

PAGE JACKSON SOLAR SCHOOL

CHARLES TOWN
WEST VIRGINIA

FINAL TECHNICAL REPORT
FOR THE

DEPARTMENT OF ENERGY

JULY 1983

CONTRACT NO. EY-76-C-05-4926
(ERDA CONTRACT NO. E(40-1)-4926)

REFURBISH AND RESTORE SOLAR SYSTEM
CONTRACT NO. DE-AC03-82SF11584

MASTER

Contract and Administration:

Raymond H. Frazier, Superintendent
Jefferson County Schools
110 Mordington Avenue - P. O. Box 728
Charles Town, West Virginia 25414
Telephone: (304) 725-9741

Technical:

John W. Pickett
Pickett • Siess & Associates, A.I.A.
8294B Old Courthouse Road
Vienna, Virginia 22180
Telephone: (703) 821-1670

DO NOT MICROFILM
THIS PAGE

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

DOE/SF/11584--T1

DOE/SF/11584--T1

DE84 010420

PAGE JACKSON SOLAR SCHOOL

Charles Town, West Virginia

FINAL TECHNICAL REPORT

JULY 1982

MASTER

Prepared for the

DEPARTMENT OF ENERGY

CONTRACT NO. EY-76-C-05-4926
(ERDA CONTRACT NO. E(40-1)-4926)

REFURBISH AND RESTORE SOLAR SYSTEM
CONTRACT NO. DE-AC03-82SF11584

Prepared by

Contract and Administration:

Raymond H. Frazier, Superintendent
Jefferson County Schools
110 Mordington Avenue - P. O. Box 728
Charles Town, West Virginia 25414

Technical:

John W. Pickett
Pickett · Siess & Associates, A.I.A.
8294B Old Courthouse Road
Vienna, Virginia 22180

NOTICE
PORTIONS OF THIS REPORT ARE ILLEGIBLE
It has been reproduced from the best available copy to permit the broadest possible availability.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED
ps

PAGE JACKSON SOLAR SCHOOL

TABLE OF CONTENTS

	Page
I. Introduction and Description	1
II. Problems and Solutions	5
III. Acceptance Test Report	11
IV. Building Plans	
V. As Built Plans	
VI. Control Drawings	
VII. Operating and Maintenance Instructions and Diagrams	22

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

FIGURES, TABLES, PHOTOS AND DRAWINGS

I. Introduction and Description

Figure 1. Schematic

II. Problems and Solutions

Figure 1. Repair Prototype No. 1
Figure 2. Repair Prototype No. 2
Figure 3. Repair Prototype No. 3
Figure 5. Roof Plan
Figure 6. Collector Inlet Sensor
Figure 7. Collector Outlet Sensor
Figure 8. Absorber Plate Sensor
Figure 9. Collector Test Assembly
Figure 10. Test Schematic
Figure 11. Incident Solar Radiation (6/9/82)
Table 1. Collector Data (6/9/82)
Table 2. Collector Data (6/14/82)
Table 3. Collector Data (6/15/82)
Figure 12. Collector Performance (6/9/82)
Figure 13. Absorber Plate Performance (6/9/82)
Table 4. Estimated Collector Efficiencies (6/9/82)
Photos Clamping Methods Tested
Photo Continuous Copper Clamp
Photo Refurbished Collector

III. Acceptance Test Report

Figure 1. Solar Energy System Schematic
Table 1. Temperature Instrumentation
Table 2. Flow Rate Instrumentation
Table 3. Power Instrumentation
Table 4. Miscellaneous Instrumentation
Figure 2. Incident Insolation (I001)
Figure 3. Array Flowrate (W100)
Figure 4. Array Inlet Temperature (T100)
Figure 5. Array Outlet Temperature (T150)

Figure 6.	Instantaneous Array Efficiency
Figure 7.	Instantaneous Array Efficiency
Figure 8.	Measured Instantaneous Collector Array Performance
Figure 9.	Heating Loop Flowrate (W401)
Figure 10.	Heating Loop Supply Temperature (T451)
Figure 11.	Heating Loop Return Temperature (T401)
Figure 12.	Total Space Heating Load
Figure 13.	Storage Tank #1 Temperature (T200)
Figure 14.	Storage Tank #1 Temperature (T201)
Figure 15.	Storage Tank #2 Temperature (T202)
Figure 16.	Auxiliary Boiler Flowrate (W400)
Figure 17.	Total System Parasite Power
Photos	Refurbished Collector Array From Observation Deck

IV. Building Plans

A-1	Site Plan
A-2	Floor Plan
A-3	Roof Plan
A-4	Elevations
A-5	Reflected Ceiling Plan

V. As Built Plans

PPG Solar Collector Collector Section Solar and Dual Temperature Water Flow Diagram

VI. Control Drawings

1	System Display
2	Display Panel
3	Piping Diagram & Display Panel Details
4	Equipment Room Panel
5	Air Handling Units No. 1, 3, 5
6	Air Handling Units 2, 4, V.A.V. Boxes
7	Fan Coil Unit, Mech. Rm. Ventilation, Air Supply, Cool Down, Aux. Heat, Cool Tower

VII. Operating and Maintenance Instructions and Diagrams

1	Overall Schematic Design
2	Solar Piping

I. INTRODUCTION AND DESCRIPTION

The Page Jackson Elementary School in Charles Town, West Virginia, uses a solar energy system to provide space heating and cooling for a 52,600 sq.ft. school building. A total of 11,215 sq. ft. of PPG Industries, Inc., double-glazed, flat plate collectors (facing south at a 45° tilt from the horizontal) are used in conjunction with glass mirrored reflectors facing north at a 38° tilt from the horizontal) to collect the available solar energy. A schematic of the overall solar heating and cooling system is shown in Figure 1.

The solar energy system at Page Jackson is of the drainback type. Deionized water is circulated from the cooler of two interconnected 10,000 gallon storage tanks through the collectors when the absorber plate temperature sensor exceeds the storage tank water temperature sensor by 10°F. Drainback to the storage tanks will occur when this differential falls to 3°F.

Space heating for the school is provided by circulating warm water from the storage tanks through five air handling units (AHU's). A 780,000 Btu/Hr oil-fired boiler will add supplemental energy to the storage tank water as necessary to maintain a water supply temperature of at least 110°F. to the AHU's.

Space cooling to the building is provided by a 100 ton Trane packaged absorption water chiller when sufficiently hot solar water is available. A 120 ton centrifugal chiller acts as a backup to the solar unit. Water which is cooled by either method is used directly for space cooling and is not stored.

The solar energy system began operation late in the summer of 1977. Numerous technical problems with the on-site data acquisition system (DAS) prevented an in-depth analysis of the overall system performance until November of 1978.

SYSTEM DESCRIPTION

System Location:	Charles Town, West Virginia
Application:	Space Heating and Cooling
Collector Area, Gross/Net/Number:	9732 sq. ft. / 9496 sq. ft.
Reflector Area (sq. ft.):	9215
Conditioned Floor Area (sq. ft.):	52,600
Site Latitude:	39°N
Collector Tilt:	45° from the horizontal facing south
Collector Fluid:	Softened Water
Collector Type:	Flat Plate, PPG Model A-414
Storage Volume:	20,000 gallons total capacity; 17,500 gallons normal capacity
System Schematic:	See Figure 1.

System Narrative:

The Page Jackson Elementary School in Charles Town, West Virginia, uses a solar energy system to provide space heating and cooling for a 52,600 sq.ft. school building. The solar energy system is designed to provide approximately 85% of the space heating and 50% of the space cooling energy requirements of the school. It has an array of 538 PPG Industries, Inc. double glazed, flat plate collectors (gross area = 9,732 sq. ft.) which face due south at a 45° tilt from the horizontal. The collectors are used in conjunction with glass mirrored reflectors (facing north at a 38° tilt from the horizontal) to collect the available solar energy.

Water is used as a medium for delivering solar energy from the collector array to storage. Freeze protection is accomplished through a draindown system. The solar heated water is stored in two interconnected 10,000-gallon storage tanks and is used for space heating and cooling. When the solar energy is insufficient to meet the heating demands, a 780,000 Btu/hr

oil-fired boiler is used to provide auxiliary hot water for heating. In the space cooling mode, the hot water from storage is supplied to a 100-ton Trane absorption chiller to generate chilled water. A conventional 120-ton Trane centrifugal chiller is used as a backup whenever solar energy is insufficient to meet the space cooling demand.

In general, there are five modes of system operation. A description of these modes follows:

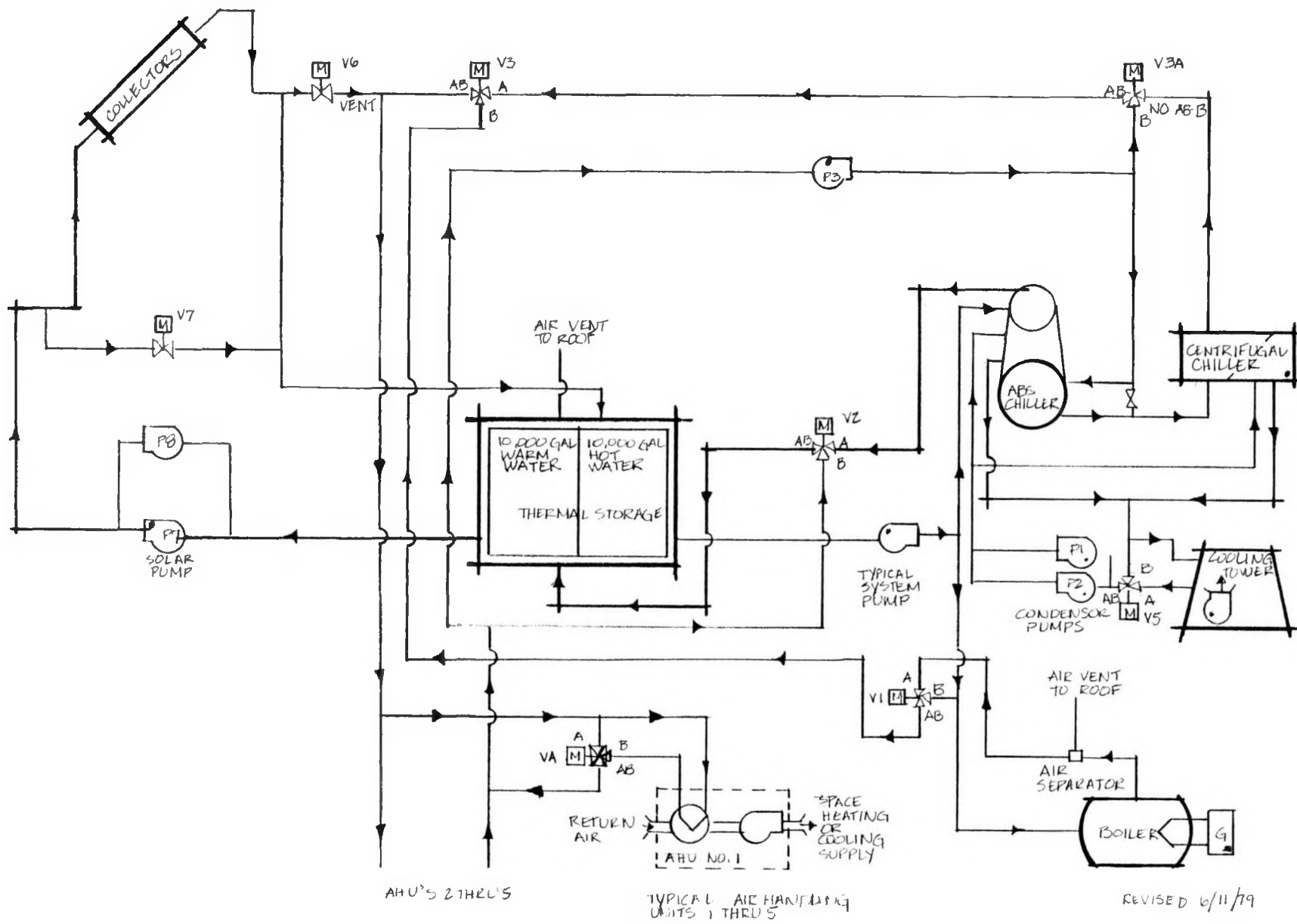
Mode 1 - Solar Collection: The collector subsystem operates independently of the other subsystems. When the collector absorber plate temperature sensor exceeds the storage tank water temperature sensor by 10°F, the collector loop circulation pump will activate, automatic air vents in the loop will open, and water will be circulated from the two interconnected 10,000-gallon storage tanks through the collector array. After a 5-minute filling period, the automatic air vents will close, allowing normal collector loop circulation.

Mode 2 - Space Heating: This mode is entered when the manual SUMMER-WINTER-AUTOMATIC switch is set to AUTOMATIC and the outside ambient temperature is below 60°F, or when the switch is set to WINTER. Whenever the room temperature in a zone is less than 68°F, water from the storage tank will be circulated through hydronic coils in the multi-zone air handling units. If the storage tank water temperature falls below 113°F, the oil-fired boiler will activate. Water at 160°F from the boiler will be mixed as required with water from the storage tank to maintain a supply temperature of 110°F to the air handling units. When the storage tank water temperature rises above 116°F, or the return air temperature from the air handling units rises above 68°F, the boiler will be deactivated.

Mode 3 - Space Cooling: This mode is entered when the manual SUMMER-WINTER-AUTOMATIC switch is set to AUTOMATIC and the outside ambient temperature is above 68°F, or when the switch is set to SUMMER. There are two modes of space cooling: one utilizes the absorption chiller, the other the centrifugal chiller. These chillers will not operate simultaneously. When the hot water thermal storage temperature rises above 180°F, system pumps are activated to circulate flow through the absorption chiller. When the hot water thermal storage temperature drops below 171°F, the absorption chiller will no longer be used for space cooling. If there is a demand for space cooling and the storage water temperature is below 171°F, the backup centrifugal chiller is used to satisfy the demand. In all cases, chilled water is used directly for space cooling and is not stored.

Mode 4 - System Draindown: When the temperature differential between the collector absorber plate and the storage tank water falls below 3°F, the circulation pump will be deactivated, the vacuum breakers will open, and the water in the collector loop will drain back into the storage tanks.

Mode 5 - Electrical Power Failure: To prevent overheating of the collectors in the event of an electrical power failure, an emergency propane fired generator will activate to operate an emergency circulation pump in the collector loop.



PAGE JACKSON SCHOOL SOLAR ENERGY SYSTEM SCHEMATIC

SCHEMATIC
FIG. 1

II. PROBLEMS AND SOLUTIONS

The solar heating and cooling system at the Page Jackson Elementary School in Charles Town, West Virginia, experienced many mechanical problems since its completion in the summer of 1977. Numerous leaks, collector glass breakage, and poor thermal performance plagued the operation of the system since its inception.

It became apparent that the major source of the system's poor thermal performance could be attributed to the ineffectiveness of the existing collector array. Data collected on the system throughout its operation indicated that calculated collector array efficiencies were between 20-25%, which was about 50% below the published vendor data. Subsequent inspection of the existing collector panels revealed that the riser tubes had separated from the absorber plate in a majority of the system's 620 collector panels. As a result, the primary mode of heat transfer from the hot absorber plate to the storage water was occurring by radiation rather than by the intended conduction.

Three methods were proposed to reestablish the thermal and mechanical bond between the riser tubes and the absorber plate; these methods are illustrated in Figures 1, 2, and 3.

A test array of six collector panels was set up to evaluate the relative thermal performances of the refurbished alternatives. Three of the six test panels involved existing collectors which were refurbished according to the illustrations of Figures 1, 2 and 3. In addition, the performances of two "used" panels (representative of the damaged array) and an original "new" panel were also monitored. Temperature sensors were placed at three locations on each test panel (collector inlet, collector outlet, and the center of the absorber

Figure 1. Repair Prototype No. 1

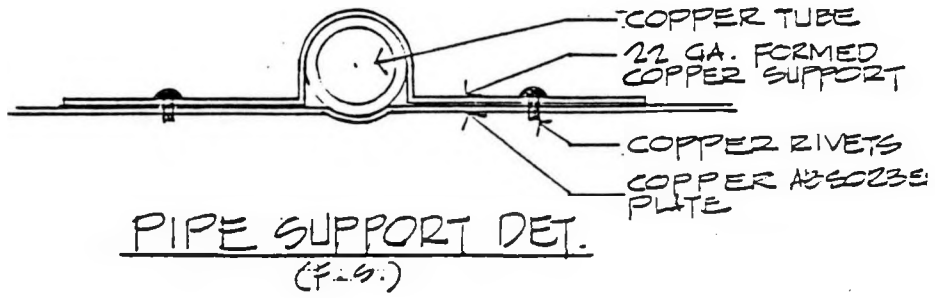
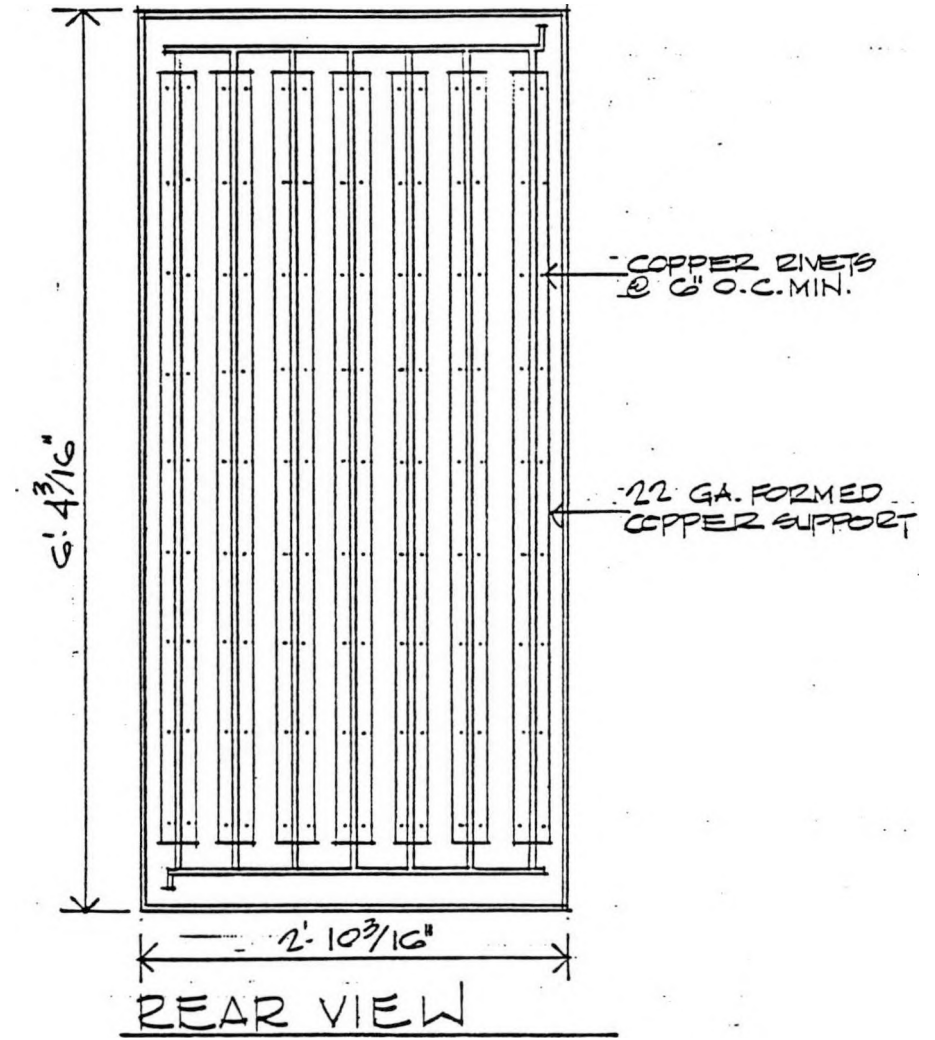


Figure 2. Repair Prototype No. 2

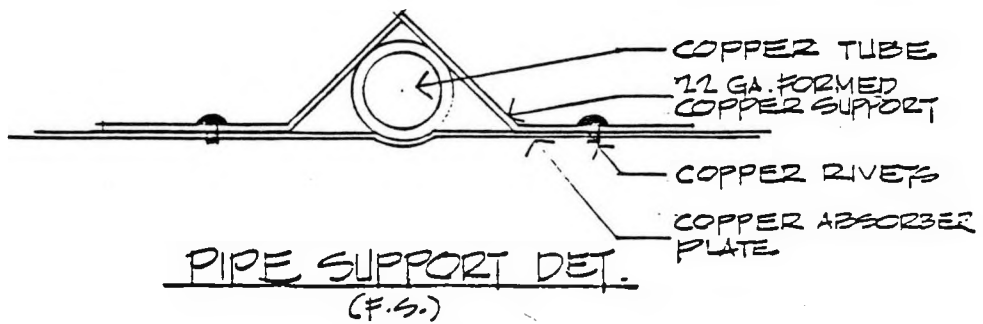
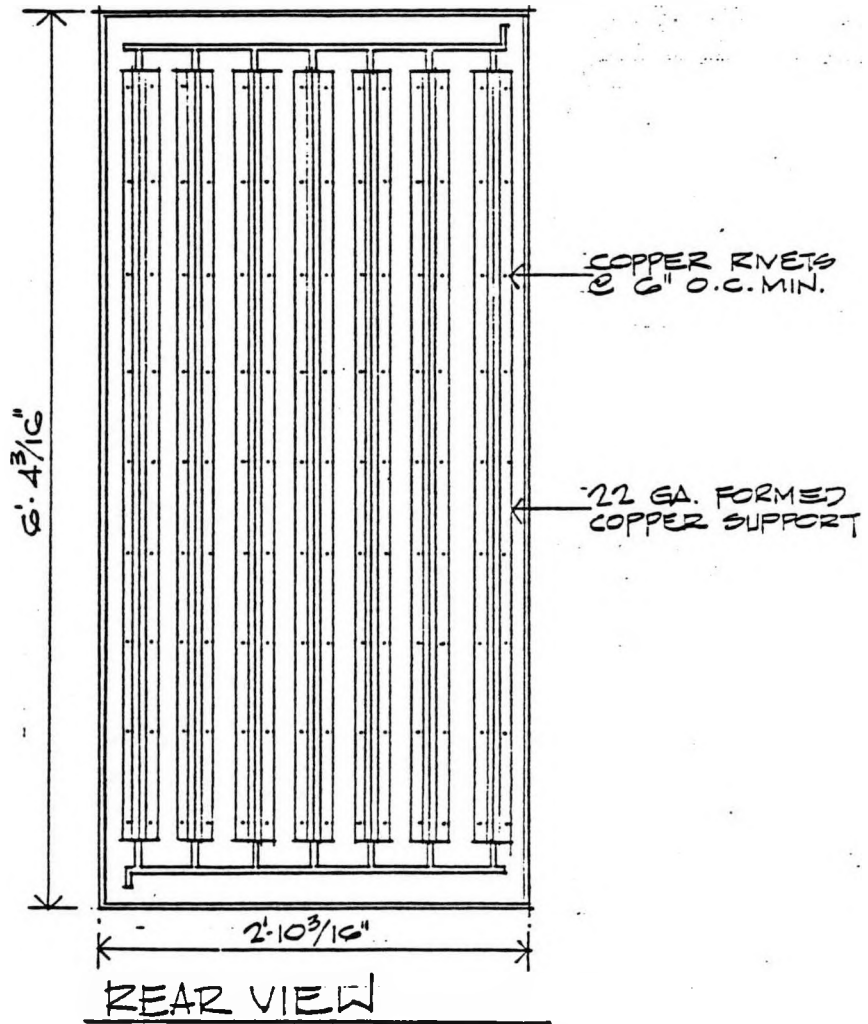
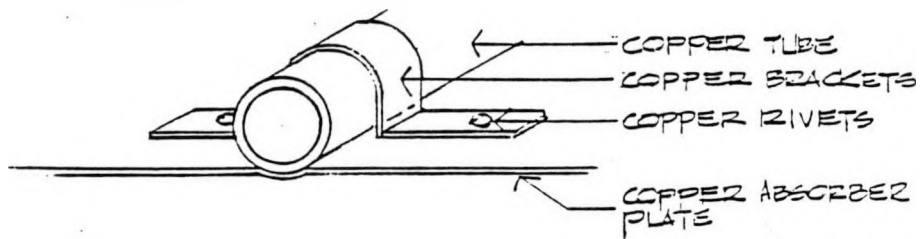
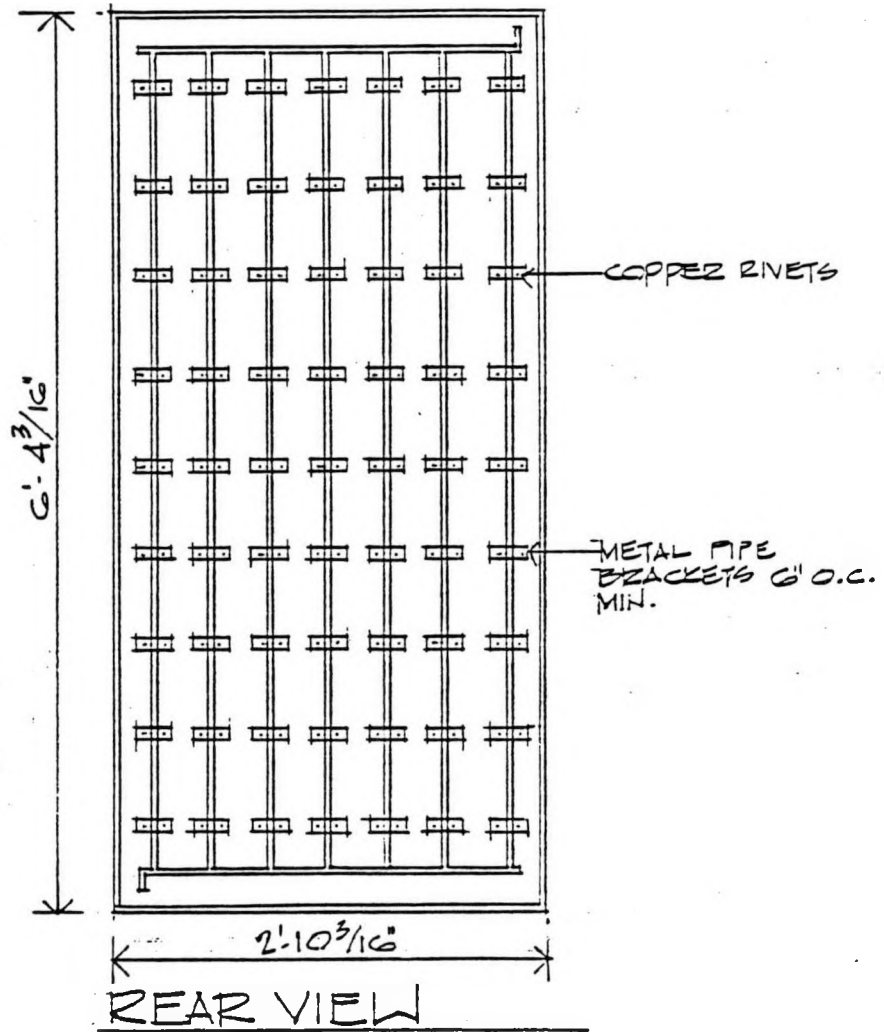


Figure 3. Repair Prototype No. 3



PIPE SUPPORT DET
(E.F.S.)

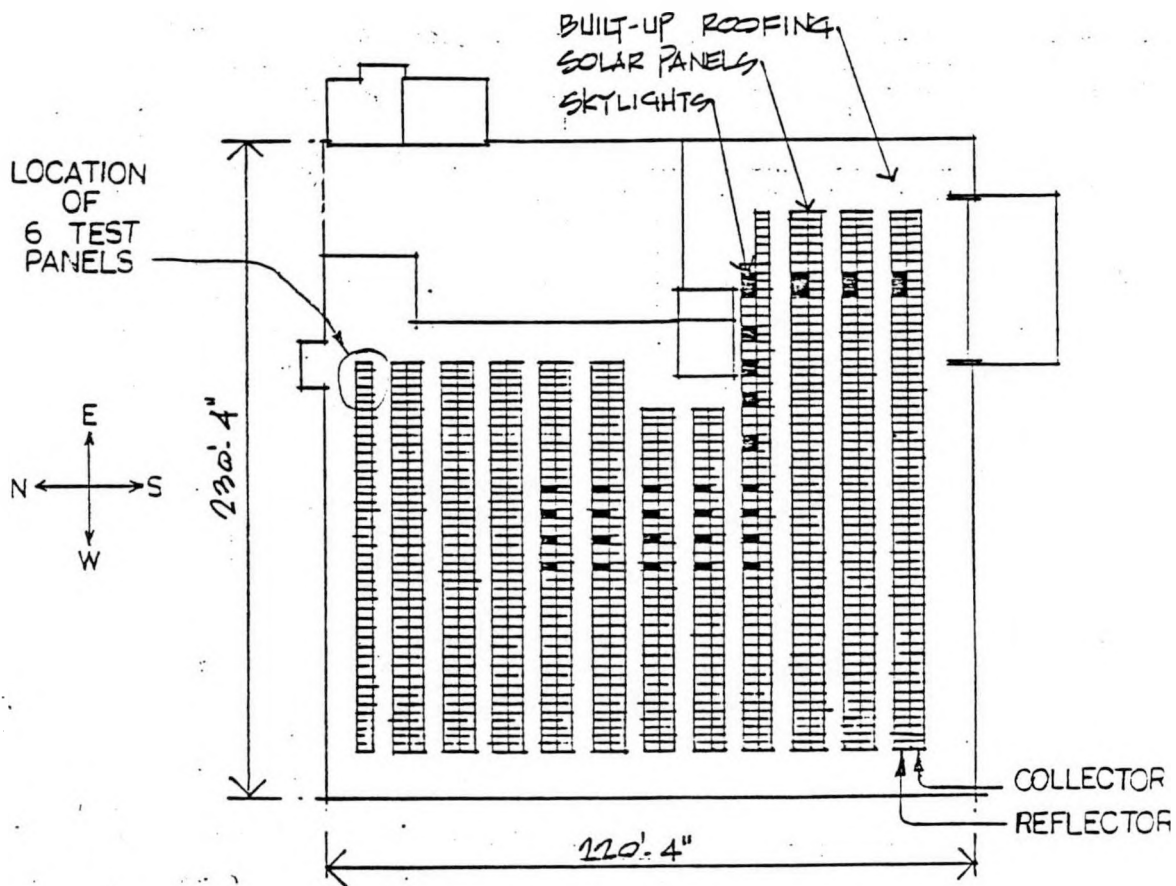
plate) to quantitatively measure the effects of the reestablished riser tube to absorber plate bond. Temperature data on the test panels was recorded for three separate days of testing; a single day under normal flow conditions, and two days under stagnation conditions.

The performance of six different panels was considered. In addition to the three refurbished panels, the performance characteristics of one unused (i.e., new) PPG collector panel and two "used" panels from the existing array were also instrumented for comparative testing purposes. The six test panels were installed into the eastern end of the twelfth row (47 panels, total) as shown in Figure 5.

Temperature sensors (Type K thermocouples) were placed on the inlet and outlet piping of each panel (see Figures 6 and 7) and on the center of each panel's absorber plate (see Figure 8). In addition, the intensity of the solar radiation striking the collector plane was monitored. Figure 9 shows the actual test assembly before installation of the test panels. Figure 10 illustrates the relative location of the six panels, in addition to the temperature sensor locations on each panel.

On June 8, 1982, D. Gearhart of ETEC arrived at the site to conduct the performance testing on the retrofit candidates. Testing on the six panels was accomplished on June 9, 14, and 15, 1982. Testing on the 9th involved normal array flow conditions; stagnation testing was performed on the 14th and 15th. A summary of the data taken during testing on the 9th, 14th, and 15th is listed in Tables 1, 2, and 3, respectively. The thermocouple switch positions in Tables 1-3 correspond to the temperature sensor locations shown in Figure 10. The variation in incident global radiation on June 9 is shown in Figure 11. The temperature rise experienced across each of the six test collectors throughout this day is shown in Figure 12. It can be seen that each of the three refurbished collector prototypes produced significantly

Figure 5. Roof Plan



EXISTING DESIGN DATA

TOTAL AREA (SINGLE FLOOR)	52,600 #
ROOF AREA COVERED WITH REFLECTORS AND COLLECTORS	18,457 #
SOLAR COLLECTOR AREA	10,943 #
SOLAR REFLECTOR AREA	10,775 #
REFLECTOR/SKYLIGHT AREA	813 #

Figure 6. Collector Inlet Sensor

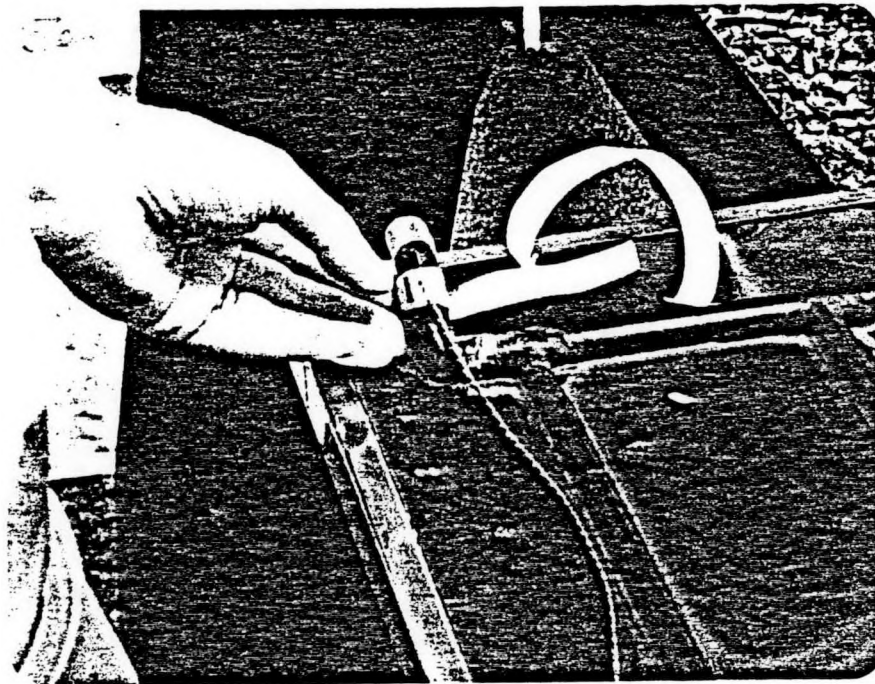


Figure 7. Collector Outlet Sensor



Figure 8. Absorber Plate Sensor

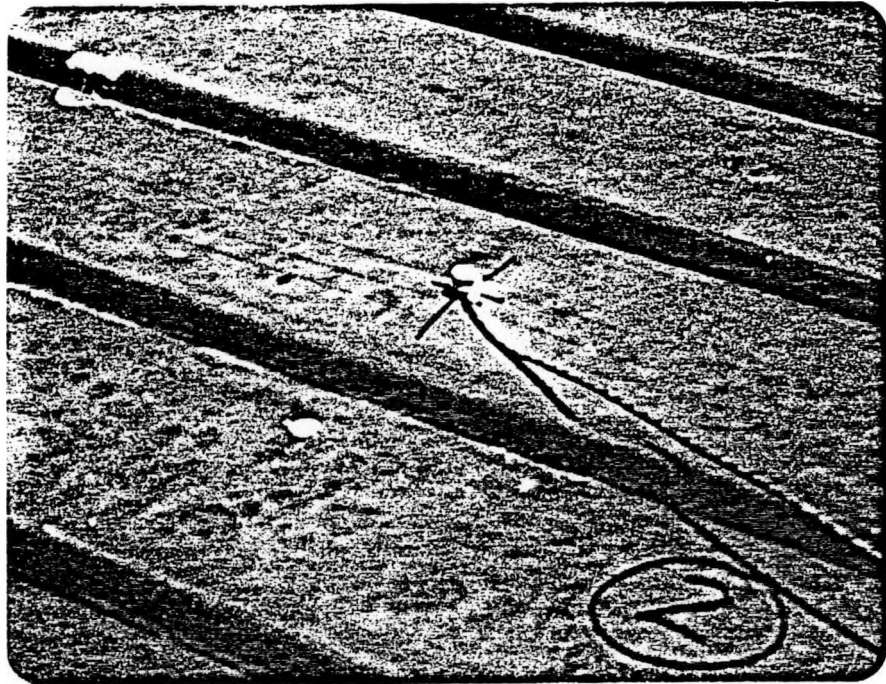


Figure 9. Collector Test Assembly

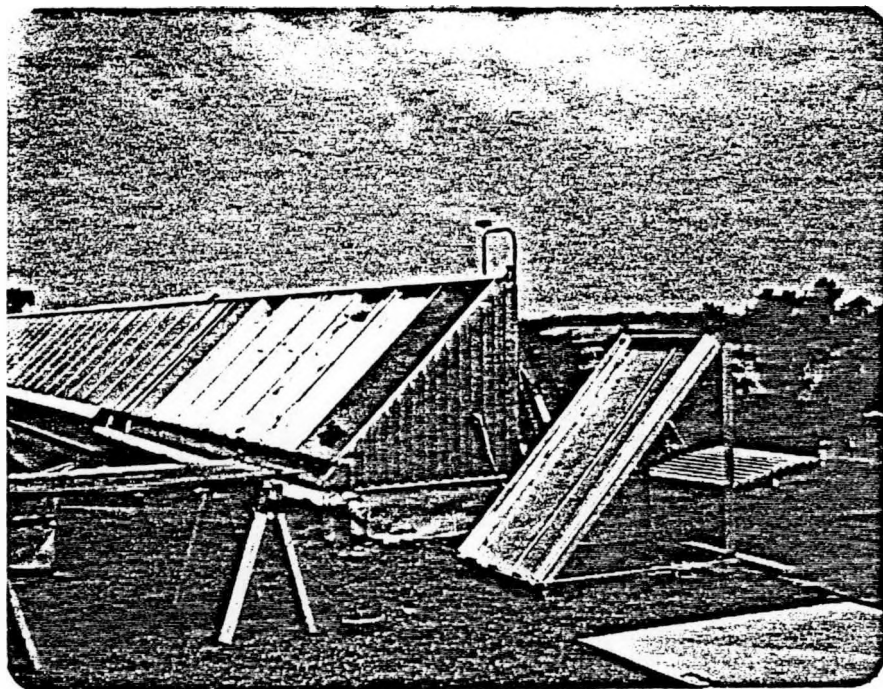
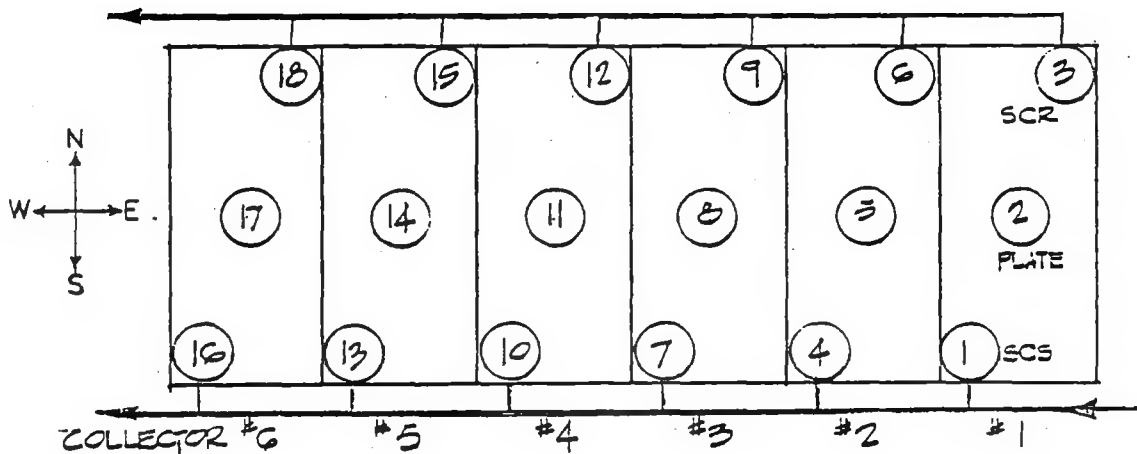





Figure 10. Test Schematic

THERMOCOUPLE LOCATION & CORRESPONDING SELECTOR SWITCH NUMBER -
FRONT VIEW OF ROW 12, END CLOSEST TO MECHANICAL ROOM.



- #1. NEW UNEXPOSED COLLECTOR
- #2. REPAIR PROTOTYPE No. 1 
- #3. REPAIR PROTOTYPE No. 2 
- #4. REPAIR PROTOTYPE No. 3  (STRAP)
- #5. EXISTING ORIGINAL COLLECTOR *
- #6. EXISTING ORIGINAL COLLECTOR **

THERMOCOUPLE TYPE:

- A. 5TC-GG-K-20-36-SMP-K-M
K = CROMEL (+) A = ALUMEL (-) SCS = 1, 4, 7, 10, 13, 16.
SCR = 3, 6, 9, 12, 15, 18.
- B. WTK-10-M-12
K = CROMEL (+) A = ALUMEL (-) PLATE = 2, 5, 8, 11, 14, 17.

* APPROXIMATELY 50% OF THE COLLECTOR TUBES WERE ATTACHED

** LESS THAN 20% OF THE COLLECTOR TUBES WERE ATTACHED

Figure 11. Incident Solar Radiation (6/9/82)

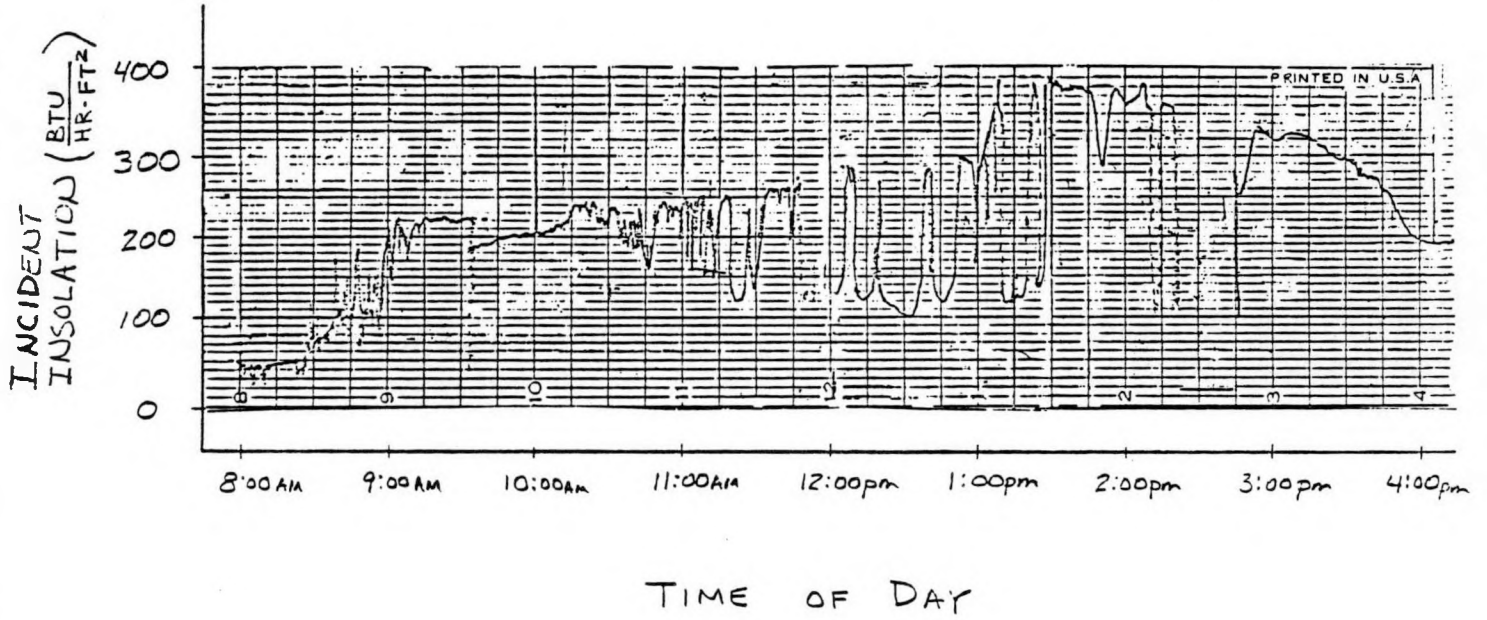








Table 1. Collector Data (6/9/82)

		TIME OF DAY												
		6:00	7:00	8:00	10:00	10:30	11:00	11:30	12:00	1:00/1:40	3:00	3:30	3:50	
	Switch Position # 1				170	168	168	169	170	172	173	178	180	181
1	NEW 2				181	181	183	177	175	197	199	197	195	191
	3				175	176	177	172	172	180	190	190	188	186
	4				172	169	169	169	171	172	173	178	180	181
2	 5				194	203	208	200	188	233	239	230	224	212
	6				175	176	177	175	174	180	187	189	188	187
	7				172	171	169	169	171	174	173	178	180	181
3	 8				200	219	237	220	224	248	258	244	234	219
	9				176	177	179	177	178	182	189	190	189	187
	10				172	169	169	169	171	172	173	178	180	181
4	 1/2 strap pipe clamp 11				222	239	250	240	232	249	273	257	249	229
	12				178	178	180	179	179	180	189	169	188	187
	13				172	169	169	169	171	172	173	178	180	181
5	BETTER OLD 14				217	230	242	239	213	246	268	251	239	221
	15				175	174	176	177	175	176	183	185	185	185
	16				171	169	170	170	171	172	174	178	180	181
6	WORSE OLD 17				253	276	292	290	247	302	327	306	289	259
	18				174	172	173	174	174	175	180	163	164	164
	Ambient Temperature °F.				80	80	80	80	Varyg		85			
Cloud Cover %	100%	100%	100%	Clear	Clear	← VARYING CLOUD COVER →					Clear	Clear	Clear	
Incident Insolation (BTU/Hr. - Ft ²)	-	-	-	200	220	200	200	193	300	380	325	290	190	
Rain	None-----													
Solar System *	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	
Solar Collector System	Off	Off	Off	On	-----	-----	-----	-----	-----	-----	-----	-----	-----	

Date: 6/9/82




*Heat to Building Heat/Cooling

Table 2. Collector Data (6/14/82)

		TIME OF DAY										
		6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00
	Switch Position # 1					167	165	169	172	cov.	179	
1	NEW	2				182	182	188	201	cov.	198	
		3				175	175	181	190	cov.	190	
		4				169	167	170	174	202	180	
2		5				200	206	219	247	272	228	
		6				174	175	180	189	223	190	
3		8				207	247	240	271	290	241	
		9				174	177	180	190	223	190	
		10				169	167	170	174	208	180	
4	 1/2 strap pipe clamp	11				220	262	279	286	310	255	
		12				175	179	185	190	225	190	
5		13				169	167	170	174	210	180	
	BETTER OLD	14				206	255	282	284	316	246	
		15				172	175	177	184	226	186	
6		16				169	168	172	176	214	180	
	WORSE OLD	17				236	311	343	353	375	301	
		18				170	172	174	181	223	185	
Ambient Temperature OUTSIDE						70	72	75	75	80	80	
Cloud Cover %						50%	30%	40%	40%	30%	40%	
Clear						50%	70%	60%	60%	70%	60%	
Rain												
Solar System ON Supply												
Solar System OFF Supply						X	X	X	X	X	X	

Date: 6/14/82

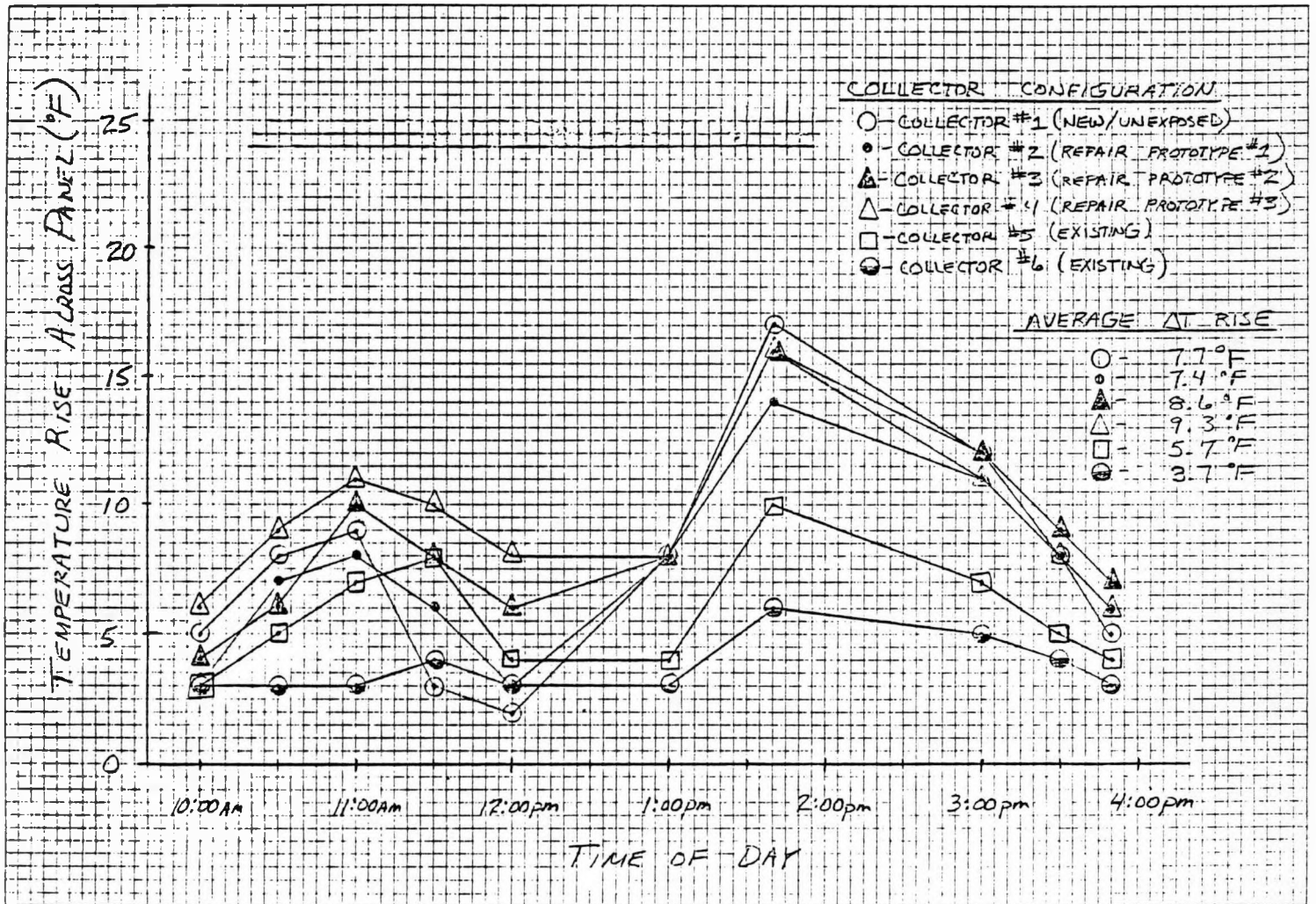
Table 3. Collector Data (6/15/82)

		TIME OF DAY										
		6:00	7:00	8:00	9:45	10:00	11:00	12:00	1:00	2:00	3:00	4:00
	Switch Position # 1				177	179	180	183	185	191	194	
1	NEW	2			182	192	195	200	213	215	212	
		3			178	185	188	194	202	207	205	
		4			179	180	180	184	187	192	195	
		5			201	209	217	249	254	253	239	
2		6			180	185	188	196	202	205	204	
		7			179	180	180	184	187	192	195	
3		8			209	220	255	270	274	270	251	
		9			180	186	190	198	203	207	204	
		10			180	180	180	184	187	192	194	
4	1/2 strap pipe clamp 	11			220	240	268	285	288	280	265	
		12			183	188	192	198	203	206	205	
		13			180	180	180	184	187	192	195	
5	BETTER OLD	14			230	238	259	281	285	270	257	
		15			183	185	187	193	197	210	200	
		16			180	181	182	186	190	194	195	
6	WORSE OLD	17			266	280	312	342	346	302	300	
		18			182	184	185	190	194	197	199	
Ambient Temperature					70	72	76	78	80	82	84	
Cloud Cover %					0%	0%	0%	0%	0%	30%	35%	
Clear					100%	100%	100%	100%	100%	70%	65%	
Rain												
Solar System ON Supply												
Solar System OFF Supply					X	X	X	X	X	X	X	

Date: 6/15/82

WATER IN TANK 184°F AT START,
200°F AT THE END OF THE DAY

Figure 12. Collector Performance (6/9/82)



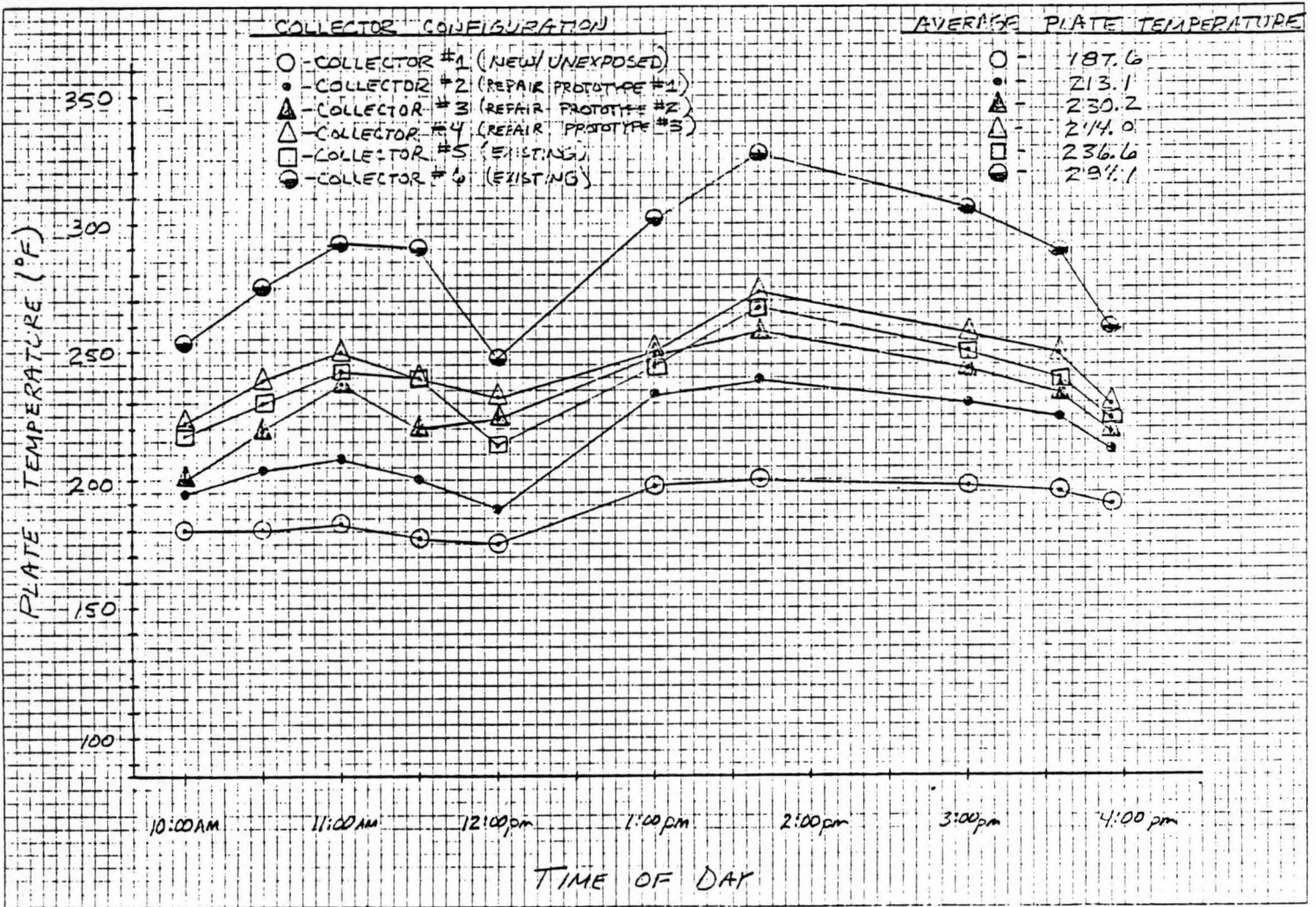
higher fluid temperature increases than the existing collector plates. Collector No. 4 (repair prototype No. 3) showed the greatest average fluid temperature rise for the day at 9.3°F. Collector No. 3 (repair prototype No. 2) had the second highest temperature rise at 8.6°F, followed by collector No. 1 (new/exposed) at 7.7°F, collector No. 2 at 7.4°F, and collector Nos. 5 and 7 at 5.7°F and 3.7°F, respectively.

The absorber plate temperatures of each collector for June 9 are plotted in Figure 13. It can be seen from Figure 13 that collector No. 1 maintained the coolest absorber plate temperature among the six test panels with an average of 187.6°F. Other average absorber plate temperatures, in increasing order, were collector Nos. 2, 3, 5, 4 and 6. Average absorber plate temperatures for these collectors were 213.1°F, 230.2°F, 236.6°F, 244.0°F, and 284.1°F, respectively. Based on absorber plate temperature, it appeared that collector panel No. 2 (repair prototype No. 1) was the most efficient of the refurbished collectors because it maintained the lowest absorber plate temperature of the three repair prototypes throughout the day.

Choosing the most viable performer on the basis of (1) highest average fluid temperature rise or (2) lowest absorber plate temperature produced conflicting results. For the refurbished collectors, the order of selection would be 4-3-2 on the basis of highest average fluid temperature rise and 2-3-4 on the basis of the lowest absorber plate temperature. Assuming equal flow to each collector in any one row, the collector with the highest fluid temperature rise should also have the lowest absorber plate temperature and, hence, the highest collector efficiency.

Because the two bases of criteria yielded directly opposite results, the possibility of imbalanced flow distribution was investigated. Using an in-flow distribution computer program and the manifold piping dimensions specified in the design, it was shown that a severe flow imbalance appeared




Figure 13. Absorber Plate Performance (6/9/82)



to exist in each of the multi-panel rows. In fact, for the 47-panel row in which the test was conducted, the predicted ratio of the maximum-to-minimum flow rates was greater than ten to one. It was suggested that major flow imbalances like that predicted by the computer model could have been the cause of the apparently random type of failure which was experienced by the collector array at Page Jackson. In fact, a similar study by an independent engineering consultant (Mueller Associates, Inc.) in July of 1979 predicted virtually identical flow imbalance tendencies for the Page Jackson collector array.

In light of the evidence for flow imbalance in the Page Jackson collector array, the previous methods discussed for evaluating the "best" of the three reworked collectors appeared inadequate. As a result, an alternative method for evaluating the relative performance of the test panels was made. Because the first of the six collectors was new and undamaged, a performance curve was available for this collector from the manufacturer. Based on this curve, the measured fluid temperature rise across the collector, the ambient air temperature, and the incident solar insolation, the efficiency of the collector was calculated. Based on this calculated efficiency and the measured parameters, the approximate flow rate through collector No. 1 was estimated. Using this flow rate and the predicted flow rate trends of the computer model, the collector efficiencies for each of the six test collectors was calculated. The results of this analysis are presented in Table 4 and indicated that the best choice among the retrofit collector alternatives was collector No. 3, with an average collector efficiency of 36.4%. Collector No. 4 was the next highest at 29.0%, followed by collector No. 2 at 14.9%. Even this method provoked somewhat skeptical results, however. The collectors with the poorest (or no) thermal bond between the absorber plate and the collector tubes (collector Nos. 5 and 6) and the highest absorber plate temperatures (see Figure 13) indicated higher efficiencies than collector No. 2, which was seen to have one of the lowest absorber plate temperatures.

Table 4. Estimated Collector Efficiencies (6/9/82)

<u>Time of Day</u>	<u>Collector #1 Efficiency</u> New	<u>Collector #2 Efficiency</u> 	<u>Collector #3 Efficiency</u> 	<u>Collector #4 Efficiency</u>  strap	<u>Collector #5 Efficiency</u> Better	<u>Collector #6 Efficiency</u> Worse	<u>Incident Insolation</u> Btu/hr-ft ²
10:00	23.3	7.7	21.3	23.0	11.7	18.0	200
10:30	33.9	16.4	29.0	31.3	17.8	16.3	220
11:00	41.9	20.6	53.2	42.1	27.4	18.0	200
11:30	14.0	15.5	42.6	38.3	31.3	23.9	200
12:00	9.6	8.0	33.1	31.8	16.2	18.6	193
1:00	24.8	13.8	28.4	20.4	10.4	12.0	300
1:40	41.7	19.0	44.8	32.3	20.6	18.9	380
3:00	34.4	17.5	39.3	25.9	16.8	18.4	325
3:30	25.7	14.2	33.0	21.1	13.5	16.5	290
3:50	24.5	16.3	39.2	24.2	16.5	18.9	190
Average Collector Efficiency	27.4	14.9	36.4	29.0	18.2	18.0	

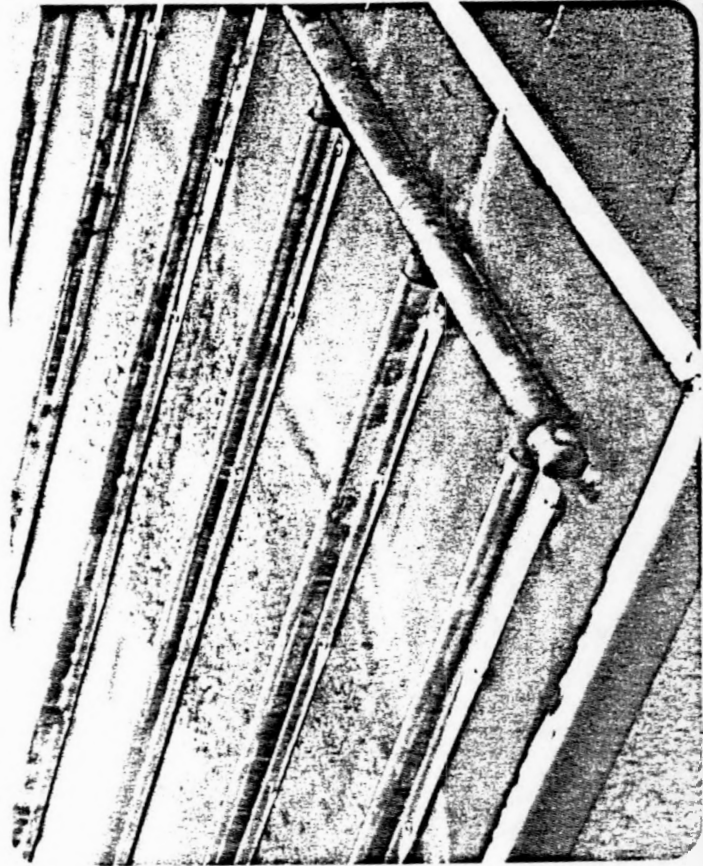
In general, however, the reattachment methods of refurbishment Nos. 1 and 2 appeared to adequately restore the metal-to-metal bond between the collector riser tubes and the absorber plate to essentially "new" conditions. Method No. 1, however, more closely followed current collector design practices, and therefore, appeared to be the better choice.

Generally speaking, flow balancing of a reverse return plumbed collector array will occur when the flow resistance through the solar collectors is large relative to the resistance of the corresponding manifold piping lines. The principal reason for the flow imbalance predicted for the Page Jackson collector array was the relatively low flow resistance through the individual collector panels. According to the manufacturer, the pressure drop through the collector piping is only 0.005 psi at the rated flow of 0.5 gpm. The flow distribution computer program predicts that if this pressure drop could be increased to 0.5 psi, the collector array would be inherently flow balanced. Calculations showed that a 0.180 in. diameter orifice in the 0.569 in. inner diameter collector outlet line would provide the 0.5 psi drop.

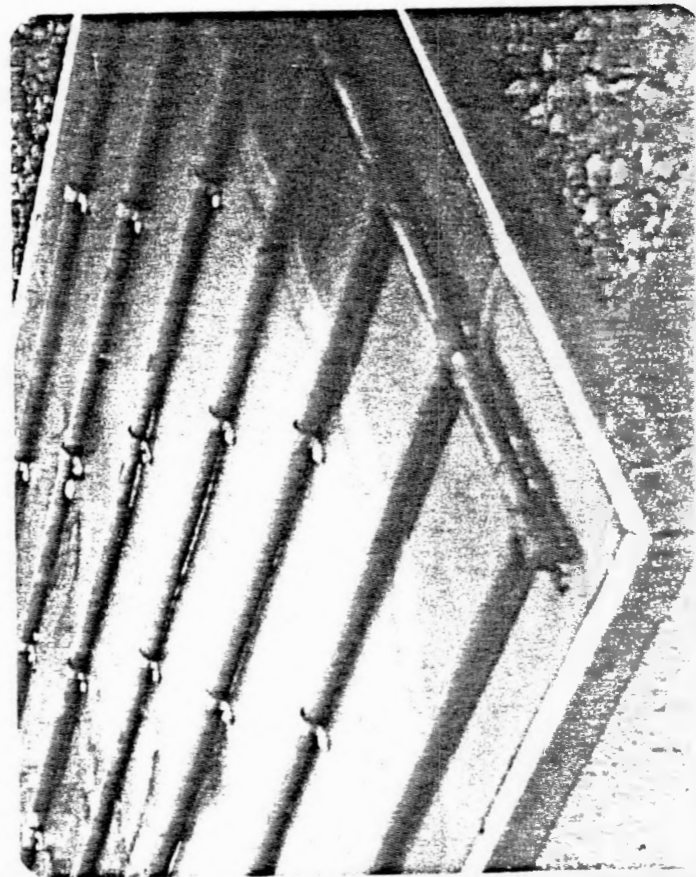
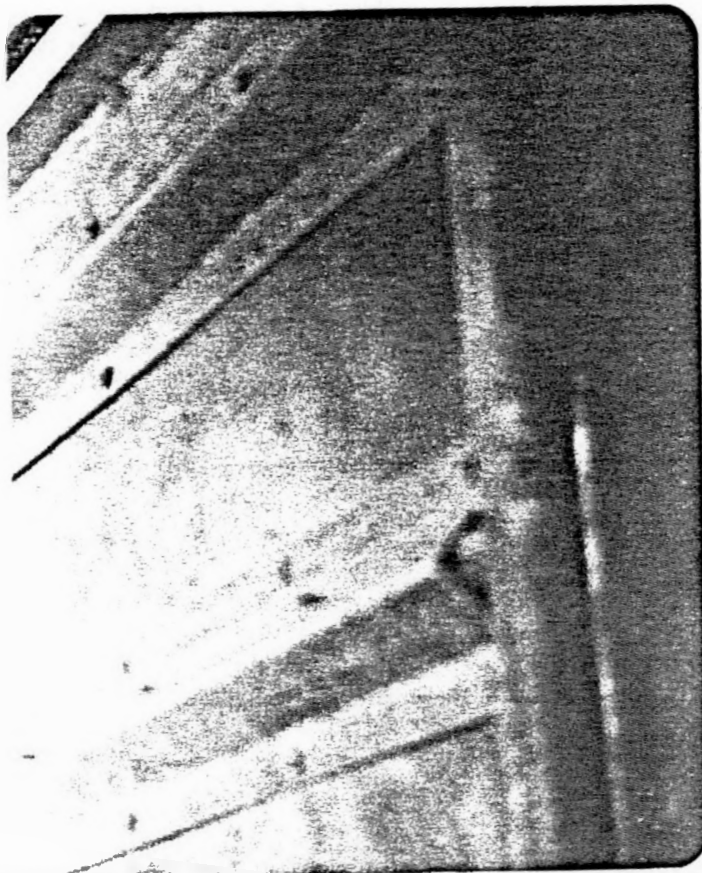
III. CONCLUSION

In general, the attachment method of refurbishment prototype No. 1 appeared to be the preferred choice for reworking the damaged collector panels. To ensure that acceptable manufacturing methods were observed in the reworking process, adequate quality control requirements were specified by the contractor. These standards met with ETEC approval prior to any renovation of the collector array.

Based on the computer program output, there appeared to be a significantly large flow imbalance within each of the twelve collector rows. This flow maldistribution could have caused the collector riser tubes to separate from the absorber plate. To ensure balanced flow within each collector row, it was recommended that the addition of a 0.180 in. diameter orifice be made to the outlet piping of each of the 620 collector assemblies. These orifices could be made by drilling 0.180-in. diameter holes into the copper end caps currently used to isolate array piping during repair periods. The addition of these orifices was highly recommended and would add minimal cost to the refurbishment project.

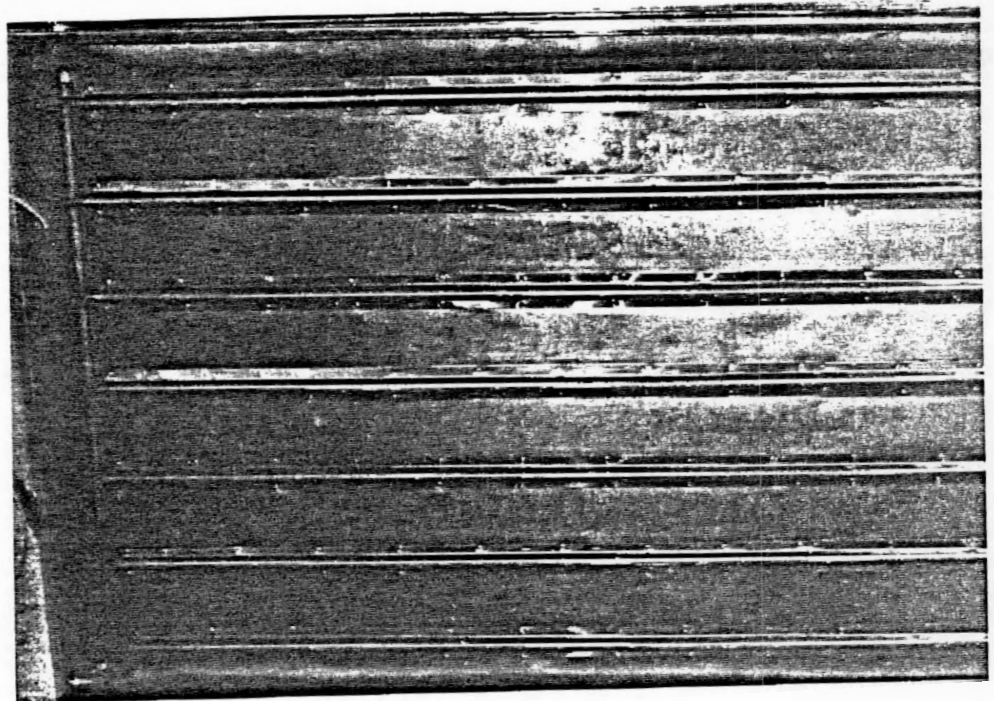


CLAMPING METHODS TESTED





CONTINUOUS COPPER CLAMP



REFURBISHED COLLECTOR

ACCEPTANCE TEST REPORT

INTRODUCTION/SUMMARY

An acceptance test of the Page Jackson Elementary School (SHAC Project #4926) was conducted during the week of December 13-18, 1982. The solar energy system for this project provides supplemental space heating and cooling for the 52,600 square foot school building.

The system has experienced many mechanical problems since its completion in the summer of 1977. Numerous leaks, collector glass breakage, and poor thermal performance became characteristic of the system during the early years of operation. Subsequent inspections of the system made it apparent that a major source of the system's poor thermal performance could be attributed to the ineffectiveness of the collector array. These inspections revealed that the riser tubes in the solar collector assemblies had separated from the absorber plates in a majority of the system's 620 collector panels. As a result, the primary mode of the heat transfer in the collector array had been occurring by radiation rather than by the intended conduction.¹ During the fall of 1982, the array was refurbished to re-establish the preferred metal-to-metal bond between the riser tubes and the absorber plate.

In general, it appears that the array refurbishment has been successful.

1. IL82-211-04-288, "Page Jackson Elementary School Solar Collector Testing and Evaluation Report", J. S. Francetiz to W. B. Ingle, 8-6-82.

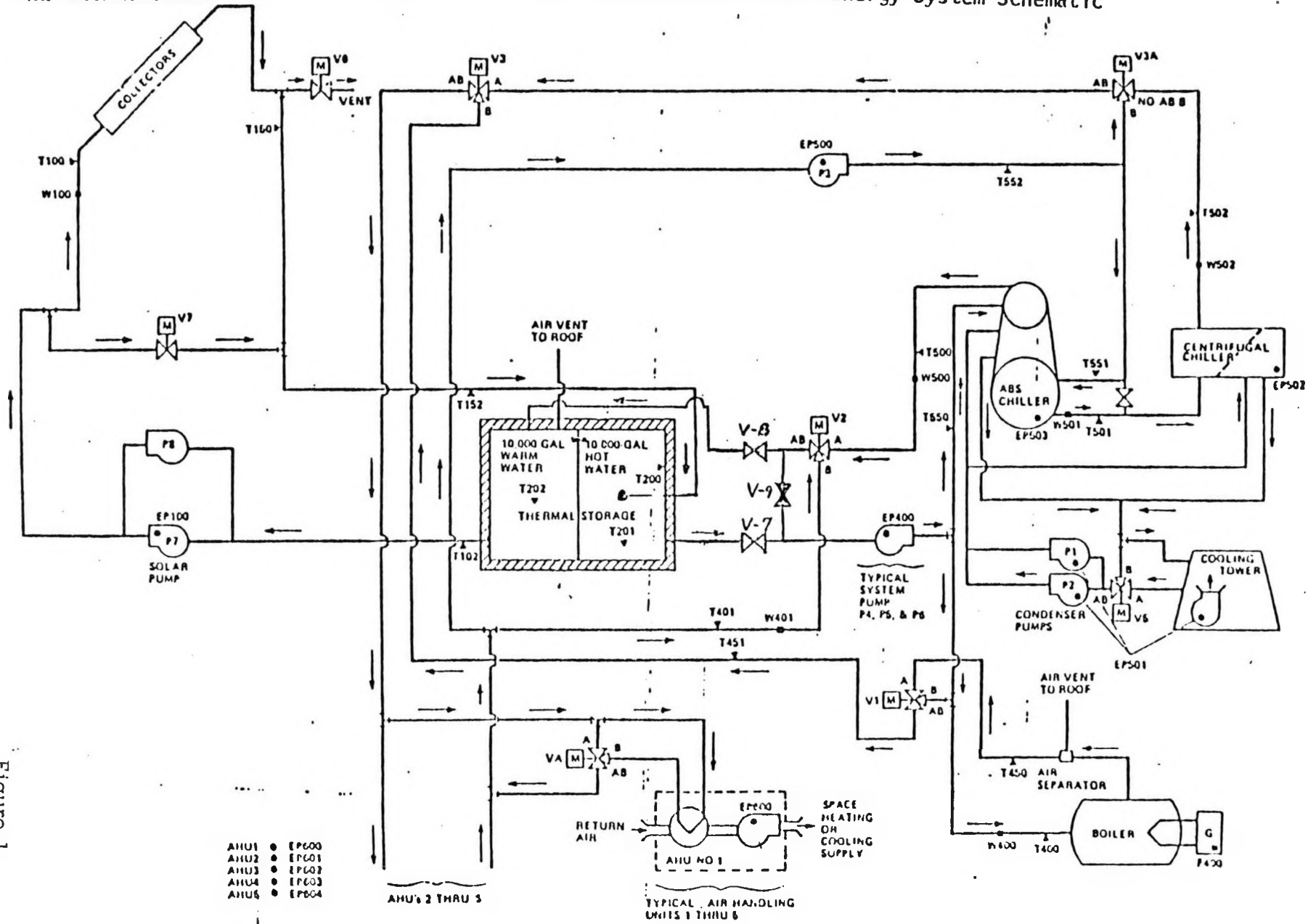
An analysis of the performance data taken on December 18, 1982, during the acceptance test (under extended steady state conditions) indicated an average collector array efficiency of 44.4%. Pre-refurbishment data indicated an operational collector array efficiency of 22% for the month of December 1978.² The day-long integrated system efficiency was calculated to be 29.2%.

In summary, the space heating subsystem appears to be in good working order. Because of low storage tank water temperatures and the potential for freezing water within portions of the condensing water cooling tower, however, the space cooling portion of the solar energy system was not tested. It is recommended that a thorough checkout of the cooling sub-system be conducted during the hot summer months to verify proper system operation.

2. "Solar Energy System Performance Evaluation, Page Jackson Elementary School, Charles Town, West Virginia, November 1978 through March 1979", SOLAR/2036-79/14, April 1979.

- ▶ T001 COLLECTOR PLANE TOTAL INSOLATION
- ▶ T001 OUTDOOR TEMPERATURE
- ▶ T600 INDOOR TEMPERATURE
- ▶ T601 INDOOR TEMPERATURE
- ▶ T602 INDOOR TEMPERATURE

Figure 1. Page Jackson School Solar Energy System Schematic



- AHU1 ● EP600
- AHU2 ● EP601
- AHU3 ● EP602
- AHU4 ● EP603
- AHU5 ● EP604

Figure 1.

DISCUSSION

System Description:

System Location: Charles Town, West Virginia

Site Latitude: 39° N.

Application: Space Heating and Space Cooling

Conditioned Area: 52,600 sq. ft.

System Type: Draindown

Collector Heat Transfer Fluid: Softened Water

Gross Collector Array Area: 10,383 sq. ft.

Reflector Area: 9215 sq. ft.

Collector Tilt: 45° from horizontal facing due south

Collector Type: Flat Plate, PPG Model A-414

Storage Volume: 20,000 gallons total capacity
17,500 gallons normal capacity

System Schematic: See Figure 1.

System Narrative:

The Page Jackson Elementary School in Charles Town, West Virginia, uses a solar energy system to provide space heating and cooling for a 52,600 sq. ft. school building. The solar energy system is designed to provide approximately 95% of the space heating and 50% of the space cooling energy requirements of the school. It has an array of 574 PPG Industries, Inc. double glazed, flat plate collectors (gross area = 10,383 sq. ft.) which face due south at a 45° tilt from the horizontal. The collectors are used in conjunction with glass mirrored reflectors (facing north at a 38° tilt from the horizontal) to collect the available solar energy.

Water is used as a medium for delivering solar energy from the collector array to storage. Freeze protection is accomplished through a drain-down system. The solar heated water is stored in two interconnected 10,000-gallon storage tanks and is used for space heating and cooling. When the solar energy is insufficient to meet the heating demands, a 780,000 Btu/hr oil-fired boiler is used to provide auxiliary hot water for heating. In the space cooling mode, the hot water from storage is supplied to a 100-ton Trane absorption chiller to generate chilled water. A conventional 120-ton Trane centrifugal chiller is used as a backup whenever solar energy is insufficient to meet the space cooling demand.

ACCEPTANCE TEST SUMMARY

ETEC representatives Jeff Francetiz and Paul Olson conducted an acceptance test of the solar space heating and cooling system at Page Jackson Elementary School in Charles Town, West Virginia, during the week of December 13-18, 1982.

The operation and performance of the solar energy system was monitored by utilizing a portable Hewlett-Packard data acquisition system (DAS) provided by ETEC. This device was connected to the existing Vitro instrumentation sensor terminals at the central junction box of the previously installed DAS. Complete listing of the sensors monitored during the acceptance test are given in Tables 1 through 4. The location of each sensor within the system is shown in Figure 1.

The performance of the solar energy system while operating on automatic in a typical space heating mode was monitored on December 18, 1982. Operational data and performance calculations on the solar energy system throughout the day was accumulated with the portable DAS. A discussion and summary of the system performance parameters on December 18 are presented here.

A thermal performance test of the solar space heating system was performed from 8:30 a.m. to 2:00 p.m. on December 18, 1982. Instantaneous insolation values for the day ranged from 100 - 275 Btu/hr-ft² under cloudless skies, while outdoor ambient temperatures ranged from 18 - 35°F. Solar noon occurred at 12:04 p.m.

Table 1. Temperature Instrumentation for Page Jackson Elementary School (IBM/VITRO)

SENSOR	NAME	RANGE (F)		MFGR.	THERMOWELL PART NO.
		Min.	Max.		
T001	Outside Ambient Air Temperature	-20	120	Minco	IS4
T100	Collector Array Inlet Temperature	30	230	Minco	F203U15
T150	Collector Array Outlet Temperature	30	230	Minco	F203U15
T102	Storage Output Temperature	30	230	Minco	F203U15
T152	Storage Inlet Temperature	30	230	Minco	F203U15
T200	Hotter Storage Tank--Top Temperature (Tank #1)	30	230	Minco	F203U15
T201	Hotter Storage Tank--Bottom Temperature (Tank #1)	30	230	Minco	F203U214
T202	Cooler Storage Tank--Middle Temperature (Tank #2)	30	230	Minco	F203U240
T400	Heating Boiler Inlet Temperature	30	230	Minco	F203U15
T450	Heating Boiler Outlet Temperature	30	230	Minco	F203U15
T401	Heating Water Return Temperature	30	230	Minco	F203U15
T451	Heating Water Supply Temperature	30	230	Minco	F203U15
T500	Absorption AC Generator Water Outlet Temperature	30	230	Minco	F203U15
T550	Absorption AC Generator Water Inlet Temperature	30	230	Minco	F203U15
T501	Absorption AC Chiller Water Outlet Temperature	-20	120	Minco	F203U15
T551	Absorption AC Chiller Water Inlet Temperature	-20	120	Minco	F203U15
T502	Centrifugal AC Chiller Outlet Temperature	-20	120	Minco	F203U15
T552	Centrifugal AC Chiller Return Water Temperature	-20	120	Minco	F203U15
T600	Inside Ambient Air Temperature	-20	120	Minco	IS4
T601	Inside Ambient Air Temperature	-20	120	Minco	IS4
T602	Inside Ambient Air Temperature	-20	120	Minco	IS4

Table 1.

Table 2. Flow Rate Instrumentation for Page Jackson Elementary School (IBM/VITRO)

SENSOR	NAME	RANGE (GPM)		MFGR.	MODEL NO
		Min.	Max.		
W100	Collector Array Flow Rate (gpm)	0	280	Ramapo	MKV-4-W07
W400	Heating Water Through Boiler Flow Rate (gpm)	0	170	Ramapo	MKV-4-W07
W401	Total Heating Water Flow Rate (gpm)	0	170	Ramapo	MKV-4-W07
W500	Absorption AC Generator Water Flow Rate (gpm)	0	170	Ramapo	MKV-4-W07
W501	Absorption AC Chiller Water Outlet Flow Rate (gpm)	0	330	Ramapo	MKV-4-W07
W502	Centrifugal Chiller Water Outlet Flow Rate (gpm)	0	330	Ramapo	MKV-4-W07
F400	Boiler Fuel Rate (gal)	0	8.5	American Meter	MKV-1/2-J07

Table 2.

Table 3. Power Instrumentation for Page Jackson Elementary School (IBM/VITRO)

SENSOR	NAME	PHASE	RANGE (kW)		MFGR.	MODEL NO
			Min.	Max.		
EP100	Collector Pump Power (P-7 & P-8)		0	12	Ohio Semitronics	PC5-18
EP400	Heating Water Pump Power (P-4, P-5, P-6)		0	18	Ohio Semitronics	PC5-27
EP500	Chilled Water Pump Power (P-3)		0	12	Ohio Semitronics	PC5-18
EP501	Cooling Tower Pump Power (P-1, P-2)		0	40	Ohio Semitronics	PC5-54
EP502	Centrifugal Chiller Power	3	0	120	Ohio Semitronics	PC5-66
EP503	Absorption Air Conditioner	3	0	6	Ohio Semitronics	PC5-9
EP600	Air Handling Unit No. 1	3	0	12	Ohio Semitronics	PC5-18
EP601	Air Handling Unit No. 2	3	0	60	Ohio Semitronics	PC5-57
EP602	Air Handling Unit No. 3	3	0	6	Ohio Semitronics	PC5-9
EP603	Air Handling Unit No. 4	3	0	60	Ohio Semitronics	PC5-57
EP604	Air Handling Unit No. 5	3	0	6	Ohio Semitronics	PC5-9

Table 4. Miscellaneous Instrumentation for Page Jackson Elementary School (ETEC's)

SENSOR	NAME	RANGE (Btu/ft ² -hr)		MFGR.	MODEL NO.
		Min.	Max		
I001* I002**	Collector Plane Total Insolation	0	396.03	Doige Products	SS-100

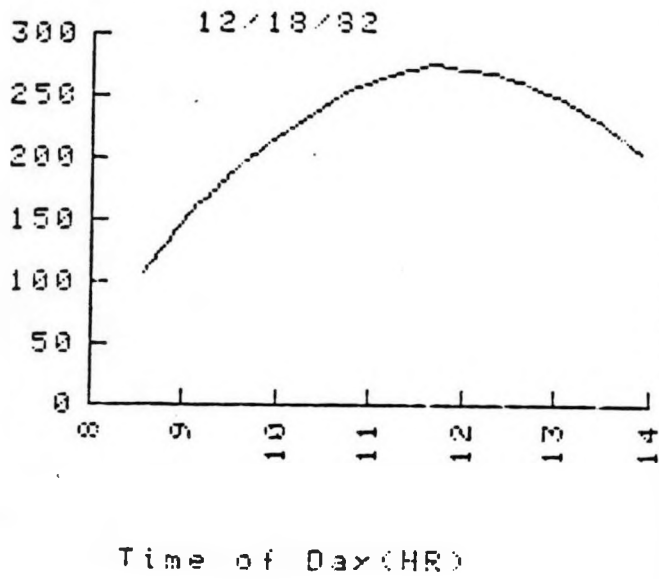
* MOUNTED ON A COLLECTOR PANEL WITH A REFLECTOR
 ** MOUNTED ON A COLLECTOR PANEL WITHOUT A REFLECTOR

Table 3. and
 Table 4.

The solar radiation intensity (as measured in the plane of the collectors) throughout the day is shown graphically in Figure 2. The average insolation for the day (from 9:08 a.m. until 2:00 p.m.) was 237.5 Btu/hr. ft². This corresponds to 1137 Btu/ft² over the same time period. Figure 3 is a plot of the solar fluid flow rate over the day, and essentially summarizes the on/off operation of the system. As it can be seen from Figure 3, system startup occurred at approximately 9:10 a.m. and continued uninterrupted until the conclusion of testing at 2:00 p.m.

Figures 4 and 5 illustrate the variation of the array inlet and outlet temperatures, respectively, throughout the day. During the period of energy collection, the average array inlet temperature was 122.7°F, while the average array outlet temperature was 130.1°F.

Of the 11.8 MTBU (1 MBTU = 10⁶ BTU) of incident energy available to the collector array, a total of 4.6 MBTU was absorbed, resulting in a day-long collector efficiency of 38.9%. Figure 6 illustrates the variation of the instantaneous collector array efficiency throughout the day. During the system performance evaluation period (11:25 a.m. to 1:55 p.m.) the average instantaneous collector efficiency was 44.4%. The variation of array efficiency during this period is shown in Figure 7. Figure 8 shows the mean collector array efficiency versus collector operating point during the system performance evaluation period (11:25 a.m. to 1:55 p.m.). These values are compared against the published collector efficiency curve based on ASHRAE 93-77 tests. Also shown are several additional efficiency curves representing the collector performance characteristics from October 1978 to



I001 (BTU/HR-SQFT) INTEGRATED AVE
 RAGE FOR THIS TIME PERIOD = 228.
 449022104

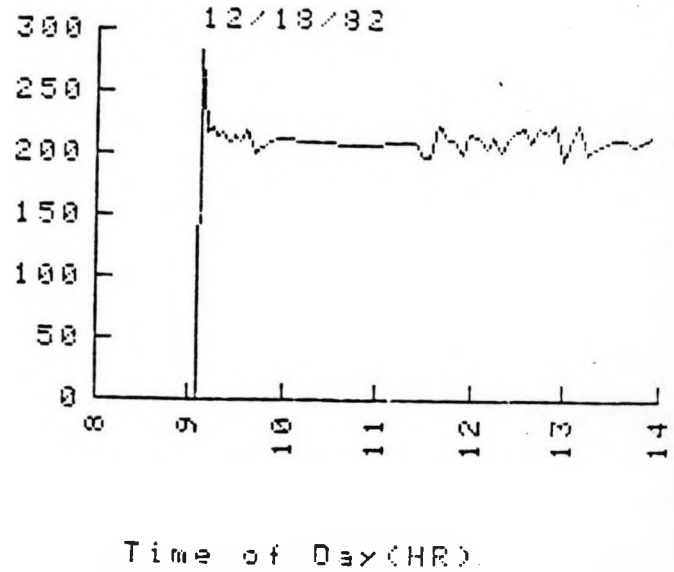
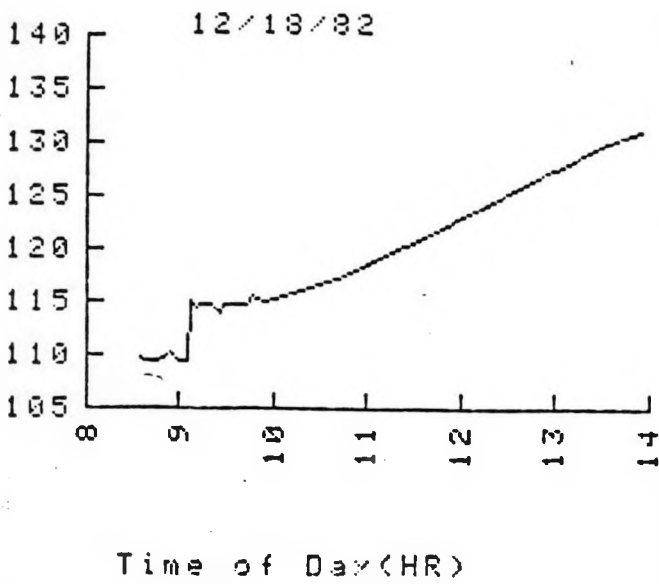


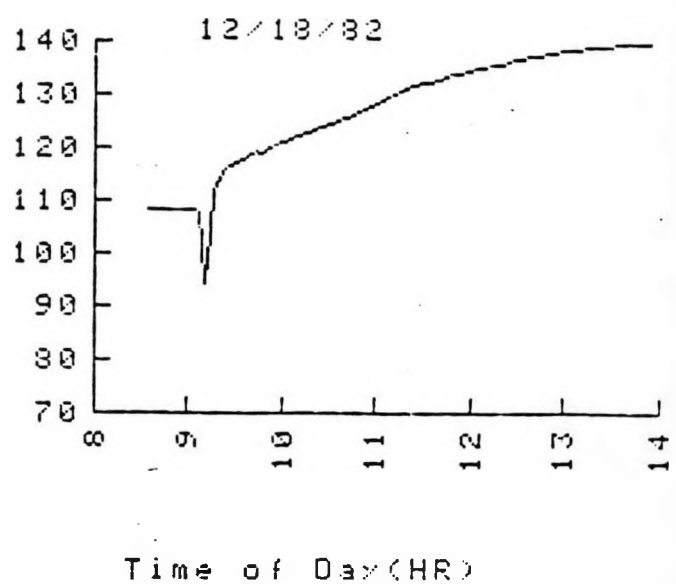
Figure 2. Incident Insolation (I001)

Figure 3. Array Flowrate (W100)



T100 (F) INTEGRATED AVERAGE FOR T
 HIS TIME PERIOD = 120.148902473

Figure 4. Array Inlet Temperature (T100)



T150 (F) INTEGRATED AVERAGE FOR T

Figure 5. Array Outlet Temperature (T150)

Figures 2, 3, 4
 and 5.

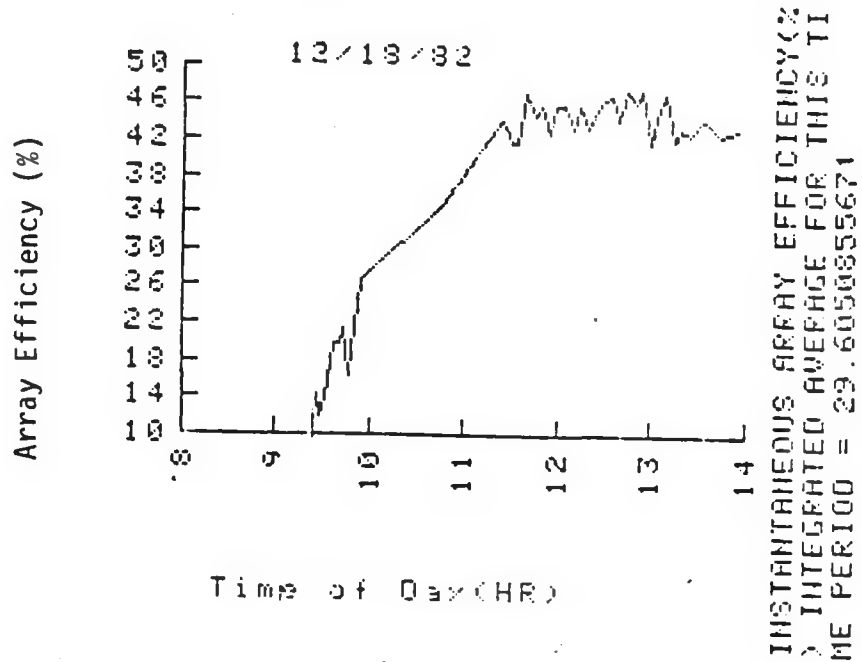


Figure 6. Instantaneous Array Efficiency

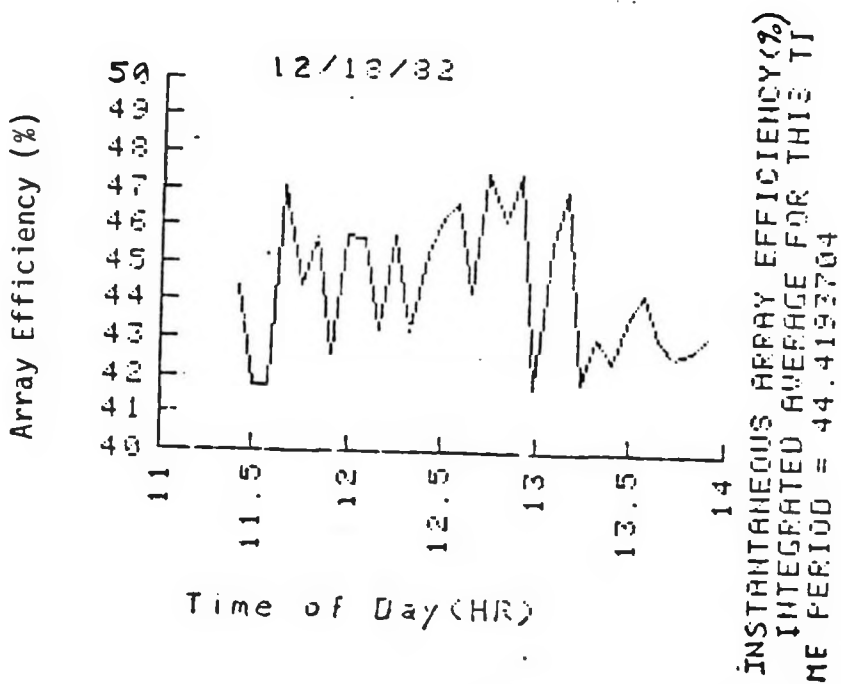


Figure 7. Instantaneous Array Efficiency

Figures 6 and 7.

April 1979. These curves allow a comparison to be made between the collector array performance before and after refurbishment. As seen in Figure 8, the collector array performance after refurbishment is approximately twice that measured before the refurbishment. In addition, the data points closely approximate the ASHRAE 93-77 curve. As a result, it appears that the collector refurbishment has successfully restored the array to optimum design conditions.

Figure 9 illustrates the variation in the flow of hot storage water to the building air handling units (AHU's). In addition, Figures 10 and 11 plot the measured supply and return water temperatures to and from the AHU's, respectively. During the period of solar energy collection, the average supply temperature to the AHU's was 130.5°F, while the average return temperature from the AHU's was 128.2°F. Over the same time period, the average flow rate to the air handling units was 120 gpm. On a daily basis, the total heating load (during the period of solar energy collection) was .66 MBTU. Figure 12 indicates the variation in the instantaneous heating load during the performance evaluation period.

Figures 13 and 14 show the variations in the upper and lower storage tank temperatures for the "hot" storage tank (tank #1) during the performance test. Figure 15 reveals the variation of the "warm" storage tank (tank #2). For the day, the average temperature of the "hot" tank was 129.2°F, while the average temperature of the "warm" tank was 124.1°F. On a day-long basis, the average storage temperature (tanks #1 and #2 combined) rose from 114.8°F at 9:08 a.m. to 137.3°F, which corresponds to a stored energy increase of 3.25 MBTU.

Figure 8. Measured Instantaneous Collector Array Performance at Page Jackson Elementary School (SHAC Project #4926), December 18, 1982.

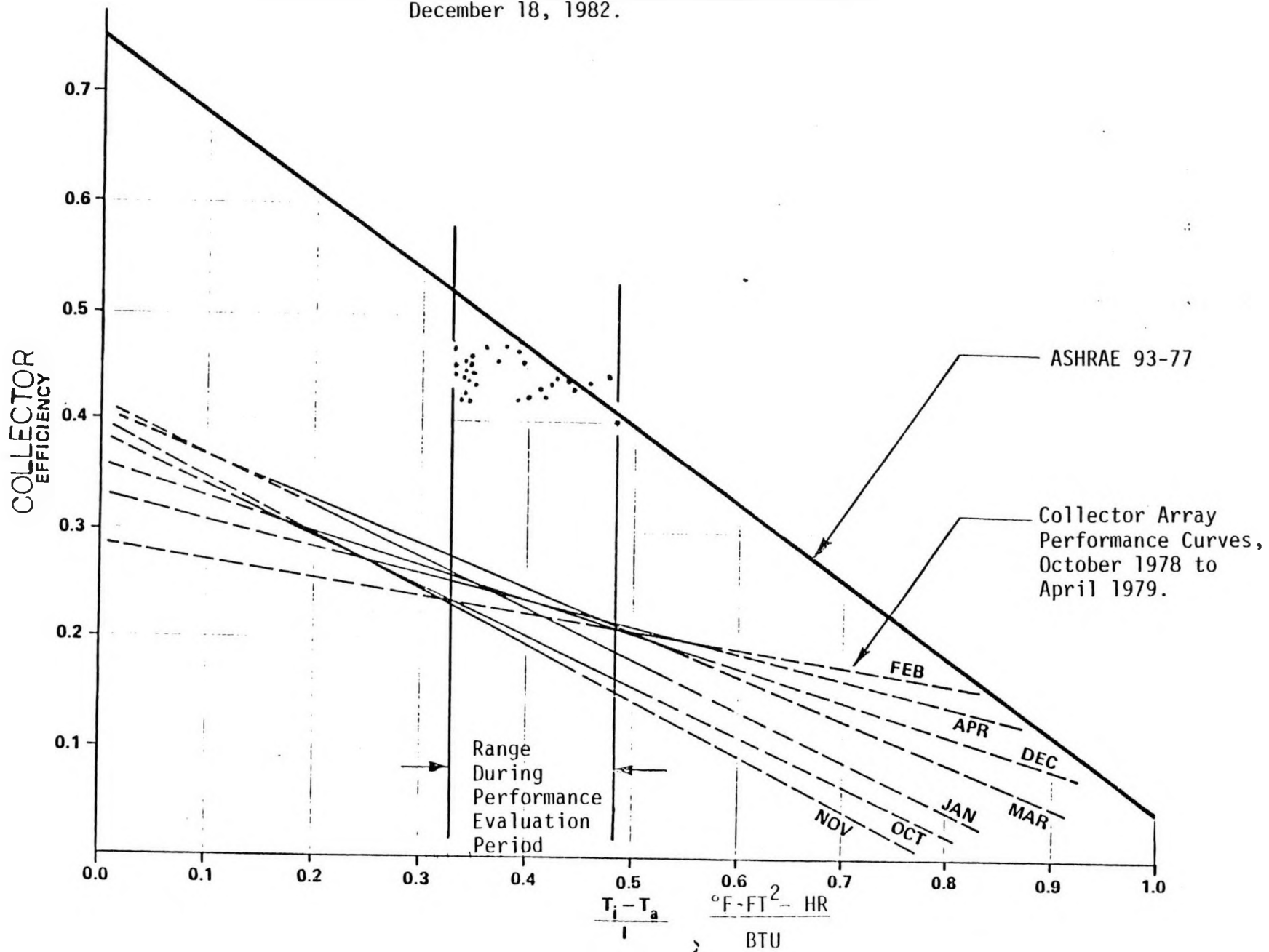


Figure 8.

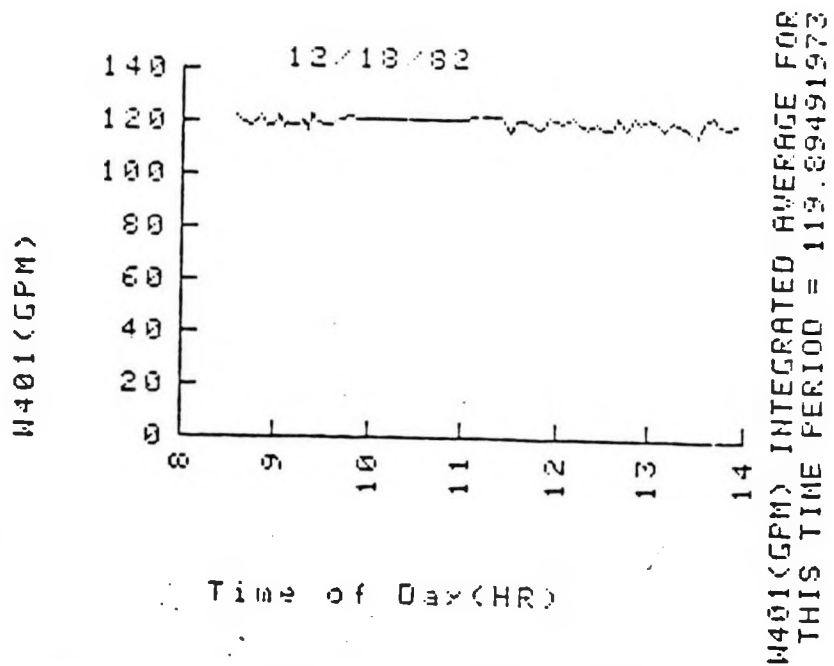


Figure 9. Heating Loop Flowrate (W401)

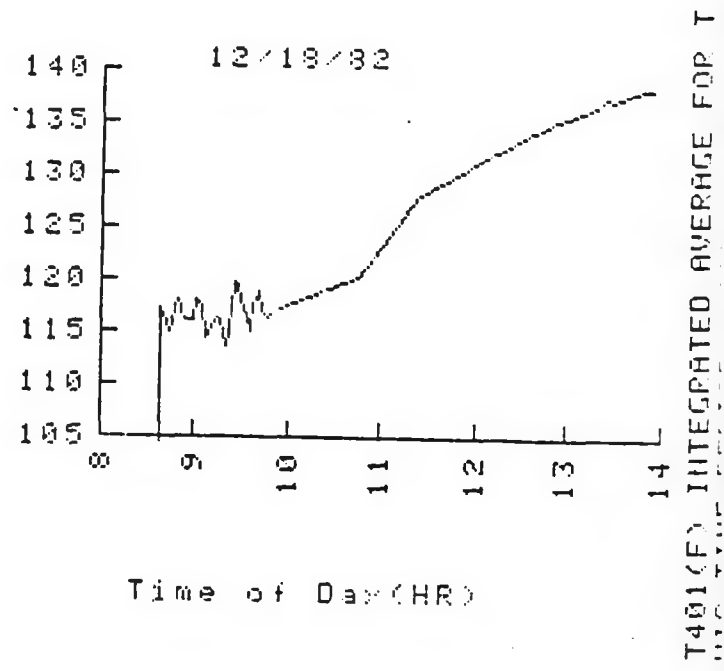
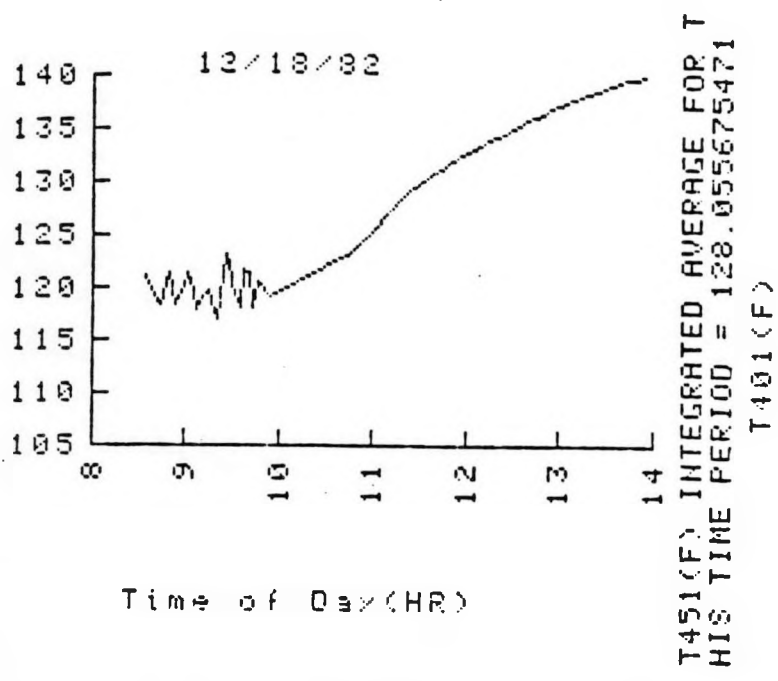


Figure 10. Heating Loop Supply Temperature (T451)

Figure 11. Heating Loop Return Temperature (T401)

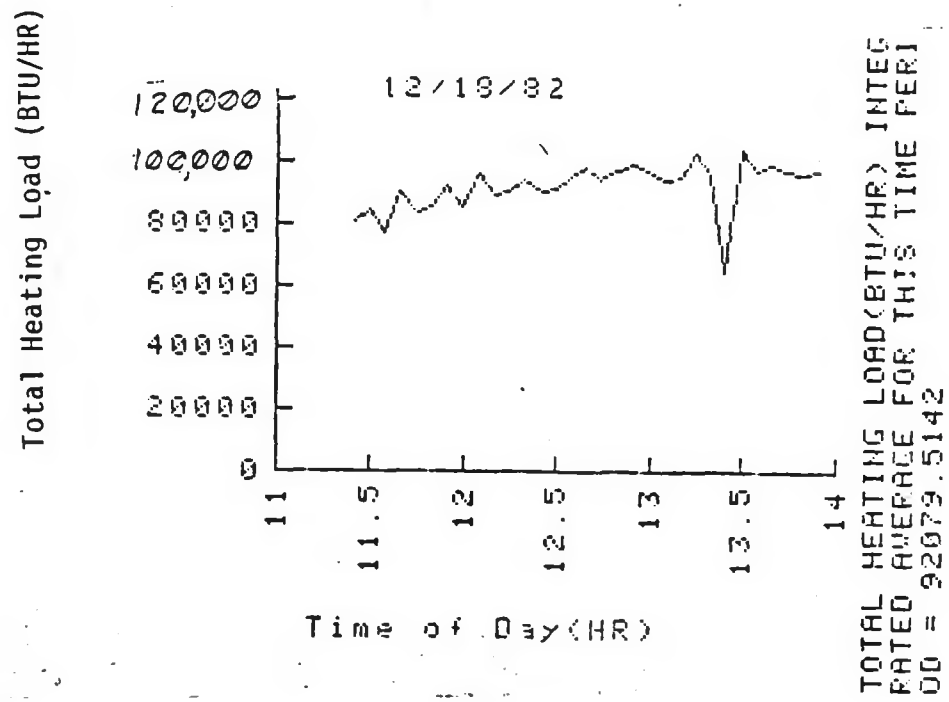


Figure 12. Total Space Heating Load

Figures 10, 11 and 12.

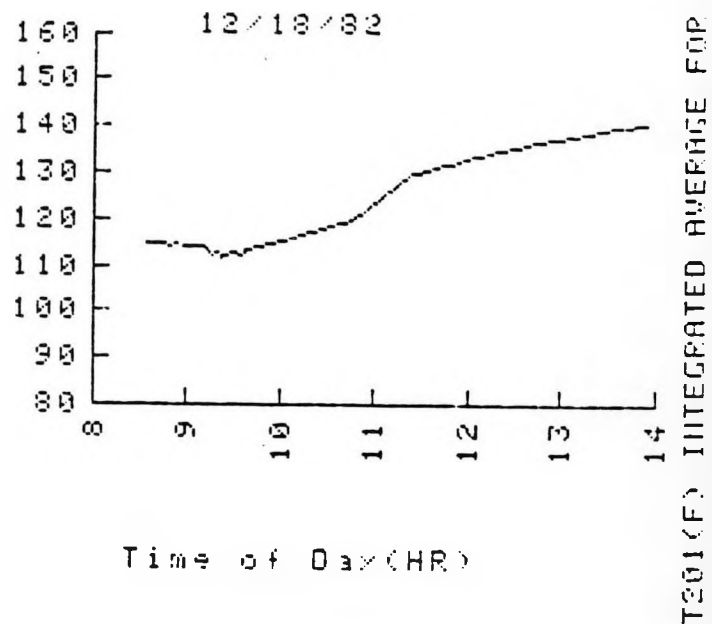
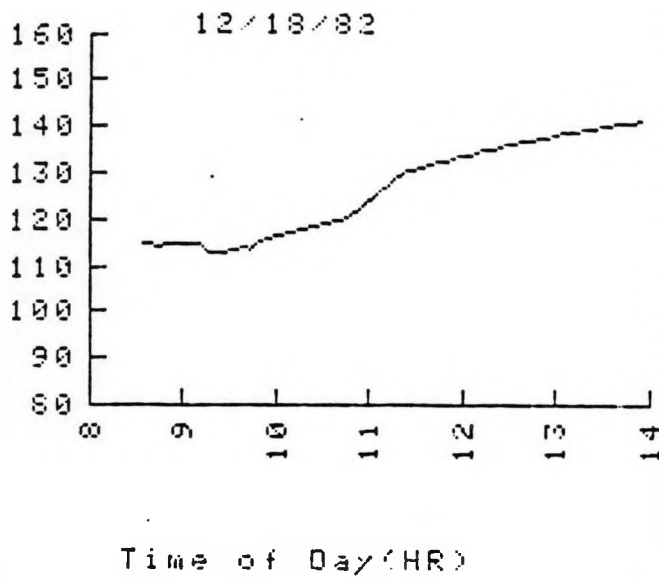


Figure 13. Storage Tank #1 Temperature (T200) Figure 14. Storage Tank #1 Temperature (T201)

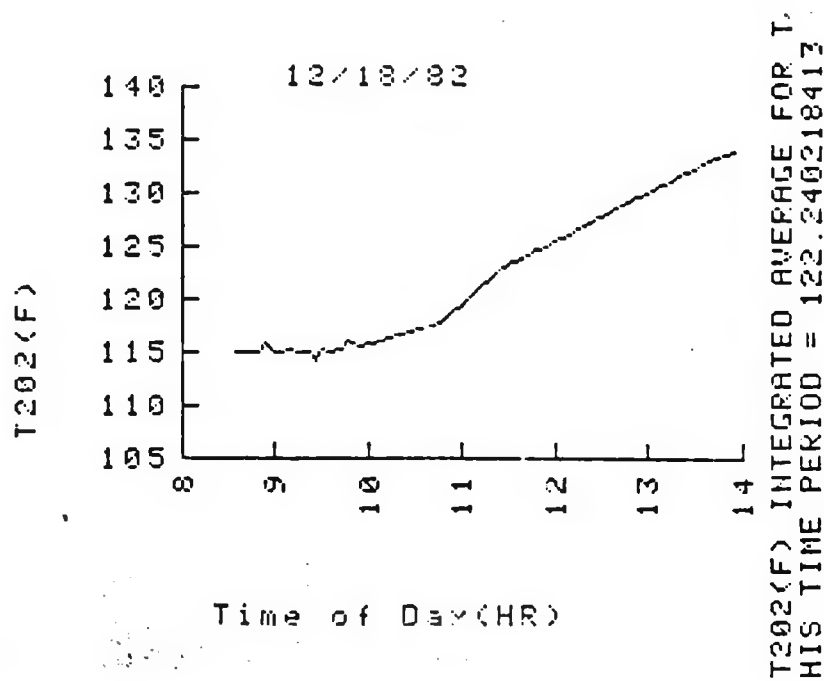


Figure 15. Storage Tank #2 Temperature (T202)

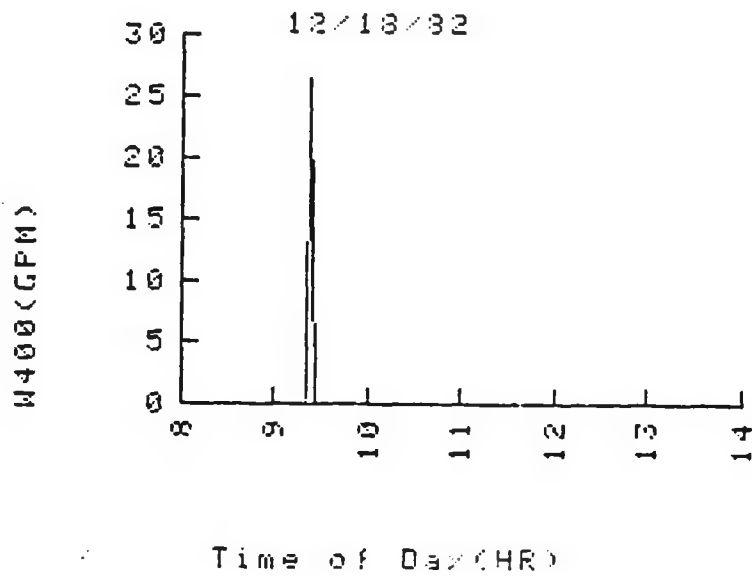
Figures 13,
14 and 15.

Essentially no auxiliary energy was consumed during the day. Figure 16 showed that the backup oil fired boiler operated only once throughout the day; this occurred at about 9:25 a.m., when the system was just starting up. A total of .03 MBTU was added to the system at this time.

Figure 17 illustrates the fluctuation in total parasitic power for the system throughout the day. The average parasitic power for the day was 14 kw. This corresponds to .23 MBTU on a daily basis.

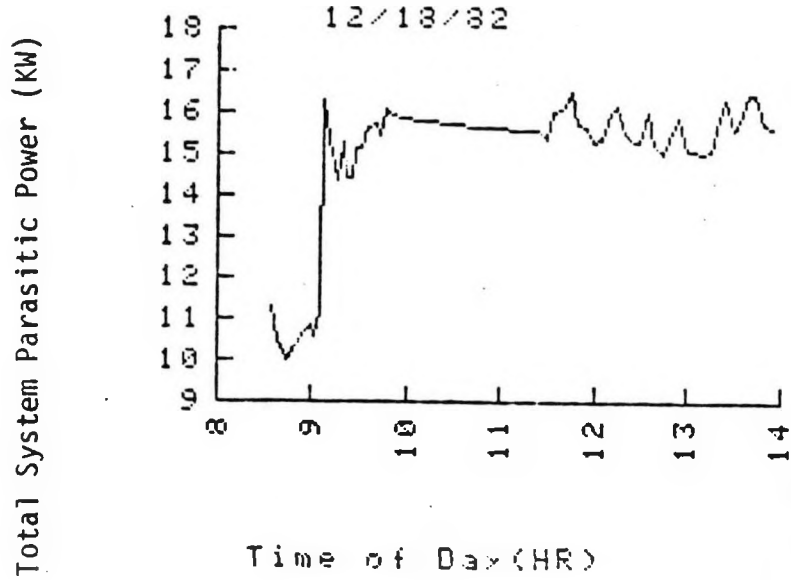
In general, the overall performance of the system was excellent. The integrated system efficiency for the day was calculated to be 29.2%.

Because of low storage tank water temperatures (i.e. less than 150°F) and the potential for freezing water in the cooling tower, the cooling portion of the solar energy system was not tested. It is recommended that additional testing be conducted during the summer months to verify the operation and performance of the solar cooling subsystem.



W400(GPM) INTEGRATED AVERAGE FOR
THIS TIME PERIOD = .24602416409
1

Figure 16. Auxiliary Boiler Flowrate (W400)



TOTAL PARASITIC POWER(KW) INTEGRATED AVERAGE FOR THIS TIME PERIOD = 15.0931499073

Figure 17. Total System Parasitic Power

Figures 16 and 17.

CONCLUSION

In general, the solar energy system and controls appear to be in good working order. The performance of the system is particularly good; in fact, much better than most. Because the refurbished collector array is now operating at near design conditions, it is anticipated that the system will begin to contribute substantially (as originally intended) to the building load. In order to ensure that the system is operating as designed while in the space cooling mode, it is recommended that the solar cooling subsystem be tested for proper operation and performance during the warmer summer months.

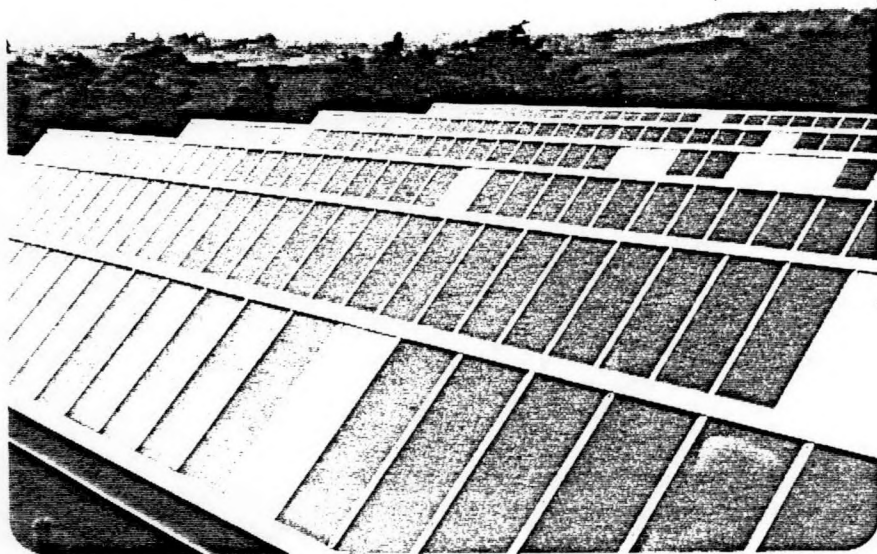
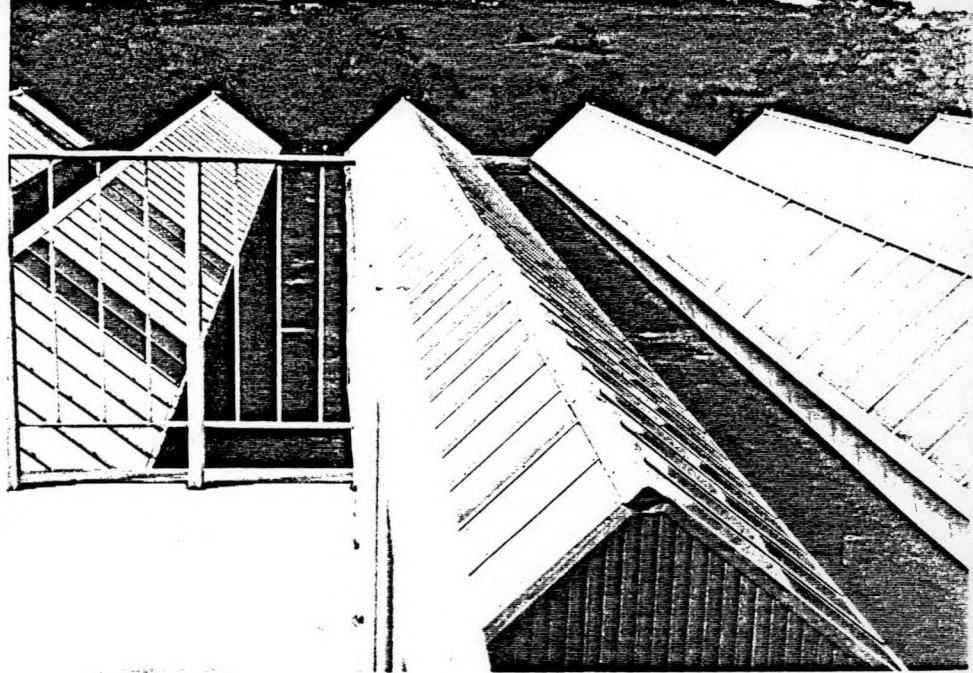
In addition to the general refurbishment of the collector array, the following changes and/or additions to the solar system have been made with the recommendations of ETEC and the Architect:

1. The time delay relay for the solar collector loop was difficult to adjust because of the wide spacing between time increments. The time difference between the successive increments was 10 minutes. This relay is normally set at 2 minutes, which made it most difficult to operate with the existing timer. Therefore, this timer was replaced by a similar unit with 1-minute time increments.
2. The cold water make-up supply line to the system was plumbed to the top of the hot storage tank (tank #1). This arrangement degraded the temperature of the water whenever make-up water was required. This line has been re-plumbed to the top of the

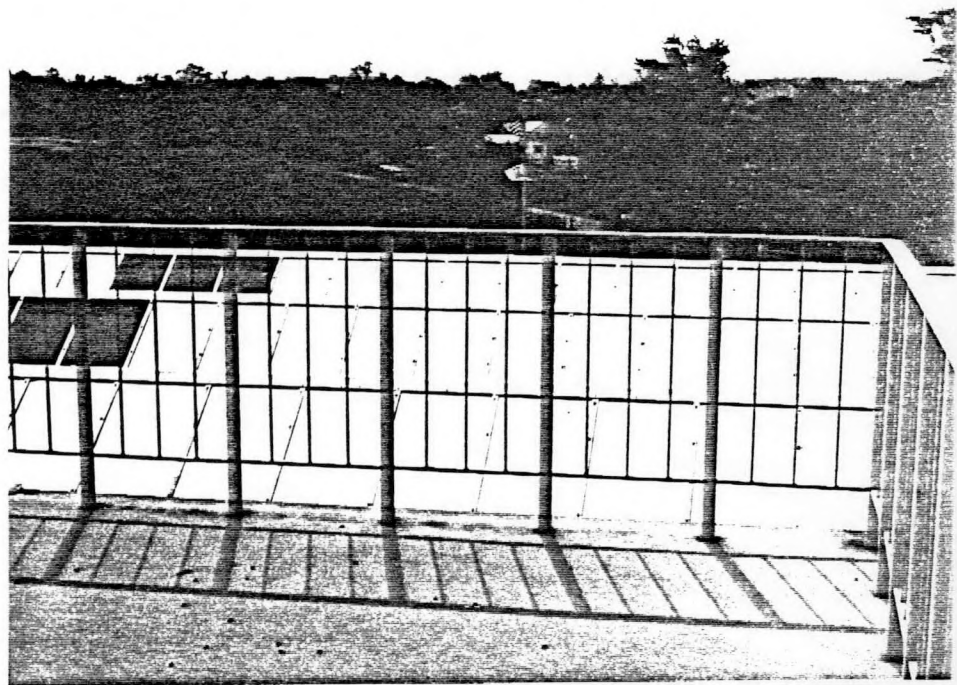
warm storage tank (tank #2).

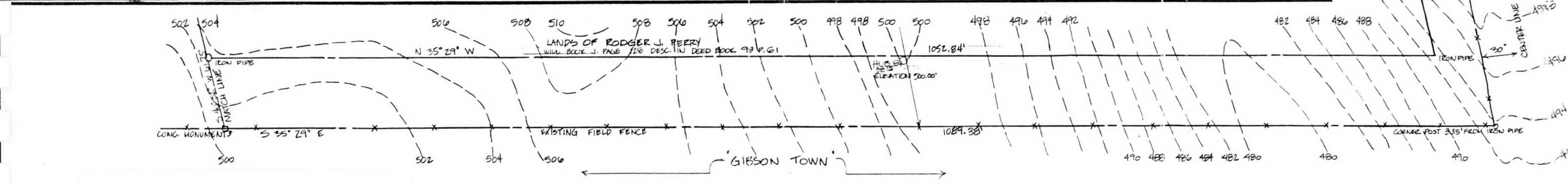
3. Based on the analysis of the test data taken during the refurbishment process, it was noted that a balanced flow did not exist in the collector array piping. It was calculated that the addition of a .180" diameter orifice to the inlet line of each collector would provide the additional flow resistance required to balance the flow distribution for each row. These orifices have been installed on each of the collector rows.
4. The collector loop circulation pump is energized whenever the temperature differential between the collector sensor and the storage sensor exceeds a specified limiting value. Upon start-up, automatic air vents located at the high points of the system will open, allowing the air within the system piping to be discharged. These vent valves are allowed to close after a specified time delay (see Item 1 above). Because the filling process tends to be uneven from row to row, a certain amount of water is discharged through these vents (to a common drain line) before the entire array has been completely vented of air. During the acceptance test, the optimum time delay for the system was found to be 2.5 minutes. When set for a 2.5 minute time delay, the minimum amount of water was discharged from the system. Based on measurements made at the vent lines of each collector row, approximately 100 gallons of water was discharged from the system. Every gallon of hot water which

is discharged from the system in this manner is replaced by an equal amount of cold make-up water, thereby representing a net energy loss to the system. In order to eliminate this loss from the system, a return line has been plumbed from the common vent discharge line to the top of the warm storage tank. This allows any discharged water to be returned to the system.



REFURBISHED COLLECTOR ARRAY
FROM OBSERVATION DECK



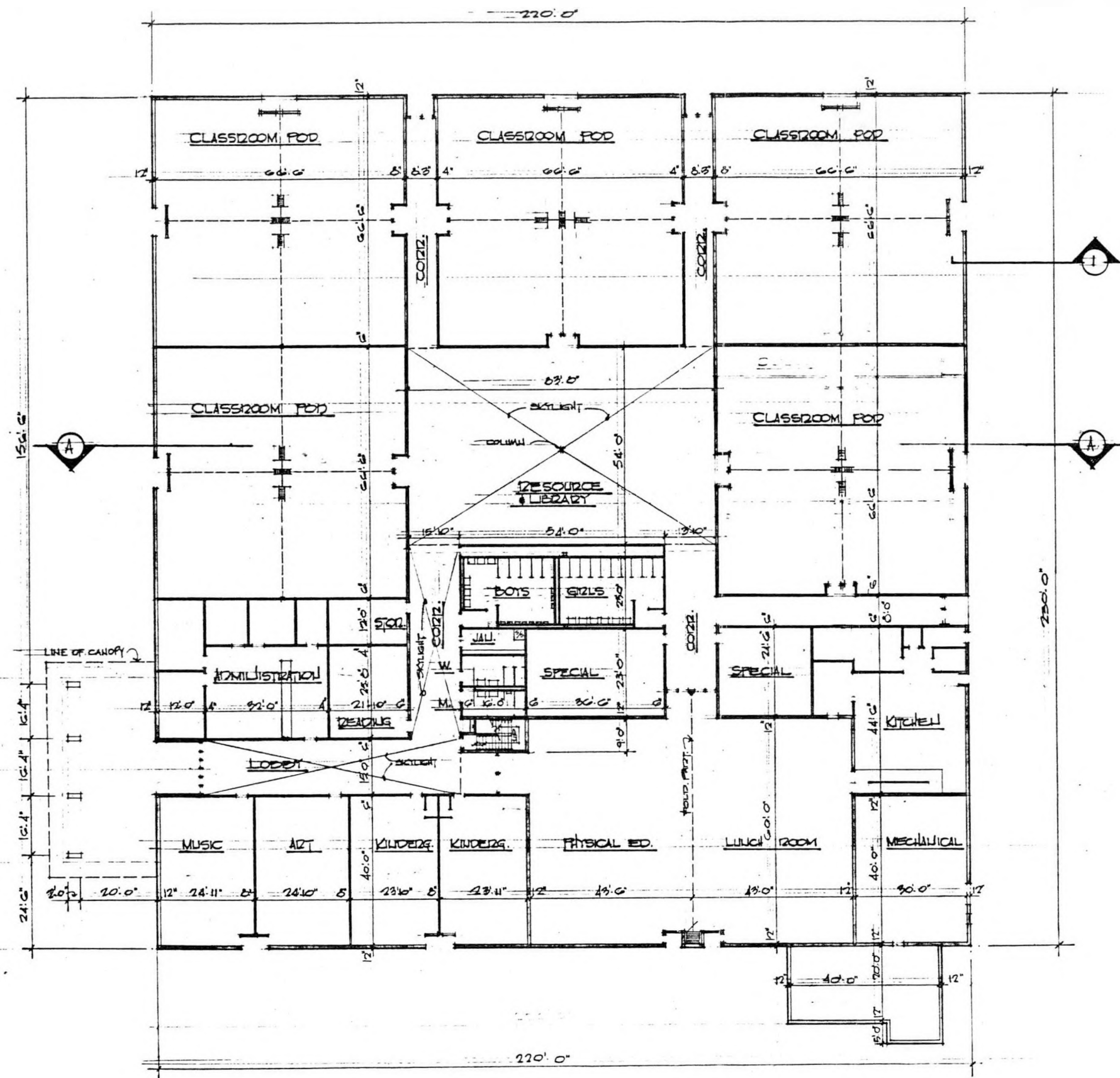


IV BUILDING PLANS

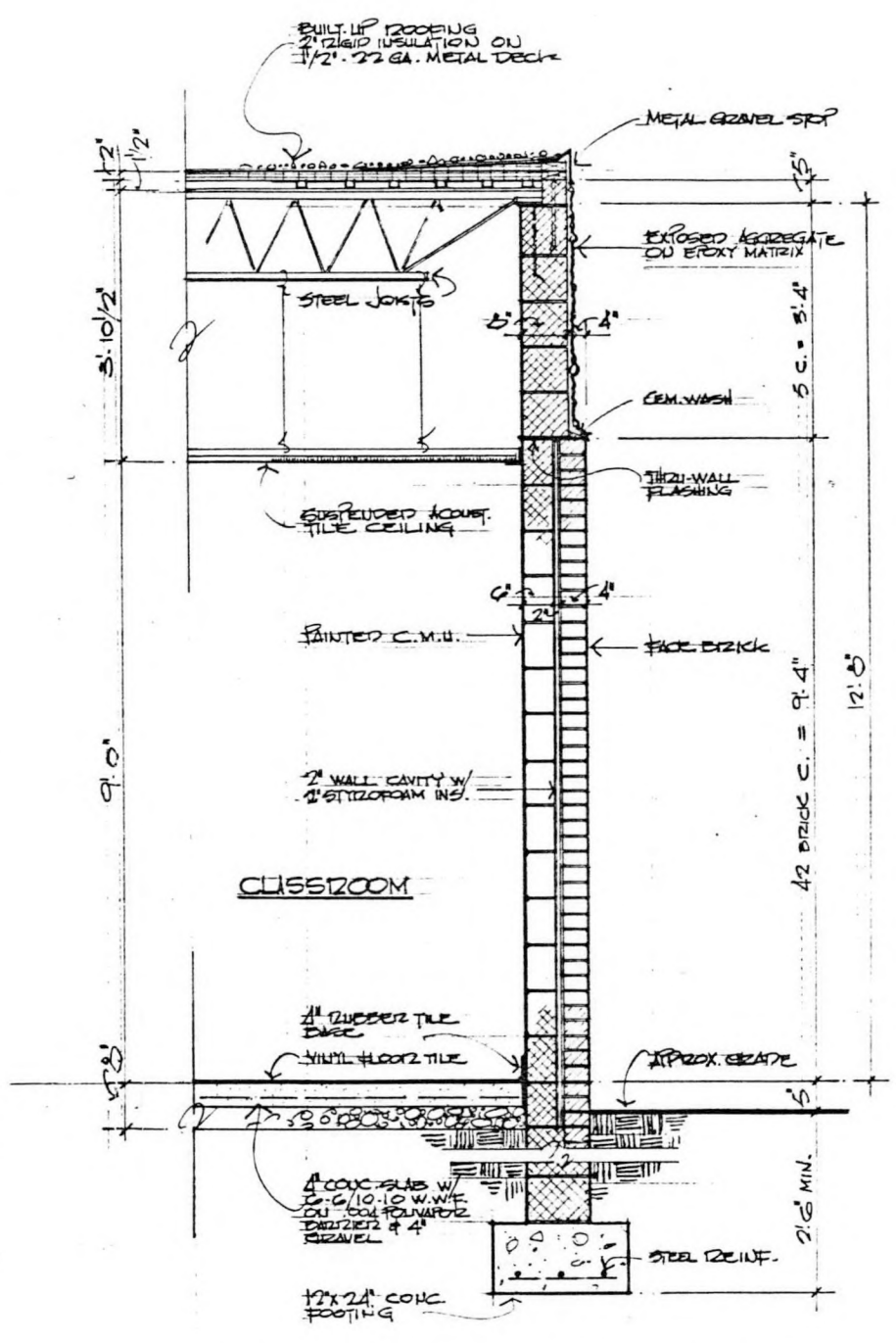
SITE PLAN
SCALE 1"=40'

SITE PLAN		DRWN	SHEET NO.
PAGE JACKSON SCHOOL		CHK'D	
JEFFERSON CO. WEST VA		DATE	
		REV'S	

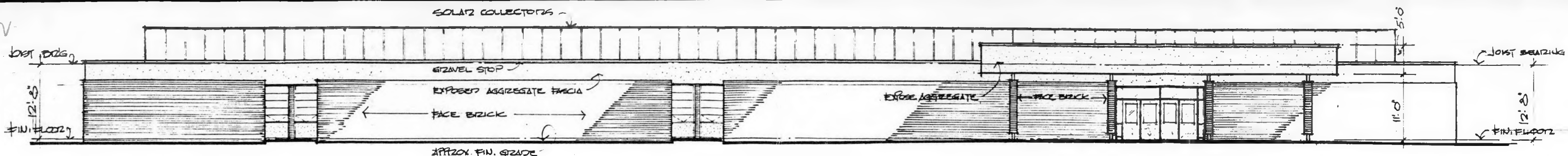
A-1



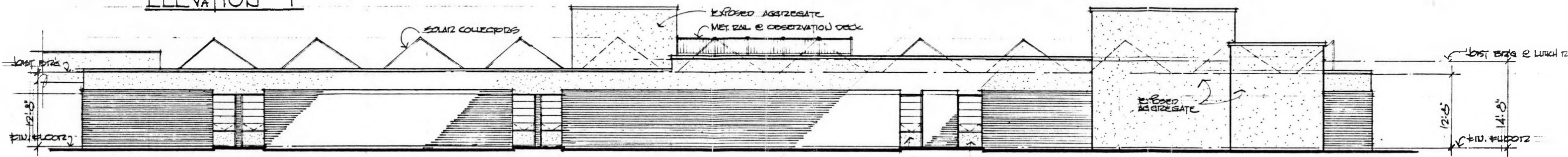
FLOOR PLAN 1/8" = 1'-0"



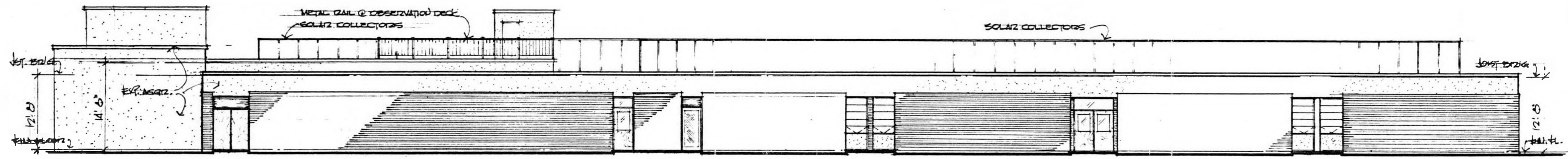
PICKETS SIESS & HOOK architects 800 WEST BRAD ST. FALLS CHURCH, VA. 22048 PH. 534-1888	FLOOR PLAN PAGE JACKSON ELEM. SCHOOL JEFFERSON CO. W. VA.	
	DATE _____ DRAWN _____ CHECKED _____	PROJECT _____ REVISIONS _____ SHEET NO. A-2



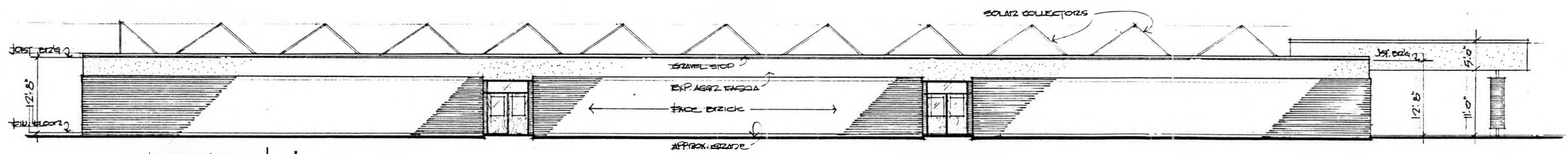
ELEVATION 1



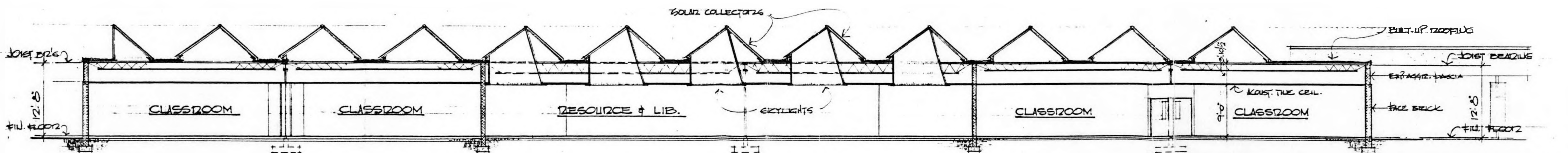
ELEVATION 2



ELEVATION 3



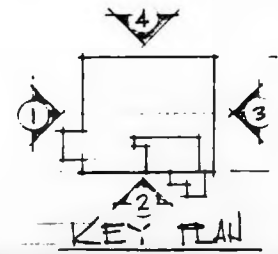
ELEVATION 4



CROSS SECTION A-A

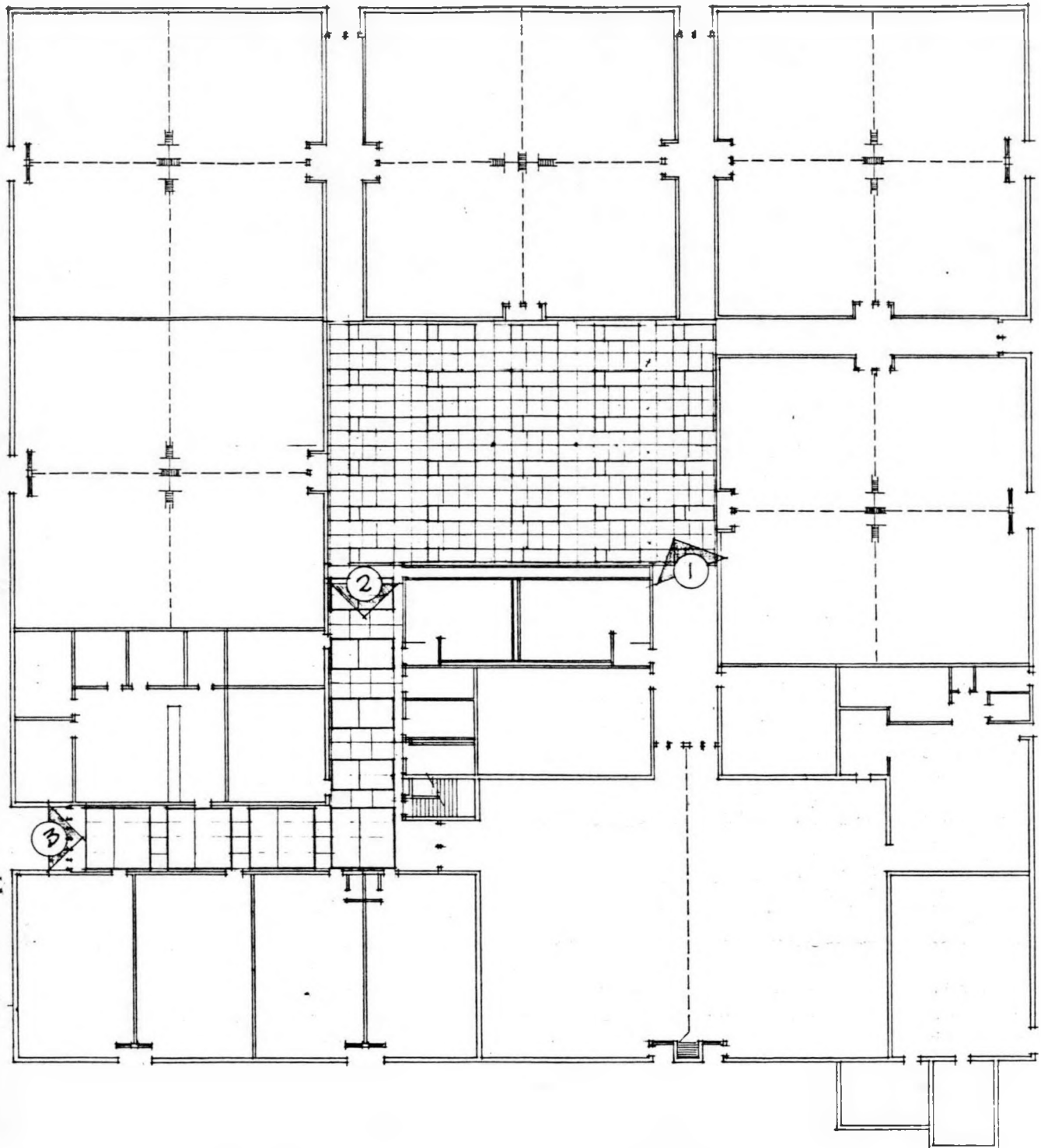
ELEVATIONS & CROSS SECTIONS

SCALE AS NOTED



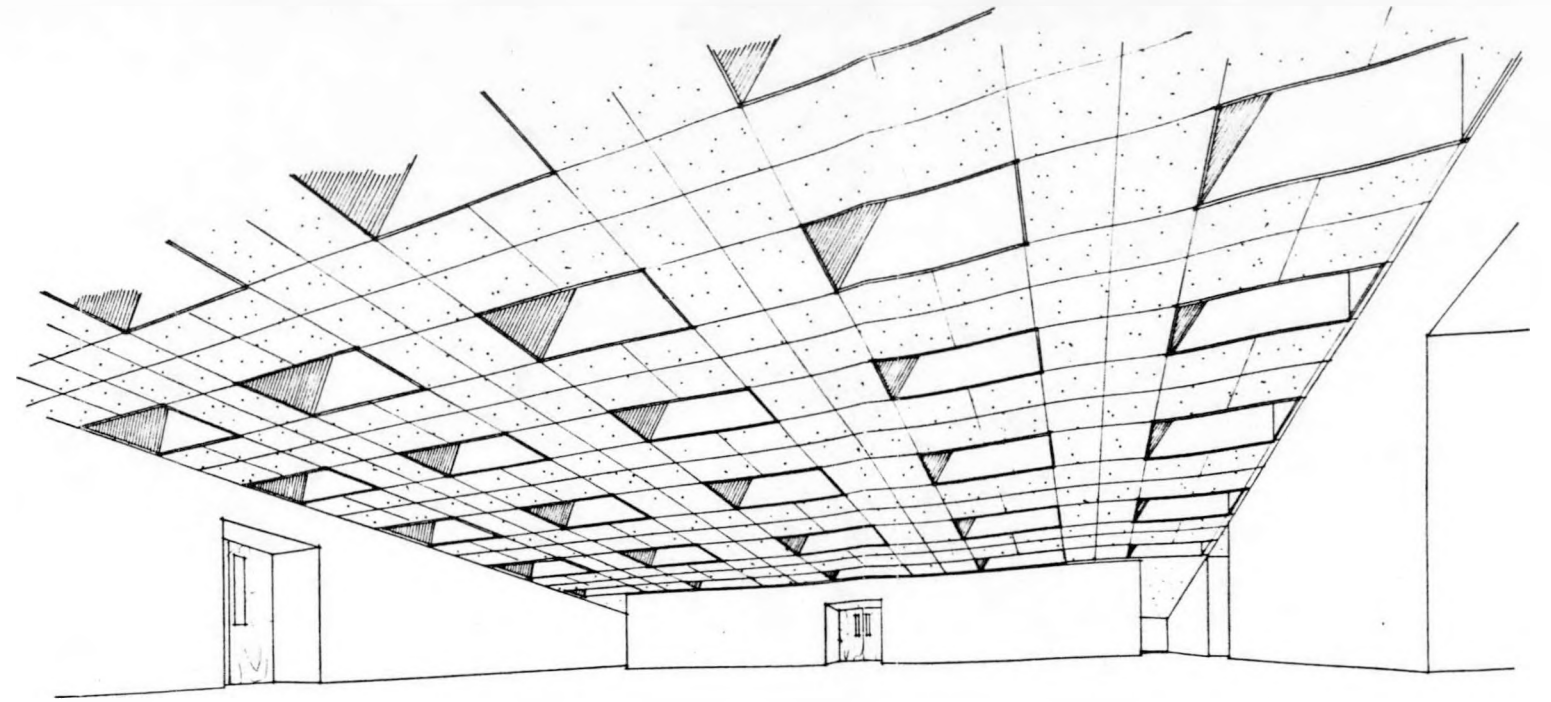
**PICKETT
SHEETS
& HOOK
architects**
800 WEST BRAD ST.
FALLS CHURCH, VA
22040 PH. 574-1000

ELEVATIONS	
PAGE JACKSON ELEM. SCHOOL	
JEFFERSON CO. W. VA.	
PROJECT	
DATE	REVISIONS
DRAWN	CHECKED
SHEET NO.	A-4

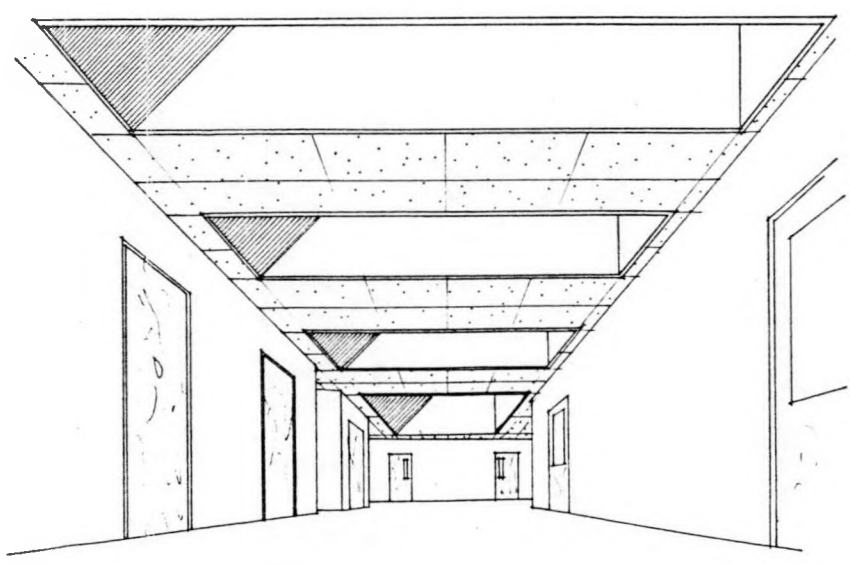


REFLECTED CEILING PLAN

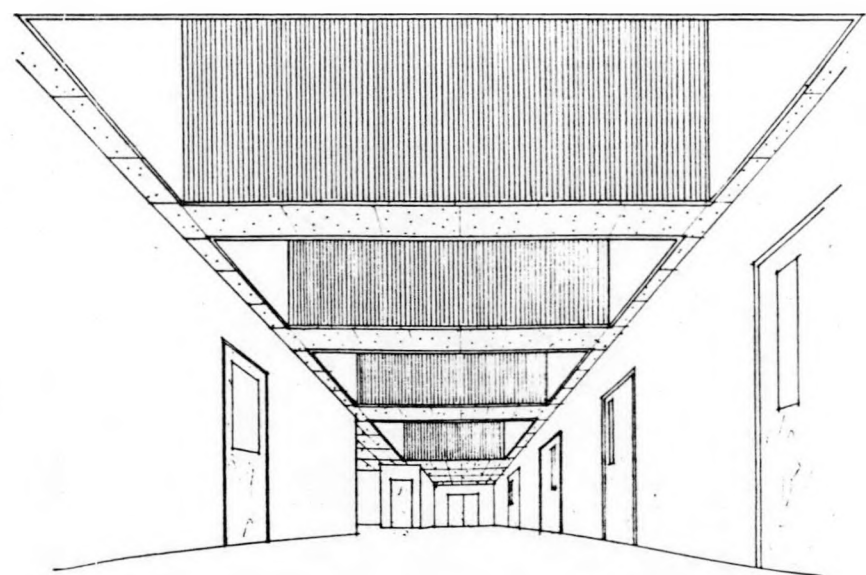
SCALE 1/4" = 1'-0"



PERSPECTIVE 1



PERSPECTIVE 2

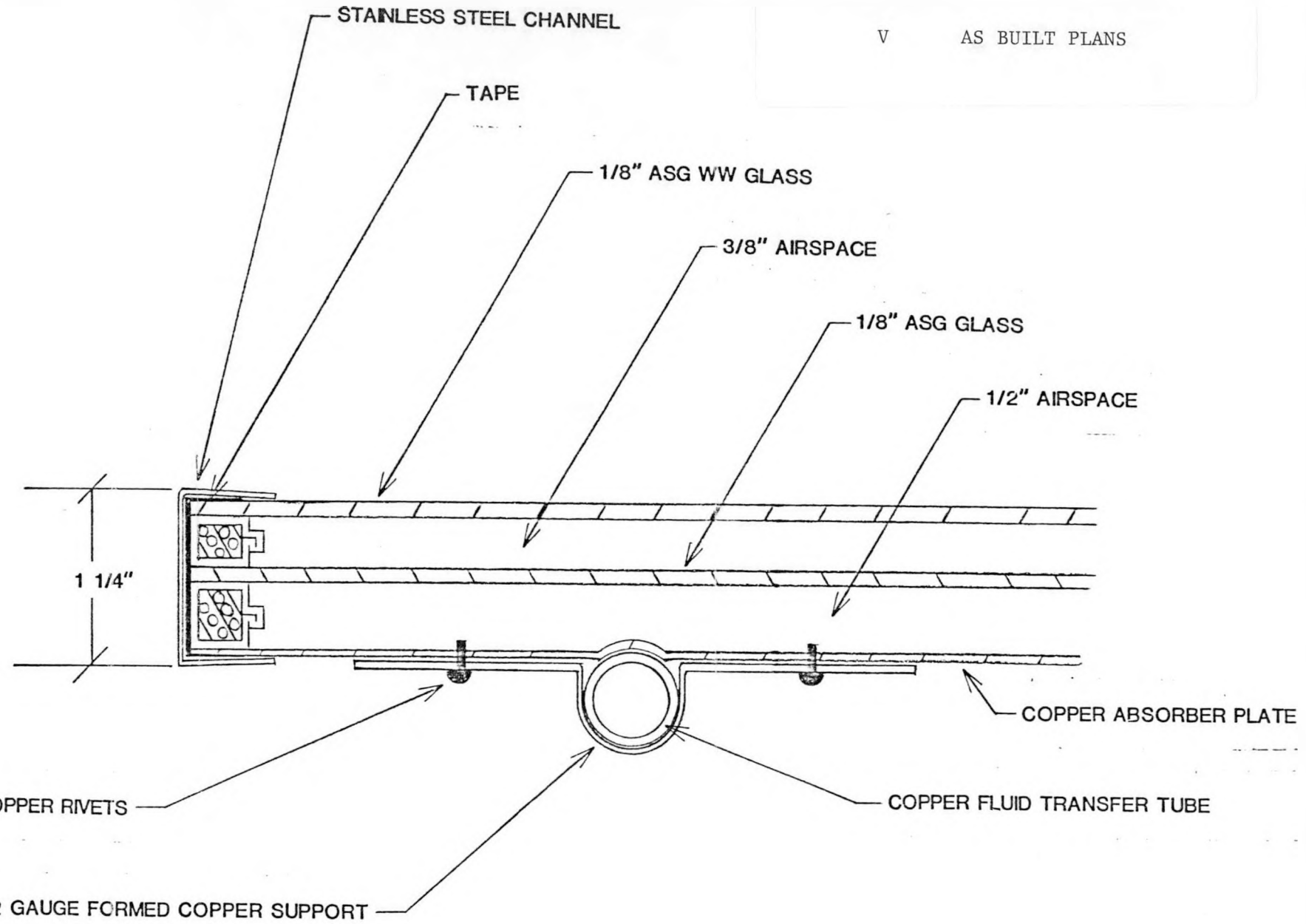
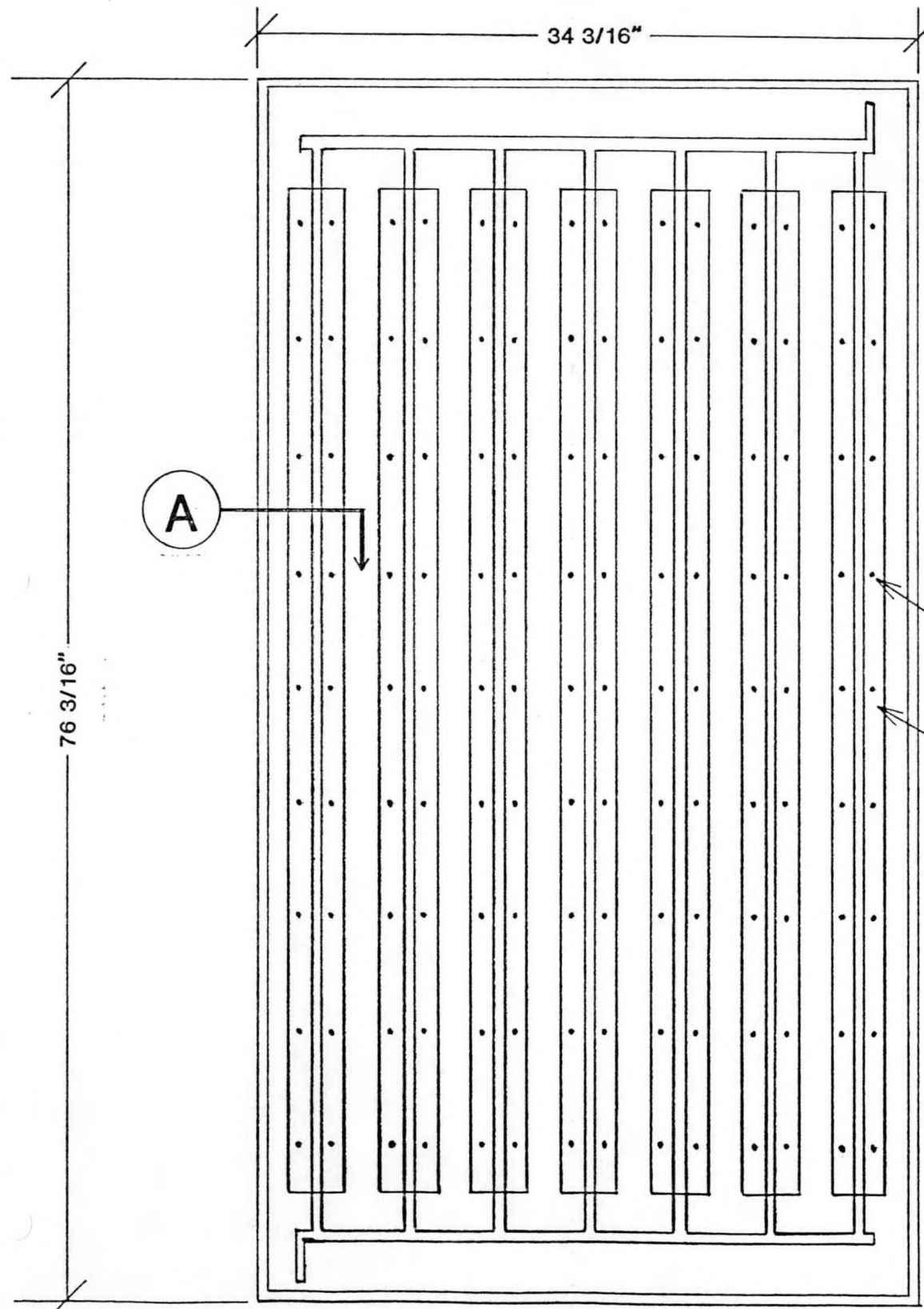


PERSPECTIVE 3

PICKETT SHEEK & HOOK architects 803 WEST HURON ST. FALLS CHURCH, VA. 22044 PH. 534-1000	REFLECTED CEILING PLAN	
	PAGE JACKSON ELEM. SCHOOL	
	JEFFERSON CO. W. VA.	
	PROJECT	
DATE	DESIGNED BY	SHEET NO. A-5
DRAWN	CHECKED	
CHECKED		

REAR VIEW

V AS BUILT PLANS



Section "A"

Full Scale

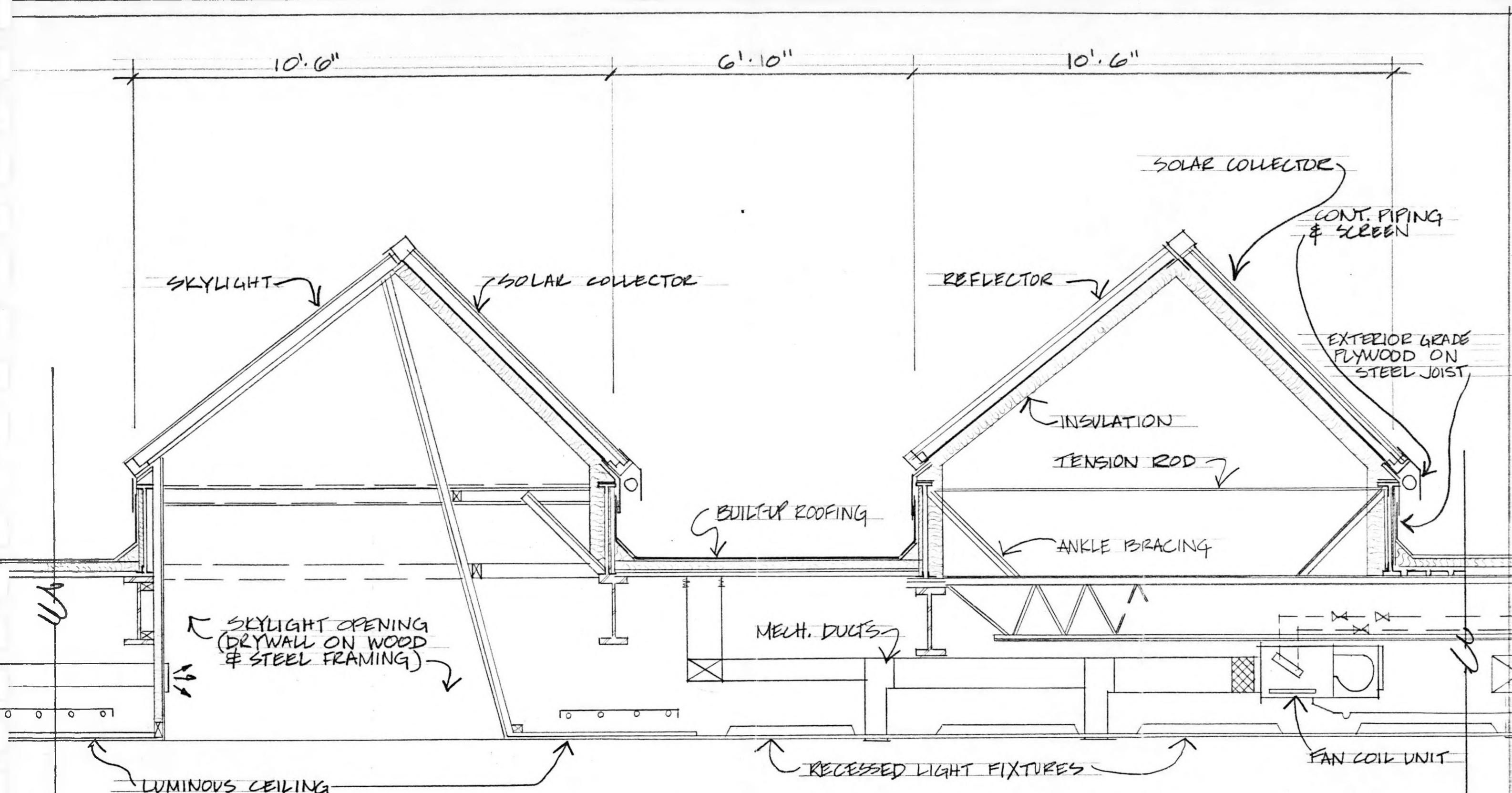
1 1/2" : 1'-0"

-7-

PAGE JACKSON SCHOOL

CHARLESTOWN, WEST VIRGINIA

PPG SOLAR COLLECTOR			
SCALE: as shown	APPROVED BY	JWP	DRAWN BY MAS
DATE: 6/30/82			
PICKETT - SIESS & ASSOCIATES			
TUBE / PLATE CONNECTION			DRAWING NUMBER PJS1

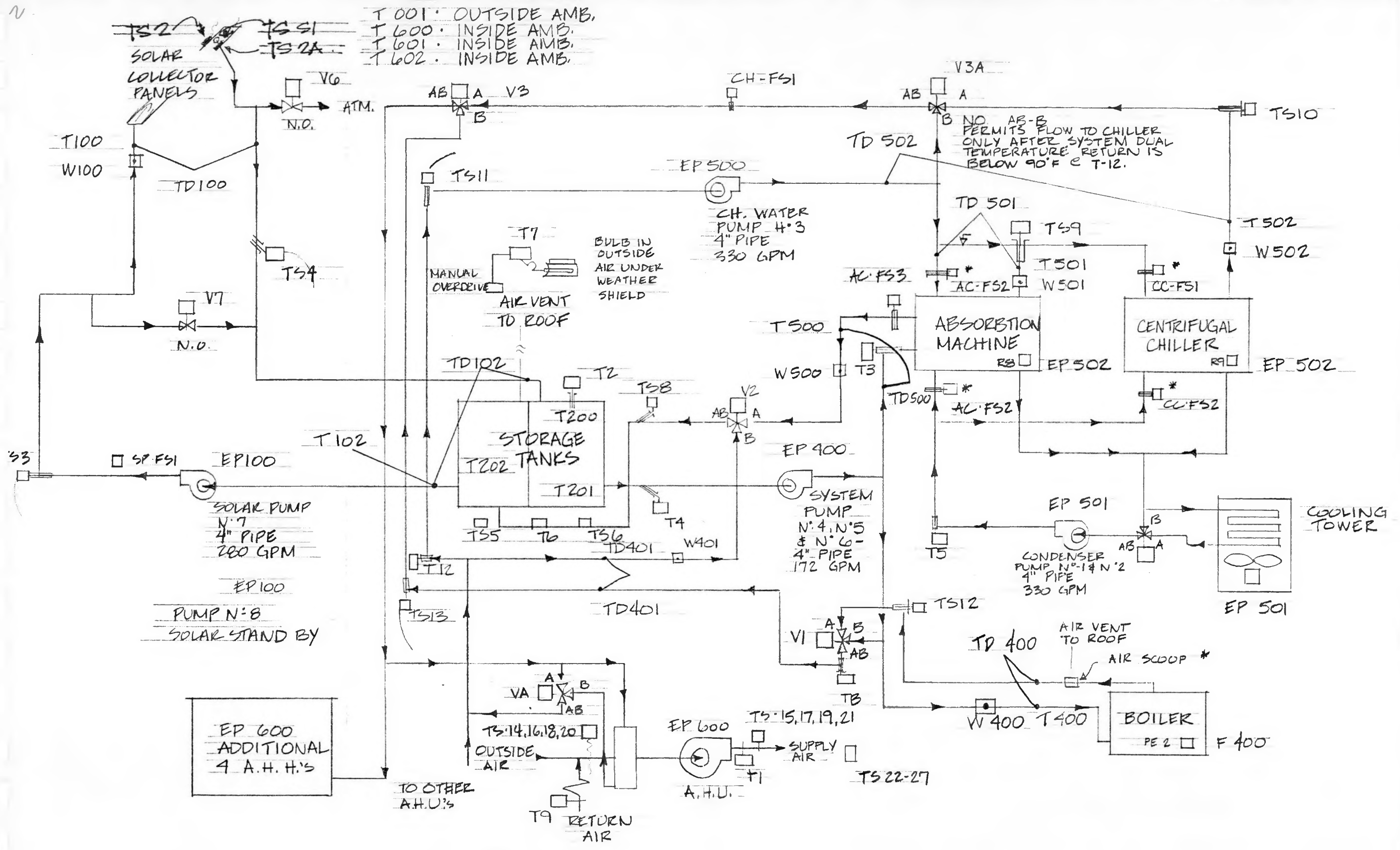


TYPICAL SECTION THRU EXISTING ROOF & SOLAR PANELS

SCALE: 1/2" = 1'-0"

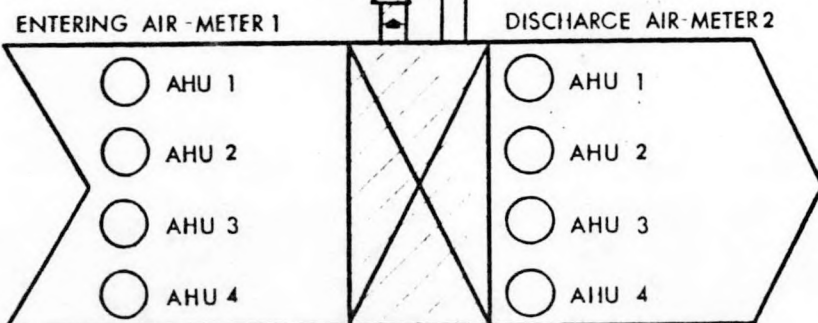
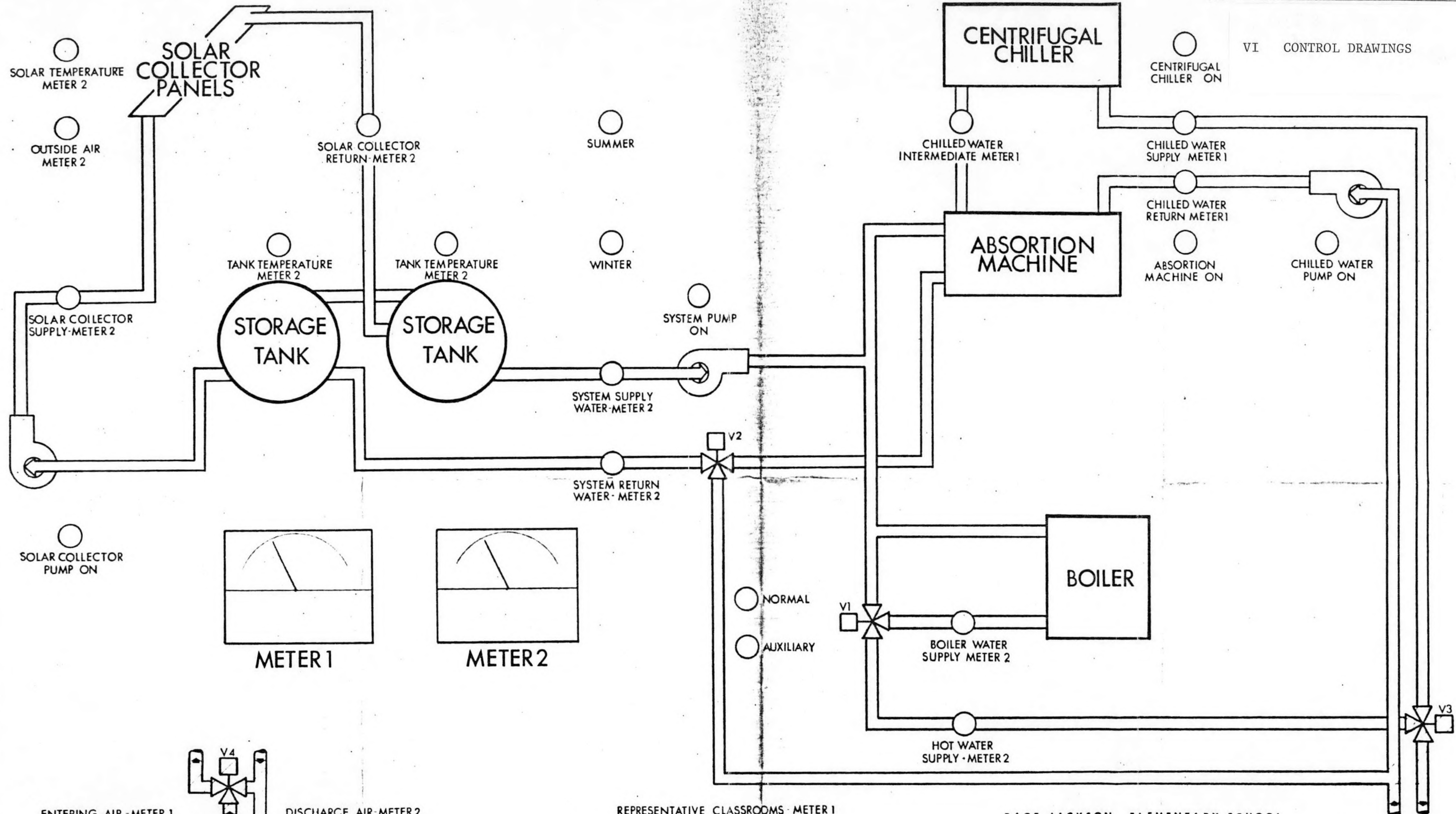
COLLECTOR SECTION

2



SOLAR AND DUAL TEMPERATURE WATER FLOW DIAGRAM

VI CONTROL DRAWINGS



- REPRESENTATIVE CLASSROOMS METER 1
- MUSIC A-1
 - ART A-4
 - CLASSROOM B 71
 - CLASSROOM B-7
 - CLASSROOM B-83
 - CLASSROOM B-82

PAGE JACKSON ELEMENTARY SCHOOL
1977

BOARD of EDUCATION
Jefferson County, West Virginia
Architects: PICKETT SIESS & HOOK, AIA
Engineer: JOHN LAWRENCE
Contractor: P. E. FOOLE & CO.

CONTROLS BY
The BARBER-CULMAN Company
MACHINERY & EQUIPMENT SALES, INC.
Baltimore, Maryland

An Energy Research & Development Project

SEQUENCE of OPERATION

General
 The Display-Status and Indication Panel, located in Resources Center, will provide Temperature and Equipment operation indication. Each temperature indication point will function thru designated Push Button (PB) as located on Flow Diagram, to provide indication with associated color-coded Temperature Meter (M-). (Also refer to schedule for indication of temperatures).
 Equipment operation indication will be provided thru Pilot Lights indicating "ON" condition when lit.
 Refer to Sheet C3 of 7 for Panel Specifications and mounting instructions.

SCHEDULE of FIELD MOUNTED EQUIPMENT

Symb.	Quan.	Catalogue Number and Description
TS1	1	TS-8501, Solid State Electronic Sensor, outdoor Air, 1/2" MNT Fitting, 1000 Ohm
---	1	AT-211 Weather Shield and Bulb Clip
TS2,24	2	MYDA-102, solid state Electronic Sensor 1000 Ohm.
TS2,13,14	14	TS-8201, Solid state electronic sensor, 6" Stem, Duct or immersion Mounting, 1000 Ohm.
---	10	AT-215, stainless steel bulb well 3/4" MNT, 9" long.
TS14,16,4	4	TS-8405, Solid state Electronic Sensor, Duct Mounting, 5' averaging element, 1000 Ohm.
TS22,27	6	TS-8111, Solid State Electronic Sensor, Plate Mounting, Non-Adjustable, Range 20-120°F.

SCHEDULE of DISPLAY PANEL MATERIAL

Symb.	Quan.	Catalogue Number and Description
Fd	1	Bussman Manufacturing Type 300 Disconnect switch with Fuseholder.
Fu	1	Bussman Manufacturing Co. Panel Mounted Fuseholder, Type NXP for 1/2" x 1/4" fuse.
M1	2	ASF-562, Solid state Electronic Indicating Meter, Scale 0-200°F.
M2	2	ASF-522, Solid state Electronic Indicating Meter, Scale 50-80°F.
PB1-27	27	CYZF-346, SPST Momentary contact Pushbutton (R) with
PL1-9	9	Panel mounting Pilot Light assemblies each consisting of: EYZP-721 sockets and connectors, EYZP-504-2 120 Volt pilot lamp. EYZP-722-2 Green Lens, EYZP-722-3 Amber Lens, EYZP-722-1 Red Lens.
TA1-27	27	TSF-B111, Solid state electronic Bridge for ASF series meters.
AFMR	1	Dorreyer 41746 120/24-1-60 Transformer 40VA.

SCHEDULE for INDICATION of TEMPERATURES

MEDIUM	SENSOR	BRIDGE	PUSH BUTTON	METER NO.
Chilled Water Supply	TS10	TS1	PB1	M1
Chilled Water Intermediate	TS9	TS2	PB2	
Chilled Water Return	TS11	TS3	PB3	
A.H.U. #1 Entering Air	TS14	TS4	PB4	
A.H.U. #2 Entering Air	TS16	TS5	PB5	
A.H.U. #3 Entering Air	TS18	TS6	PB6	
A.H.U. #4 Entering Air	TS20	TS7	PB7	
Music Rm A-1	TS22	TS8	PB8	
Art Rm A-1	TS23	TS9	PB9	
Classroom B-71	TS24	TS10	PB10	
Classroom B-7	TS25	TS11	PB11	
Classroom B-83	TS26	TS12	PB12	
Classroom B-72	TS27	TS13	PB13	
Classroom B-84	TS28	TS14	PB14	
Classroom B-92	TS29	TS15	PB15	M1
Solar Collector Supply	TS3	TS16	PB16	M2
Solar Collector Return	TS4	TS17	PB17	
Tank No. 1	TS5	TS18	PB18	
Tank No. 2	TS6	TS19	PB19	
System supply Water	TS7	TS20	PB20	
System Return Water	TS8	TS21	PB21	
Boiler supply Water	TS9	TS22	PB22	
Hot Water Supply	TS13	TS23	PB23	
Solar Plate Temperature	TS2	TS24	PB24	
Outside Air	TS1	TS25	PB25	
A.H.U. #1 Discharge Air	TS15	TS26	PB26	
A.H.U. #2 Discharge Air	TS17	TS27	PB27	
A.H.U. #3 Discharge Air	TS19	TS28	PB28	
A.H.U. #4 Discharge Air	TS21	TS29	PB29	M2

INSTALLATION NOTES

For additional Installation Notes refer to Sheet C3 of 7

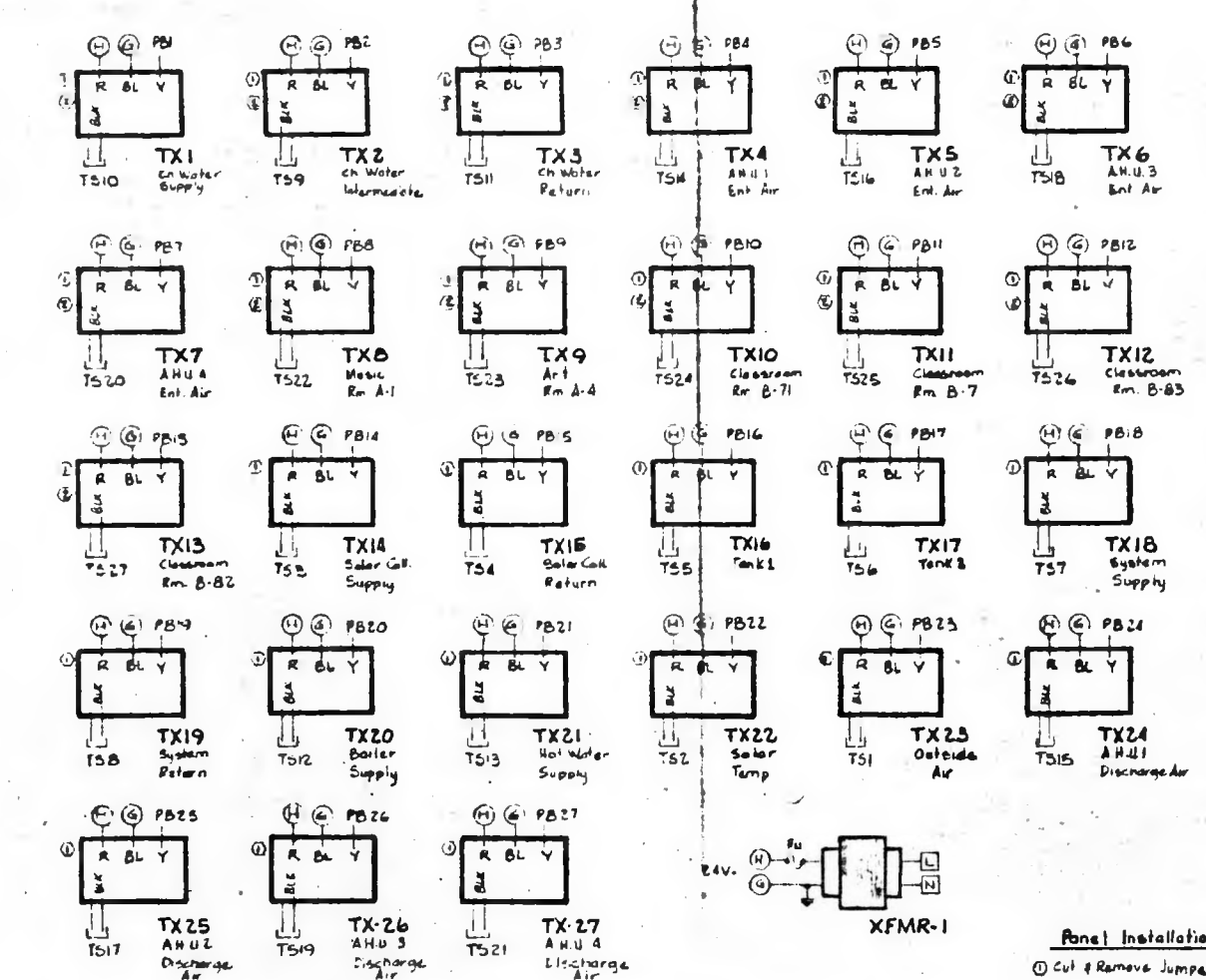
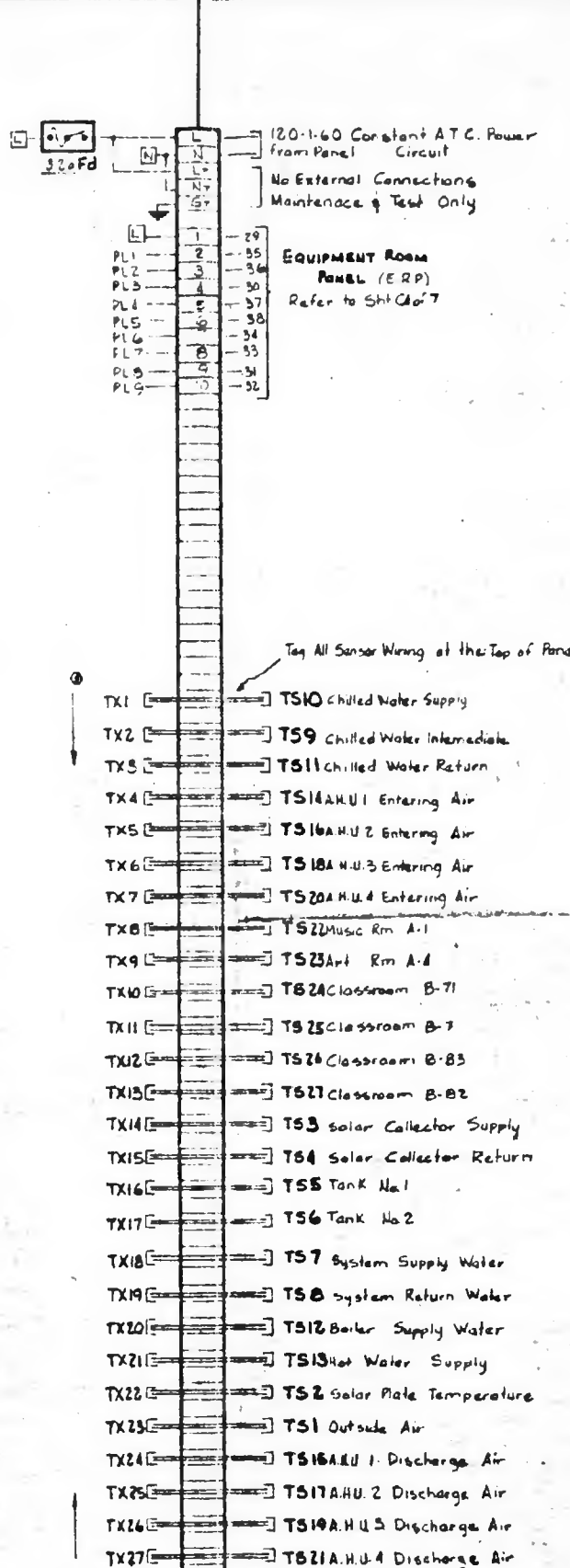
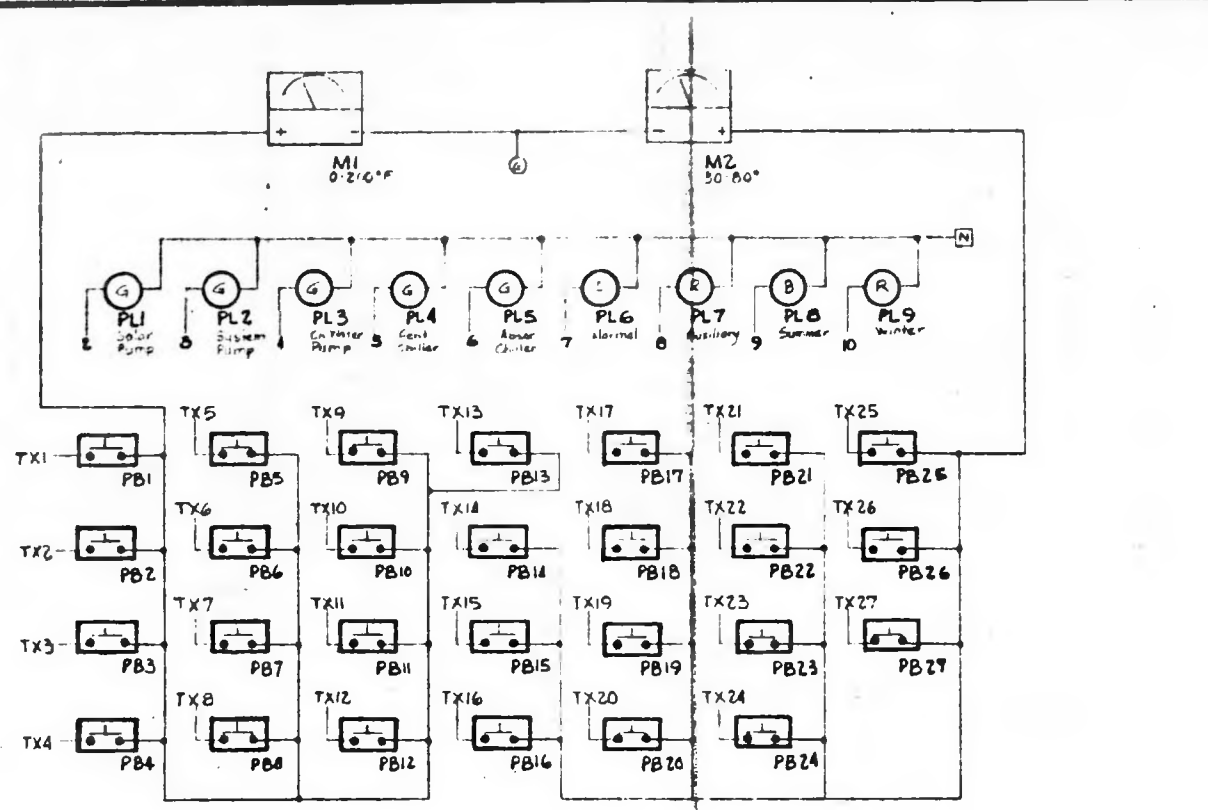
COLMAN DISPLAY PANEL

MACHINERY and EQUIPMENT SALES, Inc.
 3303 - 07 Chestnut Avenue
 Baltimore, Maryland 21211

(301) 889-2070

REVISIONS		JOB NAME
DATE	CHANGE	PAGE JACKSON ELEMENTARY SCHOOL
		LOCATION - Jefferson County, West Virginia
		ARCHITECT - PICKETT BLISS & HOOK AIA
		ENGINEER - John Lawrence
		CONTRACTOR - P. L. FOULK & CO.
		DRAWN BY - RM/sg
		CHECKED BY - BALTO - 663 - AIO
		DATE - February 18, 1977

Sheet C2 of 7



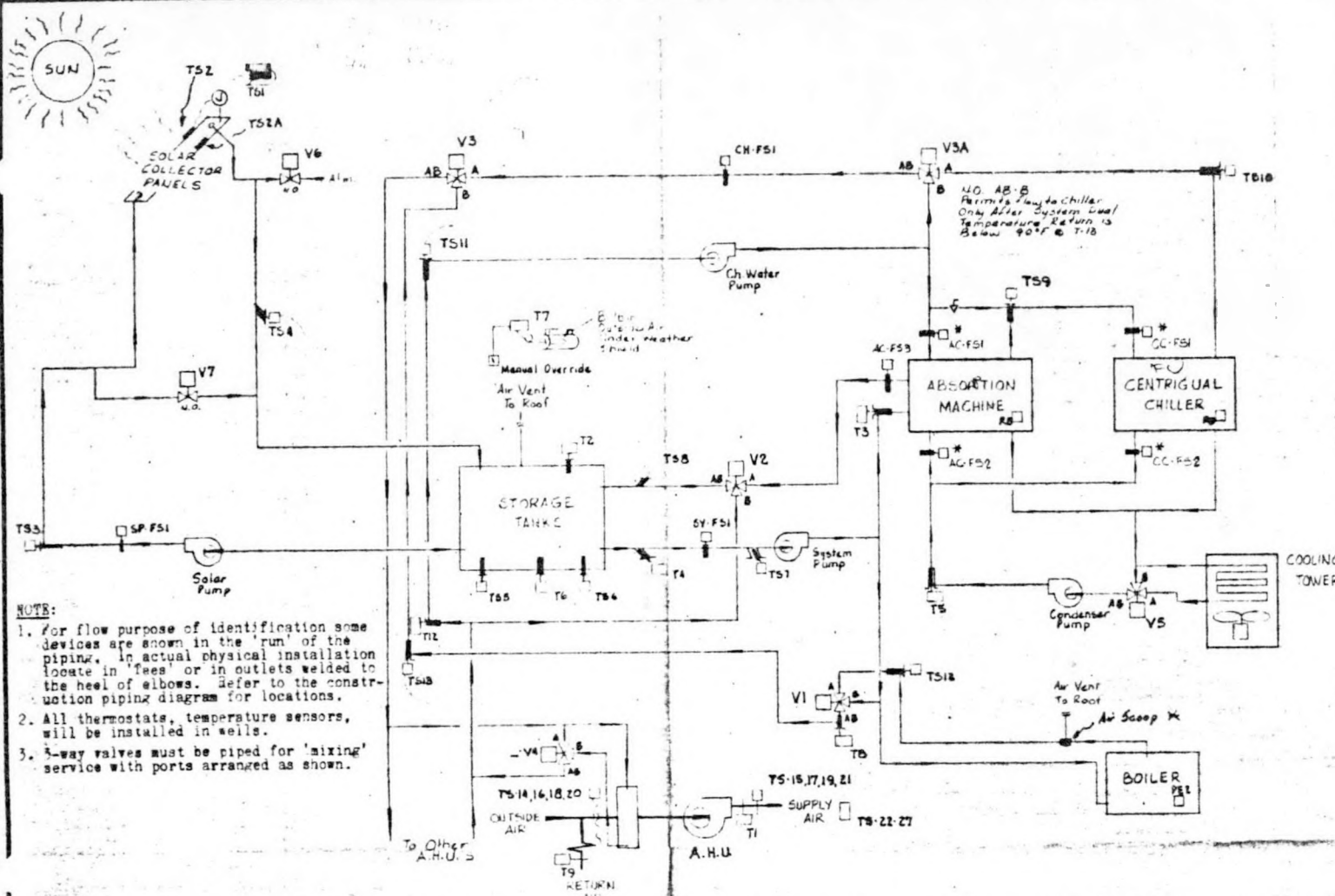
DISPLAY-STATUS INDICATION PANEL

Panel Installation Notes

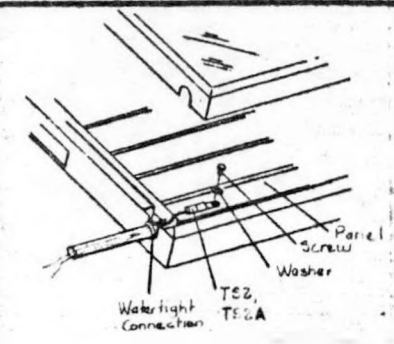
- 1. Cut & Remove Jumper J1
- 2. Remove Span. Screw for 50° sweep
- 3. Connect Sensors Directly to TX base
 Tag Wires @ Sensors and TX base and Entering Panel @ Top

INSTALLATION NOTE

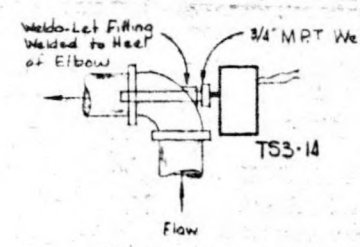
Note 1: Use two (2) or three (3) conductor twisted cable as indicated for DC control circuits. Cable to be equal to BARBER-COLMAN #B-102-3-16 for two (2) conductor and #B-103-3-15 for three (3) conductor twisted.



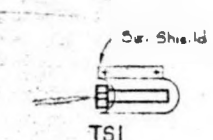
- NOTE:**
1. For flow purpose of identification some devices are shown in the 'run' of the piping. In actual physical installation locate in 'tees' or in outlets welded to the heel of elbows. Refer to the construction piping diagram for locations.
 2. All thermostats, temperature sensors, will be installed in wells.
 3. 3-way valves must be piped for 'mixing' service with ports arranged as shown.



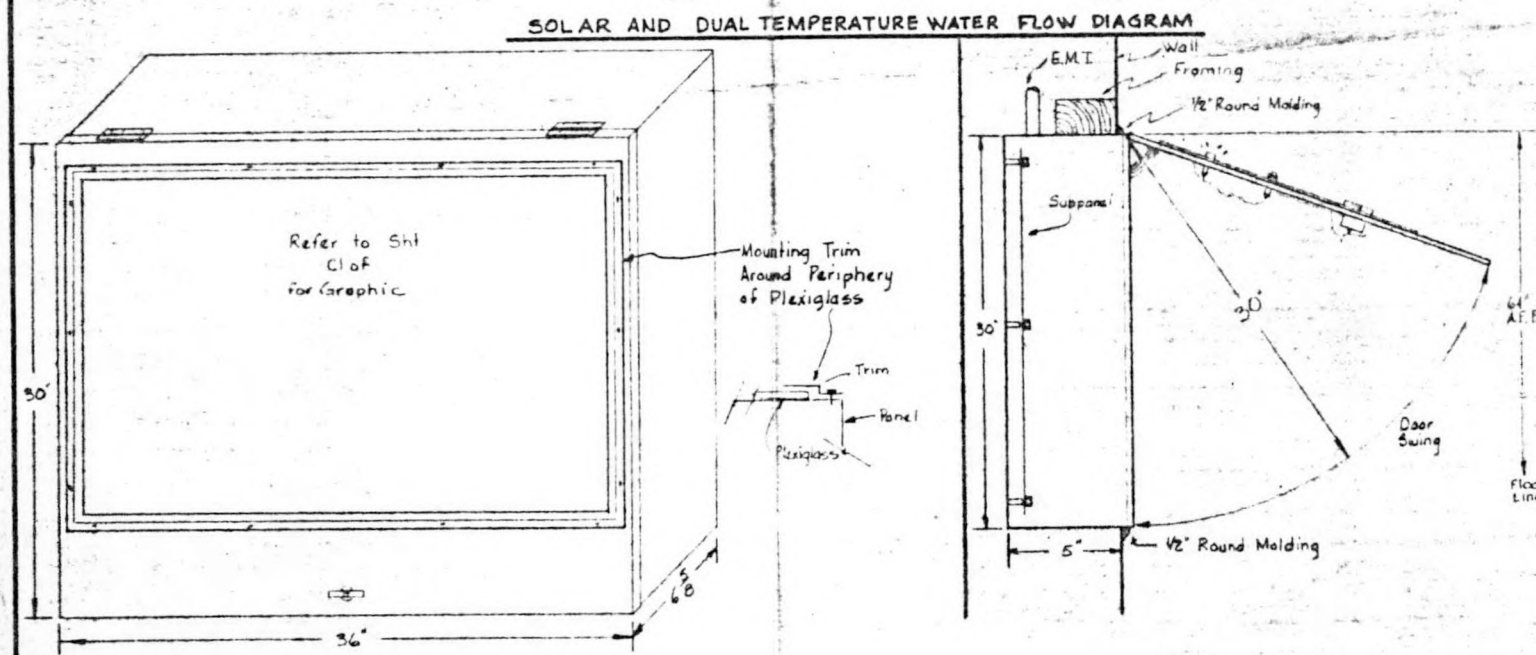
SOLAR SENSOR MOUNTING DETAIL



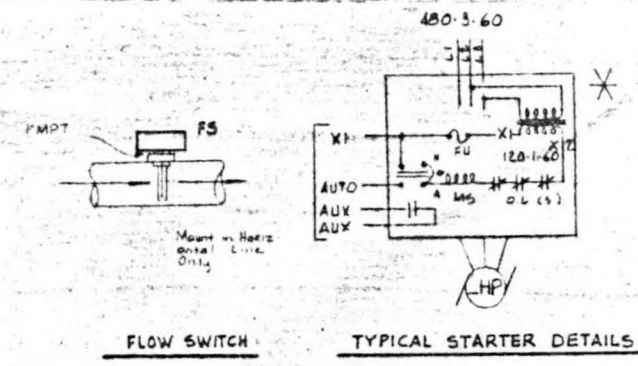
IMMERSION SENSOR



OUTSIDE SENSOR



PANEL DETAILS



FLOW SWITCH

TYPICAL STARTER DETAILS

CONNECTION DETAILS

Panel Specification

Status and Indication Panel
 Panel housing proper will be NEMA Type 1 Enclosure of code grade steel construction with additional reinforcing channel welded inside of front door to make the front as rigid as possible.
 Panel will be semi-recessed in the wall of the Resources Center that adjoins spaces A-32 and A-34. Panel housing proper will have 4" of its dimension inserted into the wall with the remaining 2 5/8" protruding from the wall. Frame the opening for the panel enclosure such that there will be sufficient clearance to shim as necessary, when installing panel box, to insure that the front cover will be optically square with the surrounding building structure. Then apply decorative welding on all sides.
 Install panel with the long dimension (36") horizontal and the front door hinge on the top.

Panel Front:
 Please refer to Sheet C1 of 1.

System flow diagram and status indication is designed to be installed on the face of the door of the steel enclosure with 1" margin on top and sides and as required to clear the door lock on the bottom of the panel.
 Sheet will be held on the door face by "L" shaped mirror mounting hardware around its periphery; double lock-nutted flush button switches; and pilot lights with spring locknuts.
 Edge mounting, as well as mounting holes, will have dimensions that will allow for expansion and contraction of the sheet without developing stresses and binding. I.e., "floating mounted" within acceptable confinement.
 All depiction, coloring, lettering will be on the reverse side of the sheet with the outer surface remaining smooth glossy or satin finish. Note: Decision on the finish is to be made by the architect and Consulting Engineer.

Coloring will be as follows:
 Solar panel flow lines will be YELLOW.
 Solar panel circulating pump and solar panel collector and storage tanks will be YELLOW one or two shades darker than the flow lines.
 Heating water lines for the dual temperature and absorption chiller circuit will be light RED with systems pump and auxiliary button shown in a darker shade of RED.
 Chilled water flow lines will be light BLUE with chillers and chilled water pump in darker shade of BLUE.
 Dual temperature coil and piping, striped - light BLUE and light RED.
 Flow lines and equipment symbols will be outlined in BLACK.
 Descriptive lettering will be reverse engraved with the lettering color filled as follows:
 Equipment identification and pilot light description - BLACK
 Temperature readout pushbutton station identification lettering will match meter housing color. Meter #1 - YELLOW, Meter #2 UNKNG.
 Remaining portion of the sheet will have a light tan color for background highlighting.
 Mounting nuts and trim to be aluminum or chrome finish.
 Steel panel housing proper can be finished with a contrasting finish to the wall color, of a matching blending color to the wall finish. (Do not have Architectural Plans or information so this color decision will have to be made by the Architect and Engineer.)

Pilot Light Colors
 Pilot lights indicating equipment 'ON' or in Operation will emit GREEN light when energized.
 Summer pilot light will be BLUE, winter pilot light will be RED, normal heat circuit will be AMBER, auxiliary heating vice will be RED.

INSTALLATION NOTES

1. Use two (2) or three (3) conductor twisted cable as indicated for DC control circuits. Cable to equal to BARNER-COLMAN #8-102-16 for two (2) conductor and #8-103-15 for three (3) conductor twisted.
2. string to conform to National Electric Code Article 725 for Signal and Control Circuits.
3. Items marked with an asterisk (*) NOT furnished, mounted, supervised or guaranteed by BARNER-COLMAN Co. Shown for circuit information only.
4. string to conform to National Electric Code Article 725 for Signal and Control Circuits.
 - a. Class I
 - b. Class II

REVISIONS		DATE	CHANGE

		PIPING DIAGRAM & DISPLAY PANEL DETAILS	
MACHINERY and EQUIPMENT SALES, Inc. 3305 -- 07 Chestnut Avenue Baltimore, Maryland 21211		(301) 869 -- 2070	
JOB NAME: PAGE JACKSON ELEMENTARY SCHOOL			
LOCATION: Jefferson County, West Virginia			
ARCHITECT: HICKETT GLESS & BOOK, AIA			
ENGINEER: John Lawrence			
CONTRACTOR: P. E. ROGUE & CO.			
DRAWN BY: AM/sc		DRAWING NO. BA.TC -- 663 -- A10	
CHECKED BY:		DATE: February 18, 1977	
DATE:		Sheet 03 of 7	

SCHEDULE OF FIELD MOUNTED MATERIAL

Table with columns: Symp. Quan., Catalogue Number and Description. Lists various electrical components like flow switches, relays, thermostats, and actuators.

PARATION of SYSTEMS

Solar Heat Generation: General: System operates under separate controls without interlock with other systems. Standby pump is used system has to be valued correctly and pump starter 'Normal Standby' selector switch must be indexed for proper service.

Mechanical Generation of Heating and Cooling: A manual SUMMER-WINTER-AUTOMATIC switch on the face of the equipment Room Panel (ERP) or an outdoor air thermostat, set as indicated in description, will select mode of operation.

SUMMER mode of Operation: (Outside air above 65°F or switch in SUMMER) System changeover valve (V-2) will position to change dual Temperature piping system from Solar Tank/Auxiliary Heating loop flow and permit System Pump, under control of the thermostat in Auxiliary Storage Tank, to circulate water through the Absorption Chiller generation section.

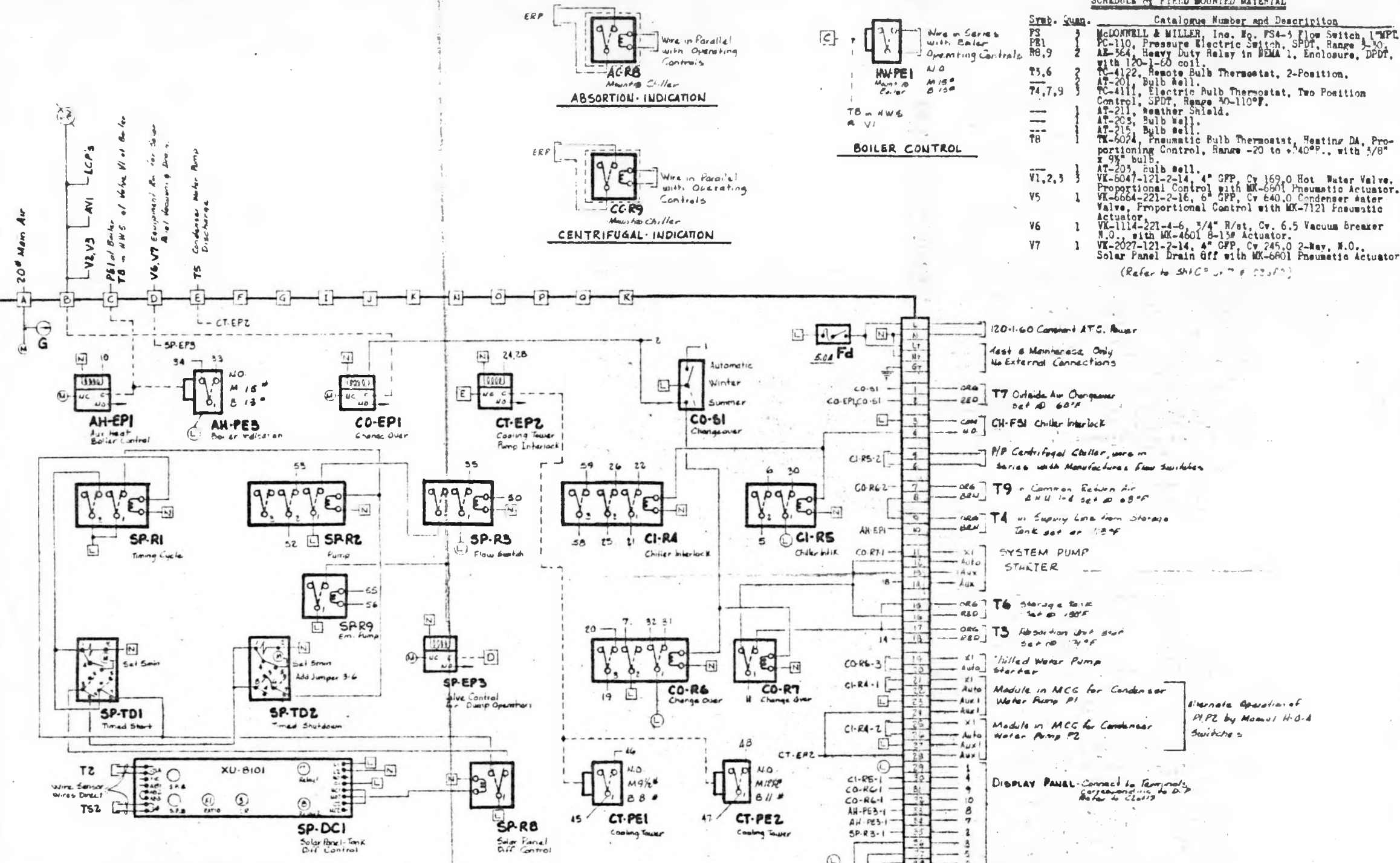
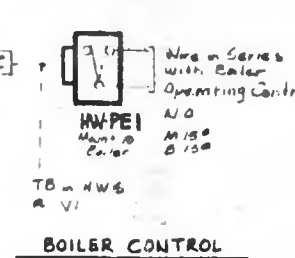
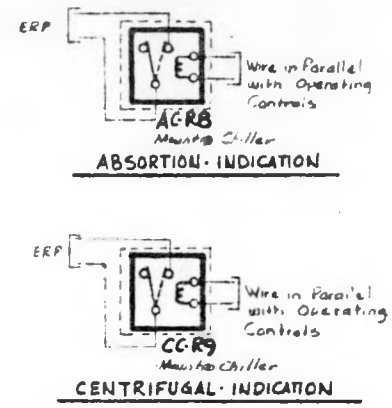
Chilled Water Pump will start. Dual temperature water will recirculate through the piping system or flow through the Chiller as determined by return water 'cool down' thermostat. If return water temperature is above set point (set @ 60°F., adjustable) water will recirculate through Chiller protection valve (V-3a).

WINTER mode of Operation: (Outside air below 60°F or switch in WINTER) Chilled Water Pump will stop. Chiller control circuits will deactivate. Electrical interlocks will stop Condenser Water Pumps and Cooling Tower Fans.

INSTALLATION NOTES

Refer to Sheet C3 of 7

EQUIPMENT ROOM PANEL. Includes logo for COLIMAN, project name PAGE JACKSON ELEMENTARY SCHOOL, location Jefferson County, West Virginia, and drawing details.



SCHEDULE OF EQUIPMENT ROOM PANEL MATERIAL. Table listing components like XU-8101 controller, solenoid valves, relays, and switches with their quantities and descriptions.

EQUIPMENT ROOM PANEL (ERP) (Typical for 1) Factory prewired 1/2" H x 30" W 6% D surface mounted NEMA 1 Enclosure with Key Lock. Locate in Equipment Room as directed in field.

SEQUENCE OF OPERATION

A. H. U. #1, #3, #5
General Information:
Air handling Unit #1 serves the peripheral area of the building in concert with Air handling Unit #2. Air handling Unit #3 serves a physical activities area that is not influenced by additional systems.

Safety Controls:
High temperature protection thermostat in the Return air (F, set w 125°F) and low temperature protection thermostat installed in serpentine manner on leaving air side of Dual Temperature coil (FA, set w 45°F) will, upon sensing normal temperatures interrupt the Supply Air Fan starter control circuit and stop the fan.

Normal Operation:
Control switch at the Central Communication Console is manually indexed to 'On' when operation of a particular Air Handling Unit is desired and indexed to 'Off' when it is desired that the unit be inoperative or under control of an unoccupied (site) thermostat for lowered space temperatures when the building is not in use.

Heating:
Room thermostat will, upon sensing temperatures below control range position the dual temperature coil valve in the full flow position. As the temperature begins to rise to the thermostat control range the valve will begin to modulate to maintain temperature.

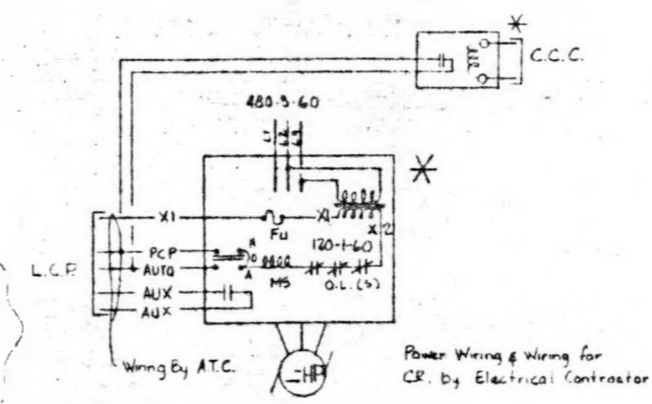
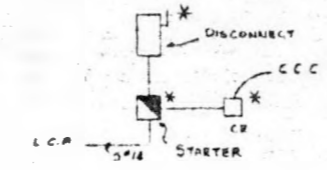
Cooling:
Room thermostat control function will have been reversed. As the space temperature begins to rise the room thermostat will modulate the control valve to pass more water through the dual temperature coil to maintain temperature.

Relief Air Control:
Operation of the Power Roof Ventilators (PRV) will be controlled by the authorized person at the Central Communication Console. Operation of these fans will exhaust a significant portion of the air entering the building through the 'minimum' outside air damper positions.

INSTALLATION NOTES

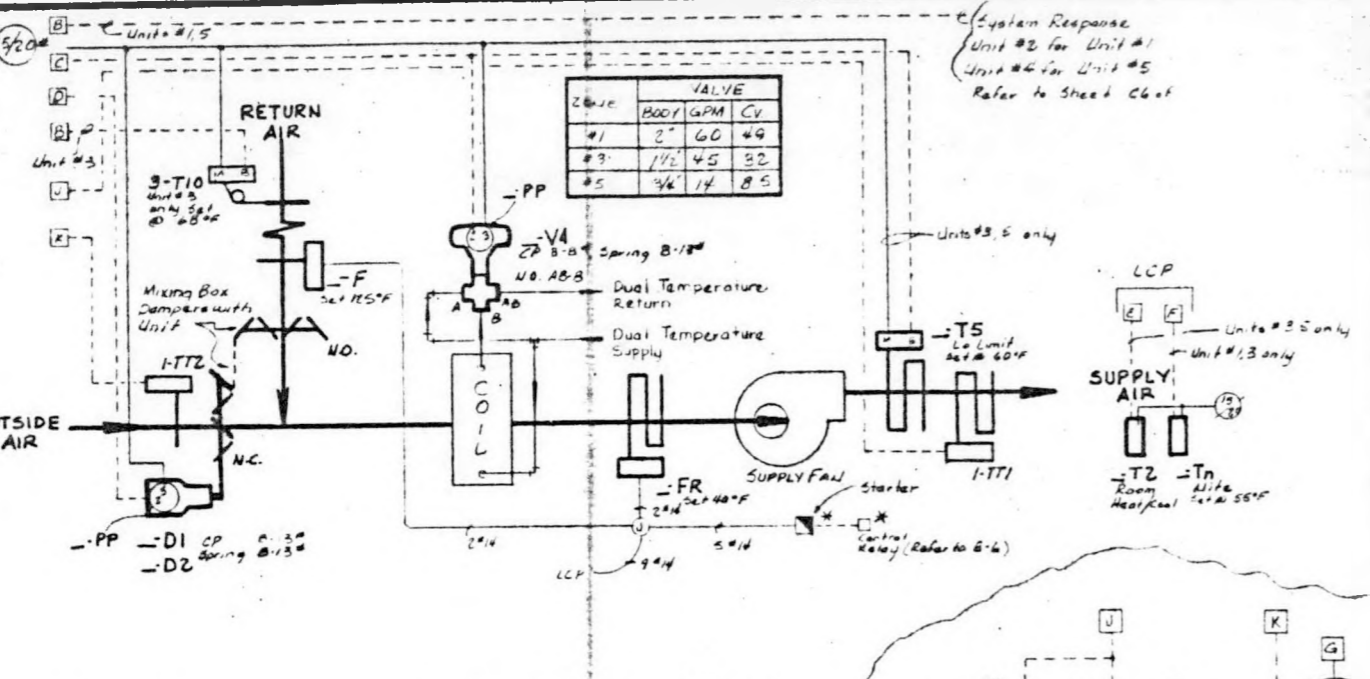
Refer to Sheet C3 of 7

COLMAN AIR HANDLING UNITS No. 1,3,5
MACHBERRY and EQUIPMENT SALES, Inc.
3305 - 07 Chestnut Avenue
Baltimore, Maryland 21211
(301) 689 - 2070
PAGE JACKSON ELEMENTARY SCHOOL
Jefferson County, West Virginia
PICKETT SLESS & HOOK AIA
John Lawrence
P. S. FOGLE & Co.
RM/so
BALTO - 663 - 46
February 18, 1977
Sheet C5 of 7

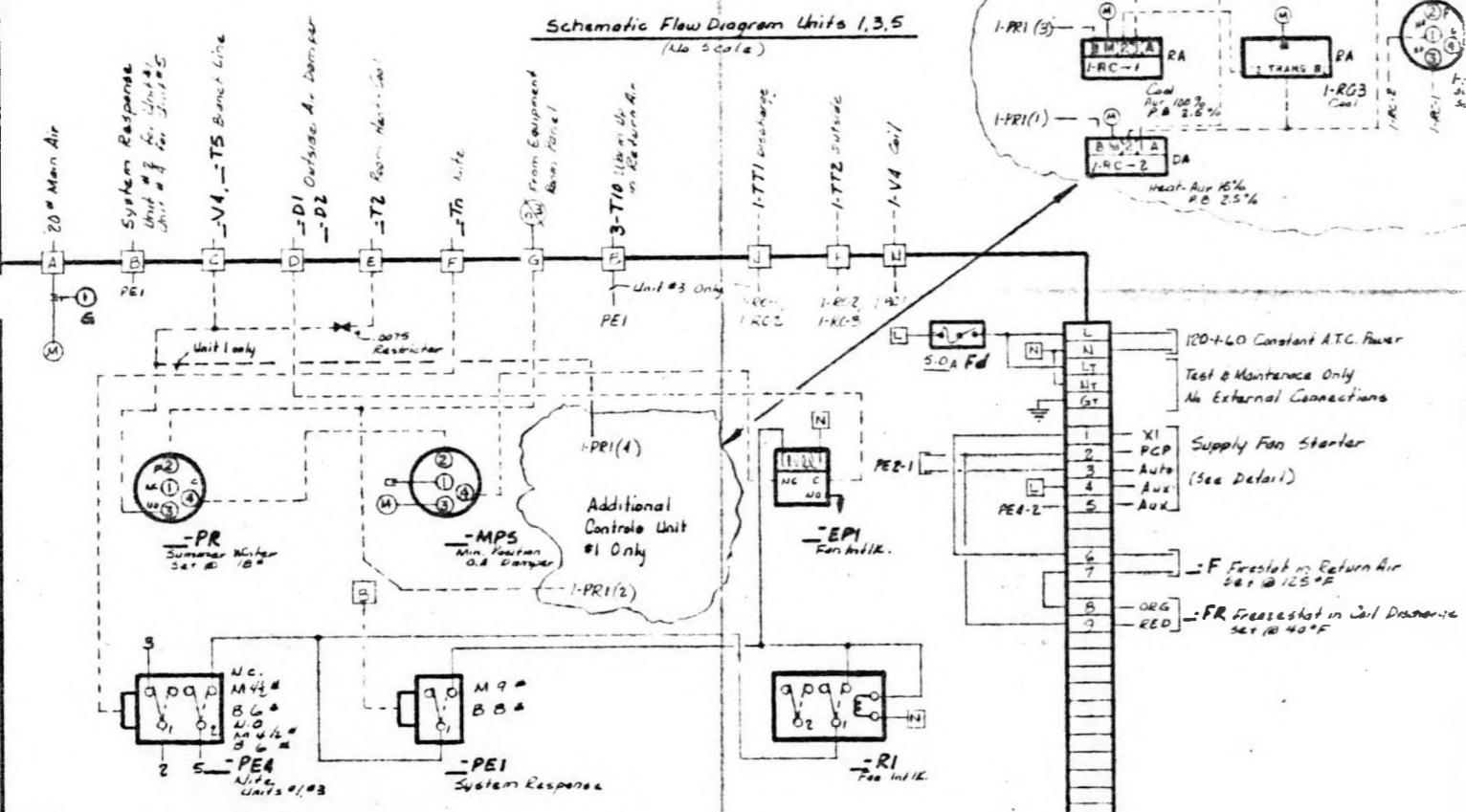


SCHEDULE OF FIELD MOUNTED CONTROL MATERIAL

Table with columns: Symb., Quan., and Catalogue Number and Description. Lists items like MK-7121-400-0-1, MK-5121-400-2, TA-5431, etc.



Schematic Flow Diagram Units 1,3,5 (No Scale)



SCHEDULE OF PANEL MOUNTED CONTROL MATERIAL

Table with columns: Symb., Quan., and Catalogue Number and Description. Lists items like AL-110-0-0-1, AK-50005, AK-53198, etc.

Factory prewired 24" x 24" x 6 5/8" D surface mounted NEMA 1 enclosure with key lock. Locate in equipment Area Adjacent to respective unit.

SEQUENCE OF OPERATION

Air handling units 2, 3 & 4:

General Information:

Air Handling Unit No. 2 will handle interior classroom heating and cooling loads through Variable Volume air distribution boxes controlled by room thermostats. Air Handling Unit No. 4 will handle Library, Special and Administrative area heating and cooling loads through Variable Volume air distribution boxes controlled by room thermostats. Discharge air temperature is controlled by sensor in the supply air. Supply air sensor, through control devices in respective Local Control Panel will modulate the flow of water through the Dual Temperature coil to achieve stable control with change in control point reset from total system response. Changes in temperature of the water being circulated to the Dual Temperature coil and changing mode of operation from heating to cooling and vice versa is accomplished by control function of the Equipment Room Control panel. Refer to Sheet C of .

Safety Controls:

High temperature protection thermostat in the Return Air (F, set @ 125°F) and low temperature protection thermostat installed in serpentine manner on leaving air side of Dual Temperature coil (PA, set @ 40°F), will upon sensing of normal temperatures interrupt the Supply Air Fan starter control circuit and stop the fan.

Electrical interlocks will close the outside air damper and open the return air damper whenever the fan is stopped for any reason, and will permit operation of the mixing box dampers when the fan is running as described below.

Safety controls must be manually reset to restore normal operation after the cause for actuation has been corrected.

Normal Operation:

Control switch at the Central Communication Console is manually indexed to 'On' when operation of a particular Air Handling Unit is desired and indexed to 'Off' when it is desired that the Unit be inoperative when the building is not in use.

With switch in the 'On' position control relay at the starter, will, through the safety controls, energize the fan starter. Fan will operate continuously.

Heating:

With hot water being circulated to the dual temperature coil the control instruments and supply air sensor will operate in the heating mode. Upon initial start up variable Volume boxes, under control of respective zone thermostat, will be in the full heat position using full air capacity. Supply air duct static pressure sensor, with boxes handling maximum air, will have the supply air duct static pressure control damper closed and will have reset supply air sensor set point for highest scheduled supply air temperature.

As the temperature begins to rise in the areas served by individual Variable Volume boxes room thermostat will begin to modulate the VV box damper to reduce air flow. As air flow is reduced through the VV box the static pressure in the supply air duct will begin to rise. Pressure sensor in the supply air duct will begin to modulate the by-pass damper to maintain constant static pressure in the supply duct. At this point of 'system response' a pneumatic electric switch will be actuated which will complete the fan electrical interlock circuit and the mixed air dampers will position to handle 'minimum outside air'. As temperature continues to rise Variable Volume boxes air quantity will decrease. As box volume decreases static pressure will rise and more air will be spilled to the ceiling plenum by the bypass damper. With this condition occurring the set point of the supply air sensor will be set to the low end of the supply air schedule; modulating valve to the dual temperature coil will modulate to bypass all water around the coil. With valve in the bypass position the outside air damper will modulate from the minimum position toward the maximum outside air position with return air damper closing proportionately. As additional outside air is handled by the system pressure in the return air plenum will increase. An increase in the return air plenum will activate the pressure relief dampers in the Roof Ventilators and excess air will vent to atmosphere. Fall in temperature within the controlled areas will reverse the control sequence except that unit will continue to handle at least 'minimum outside air'.

Cooling:

Response will be as described above on demand for cooling. i.e., when space temperature is above set point of variable Volume box thermostat box will operate at maximum air flow.

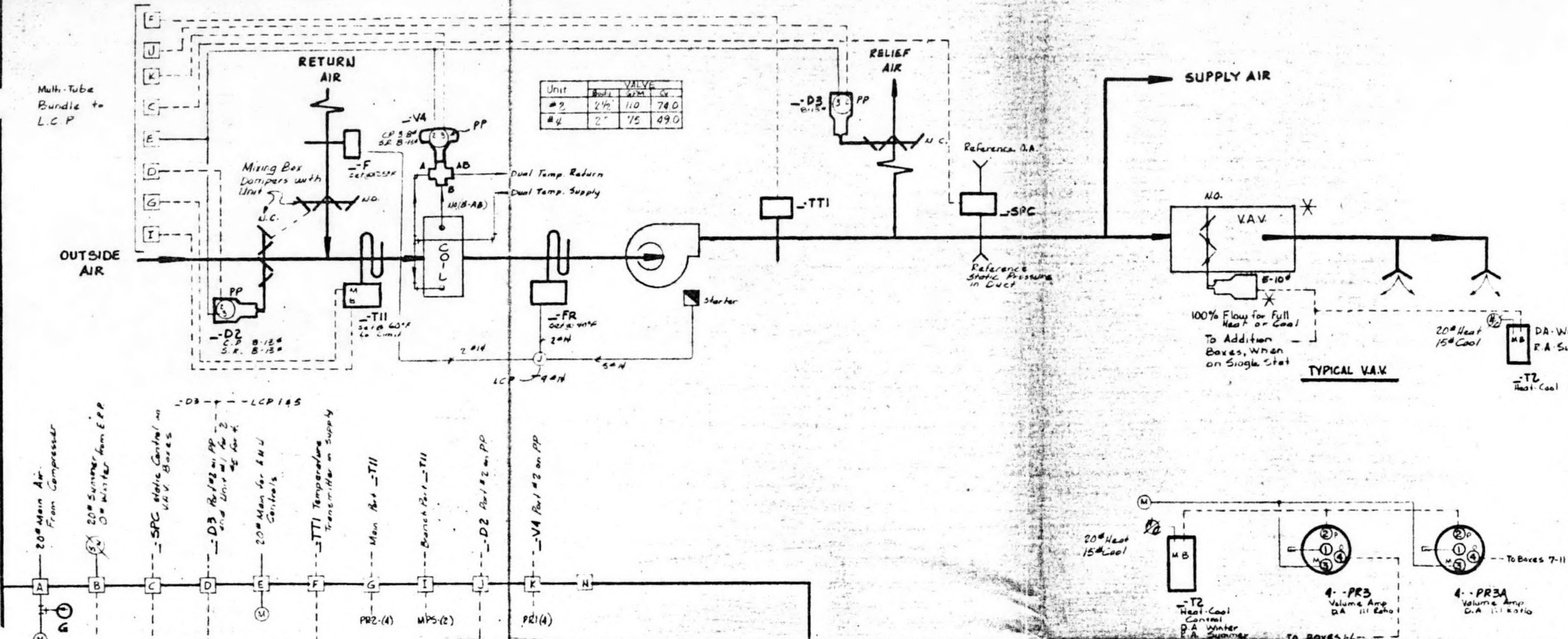
Outside air damper remains at the 'minimum outside air' position after initial 'system response' signal but the supply air sensor set point will be reset as 'system response' signal changes from maximum to minimum cooling demand.

Variable Volume Box Control:

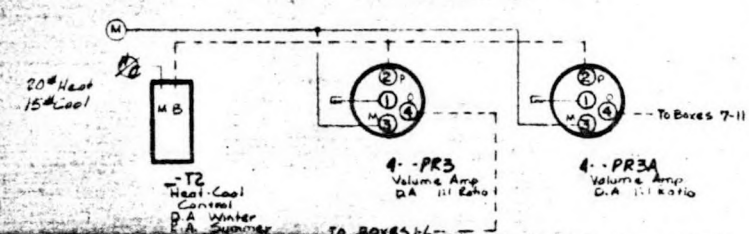
Individual boxes are controlled by separate room thermostats. Control function (Heating or Cooling) of the thermostat is changed through the Master 'Summer-Winter' control system in the Equipment Room Control Panel. Boxes will handle maximum air for maximum heating or cooling demand and will modulate to the minimum air quantity when the heating or cooling demand has been satisfied.

Supply Air Duct Static Pressure Control:

Differential pressure controller, reference to atmosphere and to the static pressure within the supply air duct, will, through control devices in the Local Control Panel: 1) Modulate the pressure relief to relieve excess air to the ceiling return air plenum and 2) reset the control point of the supply air temperature sensor to provide scheduled air temperatures comparable with system demand.



Unit	Model	Size	CR
#2	2 1/2"	110	74.0
#4	2"	75	49.0



VARIABLE VOLUME BOX CONTROL
(Quan. as Noted on Mech. Drawings)

SCHEDULE of FIELD MOUNTED CONTROL MATERIAL

SYMB.	QUAN.	DESCRIPTION
D1	2	MK-7121-400-0-1, Pneumatic Damper Actuator, Spring Range 8-13#, with Positive Positioner, Proportional Control.
U3	2	MK-3121-4-0-2, Pneumatic Damper Actuator, Spring Range 3-13#, with Positive Positioner, Proportional Control.
F	2	TA-3431, Manual reset, Fire Protection Thermostat, Scale 100-160°F Factory set and locked @ 125°F.
FR	2	TC-514, Low Temperature Limit Thermostat, Scale 34 to 60°F., 20' Vapor Filled Sensing Element, Manual Reset.
PR3	2	AX-5060, Direct Acting 1:1 Ratio Pneumatic Amplifying Relay.
T2	42	TK-1201-404-0-2, Pneumatic Room Thermostat, Heating/Cooling, Proportional Control, Scale 55-65°F with blank cover and concealed set point.
TI1	2	TK-4012, Pneumatic Bulb Thermostat with averaging element, Scale 30 - 90°, Low Limit sized air.
TT1	2	TKS-9014, Pneumatic temperature Transmitter, Duct Mounting, Range 0 - 100°F., Proportional Control.
SPC	2	PKS-2011, Pneumatic Pressure Transmitter, Range -.25 to 6.0" water gauge, Span 2.0" water gauge, proportional control.
VA	2	AK-501, static pressure probe, duct mounting.
VA	1	VK-8047-121-1-12, 2 1/2" GSP, 3-way water valve, Cv 74.0, with MK-6821-400, 8-1 1/2" actuator.
VA	1	VK-8047-121-1-11, 2" GSP, 3-way water valve, Cv 49.0, with MK-6821-400, 8-1 1/2" actuator.
PP	2	AK-5109-0-1, pneumatic Positive Positioner with -
PP	2	AM-506 positioner linkage kits for MK-6800 series actuators.

SCHEDULE of PANEL MOUNTED CONTROL MATERIAL
(Accumulative - 2 Panels)
Catalogue Number and Description

SYMB.	QUAN.	DESCRIPTION
EPI	2	AL-110-0-0-1, Solenoid Air Valve with 120-1-60 coil.
Fd	2	Busseman Manufacturing Type S30 Disconnect Switch with Fuseholder.
MPS	2	AA-50605, minimum Position pneumatic relay with AA-53198 Index Plate and adjusting knob.
PR1	2	AA-53198 'Minimum Outside Air' plate and adjusting knob.
PR1,2	4	RC-110, pressure electric switch, SPDT, range 3-30 psi.
PR1	4	AK-50401, 3-way switching pneumatic relay, set point adjustable with set fixed differential.
R/C1,2	2	AA-314A, 28%BAAC1 Enclosed, Pilot Duty, bracket Mounted Relay, SPDT with 120-1-60 coil.
R/C1,2	4	AA-3002, Pneumatic Receiver/Controller, Dual Input, proportional Control, range 0 - 100°F.
R/C3	2	AA-1001, pneumatic Receiver/Controller, Single Input, proportional Control, range 0 - 6"
T2	4	AL-362, 1 1/2" Pressure Gauge, 0 - 30w.

LOCAL CONTROL PANEL NO. (LCP-)

(Typical for 2)
Factory prewired/piped 36" x 24" x 6 5/8" D surface mounted NEMA 1 enclosure with key lock. Locate in equipment area adjacent to respective unit.

INSTALLATION NOTES

Refer to Sheet C3 of 7

		AIR HANDLING UNITS 2,4, V.A.V. BOXES	
		MACHINERY and EQUIPMENT SALES, Inc. 1303 -- 07 Chestnut Avenue Baltimore, Maryland 21211 (301) 889 -- 2370	
- REVISIONS - DATE CHANGES		JOB NAME PAGE JACKSON ELEMENTARY SCHOOL LOCATION Jefferson County, West Virginia ARCHITECT PICKETT SIESS & BOOK AIA ENGINEER John Lawrence CONTRACTOR P. R. POOLE & CO. DRAWN BY RM/sc CHECKED BY DATE February 18, 1977	
		DRAWING NO. BALTO -- 665 -- A10 Sheet C6 of 6	

OPERATION OF SYSTEMS

Fan Coil Unit Controls:

Air pressure main serving the wall thermostat will change the action of the thermostat to match the operation mode of the system.
 With hot water being circulated through the system the thermostat will have a heating function. On call for heat it will open the valve to the dual temperature water coil. When the valve is in the full open position the Fan Coil unit fan motor will start. Fan will continue to run until heat is not required and the valve is shut.
 With chilled water circulating in the system the thermostat will have a cooling function. On a call for cooling the valve will be opened. When the valve is full open the fan motor will be started. Fan motor continues to run until cooling demand is satisfied and the valve closes.

Equipment Room Ventilation:

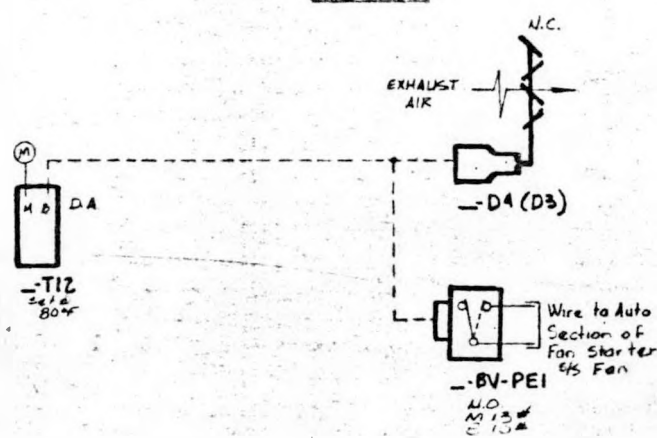
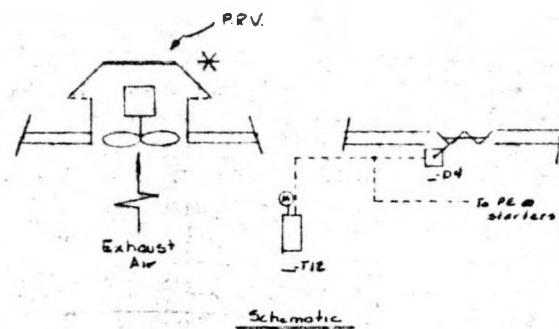
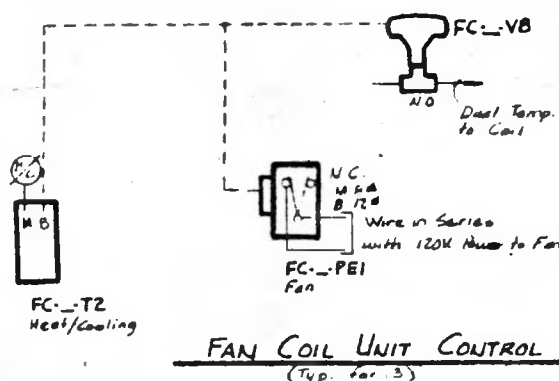
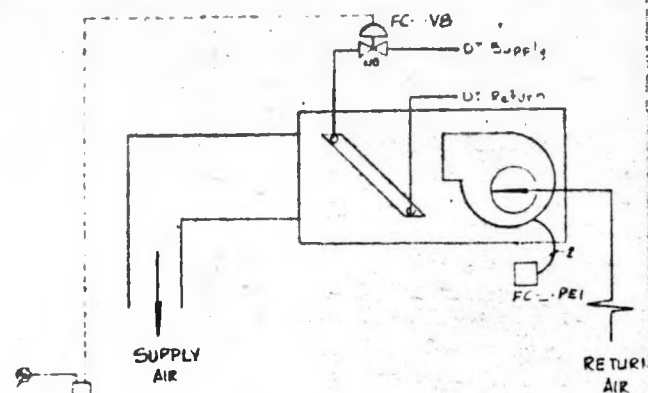
As the temperature in the space rises the wall thermostat will gradually open the outside air damper. When the damper reaches the full open position the Power Roof Ventilator motor will be started through the 'Auto' section of its magnetic starter control station. As temperature is reduced the fan will be stopped and the damper will modulate closed.

SCHEDULE of FIELD MOUNTED CONTROL EQUIPMENT

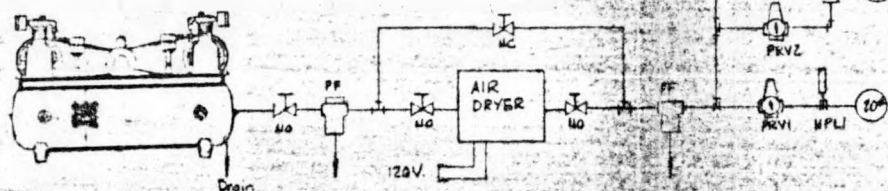
Symb.	Quan.	Catalogue Number and Description
D3	1	MK-4421, Proportioning Pneumatic Damper Actuator, Spring Range 8 - 15"
D4	1	MK-5121, Proportioning Pneumatic Damper Actuator, Spring Range 8 - 15"
T2	3	TK-1201-404-0-2, Pneumatic Room Thermostat, Heating/Cooling, Proportional Control, Scale 55-85°F with blank cover and concealed set point.
T12	1	TK-1201-404-1, Pneumatic Room Thermostat, Heating DA, Proportional Control, Range 55 - 85°F.
PE1	5	PC-110, Pressure Electric Switch, SFDT, Range 3-30 psig.
VB	3	VK-1114-221-4-4, 1/2" Radiator Valve, Straight Pattern, B.O., Cv 3.5, Proportional Control with MK-2690 Pneumatic Actuator.

INSTALLATION NOTES

Refer to Sheet C5 of 7.

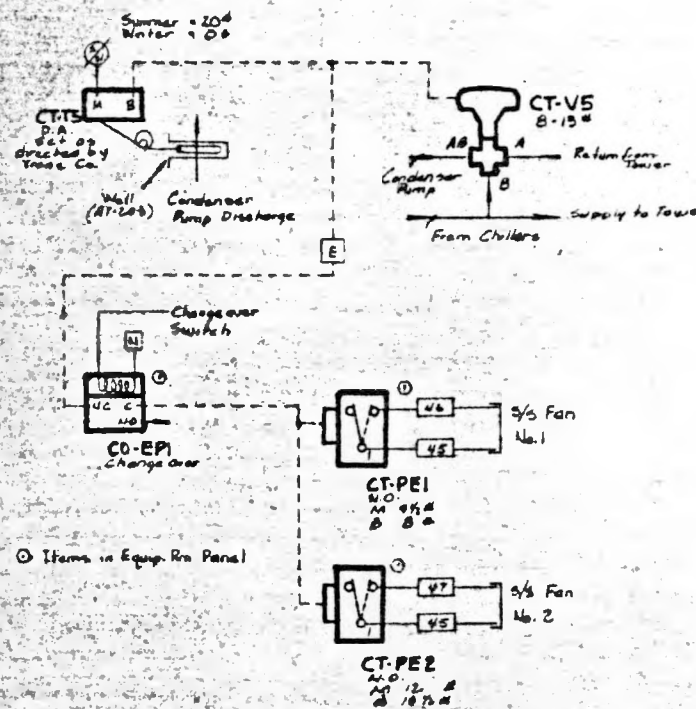
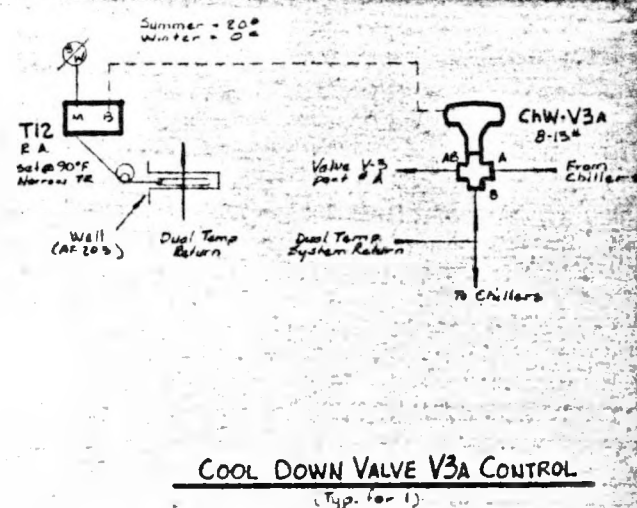
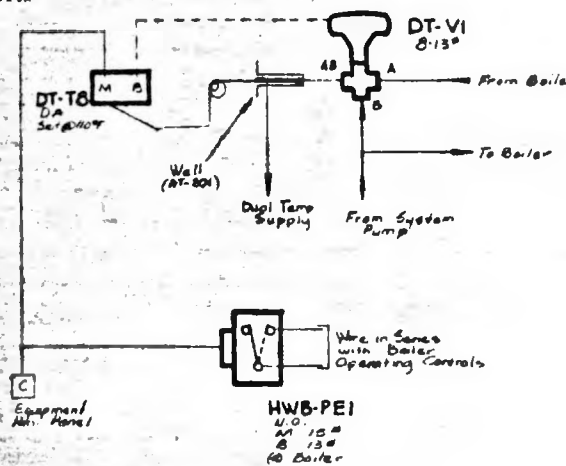


208-3-60 Constant power source from Panel WH Circuits 5 (Provided under Electrical Section)



Material:

- Compressor -- 1 ITT Model #K-216-6-11-3 Duplex Compressor, 7.8 CPM @ 90-80 PSI with 2 HP, 208-3-60 motor with Enclosed Belt Guard, 80 Gallon Tank, Automatic Tank Drain, Automatic Pressure Switch (60 - 80#), Magnetic Motor Starter with 3 overloads, Alternator switch with
- Dryer 1 Hankison Model #8010 Capacity 10 CPM
- FF, PF 2 AL-479, Absorbent prefilter and oil removal filters
- PRV1,2 2 AL-483, Pressure Regulator with --
- HPL-1,2 2 AL-322, Back sets Mounted Pressure Gauge (0-30#)
- AV1 2 AL-412, Air Pressure Relief
- 1 VK-3144-221-1-4, 1/2" Radiator VSP, Changeover Control, Pop Position Cv 3.3 with MK-2690 Pneumatic Actuator.



CONNECTION DETAILS

		FAN COIL UNIT, MECH. RM VENTILATION, AIR SUPPLY, COOL DOWN, AUX HEAT, COOL TOWER	
MACHINERY and EQUIPMENT SALES Inc.		3303 - 07 Chestnut Avenue Baltimore, Maryland 21211 (301) 899 - 2070	
REVISIONS	DATE	CHANGE	JOB NAME PAGE JACKSON ELEMENTARY SCHOOL
			LOCATION Jefferson County, West Virginia
			ARCHITECT PICKETT STESS & HOOK AIA
			ENGINEER JOHN LAWRENCE
			CONTRACTOR P. E. POOLE & Co.
			DRAWING NO. BALTO - 665 - 810
			CHECKED BY
			DATE February 18, 1977 Sheet C7 of 7.

OPERATION AND MAINTENANCE INSTRUCTIONS

IN GENERAL

Page Jackson has a dual source of energy for the heating and cooling of the building - solar and a conventional oil fired boiler which with the proper valves and controls is in line with the storage tanks and with a manual by-pass which exclude the tanks completely in a close loop.

There are eight pumps that make the system function. The first group of three (P-1, P-2 and P-3) are the cooling pumps.

- P-1 Cooling Tower Pump.
- P-2 Cooling Tower Pump 2, if needed, can be used as a backup for Pump 3 via manual by-pass of valves in the line.
- P-3 Cooling System Pump; note that this pump is in a close loop with A.H.U.'s and A.C. generators.
- P-4 Heating System backup.
- P-5 Main Heating System, and A.C.G. hot water supply in summer.
- P-6 Heating System backup; note that these three pumps are connected in a group and by-pass is completed via in-line manual valves.

And finally, the last group, the Solar H.W. Collection Pumps (P-7 - P-8).

- P-8 Emergency Solar Pump, which is activated manually only when the panels are getting over 300°F. and there is a power failure, and the Emergency Generator is "ON".

SOLAR MODE

P-7 is the main pump for this mode; no manual switching is needed to activate or deactivate this mode; it is done electronically. Two sensors, one in Tank #1, one in the first panel of Row #12 in the east side, are governing the Electronic Controller located in the Mechanical Room Main Panel Control.

When the sensor in the panel plate senses temperature ten degrees higher than tank water, the controller will energize P-7, and will remain ON as long as this differential is maintained.

When the sensor in the Water Tank senses temperature in the tank of only four degrees higher than the panel plate, the controller will de-energize P-7 and water flow through the system will stop. When P-7 is energized, a dump system is also energized through a timer that leaves the dump valve at the end of each row open for a period of 3 minutes, which leaves air out of each row until each row is full with water, so no airlock will be possible. When P-7 de-energizes, the dump system also de-energizes, opening the dump valves so all the water will flow back to the tanks, leaving the solar panels dry.

HEATING MODE

Operation:

Out of eight pumps, only P-4, P-5 and P-6 are in loop in this mode. P-5 is the Main Heating System Pump. Before this pump is turned on, various steps have to be taken.

First, the switch on the face of the Main Panel Control has to be set on "WINTER". This setting will put the system pumps, the A.H.U., the boiler and the storage tanks in loop. Filling of the loop with water is done automatically with the tank water. No other water supply is needed, since make-up water is accomplished through an automatic filler located on the face of Tank #1.

After the above has been accomplished, P-5 can be turned on, and the A.H.U.'s can be turned on for the various sections of the school at any time that the water temperature in the storage tanks falls below 120°, a modulating valve located at the right above the boiler will put the boiler into the loop in order to maintain the water temperature at 120°F. The controller for this valve is located on the face of A.H.U. #4. From time to time this controller has to be checked and corrected.

If at any time due to controls or other reasons the storage tank water has fallen below 90°, the boiler will not be able to make up 30° water for the tank and supply heat to the building. In these rare cases, it is advisable to put the manual tank by-pass into play. This way, the boiler will supply only the A.H.U., which would be enough to supply heat to the school while waiting for a sunny day to bring tank water up to a workable degree.

There is no need at night or weekends, when the school is not used, to have all the A.H.U.'s on, since only one can keep the school reasonably warm during such time. It has been found that A.H.U. #1 can do such job with a minimal waste of energy.

COOLING MODE

In order to cool the school, there are five steps to complete:

Step One - The cooling tower has to be filled with fresh water. The fresh water supply valve is located in the Tank Room overhead on the west side wall. Once this valve has been turned on, it has to stay on for the cooling season.

Step Two - Switch on the face of main panel control has to be set on "SUMMER".

Step Three - Cooling system loop (this includes P-3, A.H.U.'s and chillers), has to be filled with water not more than 80° and a heat pressure not less than 10 pounds has to be given to P-3. Filling the loop and giving pressure is accomplished by opening fresh water valve located right above the central chiller at left.

Step Four - Turn chiller pump on. This should activate P-1 and P-2 and cooling tower. These switches should ALWAYS be left on "AUTOMATIC".

Step Five - After making sure that the Centrovac is in good working condition, turn the switch on the chiller control panel to "ON". After the chiller has begun to cool water, turn the respective A.H.U. switches on. These switches are located on the east side of the Mechanical Room next to the boiler.

In order to turn the absorption chiller on after all the above steps have been taken, P-5 must be turned on. Note P-5 in the Summer Mode will not turn on if the solar water is less than 180°, and the absorption will not turn on if P-5 is OFF. Do not put P-5 on "MANUAL" in the "Summer Mode". Doing so will damage the absorption chiller. The absorption and Centrovac can be run in conjunction or one at a time. Do not attempt to turn "ON" either chillers if one of Step 1 through Step 4 has failed. To do so would damage equipment permanently.

GENERAL MAINTENANCE

Best performance and long life of equipment is achieved when equipment is properly and regularly maintained.

Pumps - Pumps should be checked for proper alignment yearly or when a different sound is noted. Pumps should be greased twice yearly with a good grade grease as per pump directions.

Pumps, Strainers and A.H.U. strainers - Should be cleaned yearly for proper water flow. In-line strainer in Centrovac should be cleaned before cooling season starts.

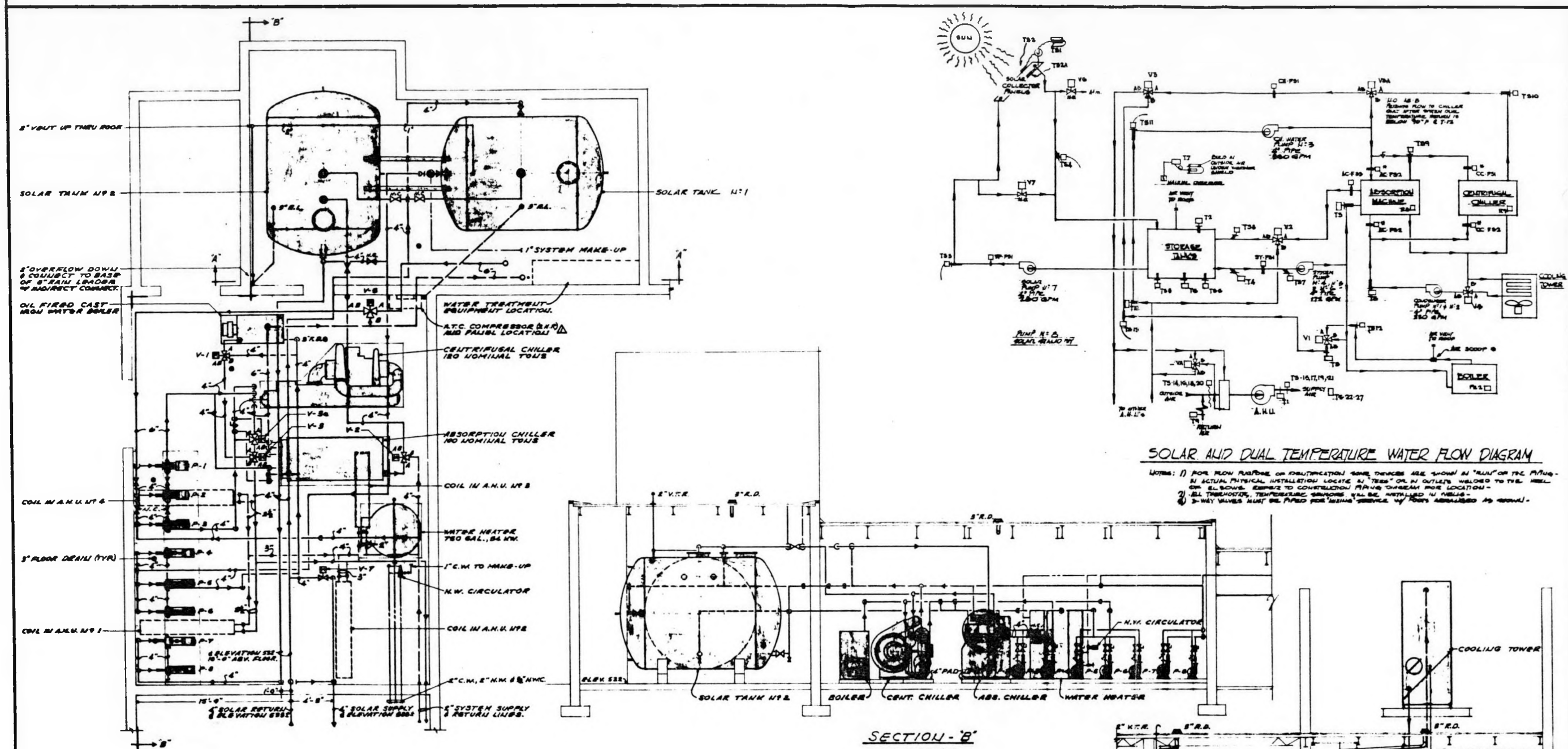
A.H.U.'s - A.H.U.'s bearings should be greased twice yearly and filters inside A.H.U.'s should be cleaned once a year.

Boiler - Boiler should be cleaned and checked once a year before heating season starts; nozzle of oil burner should be replaced yearly. The boiler has three electric switches - one in the breaker box in the Kitchen, one Emergency Switch in the Mechanical Room to the right of the front door, and one in the boiler control panel. All these switches have to be "ON" for the boiler to energize when called to do so.

Chillers - Chiller should be properly serviced by a qualified firm prior to cooling season. Since proper liquid level and vacuum pressures are the heart of the operation of the machines, it is important to have these and the chambers cleaned every year.

Proper water treatment is also important. Before starting the cooling tower, it is important to put in five gallons of cooling tower water treatment chemical. Make sure that you have enough supply in the drum that will last through the

season as it has to be fed daily through a chemical feeder in the cooling tower piping. Also, an oxidizer chemical has to be added to the solar water whenever it is needed. A chemical supplier representative will come from time to time to test the water and advise if more or less chemical is needed in the water; or a water test kit can be supplied for this purpose.



SOLAR AND DUAL TEMPERATURE WATER FLOW DIAGRAM

NOTES: 1) FLOW DIRECTIONS ON DISTRIBUTION MAINS DEVICES ARE SHOWN IN "SUN" OR THE "MAY" IN ACTUAL PHYSICAL INSTALLATION LOCATE IN "TWO" OR IN OUTLET WELDED TO THE WELLS OR ELBOWS. REFER TO CONNECTION MAINS OVERSEAS FOR LOCATION.
 2) ALL THERMOSTATS, TEMPERATURE SENSORS WILL BE INSTALLED IN MALLS.
 3) 3-WAY VALVES MUST BE PROVIDED FOR ISSUES SERVICE OF FLOORS ADJACENT AS SHOWN.

LOWER - EQUIPMENT ROOM PLAN
SCALE: 1/4" = 1'-0"

SECTION - B'
SCALE: 1/4" = 1'-0"

SECTION - A'
SCALE: 1/4" = 1'-0"

PUMP SCHEDULE							
UNIT NO.	DRIVE	GPM	HEAD	H.P.	Q.P.M.	BLUC.	REMARKS
P-1	COND.	890	68	10	1750	400-98	
P-2	COND.	890	68	10			P-2 STAND BY
P-3	COND.	890	68	10			
P-4	COND.	178	68	5			
P-5	COND.	178	68	5			
P-6	COND.	178	68	5			
P-7	SOLAR	280	49	5			P-7 ON EMERGENCY DISTRIBUTION
P-8	COND.	80	49	5			

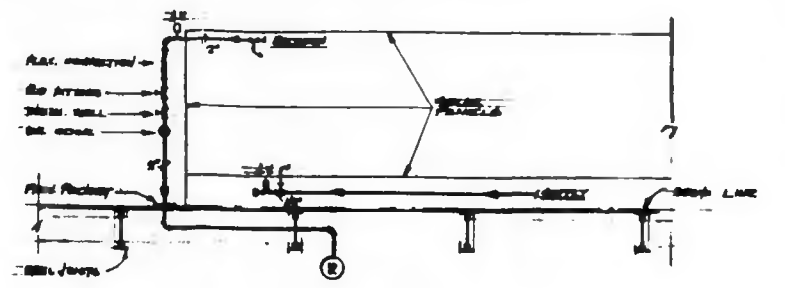
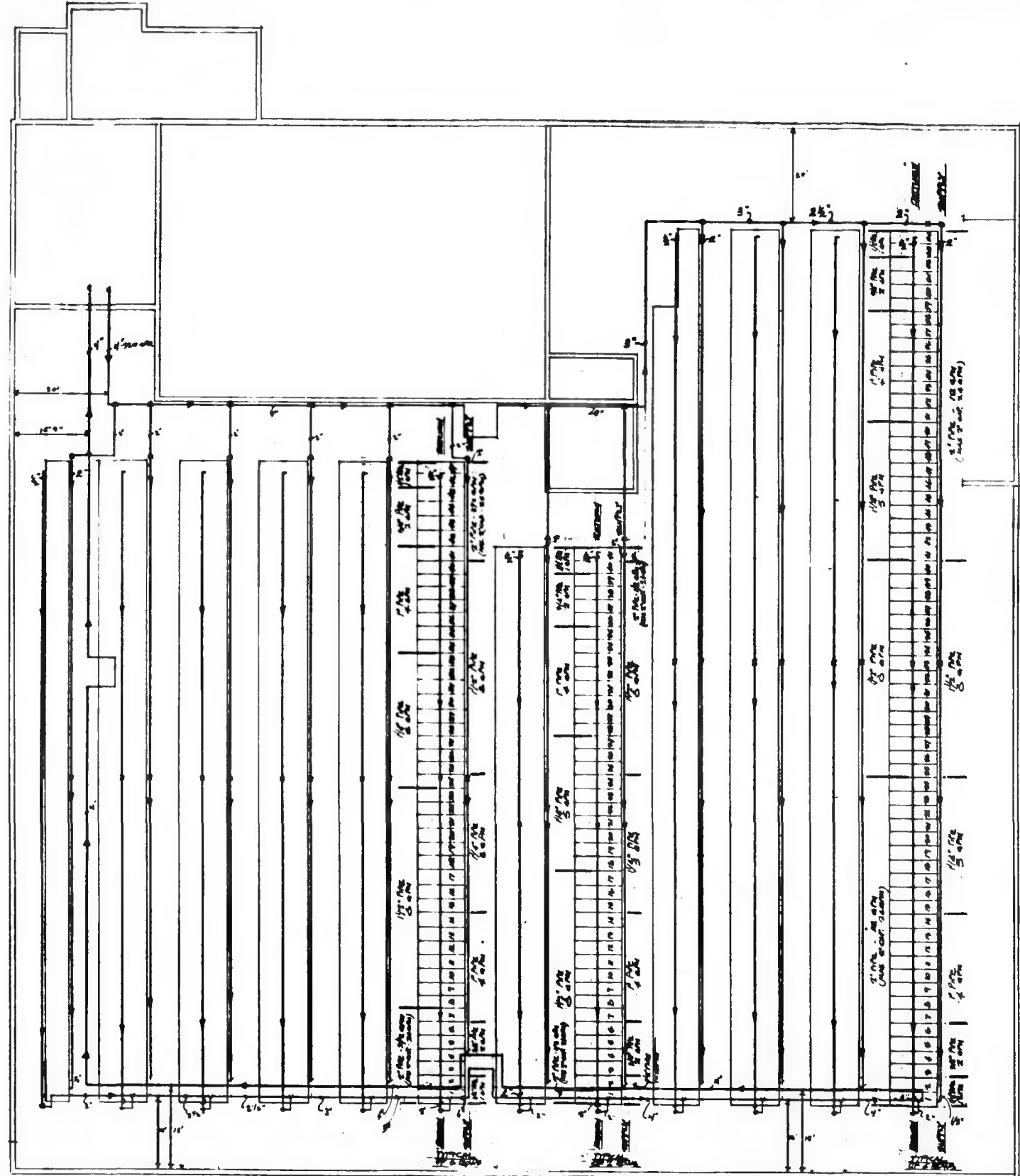
NOTE: 2 H.P. AIR COMPRESSORS TO BE ON EMERGENCY DISTRIBUTION PANEL.

AIR CONDITIONING UNIT SCHEDULE (A.H.U.)																
UNIT NO.	CFM	O.A. CFM	S.A.F. #20	COOLING				HEATING				G.P.M.	ELECT. KW	ELECT. PHASE		
				NET CAP. BTU/H	ENT. AIR DB	W.B. LVS.	WTE. TEMP. WNT.	NET CAP. BTU/H	ENT. AIR DB	W.B. LVS.	WATER TEMP. WNT.					
1	11200	1120	0.75	301,000	79.8	66.8	55	48	287,000	62.1	110	100	60	2 1/2	480	3P
2	17700	2900	1.18	547,000	80.0	66.9	55	48	276,000	61.9	110	100	110	3 1/2	480	3P
3	5000	1200	0.48	228,000	80.9	66.9	58	48	164,500	60.75	110	100	45	2 1/2	480	3P
4	12800	800	0.4	274,000	77	66	58	48	160,500	61.6	110	100	75	3 1/2	480	3P
5	2280	200	0.75	64,000	77.8	66.3	58	48	38,600	61.8	110	100	14	1 1/2	480	3P

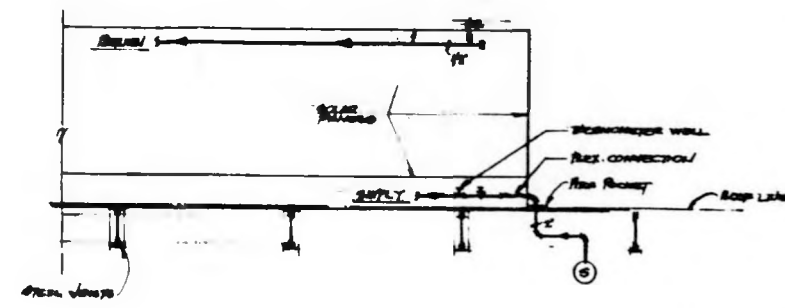
FAN COIL SCHEDULE																
UNIT NO.	CFM TOTAL	COOLING				HEATING				ELECTRICAL	REMARKS					
		NET CAP. BTU/H	ENT. AIR DB	W.B. LVS.	WTE. TEMP. WNT.	NET CAP. BTU/H	ENT. AIR DB	W.B. LVS.	WATER TEMP. WNT.							
1, 2, 3	129	75	68	58	87	84	64	2.6	70	110	100	5	F	1/2	120	1P

CHILLER SCHEDULE																	
UNIT NO.	TONS	REFRIGERANT				POLYMER	CONDENSER				EVAPORATOR				ELECT. DATA		
		ENT. DB	ENT. W.B.	ENT. WTE.	ENT. WNT.		ENT. DB	ENT. W.B.	ENT. WTE.	ENT. WNT.	ENT. DB	ENT. W.B.	ENT. WTE.	ENT. WNT.			
CH-1	110	86	66	53.0	10	0.008	85	75	180	10	-	-	-	108.2	480 V	3P	
CH-2	100	86	66	53.0	0	0.008	85	75	270	8.1	120	116	150	8.1	7.8	480 V	3P

1/2 NOMINAL TONS - ACTUAL TONS (DETERMINED) BY 3 TONS



RETURN PIPING DET. - NO SCALE



SUPPLY PIPING DET. - NO SCALE

SOLAR PANEL PIPING SIZE

SCHEDULE (A)

- SUPPLY -

Panel	Number of Panels	Panel Size
1 row 2	2	12' - 1.67m
2 row 4	4	12' - 2.00m
3 row 6	6	12' - 2.33m
4 row 8	8	12' - 2.67m
5 row 10	10	12' - 3.00m
6 row 12	12	12' - 3.33m
7 row 14	14	12' - 3.67m
8 row 16	16	12' - 4.00m
9 row 18	18	12' - 4.33m
10 row 20	20	12' - 4.67m
11 row 22	22	12' - 5.00m
12 row 24	24	12' - 5.33m

- RETURN -

Panel	Number of Panels	Panel Size
1 row 2	2	12' - 1.67m
2 row 4	4	12' - 2.00m
3 row 6	6	12' - 2.33m
4 row 8	8	12' - 2.67m
5 row 10	10	12' - 3.00m
6 row 12	12	12' - 3.33m
7 row 14	14	12' - 3.67m
8 row 16	16	12' - 4.00m
9 row 18	18	12' - 4.33m
10 row 20	20	12' - 4.67m
11 row 22	22	12' - 5.00m
12 row 24	24	12' - 5.33m

SCHEDULE (B)

- SUPPLY -

Panel	Number of Panels	Panel Size
1 row 2	2	12' - 1.67m
2 row 4	4	12' - 2.00m
3 row 6	6	12' - 2.33m
4 row 8	8	12' - 2.67m
5 row 10	10	12' - 3.00m
6 row 12	12	12' - 3.33m
7 row 14	14	12' - 3.67m
8 row 16	16	12' - 4.00m
9 row 18	18	12' - 4.33m
10 row 20	20	12' - 4.67m
11 row 22	22	12' - 5.00m
12 row 24	24	12' - 5.33m

- RETURN -

Panel	Number of Panels	Panel Size
1 row 2	2	12' - 1.67m
2 row 4	4	12' - 2.00m
3 row 6	6	12' - 2.33m
4 row 8	8	12' - 2.67m
5 row 10	10	12' - 3.00m
6 row 12	12	12' - 3.33m
7 row 14	14	12' - 3.67m
8 row 16	16	12' - 4.00m
9 row 18	18	12' - 4.33m
10 row 20	20	12' - 4.67m
11 row 22	22	12' - 5.00m
12 row 24	24	12' - 5.33m

SCHEDULE (C)

- SUPPLY -

Panel	Number of Panels	Panel Size
1 row 2	2	12' - 1.67m
2 row 4	4	12' - 2.00m
3 row 6	6	12' - 2.33m
4 row 8	8	12' - 2.67m
5 row 10	10	12' - 3.00m
6 row 12	12	12' - 3.33m
7 row 14	14	12' - 3.67m
8 row 16	16	12' - 4.00m
9 row 18	18	12' - 4.33m
10 row 20	20	12' - 4.67m
11 row 22	22	12' - 5.00m
12 row 24	24	12' - 5.33m

- RETURN -

Panel	Number of Panels	Panel Size
1 row 2	2	12' - 1.67m
2 row 4	4	12' - 2.00m
3 row 6	6	12' - 2.33m
4 row 8	8	12' - 2.67m
5 row 10	10	12' - 3.00m
6 row 12	12	12' - 3.33m
7 row 14	14	12' - 3.67m
8 row 16	16	12' - 4.00m
9 row 18	18	12' - 4.33m
10 row 20	20	12' - 4.67m
11 row 22	22	12' - 5.00m
12 row 24	24	12' - 5.33m

- NOTES
- 1) - BASIC FLOW RATE = 1/2 GPM PER PANEL -
 - 2) - ALL PIPING SHALL BE L-COPPED PIPE -
 - 3) - MAINS TO FALL BACK IN MECHANICAL ROOM -

SOLAR PANELS SUPPLY & RETURN PIPING PLAN SCALE 1/8" = 1'-0"