATER LINE
---- ELECTRICAL CONDUCTOR

IPS- INSTRUMENTED PIPE SECTION
EP- ELECTRICAL POWER
RH- RELATIVE HUMIDITY
RF- RAIN FALL
WD- WIND DIRECTION
WV WIND VELOCITY
SI- SOLAR RADIATION

STEPHEN W. SEALE JR.

Stephen W. Sealock PE 16DEC80

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CATER

SAN LEANDRO SANLEANDRO CA.

BB SOLAR IPH SYSTEM
PIPING & INSTRUMENTATION DIAGRAM

SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS 78284

EZ 6/80 NOT-TO SCALE
7/10 02-5821 CI-270

At each delta-T string a circuit setter is installed at the inlet to provide the capability to both set the flow rate in each string as well as measure the resultant flow. At the outlet of each string a thermometer well is provided so that the outlet temperature can be measured by inserting one of the six spare thermometers in these wells. Each delta-T string also is provided with shut-off valves at each end, a pressure relief valve and a drain. Each drive row is supplied with a temperature switch and a light switch for individual protection and control.

At the exit of each bank of collectors is a temperature regulating valve (TRV) with a by-pass line set at 10% of design flow. The TRV's are activated by a temperature probe set at the HHWR design temperature. Operationally, when the system starts up water is passed from the collector field at 10% flow as the first slug of hot water from the plant reaches the system outlet, where the TRV temperature probe is located, the TRV opens and full design flow is initiated. The objective of this TRV is, therefore, to minimize the thermal shock on the plant HHWR.

B. Initial System Start-Up

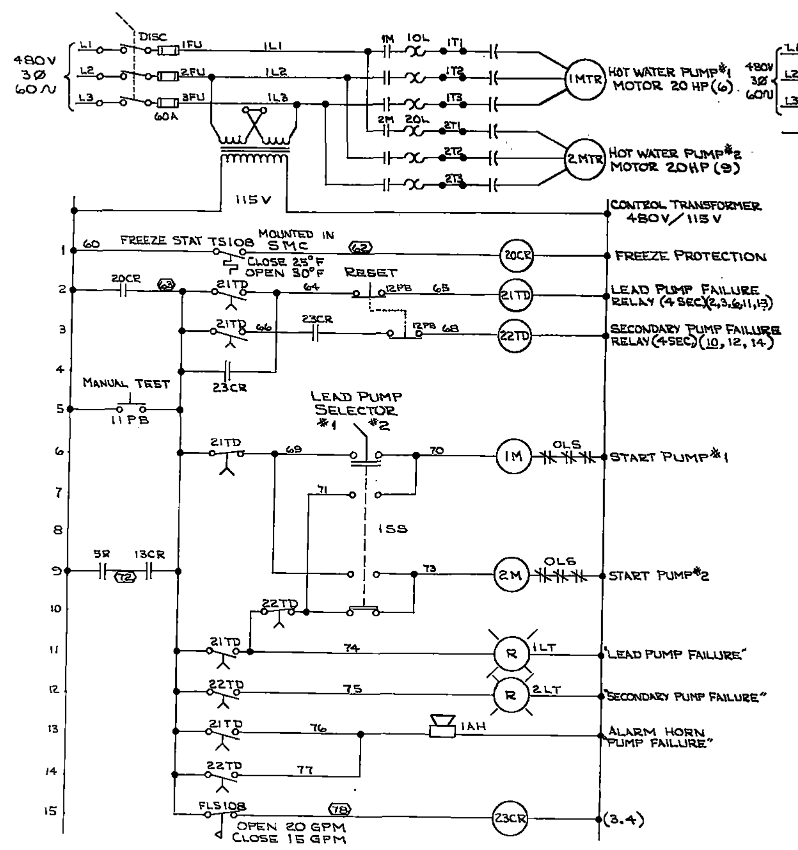
The start-up sequence can best be described by referring to Figure 3. The first step in the start-up sequence is to open the isolation valve between the HHWR line and the pumps. The plant operating pressure fills the line up to the pumps, venting the air via the air vent in the pump suction line. The next step is to verify that all upstream shut-off valves for the collectors are closed and the downstream valves are open. The ball valve leading to the south field is open and the ball valve leading to the north field is closed. After all of the tests and inspection for the pump are performed per the mechanical and electrical specifications, the pump is turned on and all the air between the pump and the collectors is evacuated via the air vent located in the deadend of the inlet manifold. The isolation valve between the exit manifold and the plant HHWR line is opened with the next step being to open the isolation valves on each of the inlet sections of the collector rows one at a time, the idea being to flush the air from each receiver tube individually. Since the exit manifold is sloped up to the deadend, which has an air vent, the air from each receiver flows "uphill" to the air vent and the water flows "downhill" to the plant return line. After each row is cleared, the inlet isolation valve is closed; this provides a high velocity through each row. Once all of the rows in the south bank are cleared, then the north bank isolation valve is opened, the south bank valve is closed, and the same process is followed for the north field as was followed for the south field. The system outlet valve at the HHWR line is now opened for system operation.

C. System Flow Balancing

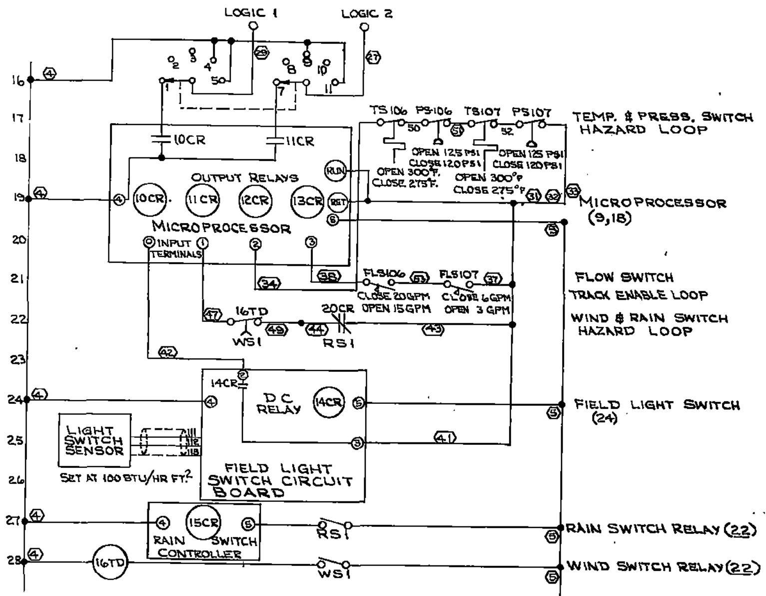
Once the flow in the entire field is stabilized, the ball valves to each field are adjusted to give the proper ratio of flow between the two fields. The flow rate to each field is as high as possible with the proper ratio. The measured flow rate, therefore, is higher than that indicated for final operation. The next step in balancing is to adjust the circuit settler valves for each collector row (note this process is conducted with the collectors in the stow position). Once all of the collector row flow rates are set, the total flow to each bank is checked. The total system is now balanced for the cold condition. The next step is to focus the collectors and allow adequate time for the temperature rise in the system to stabilize. A set of mercury thermometers are mounted in the thermowells provided at the exit of each collector row. Final adjustment of the circuit settlers is made to provide a constant temperature output for all rows under clear sky conditions. This step is only a check because the cold condition flow balancing should provide a constant outlet temperature. Once the balancing has been accomplished, the system is shut-down and allowed to undergo the standard automatic start-up.

D. System Operation Sequence

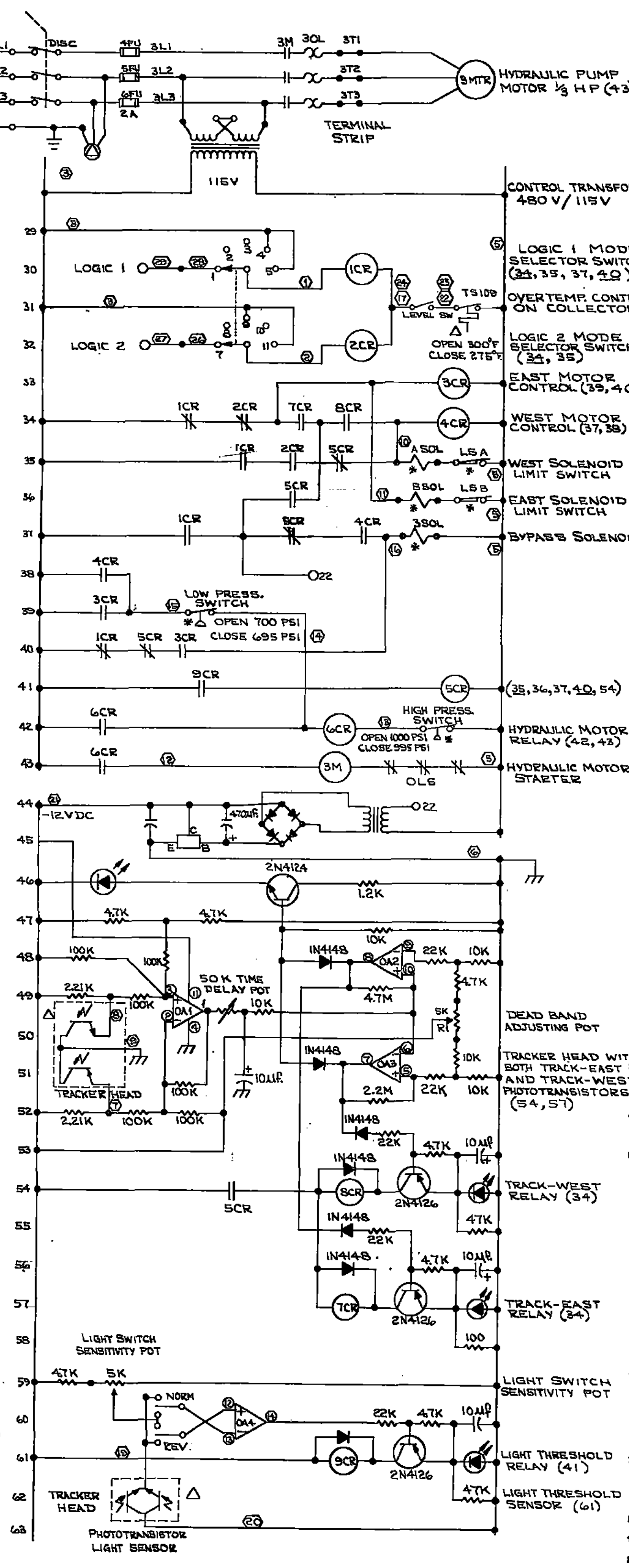
The system sequence of operation can best be understood by referring to the system elementary diagram shown in Figure 4. The Solar Process Heat System will only operate if the plant process hot water system is operating. If this process hot water system is operating, then the collector system central controller takes over when the central controller's direct normal light switch indicates minimum present direct normal levels for a minimum period of 5 minutes. The central controller issues a "track ready" command, if the wind speed is below 40 mph and there is no rainfall, to start



PUMP CONTROL PANEL ELEMENTARY DIAGRAM
NOTE: SUPPLIED BY CONTRACTOR



SOLAR MASTER CONTROL PANEL ELEMENTARY DIAGRAM
NOTE: PROVIDED BY OTHERS, WIRED AND INSTALLED BY CONTRACTOR



PUMP CONTROL PANEL

SEQUENCE OF OPERATION

1. Power will be supplied to the field pumps only when contacts 5R and 13CR (line 9) are closed.
   a. Contact 5R (line 9) is closed by relays in the boiler room on the MCC-4 control panel when the plant process hot water is operating.
   b. Contact 13CR (line 9) is closed by relay 13CR (line 19) in the Solar Master Control.
2. Power is supplied to the selected lead pump (shown as pump #1) by energizing relay 1M (line 6) which closes contact 1M, in the primary motor starter circuit thereby starting pump #1.
2. Power is also supplied to relay 23CR (line 15) through normally closed FLS108 (line 15) which closes contact 23CR (line 3 & 4). This provides power to time delay relay 21TD (line 2). If flow is not established, as indicated by FLS108, within the 4 sec. time delay then:
   a. contacts 21TD on line 2 close, latching relays 21TD (line 2) and 22TD (line 3)
   b. contacts 21TD on line 6 open, disconnecting power to the lead pump
   c. contacts 21TD on line 13 close, to power the alarm horn
   d. contacts 21TD on line 11 close, illuminating the lead pump failure light (1LT line 11) and energizing relay 2M (line 9) whose contacts provide power to the secondary motor starter.
4. When power is supplied to pump #2, time delay relay 22TD (line 3) is also energized. If flow does not begin 4 sec. from the time 22TD is energized (step 3a) then:
   a. contacts 22TD on line 10 open disconnecting power to 2M (the secondary pump starter)
   b. contacts 22TD on line 12 close to illuminate the secondary pump failure light 2LT (line 12)
   c. contacts 22TD on line 14 close to power the alarm horn 1AH (line 13)
5. If any time freeze stat TS108 (line 1) indicates an ambient temperature of 25F, relay 20CR (line 1) is energized which provides power to relay 1M (line 6) thereby starting the lead pump.
6. The lead pump can be changed from pump #1 to pump #2 by manually activating the lead pump selector switch (line 6).

SOLAR MASTER CONTROL

SEQUENCE OF OPERATION

1. When the field light switch sensor (line 25) indicates minimum present direct normal sunlight for a period of 15 minutes, relay 13CR (line 19) is energized (track ready command) and the field pump control circuit is activated.
2. Five minutes after the track ready command has been issued, relays 10CR and 11CR (line 18) (logic 1 and logic 2) energize giving the two collector control wires a "+ +" signal which directs the collectors out of the stow position by activating the west solenoid (line 35) and the fast track bypass solenoid (line 37). This signal is continued for five minutes which will allow each row to acquire the sun.
3. After five minutes, the microprocessor (line 18) will de-energize 11CR thereby opening contact 11CR (line 18) giving a "+-" signal. The "+-" signal is the automatic track signal and is maintained until the minimum direct normal light level is not met.
4. If the minimum direct normal light level is not met, then 10CR is released and 11CR is energized providing the signal for central dead band "-+" and all collectors will remain in dead band until the central controller resumes the automatic track signal "+-".
5. Each tracker has sufficient acquisition aperture to reacquire the sun if this signal is replaced within one hour. If direct normal minimums are not met for a preset period up to 45 minutes, the central controller will provide a "--" stow signal which de-energizes 1CR (line 30) and 2CR (line 32). The collectors will be driven to stow position at this time (see Row Collector Control sequence of operation).
6. Other conditions which will cause the central controller to provide a "--" signal to stow the collectors are: rainfall (detected by 15CR (line 27)) and high wind speeds (detected by 16TD (line 28)). The accumulated, pressurized hydraulic fluid in the tracking system has sufficient power to stow the collectors in the event A/C power line loss, which will obviously provide a "--" signal.
7. In the event of a loss of flow at FLS106 or 107 (line 21), overtemperature at TS106 or 107 (line 17), or overpressure at PS106 or 107 (line 17), the hazard loop will be opened which will cause a "--" stow signal.

ROW COLLECTOR CONTROL

SEQUENCE OF OPERATION

1. Relays 1 and 2CR (line 30 and 32) are energized by the logic 1 and logic 2 outputs of the solar master control. When 1 and 2CR are energized contacts 1CR and 2CR (lines 35 and 37) engage and activate the west and bypass solenoids (lines 35 and 37).
2. These solenoids will remain activated for 5 min or until the row light threshold sensor (line 60) determines the collector has acquired the sun. The light threshold relay 9CR (line 60) energizes relay 5CR (line 41) which opens contact 5CR (lines 35, 37, 40) and deactivates the west and bypass solenoids (lines 35, 37).
3. At this time the collector is in the automatic track mode. The tracker head (line 54) contains 2 phototransistors, one located on the east side and one located on the west side. The outputs of these transistors are directly proportional to the amount of light they are exposed to.
4. The outputs from the phototransistors are input to OA1 (Operational Amplifier 1 line 53). OA1 is configured as an analog subtractor. Its output is the difference between the outputs of the phototransistors.
5. The output of OA1 is input to OA2 and OA3 (lines 52 and 55) which are configured as comparators. They compare the output of OA1 to the high and low bounds of the deadband. The deadband is a range of voltage (set by R1 line 52) that does not produce an output from either comparator. This band is necessary to prevent the circuit on the collector from oscillating.
   a. If the output of OA1 is greater than the high bound of the deadband (i.e., the west phototransistor is irradiated significantly more than the east phototransistor) then OA3 (line 55) will produce an output which will energize 8CR (line 58). When contacts 8CR close (line 34) relay 4CR (the west motor control line 34) and the west solenoid (line 35) are activated causing the collector to track west.
   b. If the output of OA1 (line 53) is less than the low bound of the deadband (i.e., the east phototransistor is irradiated significantly more than the west phototransistor), then OA2 (line 52) will produce an output which will energize 7CR (line 51). When contacts 7CR (line 36) close, relay 3CR (the east motor control line 33) and the east solenoid are activated causing the collector to track east. Tracking is continued until the balance of irradiation on the phototransistors is changed or one of the limit switches LS1 or LS2 (lines 35 and 37) are tripped indicating the collector has traveled too far in a given direction.
6. When either motor control relay 3CR or 4CR is energized the appropriate contact 3CR or 4CR (lines 38 or 39) is closed which will energize relay 6 (line 42) which closes contact 6CR (line 43) thereby activating the hydraulic motor starter if the hydraulic pressure is less than 700 psi as determined by the low pressure switch (line 39). When the pressure exceeds 1000 psi as determined by the high pressure switch (line 42), relay 6CR (line 42) is de-energized, contact 6CR (line 43) is opened and the hydraulic motor starter (line 43) is turned OFF.
7. If the overtemperature switch TS109 (line 31) indicates a temperature greater than 300 F, or logic 1 and 2 are given a "--" signal, then both relay 1CR and 2CR (lines 30 and 32) are de-energized which opens contacts 1CR and 2CR (line 35) thereby activating the west solenoid and driving the collector to stow.

NOTES:

1. Unnumbered conductors are on printed circuit board.
2. Wire all stow switches in a given collector group in series. Carry 2 conductors each group down to solar distribution panel.

Δ on collector

1-1-81	BID ISSUE	
DATE	REASON FOR ISSUE	ADD'N & BULL'N

RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO
PLANT SAN LEANDRO CITY SAN LEANDRO STATE CA
BUILDING DESIGNATION BB
SHEET CONTENTS SOLAR IPH SYSTEM ELEMENTARY DIAGRAM DESCRIPTION OF OPERATION
FIELD RELEASE APPROVED DATE
D & C FILE NO.
D & C LOG N

SOUTHWEST RESEARCH INSTITUTE
6220 CULEBRA ROAD
POSTAL DRAWER 28510
SAN ANTONIO, TEXAS 78284

DRAWN EZ DATE 4-81
SCALE
CHECKED DATE
CONSULTANTS FILE NO. 02-5821
APPROVED DATE
PLANT FILE NO.
SHEET NO. E-242

the system flow pumps. After a 2-minute delay to allow fluid flow to be established, the collectors are directed out of the stow position which takes about 30 seconds for early morning conditions. As each collector row approaches the sun and falls within 20° of focus, one of the row controller's light sensors will switch the row to automatic track. This signal is maintained as long as the minimum light level is met and the receiver tube temperature is below the critical value. The temperature regulating valve on each bank will open when its temperature sensor indicates a temperature in excess of the HHWR design temperature. Prior to the opening of the regulator, a 10% by-pass is provided for cold start-up. If direct normal radiation minimums are not met and the outlet temperature falls below the HHWR line temperature, the temperature regulator closes and the flow drops to the 10% level. In the event that this continues for a preset period (adjustable up to 45 minutes), the central collector controller will stow the collectors and shut off the pump. The collectors will remain in this position until the original automatic start-up sequence is reinitialized.

The only exception to the above operating scenario is when the field temperature switch senses a freeze condition and the above automatic sequence is overridden. When this occurs the system pump turns on and the 10% by-pass flow is pumped through the collectors. The pumps will cycle on and off throughout the freeze condition based on a predetermined timing cycle to prevent damage to the system. The number of times that this occurs is anticipated to be only one day during an average year.

E. System Photographs

With this description of operation in mind, the following set of pictures can be better understood. Figure 5 shows an aerial view of the plant roof top with the north collector bank at the left side of the photograph and the larger south collector bank at the right side. The solar master control panel and the weather station are both located in the upper left portion of the roof. A single collector row is shown in Figure 6 with the observation platform located to the upper left of the collector. The view from the observation platform looking between rows

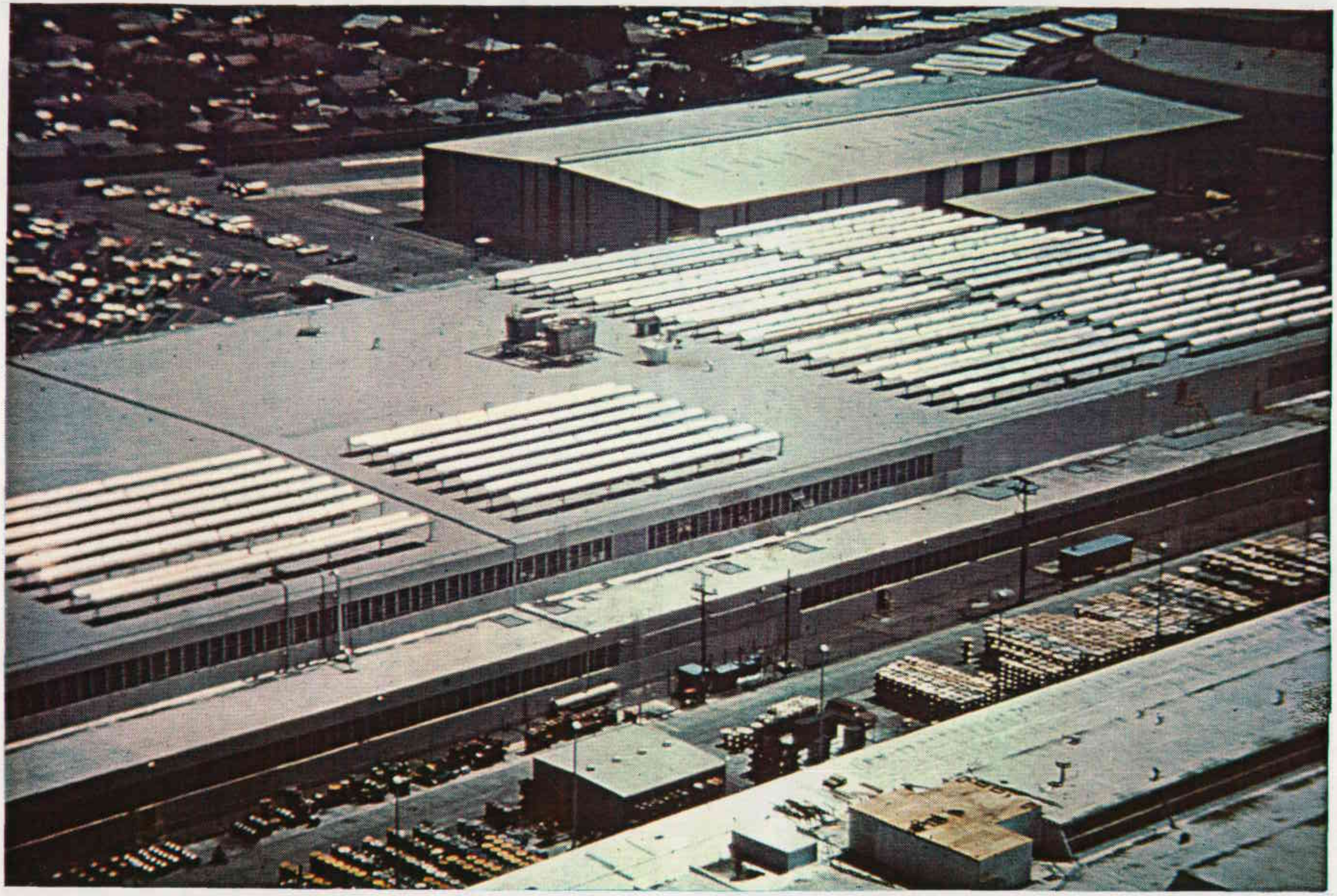


FIGURE 5. AERIAL VIEW OF THE COLLECTOR FIELD

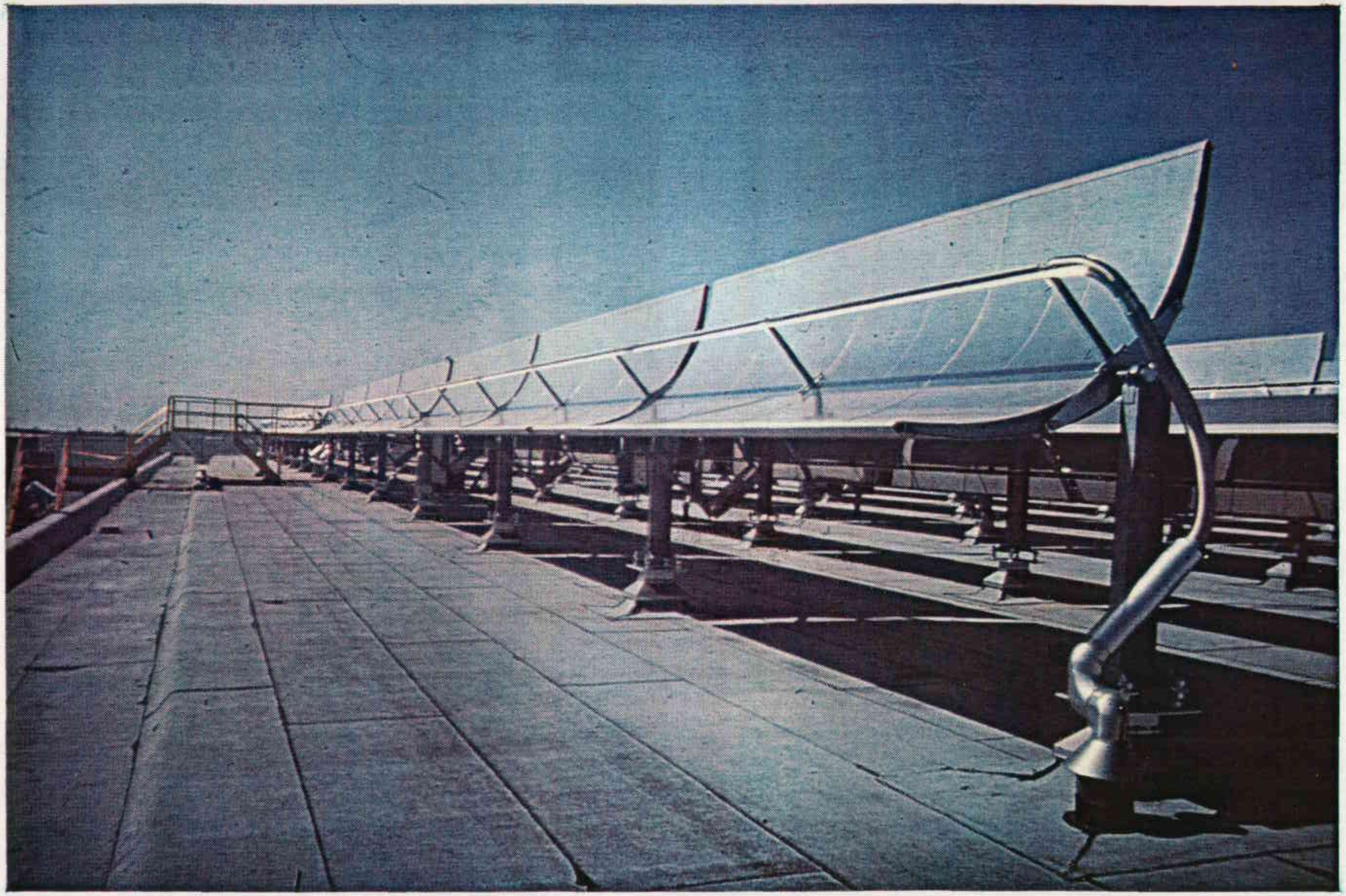


FIGURE 6. SINGLE COLLECTOR ROW

of the delt-T string, showing the row piping, is presented in Figure 7. Figure 8 shows a row drive pylon with control panel along with structural mounting hardware. An interior view of the row control panel is shown in Figure 9. The high voltage (480 VAC) motor control hardware is located to the right of the partition and the low voltage (120 VAC and 12 VDC) control board to the left. The individual row temperature switch is shown in Figure 10 and the row tracker head is shown in Figure 11. The collector row end piping is shown in Figure 12 with the collector in focus. Note the number stenciled on the end pylon, each drive row has its own unique number to facilitate operation and maintenance records. Figure 13 shows one of the system outlet piping downcomers. This downcomer is located on the second floor of the plant and includes (starting from the top) the TRV temperature probe; flow, temperature and pressure switches; straining; TRV; and by-pass loop with circuit setter. The electrical power distribution panel, located on the second floor, is shown in Figure 14. The upper section houses the data acquisition sensor terminal blocks and the lower section houses the high voltage power switch gear. Figure 15 shows the solar master controller with the central light switch, wind switch, rain switch, and freeze sensor mounted on the exterior. The pump control panel is shown in Figure 16 with the Venturi flow gauges (in the upper right hand corner), and pump capacitors (in the lower right hand corner).

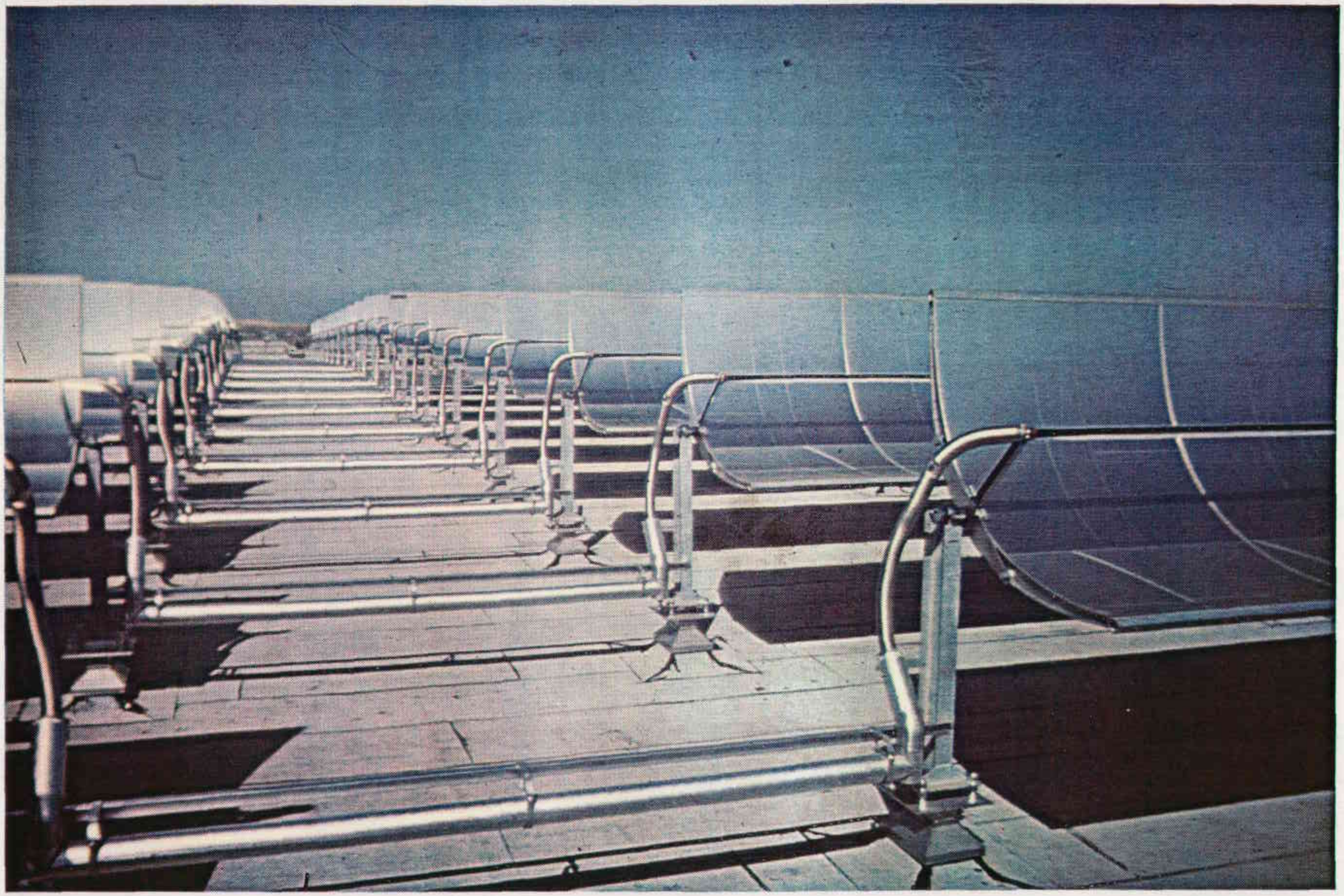


FIGURE 7. PIPING BETWEEN COLLECTOR ROWS

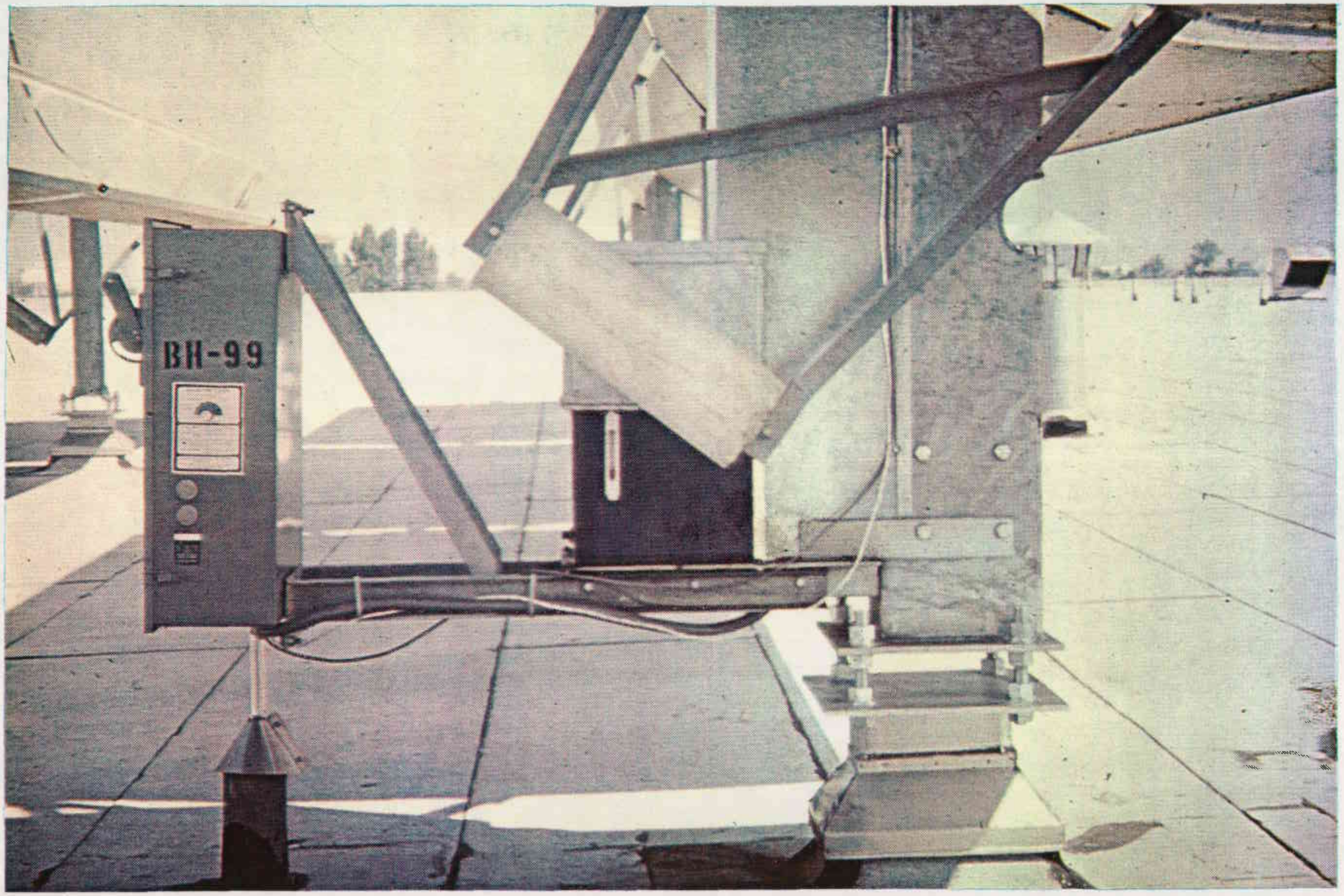


FIGURE 8. COLLECTOR DRIVE PYLON

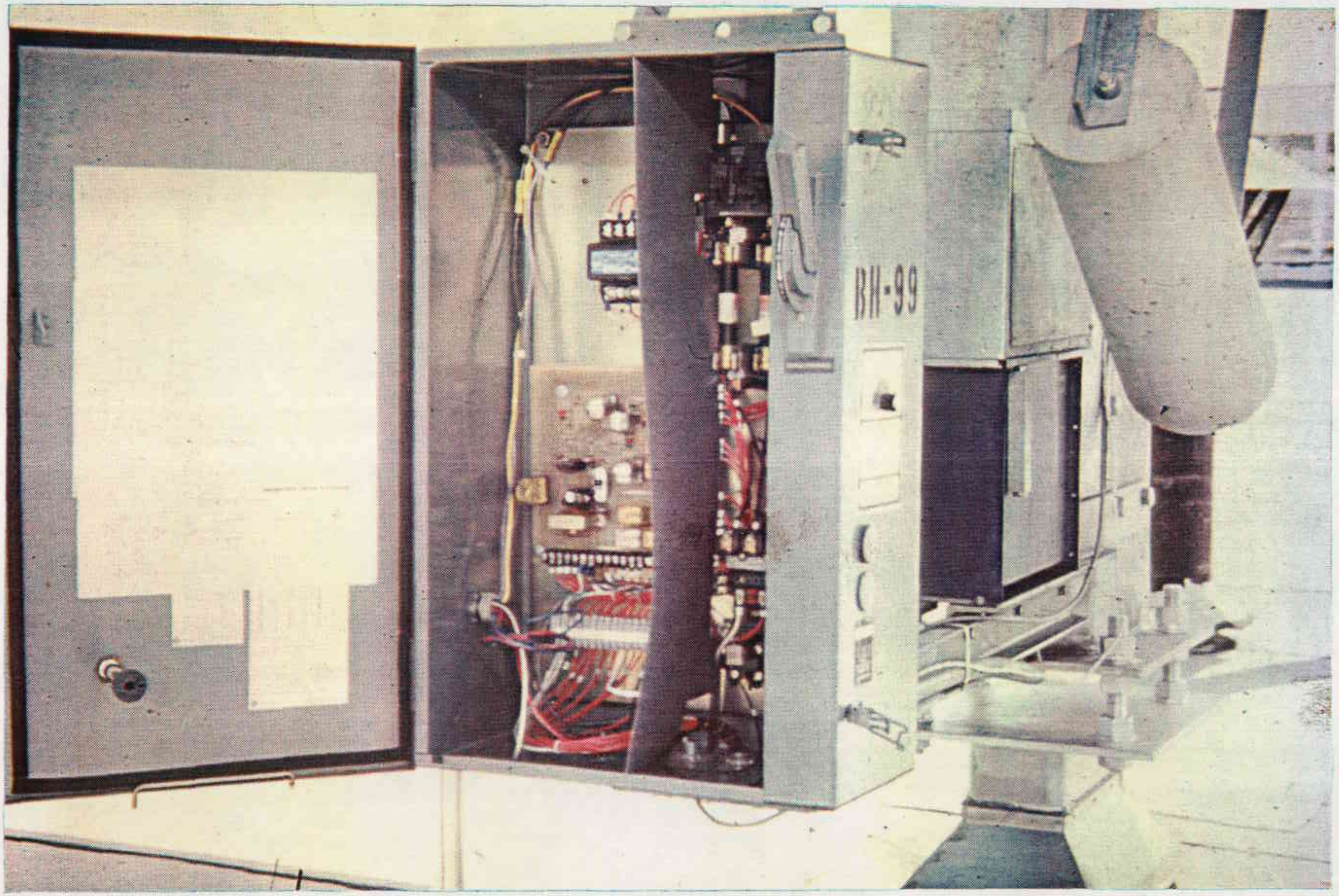


FIGURE 9. COLLECTOR ROW CONTROL PANEL

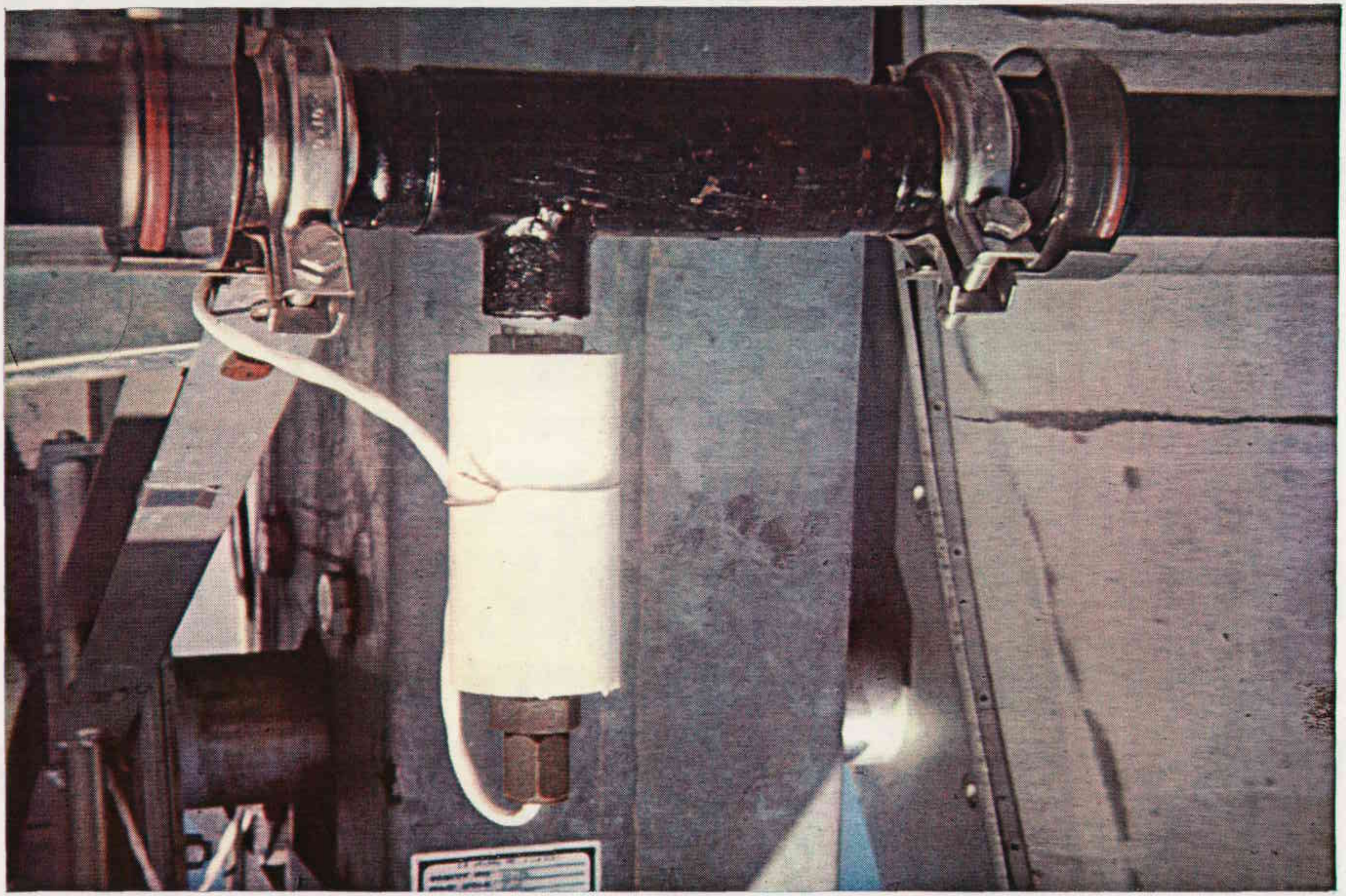


FIGURE 10. COLLECTOR ROW TEMPERATURE SWITCH

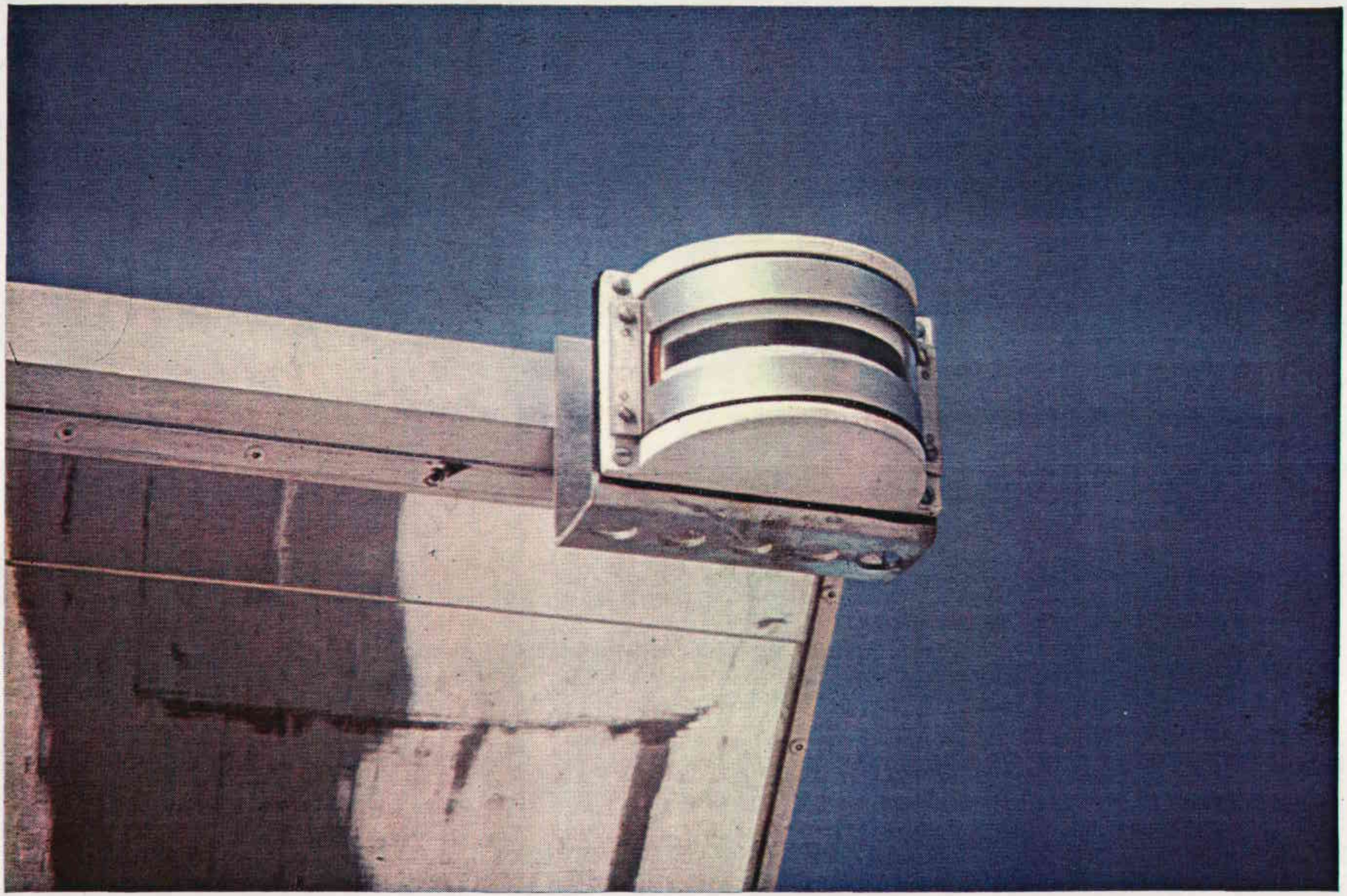


FIGURE 11. COLLECTOR ROW TRACKER HEAD

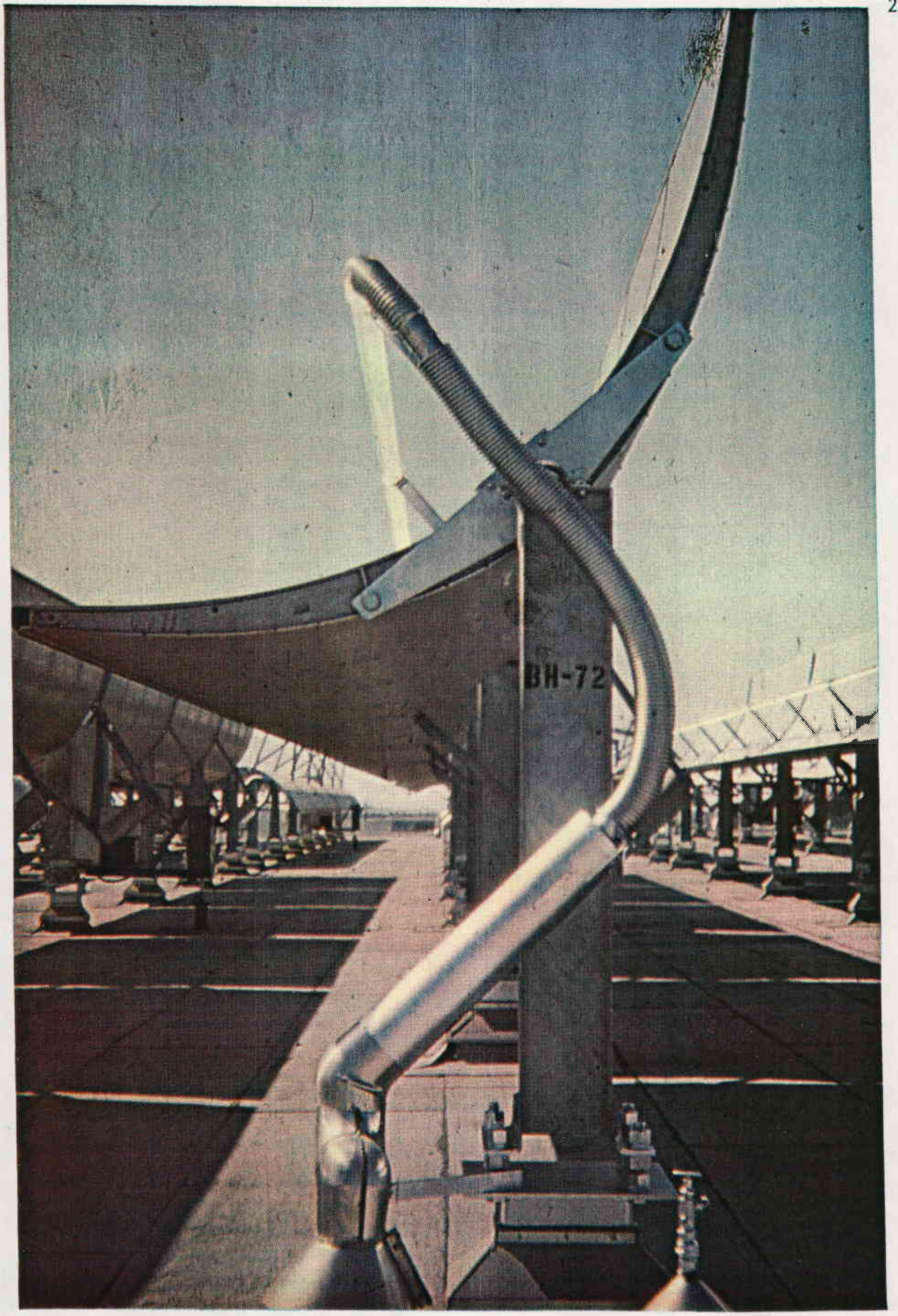


FIGURE 12. COLLECTOR ROW END PIPING

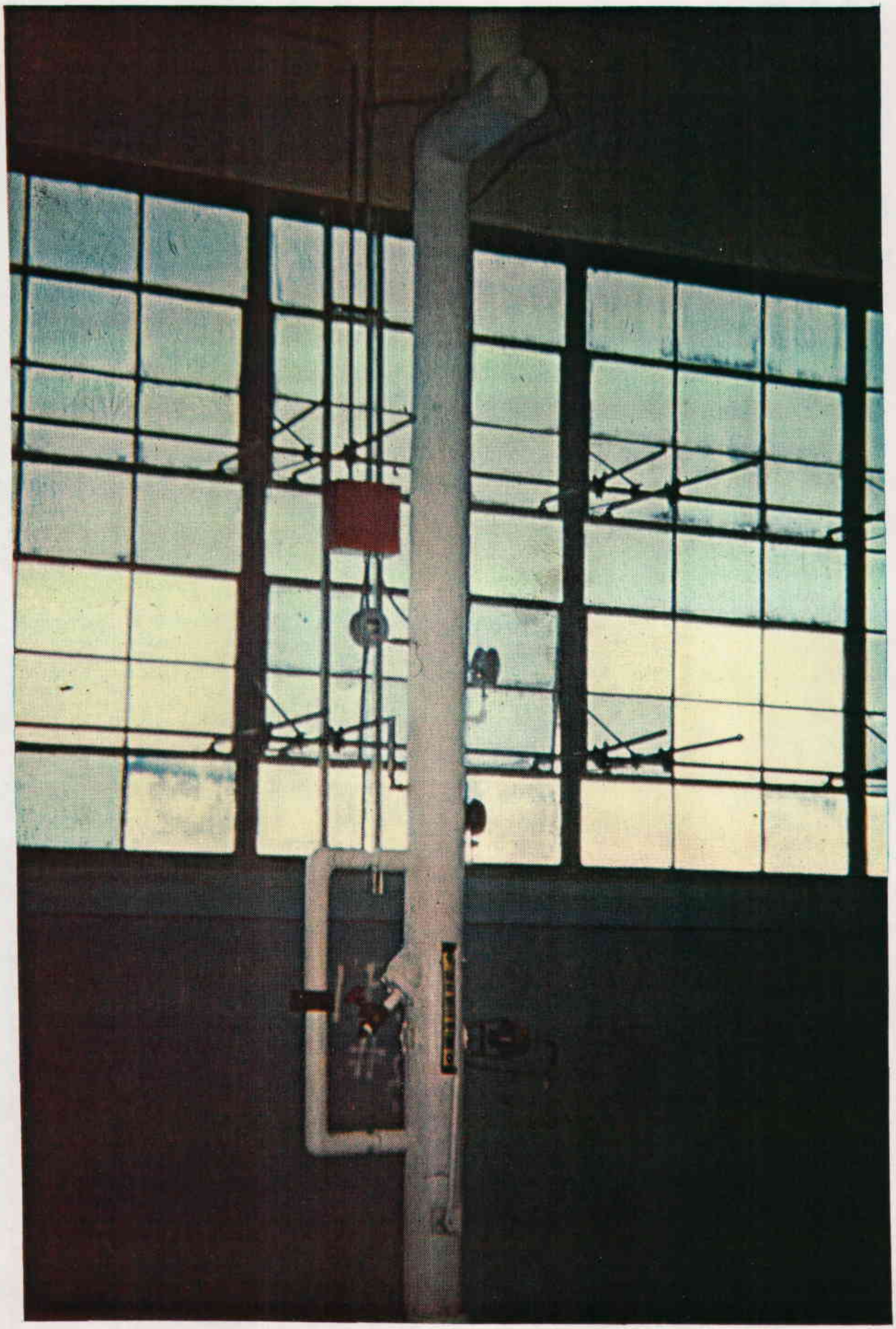


FIGURE 13. SYSTEM OUTLET PIPING WITH TRV

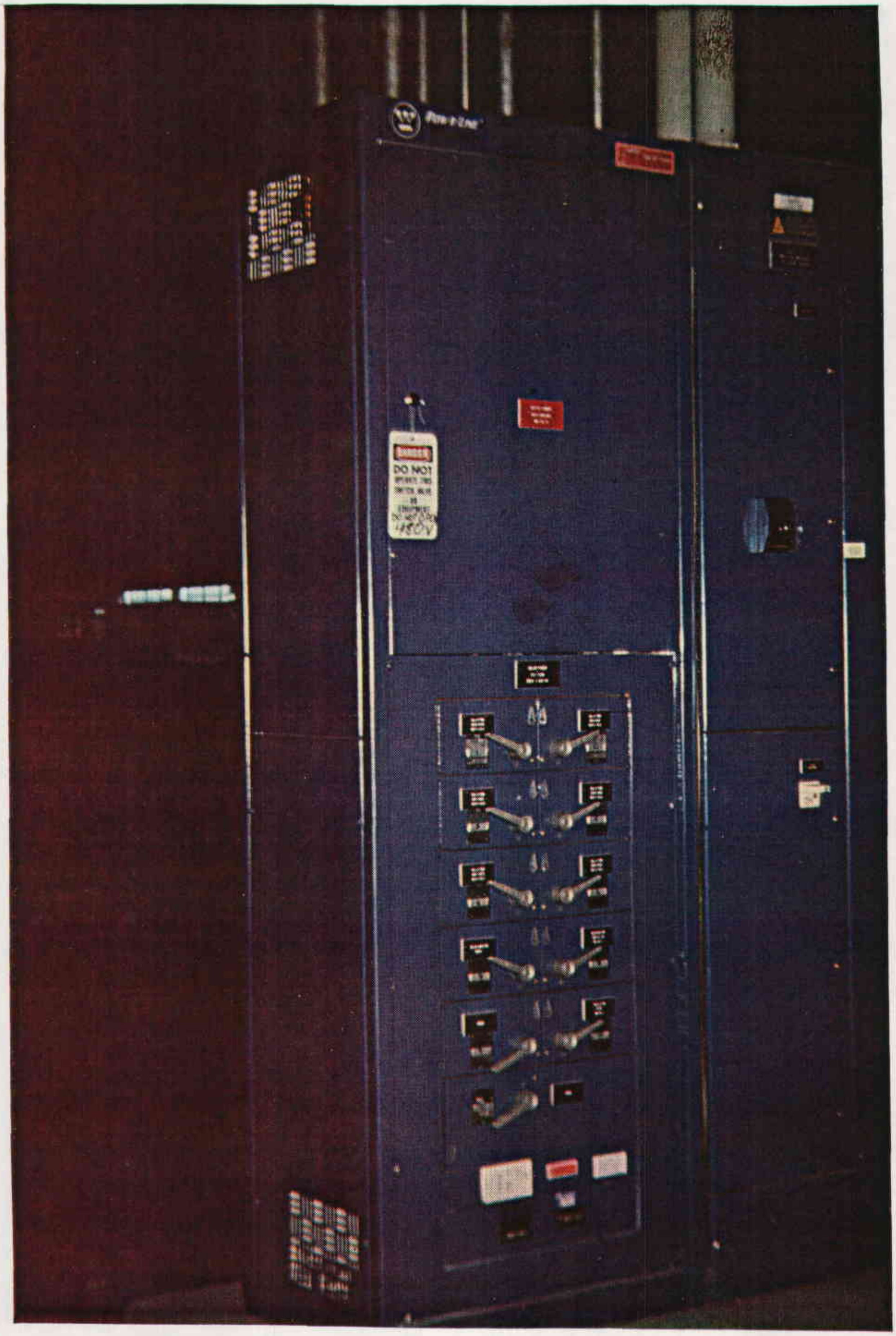


FIGURE 14. ELECTRICAL POWER DISTRIBUTION PANEL

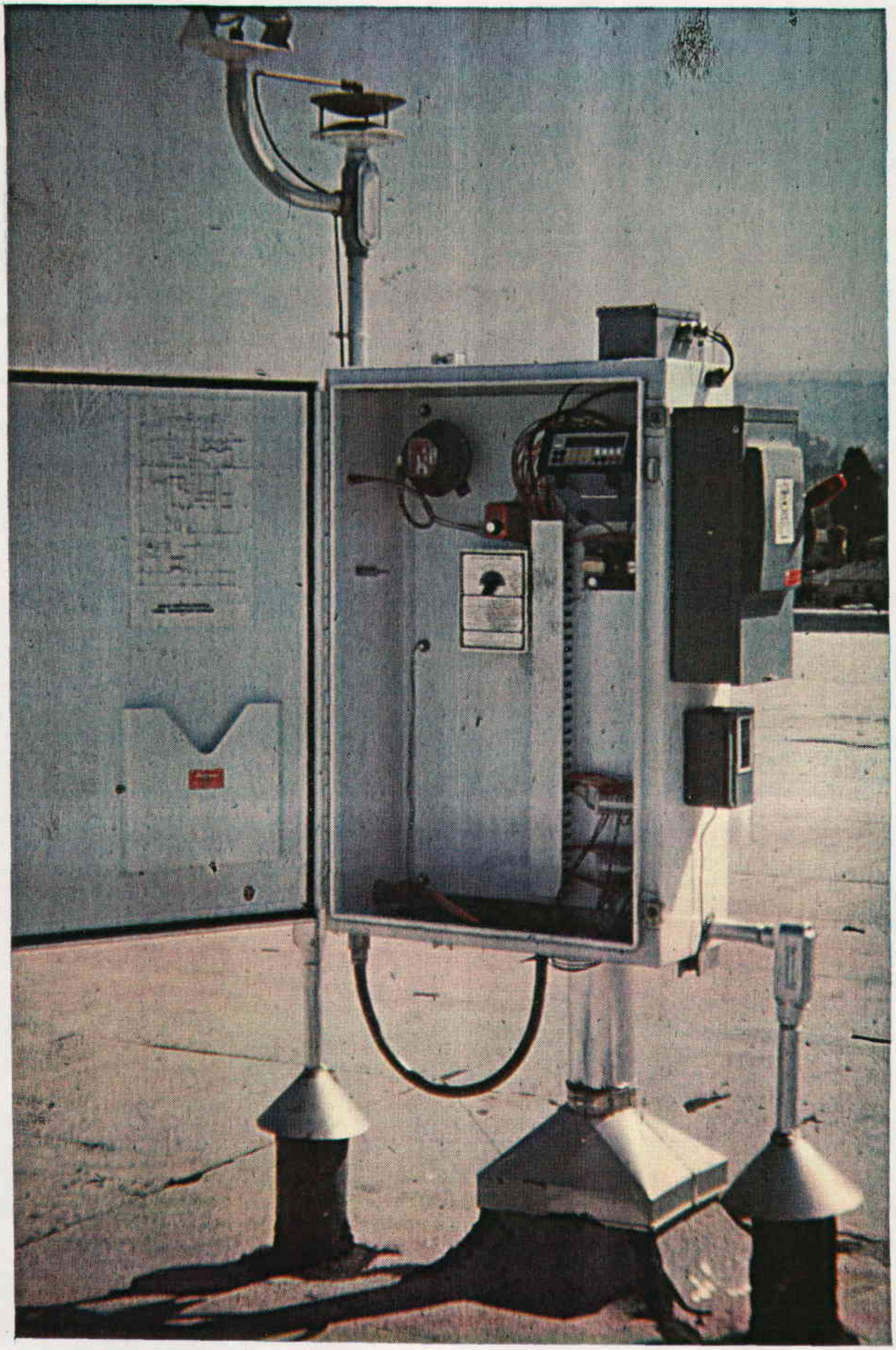


FIGURE 15. SOLAR MASTER CONTROL PANEL

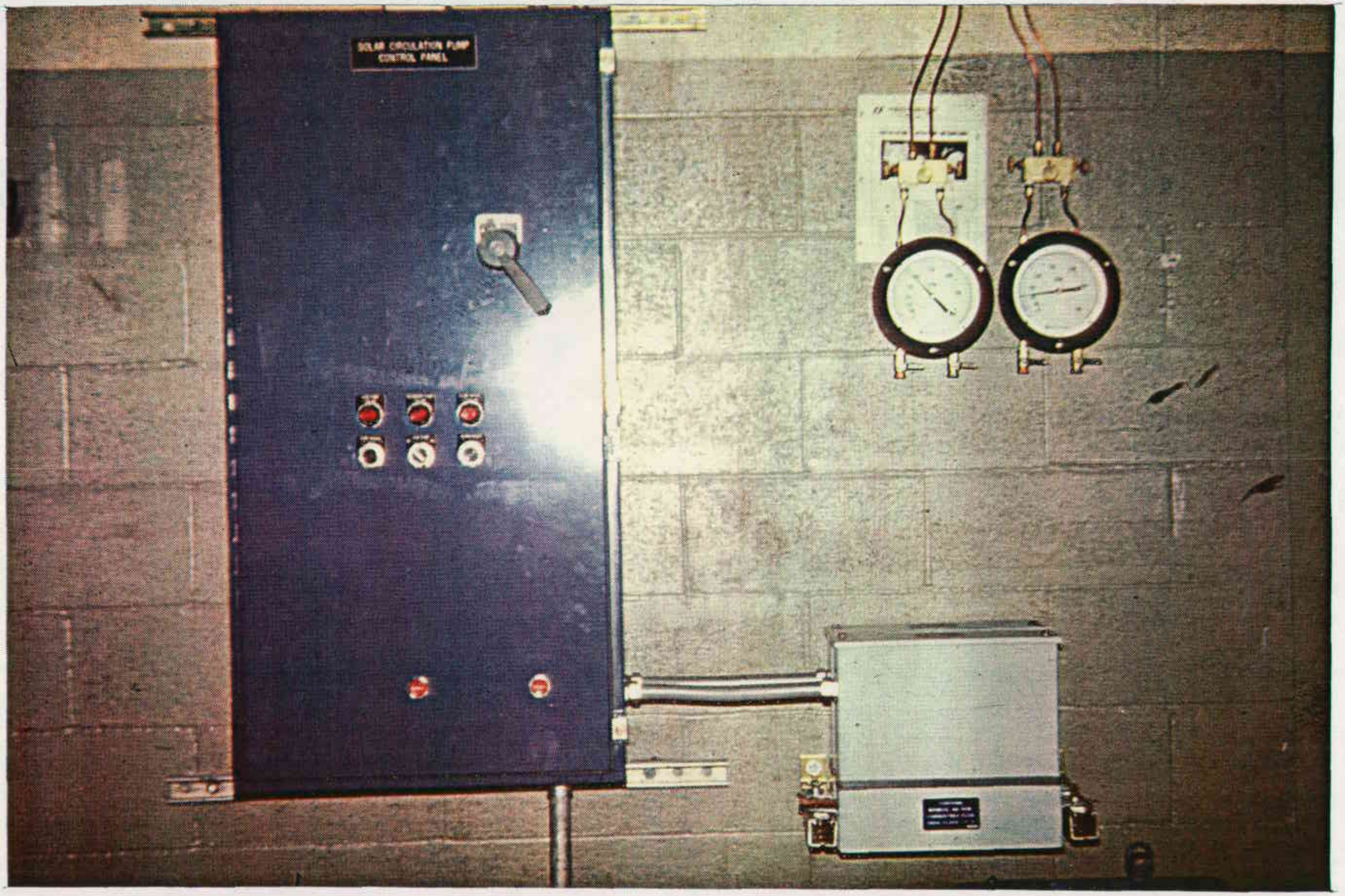


FIGURE 16. PUMP CONTROL PANEL

INSTRUMENTATION

IV. AUTOMATIC DATA ACQUISITION SYSTEM

A. Introduction

A computer based data acquisition system (DAS) was designed and installed to monitor the performance of the solar system. This DAS collects data from various sensors that measure temperature, flow, etc., and processes these data to produce complete summaries of system thermal performance.

By way of introduction, it may be helpful to present photographs of certain facets of the system so the reader is familiar with the hardware before the DAS is discussed.

Photographs of specific portions of the DAS hardware are shown in Figures 17 through 19. Figure 17 shows the computer hardware. On the left is the LA36 line printer for obtaining "hard copy" of desired data lists and graphs. Next to this is a cabinet which supports the VT100 terminal, 11/23 CPU, and both disk drives. Third from the left is the power supply cabinet, and last is the first floor terminal box for the sensor wiring.

Figure 18 shows the two pyranometers mounted on a collector to measure total radiation and diffuse radiation in the collector plane (SI100 and SI101).

Finally, Figure 19 shows the weather station mount. The anemometer (WV001, WD001) and the ambient temperature sensor (T001) are mounted on this structure.

B. Data Acquisition System (DAS) Objectives

The selection of parameters for the performance evaluation is based on a set of objectives established in the "Data Acquisition and Analysis Guidelines for IPH Demonstration Projects" by Kutsler and Kearney from SERI. These objectives are as follows:

- Determine the energy delivered to the process by solar collector system on a monthly and an annual basis.

FIGURE 17. COMPUTER DATA ACQUISITION SYSTEM

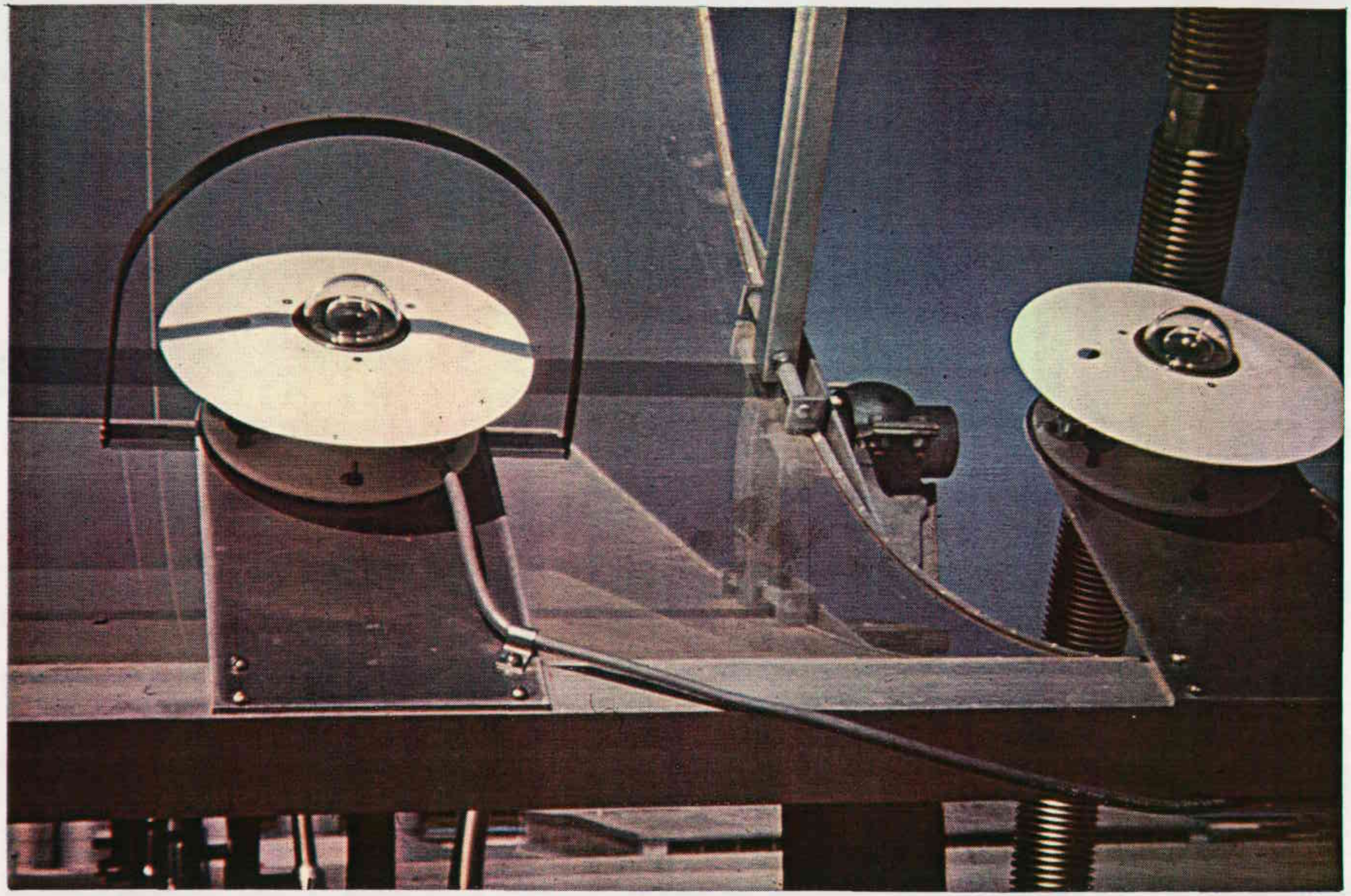


FIGURE 18. SOLAR RADIATION MEASUREMENT SENSORS

FIGURE 19. WEATHER STATION

- Determine parasitic energy used by the solar collector tracking and pumping system on a monthly and an annual basis.
- Determine the percent of solar energy to other fuel sources on a monthly and annual basis.
- Determine collector array efficiency on a "instantaneous", daily, weekly, and annual basis.
- Determine significant losses (piping runs, etc.).
- Determine changes in collector system operational characteristics with weather exposure.
- Determine long-term reliability in terms of materials, components, and system performance.

To achieve the objectives, a set of parameters must be measured and used to determine the following:

- Short-wave solar radiation available at the collector field.
- Thermal energy collected by the collector field.
- Solar-thermal energy transferred to the process.
- Thermal energy losses from the system.
- Non-solar thermal energy transferred to the process.
- Parasitic energy required for collector tracking and pumping.
- Environmental conditions affecting the thermal loss characteristic of the collector field.

A discussion of each of the above topics to be addressed by the DAS follows below. For purposes of this discussion and the remaining subsections, the titles of each of the required transducers are introduced here.

1. Solar Radiation

Short-wave solar radiation measurements consist of three categories: direct beam, diffuse horizontal, and total horizontal. The direct beam component is the focusable component of energy included within a 1/2° cone about the sun's center. When passing through a turbid atmosphere, with large aerosols, a significant amount of energy is translated into a cone of about ±5°. This energy is designated as the circumsolar component. This circumsolar component has the same general angular time variations as the direct component and results from forward scattering of the sun's rays. The diffuse component ("sky radiation") results from atmospheric scattering. This component requires a measurement with a stationary, horizontal, absorbing surface. Radiation which is available to the collectors is limited to direct, circumsolar, and a portion of the diffuse. The available radiation is limited by the collector acceptance angle. Thus, to measure the total radiation seen by the collector, two pyranometers were mounted to track with a collector row. One will provide total radiation as a function of collector angular position, and the other will have a shadow band to block radiation in the collector aperture; thus, the radiation at the collector is the difference between the total and the shadowed measurements. The specific designations for each pyranometer are:

SI100 - Solar Radiation in the Plane of the Collector
SI101 - Solar Radiation in the Plane of the Collector with Shadow Band
SI102 - Total Horizontal Solar Radiation

2. Thermal Energy

To determine the thermal performance of the solar collector system, temperature and volumetric flow rates will be measured. These measurements will allow the determination of the solar energy transferred to the process, and thermal losses from the solar collector system, piping, and non-solar thermal energy transferred to the process. The temperature and flow measurements required to categorize the thermal performance are as follows:

TE100, TE101 - North and South Collector Bank Inlet Temperatures, Respectively
TE102, TE103 - North and South Collector Bank Outlet Temperatures, Respectively
TE104, TE105 - North and South Collector Row Inlet Temperatures, Respectively

TE106, TE107 - North and South Collector Row Outlet Temperatures, Respectively
TE110 - Supply Pump Outlet Temperature
TE112 - Supply Pump Inlet Temperature
FE100, FE101 - North and South Collector Bank Inlet Flow Rates, Respectively
FE102, FE103 - North and South Collector Bank Outlet Flow Rates, Respectively
FE104, FE105 - North and South Collector Row Flow Rates, Respectively
FE200, FE202 - Natural Gas Boiler Flow Rates

With these measured quantities, the thermal energy transferred for each of the specific cases can be calculated using the following equation:

$$Q = m \, C_p \, (T_{f,o} - T_{f,i})$$

The thermal energy from the solar collectors, non-solar energy, and thermal pipe losses require the calculation of mass flow rate, m, by multiplying the volume flow rate, w, by the density, ρ, at the average fluid temperature. This result is then multiplied by the fluid specific heat (C_p) at the average fluid temperature and then multiplying by the temperature differential. Thermal losses are given by comparison of single row performance and collector bank performance after flow balancing is verified. Non-solar energy supplied is derived by measuring gas flow rate to the existing boilers. The use of multiple flow meters in each loop provides redundancy in the measurements. Each temperature location will contain dual RTD sensors to provide redundancy in the event of a sensor failure. A set of pressures across the collector banks will also be measured. These sensors provide information on abnormal system conditions (i.e., ruptured collector tube). The pressure sensors are designated as follows:

PE100 - Supply Pump Inlet Pressure
PE102 - Supply Pump Outlet Pressure
PE104 - South Field Single Row Inlet Pressure
PE105 - North Field Single Row Inlet Pressure

PE106 - South Field Single Row Outlet Pressure
PE107 - North Field Single Row Outlet Pressure

3. Parasitic Losses

Parasitic losses result from the energy required to power fluid transfer pump motors and the tracking system hydraulic pump drive motors. The electrical power will be measured by A.C. wattmeter transducers. The transducers are:

EP601 - Power to Primary Pump
EP602 - Power to Secondary Pump
EP603 - Power to Pylons BH 69-80
EP604 - Power to Pylons BH 47-58
EP605 - Power to Pylons BH 99-106
EP606 - Power to Pylons BH 91-98
EP607 - Power to Pylons BH 81-90
EP609 - Power to Controls

4. Environmental Conditions

Several environmental conditions other than solar radiation affect the operation of the collector field. The parameters are as follows:

Wind Speed - WV001
Wind Direction - WD001
Ambient Temperature - TE001

Wind speed and direction not only affect the convective loss from the absorber tube, but also tracking accuracy of the reflector. Ambient air temperature is a standard measurement and also provides information on losses from the collector tube, as well as external piping.

The following subsections describe the DAS hardware and software which were used to accommodate the goals discussed above.

C. DAS Hardware

The DAS hardware configuration is shown in the block diagram given in Figure 20. Sensor-signal conditioner combinations are located appropriately throughout the solar collector system. Their outputs are run in shielded cable

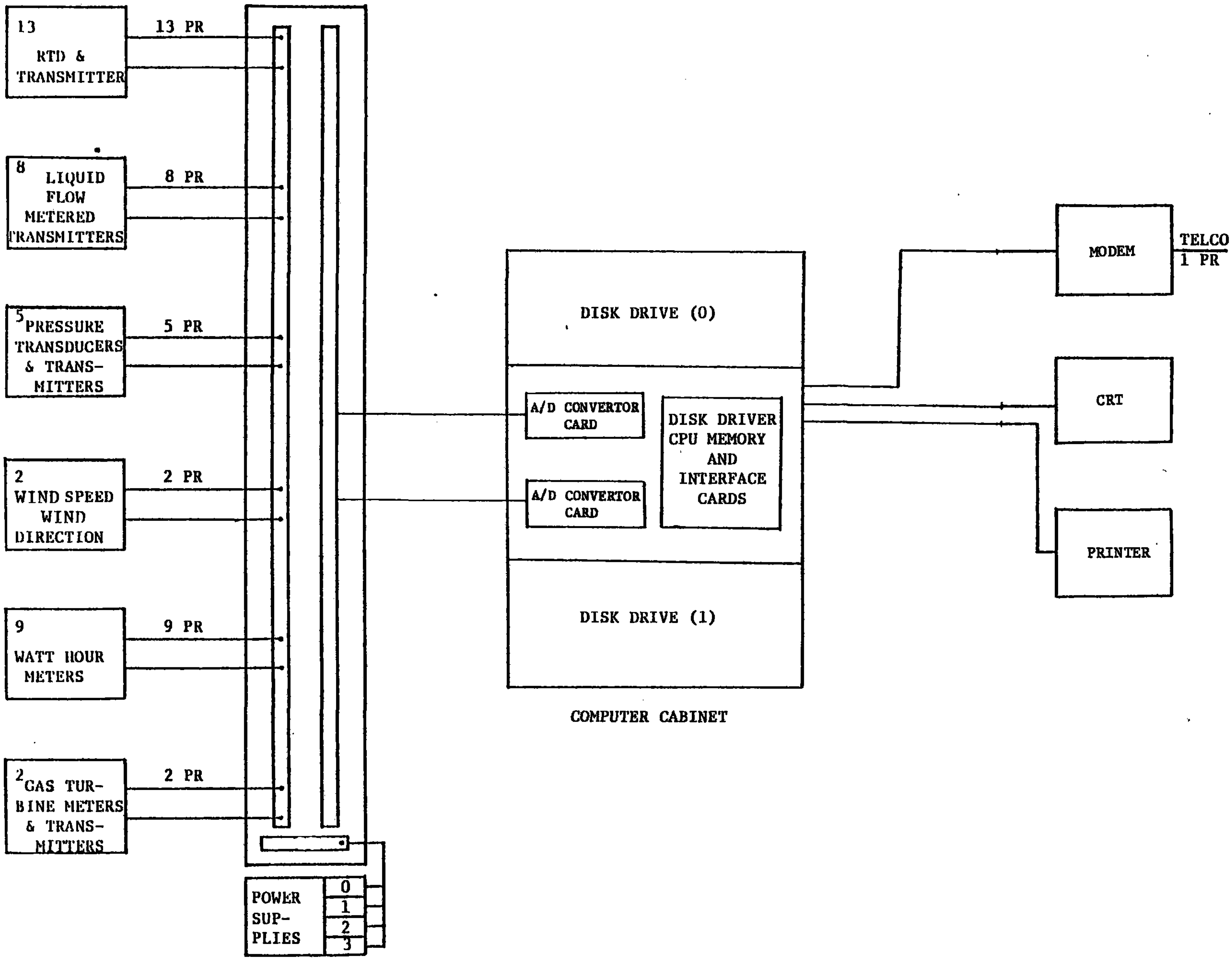


FIGURE 20. BLOCK DIAGRAM

to the computer, which periodically scans, processes, and records the signals and certain computed information. The DAS hardware can logically be broken into three sections:

- computer hardware
- sensors and signal conditioners
- wiring and termination hardware

1. Computer Hardware

The DAS is based on the model SM-WXLLA BX PDP-11/23 microcomputer system. This basic system is comprised of the following:

- PDP-11/23 CPU
- 32k words of memory
- two RL01 5 megabyte disk drives
- interface cards
- VT100 terminal (modified for graphics)

The following additional peripheral equipment is interfaced to complete the computer hardware package:

- uninterruptible power supply (UPS)
- LA36 line printer (modified for graphics)
- UDS 103LP automatic answer modem
- analog to digital converter cards

a. PDP 11/23 CPU

The PDP 11/23 is the heart of the computer hardware. This CPU provides the capability to perform all the functions necessary for collecting, processing, and storing the required data. The RSX-11M operating system is implemented with the 11/23 to provide user-oriented system capabilities. This operating system is relatively easy to learn and uncomplicated to use, as far as microcomputer operating systems are concerned.

b. Memory

The 32K words of memory supply space to hold the DAS software tasks and data for processing the data. The memory will not hold the entire DAS software, so an overlay structure was implemented, as discussed below.

c. RL01 Disk Drives

The 5 megabyte RL01 disk drives provide permanent storage of the DAS software, RSX-11M operating system, and system data. One drive is set aside for storage of data so that data disks can be readily changed with no affect on system operation.

d. Interface Cards

Various circuit board cards are necessary to interface the computer to the disk drives, line printer, CRT terminal, the analog/digital converters, and the modem for phone line hookup.

e. VT100 Terminal

A VT100 which was modified for graphics capability is used for controlling the computer hardware and for user interface with the system.

f. Uninterruptible Power Supply

The UPS consists of two packages. One contains a group of sealed maintenance-free batteries. The other is an inverter which converts the DC voltage to 110 volt AC when input power is interrupted. The batteries will support the system for 6-minutes without power. Since the UPS is connected to the building's emergency power, the system should only have to utilize the batteries for a few seconds while the emergency generator is started.

g. LA36 Line Printer

The LA36 is the DEC standard 300 baud hardcopy terminal, however, the DAS has been configured to treat the terminal as a line printer and ignore input from the LA36 keyboard. The LA36 has also been modified to operate as a graphics printer. This was accomplished by purchasing special hardware and software from the Selemar Corporation.

h. UDS 103LP Modem

The modem allows a user with a compatible modem and terminal to call and interact with the DAS over the phone.

i. Analog to Digital Converter Cards

The two RTI 1250 cards provide the interface between the computer and the analog signals output by the sensors and signal conditioners. Input signals are connected from the first floor termination box to a 50 wire ribbon cable which plugs into the 1250 card. There are 32 channels on each card numbered 0 to 31. The cards are set to receive 0 to 10 volt inputs. They return to the computer a number between 0 and 4096 which is directly proportional to the input voltage.

2. Sensors and Signal Conditioners

Making accurate measurements in an industrial environment poses many problems. Vibration, noise and electromagnetic interference are but a few of the difficulties to be contended with. RTD's, flow meters and other sensing devices typically output signals which are less than one-tenth of a volt. These signals are easily corrupted by the aforementioned factors and are also greatly affected by the resistance of the wires running out to the sensors. In order to deal with these problems, a signal conditioner was mounted at each sensor. The signal conditioners convert/clean-up the millivolt input signal into a linearized amplified current signal. The amplified current signal has greater noise immunity and is unaffected by the resistance of the wires running from the sensor to the computer.

All of the signal conditioners in this system are of the "two wire" variety. This means that the power and the output signal are one and the same. Therefore, it is not necessary to have both power and signal wires. The greater the input stimulus, the more current the signal conditioner draws. Although the signal conditioners for temperature, flow, radiation and wind sensors are mounted physically next to the sensors they are separate items and may be calibrated and serviced separately from the sensor. On the other hand, signal conditioners for the pressure and electrical power sensors are enclosed inside the sensor housing. These sensor-signal conditioner combinations, referred to as transducers or transmitters, were purchased as a single unit and must be serviced as such. The 38 sensor designations are listed in the previous subsection. The location of each of the sensors is shown in the system P&ID (Figure 3).

3. Wiring and Termination Hardware

The wiring and termination hardware is that equipment necessary to provide power to the sensors and to route the sensor output signals to the computer.

The sensors are located throughout the solar system and manufacturing plant, so that the signals must be routed from each of the sensors to a terminal box located on the second floor. This second floor box is connected to a terminal box located near the computer on the first floor. The conduit routing is as shown in the as-built drawings (Section IX).

The wiring for each sensor can be represented by the same general schematic, shown in Figure 21. Twenty-four VDC power is supplied to each sensor via the wiring. The signal conditioner controls the current through the wiring at a level proportional to the input from the sensor. The 500 Ω precision resistor provides a voltage differential due to the current forced through it. This voltage is sensed by the A/D cards in the computer hardware and is converted to engineering units during the data processing operations of the DAS.

D. DAS Software

The DAS software is comprised of 23 separate operating tasks. Each of these tasks is a block of executable code made up of one or more programs which performs a specialized function or process on the solar system data. These processes range from the collection of the raw data from the sensors to plotting a monthly summary of system performances seen in the following list:

- realtime display and analysis of data
- listings of historical data
- plots of historical data
- daily performance table
- daily summary graph
- monthly performance table
- monthly performance graph
- permanent storage file of recorded data

All 23 tasks are not listed here since several of the tasks may be necessary to provide any one of the above services.

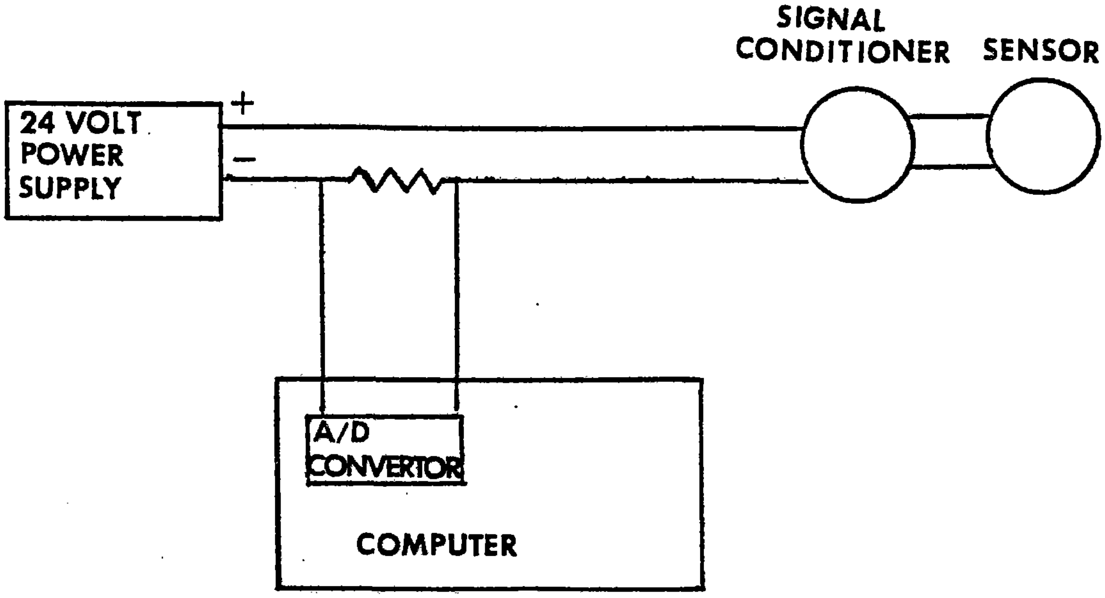


FIGURE 21. SENSOR CURRENT LOOP WIRING

The complete software system has been broken down in this manner so that only 32K words of memory are required for task storage at any given time. This means that tasks are brought into memory as required, to perform its operation. The RSX-11M operating system is well suited to provide this capability. This operating system can support various task priorities, so that data acquisition is not delayed for the sake of, say, plotting performance summaries.

The tasks in this system are divided into two major groups: the data acquisition tasks and the user interface tasks.

The data acquisition tasks collect, process, and store the data from the signal conditioners. These tasks receive the highest priority of all the system tasks. Whenever the A/D's need to be scanned and data needs to be processed for storage, the DAS stops any user interface operation, performs this function, and returns to the user interface task. In this manner no data is lost or missed.

The user interface tasks allow the user to list or plot raw data, construct hourly, daily, or monthly summaries in the form of tables or graphs, and to halt and maintain the system.

The listing of raw data and the printing or plotting of performance summaries are given low priority with deference to the data acquisition tasks. The DAS halt and maintenance tasks bring the system to an orderly halt so that the hardware can be maintained, disks may be changed, etc.

In summary, the data acquisition system supplied for this project provides a highly flexible, reliable system for data acquisition and processing requirements.

CONSTRUCTION PROBLEMS

V. CONSTRUCTION PROBLEMS ENCOUNTERED

The problems encountered during construction were of two board class: installation problems and collector hardware problems. The installation problems will be discussed by reviewing the field orders submitted by the contractor. Since the solar collectors are the only prototype equipment on the job, it was expected that this equipment be a significant source of problems. This expectation was indeed realized; therefore, these problems will be discussed separately.

A. Field Order Changes

1. Structural Revisions

This change was necessitated by a number of separate conditions. One conflict arose when the local code authority reviewed the structural calculations and questioned a number of the simplifying assumptions. In addition to this, there were a number of structural members involved in providing load carrying capabilities for the collector supports that were damaged prior to this work that needed to be repaired. While this damage did not effect the integrity of the existing structure, it did prevent the required modifications. Other problems were due to miscellaneous field conflicts with previous modifications and existing hardware. It should be pointed out that since the structural modification does cover approximately a five acre area with 420 support pylons, it was not practical to cover all of the field conflicts in the initial design effort. The last area covered in this field change accounted for a number of locations where the roof support members were displaced from their original location. In summary, this particular field order constituted the largest field order encountered during construction in terms of cost, schedule and effort.

2. Stainless Steel Flashings

Due to the large number (540) of roof penetrations, an effort was made to improve the sealing technique. It was determined during construction that changing the galvanized flashing to stainless steel would provide a higher quality seal.

3. Collector End Piping Modification

The collector manufacturer changed the receiver design between the time the bid package was completed and the equipment delivered. This resulted in a change in piping connection location. All 120 end connections had to be modified to account for this change.

4. Modify Pylon Detail to Attach Existing Cross Braces

This change order consists of increasing the notches in the support tubing to accommodate the existing gusset plates. This modification was required on approximately 200 pylon supports.

5. Relocation of Computer System

The original computer location was designated to be on the second floor adjacent to the system pumps and control panels. A more suitable office area was identified during construction. The change order covered all wiring necessary to account for this change. The original terminal blocks located above the power distribution station on the second floor were to remain and a second set of terminal blocks were added in the first floor office area.

6. Painting Modification

Since the entire second floor truss members will eventually be repainted under a future renovation, it was decided that to keep the painting subcontract within budget after all the structural steel modification in change orders one and four, all finish coats of paint for the structural steel were deleted and all new steel would only be primed.

7. Replace Computer System Transformer

It was determined after a transformer failure, that the 1KVA electrical load of the computer system required a 3KVA transformer due to a condition that occurred when the UPS system was simultaneously providing power to the computer and charging batteries after a power failure.

8. Relocate Electrical Penetrations

The row control panel on the collector drive pylons were relocated from the front of the pylon to the back when it was determined that it was not possible to rotate the mirrors with the panel door open.

The change occurred at the vendor's shop before delivery, but after electrical conduit and roof penetrations for this conduit had been made. This change order covered the relocation of these conduits and penetrations.

9. Wattmeter Modification

This change order was initiated to provide a terminal block and disconnect for the wattmeter wiring so that maintenance could be performed on this meter without the meter being "hot." Since the power wiring is 480 VAC, this change order removed a potential safety problem.

10. Chipped Collector Receiver Glass

A significant number of receiver tubes were received on site and installed when it was determined that minor chips in the glass covers could lead to larger glass breakage problems. This change order covered removal of those receivers previously installed and crating them for return to the vendor. This problem will be outlined in more detail under collector problems.

11. Relocate Flow Switches

The original design called for a horizontally mounted flow switch. After catalog cuts were received from the subcontractor, it was determined that a vertically mounted switch would be better. This change order covered the relocation of the flow switch threadolets to accommodate this change.

12. Modify Alarm Panel Wiring

The alarm panel includes indicators for collector stow position as provided by contacts on existing stow switches. It was determined that the signal from this switch required power and would, therefore, be a source of foreign power in the collector row control box unless it was isolated by a transformer. The change order was initiated to accommodate the rewiring necessary for this modification.

B. Collector Hardware Problems

1. Change in Receiver Tube Design

Due to problems on previous installations the vendor redesigned the collector receiver tube. The new design appears to be far superior to the previous design. We were not notified by the vendor of this change until after the bid package was sent out to the bidders. This affected the labor for installation as well as a change in piping location for the interface piping.

2. Equipment Delivery

A major problem arose with equipment delivery. The original order was placed with the vendor in October of 1980. The original schedule was to have all equipment on site by mid July 1981. The last of the receivers were not received on site until January 1982; however, 40% of the receivers delivered were chipped and the replacements for these receivers did not arrive until March 1982. This 8-month delay caused numerous problems on site with scheduling various subcontractors that had to install, provide piping and electrical connections to this equipment.

3. Replace Collector Temperature Switches

An estimate was made early in the design process that the setting on the temperature switches would be 250°F. This was conveyed to the vendor at that time. After the design was completed the new setting was identified as 300°F. This information was also conveyed to the vendor and appears on the control drawing mounted on each row control panel. This information, however, was not passed on to the manufacturing staff, so that all the switches supplied to the site were 250°F switches. This problem was identified in February but the replacement switches were not received until June.

4. Segragation of 480V and 120V in Row Control Panel

The vendor-supplied row control panel was inspected by the local code authority and deemed in violation of the electrical code. The source of the violation was the mixing of high voltage power wiring with the low voltage control wiring. A dielectric partition was added and cable insulation was included for the tracker head wiring to resolve the problem and receive approval from the building inspector.

5. Collector Pylon/Mirror Interference

Due to the thermal expansion of the mirrors, bearing assembly mounting plate deflections, and close mounting tolerances, a problem with the mirror/bearing assembly mounting bolts hitting the support pylon occurred that damaged a number of mirrors and receivers. To solve this problem, collars were designed to prevent the bolts from contacting the pylons. The thermal expansion load would then be transmitted to the pylon through the bearing and result in a deflection of the pylon. This condition was deemed acceptable and no future problem is anticipated.

6. Miscellaneous Drive and Control Problems

There are a number of minor problems with the drive and control systems that have been identified. The results of these problems are hydraulic leaks and lack of dependable operation. All of these can be handled by the maintenance staff, but a long-term solution should be identified and implemented to reduce the maintenance cost. Specific recommendations will be made during operation as more experience is gained with this hardware. Some of the specific components have been replaced; some with identical components and some with higher quality components. The items that should be investigated are: hydraulic accumulators, hydraulic cylinders, by-pass valves and solenoids, pressure switches, four-way valves, mode sector switches, relays, control transformers, and hydraulic filters.

7. Rusty Hose/Receiver Fittings

The fittings that connect the collector flex hose to the receiver were not finished in the factory; therefore, these had to be painted on site.

8. Spot Weld Defects in Receiver Mounting Brackets

A number of receivers fell off of their mounting brackets. These were identified as a quality control problem with a spot welding process. These brackets were replaced.

RECOMMENDATIONS

VI. RECOMMENDED MODIFICATIONS

The problems that arose during construction were resolved as they were identified. A number of recommendations are outlined here to either increase performance or to decrease maintenance.

1. Move Existing Tracker Head from the Mirror Edge to the Receiver

With the tracker head in the current location at the mirror edge, the first thing that is shaded by adjacent mirrors in the afternoon is the tracker head. This deactivates the tracking system. The control light switch still signals adequate light level and so the pump remains on and thermal energy is dumped to the environment. If the tracker head is moved to the center of the mirror over the receiver, one-half of the mirror would have to be shaded before the tracker head is shaded. Since this would only happen early in the morning or late in the afternoon, the intensity would be much smaller and probably below the light threshold of the control light switch. To assure this condition, "blinders" should be added to the control light switch to prevent this condition from occurring. This modification has been implemented on a previous project and has been successful in increasing thermal output of the system.

2. Control Upgrade

In addition to the condition outlined above, an additional problem occurs when clouds or haze exist during system start-up. Since the sensitivity of the different row control electronics and tracker head light switch are not consistent, various collectors will miss the sun under unique cloud cover conditions. This problem can be resolved by implementing (1) a tracker head that operates on focused sunlight, i.e., a flux-line tracker; (2) a high grade row control package; and (3) a high grade central light switch and electronics

3. Upgrade Hydraulic Drives

The hydraulic fluid leak and malfunction problems outlined previously should be reduced or eliminated with a higher quality hydraulic package.

4. Thermal Storage

Due to a combination of reduced load resulting from recently implemented conservation techniques, waste heat from other sources, and idle plant operations on the weekend and holidays, the solar utilization could be increased by implementing a thermal storage system.

COST COMPARISON

VII. CONSTRUCTION COST COMPARISON

ITEM	BID	ACTUAL
Painting	27,248	27,608
Structural	282,446	379,186
Electrical	145,618	157.528
Mechanical	344,800	350,314
Sheet Metal	48,420	56,179
Roofing	42,950	47,495
General Contractor	310,972	176,226
SUBTOTAL	1,202,454	1,194,536
Collectors	1,242,535	1,246,144
SUBTOTAL	2,444,989	2,440,680
DAS	200,000	200,000
Management	187,000	187,000
TOTAL	2,831,989	2,827,680

PERFORMANCE

VIII. ASSESSMENT OF PERFORMANCE

Since the official acceptance test and checkout was not available at the time of publication, preliminary data will be presented to assess system performance. Instantaneous data for both the north field and south field were taken. The total radiation on the horizontal, flow rates and temperature differences were measured. These data were then used to compute the thermal efficiency of each field. The radiation level was not at a peak condition but at a normal operation level. The collector fine tuning had not yet been conducted and the collectors had not been washed since installation was complete. The following data are, therefore, typical of normal every day operation and not ideal or peak operation.

Radiation	Area	Efficiency	Field
219 BTU/hr ft^2	13,440 ft^2	33.0%	North
214 BTU/hr ft^2	36,960 ft^2	32.9%	South

AS-BUILT DRAWINGS

IX. AS-BUILT DRAWINGS

CATERPILLAR TRACTOR CO.
SOLAR PROCESS HEAT SYSTEM
SAN LEANDRO, CALIFORNIA

COLLECTOR DRAWINGS

H-200	Collector Layout
H-201	Collector Row
H-202	Support Pylons
H-203	Mirror Module
H-204	Receiver Tube Assembly

MECHANICAL DRAWINGS

H-220	Collector Piping Schematic
H-221	Second Floor Piping Plan
H-222	Second Floor Piping Sections
H-223	First Floor Piping
H-224	Collector Piping - Roof
H-225	Solar HHW Pumps
H-226	Pump Outlet Piping
H-227	Piping Support Details
H-228	Cold Water Piping

ELECTRICAL DRAWINGS

E-240	Single Line, Block Diagram Legend & Abbreviations
E-241	Power Distribution Floor Plan
E-242	Elementary Diagram Description of Operation
E-243	Building Sections
E-244	Miscellaneous Details Plan & Elementary

STRUCTURAL DRAWINGS

S-280	Roof Truss Structural Reinforcement Plan (South Field)
S-281	Roof Truss Structural Reinforcement Plan (North Field)
S-282	Truss Reinforcement Details
S-283	Structural Details
S-284	Structural Details
S-285	Platform and Walkway Details

CONTROL AND INSTRUMENTATION DRAWINGS

CI-261	Control Floor Plan
CI-262	Sensor Element Location
CI-265	Enclosures Details
CI-267	Specifications List
CI-270	Piping and Instrumentation Diagram
CI-271	Solar Weather Station
CI-275	Sensor Connections Overview
CI-276	Power to Motor Controls

AS-BUILT

1-1-81 BID ISSUE

SAN LEANDRO SANLEANDRO CA.
SOLAR IPH SYSTEM
B-B TITLE SHEET

SOUTHWEST RESEARCH INSTITUTE
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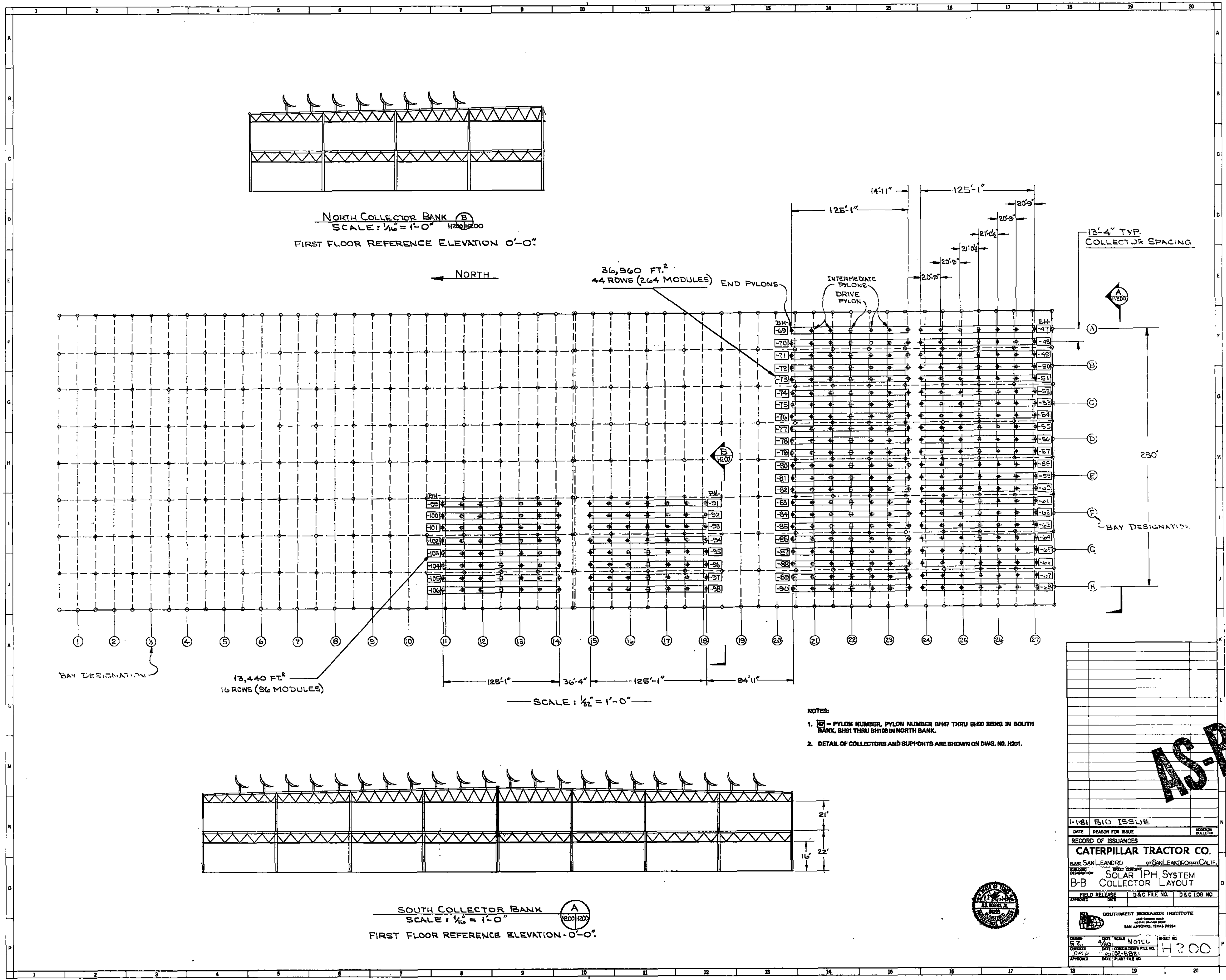
SAN ANTONIO, TEXAS 78284

EZ 7/80
TMD 7/80 02-5821 T-100



NORTH COLLECTOR BANK (B H200/H200)
SCALE: 1/16" = 1'-0"
FIRST FLOOR REFERENCE ELEVATION 0'-0".

SCALE: 1/32" = 1'-0"

SOUTH COLLECTOR BANK (A H200/H200)
SCALE: 1/16" = 1'-0"
FIRST FLOOR REFERENCE ELEVATION - 0'-0".

NOTES:

1. [47] = PYLON NUMBER, PYLON NUMBER BH47 THRU BH90 BEING IN SOUTH BANK, BH91 THRU BH106 IN NORTH BANK.

2. DETAIL OF COLLECTORS AND SUPPORTS ARE SHOWN ON DWG. NO. H201.

DATE	REASON FOR ISSUE	ADDENDA BULLETIN
1-1-81	BID ISSUE	

RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.

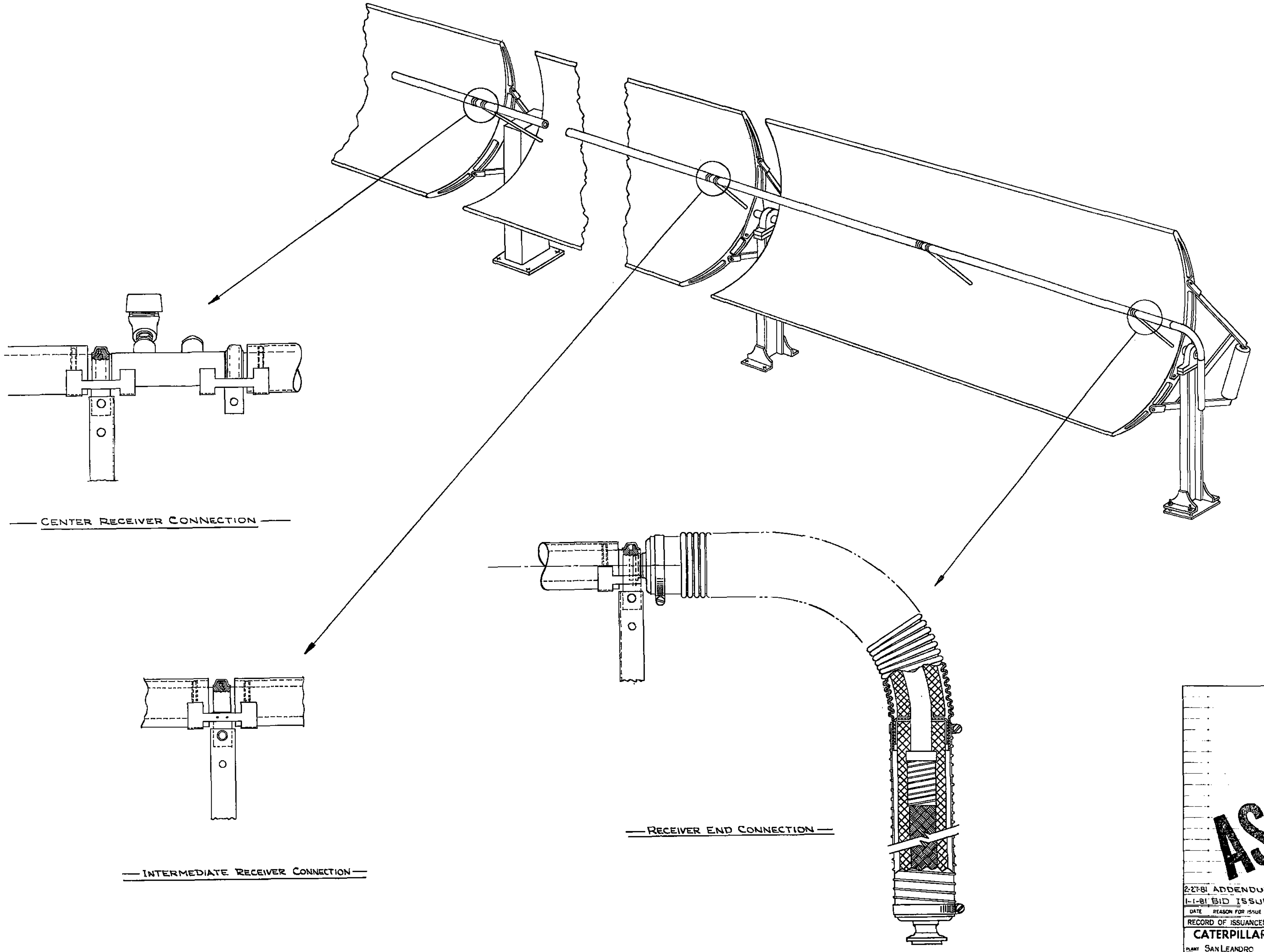
PLANT SAN LEANDRO CITY SAN LEANDRO STATE CALIF.

BUILDING DESIGNATION B-B
SHEET CONTENT SOLAR IPH SYSTEM COLLECTOR LAYOUT

FIELD RELEASE		D&C FILE NO.	D&C LOG NO.
APPROVED	DATE		

SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS 78284

DRAWN E.Z.	DATE 4/80	SCALE NOTED	SHEET NO. H200
CHECKED DMV	DATE 80	CONSULTANTS FILE NO. 02-5821	
APPROVED	DATE	PLANT FILE NO.	



AS-BUILT

2-27-81 ADDENDUM #1
1-1-81 BID ISSUE
DATE REASON FOR ISSUE
RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.

PLANT SAN LEANDRO SAN LEANDRO STATE CA.

BUILDING DESIGNATION B-B

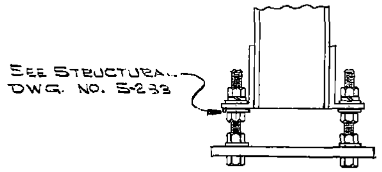
SOLAR IPH SYSTEM
COLLECTOR ROW

FIELD RELEASE
APPROVED DATE
D&C FILE NO. D&C LOG NO.

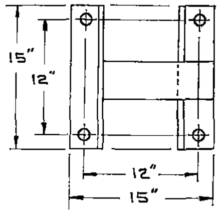
SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS 78284

DESIGN E.Z. DATE 3-81
SCALE NOT TO SCALE
CHECKED DATE
02-5821
H201
APPROVED DATE

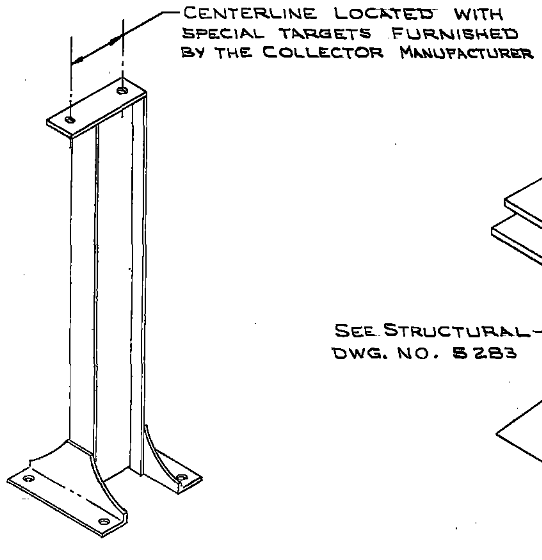
18



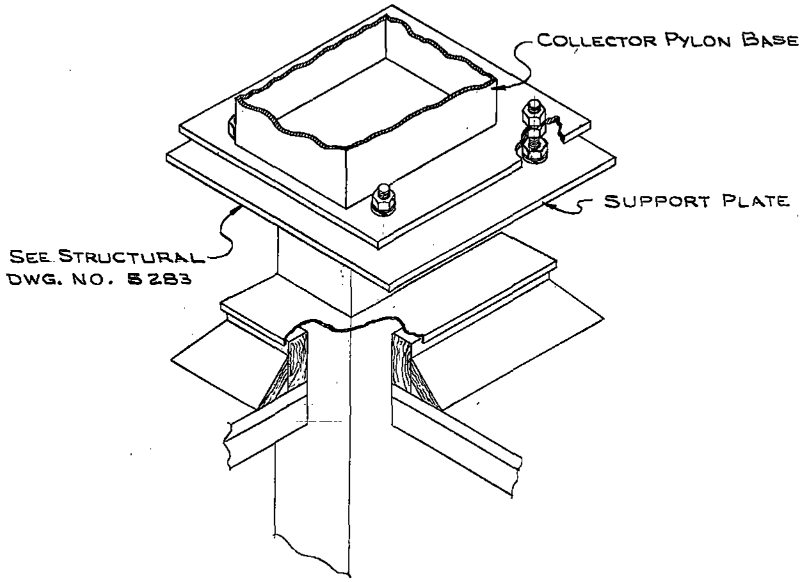
PYLON CONNECTION DETAIL



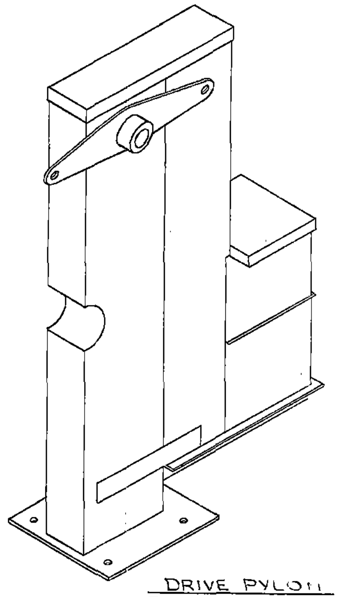
PYLON BASE DIMENSIONS FOR ALL INTERMEDIATE AND END PYLONS



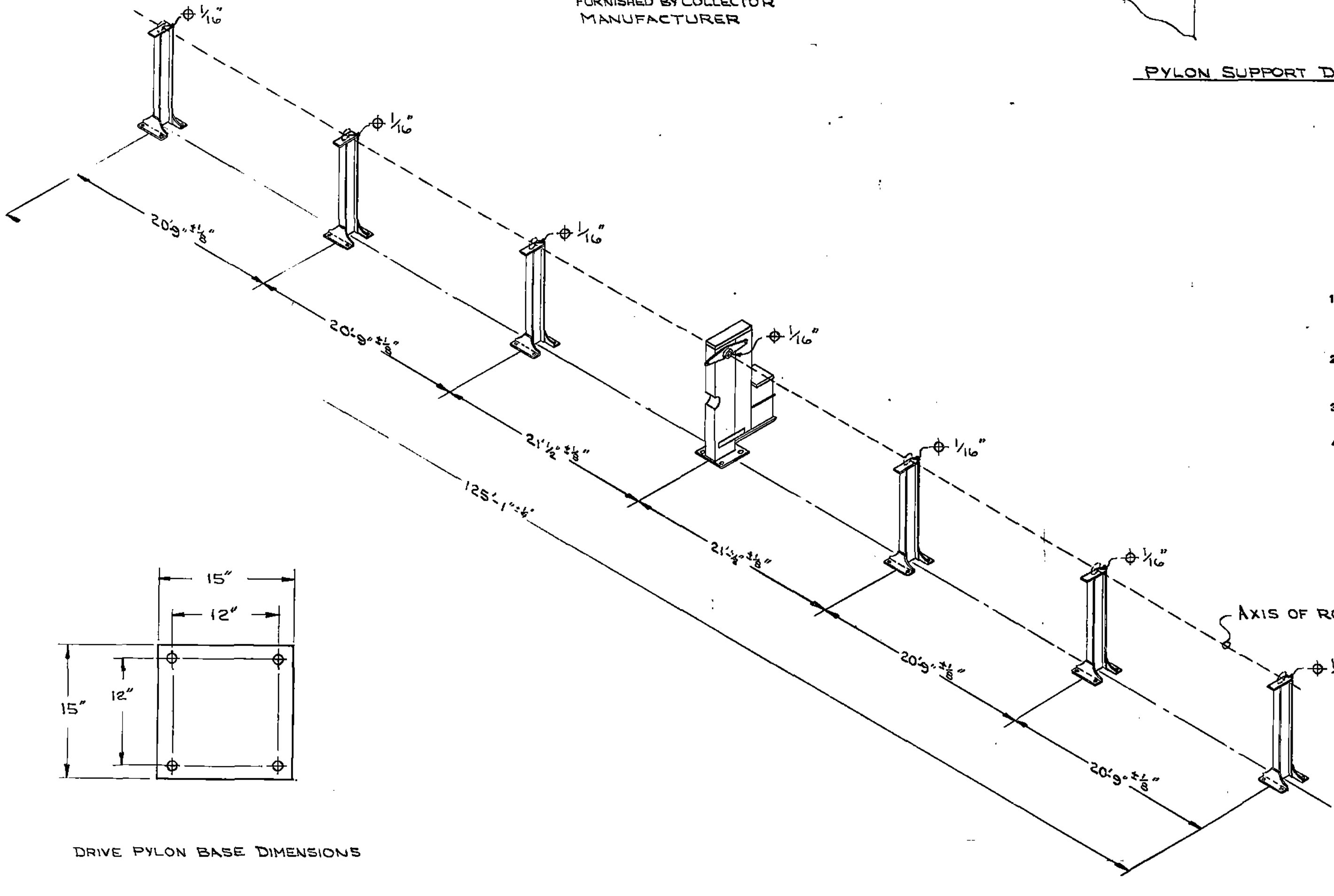
SUPPORT PYLON
FURNISHED BY COLLECTOR MANUFACTURER



PYLON SUPPORT DETAIL



DRIVE PYLON
FURNISHED BY COLLECTOR MANUFACTURER



ALL CENTERLINES OF EACH PYLON MUST BE ALIGNED TO WITHIN ±1/16" IN BOTH THE VERTICAL AND HORIZONTAL DIRECTIONS TO THE CENTERLINE OF THE DRIVE PYLON.

INSTALLATION AND ALIGNMENT OF SUPPORT AND DRIVE PYLONS

1. ROOF TOP MOUNTING PLATES SHALL BE PREPARED TO ACCEPT THE PYLON BOLT PATTERN AND SPACING PER STRUCTURAL DRAWINGS. THE DOUBLE NUT TECHNIQUE IS USED TO FASTEN THE BOTTOM OF THE PYLONS AND ALLOW FOR ADJUSTMENT AND ALIGNMENT.
2. PYLONS SHALL BE INSTALLED AND ALIGNED WITH A LASER TRANSIT. CARE SHOULD BE TAKEN TO OBTAIN A TRUE LINE OF SIGHT THROUGH THE CENTER OF THE AXIS OF ROTATION TO WITHIN ± 1/16".
3. DRIVE PYLONS SHALL BE IN THE STOW POSITION AND FILLED WITH HYDRAULIC FLUID TO PREVENT ROTATION.
4. MIRROR MODULES CANNOT BE INSTALLED UNTIL PYLONS ARE ALIGNED AND TIGHTENED TO THE SUPPORT PLATES AS INDICATED ABOVE.

DRIVE PYLON BASE DIMENSIONS

AS-BUILT

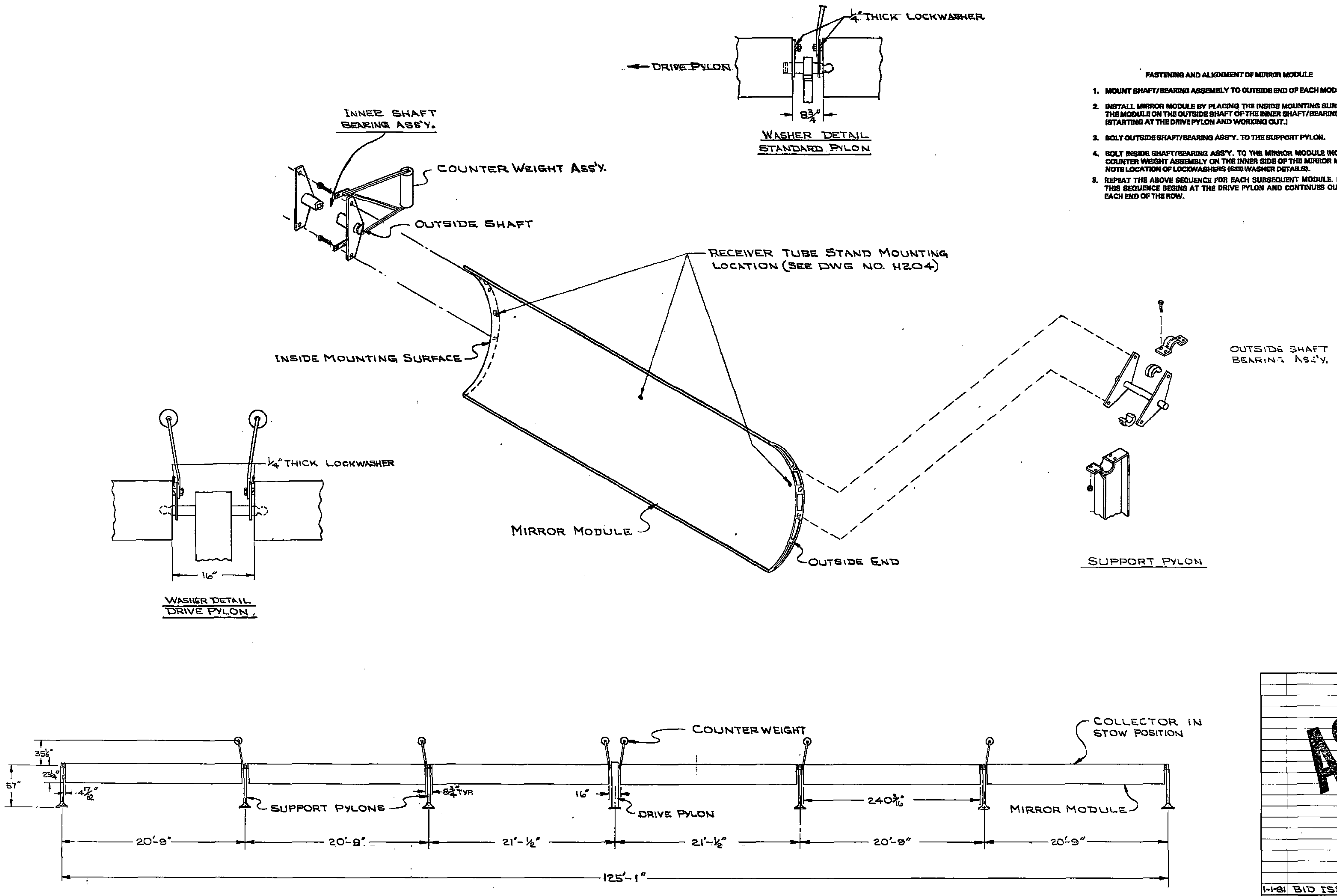
DATE	REASON FOR ISSUE	ADDENDA BULLETIN
1-1-81	BID ISSUE	

RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.
PLANT SAN LEANDRO CITY SAN LEANDRO STATE CALIF.
BUILDING DESIGNATION B-B
SHEET CONTENT SOLAR IPH SYSTEM SUPPORT PYLONS
FIELD RELEASE APPROVED DATE | D&C FILE NO. | D&C LOG NO.

SOUTHWEST RESEARCH INSTITUTE
6220 CULEBRA ROAD
POSTAL DRAWER 28510
SAN ANTONIO, TEXAS 78284

DRAWN EZ DATE 4/80 SCALE NOT TO SCALE
CHECKED DMD DATE 4/80 CONSULTANTS FILE NO. 02-5821
APPROVED DATE PLANT FILE NO.
SHEET NO. H202



FASTENING AND ALIGNMENT OF MIRROR MODULE

1. MOUNT SHAFT/BEARING ASSEMBLY TO OUTSIDE END OF EACH MODULE.
2. INSTALL MIRROR MODULE BY PLACING THE INSIDE MOUNTING SURFACE OF THE MODULE ON THE OUTSIDE SHAFT OF THE INNER SHAFT/BEARING ASS'Y. (STARTING AT THE DRIVE PYLON AND WORKING OUT.)
3. BOLT OUTSIDE SHAFT/BEARING ASS'Y. TO THE SUPPORT PYLON.
4. BOLT INSIDE SHAFT/BEARING ASS'Y. TO THE MIRROR MODULE INCLUDING COUNTER WEIGHT ASSEMBLY ON THE INNER SIDE OF THE MIRROR MODULE. NOTE LOCATION OF LOCKWASHERS (SEE WASHER DETAILS).
5. REPEAT THE ABOVE SEQUENCE FOR EACH SUBSEQUENT MODULE. NOTE THAT THIS SEQUENCE BEGINS AT THE DRIVE PYLON AND CONTINUES OUTWARD TO EACH END OF THE ROW.

AS-BUILT

DATE	REASON FOR ISSUE	ADDENDA BULLETIN
1-1-81	BID ISSUE	

RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.

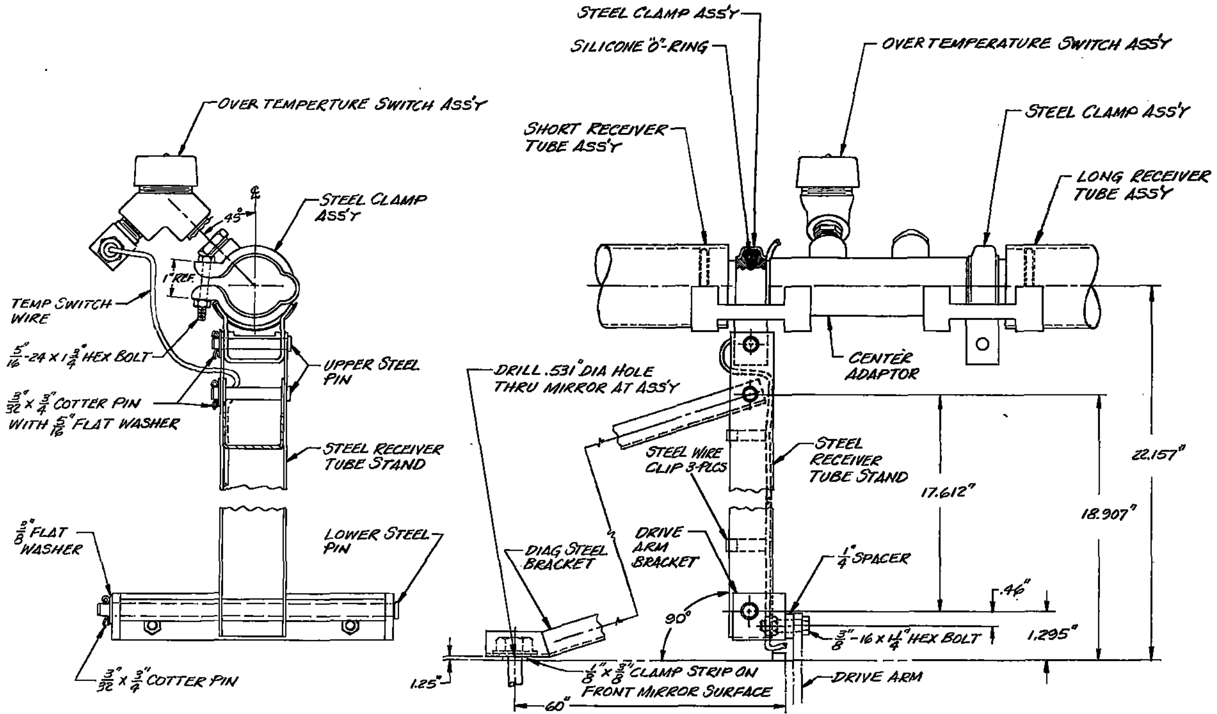
PLANT SAN LEANDRO CITY SAN LEANDRO STATE CALIF.

BUILDING DESIGNATION B-B
SHEET CONTENT SOLAR IPH SYSTEM
MIRROR MODULE

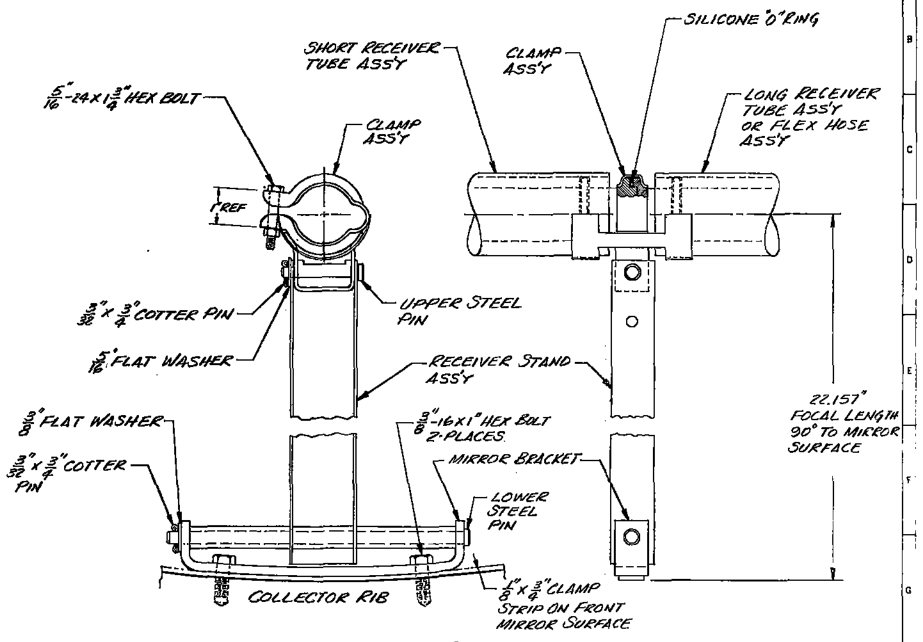
FIELD RELEASE APPROVED DATE | D&C FILE NO. | D&C LOG NO.

SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS 78284

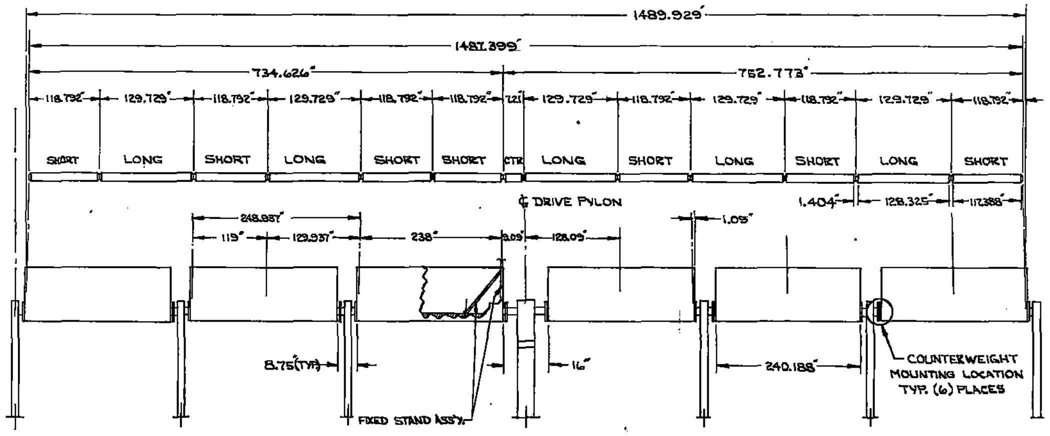
DESIGN EZ	DATE 4/80	SCALE NOT TO SCALE	SHEET NO. H203
CHECKED DMD	DATE 4/80	CONSULTANT'S FILE NO. 02-5821	
APPROVED	DATE	PLANT FILE NO.	



CENTER RECEIVER CONNECTION DETAIL



INTERMEDIATE RECEIVER CONNECTION DETAIL



RECEIVER INSTALLATION

1. The T-700 modular receiver stand features a swing arm design to allow for thermal expansion. Each mirror module requires two stands with the exception of the center (left) mirror, which requires three and a brace. One stand is mounted at the center of each mirror with two 3/8" bolts passing through the mounting bracket. The stand must be mounted to the curved bracket with the long clevis pin before bolting to the mirror. See Intermediate Receiver Connection Detail. The receiver tube stand is channel shaped and the flanges should always point away from the drive pylon. Each side of the row is the mirror image of the other.

   The second stand is mounted at the end of the collector, away from the drive pylon. The bracket at this location is flat and is bolted to the drive arm with the flanges pointed inside the mirror. At this point, the angle brace at the main center module should be mounted to locate the center stand, per Center Receiver Connection Detail. This fixed stand assembly is the location for the receiver and thermal expansion is from this point in both directions. A 1/2" hole should be drilled through the mirror in order to locate the lower point of the brace. Make certain that the receiver stand is perpendicular to the mirror when this hole is drilled.

2. The receiver flange clamp is now mounted to the top of each receiver tube stand with the short clevis pin and cotter pin. The opening of the clamp should be pointed up to hold each end of the receiver during installation. The clamp uses one 1/4" bolt and nut and must be forced open to accept the flanges.

3. The entire receiver assembly is made up of five long and seven short receivers and a center adaptor section. The center adaptor makes up the difference in mirror gap at the drive pylon and contains the overtemperature switch. Both ends of the center adaptor are made with the female half of the "V" flange and the receivers have a male on one end and a female on the other end. In this way both ends of the receiver assembly terminate in a female flange with the top hose flange being male.

4. The "V" flanges are sealed with an "O" ring. Before placing the seal in the flange, inspect both sealing surfaces well to insure that no nicks, burrs or scratches are present.

   Assembly must begin at the center, fixed location receiver stand, installing the two short receivers on that center left module with the male ends pointed to the drive pylon. A seal should be installed at the center point of the mirror where the two receivers mate and the other ends of each receiver should rest in the "V" clamp which has been opened for that purpose. Care should be taken to not allow either end to fall out of the clamp since damage will occur to the receiver assembly.

   Next, the center receiver adaptor should be installed with the temperature switch already mounted to avoid any unnecessary loads due to tightening. The seal is placed between the male end of the center short receiver and one female end of the center adaptor and the clamp at the center tightened. The temperature switch should be located as in the center receiver connection detail in order to avoid fouling of the drive pylon at the stow position. The balance of the receivers are installed in the same way from the center out to the ends so that each end of the row is the mirror image with the exception of the one odd short receiver at the center.

5. The thermal, insulated flex hoses should be installed next. The top part of the assembly is formed to a 90 degree bend and the hose is not flexible in this area. The male fitting on this end of the hoses mate to the female end of the receiver at each end of the row. Tighten the clamp with the 90 degree bend aligned with the receiver stand as shown on Drawing H201.

   The lower connection of the hose should be made next. A tortional load must not be placed on the hose at any time and care should be taken to align the hose properly. Align the hose with hoses installed. Rotate the collector with the manual controls to insure that the hose is not fouled or bound at any position. Do not pause with the collector near focus as overheating and damage to the receiver will occur.

   The receiver and hose connections should now be checked for leaks. If pressure is applied to the receiver and hose assembly, the hose should be fastened at both ends or a sudden pressure will straighten out the hose. A hydrostatic pressure test up to 250 psi is recommended and, if water is used, a corrosion inhibitor is required.

AS-BUILT

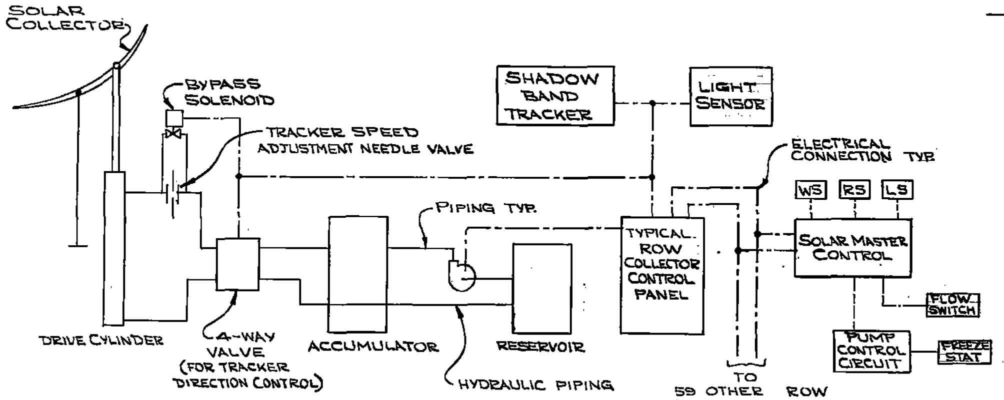
DATE	REASON FOR ISSUE
2-27-81	ADDENDUM #1
1-1-81	BID ISSUE

RECORD OF ISSUANCES

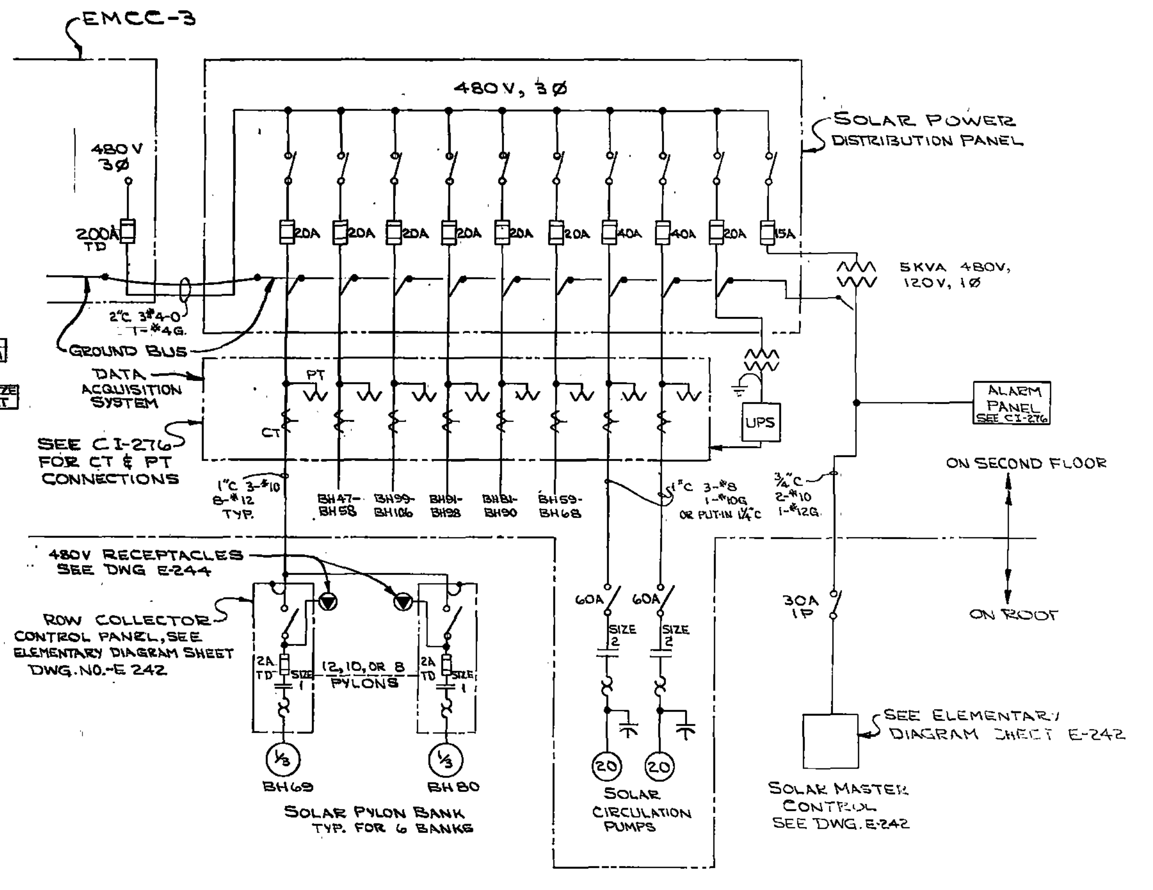
CATERPILLAR TRACTOR CO.
PLANT SAN LEANDRO CITY SAN LEANDRO STATE CA.
BUILDING DESIGNATION B-B
SHEET CONTENT SOLAR IPH SYSTEM
RECEIVER TUBE ASSEMBLY
FIELD RELEASE APPROVED DATE | D&C FILE NO. | D&C LOG NO

SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS 78284

DRAWN E.Z. DATE 3-81
CHECKED DMD DATE 4-14
APPROVED DATE
SCALE NOT-TO-SCALE
CONSULTANTS FILE NO 02-5821
PLANT FILE NO
SHEET NO H-204



BLOCK DIAGRAM
TYPICAL COLLECTOR CONTROL OPERATION
NO SCALE



SINGLE LINE OF SOLAR POWER DISTRIBUTION
NO SCALE

COLLECTOR CONTROL OPERATION

1. WHEN SUFFICIENT LIGHT IS AVAILABLE, SOLAR MASTER CONTROL TELLS THE ROW COLLECTOR CONTROL PANEL TO UNSTOW AND COMMENCE TRACKING THE SUN.
2. BYPASS SOLENOID OPERATES TO PROVIDE RAPID MOVEMENT INTO TRACKING POSITION.
3. SHADOW BAND TRACKER TRACKS SUN FOR MAXIMUM INPUT RADIATION.
4. SOLAR MASTER CONTROL OVERRIDES ALL SIGNALS IN EVENT OF RAIN, WIND, HIGH WATER TEMPERATURE AND STOWS ALL COLLECTORS

ABBREVIATIONS FOR E & CI DWGS.

FE - FLOW ELEMENT
TE - TEMPERATURE ELEMENT
PE - PRESSURE ELEMENT
WV - WIND VELOCITY
RF - RAIN FALL
RH - RELATIVE HUMIDITY
WD - WIND DIRECTION
FS - FLOW SWITCH
AVV - AIR VENT VALVE
PRV - PRESSURE RELIEF VALVE
ISV - ISOLATION VALVE
TRV - TEMPERATURE REGULATED VALVE
CSV - CIRCUIT SETTER VALVE WITH FLOW INDICATOR
DRV - DRAIN VALVE
LS - LIGHT SWITCH
RS - RAIN SWITCH
WS - WIND SWITCH
TS - TEMPERATURE SWITCH
FS - FLOW SWITCH
PS - PRESSURE SWITCH
Ⓣ THERMOMETER
Ⓟ PRESSURE GAGE
Ⓕ VENTURI FLOWMETER W/ PRESSURE GAGE
ⓉⓉ TEMPERATURE TAP
IPS - INSTRUMENTATED PIPE SECTION
EP - ELECTRICAL POWER (WATTMETER)
SET - SENSOR ELEMENT TERMINATION
PB - PULL BOX
RDC - REMOTE DATA COLLECTION
HHWR - HEATING HOT WATER RETURN
ID - INNER DIAMETER
RCC - ROW COLLECTOR CONTROL
SPD - SOLAR POWER DISTRIBUTION
CT - CURRENT TRANSFORMER
PT - POTENTIAL TRANSFORMER
UPS - UNINTERRUPTABLE POWER SUPPLY
SMC - SOLAR MASTER CONTROL
BCG - BARE COPPER GROUND

SINGLE LINE LEGEND

- SWITCH, 3 POLE UNLESS NOTED
▯ - FUSE, SIZE AS NOTED
○ - MOTOR, HORSE POWER AS NOTED
- MAGNETIC STARTER
⬚ - MISCELANEOUS DEVICE AS NOTED
- POWER FACTOR CAPACITOR
- CURRENT TRANSFORMER
- POTENTIAL TRANSFORMER
● SPECIAL RECEPTACLE AS NOTED
GROUND WIRE CONNECTION TO CIRCUIT

PLANS LEGEND

—— - EXPOSED CONDUIT
- FLEX CONDUIT CONNECTION
Ⓙ - JUNCTION BOX, TYPE FS OR FD
☒ - COMBINATION STARTER
□ - MISCELANEOUS DEVICE AS NOTED

AS-BUILT

1-1-81 BID ISSUE

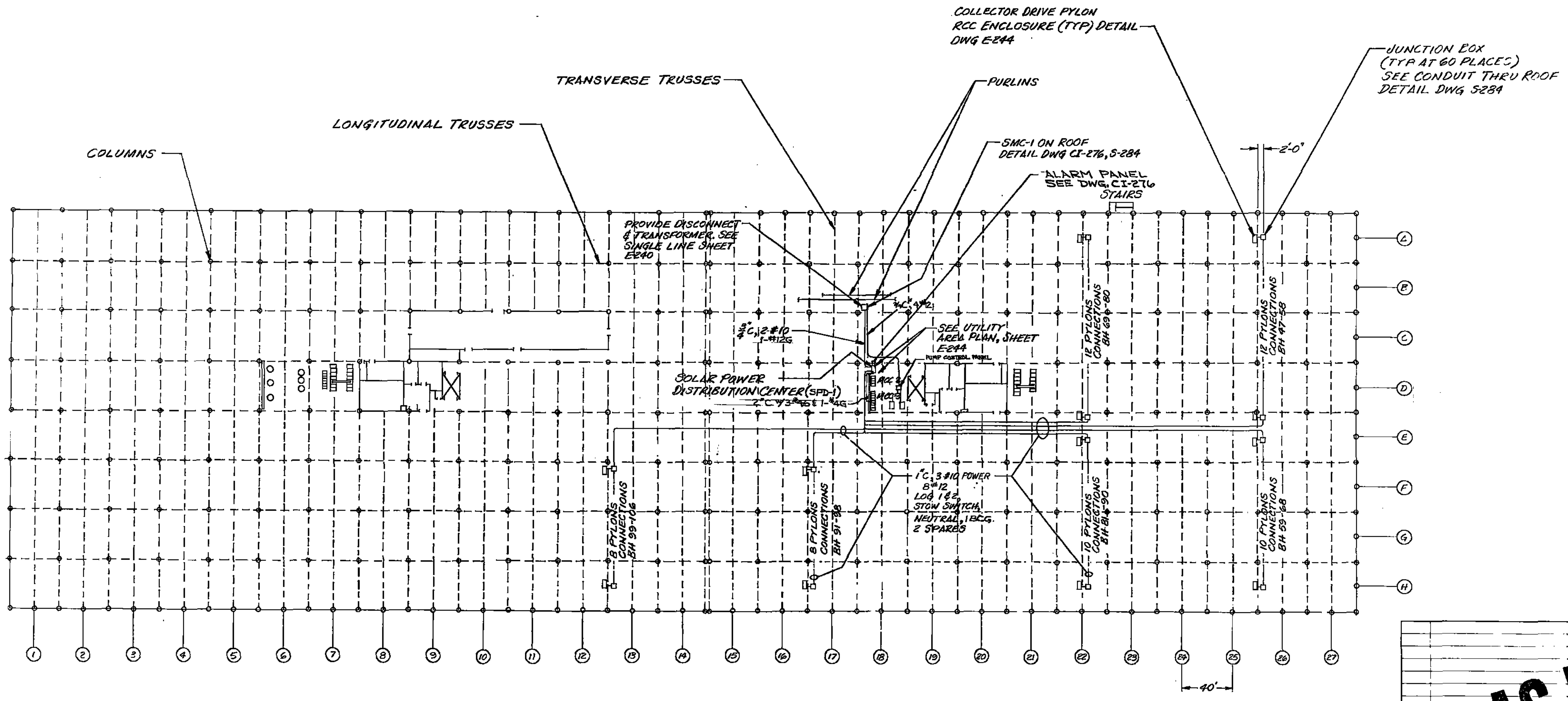
CATERPIL[illegible] [illegible]CTOR CO.
SAN LEANDRO SAN LEANDRO CA.

B-B
SOLAR IPH SYSTEM
SINGLE LINE, BLOCK DIAGRAM
LEGEND AND ABBREVIATIONS

SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS 78284

E.Z. 11-22-80
M.H. 12-80
[illegible] 12/80

E-240



NORTH ←

SECOND FLOOR PLAN

NOTES:
1. SEE E-244 FOR CONDUIT SUPPORT DETAILS
2. WIRING FOR CONTROL TEMPERATURE, PRESSURE & FLOW SWITCHES ARE RUN IN RDC CONDUITS. SEE CI-261, CI-262, CI-270.

AS-BUILT

DATE	REASON FOR ISSUE	ADD. NDA BULLETIN
1-1-81	BID ISSUE	

RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.

PLANT SAN LEANDRO CITY SAN LEANDRO STATE CALIF.

BUILDING DESIGNATION BB
SHEET CONTENT SOLAR IPH SYSTEM
POWER DISTRIBUTION FLOOR PLAN

FIELD RELEASE APPROVED	DATE	D & C FILE NO.	D & C LOG NO.

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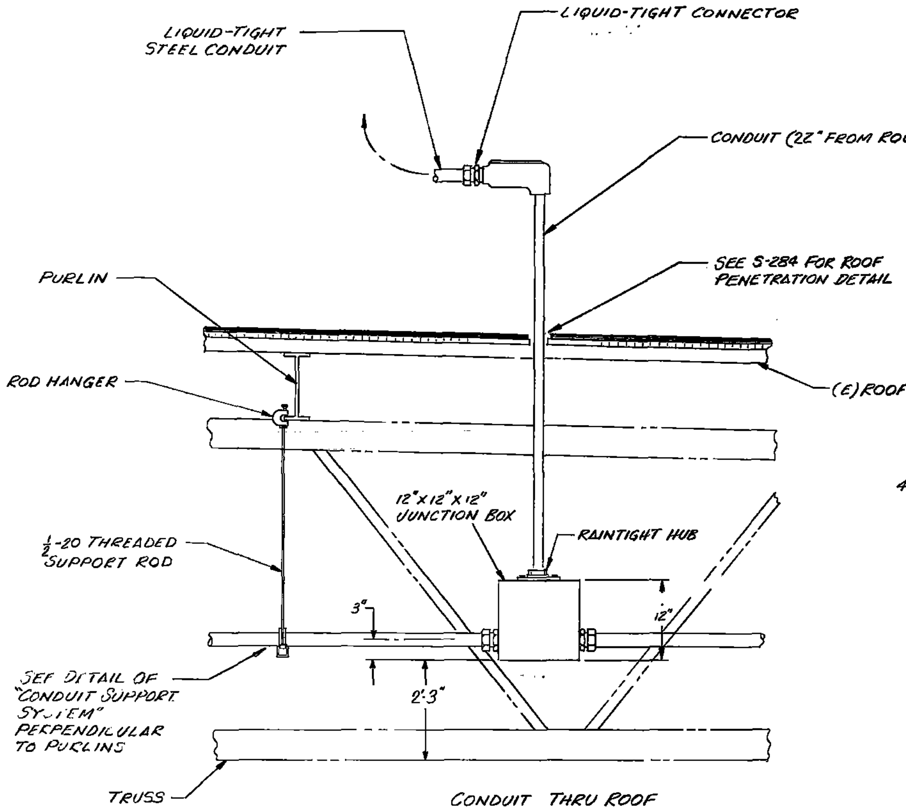
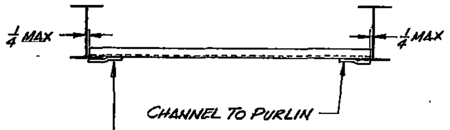
SAN ANTONIO, TEXAS 78284

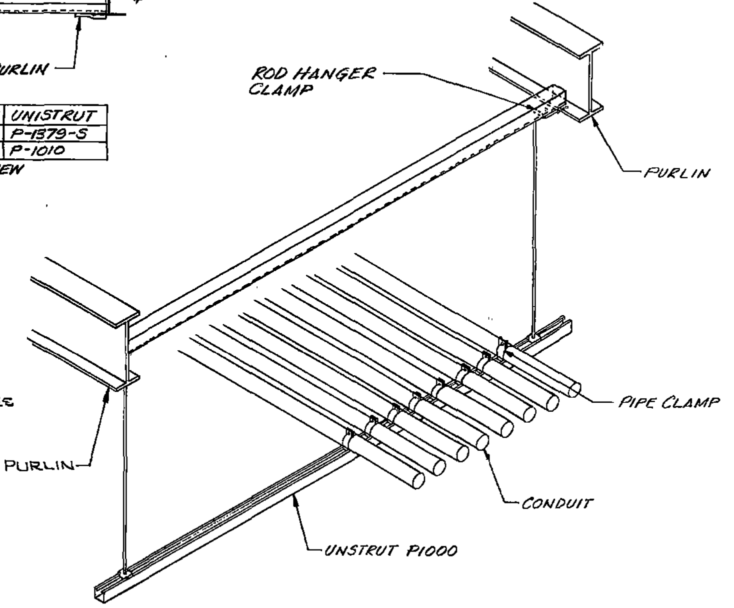
DRAWN J.M.	DATE 2/80	SCALE 1/32"=1'-0"	SHEET NO E-241
CHECKED J.M.	DATE 2/80	CONSULTANTS FILE NO. 02-5821	
APPROVED	DATE	PLANT FILE NO.	



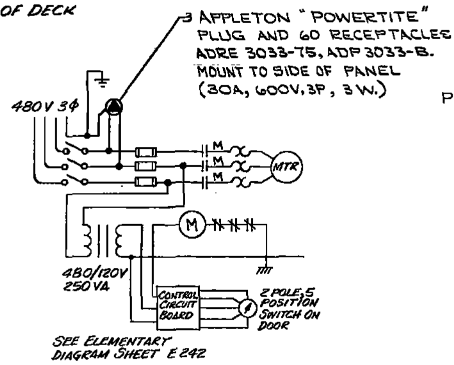
CONDUIT THRU ROOF
TYPICAL AT 60 PLACES
SCALE: 1½"=1'-0"



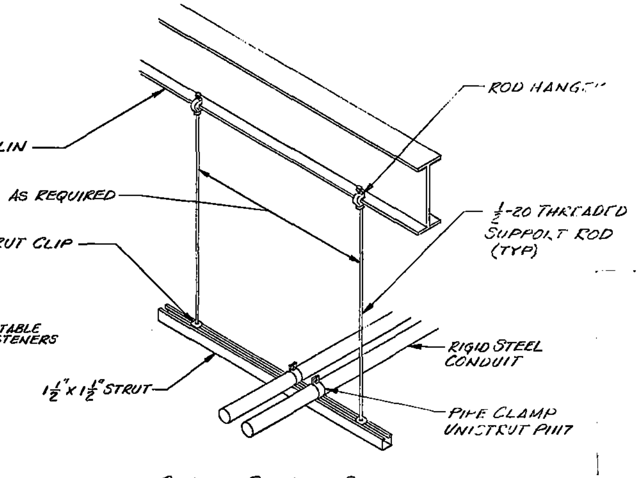
	B-LINE	UNISTRUT
CLAMP	B-211	P-1379-S
½"NUT	N-225	P-1010
½"HEX HD CAP SCREW		



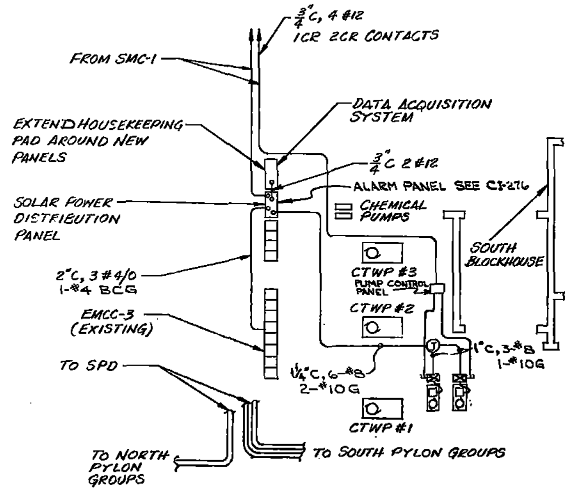
CONDUIT SUPPORT SYSTEM
(PARALLEL TO PURLINS)
SCALE: ½"=1'-0"



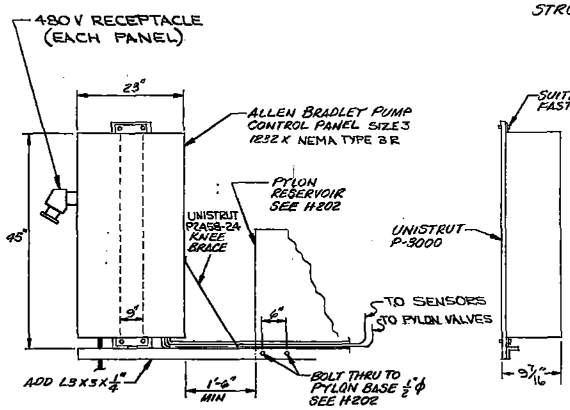
ROW COLLECTOR CONTROL PANEL WIRING
NO SCALE



CONDUIT SUPPORT SYSTEM
(PERPENDICULAR TO PURLINS)
SCALE: ½"=1'-0"



UTILITY AREA PLAN
SCALE: ⅛"=1'-0"



ROW COLLECTOR CONTROL PANEL SUPPORT
NO SCALE

NOTE: PROVIDE THIS INSTALLATION 60 PLACES

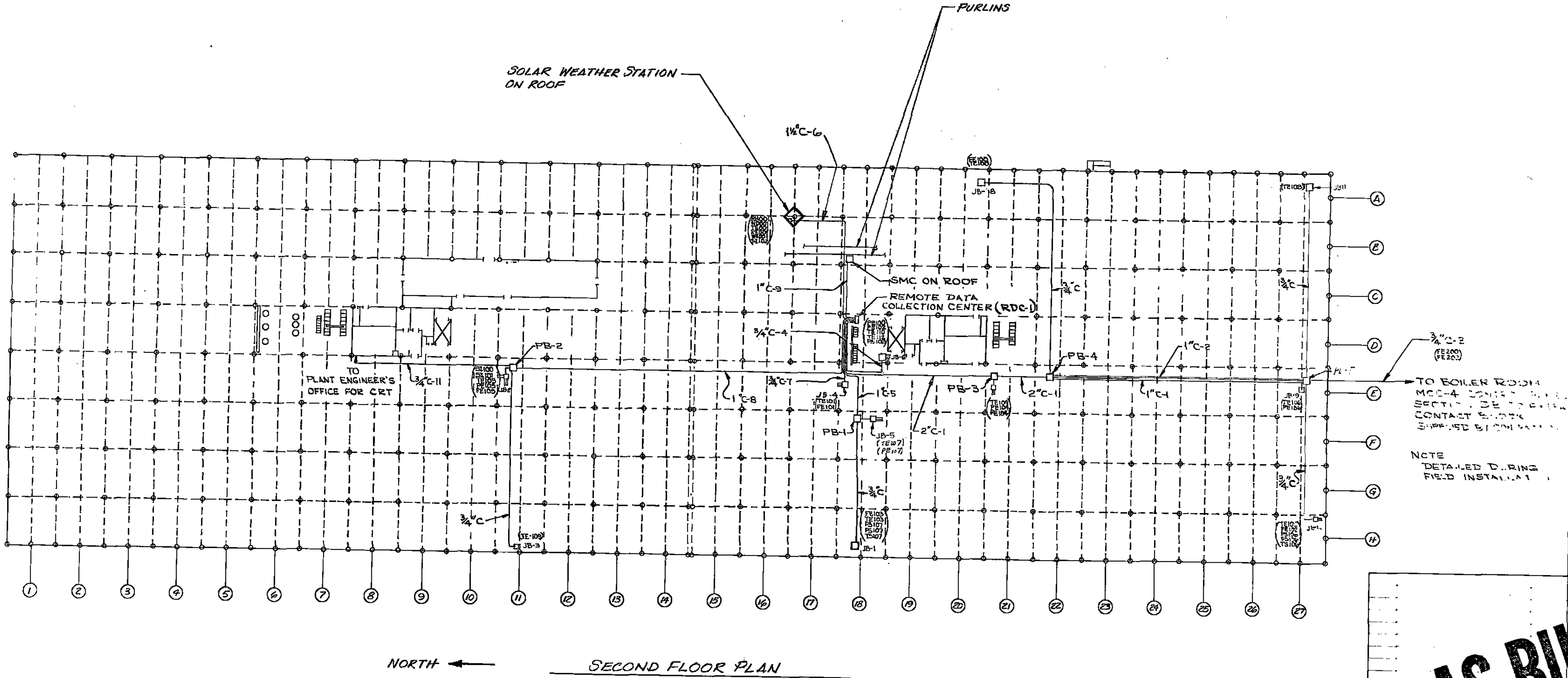
AS-BUILT

1-1-81 BID ISSUE

CATERPILLAR TRACTOR
SAN LEANDRO SAN LEANDRO CALIF.
SOLAR IPH SYSTEM
BB MISCELANEOUS DETAILS
PLAN, ELEMENTARY

SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS 78284

P.G. 3/80 NOTED
J.M. 3/80 02-5821
E244



SECOND FLOOR PLAN

AS-BUILT

NOTES:
1. SENSOR LOCATIONS SHOWN ON ISOMETRIC PIPING DRAWING NO CI-262
2. SEE DWG. E-242 FOR DEFINITIONS OF JB & P.B.
3. SEE DWG. CI-275 FOR COORDINATION OF JUNCTION BOXES, CONDUIT & PULL BOXES AND TERMINATIONS.
4. ALL CONDUIT SHALL BE RIGID STEEL AND FIELD VERIFY SIZES.
5. CHECK WITH OWNER'S REPRESENTATIVE FOR LOCATION OF CONDUIT C-11-RDC-1 TERMINATION.
6. LOCATE SENSORS AS CLOSE AS POSSIBLE TO JUNCTION BOXES
7. CONNECTIONS BETWEEN SENSORS & JUNCTION BOXES SHOULD BE WITHIN FLEX CONDUIT

STEPHEN W. SEALE, JR.
30653

DATE	REASON FOR ISSUE
4-14-81	ADDENDUM #2
1-1-81	BID ISSUE

RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.
PLANT SAN LEANDRO CITY SAN LEANDRO STATE CALIF.
BUILDING DESIGNATION B-B
SHEET CONTENT SOLAR IPH SYSTEM CONTROL FLOOR PLAN
FIELD RELEASE APPROVED DATE
D&C FILE NO.
D&C LOG NO.

SOUTHWEST RESEARCH INSTITUTE
6220 CULEBRA ROAD
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SAN ANTONIO, TEXAS 78284

DRAWN J.M. DATE 1/80
CHECKED DATE 11/80
APPROVED DATE
SCALE 1/32"=1'-0"
CONSULTANTS FILE NO C2-5821
PLANT FILE NO
SHEET NO CI 261

LENGTH	MANUFACTURE * AND MODEL *	RDC TERMINAL BLOCK	CONDUIT	TRANSDUCER / FUNCTION		DESCRIPTION
430′	BELDON 8760	TB-3	C-1	FE-100-DP		SOLAR COLLECTOR FIELD "A" INLET FLOW
430′	8760	TB-3	C-1	TE-100-R		SOLAR COLLECTOR FIELD "A" INLET TEMPERATURE
570′	8760	TB-3	C-2	FE-102-DP		SOLAR COLLECTOR FIELD "A" OUTLET FLOW
570′	8760	TB-3	C-2	TE-102-R		SOLAR COLLECTOR FIELD "A" OUTLET TEMPERATURE
190′	8760	TB-3	C-1	FE-104-DP		SINGLE COLLECTOR ROW FIELD "A" FLOW
190′	8760	TB-3	C-1	TE-104-R		SINGLE COLLECTOR ROW FIELD "A" INLET TEMPERATURE
190′	8760	TB-3	C-1	PE-104-SG		SINGLE COLLECTOR ROW FIELD "A" INLET PRESSURE
450′	8760	TB-3	C-1	TE-106-R		SINGLE COLLECTOR ROW FIELD "A" OUTLET TEMPERATURE
450′	8760	TB-3	C-1	PE-106-SG		SINGLE COLLECTOR ROW FIELD "A" OUTLET PRESSURE
90′	8760	TB-2	C-4	PE-100-SG		SOLAR FIELD SUPPLY PUMP INLET PRESSURE
90′	8760	TB-2	C-4	PE-102-SG		SOLAR FIELD SUPPLY PUMP OUTLET PRESSURE
90′	8760	TB-2	C-4	TE-112-R		SOLAR FIELD SUPPLY PUMP INLET TEMPERATURE
90′	8760	TB-2	C-4	TE-110-R		SOLAR FIELD SUPPLY PUMP OUTLET TEMPERATURE
1000′	8760	TB-3	C-3	FE-200DP		TURBINE METER PICKOFF FOR BOILER #1 NATURAL GAS FLOWRATE
1000′	8760	TB-3	C-3	FE-202DP		TURBINE METER PICKOFF FOR BOILER #2 NATURAL GAS FLOWRATE
620′	8760	TB-3	C-2	TE-108-R		COLLECTOR FIELD "A" AMBIENT TEMPERATURE
150′	8760	TB-2	C-7	FE-101-DP		SOLAR COLLECTOR FIELD "B" INLET FLOW
150′	8760	TB-2	C-7	TE-101-R		SOLAR COLLECTOR FIELD "B" INLET TEMPERATURE
210′	8760	TB-1	C-5	FE-103-DP		SOLAR COLLECTOR FIELD "B" OUTLET FLOW
210′	8760	TB-1	C-5	TE-103-R		SOLAR COLLECTOR FIELD "B" OUTLET TEMPERATURE
340′	8760	TB-1	C-8	FE-105-DP		SINGLE COLLECTOR ROW FIELD "B" INLET FLOW
340′	8760	TB-1	C-8	TE-105-R		SINGLE COLLECTOR ROW FIELD "B" INLET TEMPERATURE
300′	8760	TB-1	C-8	PE-105-SG		SINGLE COLLECTOR ROW FIELD "B" INLET PRESSURE
200′	8760	TB-1	C-5	TE-107-R		SINGLE COLLECTOR ROW FIELD "B" OUTLET TEMPERATURE
200′	8760	TB-1	C-5	PE-107-SG		SINGLE COLLECTOR ROW FIELD "B" INLET PRESSURE
475′	8760	TB-1	C-8	TE-109-R		COLLECTOR FIELD "B" AMBIENT TEMPERATURE
150′	8621	TB-2	C-6	WV-001-DP		WIND VELOCITY OPEN ROOF
150′	9365	TB-2	C-6	RF-001-DC		RAIN FALL
150′	8690	TB-2	C-6	RH-001-AM		RELATIVE HUMIDITY
150′	8621	TB-2	C-6	WD-001-P		WIND DIRECTION ON OPEN ROOF
150′	8760	TB-2	C-6	TE-001-R		AMBIENT AIR TEMPERATURE
150′	8760	TB-2	C-6	SI-102-AM		SOLAR INSOLATION TOTAL HORIZONTAL
150′	8760	TB-1	C-8	SI-100-AM		SOLAR INSOLATION TOTAL TRACKED
* 150′	8760	TB-1	C-8	SI-101-AM		SOLAR INSOLATION TOTAL TRACKED WITH SHADOW BAND
* 570′	8760	TB-3	C-2	FS-106-NO		FLOW SWITCH FIELD "A" OUTPUT
* 570′	8760	TB-2	C-4	FS-108-NO		FLOW SWITCH FIELD "A" OUTPUT
200′	8760	TB-1	C-5	FS-107-NO		FLOW SWITCH FIELD "B" OUTPUT
30′	8760	TB-4	C-10	EP-601-A		ELECTRICAL POWER PUMP MOTOR PRIMARY
30′	8760	TB-4	C-10	EP-602-A		ELECTRICAL POWER PUMP MOTOR BACKUP
30′	8760	TB-4	C-10	EP-603-A		ELECTRICAL POWER SOLAR COLLECTOR PYLONS (BH69-BH80)
1060′	8723		C-11	ENGINEER CRT	DEC VT 100	ENGINEER'S DISPLAY CRT
1060′	8723			MAINT. PRINTER	DEC LA-120	MAINTENANCE PRINTER FOR PERFORMANCE EVALUATION
420′	8723			MAINTENANCE CRT	DEC VT 100	MAINTENANCE DISPLAY CRT
	TELCO		C-12	TELEPHONE LINE	TELCO RJ455	COMMUNCATION LINK FOR REMOTE MODEN OPERATION
550′	8760	TB-3	C-2	TS-106-NC		OVERTEMPERATURE SWITCH FOR HAZARD LOOP FIELD "A"
200′	8760	TB-1	C-5	TS-107-NC		OVERTEMPERATURE SWITCH FOR HAZARD LOOP FIELD "B"
150′	8760		C-9	TS-108-NC		FREEZE-STAT FOR PUMP CONTROL
550′	8760	TB-3	C-2	PS-106-NC		OVER PRESSURE SWITCH FOR HAZARD LOOP FIELD "A"
200′	8760	TB-1	C-5	PS-107-NC		OVER PRESSURE SWITCH FOR HAZARD LOOP FIELD "B"
30′	8760	TB-4	C-10	EP-604-A		ELECTRICAL POWER SOLAR COLLECTOR PYLONS (BH47-BH58)
30′	8760	TB-4	C-10	EP-605-A		ELECTRICAL POWER SOLAR COLLECTOR PYLONS (BH99-BH106)
30′	8760	TB-4	C-10	EP-606-A		ELECTRICAL POWER SOLAR COLLECTOR PYLONS (BH91-BH98)
30′	8760	TB-4	C-10	EP-607-A		ELECTRICAL POWER SOLAR COLLECTOR PYLONS (BH81-BH90)
30′	8760	TB-4	C-10	EP-608-A		ELECTRICAL POWER SOLAR COLLECTOR PYLONS (BH59-BH68)
30′	8760	TB-4	C-10	EP-609-A		ELECTRICAL POWER TO ALL CONTROLS

* SUPPLIED BY ELECTRICAL CONTRACTOR

NOTES:
1. CONDUIT SIZES PER DWG. CI-261.
2. WIRE GAGE SHOULD BE # 22 OR THICKER
3. FIELD VERIFY ALL CABLE LENGTHS.

STEPHEN W. BEALE, JR.
40380

Stephen W. ... PE 40380

AS-BUILT

DATE	REASON FOR ISSUE	ADDENDA BULLETIN
4-14-81	ADDENDUM #1	
1-1-81	BID ISSUE	

RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.

PLANT SAN LEANDRO CITY SAN LEANDRO STATE CALIF.

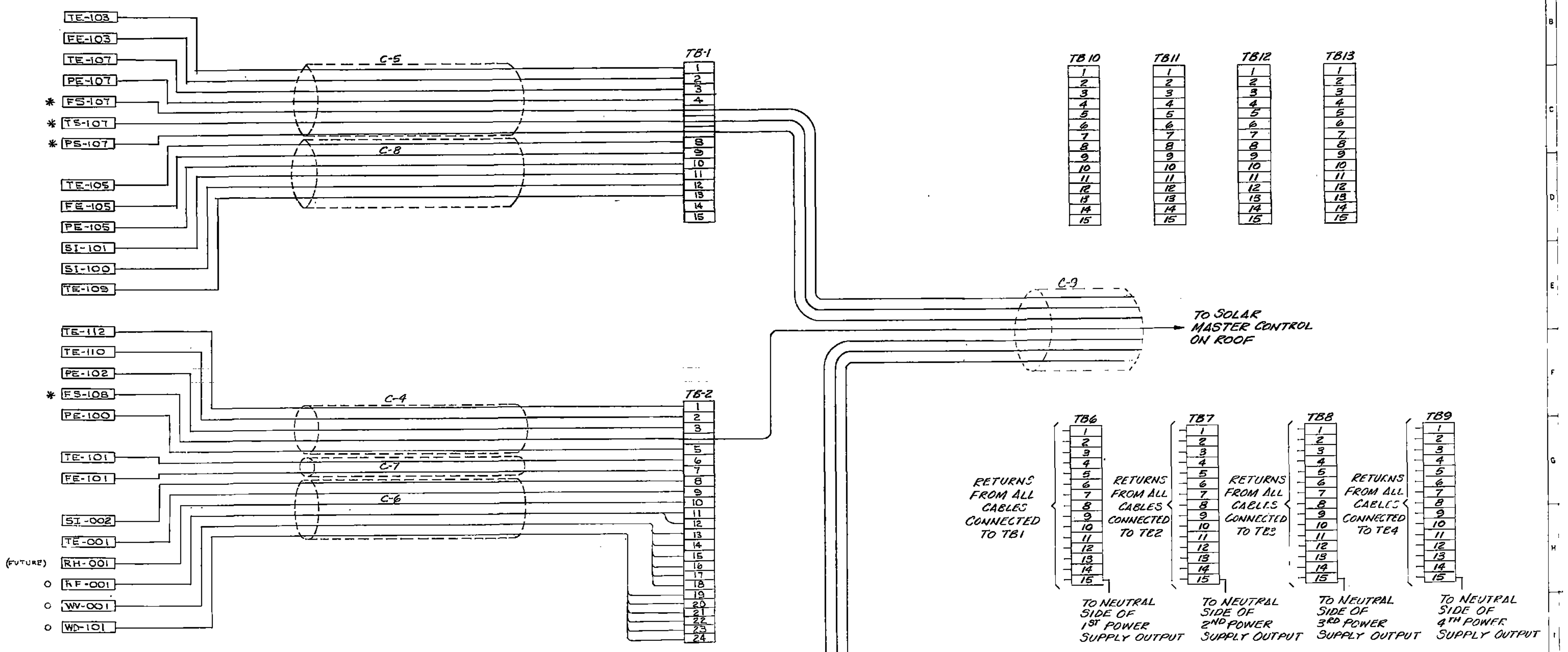
BUILDING DESIGNATION B-B

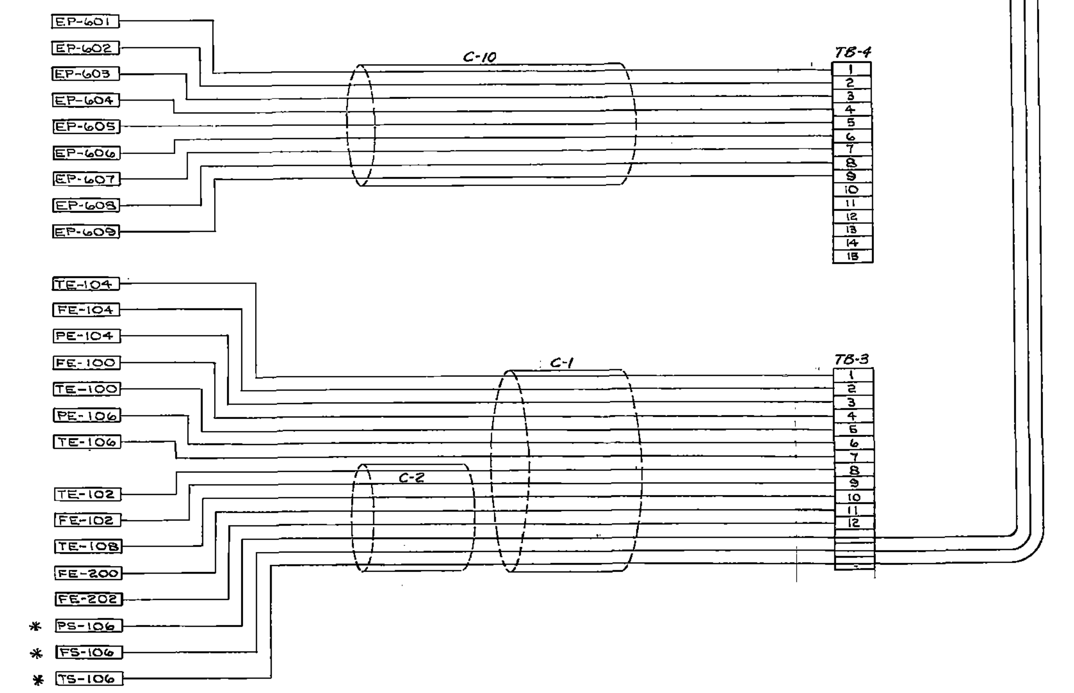
SHEET CONTENT SOLAR IPH SYSTEM SPECIFICATIONS LIST

FIELD RELEASE APPROVED DATE | D&C FILE NO. | D&C LOG NO.

SOUTHWEST RESEARCH INSTITUTE
6220 CULEBRA ROAD
POSTAL DRAWER 28510
SAN ANTONIO, TEXAS 78284

DRAWN E.Z. DATE 4/80
CHECKED DATE
SCALE —
CONSULTANTS FILE NO. 02-5821
APPROVED DATE
PLANT FILE NO.
SHEET NO. CI-267





NOTES

1. ALL CABLES SHALL BE TAGGED ACCORDING TO THE SENSOR'S NAME AND LABELED AT EVERY TERMINATION.
2. POWER SUPPLY PROVIDED BY DATA ACQUISITION CONTRACTOR
3. TERMINAL BLOCKS 10-13 ARE SPARE TERMINAL BLOCKS FOR DATA ACQUISITION CONTRACT.
4. INCLUDE SPARE CABLES IN EACH OF THE FOLLOWING CONDUITS: C-1 C-2, C4 C5, C6, C8, C9, C10
5. LINES FROM SENSORS TO TERMINAL BLOCKS 1-4 REPRESENT BELDON 8760 SHIELDED PAIRS UNLESS OTHERWISE NOTED
6. THE GROUND OR RETURN SIDES OF EACH PAIR ARE BUSSED TOGETHER AS SHOWN ON TERMINAL BLOCKS 6-9 UNLESS OTHERWISE NOTED
7. CONNECTIONS TO TERMINAL BLOCKS 1-4 REPRESENT ONLY THE SIGNAL (HOT) CONDUCTOR OF EACH CABLE.
8. REFER TO DRAWING E-242 FOR TERMINATION OF SWITCHES AT SOLAR MASTER CONTROLLER

° SEE DRAWING CI-267 FOR CABLE SPECIFICATIONS

* PULL ENTIRE CABLE THROUGH TO SOLAR MASTER CONTROL WITHOUT TERMINATION

AS-BUILT

DATE	REASON FOR ISSUE	ADDENDA BULLETIN
4-14-81	ADDENDUM #2	
1-1-81	BID ISSUE	

RECORD OF ISSUANCES

CATERPILLAR TRACTOR CO.
PLANT SAN LEANDRO CITY SAN LEANDRO STATE CA.
BUILDING DESIGNATION B-B
SHEET CONTENT SENSOR CONNECTION OVERVIEW
FIELD RELEASE APPROVED DATE | D&C FILE NO. | D&C LOG NO.

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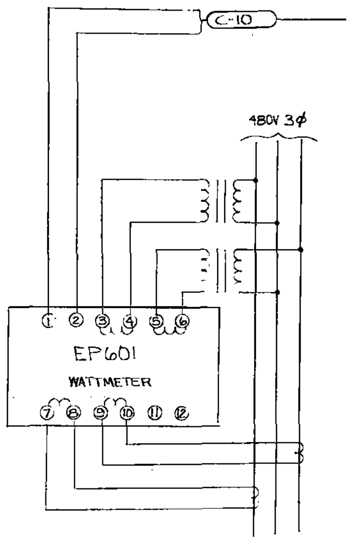
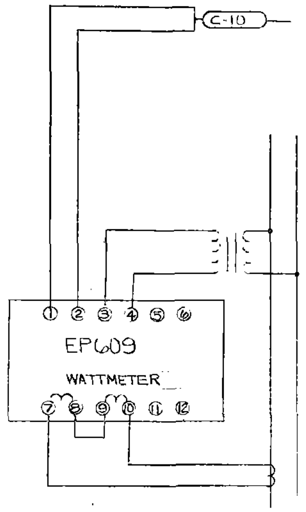
POSTAL DRAWER 28510
SAN ANTONIO, TEXAS 78284

DRAWN EZ DATE 4-81
CHECKED DATE
APPROVED DATE
SCALE
CONSULTANTS FILE NO 02-5821
PLANT FILE NO
SHEET NO CI-275

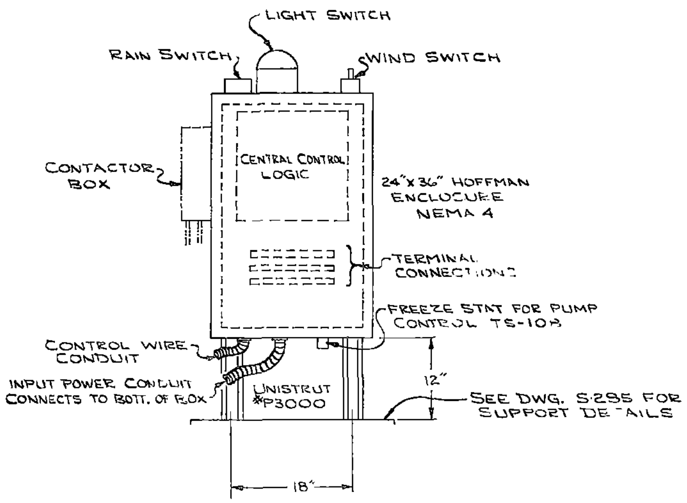
30653



TYPICAL 3Ø WATTMETER CONNECTIONS
(EP601-608)

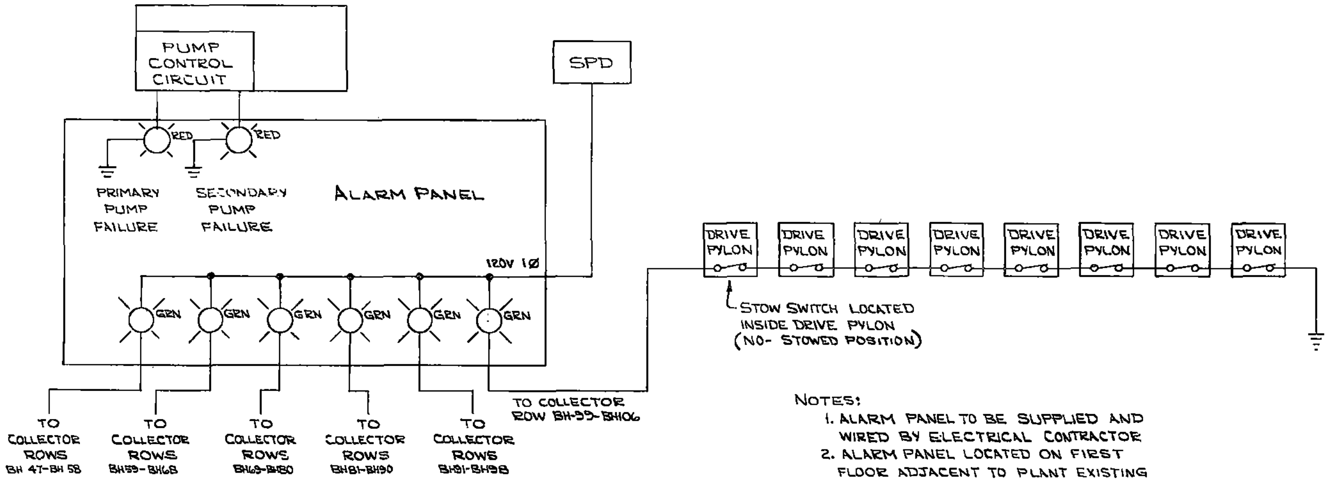


TYPICAL 1Ø WATTMETER CONNECTIONS
(EP609)



SOLAR MASTER CONTROLLER (SMC-1)

RDC CURRENT & POTENTIAL TRANSFORMER CONNECTIONS (EP601-EP609)
SEE DWG. E-240, SUPPLIED AND INSTALLED BY ELECTRICAL CONTRACTOR



ALARM PANEL SYSTEM BLOCK DIAGRAM
NO SCALE

NOTES:
1. ALARM PANEL TO BE SUPPLIED AND WIRED BY ELECTRICAL CONTRACTOR
2. ALARM PANEL LOCATED ON FIRST FLOOR ADJACENT TO PLANT EXISTING ALARM PANELS. CHECK WITH OWNERS REP FOR EXACT LOCATION.

AS-BUILT

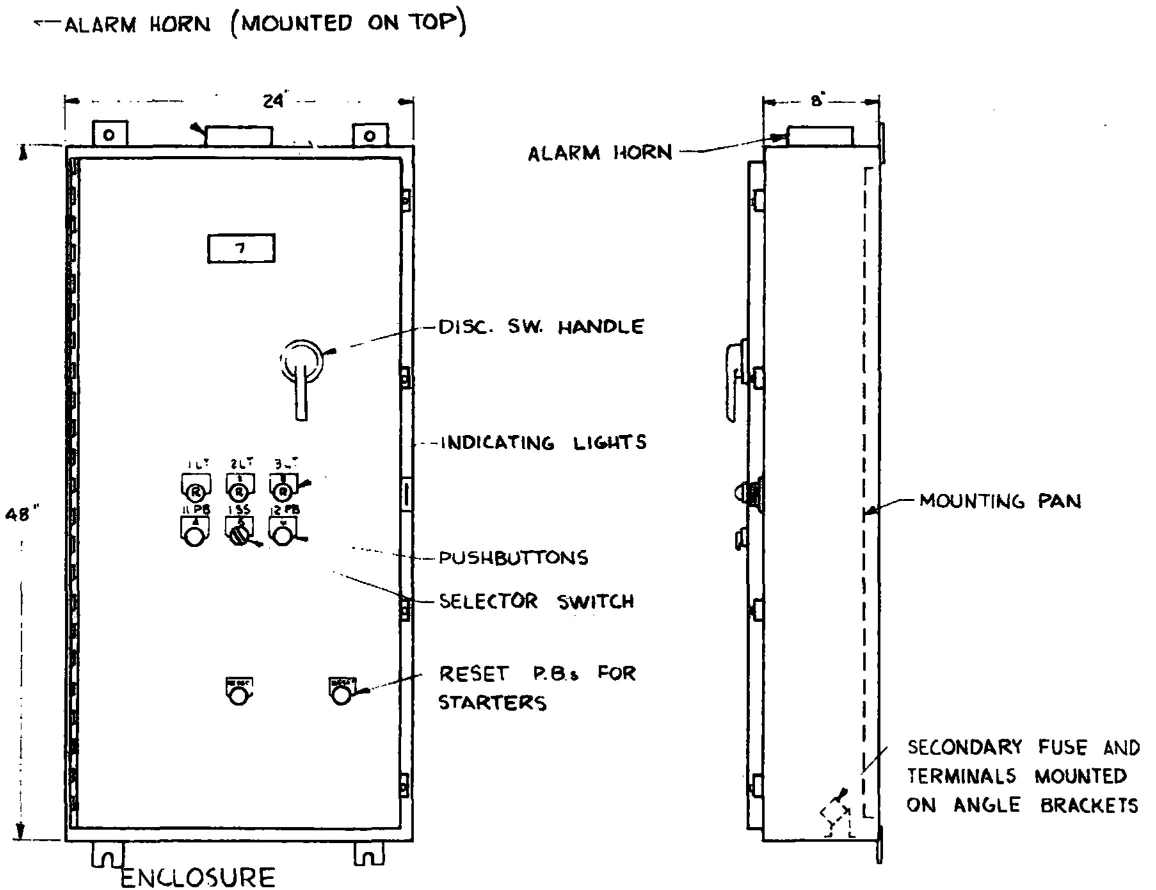
4-14-81 ADDENDUM #2
1-1-81 BID ISSUE

SAN LEANDRO SANLEANDRO CA.
SOLAR IPH SYSTEM
B B POWER TO MOTOR COTROLS

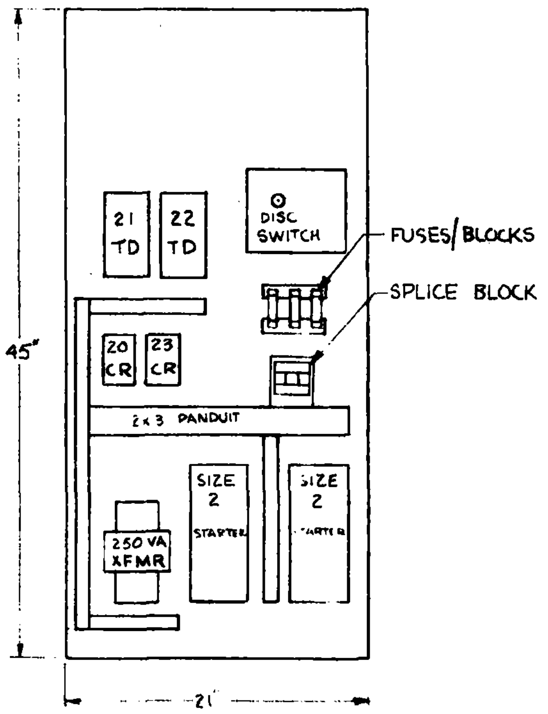
SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS 78284

EZ 11-24-80
M.H. 12-21-80 02-5821 CI-276

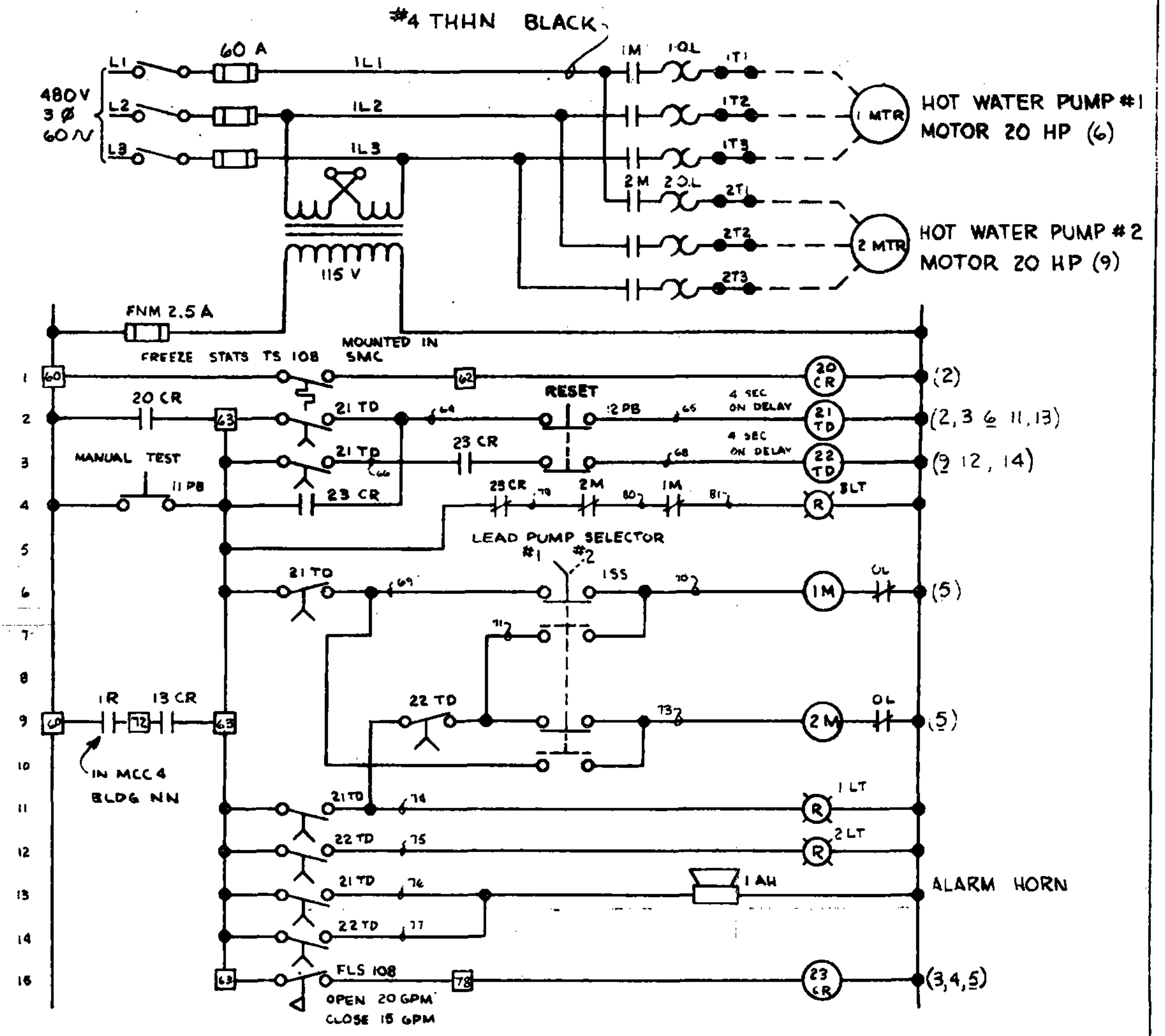
16 DEC 80



ENCLOSURE
SCALE: 1/8"=1"



MOUNTING PANEL
SCALE: 1/8"=1"



PUMP CONTROL PANEL SCHEMATIC
NO SCALE

BILL OF MATERIALS:

ENCLOSURE - 48 x 24 x 8 NEMA 12 PAINTED
RUSTOLEUM # 925 FEDERAL SAFETY BLUE

FUSED DISCONNECT SWITCH ALLEN BRADLEY: 60A 600V
CAT NO 1494R-N60

SIZE 2 STARTERS - ALLEN BRADLEY: # 509 COD
W/AUX CONTACTS # 595AB

ALARM HORN - FEDERAL: MODEL 350

TRANSFORMER - ACME 250 VA 480 120 # TA-1-81305

TERMINAL BLOCKS - CONNECTRON: # NFT-3 600V

TIME DELAY RELAY - AGASTAT: # 7014 AC 4PDT 10A
600V CONTACTS 2-20 SEC ON DELAY 120 VAC COIL

CONTROL RELAYS - ALLEN BRADLEY: TYPE P # 700P400-AL

PUSHBUTTONS - ALLEN BRADLEY: 800T SERIES
FLUSH BLACK HEADS CONTACTS AS REQD.

SELECTOR SWITCH - ALLEN BRADLEY: # 800T-H2B

PILOT LIGHT - ALLEN BRADLEY: # 800T-P16R
W/RED LENS

FUSES/FUSE BLOCKS - ALLEN BRADLEY: # 1491-R266
W/ECON: FUSE # ECSR-60

SPLICE BLOCK - MARATHON: # 1423570

NOTES:

1. ALL POWER WIRING TO BE # 4 THHN BLACK
2. ALL CONTROL WIRING TO BE # 16 MTW RED W/ VINYL SLEEVE WIRE MARKERS

NO.	ENGRAVING SCHEDULE:
1.	LEAD PUMP FAILURE
2.	SECONDARY PUMP FAILURE
3.	FLOW SWITCH STUCK ON
4	PUMP MANUAL TEST
5.	LEAD PUMP #1 #2
6.	ALARM RESET
7.	SOLAR CIRCULATION PUMP CONTROL PANEL (1/2" LETTERING)

AS-BUILT
JUN 19 1981

REVISIONS	SYM.	DATE
PER ENG NOTES	1	5-8
FOR APPROVAL	0	4-28

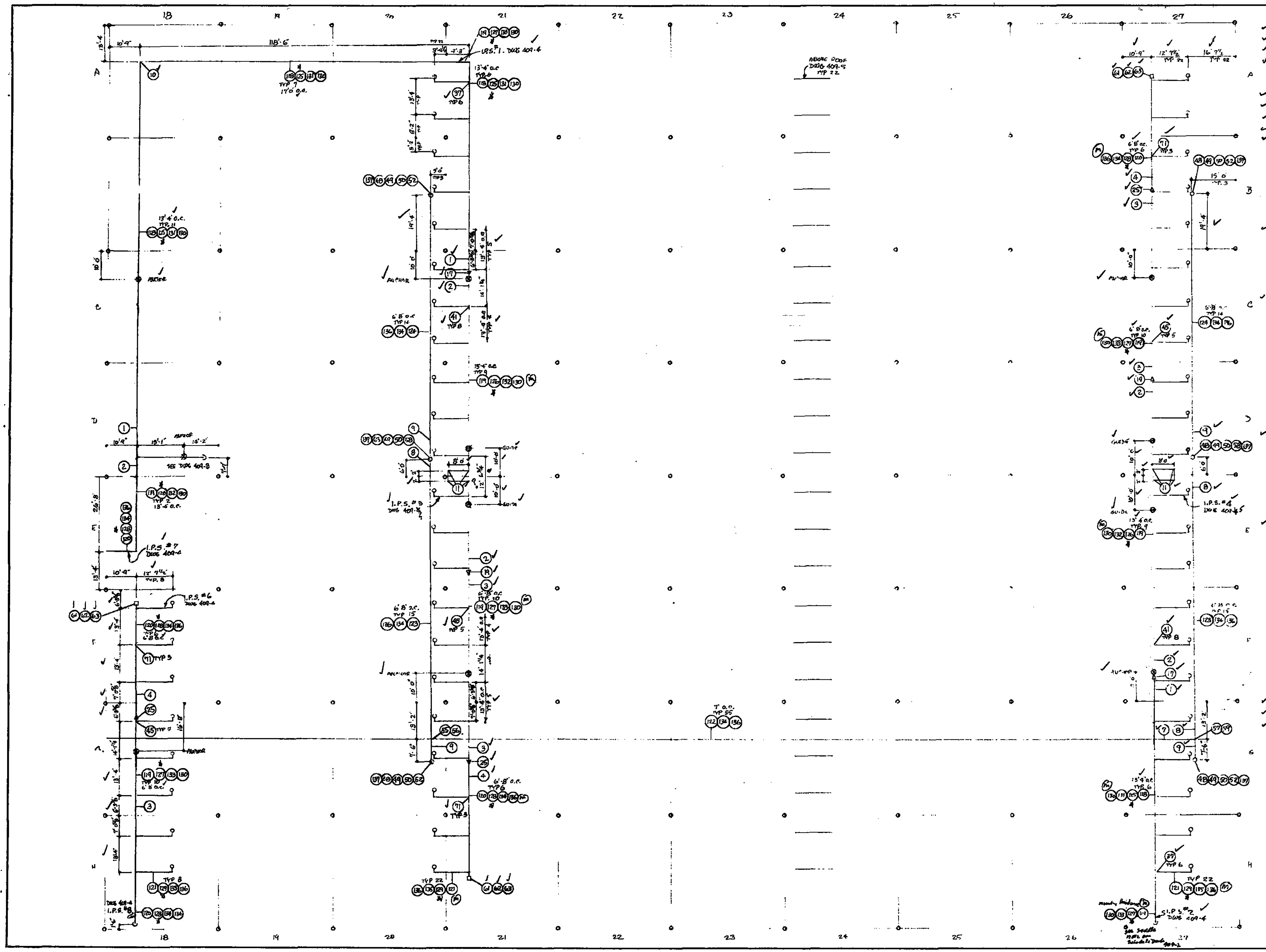
APTOS CONTROL SYSTEMS INC.
P. O. BOX 732
WATSONVILLE, CA 95076

FOR: PHILLIPS & OBER
ELECTRIC SUPPLY
SAN FRANCISCO CA.

TITLE: PUMP CONTROL PANEL

SF 35986
DRN. BY: PEYTON
CHKD. BY:
A.C.S. JOB NO.: 195 681

195-1



MARK	QUAN	ITEM
1	610	6 SCH 40 BLACK PIPE - PE
2	570	4
3	285	5
4	160	2 T.&C.
5	5	1½
6	2,100	1
7	580	1½ GALV
8	200	1¼
9	260	1
10	13	6 STD LR 90° ELL
11	13	4
12	6	3
13	2	6 45°
14	4	4
15	1	6 CAP
16	3	3
17	5	6x4 ECCENTRIC REDUCER
18	3	6x3
19	3	4x3
20	2	4x2
21	5	3x2
22	1	6x4 CONCENTRIC
23	1	6x3
24	3	4x3
25	1	3x2
26	4	6 TEE
27	3	3
28	1	6x4 LR REDUCING 90° ELL
29	6	6 WELD NECK FLANGE - FF
30	8	4
31	7	3
32	14	6 SLIP ON
33	7	4
34	9	3
35	3	6x2 THREADOLET
36	2	6x1½
37	16	6x1
38	5	6x¾
39	1	6x½
40	3	6x¼
41	16	4x1
42	2	4x¾
43	2	4x¼
44	1	3x2
45	24	3x1
46	5	3x¾
47	1	3x¼
48	8	¾" CHICAGO 387LF HOSE BIBB
49	8	¾xC STD GALV NIPPLE
50	8	1x¾ STD GALV MALL REDUCER
51	3	1½ 90° ELL
52	7	1
53	1	1½ TEE
54	1	1½x1x1
55	1	1½x1½x1¼
56	1	1½x1½x1
57	1	1¼x1¼x1½
58	2	1¼x1x1
59	1	1¼x1 REDUCER
60	2	1½ UNION
61	4	1 METRAFLEX MV-15 AUTOMATIC AIR VENT
62	4	1 WALWORTH 2 GATE VALVE
63	4	2x1 STD BLACK MALL RED. 90° ELL
64	2	1½ 90° ELL
65	142	1
66	4	¼
67	90	1 45°
68	30	1 45° WYE
69	120	1¼x1 REDUCER

AS-BUILT

JUN 19 1981

REV.	DATE	BY	CHANGE

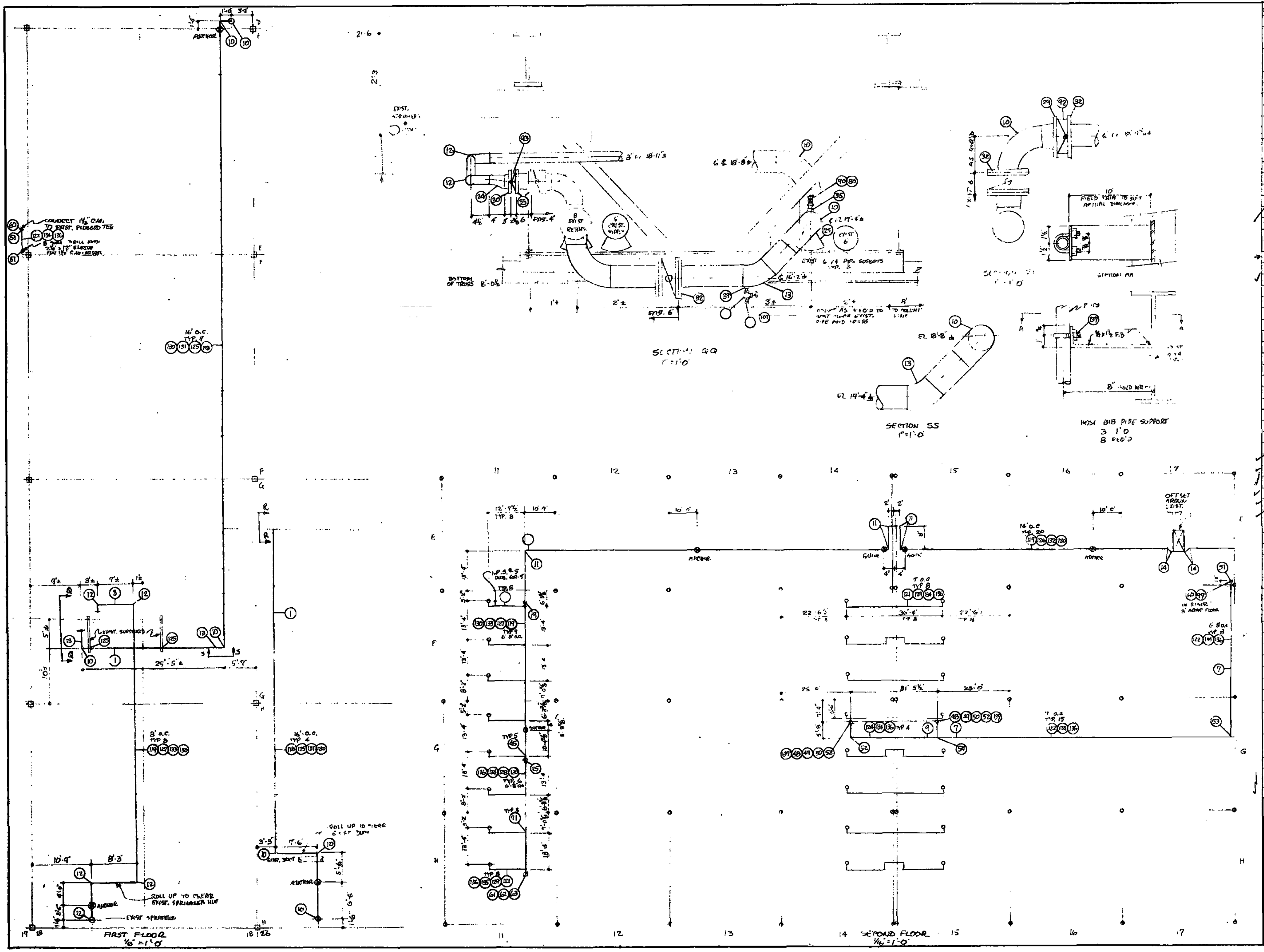
MONTEREY MECHANICAL CO.

8275 SAN LEANDRO STREET
OAKLAND, CALIFORNIA 94621
(415) 632-3173
Calif. Lic. No. 240442

TITLE
SECOND FLOOR - SOUTH PIPING

CUSTOMER
CATERPILLAR TRACTOR CO.

DRAWN BY	SCALE	DATE	DWG. NO.	SH.	OF	REV.
GHG	1/16 = 1'0"	5/5/8	409-1			
CHECKED BY						



MARK	QUAN	ITEM
70	2	2x½x2 STD BLACK MALL TEE
71	12	2x2x1
72	2	2x2x¾
73	2	1x½x1
74	22	1x¾x1
75	12	1x1x¾
76	30	1
77	8	¾
78	2	1½ UNION
79	2	1
80	4	2 PLUG
81	4	1
82	12	¾
83	8	½
84	22	1 CAP
85	8	2 STD. C.I. SCREWED COMP. FLANGE
86	16	1
87	7	6 POWELL 4222T BALL VALVE
88	5	4
89	2	3
90	1	2 NIBCO T-580
91	68	1
92	1	6 TECHNOCHECK CHECK VALVE
93	3	4
94	1	6 SPENCE C34 T52 TEMP. REG. VALVE
95	1	3
96	5	2 WALWORTH 95 GLOBE VALVE
97	2	1½
98	2	1¼
99	8	1
100	12	¾
101	1	½
102	5	6 MUELLER 751 STRAINER
103	1	4
104	2	3
105	4	1
106	1	1½ B. & G. CIRCUIT SETTER
107	30	1¼
108	1	1
109	86	¾ TRERICE 3-4JD2 EXT. NECK THERMOWELL
110	4	TRERICE BX93406 9" THERMOMETER 30/300°
111	6	¼ STAINLESS STEEL NEEDLE VALVE
112	6	¼ ASHCROFT 2642 GAUGE 0/100 PSI
113	1	6 GERAND 743 VENTURI - WELD END
114	1	4 670
115	2	½ 3000# HALF COUPLING
116	60	1¼ x 4 XH NIPPLE - CUT IN HALF & WELDED TO UNION
117	30	1¼ x 6 STD NIPPLE
118	41	16 ELCEN 14 ROLLER HANGER 6" PIPE WITH 4" INS.
119	87	10 14A 4 & 3" 3"
120	26	8 12 CLEVIS 2"
121	158	5
122	90	1½
123	30	1¼
124	28	1
125	43	6x4 ELCEN 25 [illegible]
126	38	4x3 25
127	49	3x3
128	26	2x3
129	158	1x2 253
130	28	ELCEN 95 ADJ. BEAM CLAMP
131	41	¾ ELCEN 235 ROD SOCKET FOR 95 - 6 PIPE
132	38	5/8 4
133	49	½ 3
134	196	3/8 ELCEN 29A C CLAMP - 2" & SMALLER PIPE
135	60	3/8 ELCEN 26 EXTENSION C CLAMP - 1 SUPPLY & RETURN
136	256	ELCEN 29B C CLAMP RETAINER
137	84	1" IPS x 3/8 ELCEN 68 U BOLT FOR PIPE SUPPORT
138	2	3" METRAFLEX SL PUMP CONNECTOR
139	2	4

add extended-neck Tee-Handle for insulation clearance

Lug-lock

provide a hinged [illegible]

Use Compound insulation or Calcium Silicate Option 1502-6 [illegible]

AS-BUILT

JUN 19 1981

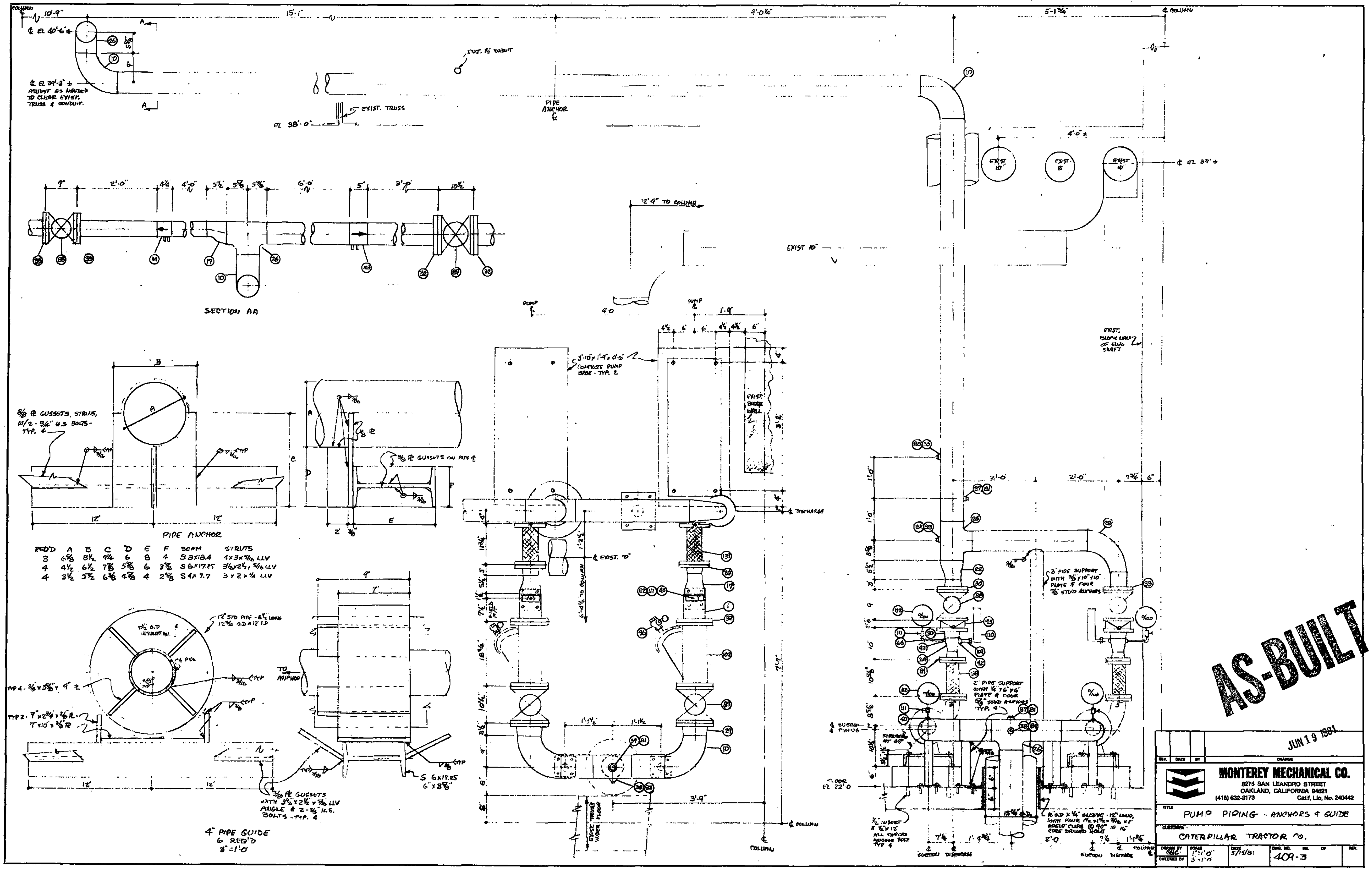
REV.	DATE	BY	CHANGE

MONTEREY MECHANICAL CO.
8278 SAN LEANDRO STREET
OAKLAND, CALIFORNIA 94621
(415) 632-3173
Calif. Lic. No. 240442

TITLE
SECOND FLOOR - NORTH PIPING

CUSTOMER
CATERPILLAR TRACTOR CO

DRAWN BY	SCALE	DATE	DWG. NO	SH	OF	REV.
GHG	1/16 - 1'-0" 1/8 - 1'-0"	5/15/81	409-2			
CHECKED BY						



PIPE ANCHOR

REQ'D	A	B	C	D	E	F	BEAM	STRUTS
3	6⅝	8½	9¼	6	8	4	S 8x18.4	4x3x5/16 LLV
4	4½	6½	7⅞	5⅝	6	3⅜	S 6x17.25	3½x2½, 5/16 LLV
4	3½	5½	6⅜	4⅝	4	2⅝	S 4x 7.7	3 x 2 x ¼ LLV

JUN 19 1981

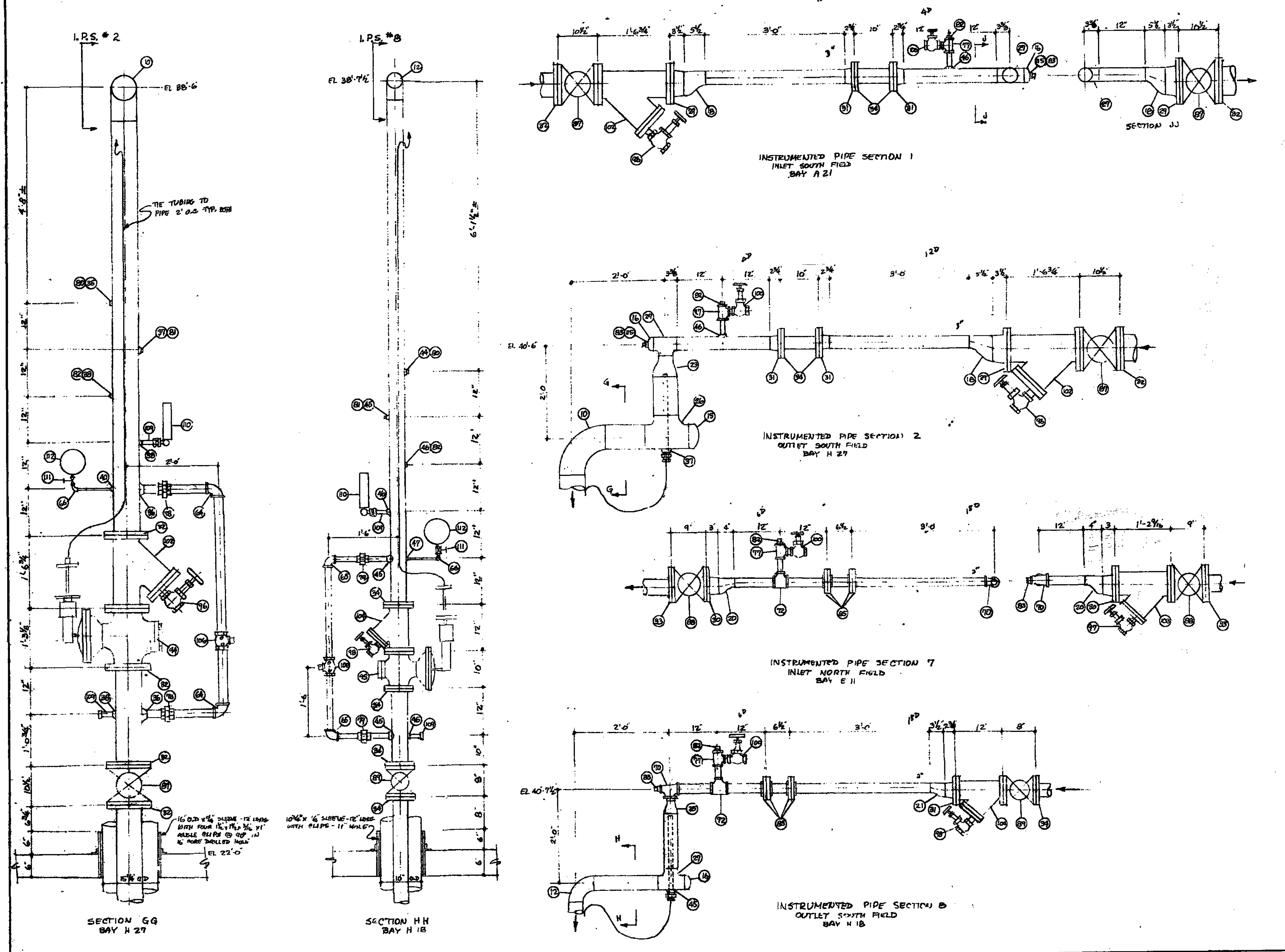
REV.	DATE	BY	CHANGE

MONTEREY MECHANICAL CO.
8275 SAN LEANDRO STREET
OAKLAND, CALIFORNIA 94621
(415) 632-3173 Calif. Lic. No. 240442

TITLE
PUMP PIPING - ANCHORS & GUIDE

CUSTOMER
CATERPILLAR TRACTOR CO.

DRAWN BY	SCALE	DATE	DWG. NO.	SH.	OF	REV.
GHG	1"=1'0" 3"=1'0"	5/15/81	409-3			
CHECKED BY						



AS-BUILT

JUN 19 1981

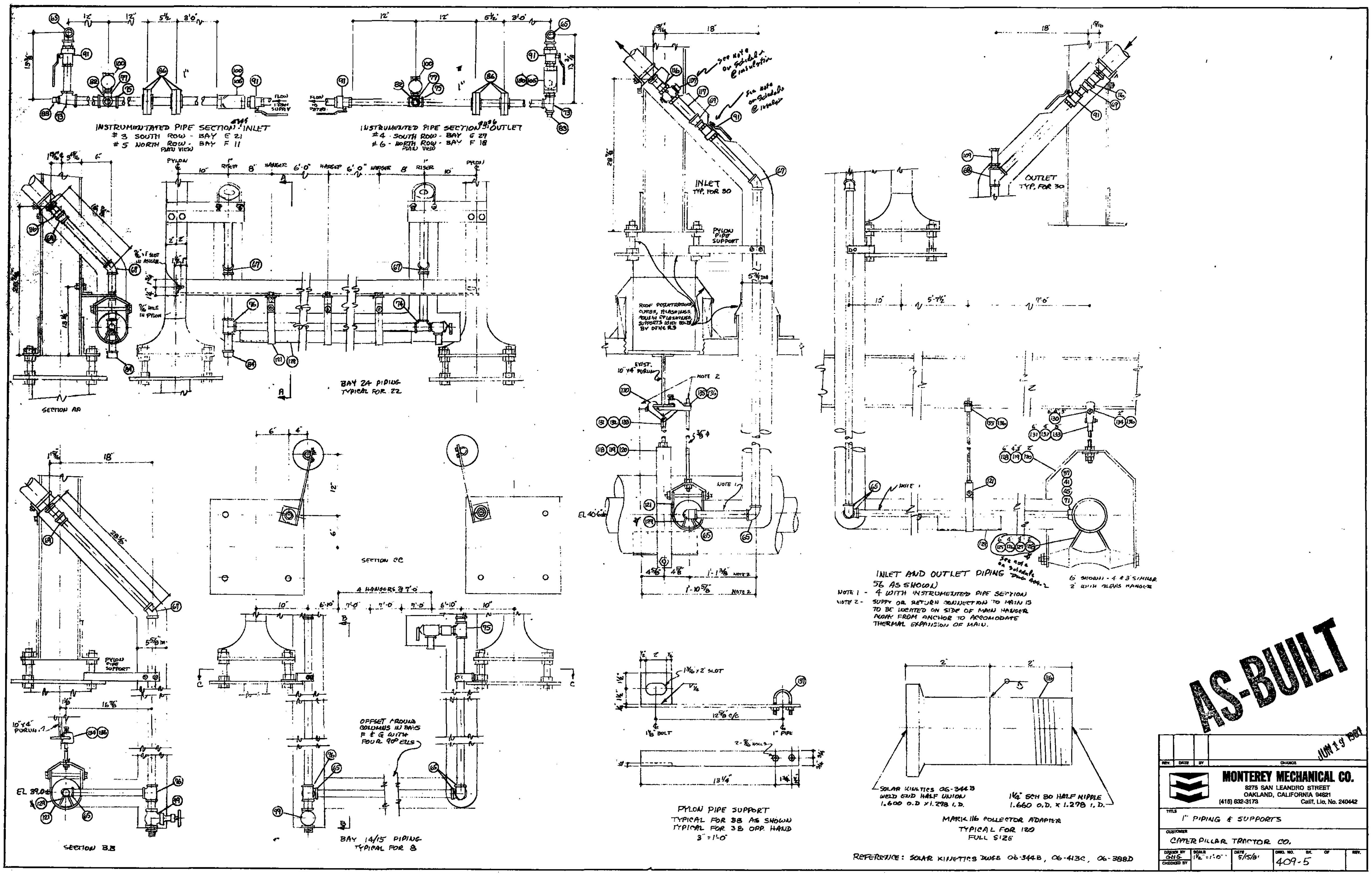
REV.	DATE	BY	CHANGE

MONTEREY MECHANICAL CO.
8275 SAN LEANDRO STREET
OAKLAND, CALIFORNIA 94621
(415) 632-3173
Calif. Lic. No. 240442

TITLE
INSTRUMENTATED PIPE SECTIONS

CUSTOMER
CATERPILLAR TRACTOR CO.

DRAWN BY	SCALE	DATE	DWG. NO.	SH.	OF	REV.
SMG	1" = 1'-0"	5/15/81	409-4			
CHECKED BY						



INSTRUMENTATED PIPE SECTION #3 #5 : INLET
3 SOUTH ROW - BAY E 21
5 NORTH ROW - BAY F 11
PLAN VIEW

INSTRUMENTED PIPE SECTION #4 #6 : OUTLET
4 - SOUTH ROW - BAY E 27
6 - NORTH ROW - BAY F 18
PLAN VIEW

SECTION AA

BAY 24 PIPING
TYPICAL FOR 22

SECTION CC

SECTION BB

BAY 14/15 PIPING
TYPICAL FOR 8

INLET AND OUTLET PIPING
56 AS SHOWN

NOTE 1 - 4 WITH INSTRUMENTED PIPE SECTION

NOTE 2 - SUPPY OR RETURN CONNECTION TO MAIN IS TO BE LOCATED ON SIDE OF MAIN HANGER AWAY FROM ANCHOR TO ACCOMODATE THERMAL EXPANSION OF MAIN.

PYLON PIPE SUPPORT
TYPICAL FOR 38 AS SHOWN
TYPICAL FOR 38 OPP. HAND
3" = 1'-0"

MARK 116 COLLECTOR ADAPTER
TYPICAL FOR 120
FULL SIZE

REFERENCE: SOLAR KINETICS DWGS 06-344B, 06-413C, 06-388D

AS-BUILT
JUN 19 1981

REV.	DATE	BY	CHANGE

MONTEREY MECHANICAL CO.
8275 SAN LEANDRO STREET
OAKLAND, CALIFORNIA 94621
(415) 632-3173 Calif. Lic. No. 240442

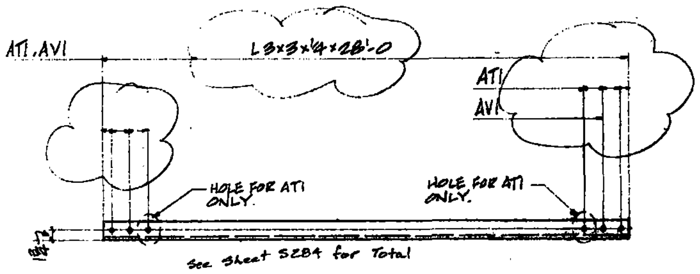
TITLE
1" PIPING & SUPPORTS

CUSTOMER
CATERPILLAR TRACTOR CO.

DRAWN BY	SCALE	DATE	DWG. NO.	SH.	OF	REV.
GHG	1½" = 1'-0"	5/15/81	409-5			
CHECKED BY						

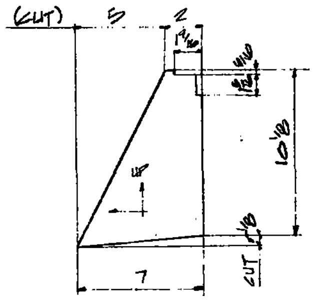
FURNISH PLAIN MATERIAL

84 - L1¼×1¼×¼×3'-7 ~ A1	(FOR TRUSS T1R, T1R-1)
84 - L1¼×1¼×¼×3'-8⅝ ~ B1	(FOR TRUSS T1R, T1R-1)
84 - L1¼×1¼×¼×3'-10¼ ~ C1	(FOR TRUSS T1R, T1R-1)
84 - L1¼×1¼×¼×4'-0 ~ D1	(FOR TRUSS T1R, T1R-1)
84 - L1¼×1¼×¼×13'-4 ~ H1	(FOR TRUSS T1R, T1R-1)
4 - L1¼×1¼×¼×4'-1 ~ K1	(FOR TRUSS T1R-1)
8 - L1¼×1¼×¼×6'-8 ~ M1	(FOR TRUSS T1R-1)
136 - L1¼×1¼×¼×20'-0 ~ P1	(FOR TRUSS T1R-1, T5R, T6R, T7R)
84 - L1¼×1¼×¼×4'-6⅝ ~ S1	(FOR TRUSS T2R)
84 - L1¼×1¼×¼×4'-8⅜ ~ T1	(FOR TRUSS T2R)
84 - L1¼×1¼×¼×5'-4⅝ ~ V1	(FOR TRUSS T3R)
84 - L1¼×1¼×¼×5'-6⅞ ~ W1	(FOR TRUSS T3R)
56 - L1¼×1¼×¼×6'-2⁹⁄₁₆ ~ AA1	(FOR TRUSS T4R)
56 - L1¼×1¼×¼×6'-4⅜ ~ AB1	(FOR TRUSS T4R)
56 - L1¼×1¼×¼×6'-1¼ ~ AC1	(FOR TRUSS T4R)
264 - L1¼×1¼×¼×6'-6 ~ AD1	(FOR TRUSS T5R)
44 - L1¼×1¼×¼×10'-0 ~ AH1	(FOR TRUSS T5R)
176 - L1¼×1¼×¼×7'-0 ~ AK1	(FOR TRUSS T6R)
176 - L1¼×1¼×¼×7'-9¾ ~ AM1	(FOR TRUSS T7R)
56 - L1¼×1¼×¼×8'-6 ~ AP1	(FOR TRUSS T8R)
4 - L1¼×1¼×¼×4'-6 ~ BH1	(FOR TRUSS T1R-1)
56 - L1¼×1¼×¼×6'-7¼ ~ BK1	(FOR TRUSS T4R)

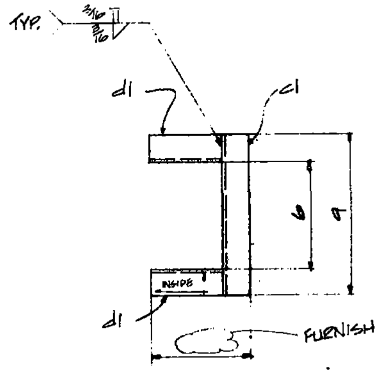


6 - SWAY BARS ~ AT1 (AS NOTED)

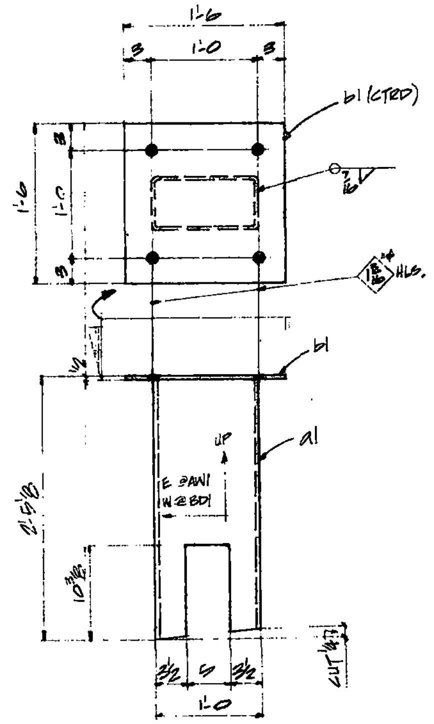
ONE - SWAY BAR ~ AV1 (AS NOTED)



120 - STIFFENER ℄'s ~ BB1

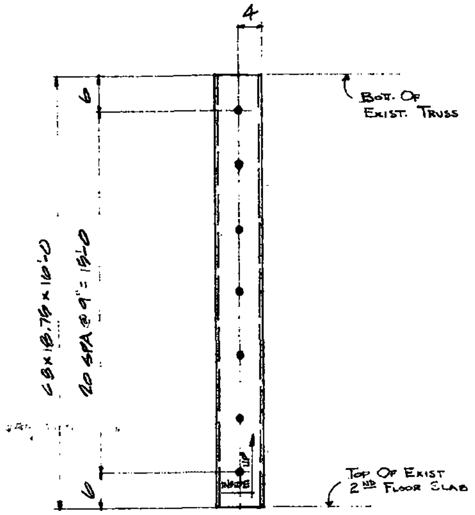


120 - ANGLE FRAMES ~ BC1

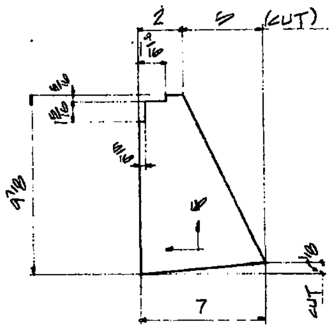


38 - DRIVE PYLON POSTS ~ AW1 (AS NOTED).

22 - DRIVE PYLON POSTS ~ BD1 (AS NOTED)



134 ~ CHANNELS ~ AS1
(SEE DWG E1 & E5 FOR LOCATION)



120 - STIFFENER ℄'s ~ BA1

SUBMITTAL REVIEW
☐ No Exceptions Taken
☒ Make Corrections Noted
☐ Amend and Resubmit
☐ Reject - See Remarks
By Frank Fong Date 5/26/81

JUN 19 1981

SHOP NOTE

REF. DWG: S280 - S284 (INCL.)

CONTRACTORS LIC. NO. 150694

BILL OF MATERIAL

SHIPPING NO	SHIPPING MK	Δ	QTY	MATERIAL	FT	IN	MARK	T	REMARKS	TOTAL FOOTAGE	TOTAL WEIGHT	CODE
84	A1		84	L1¼×1¼×¼	3	7	A1		1.92	300.72	577	
84	B1		84		3	8⅝	B1			312.18	600	
84	C1		84		3	10¼	C1			323.40	621	
84	D1		84		4	0	D1			336.00	645	
84	H1		84		13	4	H1			1120.00	2151	
4	K1		4		4	1	K1			16.33	31	
8	M1		8		6	8	M1			53.34	102	
136	P1		136		20	0	P1			2720.0	5222	
84	S1		84		4	6⅝	S1			382.26	734	
84	T1		84		4	8⅜	T1			394.80	758	
84	V1		84		5	4⅝	V1			452.76	867	
84	W1		84		5	6⅞	W1			464.52	892	
56	AA1		56		6	2⁹⁄₁₆	AA1			348.32	669	
56	AB1		56		6	4⅜	AB1			356.72	685	
56	AC1		56		6	1¼	AC1			341.60	656	
264	AD1		264		6	6	AD1			1716	3295	
44	AH1		44		10	0	AH1			440.00	845	
176	AK1		176		7	0	AK1			1232	2365	
176	AM1		176		7	9¾	AM1			1375.56	2639	
56	AP1		56		8	6	AP1			476.00	914	
4	BH1		4		4	6	BH1			18.00	35	
56	BK1		56	L1¼×1¼×¼	6	7¼	BK1			369.60	710	
134	AS1		134	C8×18.5	16	0	AS1			2144	39664	
6	AT1		6	L3×3×¼	28	0	AT1		4.9	168.00	823	
1	AV1		1	L3×3×¼	28	0	AV1			28.00	137	
38	AW1		38	DRIVE PYLON POST			AW1					
22	BD1		22	DRIVE PYLON POST			BD1					
			60	TS 12×6×.500	2	4⅞	a1		57.11	143.40	8190	
			60	℄½×18	1	6	b1		30.6	90.00	2754	
120	BA1		120	℄¼×7	0	9⅞	BA1		5.95	98.40	585	
120	BB1		120	℄¼×7	0	10¼	BB1			102.00	607	
120	BC1		120	FRAME			BC1					
			120	L1½×1½×¼	0	9	c1		2.34	[illegible]	[illegible]	
			240	L1½×1½×¼	0		d1					

ERECTION BOLTS (NET)

3814	⅝"Φ A325	0	2½
40	⅝"Φ A325	0	1¾
240	1⅛"Φ A325	0	6

1162	L 1¼×1¼×¼	21615
2144	C 8×18.5	39664
196	L 3×3×¼	960
143	TS 12×6×.500	8190
[illegible]	℄ ½×18	2754
[illegible]	℄ ¼×7	1172
90	L 1½×1½×¼	211
		74566

No	DATE	REVISIONS
1		
2		
3		
4		

AS-BUILT

SPECIAL NOTES

HOLES = 11/16"Φ U.N.
R&S Proj. No. 1469 - Spec Sect. 5.02 & 5.03

APPROVAL INFO
REC'D
APP RECD

FINISH SCHEDULE	☒
TRESCO No. 1262 ORO-TEX RED PRIMER	☐
TTP615D BASIC LEAD CHROM PRIMER TP II	☐
GREEN ZINC CHROMATE or TNEMEC 99	☐
HOT DIP GALVANIZE	☐
TNEMEC #1009 GRAY	☒

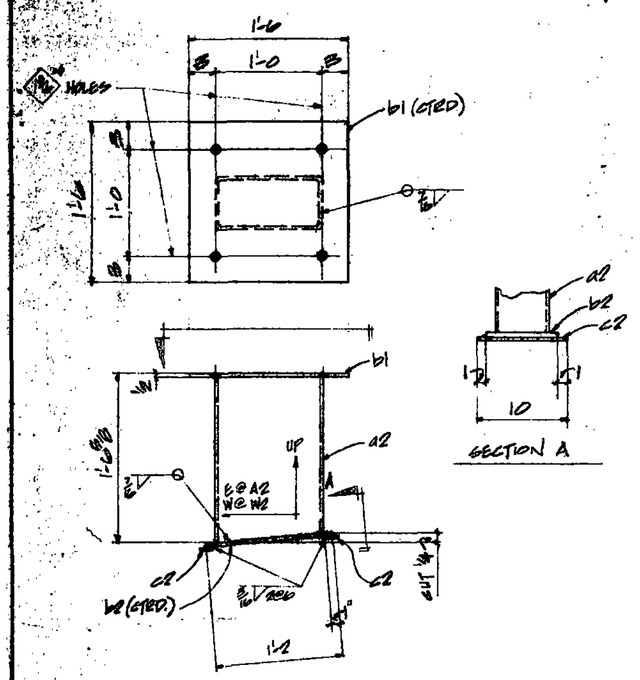
TITLE
ITEM MISCELLANEOUS DETAILS
JOB CATERPILLAR TRACTOR CO.
LOCATION SAN LEANDRO, CA.
ARCH ENGR BISSELL & KARN INC.
CONTRACTOR RUDOLPH & SLETTEN.

COPIES ISSUED

	NO	DATE	NO	DATE	NO	DATE	NO	DATE
APPROVAL	1-3	5/16	2/P	5/12				
SHOP								
FIELD								
ERECTION								
SUPT								
PURCHASE								
INSPECTOR								
ESTIMATING								

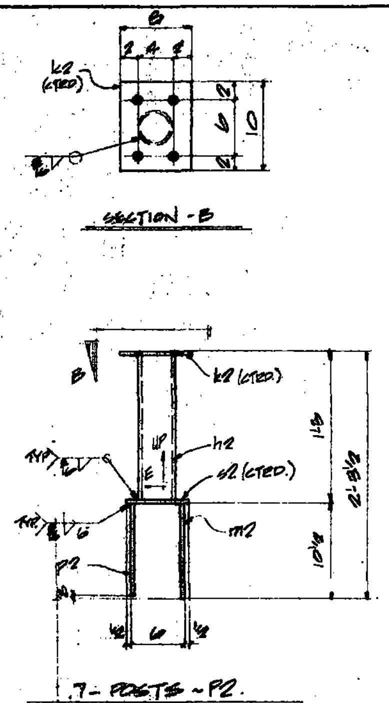
CASCADE METALS CORPORATION
P.O. BOX 5370 & 1150 MABURY ROAD • SAN JOSE, CALIF. 95150 • 294-8318

DWG DATE 4/28/81
QTY 2
DWG BY PWC
CHKD BY PWC
JOB NO. 332
SEQ. NO. 0107
DWG. NO. D1
REV. Δ

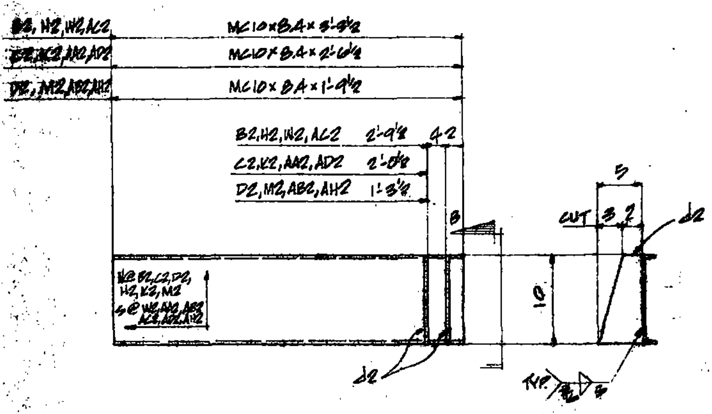


228 – SUPPORT PYLON POSTS ~ A2

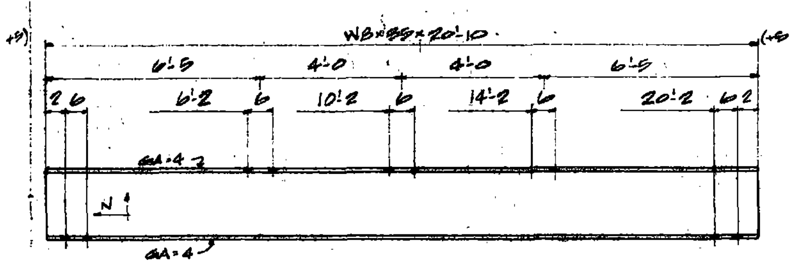
132 – SUPPORT PYLON POSTS ~ W2



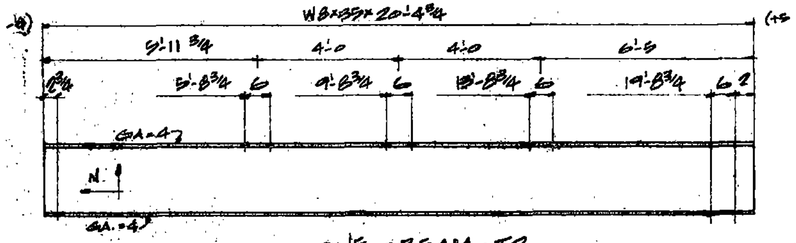
7 - POSTS ~ P2



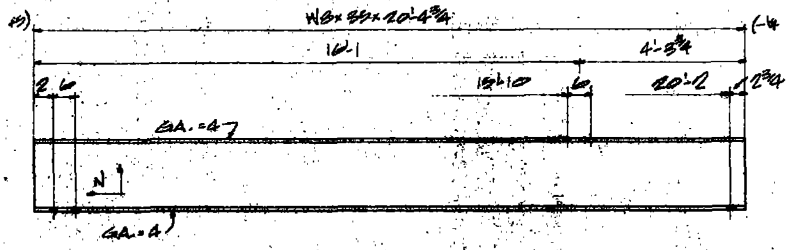
60 – CHANNELS ~ B2 (AS SHOWN & NOTED)
60 – CHANNELS ~ C2 (AS SHOWN & NOTED)
60 – CHANNELS ~ D2 (AS SHOWN & NOTED)
60 – CHANNELS ~ H2 (OPP. HAND & NOTED)
60 – CHANNELS ~ K2 (OPP. HAND & NOTED)
60 – CHANNELS ~ M2 (OPP. HAND & NOTED)
60 – CHANNELS ~ W2 (OPP. HAND & NOTED)
60 – CHANNELS ~ AA2 (OPP. HAND & NOTED)
60 – CHANNELS ~ AB2 (OPP. HAND & NOTED)
60 – CHANNELS ~ AC2 (AS SHOWN & NOTED)
60 – CHANNELS ~ AD2 (AS SHOWN & NOTED)
60 – CHANNELS ~ AH2 (AS SHOWN & NOTED)



2 - BEAMS ~ S2



ONE - BEAM - T2



ONE - BEAM ~ V2

SUBMITTAL REVIEW

BISSELL & KARN, INC. - CIVIL ENGINEERS

☒ No Exceptions Taken
☐ Make Corrections Noted
☐ Amend and Resubmit
☐ Reject - See Remarks

By Frank Fern Date 5/26/81

NOTE

JUN 19 1981

REF. DWG.: [illegible]

CONTRACTORS LIC. NO. 150594

AS-BUILT

SHIPPING		BILL OF MATERIAL										
NO.	MK	△	QTY	MATERIAL	FT.	IN	MARK	T	REMARKS	TOTAL FOOTAGE	TOTAL WEIGHT	CODE
228	A2		228	SUPPORT PYLON POST			A2					
132	W2		132	SUPPORT PYLON POST			W2					
			360	PL ½ × 18	1	6	b1		33.6	540.00	16.524	
			360	TS 12 × 6 × .500	1	6⅛	a2		57.11	913.62	31045	
			360	PL ½ × 8	1	2	b2		13.6	421.20	5728	
			720	PL ¼ × 1½	0	10	c2		1.28	597.60	765	
60	B2		60	MC10 × 8.4	3	3½	B2			197.40	1619	
60	C2		60		2	6½	C2			152.40	1250	
60	D2		60		1	9½	D2			107.40	881	
60	H2		60		3	3½	H2			197.40	1619	
60	K2		60		2	6½	K2			152.40	1250	
60	M2		60		1	9½	M2			107.40	881	
60	W2		60		3	3½	W2			197.40	1619	
60	AA2		60		2	6½	AA2			152.40	1250	
60	AB2		60		1	9½	AB2			107.46	881	
60	AC2		60		3	3½	AC2			197.40	1619	
60	AD2		60	do	2	6½	AD2			152.40	1250	
60	AH2		60	MC10 × 8.4	1	9½	AH2			[illegible]	909	
			1440	PL ¼ × 5	0	10	d2		1.25	1195.2[illegible]	5080	
7	P2		7	POST			P2		10.77			
			7	STD. PIPE × 4"	1	2	h2		S.2.E	8.19	88	
			7	PL ½ × 8	0	10	k2		13.6	5.81	77	
			7	PL ¼ × 6	0	10½	m2		10.2	6.09	62	
			7	PL ½ × 6	0	10⅜	p2			6.02	61	
			7	PL ½ × 6	0	7	s2			4.06	41	
2	S2		2	W8 × 35	20	10	S2			41.66	1458	
1	T2		1	W8 × 35	20	4¾	T2			20.40	714	
1	V2		1	W8 × 35	20	4¾	V2			20.40	714	
				ERECTION BOLTS (NET)								
			1440	⅞"ø A325	0	6						
			68	⅝"ø A325	0	2						
			544	TS 12 × 6 × .500	31045							
			3829	MC 10 × 8.4								
			1773	PL ¼	5875							
			8	2 std Pipe × 4"	88							
			783	PL ½	22495							
			72	W8 × 35	2886							
					77359							

No.	DATE	REVISIONS
△1		
△2		
△3		
△4		

SPECIAL NOTES	APPROVAL INFO.
HOLES = 11/16"ø TYP. U.N.	APP. REQ.
R & S. Proj. No. 1469 – Spec. Sect. 5.02 & 5.05	APP. RECD.

FINISH SCHEDULE	☒
TRESCO No 1282 ORO-TEX RED PRIMER	☐
TTP615D BASIC LEAD CHROM PRIMER TP II	☐
GREEN ZINC CHROMATE or TNEMEC 99	☐
HOT DIP GALVANIZE	☐
TNEMEC #1009 GRAY	☒

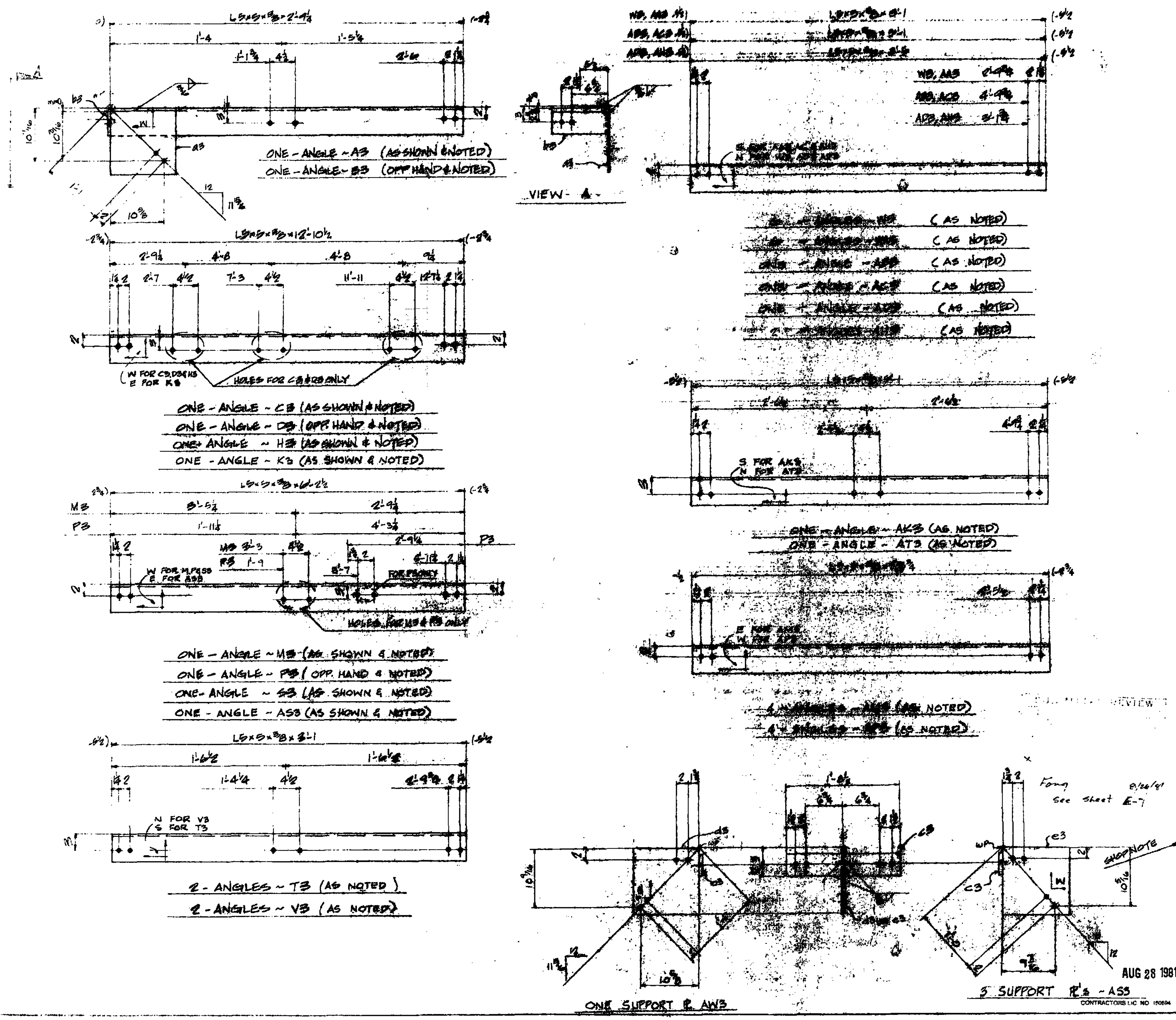
TITLE

ITEM: MISCELLANEOUS DETAILS
JOB: CATERPILLAR TRACTOR CO.
LOCATION: SAN LEANDRO, CA.
ARCH./ENGR.: BISSELL & KARN INC.
CONTRACTOR: RUDOLPH & SLETTEN

CASCADE METALS CORPORATION
P.O. BOX 5370 • 1150 MABURY ROAD • SAN JOSE, CALIF. 95150 • [illegible]

COPIES ISSUED	NO.	DATE	NO.	DATE	NO.	DATE	NO.	DATE
APPROVAL	[illegible]	5/12	[illegible]	5/12				
SHOP								
FIELD								
ERECTION								
SUPT.								
PURCHASE								
INSPECTOR								
ESTIMATING								

FULL PRINT		B.L.			
DATE	5/12	5/12	DWG. DATE	[illegible]	JOB NO. [illegible]
QTY	[illegible]	2	DWG. BY	[illegible]	REQ. NO. 0108
DATE			CHKD. BY	[illegible]	DWG. NO. D2 △
QTY					
DATE					
QTY					



BILL OF MATERIAL

SHIPPING NO	SHIPPING MK	△	QTY	MATERIAL	FT	IN	MARK	T	REMARKS	TOTAL FOOTAGE	TOTAL WEIGHT	CODE
1	A3		1	L5x5x3/8	2	9¼	A3					
1	B3		1	L5x5x3/8	2	9¼	B3					
			2	PL ¼x12	1	0	a3					
			2	PL ¼x4	0	10	b3					
1	C3		1	L5x5x3/8	12	10½	C3					
1	D3		1	L5x5x3/8	12	10½	D3					
1	H3		1	L5x5x3/8	12	10½	H3					
1	K3		1	L5x5x3/8	12	10½	K3					
1	M3		1	L5x5x3/8	6	2½	M3					
1	P3		1	L5x5x3/8	6	2½	P3					
1	S3		1	L5x5x3/8	6	2½	S3					
1	AS3		1	L5x5x3/8	6	2½	AS3					
2	T3		2	L5x5x3/8	3	1	T3					
2	V3		2	L5x5x3/8	3	1	V3					
6	W3		6	L5x5x3/8	3	1	W3					
6	AA3		6	L5x5x3/8	3	1	AA3					
1	AB3		1	L5x5x3/8	5	1	AB3					
1	AC3		1	L5x5x3/8	5	1	AC3					
1	AD3		1	L5x5x3/8	3	5	AD3					
2	AH3		2	L5x5x3/8	3	5	AH3					
1	AK3		1	L5x5x3/8	5	1	AK3					
1	AT3		1	L5x5x3/8	5	1	AK3					
4	AM3		4	L5x5x3/8	2	8¾	AM3					
4	AP3		4	L5x5x3/8	2	8¾	AP3					
1	AW3		1	SUPPORT PL			AW3					
			1	PL ¼x4	1	8½	c3					
			1	PL ¼x12	1	0	d3					
3	AS3		3	SUPPORT PL			AS3					
			3	PL			c3					
			3	PL ¼ x 10¾	0	11¾	e3					

ERECTION BOLTS (NET) (SUMM ON E7)

62	¾"ø A325	0	1¾
12	¾"ø A325	0	2

AS-BUILT

No	DATE	REVISIONS
1		
2		
3		
4		

SPECIAL NOTES

HOLES 13/16" TYP. U.N.
MIN. EDGE DIST. = 1¼" U.N.

APPROVAL INFO

FINISH SCHEDULE	☒
TRESCO No 1262 ORO-TEX RED PRIMER	
TTP615D BASIC LEAD CHROM PRIMER TP II	
GREEN ZINC CHROMATE or TNEMEC 99	
HOT DIP GALVANIZE	

TITLE

ITEM ANGLES
JOB CATERPILLAR TRACTOR CO.
LOCATION SAN LEANDRO, CA.
ARCH./ENGR. BISSELL & KARN INC.
CONTRACTOR RUDOLPH & SLETTEN

CASCADE METALS CORPORATION
P.O. BOX 5310 • 1150 NABURY ROAD • SAN JOSE, CALIF. 95150 • 294-8310

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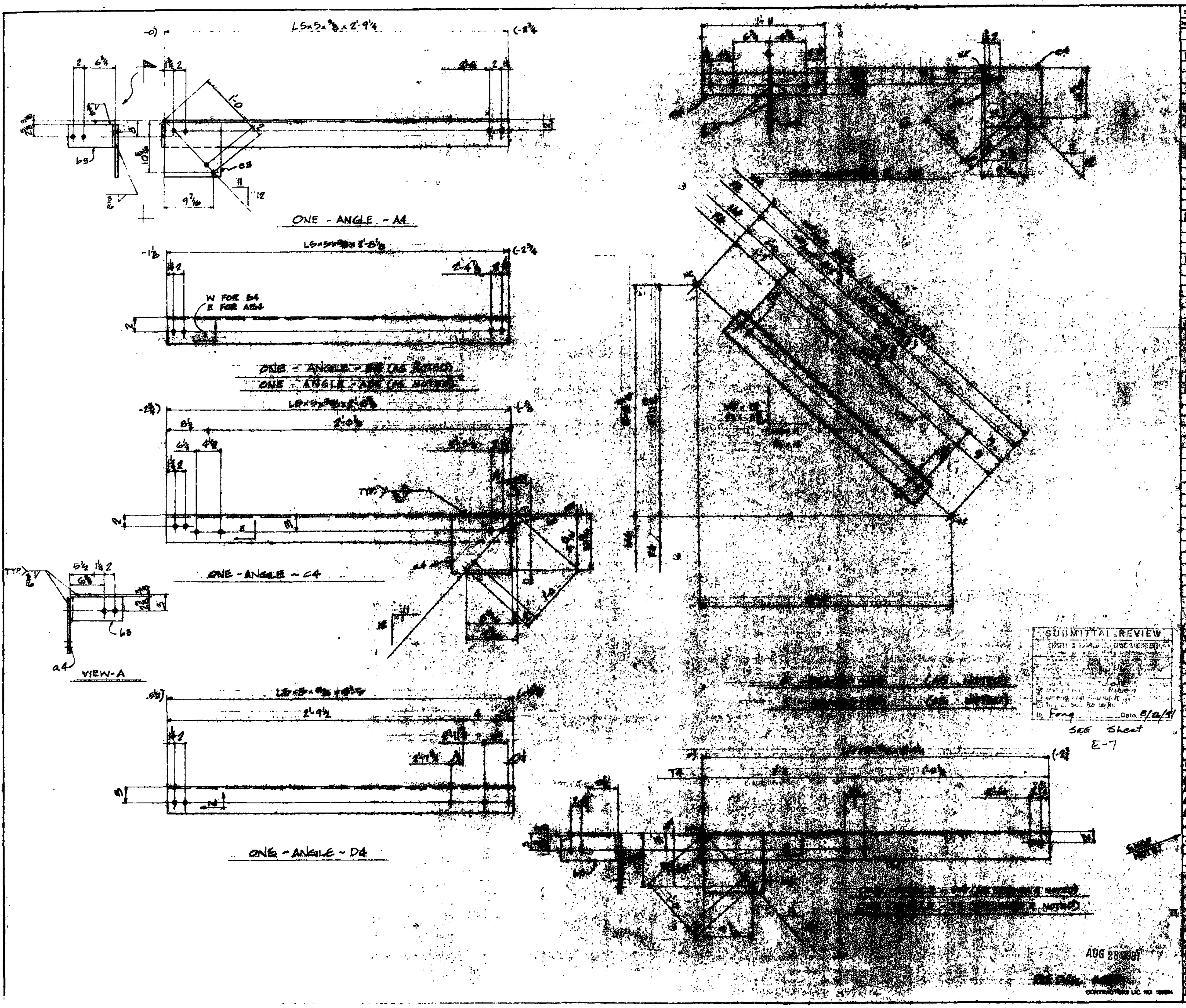
APPROVAL	1-5	8/3	1-5	8/24				
SHOP								
FIELD								
ERECTION								
SUPT								
PURCHASE								
INSPECTOR								
ESTIMATING								

DATE 8/3
DWG. DATE 8/1/81
DWG. BY PMC/GM
CHKD BY HG 8/4/81
JOB NO. 332
SEQ. NO. 0211
DWG. NO. D3
REV. △



SUBMITTAL REVIEW

By Fong Date 8/28/91

BILL OF MATERIAL

SHIPPING NO.	MK.	△	QTY	MATERIAL	FT	IN.	MARK	T	REMARKS	TOTAL FOOTAGE	TOTAL WEIGHT	CODE
1	A4		1	L5x5x3/8	2	9¼						
			1	PL ½x4	0	10	b3					
			1	PL ½x10¾	0	11¾	a3					
[illegible]	[illegible]		1	[illegible]	[illegible]	[illegible]	[illegible]					
[illegible]	[illegible]		1	[illegible]	[illegible]	[illegible]	[illegible]					
[illegible]	[illegible]		1	[illegible]	[illegible]	[illegible]	[illegible]					
			1	PL ½x10¾	0	11¾	a4					
			1	PL ½x4	0	10	b3					
1	[illegible]		1	L5x5x3/8	[illegible]	[illegible]	[illegible]					
1	H4		1	SUPPORT PL			H4					
			1	PL ½x10¾	0	11¾	e4					
			1	[illegible]	1	11	[illegible]					
[illegible]	[illegible]		[illegible]	[illegible]	2	[illegible]	[illegible]					
[illegible]	[illegible]		[illegible]	[illegible]	2	9¼	[illegible]					
1	[illegible]		1	[illegible]	[illegible]	[illegible]	T4					
			1	[illegible]	[illegible]	[illegible]	[illegible]					
			[illegible]	[illegible]	0	10	b3					
			[illegible]	PL ½x10¾	0	11¾	[illegible]					

ERECTION BOLTS (NOT) (SUMM ON E7)

AS-BUILT

REVISIONS

SPECIAL NOTES

APPROVAL INFO

FINISH SCHEDULE

TITLE

ITEM: ANGLES

JOB: CATERPILLAR TRACTOR CO.

LOCATION: SAN LEANDRO, CA.

ARCH./ENGR. [illegible]

CONTRACTOR: [illegible]

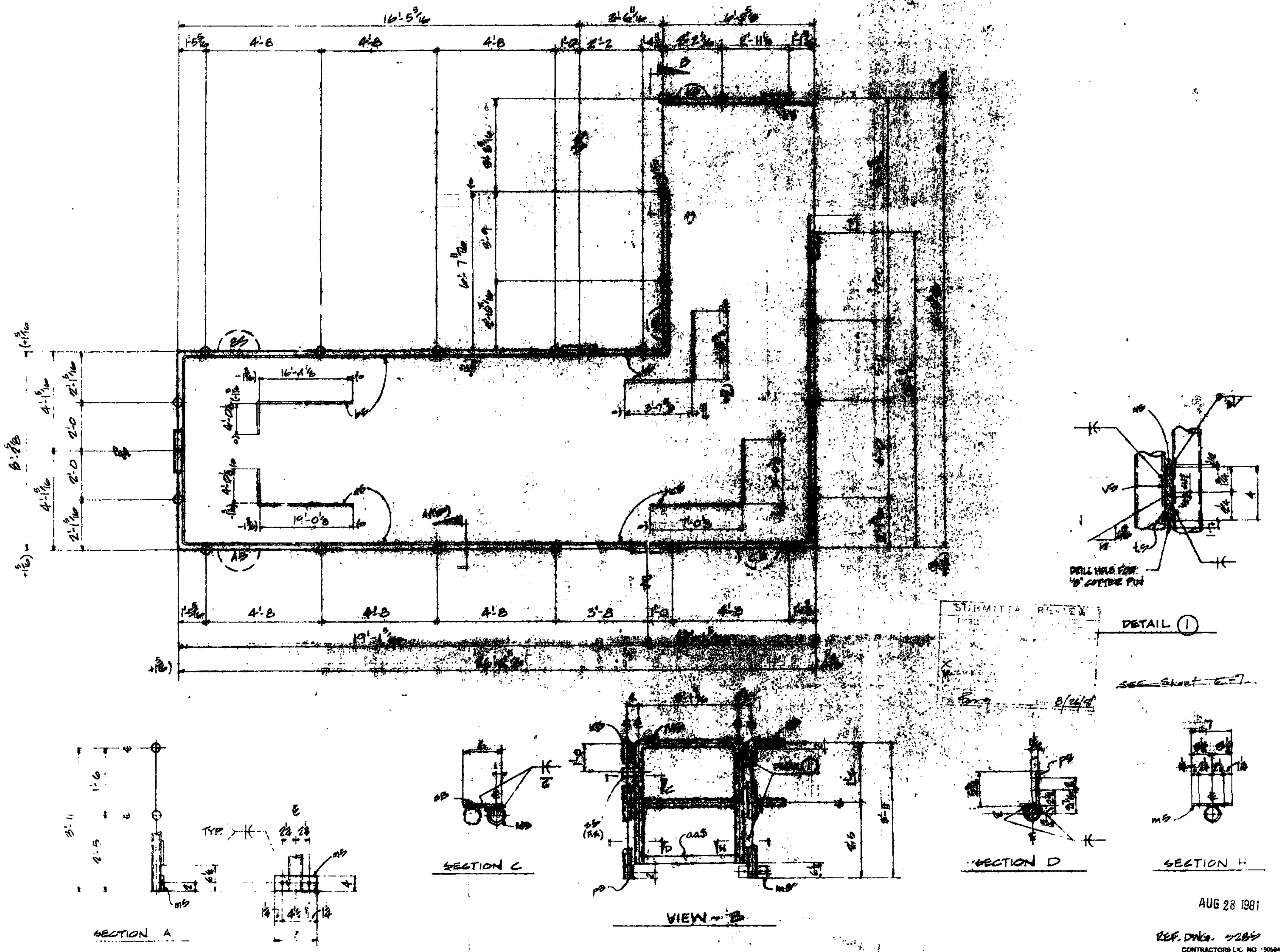
CASCADE METALS CORPORATION

JOB NO. 352

DWG NO. 0212

SHEET NO. D4

CHK'D BY HG 7/14/91



DETAIL ①

~~SEE Sheet E-7~~

SUBMITTAL REVIEW

8/26/81

AUG 28 1981

REF. DWG. 5285

CONTRACTORS LIC NO 150594

BILL OF MATERIAL

NO.	MK	△	QTY	MATERIAL	FT	IN	MARK	REMARKS
1	AS		1	1½" STD. PIPE	66	0	AS	APPROX. LIN. FT.
			1	PL ¼×4	23	0¼	aS	BENT
			6	PL ⅜×4	0	7	mS	
1	BS		1	1½" STD. PIPE	61	0	BS	APPROX. LIN. FT.
			1	PL ¼×4	20	4¼	bS	BENT
			5	PL			mS	
1	CS		1	1½" STD. PIPE	60	0	CS	APPROX. LIN. FT.
			1	PL ¼×4	21	0¼	cS	BENT
			5	PL			mS	
1	HS		1	1½" STD. PIPE	32	6	HS	APPROX. LIN. FT.
			1	PL ¼×4	10	4¼	hS	BENT
			3	PL			mS	
			2	½" STD. PIPE	0	2¼	tS	
1	KS		1	1½" STD. PIPE	18	6	KS	APPROX. LIN. FT.
			1	PL ¼×4	6	2⅝	kS	
			1	PL			mS	
			1	PL ⅜×4	0	7¼	pS	BENT
1	MS		1	1½" STD. PIPE	13	0	MS	APPROX. LIN. FT.
			1	PL ¼×4	0	6	sS	
			2	½" STD. PIPE	0	2¼	vS	
			2	½" ROD	0	5½	wS	
			1	PL ¼×4	3	1[illegible]	aaS	

No	DATE	REVISIONS
△1		
△2		
△3		
△4		

AS-BUILT

SPECIAL NOTES

HOLES = 13/16"
MIN. EDGE DIST. = 1¼"

APPROVAL INFO

FINISH SCHEDULE	☒
TRESCO No. 1262 ORO TEX RED PRIMER	
TYPE 15D BASIC LEAD CHROM PRIMER	
GREEN ZINC CHROMATE or TNEMEC 99	
HOT DIP GALVANIZE	

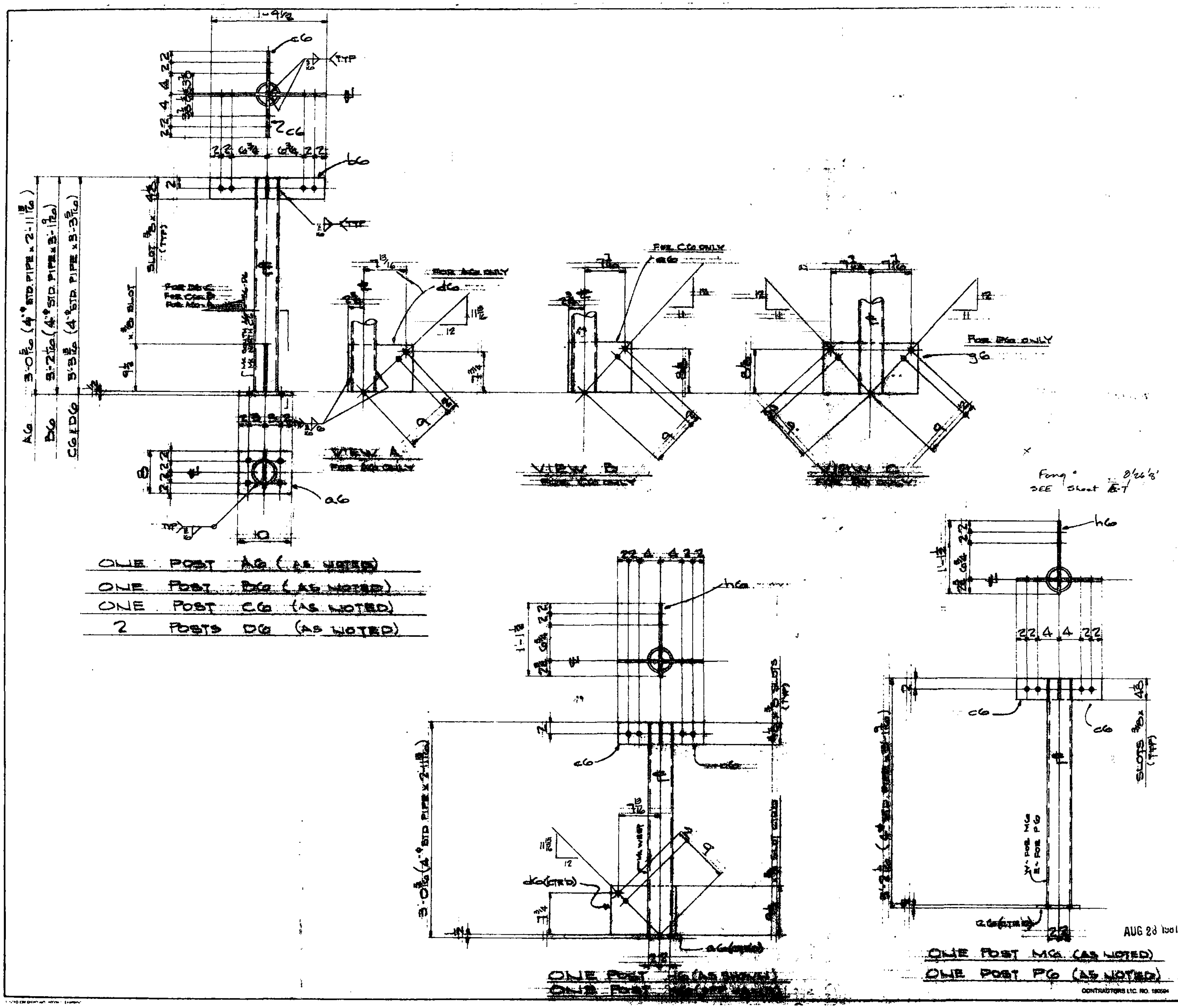
TITLE
ITEM HANDRAIL
JOB CATERPILLAR TRACTOR CO.
LOCATION SAN LEANDRO CA
ARCH ENGR BISSELL & KARN
CONTRACTOR RUDOLPH & SLETTEN

CASCADE METALS CORPORATION

COPIES ISSUED

	NO	DATE	NO	DATE	NO	DATE	NO	DATE
APPROVAL	1-5	8/3	3P	8/1				
SHOP								
FIELD								
ERECTION								
SUPT								
PURCHASE								
INSPECTOR								
ESTIMATING								

DWG. NO. D5



AUG 28 1981

CONTRACTORS LIC. NO. 180594

BILL OF MATERIAL

NO	MK	△	QTY	MATERIAL	FT	IN	MARK	REMARKS
1	AG		ONE	4"φ STD. PIPE	2	11 13/16	AG	
1	BG		ONE	4"φ STD. PIPE	3	1 9/16	BG	
1	CG		ONE	4"φ STD. PIPE	3	3 5/16	CG	
2	DG		2	4"φ STD. PIPE	3	3 5/16	DG	
			5	PL 1/2 x 8	0	10	aG	
			1	PL 1/4 x 4	1	9 1/2	bG	
			10	PL 1/4 x 4	0	7 1/2	cG	
			1	PL 1/4 x 9 3/8	0	11 3/4	dG	
			1	PL 1/4 x 9 3/8	0	11 1/2	eG	
			1	PL 1/4 x 9 3/8	1	5 1/2	gG	
1	HG		ONE	4"φ STD. PIPE	2	11 13/16	HG	
1	KG		ONE	4"φ STD. PIPE	2	11 13/16	KG	
			2	PL 1/2 x 8	0	10	aG	
			4	PL 1/4 x 4	0	7 1/2	cG	
			2	PL 1/4 x 9 3/8	0	11 3/4	dG	
			2	PL 1/4 x 4	1	1 1/2	hG	
1	MG		ONE	4"φ STD. PIPE	3	1 9/16	MG	
1	PG		ONE	4"φ STD PIPE	3	1 9/16	PG	
			2	PL 1/2 x 8	0	10	aG	
			4	PL 1/4 x 4	0	7 1/2	cG	
			2	PL 1/4 x 4	1	1 1/2	hG	

ERECT BOLTS (SUMM ON E7)

28	5/8"φ A325	0	1 3/4
48	5/8"φ A325	0	2

AS-BUILT

REVISIONS

No	DATE	
1		
2		
3		
4		

SPECIAL NOTES

OPEN HOLES 11/16"φ U.N.
MIN EDGE DIST = 1 1/4" U.N.

APPROVAL INFO

FINISH SCHEDULE

- ☒
- TRESCO No 1762 ORO-TEX RED PRIMER
- TTP615D BASIC LEAD CHROM PRIMER TP
- GREEN ZINC CHROMATE or TNEMEC 99
- HOT DIP GALVANIZE

TITLE

ITEM POST
JOB CATERPILLAR TRACTOR CO
LOCATION SAN LEANDRO CA
ARCH ENGR BISSELL & KARN INC
CONTRACTOR RUDOLPH & SLETTEN

CASCADE METALS CORPORATION
P.O. BOX 5370 • 1150 MABURY ROAD • SAN JOSE

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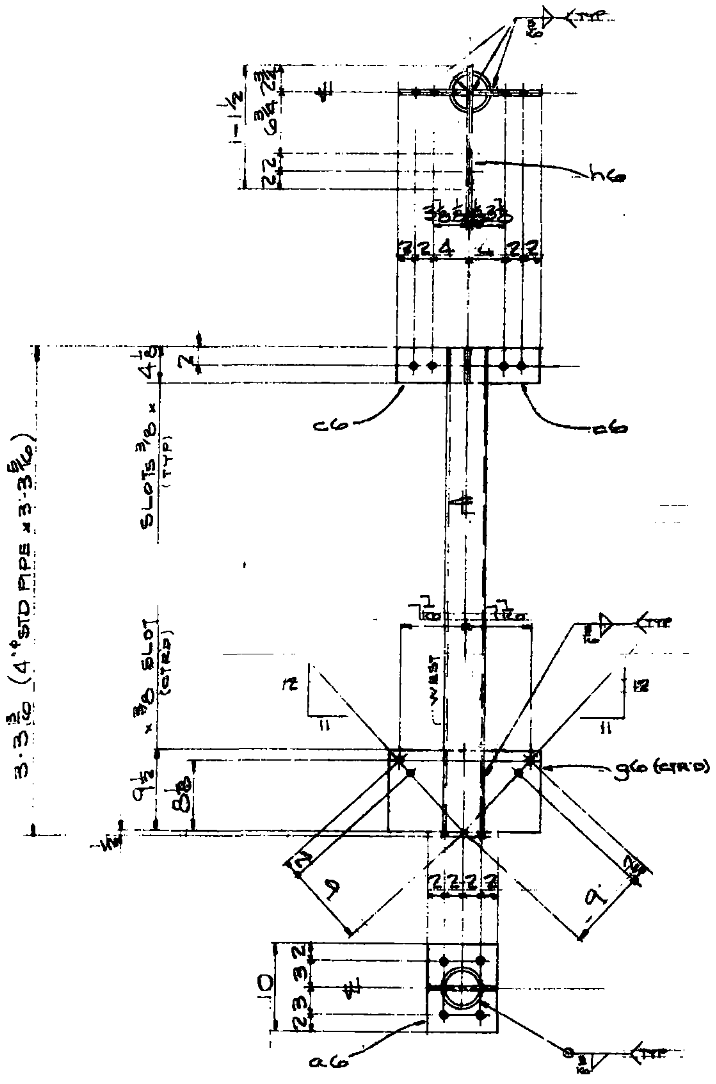
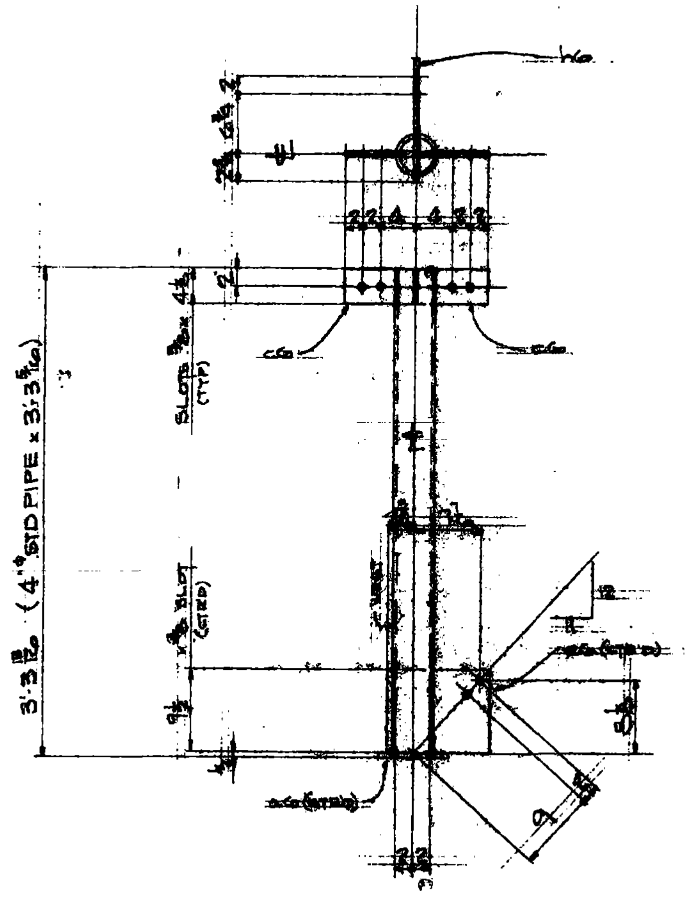
	NO	DATE	NO	DATE	NO	DATE	NO	DATE
APPROVAL	1-5	8/3	2-5	8/3				
SHOP								
FIELD								
ERECTION								
SUPT								
PURCHASE								
INSPECTOR								
ESTIMATING								

DWG BY JS
CHKD BY MS 7/30/81
JOB NO 332
SEQ. NO. 0214
DWG. NO. D6



ONE POST A7



ONE POST B7

BILL OF MATERIAL

NO	MK	Δ	QTY	MATERIAL	FT	IN	MARK	REMARKS
1	A7		ONE	4"Φ STD. PIPE	3	3 13/16	A7	
			1	PL 1/4 x 8	0	10	a6	
			2	PL 1/4 x 4	0	7 3/8	c6	
			1	PL 1/4 x 9 3/8	1	5 1/2	g6	
			1	PL 1/4 x 4	1	1 1/2	h6	
1	B7		ONE	4"Φ STD PIPE	3	3 13/16	B7	
			1	PL 1/2 x 8	0	10	a6	
			2	PL 1/4 x 4	0	7 3/8	c6	
			1	PL 1/4 x 9 3/8	0	11 1/2	e6	
			1	PL 1/4 x 4	1	1 1/2	h6	

ERECTION BOLTS (SUMM ON E7)

14	5/8"Φ A325	0	1 3/4
4	5/8"Φ A325	0	2

Fang 8/26/8

SEE SHEET E-7

AS-BUILT

No	DATE	REVISIONS
1		
2		
3		
4		

SPECIAL NOTES

OPEN HOLES 11/16"Φ UN

MIN. EDGE DIST. = 1 1/4" UN

APPROVAL

FINISH SCHEDULE

- TRESCO No 1262 ORO-TEX RED PRIMER
- TTP615D BASIC LEAD CHROM PRIMER TP II
- GREEN ZINC CHROMATE or TNEMEC 99
- HOT DIP GALVANIZE

☒

TITLE

ITEM POST

JOB CATERPILLAR TRACTOR CO.

LOCATION SAN LEANDRO, CA

ARCH ENGR BISSELL & KARN INC.

CONTRACTOR RUDOLPH & SLETTEN

CASCADE METALS CORPORATION

P.O. BOX 5370 • 1150 MABURY ROAD • SAN JOSE, CALIF 95150

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	NO	DATE	NO	DATE	NO	DATE	NO	DATE
APPROVAL	3-5	8/3	2-1	7/13				
SHOP								
FIELD								
ERECTION								
SUPT								
PURCHASE								
INSPECTOR								
ESTIMATING								

JOB NO. 332

SEQ. NO. 0215

DWG. BY 7.7.

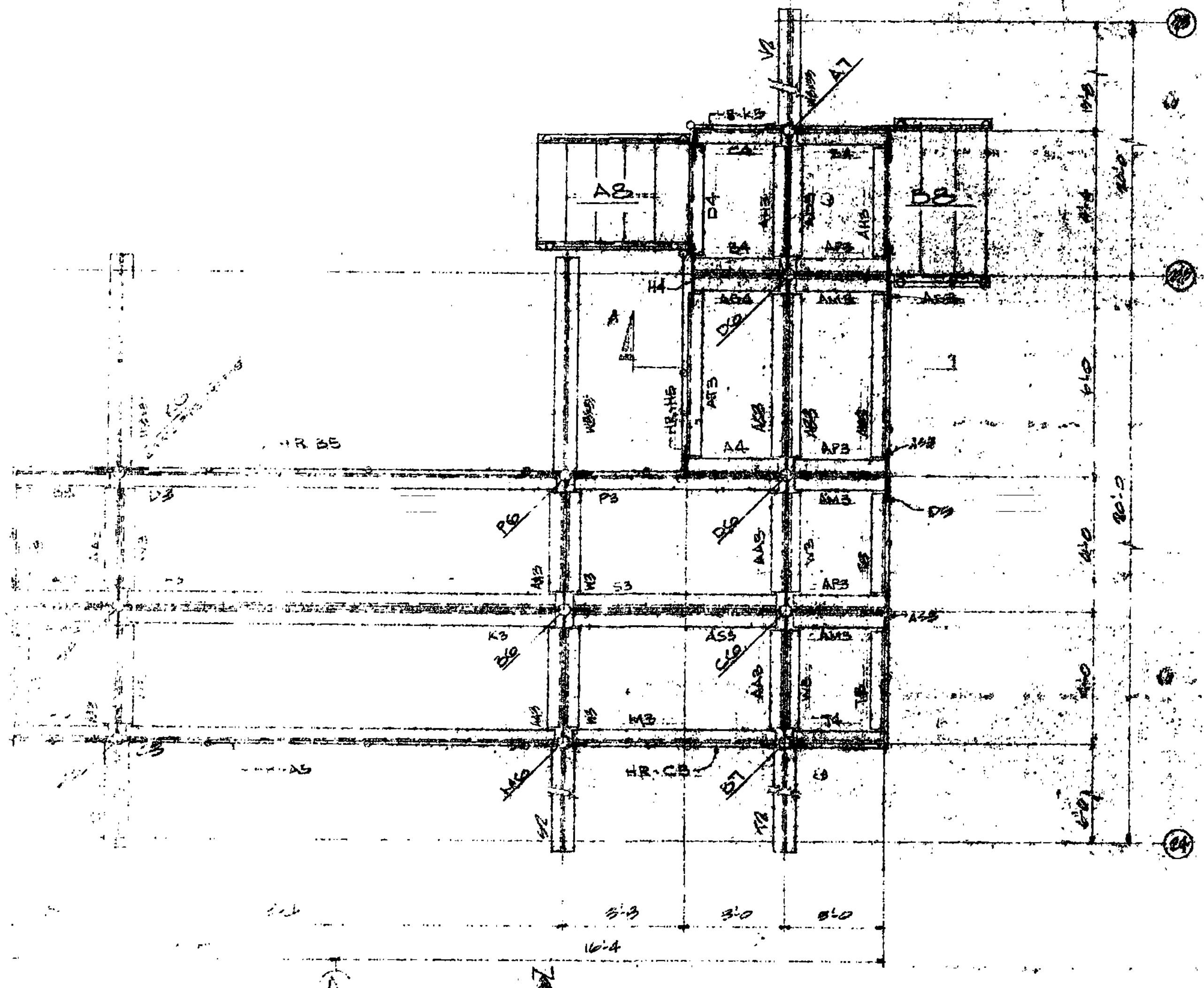
CHKD BY 7/14/8

DWG. NO. D7

REV. 0

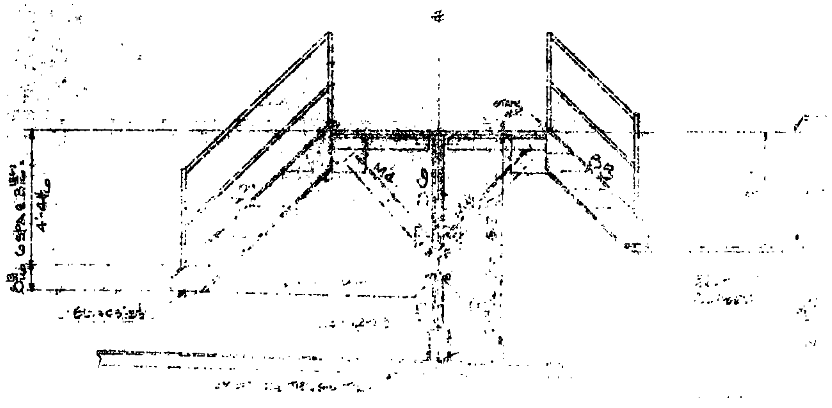
AUG 28 19..

CONTRACTORS LIC NO 150894

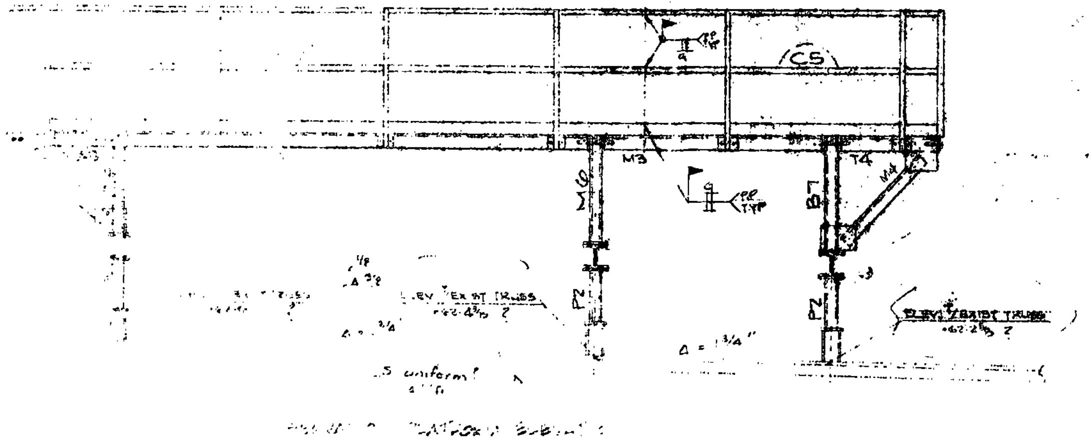


OBSERVATION PLATFORM FRAMING PLAN

ALL MEMBERS L 5x3x5/16 LLH.



SECTION A



Dimensioning
Based upon
Slope
AFFECTS ALL
SHEET

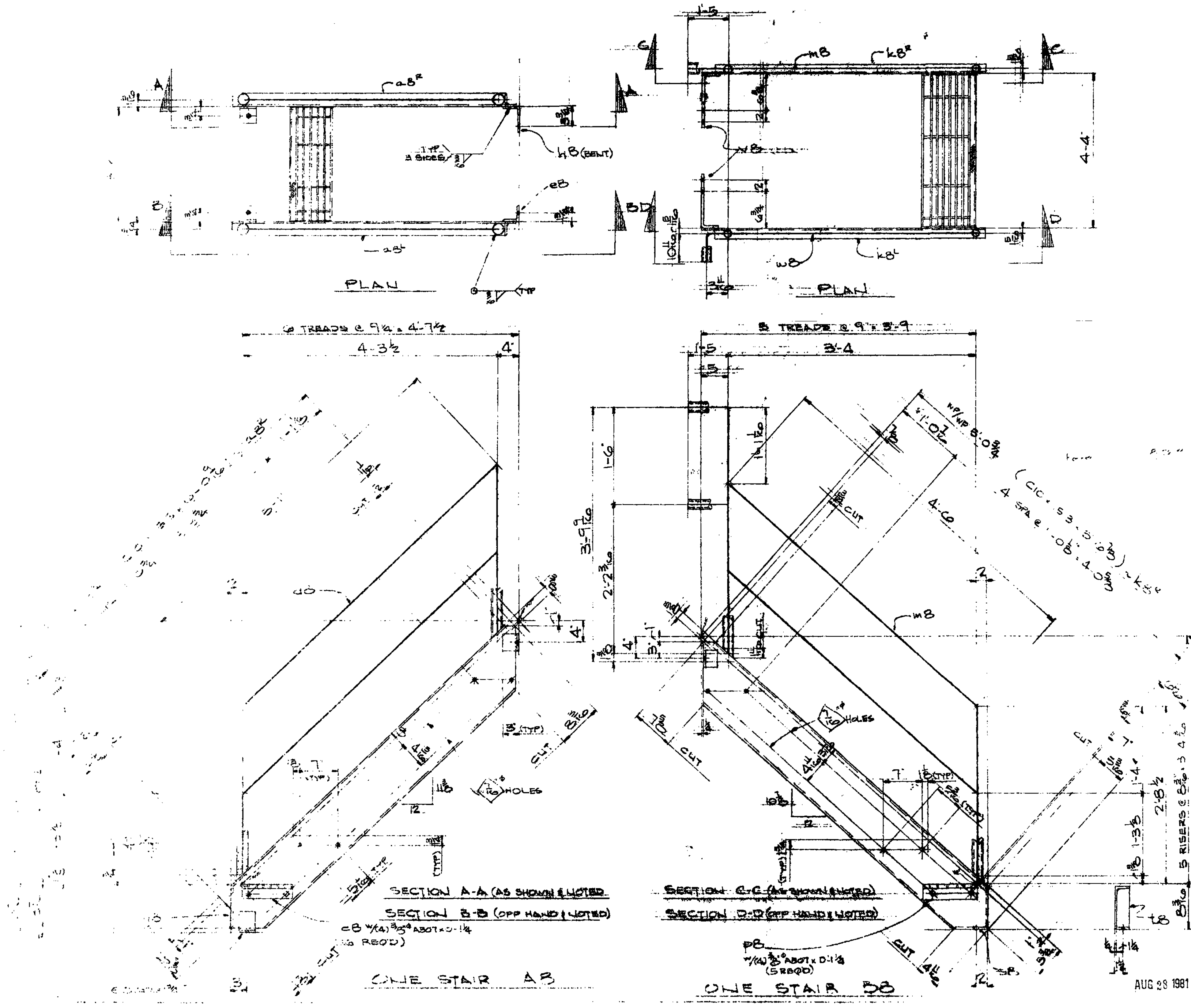
AS-BUILT

AUG 28 1981

ERECTION SUMMARY

SPECIAL NOTES

FINISH SCHEDULE



SHIPPING NO	MK	△	QTY	MATERIAL	FT	IN	MARK		REMARK
1	AB		ONE	STAIR			AB		
			1/1	C10 x 15.3	6	10 9/16	a8 R/L		
			12	GRATING TREADS x 3/16					
				B.B. x 10 15/16	3	0			
				W/CHKD PL NOSING			c8		
			2	1½"Φ STD. PIPE	17	6	d8		APPROX LIN. FT
			3	[illegible] x ¼	0	3	e8		
			2	PL ¼ x 3/8	0	1¼	g8		
			1	PL ¼ x 3	0	7½	h8		BENT
1	B8		ONE	STAIR			B8		
			1/1	C10 x 15.3	5	6⅝	k8 R/L		
			1	1½ Φ STD PIPE	18	6	m8		APPROX LIN. FT
			3	GRATING TREAD		10 15/16			3/16 BB
				4'-4 W/CHKD PL			n8		
			2	PL ¼ x 2⅜	0	5¾	s8		
			2	PL ¼ x 2⅜	0	6½	t8		
			2	PL ¼ x 3	0	6½	v8		
			1	1½ Φ STD PIPE	18	0	w8		APPROX. LIN. FT.
				ERECTION BOLTS 5% MIN. [illegible]					
			2	3/8Φ A325	0	1½			

AS-BUILT

REVISIONS

SPECIAL NOTES

OPEN HOLES 11/16" DIA
MIN. EDGE DIST = 1¼

FINISH SCHEDULE

GREEN ZINC CHROMATE [illegible]

NO [illegible] GALVANIZE

COPIES ISSUED

TITLE

STAIR

CATERPILLAR TRACTOR

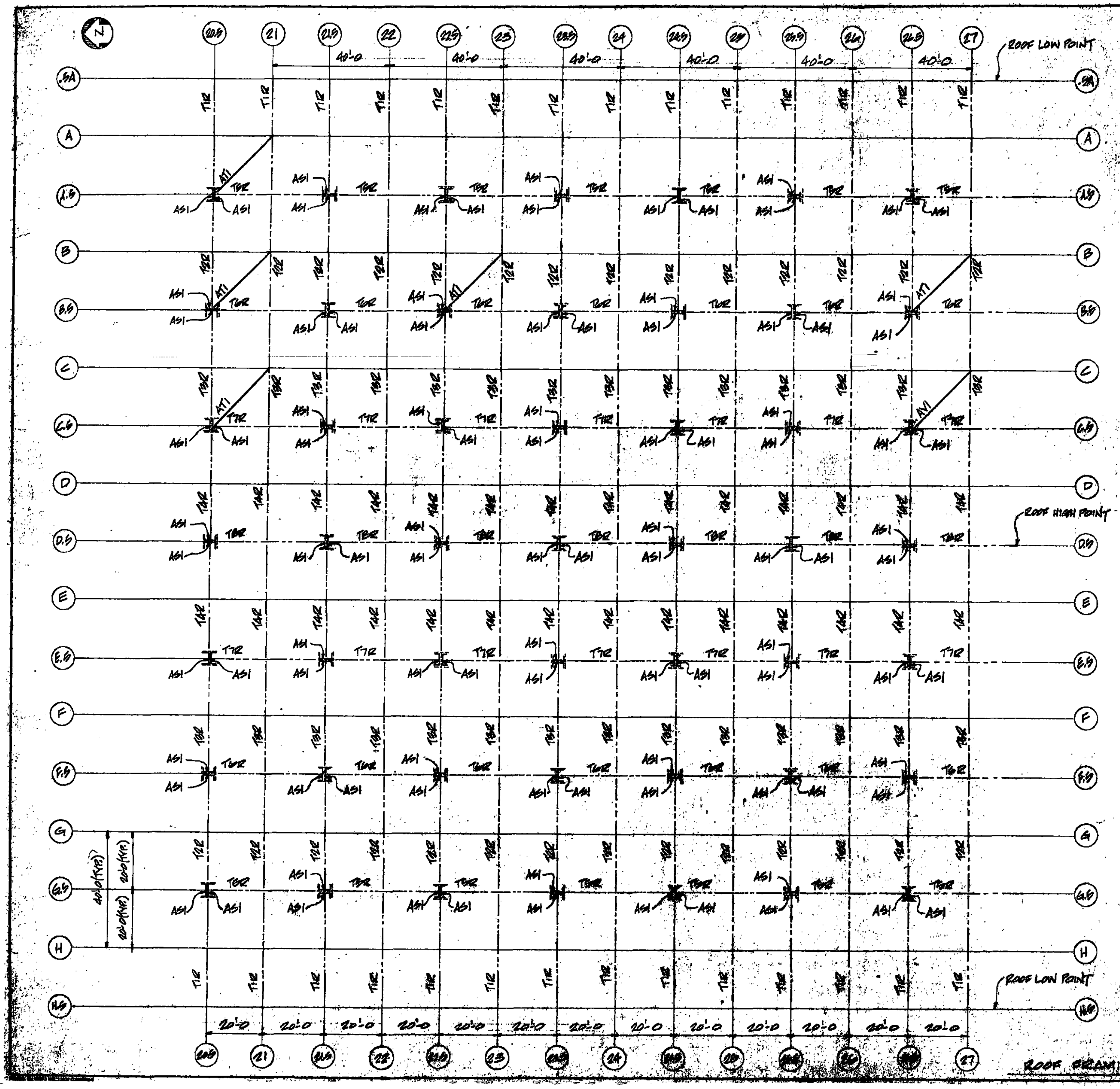
LOCATION SAN LEANDRO

ARCH./ENGR. BISSELL & [illegible]

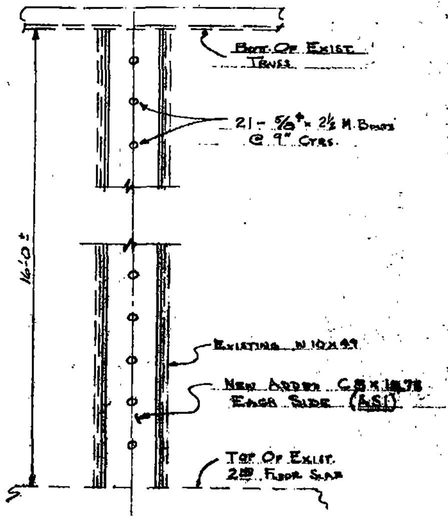
CONTRACTOR RUDOLPH & [illegible]

CASCADE METALS CORPORATION

AUG 28 1981



ROOF FRAMING PLAN



COLUMN REINFORCEMENT AS SHOWN IN PLAN (AS1)
(ALSO SEE PLAN ON DWG. E3)

SUBMITTAL REVIEW
BISSELL & KARN INC. CIVIL ENGINEERS
☒
☐
☐ Amend and Resubmit
☐ Reject - See Remarks
By Frank Fong Date 6/26/81

AS-BUILT

JUN 19 1981

NO.	MK.	△	QTY.	MATERIAL	FT.	IN.	MARK	REMARKS	TOTAL FOOTAGE	TOTAL WEIGHT	CODE

SHIPPING — BILL OF MATERIAL

No.	DATE	REVISIONS
1		
2		
3		
4		

SPECIAL NOTES

Work This Dwg. With E3, E5 & E6
R&S Proj. No. 1969 - Spec. Sect. 5.02 & 5.03 - Dwgs. S250 Thru S2[illegible]

APPROVAL [illegible]

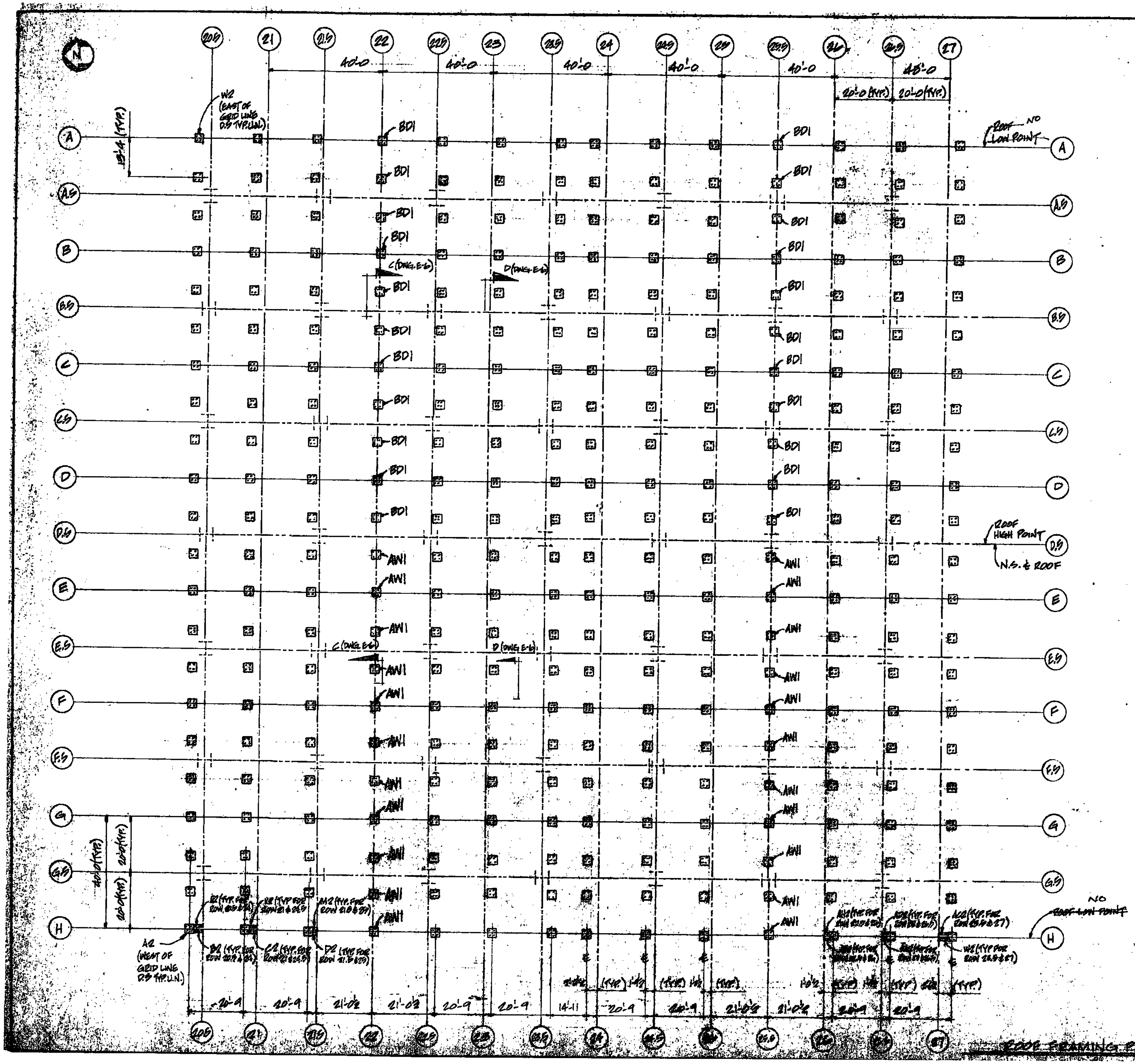
FINISH SCHEDULE	☒
TRESCO No. 1262 ORO-TEX RED PRIMER	
TTP615D BASIC LEAD CHROM PRIMER TP II	
GREEN ZINC CHROMATE or TNEMEC 99	
HOT DIP GALVANIZE	

TITLE
ITEM: REINFORCED EXISTING STEEL
JOB: CATERPILLAR TRACTOR CO.
LOCATION: SAN LEANDRO, CA
ARCH./ENGR: BISSELL & KARN INC.
CONTRACTOR: RUDOLPH & SLETTEN

CASCADE METALS CORPORATION

COPIES ISSUED

	NO.	DATE	NO.	DATE	NO.	DATE	NO.	DATE
APPROVAL	3	6/11						
SHOP								
FIELD								
ERECTION								
GEN.								
PURCHASING								
INSPECTOR								



ROOF FRAMING PLAN

SUBMITTAL REVIEW

BISSELL & KARN INC. CIVIL ENGINEERS

☐ No E[illegible]
☒ [illegible]
☐ [illegible]
☐ Reject - See Remarks

By Frank Fong Date 6/26/81

AS-BUILT

JUN 19 1981

NO.	MK.	△	QTY.	MATERIAL	FT.	IN.	MARK	REMARKS	TOTAL FOOTAGE	TOTAL WEIGHT	CODE

SHIPPING

BILL OF MATERIAL

No.	DATE	REVISIONS
1		
2		
3		
4		

SPECIAL NOTES

Work This Dwg. With E4 & E6
R&S Proj. No 1469 - Spec. Sect 5.02 & 5.03 - Dwg's S200 Thru S285

APPROVAL INFO.

FINISH SCHEDULE	☒
TRESCO No. 1282 ORO-TEX RED PRIMER	
TTP615D BASIC LEAD CHROM PRIMER TP II	
GREEN ZINC CHROMATE or TNEMEC 99	
HOT DIP GALVANIZE	

TITLE

ITEM: REINFORCED PYLON LOCATION
JOB: CATERPILLAR TRACTOR CO.
LOCATION: SAN LEANDRO, CA
ARCH./ENGR: BISSELL & KARN INC.
CONTRACTOR: RUDOLPH & SLETTEN.

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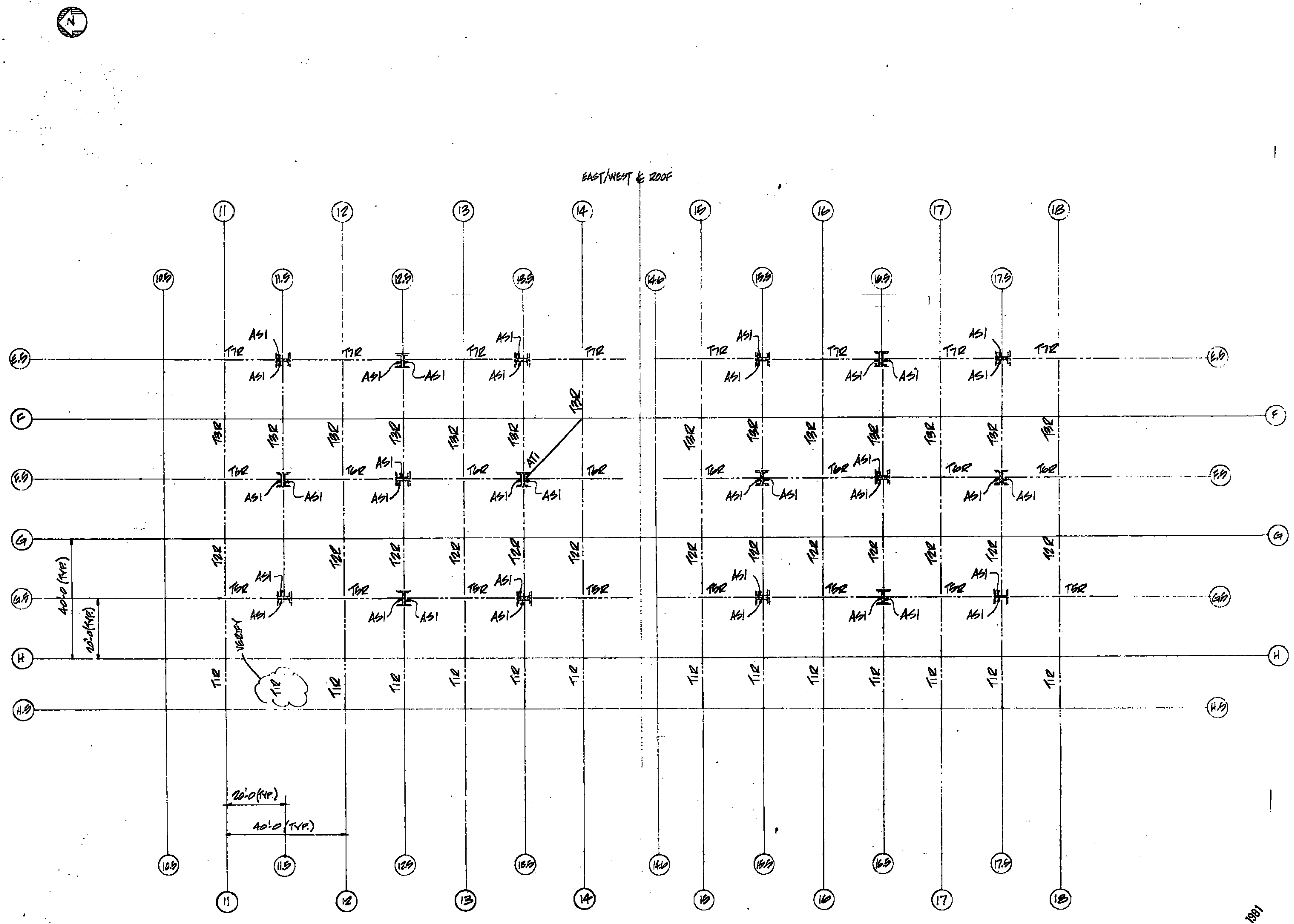
DATE 5/12
QTY. 1-3 2-4

DWG. DATE 4/24/81
DWG. BY [illegible]
CHKD. BY

JOB NO. 332
SEQ. NO. 0.1 02
DWG. NO. E2



JUN 19 1981

SUBMITTAL REVIEW

Frank Fong 5/26/81

PARTIAL ROOF FRAMING PLAN

NO.	MK.	△	QTY.	MATERIAL	FT.	IN.	MARK	REMARKS			CODE

SHIPPING — BILL OF MATERIAL

AS-BUILT

No.	DATE	REVISION
1		
2		
3		
4		

SPECIAL NOTES

Work This Dwg. With E1, E5 & E6

R&S Proj. No. 1469 - Spec. Secm. 5-02 & 5-03 - Dwg's. S280 Thru S285

APPROVAL INFO.

FINISH SCHEDULE ☒

TRESCO No. 1262 ORO-TEX RED PRIMER

TTP815D BASIC LEAD CHROM PRIMER TP II

GREEN ZINC CHROMATE or TNEMEC 99

HOT DIP GALVANIZE

TITLE

ITEM: REINFORCED EXISTING STEEL

JOB: CATERPILLAR TRACTOR CO.

LOCATION: SAN LEANDRO, CA.

ARCH./ENGR: BISSELL & KARN INC.

CONTRACTOR: RUDOLPH & SLETTEN.

CASCADE METALS CORPORATION

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SUPT.								
PURCHASE								
INSPECTOR								

DATE	5/12	
QTY.	1-5 2-P	
DATE		
QTY.		
DATE		
QTY.		

DWG. DATE 4/28/81

DWG. BY PWC

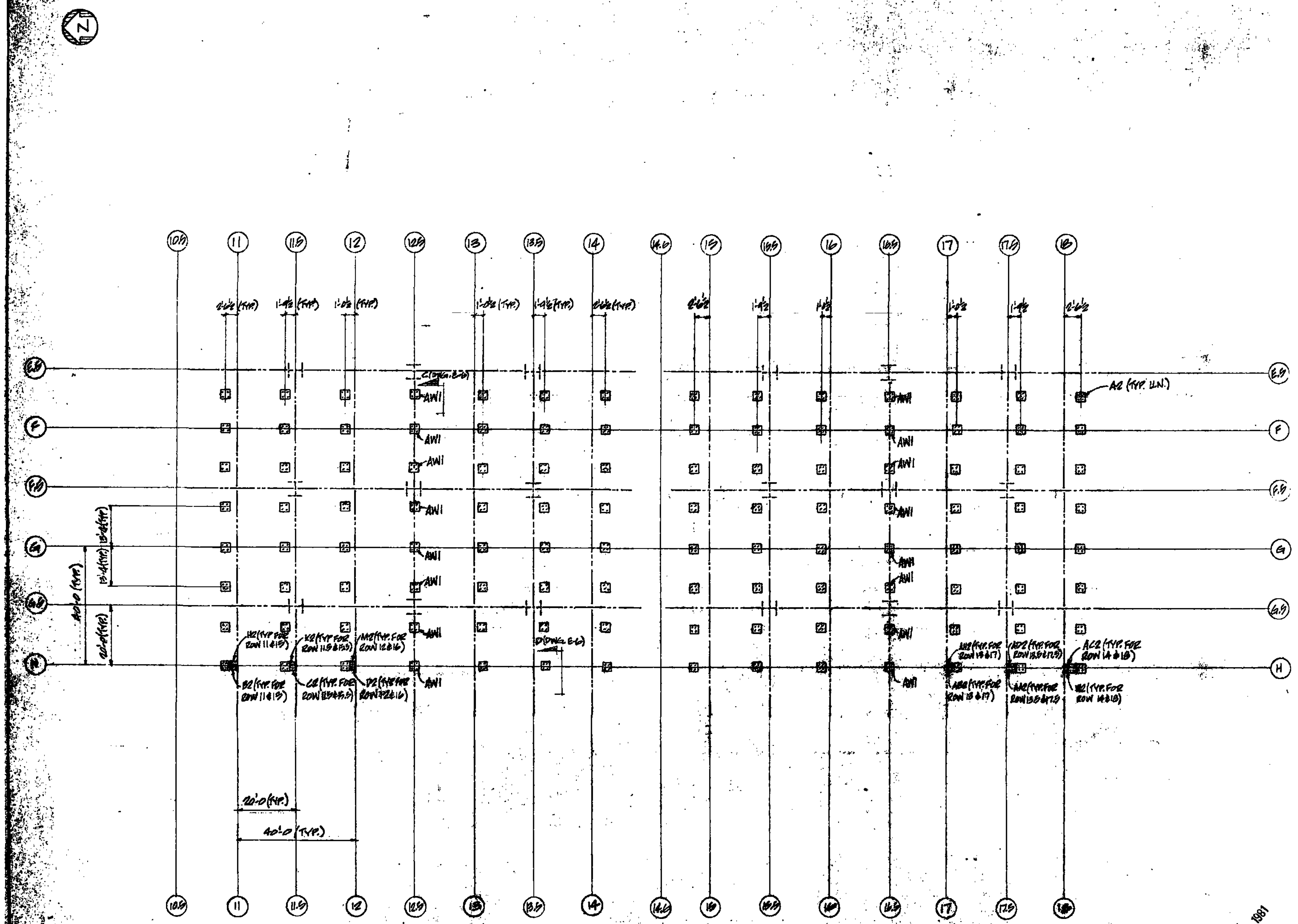
CHKD. BY PWC

JOB NO. 332

SEQ. NO. 0103

DWG. NO. E3

REV. △



PARTIAL ROOF FRAMING PLAN

SUBMITTAL REVIEW

☒ No Exceptions Taken
☐ Make Corrections Noted
☐ Amend and Resubmit
☐ Reject - See Remarks

By Frank Fong Date 6/26/81

JUN 1 9 1981

AS-BUILT

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SHIPPING — BILL OF MATERIAL

No.	DATE	REVISIONS
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SPECIAL NOTES — APPROVAL INFO.

Work This Dwg. With E2 & E6
R & S Proj. No. 1469 - Spec. Sect. 5.02 & 5.08 - Dwgs. S280 & S285

FINISH SCHEDULE	☒
TRESCO No. 1282 ORD-TEX RED PRIMER	
TTP615D BASIC LEAD CHROM PRIMER TP II	
GREEN ZINC CHROMATE or TNEMEC 89	
HOT DIP GALVANIZE	

TITLE

ITEM: REINFORCED PYLON LOCATION
JOB: CATERPILLAR TRACTOR CO.
LOCATION: SAN LEANDRO, CA.
ARCH./ENGR.: BISSELL & KARN INC.
CONTRACTOR: RUDOLPH & SLETTEN

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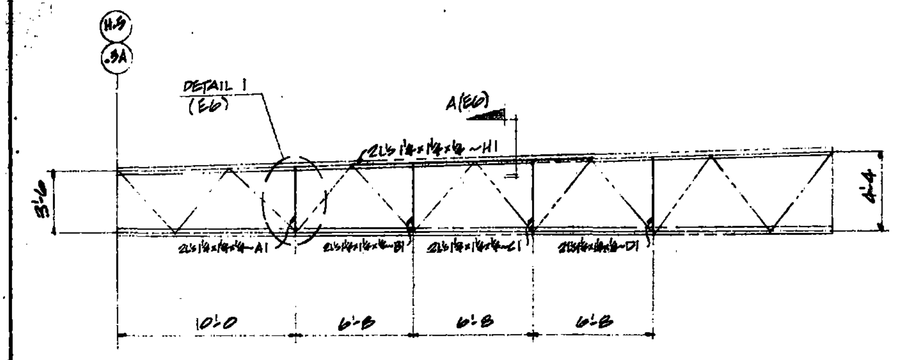
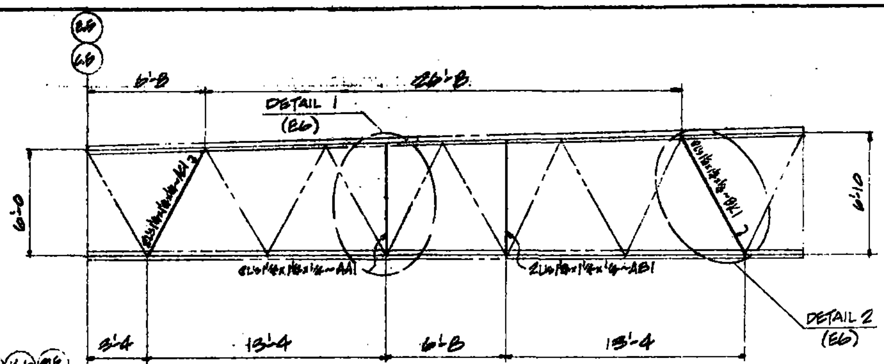
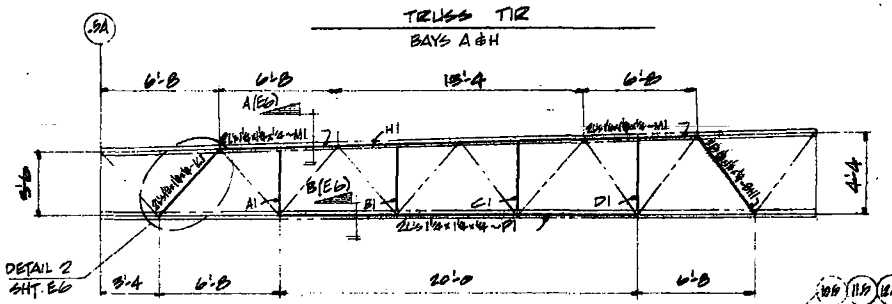


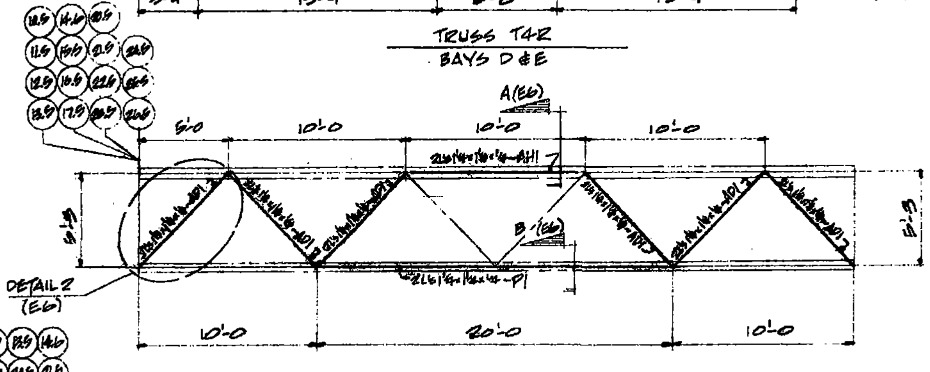
TRUSS T1R
BAYS A & H



TRUSS T4R
BAYS D & E

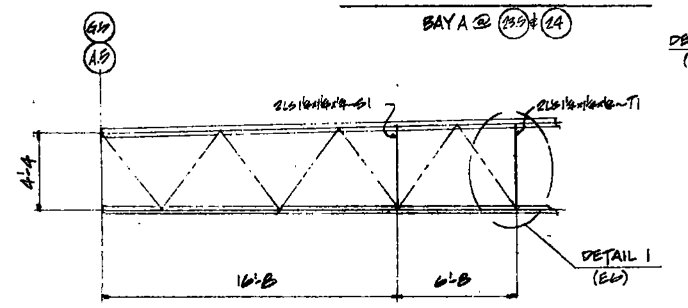


TRUSS T1R-1
BAY A @ 23.5 & 24

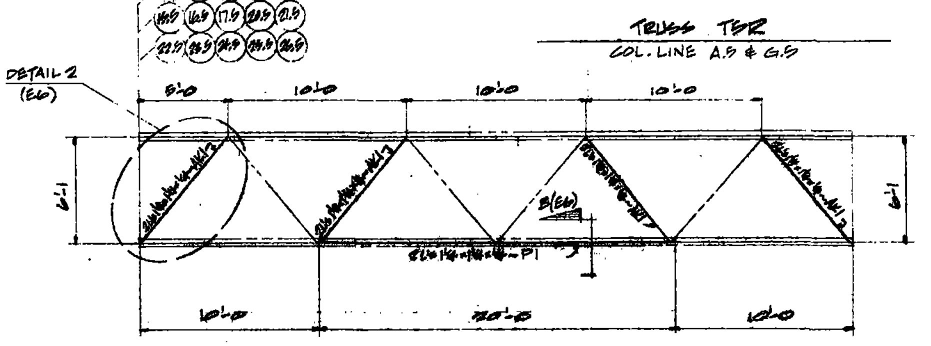


TRUSS T5R
COL. LINE A.5 & G.5

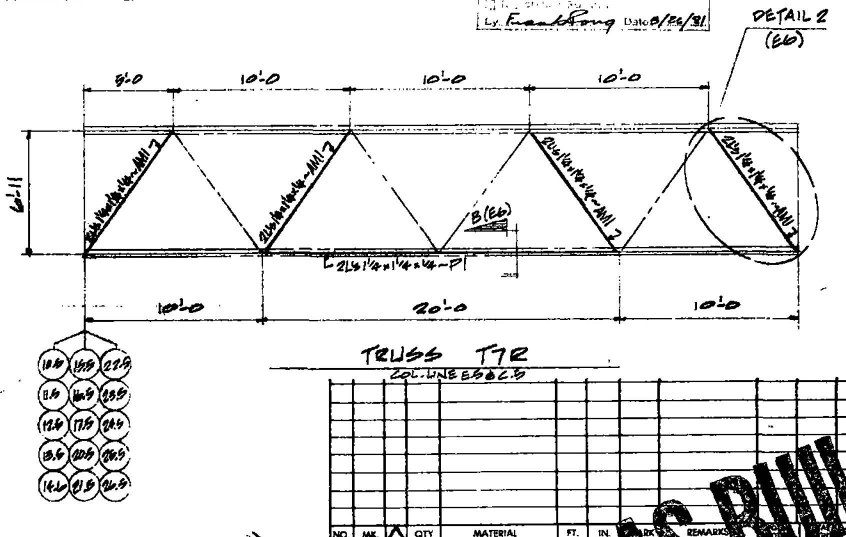
SUBMITTAL REVIEW
☒
By Frank Pong Date 8/26/81



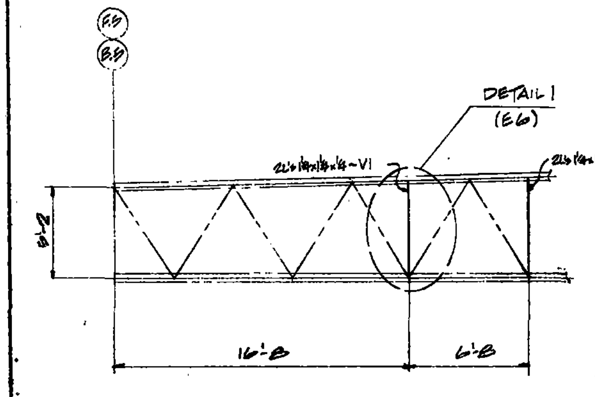
TRUSS T2R
BAYS B & G



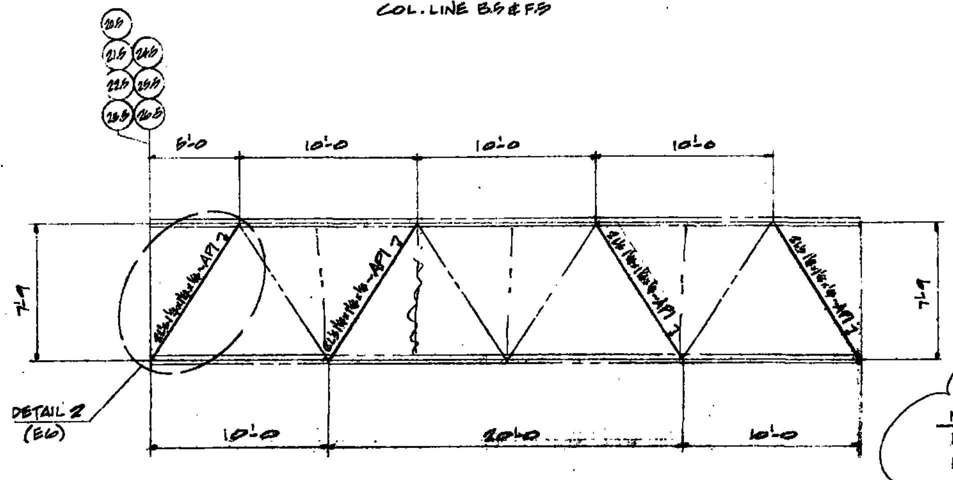
TRUSS T6R
COL. LINE B.5 & F.5



TRUSS T7R
COL. LINE E.5 & C.5



TRUSS T3R
BAYS C & F



TRUSS T8R
COL. LINE D.5

JUN 19 1981

NOTE: SPOT CHECK LENGTH OF DIAGONAL BRACES @ VARIOUS LOCATIONS PRIOR TO FABRICATION.

AS-BUILT

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SHIPPING BILL OF MATERIAL

REVISIONS

No.	DATE	
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△		
△		
△		

SPECIAL NOTES

WORK THIS DWG. WITH E1, E3 & E6
R&S PROJ. No. 1469 - SPEC. SECT. 5.02 & 5.03 - DWG'S 5280 & 5285

APPROVAL INFO.

FINISH SCHEDULE ☒
- TRESCO No 1262 ORO-TEX RED PRIMER
- TTP615D BASIC LEAD CHROM PRIMER TP II
- GREEN ZINC CHROMATE or TNEMEC 99
- HOT DIP GALVANIZE

TITLE
ITEM: TRUSS ELEVATIONS
JOB: CATERPILLAR TRACTOR CO.
LOCATION: SAN LEANDRO
ARCH./ENGR: BISSELL & KARN INC
CONTRACTOR: RUDOLPH & SLETTEN

CASCADE METALS CORPORATION
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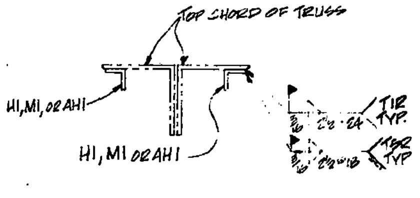
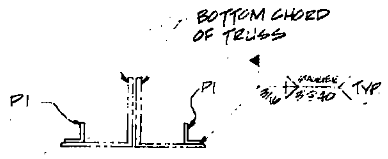
PURCHASES								
INSPECTOR								

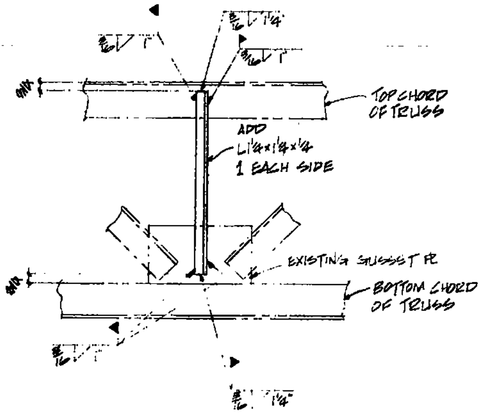
DATE 6/15
QTY. 1-S 2-P
DWG. DATE 4/24/81
DWG. BY PMC/GM
CHKD. BY PMC
JOB NO. 392
SEQ. NO. 0105
DWG. NO. E5



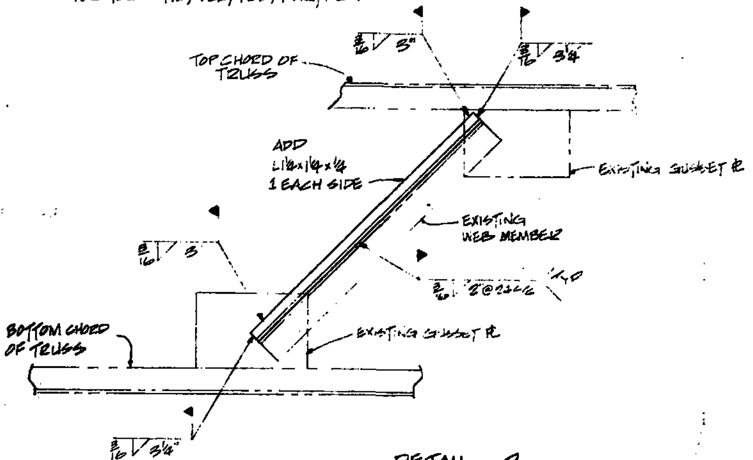
SECTION A
FOR TRUSS T1R T1E-1, T5R



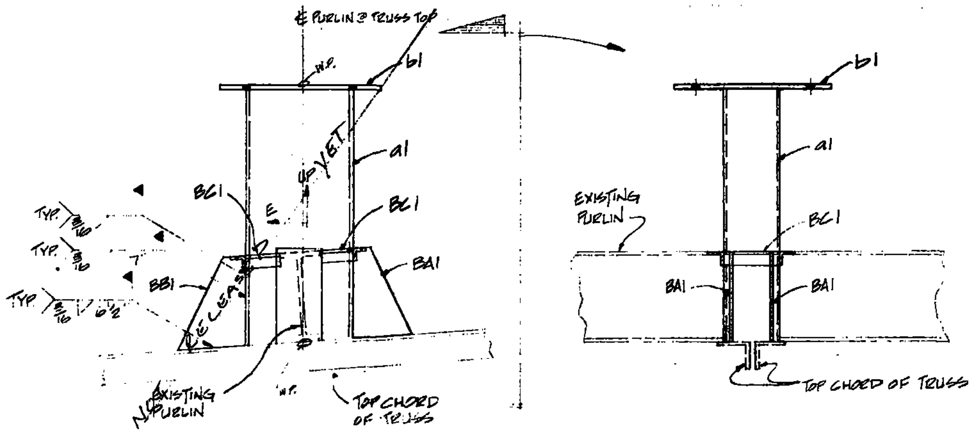
SECTION B
FOR TRUSS T1R-1, T5R, T6R, T7R



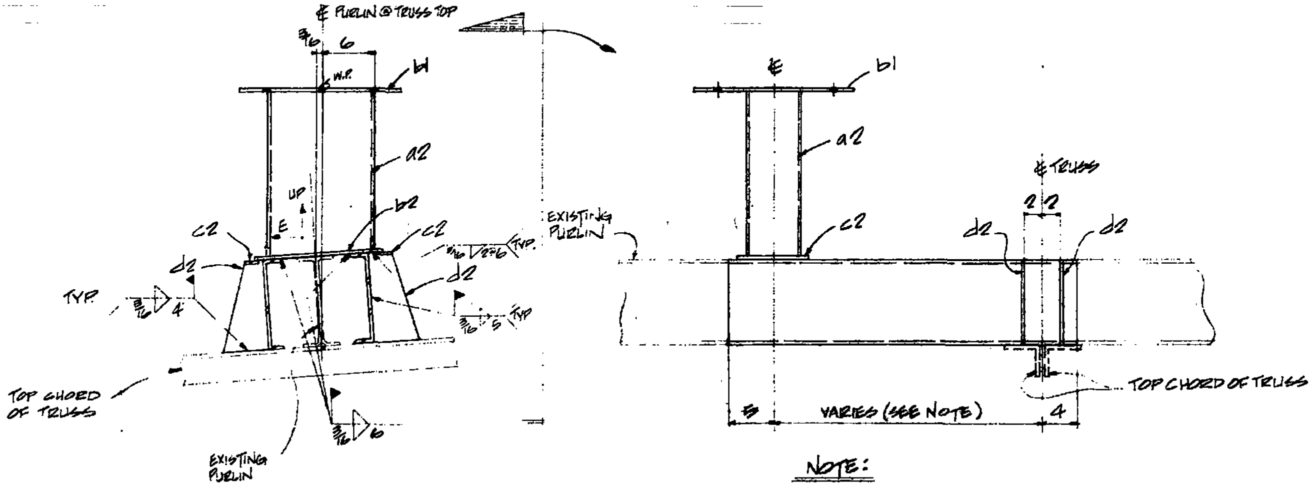
DETAIL 1
FOR TRUSS T1R, T2R, T3R, T4R, T1R-1



DETAIL 2
FOR TRUSS T1R-1, T4R, T5R, T6R, T7R, T8R



VIEW C
DRIVE PYLON SUPPORT



VIEW D
SUPPORT PYLON CONNECTION

NOTE:

1'-0½ FOR D2, M2, AB2, AH2
1'-9½ FOR C2, K2, AA2, AD2
2'-6½ FOR B2, H2, W2, AC2

SUBMITTAL REVIEW
BISSELL & KARN, INC. ENGINEERS
☐ No Exceptions Taken
☒ Note Corrections Indicated
☐ Amend and Resubmit
☐ Reject - See Remarks
By Frank Fong Date 6/22/81

JUN 19 1981

AS-BUILT

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SHIPPING	BILL OF MATERIAL									

No.	DATE	REVISIONS
△1		
△2		
△3		
△4		

SPECIAL NOTES	APPROVAL INFO.
WORK THIS DWG. WITH E2, E4 & E5	
R & S PROJ. No 1469 - SPEC. SECT. 5.02 & 5.03 - DWG'S S280 & S285	

FINISH SCHEDULE	☒
TRESCO No. 1262 ORO-TEX RED PRIMER	
TTP615D BASIC LEAD CHROM PRIMER TP II	
GREEN ZINC CHROMATE or TNEMEC 99	
HOT DIP GALVANIZE	

TITLE
ITEM: MISC. SECTIONS & DETAILS
JOB: CATERPILLAR TRACTOR CO.
LOCATION: SAN LEANDRO, CA.
ARCH./ENGR: BISSELL & KARN INC.
CONTRACTOR: RUDOLPH & SLETTEN.

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INSPECTOR								

DATE 5/12
QTY. 1-S, 2-P
DWG. DATE 4/29/81
DWG. BY MAC/GM
CHKD. BY MAC/GG
JOB NO. 442
SEQ. NO. 0106
DWG. NO. E6
REV. △