(NASA-CR-161357) SOLAR HEATING SYSTEM DESIGN PACKAGE FOR A SINGLE-FAMILY RESIDENCE AT WILLIAM O'BRIEN STATE PARK, MINNESOTA (Honeywell, Inc.) 173 p HC A08/MF A01 CSCL 10A G3/44

N80-20866

Unclas 47622

DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-161357

SOLAR HEATING SYSTEM DESIGN PACKAGE FOR A SINGLE-FAMILY RESIDENCE AT WILLIAM O'BRIEN STATE PARK, MINNESOTA

Prepared from documents provided by

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Under Contract NAS8-32093 with

National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy

U.S. Department of Energy

Solar Energy

CONTENTS

SECTION 1

1.0 COST TRADE STUDIES

A. SOLAR HEATING SYSTEM DESIGN YEAR

A base solar year for the design of the solar heating system and demonstration of solar capabilities was sought for the site at William O'Brien State Park in Minnesota. Minneapolis-St. Paul climatological data for the years 1949-1975, inclusive, were analyzed. Also daily averages (by month) of solar energy incident on a horizontal surface at St. Cloud, Minnesota were used as an additional aid and are given in the following table.

Daily Averages of Solar Energy Received on a Horizontal Surface (monthly) for Latitude 46° N*

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
627	878	1461	1734	2070	2066	2118	1667	1343	1048	646	561

* Averages are BTU/ft^2 - day

From an abundance of weather parameters available, the minimum number that would provide a good estimate of heating seasons was sought. The following parameters were used:

1. Number of clear and partly cloudy days for each month.
2. Average sky cover indicator for each month.
3. Percent of possible sunshine for each month.
4. Degree days for each month.
5. Ratio of degree days-to-average solar incidence for each month.

Parameter 5 is defined as:

$$\frac{\text{Degree Days}}{\text{Avg. Incidence}} = \frac{\text{Monthly Degree Days}}{(\text{Possible Sunshine/Mo.})\ (\text{Daily Avg. Solar Incidence})}$$

This parameter, as defined, does not take into account the number of days in each month. However, since the number of days in a given month changes only slightly from one year to another, insignificant error is anticipated when the parameter is used for comparison purposes. Also, since the total number of days is the same for each year, a correcting effect is anticipated when summing monthly totals to give final yearly results.

An eight month heating season was selected for the William O' Brien site. Table 2 shows a monthly and yearly summary of the parametric results for the years 1957, 1958, 1959, 1960, 1964, 1966 and 1974. These years were the final candidates selected after a preliminary elimination analysis based on a four core month heating season. The four core months were January, February, November, and December; they account for approximately 66% of the total yearly heating load.

Figure 1 shows a yearly comparison of the results given in Table 1. For solar demonstration purposes, a heating season with both high degree days and low ratio degree days-to- possible solar incidence is desirable The year 1964 meets both of these requirements for solar demonstration purposes while 1958 meets the latter one. The year 1958 was selected for three reasons: (1) it appeared to be a good solar insolation year, (2) results based on 1958 would be more representative of typically expected years than 1964, and (3) the information for 1958 was immediately available. Also, some preliminary system trade off analysis had been done with 1957 weather data, again because of weather tape availability.

Referring to Table 1, the year 1958 showed 1519 maximum monthly degree days in December. Also, the coldest months of the season in the site area, January and February, indicate that the winter probably was relatively warm. In 1966, January showed 1909 degree days as compared to 1311 for the year 1958. Therefore, it was anticipated that the design day (coldest day of year) for 1958 would give a design heating load lower than normally predicted for the site area.

B. SITE ENERGY CONSERVATION MODIFICATIONS

Initial calculations to determine the sensible heating load and the load due

TABLE 1. SUMMARY OF PARAMETERS FOR DETERMINATION OF HEATING SEASON FOR WM. O' BRIEN SITE

TABLE 1 SUMMARY OF PARAMETERS FOR DETERMINATION OF HEATING SEASON FOR WM. O' BRIEN SITE

Year		Total	Jan.	Feb.	March	April	Sept.	Oct.	Nov.	Dec.
1974	Clear/P. Cloudy	54/68	7/9	9/4	2/10	3/5	10/12	8/10	4/9	6/9
	Avg. Sky Cover		6.3	6.2	7.7	6.6	5.1	6.0	7.1	6 7
	Pct. of Possible		60	63	51	56	62	58	37	54
	Degree Days	7554	1642	1344	1092	525	289	467	[illegible]33	1252
	D. D./Avg. Incidence	17.9	4.3	2.4	1.5	0.55	0.35	0.77	3.9	4.1
1966	Clear/P. Cloudy	68/ 0	11/7	9/6	8/4	5/8	9/12	12/4	7/4	9/5
	Avg Sky Cover		5.7	5.9	6.9	7.6	5.4	5.8	7.0	6.4
	Pct. of Possible		61	66	47	41	70	60	39	46
	Degree Days	8053	1909	1358	899	678	135	536	1042	1446
	D. D./Avg. Incidence	29.3	5.9	2.3	1.3	0.95	0 20	0.85	4.1	5.6
1964	Clear/P. Cloudy	66/72	12/9	12/7	6/11	6/6	9/10	10.9	6/12	5/8
	Avg. Sky Cover		5.0	5.0	6.6	7.1	5.9	5.3	5.9	7.0
	Pct. of Possible		60	73	63	62	54	56	52	49
	Degree Days	7512	1390	1186	1209	543	224	515	894	1551
	D. D./Avg. Incidence	16.8	3.7	1.8	1.3	0.51	0.31	0.88	2.7	5.6
1960	Clear/P.Cloudy	58/64	10/3	8/7	9/9	4/11	13/6	13/8	5/9	6/11
	Avg. Sky Cover		6.6	6.0	5.8	7.1	5.1	4.5	7.1	6.6
	Pct. of Possible		48	64	58	45	56	70	50	59
	Degree Days	7938	1467	1364	1395	574	202	503	943	1490
	D.D. Avg. Incidence	18.0	1.9	2.4	1.6	0.74	0.27	0.69	2.9	4.5
1959	Clear/P.Cloudy	54/67	9/11	8/6	7/9	7/8	10/8	5/5	3/9	4/9
	Avg. Sky Cover		5.7	5.7	6.6	6.6	5.8	7.4	7.5	7.4
	Pct. of Possible		67	72	65	56	57	37	49	47
	Degree Days	7546	1686	1334	956	530	152	634	1181	1073
	D.D./Avg.Incidence	17.3	4.0	2.1	1.0	0.55	0.2	1.6	3.7	±.1
1958	Clear/P.Cloudy	78/60	10/4	12/8	10/4	7/12	10/10	12/7	7/9	10/6
	Avg. Sky Cover		6.1	4.4	6.1	5.8	5.3	5.2	6.1	5.8
	Pct. of Possible		45	71	51	62	65	64	49	62
	Degree Days	7049	1311	1383	980	507	108	370	871	1519
	D.D./Avg. Incidence	16.5	4.6	2.2	1.3	0.47	0.12	0.61	2.8	4.4
1957	Clear/P. Cloudy	63/66	9/9	8/7	6/12	7/12	11/10	9/5	5/4	8/7
	Avg. Sky Cover		5.7	6.3	6.3	6.0	5.0	6.7	7.7	6.7
	Pct. of Possible		62	52	62	66	63	41	27	44
	Degree Days	7422	1698	1241	1065	545	184	500	963	1226
	D. D./Avg. Incidence	20.7	4.4	2.7	1.2	0.48	0.22	1.2	5.5	5.0

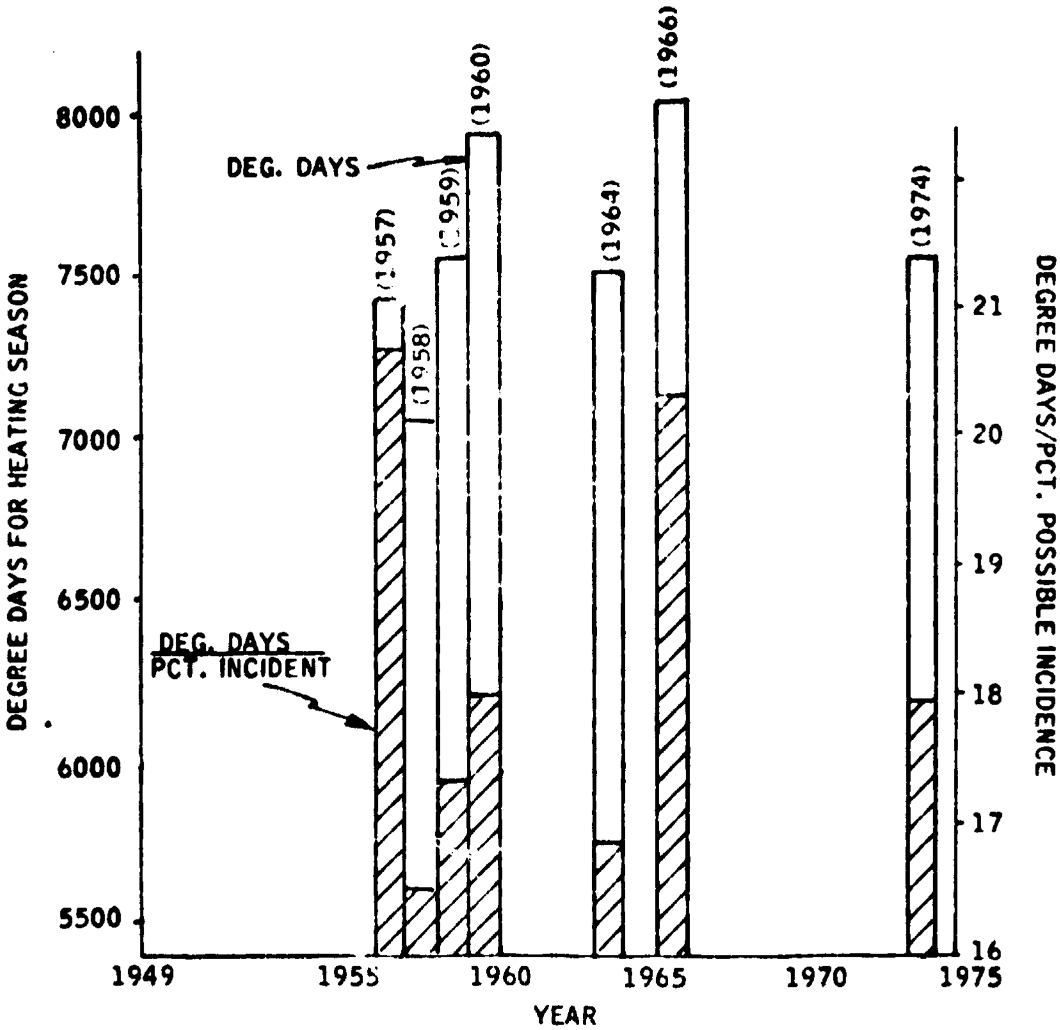

FIGURE 1
HEATING SEASON SELECTION FOR
WILLIAM O'BRIEN SITE

to infiltration were performed for the William O'Brien site as it originally existed. Calculation results showed the following conditions:

UA = 750 BTU/Hr. - ^{o}F (approx.)

Infiltration = 125 cfm (approx.)

Simulation heating load analysis showed that, with 28 collector modules (504 sq. ft.), less than a 30% solar contribution could be expected. Therefore, energy conservation measures were needed to make the site feasible for solar assisted heating.

The following energy conserving measures will be made at the retrofit solar heating site.

1. All windows on the house are single glaze but have storm windows added during the heating season. Due to the age of the structure (20± years), weatherstripping will be done on all windows exposed to outdoor conditions.
2. The attic presently has only 4 inches of loose fill insulation. Six more inches of insulation will be added in the attic.
3. The air duct in the present tuck-under garage, an unheated space, is uninsulated. Fiberglass blanket insulation (1 inch thick) will be provided.
4. The walls of the exposed basement consist of 12 inch thick concrete block and are a large contributor to the total sensible heat loss from the building. This interior wall envelope will have 1 1/2 inch styrofoam insulation and 5/8 inch gypsum board added.
5. The main building walls have only 2 inches of fiberglass insulation; more insulation should be added. Such a renovation would be quite costly, and therefore these walls will be left in their existing condition.

6. The new addition to the house will be a garage; the present tuck-under garage will be modified to house solar equipment. The present garage door will be closed with concrete blocks, and a window will be installed in its place. Also, two of the presently exposed walls will have 3/4 inch styrofoam insulation added, and the north facing wall will be finished with 5/8 inch gypsum board. This space will remain unheated.

7. The collector stand will be an integral part of the south facing residential wall. Both ends of the structure shall be closed off, and therefore, it will serve as a buffer shielding a large portion of the south wall of the house from environmental conditions.

With these proposed changes, a substantial decrease in sensible heat loss and also a decrease in infiltration losses was obtained. Calculations show the following conditions:

UA = 460 BTU/hr. - °F (approx.)
Infiltration = 110 cfm (approx.)

The first parameter was reduced by 39% and the latter by 12% from the values for the original building prior to the energy conservation innovations.

C. SOLAR HEATING SYSTEM OPTIMIZATION

A computer simulation model for the Wm. O'Brien solar heating site was analyzed, and results were obtained such that components optimization could be made. The system was analyzed for years 1957 and 1958 with final results based on the year 1958. Also the energy conservation improvements described earlier were implemented in the simulation model.

The system tradeoff study consisted of checking the effect on space heating and DHW contribution by solar energy for variations in the following parameters:

1. Collector area
2. Storage tank size
3. Storage tank setpoint temperature
4. Collector-side heat exchanger and solar heating coil effectiveness
5. Collector loop flow rate
6. DHW solar coil in storage tank.

Not all parameters were checked individually. Previous analyses had shown that small gains could be expected by increasing the individual heat exchanger effectiveness above .6 and that the load-side heat exchanger had a larger effect on increasing system performance. Also, from previous analyses, system flow rates were set to approximately 12 gpm in the collector loop and 8 gpm in both the direct heating and heating from storage loops. Of the three flows, the variation of collector loop flow rate has the dominant effect on increasing system performance. Therefore, only the collector loop flow variation was considered for optimization analysis.

Results of system component tradeoff analysis for total system optimization are summarized in Table 2. The effect of solar base year selection can be noted. The performance of the intially proposed solar heating system for the year 1957 was 44.4% (#1) and 46.5% (#6) for the year 1958. This was entirely due to 1958 being a better solar year. The solar energy collected was 7.7% more even though the collection efficiency was lower, 23% compared to 24.3%. Therefore, the selection of a base year for solar energy demonstration can be a factor. It is desirable to naturally have high solar incidence. However, it is just as important to have a good load heating season to reflect actual conditions that may be encountered.

The effect of varying all of the listed parameters except collector area is shown in simulation runs #2 to #5. Simulation run #2 shows the unfavorable effect of having no DHW coil inside the storage tank. Simulation runs #3, #4, and #5 show only a modest gain in total solar contribution for large changes in all parameters except collector area. These results indicate the need for more collector modules for solar energy to provide a reasonable portion of the house total energy load.

Simulation runs #6, #7, and #8 show the effect of increasing collector area from 504 sq. ft. (28 modules) to 594 sq. ft. (33 modules) to 648 sq. ft. (36 modules). The benefit is reflected mainly by the improvement in solar space heating contribution, and this is shown in Figure 2. Although the results indicate an advantage of having 648 sq. ft. of collector area, site space limitations dictated that a maximum of 33 collector modules can be installed.

Due to the space limitation imposed on the collector surface area, additional solar benefits were sought elsewhere. Simulation runs #9, #10, and #11 show

TABLE 2. WM. O' BRIEN SITE TRADE-STUDIES SUMMARY

Simulation Runs	Year	Collector Area (sq. ft.)	Collector Flow (gpm)	Storage Volume (gal.)	Storage Setpoint Temp. (°F)	HX Effectiveness		House Load		Solar Energy Collected (MBTU)	Solar Contribution			Collection Eff. (%)
						Col. Side	Load Side	Space Htg. (MBTU)	DHW (MBTU)		Sp. Htg. (%)	DHW (%)	Total (%)	
1	1957	504	12	750	100	.6	.6	81.4	22.2	45.8	39.0	64.4	44.4	24.3
2	1957	504	12	750	100	.6	.6	81.4	22.2	35.3	43.5	0.	34.2	18.7
3	1957	504	12	750	90	.6	.6	81.4	22.2	46.8	41.1	61.5	45.5	24.8
4	1957	504	12	750	100	1.0	1.0	81.4	22.2	47.7	41.1	65.0	46.2	25.3
5	1957	504	15	1000	90	.7	.7	81.4	22.2	48.0	42.7	61.3	46.7	25.4
6	1958	504	12	750	100	.6	.6	78.6	22.2	46.9	40.1	69.3	46.5	23.0
7	1958	594	12	750	100	.6	.6	78.6	22.2	50.3	43.1	73.9	49.9	20.9
8	1958	643	12	750	100	.6	.6	78.6	22.2	51.7	45.5	72.0	51.3	19.7
9	1958	594	12	1000	100	.6	.6	78.6	22.2	51.6	44.7	74.2	51.2	21.4
10	1958	594	12	1000	90	.6	.6	78.6	22.2	52.5	46.6	71.7	52.2	21.8
11	1958	594	12	1000	95	.6	.6	78.6	22.2	52.1	45.7	72.9	51.7	21.6

Results with energy conservation modifications added to site and new DHW coil in storage tank.

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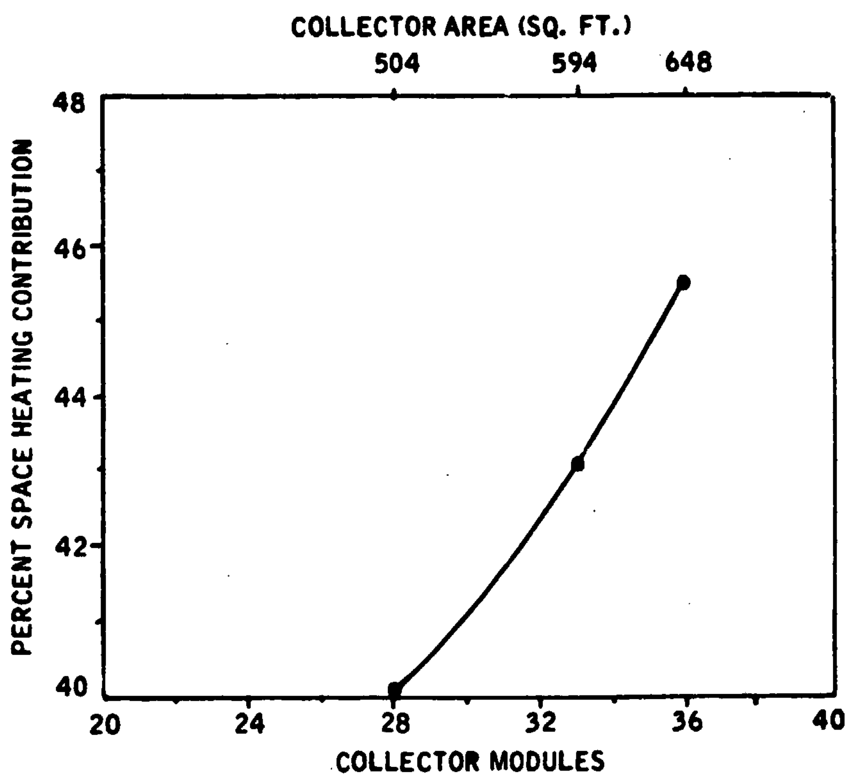


FIGURE 2. EFFECT OF COLLECTOR AREA (MODULES) ON SPACE HEATING CONTRIBUTION.

the gain in solar contribution by increasing the storage tank size to 1000 gallons capacity and decreasing the storage setpoint temperature for space heating from storage. Based on these results, a 1000-gallon storage tank size has been selected for the solar heating system. The solar gain here is due to the large number of hours spent in the heating-from-storage mode, and therefore, a larger storage tank size is beneficial.

The improvements in solar contribution due to a decrease in storage setpoint temperature are given in Table 3. Tables 4 and 5 summarize the yearly power expenditures for the heating site as a function of storage tank setpoint temperature.

By going to a 90^{o}F setpoint temperature, an additional 0.9 MBTU of energy are gained. This would amount to approximately $2 in fuel value. However, an additional 106 KW-HR of electricity are expended at a cost of approximately $4.50. Therefore, no economic advantage is gained in reducing the setpoint.

Based on simulation results and power consumption estimates for the solar heating system, the following design conditions are recommended for solar system components:

- Collector area of 594 sq. ft.
- Storage tank size of 1000 gallons
- Storage tank setpoint temperature of 100^{o}F
- Collector-side heat exchanger effectiveness of approximately 0.6.
- Collector loop flow rate of 12 gpm.

TABLE 3. EFFECT OF STORAGE SETPOINT TEMPERATURE ON THE PERFORMANCE OF SOLAR HEATING SYSTEM

Storage Setpoint Temp. (°F)	Space Htg. Load (MBTU)	DHW Load (MBTU)	Solar Contribution Space Htg. (MBTU)	Solar Contribution DHW (MBTU)	Solar Contribution Total (MBTU)	Solar Improvement (MBTU)
100	78.6	22.2	35.1	16.5	51.6	- -
95	78.6	22.2	35.9	16.2	52.1	.5
90	78.6	22.2	36.6	15.9	52.5	.9

TABLE 4. WM. O' BRIEN SITE POWER EXPENDITURES FOR DIFFERENT MODES OF OPERATION

Mode	Operation	KW/Mode	100°F Hours	100°F KW-HRS	95°F Hours	95°F KW-HRS	90°F Hours	90°F KW-HRS
1	Idle	.048	5630	271	5564	268	5492	264
2	Direct Heating	.956	254	243	254	243	253	243
3	Htg From Storage	.726	699	508	784	570	892	648
4	Charge Storage	.486	925	450	928	451	928	451
5	Purge	.482	723	349	721	348	712	344
8	Aux. Heating	.518	478	248	459	238	433	225

TABLE 5. WM. O' BRIEN SITE YEARLY ENERGY SUMMARY

Storage Setpoint Temp. (°F)	System Power Consumption (KW-HRS)	Net Solar Contribution (MBTU)	Power Consump. Difference (KW-HR)
100	2069	51.6	- -
95	2118	52.1	49
90	2175	52.5	106

D. HEATING SYSTEM COMPONENT SELECTION

The following tradeoff considerations analyzed for the important parts of the heating system are discussed:

- Domestic hot water heating coil
- Hot water heater
- Auxiliary furnace
- Pumps
- Insulation
- Heat transfer fluids

DHW Solar Heating Coil

A tradeoff comparison was made between using plain copper tubing and integral low-finned copper tubing as the preheat coil in the storage tank. As a result of the study, a Wolverine 60-196042-01 integral low-finned copper coil 33 ft. long was recommended. A recent analysis showed an advantage in using a higher-finned coil, Wolverine 66-116038-01. With the latter coil, the same heating benefit can be obtained with a 5 ft. shorter coil. This would result in saving both material and manufacturing costs and would require less space in the storage tank.

A 33 foot long Wolverine Type W/H, 66-116038-01, coil is recommended for use in the storage tank. The same length is specified as the previous coil, and therefore, the design condition has been improved. For a 160°F storage tank water temperature and 50°F tap water, the improvement is from 125°F coil outlet temperature to 133°F. This design point change is due to the fact that the only benefit from the system during late spring, summer, and early fall months is hot water heating. Therefore, the change was made to provide all hot water needs during the non-heating season portion of the year. Figures 3 and 4 show the performance improvement of the new coil.

Conventional Hot Water Heater

The hot water demand for the Wm. O'Brien site was obtained from an averaging procedure using the results presented in Figure 5. The daily hot water consumption was approximated at 20 gallons per person. The total demand became 80 gallons of hot water required daily for the site. To meet this requirement, a 40-gallon capacity hot water heater was specified for the Wm. O'Brien site.

Auxiliary Furnace

Based on simulation results for the year 1958, the peak heating load occurred on February 12 and was 46,000 BTUH. The minimum temperature was -12^{o}F, this is above the -19^{o}F design day temperature specified for Minnesota. Gas furnace sizes with 50,000 BTUH and 65,600 BTUH bonnet output were available from the Lennox G11 series. The model with the larger heating capacity was selected so that heating demands would be met for all heating seasons encountered at the site.

From previous analyses, an air volume of 1000 cfm for space heating purposes was determined. To pass this air volume through the furnace and solar coil, and existing ducting in the residence, a blower speed setting of "medium high" is used. This will leave approximately 0.3 in. of water external static pressure to overcome ducting flow resistance.

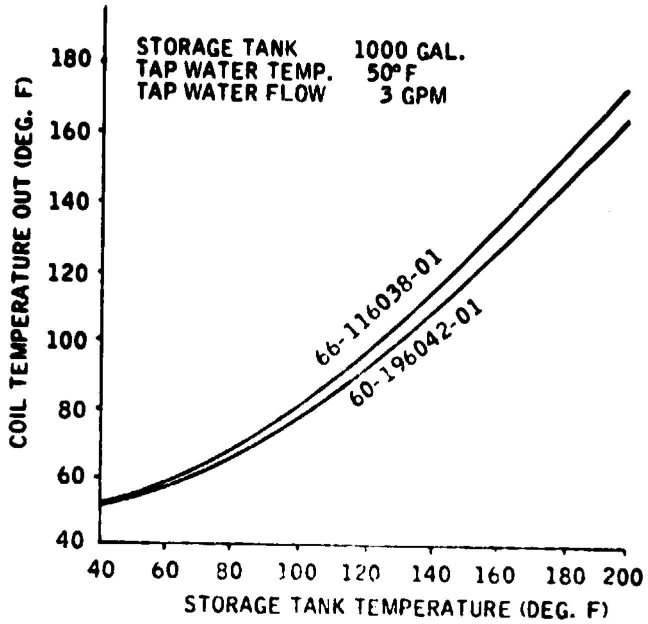


FIGURE 3. HEATING COIL PERFORMANCE

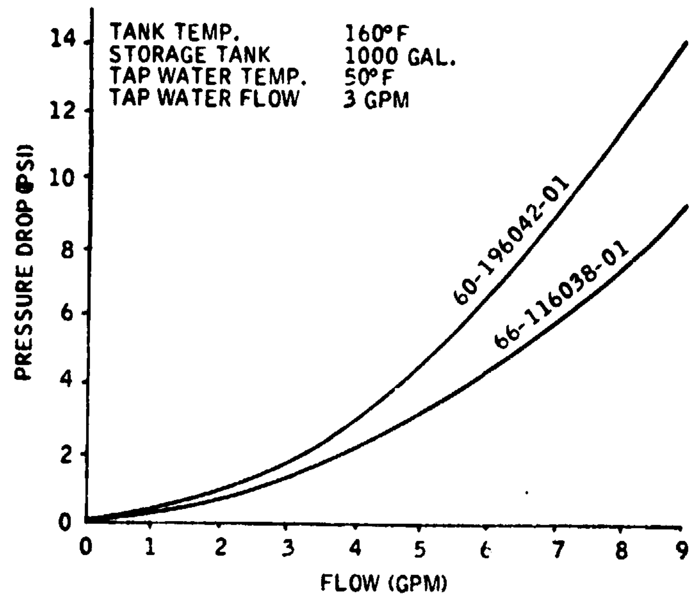
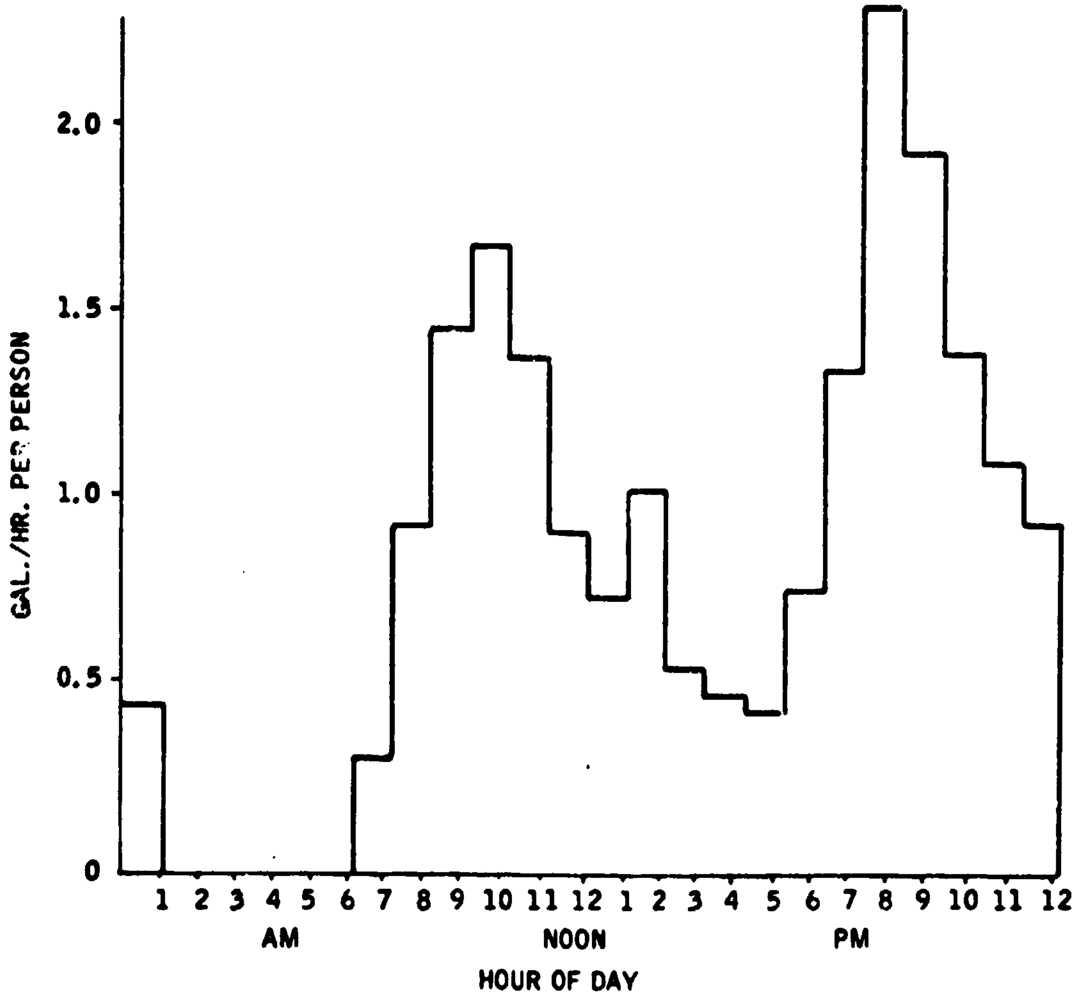


FIGURE 4. HEATING COIL PRESSURE DROP



* RESIDENTIAL WATER HEATING: FUEL CONSERVATION, ECONOMICS, AND PUBLIC POLICY, PREPARED FOR THE NATIONAL SCIENCE FOUNDATION, RAND CORPORATION, R-1498 NSF, MAY 1974, JAMES J. MUTCH.

FIGURE 5. SINGLE FAMILY RESIDENCE HOT WATER SCHEDULE

Pump Selection

The three circulating pumps have been selected and sized for the SFR heating system (Wm. O'Brien site). The final decision was based on the following criteria:

- U.S. manufacturer
- Durability and reliability
- Serviceability
- Fluid chemical compatibility
- Motor size and total efficiency
- Cost
- Availability of vendor information

The final pump selections and estimated conditions of operation are summarized in Table 6. Other manufacturers that received primary consideration were American Marsh, Aurora, Burke, Carver, Grundfos, Paco, Taro, and Thrush. In the selection procedure, the main criteria were low cost, low horsepower units, and adequate performance. The other factors were satisfied by most manufacturers considered except Grundfos, which is not a U.S. manufacturer and the serviceability, durability, and reliability have not been determined since the product is relatively new in the market.

Table 6. SFR Heating Only System Pumps

System Loop	Manufacturer	Series	Motor (Hp)	RPM	Flow (gpm)	Head (ft.)	Effc. (%)	Power (Hp)
Collector	B&G	60-1 1/4 AA	1/4	1750	12.3	20	35	.178
Direct Htg.	B&G	1" PR	1/6	1750	7.5	16	20	.152
Storage Charging	B&G	1" PR	1/6	1750	8.	16	20	.162

Insulation Selection

Results from earlier comparison studies favored the use of copper tubing over steel pipe in SFR buildings. Better workability and compatibility with water were major reasons for using copper tubing. Coupled with this was the type of insulation to use - flexible or fiberglass. Previous material and installation cost analysis showed an economic advantage in using flexible type insulation with piping sizes expected in SFR housing. Flexible insulation 3/4 inch thick has been selected for all collector subsystem piping and for all heated in-house piping which connects solar system components to existing internal plumbing. With reference to Figure 6, the piping heat loss is only 10 Btu/Hr per linear foot length for a 70^{o}F temperature drop across the insulation.

An indication of energy leakage from the storage tank to the house is obtainable from Figure 7. For 3 inches of insulation, only 2 Btu/Hr per unit surface area passes to the surroundings. However, this is the maximum loss and occurs at the two ends and the midpoint circumferential locations of the cylindrical tank. Elsewhere, losses are much less since the storage tank is positioned in a rectangular housing with insulation filling in the void space.

Heat Transfer Fluid Selection

Numerous heat transfer agents with manufacturer supplied data have been investigated. The fluids consisted of aqueous glycol solutions, hydrocarbon oils, and silicone fluids. Some of the fluids were eliminated from consideration for use in the SFR solar heating systems prior to an evaluation of their performance. Excessive cost, instability over a -30^{o}F to 300^{o}F range,

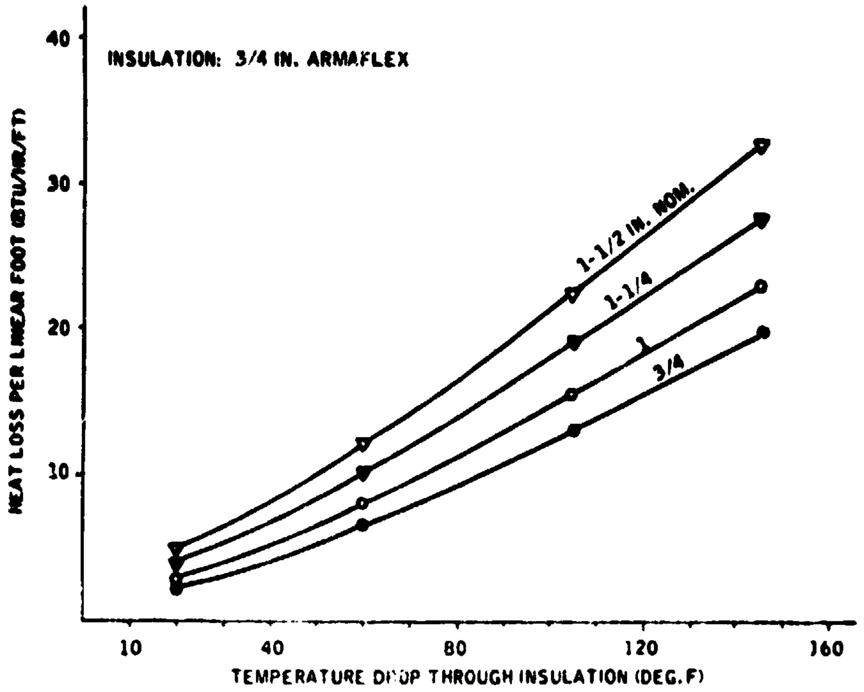


FIGURE 6. HEAT LOSS AS FUNCTION OF TEMPERATURE DIFFERENCE FOR INSULATED COPPER TUBING

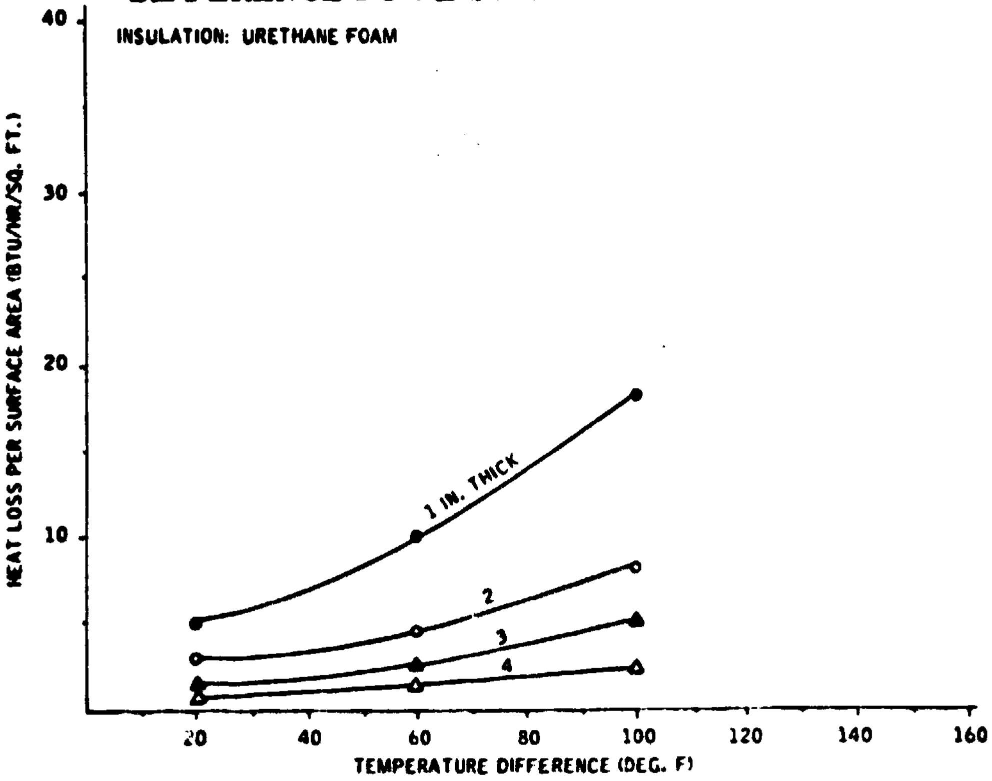


FIGURE 7. HEAT LOSS AS FUNCTION OF TEMPERATURE DIFFERENCE FOR INSULATED STORAGE TANK

fire hazard, lack of available physical property information, etc. were factors in the elimination process.

An analysis to estimate the performance of the heat transfer fluid candidates was done. Water was used as a reference, and fluid performance relative to water was obtained. The descriptive parameter is defined as the ratio of the heat transferred to the fluid flow resistance. Performance analysis results for three general groups of fluids are summarized in Figures 8 and 9. Superiority is evident in performance of 50% aqueous glycol solutions (ethylene and propylene) in the operating temperature range for present day SFR solar heating systems.

In the same heat transfer hardware, neither of the physical conditions described by Figures 8 and 9 are strictly true by themselves. An equal amount of energy transfer is specified for both conditions. In Figure 8, the same flow rate is maintained while the average temperature change is adjusted to force equal energy transfer. Figure 9 describes the opposite condition. The real situation would exist somewhere within the two limiting cases. Each individual case only holds true if the heat exchange hardware is designed to force the criteria described by Figure 8 and Figure 9. Such a comparison would have to take into consideration heat exchanger modification costs associated with each fluid.

Based on fluid compatibility properties, safety, cost, expected performance, etc., 50% aqueous ethylene flycol has been selected for use in the solar system at the Wm. O'Brien State Park residence.

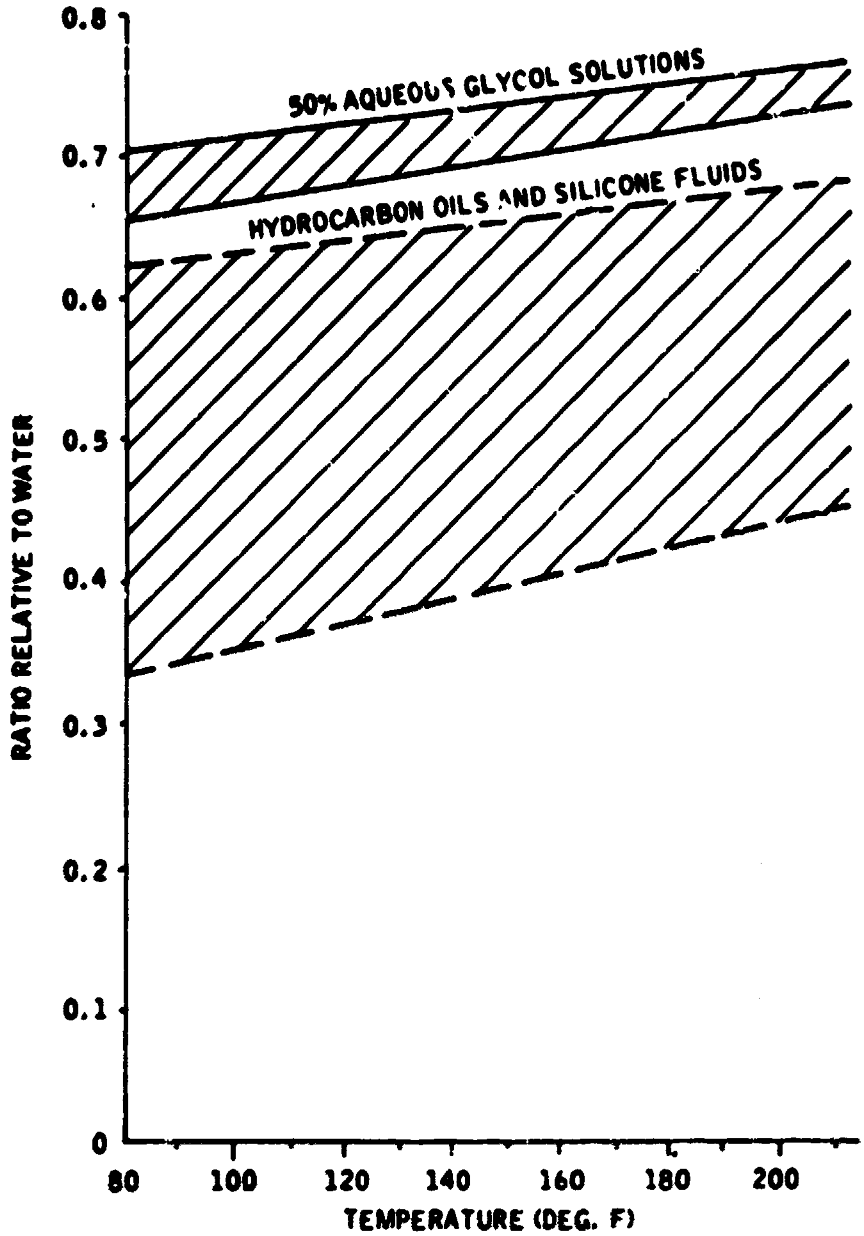


FIGURE 8. FLUID PERFORMANCE (HEAT TRANSFER/PRESSURE DROP) FOR EQUAL FLOW RATE AND HEAT TRANSFER IN TURBULENT FLOW

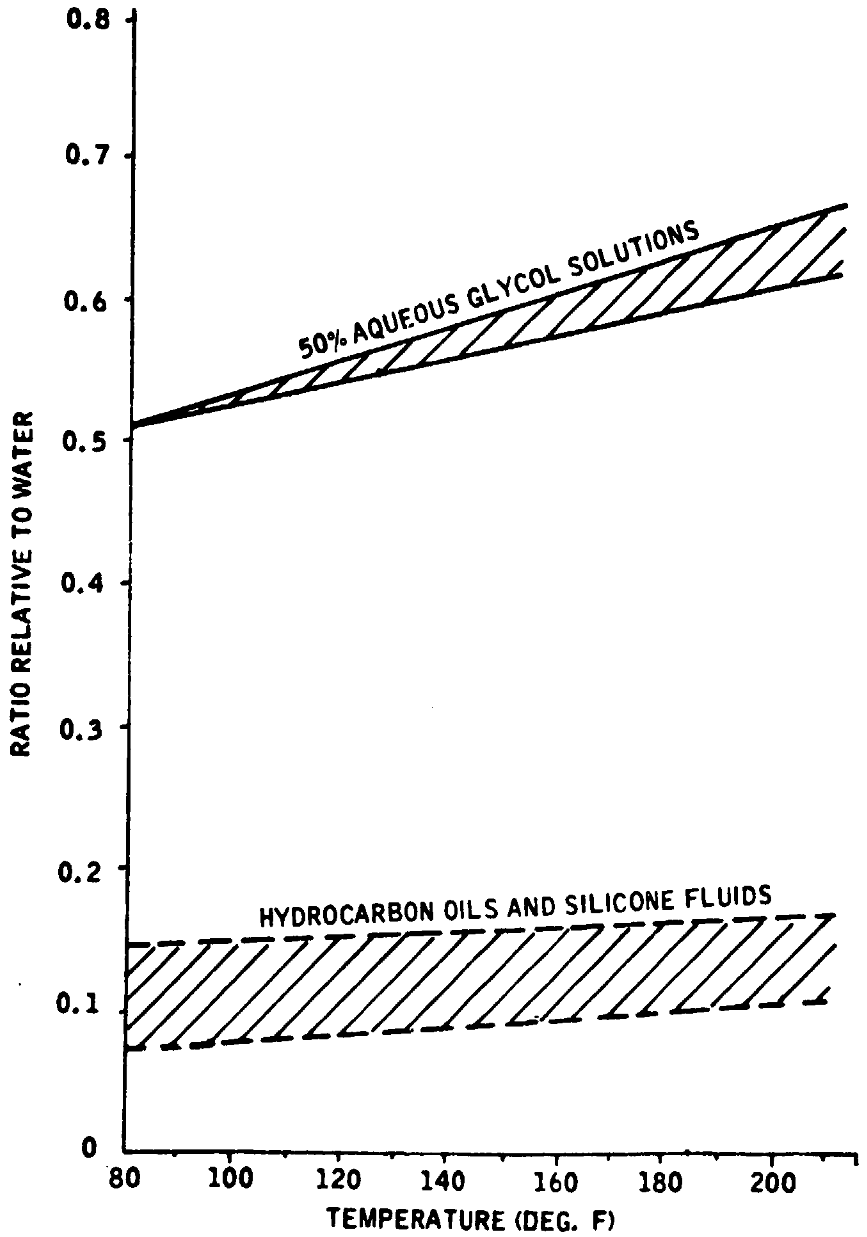


FIGURE 9. FLUID PERFORMANCE (HEAT TRANSFER/PRESSURE DROP) FOR EQUAL TEMPERATURE CHANGE AND HEAT TRANSFER IN TURBULENT FLOW

E. ENERGY TRANSPORT MODULE

Objective

To reduce installation time, associated cost, and physical space required to interconnect residential solar hydronic subsystems, a majority of the Energy Transport Module (ETM) subsystem components have been modularized into a factory-built cabinet (see Appendix F). The resulting ETM, when incorporated properly into a solar heating system, will provide a consistent, flexible interface between subsystems in various residential applications.

Design Goals

The ETM was designed to achieve the best matrix and arrangement of components within a functional, compact cabinet. Of the system components, 30 percent are included within the ETM (see Table 7 and Figures 10 and 11). Tradeoffs have been made between component installation costs of on-site work against shop installation costs for the modules. The constraints analyzed included, but were not limited to, the following:

General

1) Accommodation of the constraints listed below will not adversely affect the function or efficiency of the Energy Transport Subsystem.
2) The ETM must interface with various-sized residential solar heating systems.
3) Requirements of the Residential Interim Performance Criteria (Jan. 1, 1973) must be met.

TABLE 7 SHOP INSTALLED COMPONENTS

AMOUNT	COMPONENT
3	Pumps
1	Water-to-water heat exchanger
1	Expansion tank
1	Air separator
2	Air vents
1	Pressure relief valve
1	Motorized, 2-position valve
3	Flow balancing valves
3	Drain valves
1	Strainer
1	Solar Control Panel
1	Low level indicator
1	Relief catch basin

TOTAL = 23 Components with ETM (plus piping, fitting, wiring, and insulation)

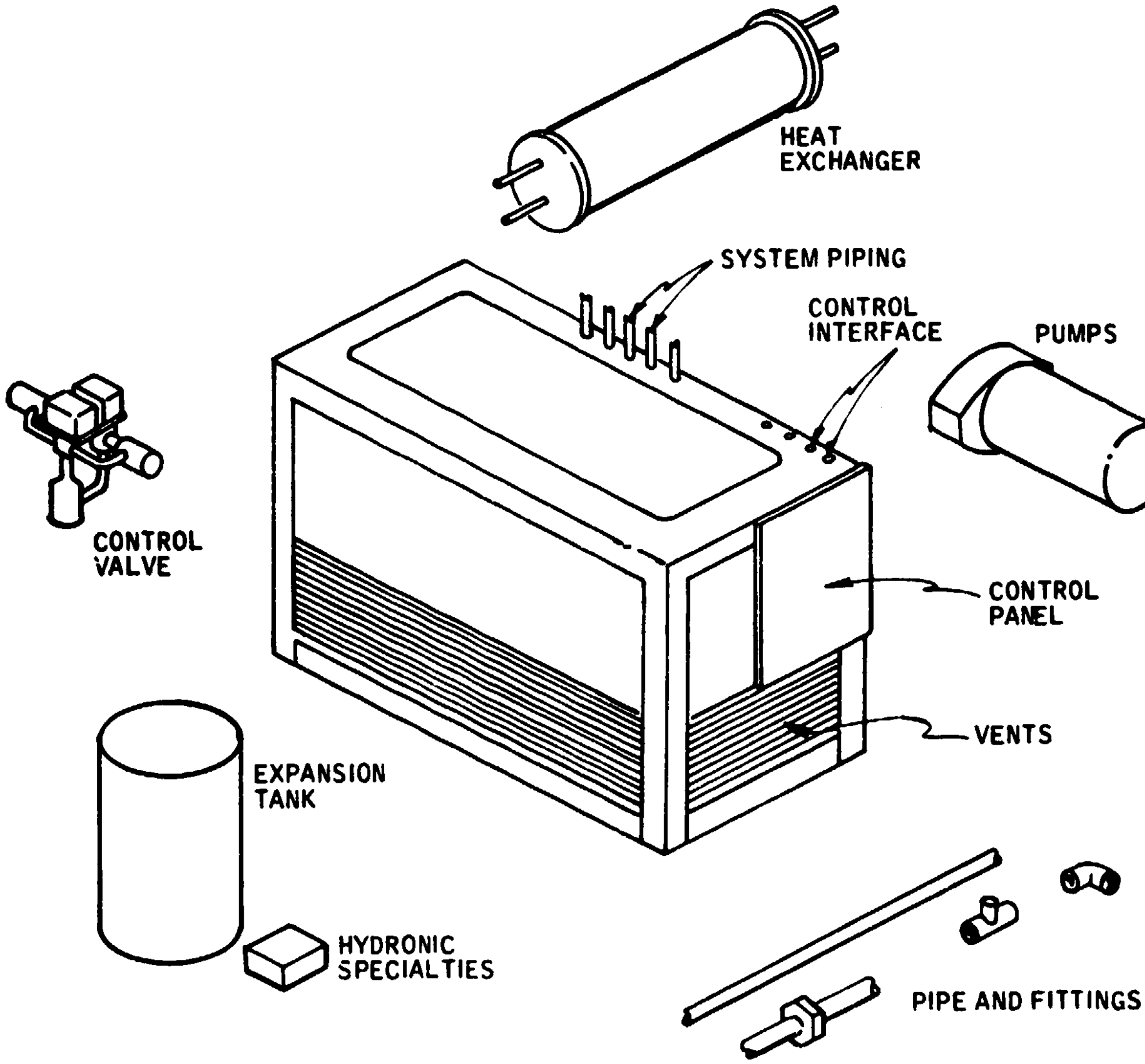


FIGURE 10. ENERGY TRANSPORT MODULE

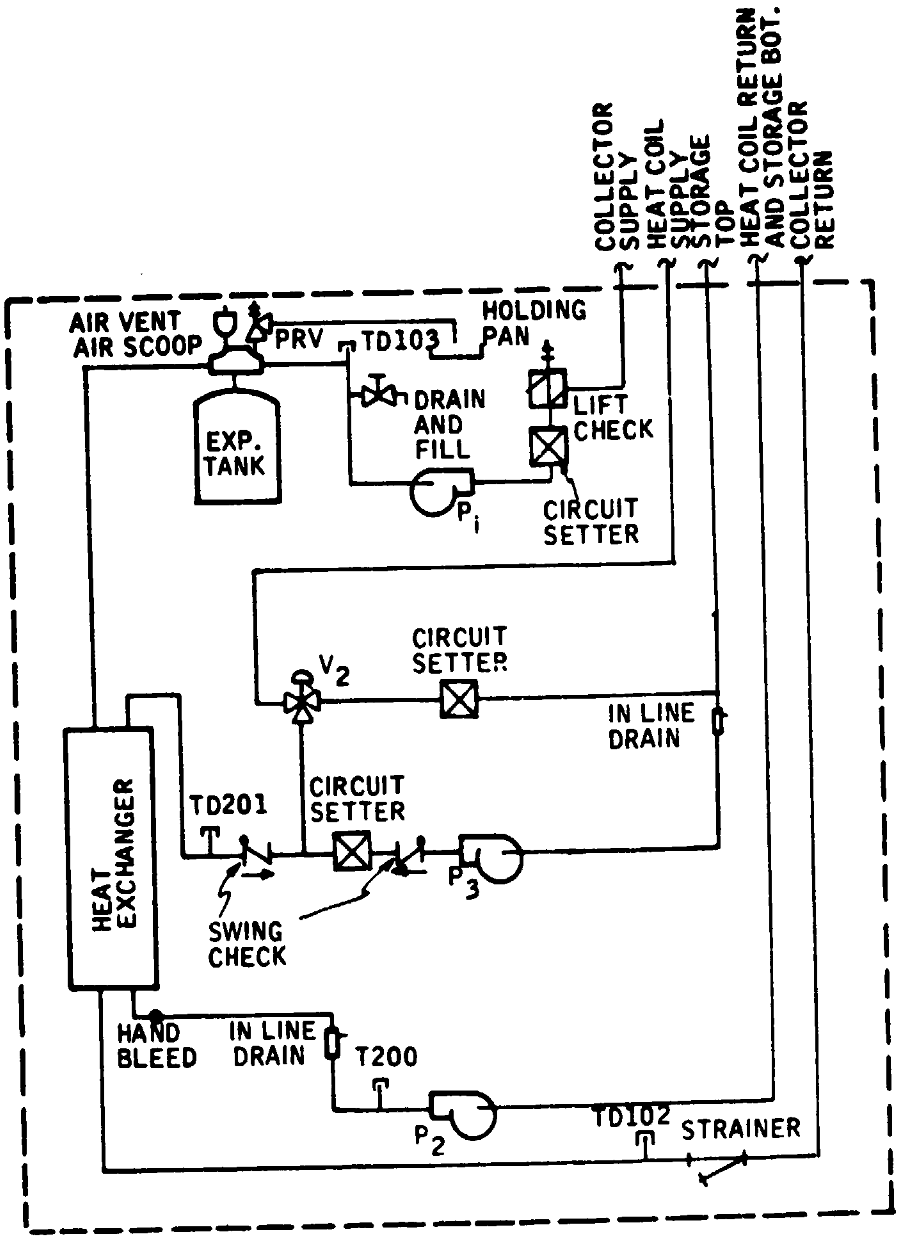


FIGURE 11. ETM COMPONENT/FLUMBING SCHEMATIC

Shipping & Installation

4) ETM must possess sufficient structural strength to sustain (undamaged) transport to the installation site.
5) Weight to be consistent with residential installations requiring no more than two men to handle the module.
6) Outside dimensions such that modules can be placed inside buildings without special entrance requirements.
7) The number of plumbing and electrical installation connections are kept to a minimum and they must be readily accessible.

Operation

8) All serviceable components are field removable without disassembly of the other module components.
9) Module internal temperatures are held to a level consistent with the service requirements of the equipment
10) Noise levels are held to a reasonable level consistent with residential installations
11) System can be leak checked and its operation checked prior to shipment.

Design Tradeoffs

The final ETM design evolved after investigating some fifteen component arrangements and holding numerous design review meetings with solar system engineers, plumbers, and mechanical/cabinet designers. It was determined that horizontally-mounted pumps and heat exchangers provided optimum performance and ease of mounting. With cabinet size being critical, a diaphragm expansion tank is preferred over a standard air cushion expansion tank since it can be physically smaller while providing the same function. Also a diaphragm-type tank eliminates the expansion tank "water logging" problem. Ease of installing the ETM on site and its adaptability into various system layouts were studied; the preferred cabinet design was one with all external connections through the same area of the cabinet top.

These component and installation criteria, a continuous effort to avoid air entrapment in plumbing lines, and attention paid to the previously mentioned design goals were considered during investigation of various ETM component orientations and plumbing arrangements. Finally, using the resulting basic ETM design, cabinet compactness was traded off against accessibility to, and function of, its components.

To determine the best insulating technique, foams, batting, individually insulated piping, and loose fill insulation were investigated. Fire, toxicity, and difficult removal are foam characteristics that excluded its use for the small quantity of demonstration modules, though some special types of foam have potential in large quantity application. Use of batting and individually insulating piping requires a considerable amount of labor time. Final selection was the use of loose wool and some standard piping insulation.

Final Energy Transport Module Design

Characteristics of the ETM design, based on the above tradeoffs and goals, are described below:

General

1 & 2) The ETM will provide a functional, efficient interface subsystem for the two systems designed in this program and also for a majority of other residential solar heating applications.

3) The fifty-seven Interim Performance Criteria requirements for Solar Energy Transport subsystems, which directly affect the ETM, have been analyzed and are met. Some requirements are discussed in this study; others (such as thermal expansion of fluids and piping, relief valves and vents, fire standards, and component design lifetimes) are discussed in the verification report.

Shipping and Installation

4) The cabinet will be fabricated with 12-gauge formed steel corner framing with welded joints and lighter-weight removable panels. The cabinet has been designed to withstand shipping loads (in its operational orientation) and handling during installation (cabinet will be handled using the side opposite the solar control box as the base).
5) ETM shipping and installation weight is about 200 pounds for components and about 150 pounds for the cabinet, or 350 pounds total.
6) The ETM external dimensions are: 28 inches wide, 32 inches high, and 45 inches long (this 45 inches would be along the wall in a usual installation). In its handling orientation, it can be placed on a dolly, resulting in ample clearance between doorways and the 28-inch-wide cabinet.
7) The basic installation procedure consists of setting the ETM in place and connecting the plumbing and external control wiring to it from the other subsystems. (The ETM is internally pre-wired.) The above actions and all others required for system startup are performed external to the cabinet or inside the cabinet through one of the removable access panels.

Operation

8) Serviceable components, both hydronic and electrical, have been made readily accessible due to internal plumbing arrangement, cabinet design (note that the Solar Control Box is externally mounted with its hinged door

exposed), insulation techniques, and removable access panels. The extent of access can also accommodate nonroutine work, such as on-site installation of Site Data Acquisition sensors or the repair/removal of a plumbing segment or component. Space adjacent to electric motors, removable union-type fittings for each pump, and components with replaceable elements allow for required servicing.

9) The insulation technique selected for the ETM was based on the following criteria, which must be simultaneously satisfied:

   a) An allowable upper temperature limit (110-125^{o}F) for interior ambient air surrounding electric motors.

   b) Cabinet exterior temperature less than 140^{o}F.

   c) Compared to the overall house cooling load, the uncontrolled heat loss from the ETM must be minimal during summer months.

   d) System efficiency due to ETM heat loss should be negligible.

   To accomplish the above, component arrangement was such that those requiring insulation and minimal servicing (such as the heat exchanger and long pipe runs) would be separated from those requiring free-flow, low-temperature ambient air and some servicing (such as pump and diverting valve motors). The heat exchanger and majority of long pipe runs were located in the upper portion of the cabinet. A 44-inch by 28-inch steel divider secured under the heat exchanger totally encloses this upper portion, which is then filled with loose insulation. The air temperature in the lower portion is kept below the design maximum by insulating straight pipe runs, providing louvers in the side panels, and allowing natural convection and air movement caused by pump motors to vent out any excess heat. Additionally, with this insulation technique, the criterion of 140^{o}F cabinet temperature, overall system efficiency, and negligible uncontrolled heat loss from the ETM were satisfied.

10) The noise level produced by the ETM in operation is low, due to:

   a) Pump selection (noise-pertinent criteria was a well-designed, quiet operating, 1750 rpm, elastically-coupled pump and motor).

   b) Design flow rate maintains three (3) feet per second flow through plumbing, which is less than ASHRAE's recommended rate of 4 feet per second.

   c) Water hammer within module is minimized by use of a slow-operating diverting-type motorized valve.

11) All modules will be tested for leaks, functional and potential shipping problems. Suitable draining and filling procedures are developed, and operation and installation procedures are delineated.

Heat Exchanger Analysis

The method used to determine the overall heat exchanger dimensions and design parameters is primarily the method of Kays and London. The following general assumptions are made in the calculations:

- The heat exchanger is considered adiabatic
- Fluid flow is steady with constant properties
- The overall heat conductance is considered to be constant for given conditions.
- A counterflow configuration is used
- The process requirements at design conditions are determined by the solar system predicted performance.

Physical Description

The geometrical and physical characteristics of the heat exchanger are shown in SK-140184 (Appendix F). The heated fluid flows in the spirally formed coils completely immersed in the heating fluid on the shell side. Heat transfer intensification of the copper tubing (type M) is produced by additional generation of turbulence on the inner and outer surface of the tube. Basically, two types of enhanced surfaces are considered:

- Circular smooth tube with bilateral heat transfer intensification. This corrugating style is a single-start helical shape performed without decreasing the wall thickness or increasing the outside diameter of the tube.
- Spirally fluted tubing that increases the radial velocity components. The associated radial mass flow increases the internal film coefficient.

Performance Predictions

Based on solar system output, the following design conditions were selected for the heat exchanger performance requirements:

- Collector fluid temperature drop of 10°F
- Collector fluid flow rate of 12 gpm.

Thus the total heat transfer through the heat exchanger amounts to 55,000 Btu/Hr. With a heated fluid flow rate of 8 gpm at 120°F and a collector outlet temperature of 140°F, the heat exchanger effectiveness is expected to be approximately 0.70. This reduces to a predicted overall heat transfer coefficient (UA) of 7000 Btu/Hr °F resulting from the individual heat transfer coefficients. Pressure drop correlations based on manufacturers data show an increase of 2.4 times the pressure drop for an equivalent plain tube heat exchanger. But the overall pressure drop on the collector fluid is expected to be maintained close to 4.0 psi.

Document F3437-D-102
29 June 1977

SOLAR HEATING AND COOLING DEVELOPMENT PROGRAM

Verification Status
for
Operational Site at
Wm. O'Brien State Park
Stillwater, Minnesota

A
Single Family Residence
Heating System

Contract NAS8-32093

Honeywell Inc.
Energy Resources Center
2600 Ridgway Parkway
Minneapolis, Minnesota 55413

Prepared by: Allen J. Baldwin

Approved by: Glen L. Merrill

2.0 VERFICATION STATUS SUMMARY
SINGLE FAMILY HEATING

A. GENERAL

Heating system design and development verification is the process of proving that the components and the system meet applicable physical and functional requirements as set forth in the Interim Performance Criteria (ref. Section II of the contract Statement of Work) and the System Performance Specification.

This document summarizes the present status of verification for a single family heating system.

Attached to this summary report are verification matrices for each of the functional subsystems in the heating system. Each matrix relates applicable subsystem and system performance requirements (interim criteria) to selected verification methods. Each Interim performance criteria paragraph in the matrix has been or is to be verified by similarity, analysis, test or inspection. In the development and qualification phases all verification is by similarity, analysis or test. In the acceptance phase all verification is by inspection or test.

B. MATRICES

On the attached matricis the method of verification is indicated by the following code:

1. = similarity
2. = analysis
3. = inspection
4. = test

The present status of each verification item is indicated by a code as follows:

C = complete
I = incomplete

ATTACHMENT

ITEM (NAME & PART NO.) Collector Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.1

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 1.3.1 Efficiency	4-C	1-C	3, 4 -I	
IPC 2.1.2 Noise or Erosion-Corrosion Analysize Fluid Velocity	2-C	2-C	3-I	
IPC 2.1.3 Operating Conditions (P & T) Check Against ASHRAE Code	2-C	2-C	3-I	
IPC 2.1.4 Fluid Flow in Collectors Check Manifolding.	2-C	2-C	3-I	
IPC 2.2.5 Thermal Changes Check Thermal Stresses	2-C	2-C	3-I	
IPC 3.1.1 Applicable Standards HUD MPS & ANSI Structural STDS	2-C	2-C	3-I	
IPC 3.2.1 Ultimate Load Combinations Stress Analysis	2-C	2-C	3-I	
IPC 3.2.2 Ice Loads Stress Analysis	2-C	2-C	3-I	

ITEM (NAME & PART NO.) Collector Subsystem	VERIFICATION CROSS REFERENCE MATRIX	WBS 1.2.2.1.1

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 3.3.1 Resistance to Damage Service Life Analysis	2-I	2-I	3-I	
IPC 3.3.2 Glasing Design MPS & ANSI A119.1 Compliance	2-C	2-C	3-I	
IPC 3.4.1 Deflection Limitations	2-C	2-C	3-I	
IPC 3.8.1 Foundation Settlement	2-I	2-I	3-I	
IPC 3.9.1 Design Provisions Effects of Ponding	2-C	2-C	3-I	
IPC 5.1.4 Dirt Retention	1-C	1-C	3-I	
IPC 5.1.5 Abrasive Wear	1-C	1-C	3-I	
IPC 5.1.6 Fluttering by Wind	1-C	1-C	3-I	
IPC 5.2.3 Thermal Cycling Stresses	1-C	1-C	3-I	
IPC 5.2.4 Leakage	1-C	1-C	3-I	
IPC 5.2.5 Deterioration of Gaskets and Seals	1-C	1-C	3-I	

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ITEM (NAME & PART NO.) Collector Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.1

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 5.3.1 Metals/Transfer Fluid Compatability	1-C	1-C	3-I	
IPC 5.3.2 Corrosion of Dissimilar Metals	2-C	2-C	3-I	
IPC 5.3.3 Corrosion by Leachable Substances	2-C	1-C	3-I	
IPC 5.3.4 Effects of Decomposition Products	2-C	1-C	3-I	
IPC 11.2.1 Chemical Corrosion Effect on Building	2-I	1-I	3-I	
IPC 11.2.2 Heat and Moisture Effect on Building	2-I	2-I	3-I	
IPC 11.3.1 Material Compatibility-Connectors	2-I	2-I	3-I	
IPC 6.1.1 Access for Subsystem Maintenance	1-C	2-C	3-I	
IPC 6.1.2 Access for Subsystem Monitoring	1-C	2-C	3-I	
IPC 6.2.1 Install. Instructions	1-I	2-I	3-I	

ITEM (NAME & PART NO.) Collector Subsystem	VERIFICATION CROSS REFERENCE MATRIX	WBS 1.2.2.1.1

VERIFICATION METHOD: 1. [illegible] 2. [illegible] 3. [illegible] 4. [illegible] N/A [illegible]

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 6.2.2 Maintenance & Operation Instructions	1-I	2-I	3-I	
IPC 6.2.3 Maintenance Plan	1-I	2-I	3-I	
IPC 6.2.4 Replacement Parts and Tools	1-I	2-I	3-I	

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ITEM (NAME & PART NO.) Collector Qual. Tests	VERIFICATION CROSS REFERENCE MATRIX	WBS 1.2.3.1

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 2.3.1 Pressure Test	2-C	4-C	3-I	
IPC 3.1.2 Service Loads	2-C	4-C	3-I	
IPC 3.7.1 Hail Size and Loading	2-C	4-C	3-I	
IPC 5.1.1 Solar Degradation	2-C	4-I	3-I	
IPC 5.1.3 Airborne Pollutants	2-C	4-C	3-I	
IPC 5.2.1 Thermal Degradation	2-C	4-C	3-I	
IPC 5.2.6 Transmission Losses Due to Out Gassing	2-C	4-I	3-I	

*All inspections will be on components.

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ITEM (NAME & PART NO.) Storage Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.2

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 1.4.1 Storage Capacity & Rate	2-C	1-C	3-I	
IPC 1.5.1 Heat Loss	2-C	1-C	3-I	
IPC 2.1.3 Operating Conditions	2-C	1-C	3-I	
IPC 2.1.6 Thermal Expansion	2-C	1-C	3-I	
IPC 2.2.4 Vacuum Relief	1-C	1-C	3-I	
IPC 2.2.5 Thermal Changes	1-C	1-C	3-I	
IPC 2.2.6 Flexible Joints	1-C	1-C	3-I	
IPC 2.3.1 Pressure/Leak Test	1-C	1-C	3-I	
IPC 2.6.3 Fluid Treatment	1-C	1-C	3-I	
IPC 2.8.1 Relief Valves & Vents	1-C	1-C	3-I	
IPC 4.1.1 Plumbing Codes & Standards	1-C	1-C	3-I	
IPC 4.3.1 Fire Standards	1-C	1-C	3-I	

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ITEM (NAME & PART NO.) Storage Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.2

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 4.7.1 Heat Protection	1-C	1-C	3-I	
IPC 6.1.1 Access for Maintenance	1-C	1-C	3-I	
IPC 6.1.2 Access for Monitoring	1-C	1-C	3-I	
IPC 6.1.3 Draining & Filling	1-C	1-C	3-I	
IPC 6.1.4 Flushing of Liquids	1-C	1-C	3-I	
IPC 6.2.1 Install. Instructions	1-C	2-C	3-I	
IPC 6.2.2 Operation Instructions	1-C	2-C	3-I	
IPC 6.2.3 Maintenance Plan	1-C	2-C	3-I	
IPC 6.2.4 Replacement Parts	1-C	2-C	3-I	
IPC 6.3.1 Ease of Maintenance	1-C	2-C	3-I	

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ITEM (NAME & PART NO.) Heating Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.3

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 1.1.1 Heating Design Temps.	1-I	1-I	3-I	
IPC 2.1.1 Equip. Capabilities	4-I	2-I	3-I	
IPC 2.2.5 Thermal Changes	1-I	1-I	1-I	
IPC 2.2.6 Flexible Joints	1-I	1-I	3-I	
IPC 2.3.1 Pressure Test	1-I	1-I	3-I	
IPC 2.6.1 Liquid Quality	1-I	1-I	3-I	
IPC 2.6.3 Fluid Treatment	1-I	1-I	3-I	
IPC 2.6.4 Freezing Protection	1-I	1-I	3-I	
IPC 2.7.1 Appl. Plumbing Stds	1-I	1-I	3-I	
IPC 4.1.1 Plumbing Codes & Stds	1-I	1-I	3-I	
IPC 4.1.2 Elect. Codes & Stds	1-I	1-I	3-I	
IPC 5.2.4 Leakage	1-I	1-I	3-I	
IPC 5.3.1 Matl. Trans. Fluid Corp	1-I	1-I	3-I	

ITEM (NAME & PART NO.) Heating Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.3

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 6.2.1 Inst. Instr.	1-I	1-I	3-I	
IPC 6.2.2 M/D Manual	1-I	1-I	3-I	
IPC 6.2.3 Maintenance Plan	1-I	1-I	3-I	
IPC 6.2.4 Replacement Parts	1-I	1-I	3-I	
IPC 6.3.1 Maintenance of H Systems	1-I	1-I	3-I	

ITEM (NAME & PART NO.)
Auxillary Energy Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.4

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 1.8.1 Design Loads	1-C	1-C	3-I	
IPC 2.1.1 Equipment Capabilities				

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ITEM (NAME & PART NO.) Hot Water Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.5

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 1.2.1 Water Design Temp.	1-C	1-C	3-I	
IPC 1.2.2 Storage Des. Capacity	1-C	1-C	3-I	
IPC 1.2.3 Solar Contribution	1-C	1-C	3-I	ORIGINAL PAGE IS OF POOR QUALITY
IPC 1.2.4 Operational Impairment	1-C	1-C	3-I	
IPC 1.5.1 Heat or Humidity Transfer Effects	1-C	1-C	3-I	
IPC 1.7.4 Hot Water Temp.	1-C	1-C	3-I	
IPC 1.8.1 Design Loads (Aux. Backup)	1-C	1-C	3-I	
IPC 2.1.2 Noise-Erosion Corrosion	1-C	1-C	3-I	
IPC 2.1.3 Operating Conditions	1-C	1-C	3-I	
IPC 2.1.6 Thermal Expansion of Fluids	1-C	1-C	3-I	
IPC 2.1.7 Pressure Drops	1-C	1-C	3-I	

ITEM (NAME & PART NO.)
Hot Water Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.5

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 2.2.1 Vibration Stress Levels	1-C	1-C	3-I	
IPC 2.2.3 Water Hammer	1-C	1-C	3-I	
IPC 2.3.1 Pressure Test: Non-potable Fluids	1-C	1-C	3-I	
IPC 2.3.2 Pressure Test: Potable	1-C	1-C	3-I	
IPC 2.5.1 Shutdown in Multi-Family Housing	1-C	1-C	3-I	
IPC 2.6.1 Liquid Quality	1-C	1-C	3-I	
IPC 2.8.1 Relief Valves & Vents	1-C	1-C	3-I	
IPC 4.2.1 System Failure Prevention	1-C	1-C	3-I	
IPC 4.2.2 Auto. Pres. Relief Valves	1-C	1-C	3-I	
IPC 4.6.1 Contamination by Materials	1-C	1-C	3-I	

ITEM (NAME & PART NO.) Hot Water Subsystem	VERIFICATION CROSS REFERENCE MATRIX	WBS 1.2.2.1.5

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 4.6.2 Separation of Circulation Loops	1-C	1-C	3-I	
IPC 4.6.3 Backflow Prevention	1-C	1-C	3-I	
IPC 4.7.1 Protection from Heated Components	1-C	1-C	3-I	ORIGINAL PAGE IS OF POOR QUALITY
IPC 5.2.3 Thermal Cycling Stresses	1-C	1-C	3-I	
IPC 5.2.4 Leakage	1-C	1-C	3-I	
IPC 5.2.5 Deterioration of Gaskets & Sealants	1-C	1-C	3-I	
IPC 5.3.1 Materials/Transfer Fluid Compatibility	1-C	1-C	3-I	
IPC 5.3.2 Corrosion of Dissimilar Materials	1-C	1-C	3-I	
IPC 5.4.1 Wear and Fatigue (Watts Valve)	1-C	1-C	3-I	
IPC 6.1.1 Accessibility for Maint. & Service	1-C	1-C	3-I	

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ITEM (NAME & PART NO.) Hot Water Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.5

VERIFICATION METHOD: 1. [illegible] 2. [illegible] 3. [illegible]ECTION 4. T[illegible] N/A NOT A[illegible]

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 6.1.3 Draining & Filling of Liquids	1-C	1-C	3-I	
IPC 6.1.4 Flushing of Liquid System	1-C	1-C	3-I	
IPC 6.1.6 Potable Water Shut-off	1-C	1-C	3-I	
IPC 6.2.1 Install. Instructions	1-C	1-C	3-I	
IPC 6.2.2 Oper. Instructions	1-C	1-C	3-I	
IPC 6.2.3 Maint. Plan	1-C	1-C	3-I	
IPC 6.2.4 Replacement Parts	1-C	1-C	3-I	
IPC 6.3.2 Maint. of DHW System	1-C	1-C	3-I	

ITEM (NAME & PART NO.)
Energy Transport Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.6

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 1.1.5 Operational Impairment (H, H, C)	1-C	1-C	3-I	
IPC 1.2.4 Operational Impairment (DHW)	1-C	1-C	3-I	
IPC 1.5.1 Heat or Humidity Transfer Effects	1-C	1-C	3-I	
IPC 1.6.1 Thermal Losses & Electrical Power	2-C	2-C	3-I	
IPC 2.1.1 Equip. Capabilities	2-C	2-C	3-I	
IPC 2.1.2 Noise or Erosion Corrosion	2-C	2-C	3-I	
IPC 2.1.6 Thermal Expansion of Fluids	2-C	2-C	3-I	
IPC 2.1.7 Pressure Drops	2-C	2-C	3-I	
IPC 2.1.3 Operating Conditions	1-C	1-C	3-I	
IPC 2.1.5 Entrapped Air	1-C	1-C	3-I	
IPC 2.2.1 Vibrating Stress Levels	1-C	1-C	3-I	

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ITEM (NAME & PART NO.) Energy Transport Sub-system	VERIFICATION CROSS REFERENCE MATRIX	WBS 1.2.2.1.6

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 2.2.3 Water Hammer	1-C	1-C	3-I	
IPC 2.2.4 Vacuum Relief Protection	1-C	1-C	3-I	
IPC 2.2.5 Thermal Changes	1-C	1-C	3-I	
IPC 2.2.6 Flexible Joints	1-C	1-C	3-I	
IPC 2.2.2 Vibration from Moving Parts	1-C	1-C	3-I	
IPC 2.3.1 Pressure Test Non-potable Fluids	1-C	1-C	3-I	
IPC 2.6.1 Liquid Quality	1-C	1-C	3-I	
IPC 2.6.3 Fluid Treatment	1-C	1-C	3-I	
IPC 2.6.4 Freezing Protection	1-C	1-C	3-I	
IPC 2.7.1 Applicable Plumbing Standards	2-C	2-C	3-I	
IPC 2.8. Relief Valves & Vents	1-C	1-C	3-I	
IPC 3.5.1 Design Provisions	2-C	2-C	3-I	

ITEM (NAME & PART NO.) Energy Transport Subsystem	VERIFICATION CROSS REFERENCE MATRIX	WBS 1.2.2.1.6

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 4.1.1 Plumbing Codes & Standards	1-C	1-C	3-I	
IPC 4.2.2 Automatic Pressure Relief Valves	1-C	1-C	3-I	
IPC 4.3.1 Applicable Fire Standards	1-C	1-C	3-I	ORIGINAL PAGE IS OF POOR QUALITY
IPC 4.3.2 Penetrations Thru Fire-Related Assemblies	1-C	1-C	3-I	
IPC 4.4.1 Provision of Catch Basins	1-C	1-C	3-I	
IPC 4.4.2 Detection of Toxic & Flammable Fluids	1-C	1-C	3-I	
IPC 4.5.1 Emergency Egress & Access	1-C	1-C	3-I	
IPC 4.5.2 Identifications and Location of Controls	1-C	1-C	3-I	
IPC 4.6.1 Contamination by Materials	1-C	1-C	3-I	

ITEM (NAME & PART NO.)
Energy Transport Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.6

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 4.6.2 Separation of Circulation Loops	1-C	1-C	3-I	
IPC 4.6.3 Backflow Prevention	1-C	1-C	3-I	
IPC 4.7.1 Protection from Heated Components	1-C	1-C	3-I	
IPC 5.1.2 Soil Corrosion	1-C	1-C	3-I	
IPC 5.1.3 Airborne Pollutants	1-C	1-C	3-I	
IPC 5.2.1 Thermal Degradation	1-C	1-C	3-I	
IPC 5.2.2 Deterioration of Heat Transfer Fluids	1-C	1-C	3-I	
IPC 5.2.3 Thermal Cycling Stresses	1-C	1-C	3-I	
IPC 5.2.4 Leakage	1-C	1-C	3-I	
IPC 5.2.5 Deterioration of Gaskets and Sealants	1-C	1-C	3-I	
IPC 5.3.1 Materials/Transfer Fluid Compatibility	1-C	1-C	3-I	

ITEM (NAME & PART NO.)
Energy Transport Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.6

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 5.3.2 Corrosion of Dissimilar Materials	1-C	1-C	3-I	
IPC 5.3.3 Corrosion by Leachable Substances	1-C	1-C	3-I	ORIGINAL PAGE IS OF POOR QUALITY
IPC 5.4.1 Wear & Fatigue	1-C	1-C	3-I	
IPC 6.1.1 Access for System Maintenance	1-C	1-C	3-I	
IPC 6.1.2 Access for System Monitoring	1-C	1-C	3-I	
IPC 6.1.3 Draining & Filling of Liquids	1-C	1-C	3-I	
IPC 6.1.4 Flushing of Liquid Subsystems	1-C	1-C	3-I	
IPC 6.1.6 Potable Water Shutoff	1-C	1-C	3-I	
IPC 6.2.1 Install. Instructions	1-C	1-C	3-I	
IPC 6.2.2 Maintenance & Operation Instructions	1-C	1-C	3-I	
IPC 6.2.3 Maintenance Plan	1-C	1-C	3-I	

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ITEM (NAME & PART NO.)

Energy Transport Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.6

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 6.2.4 Replacement Parts	1-C	1-C	3-I	
IPC 6.3.1 Maintenance of H & HC Systems	1-C	1-C	3-I	
IPC 6.3.2 Maintenance of DHW Systems	1-C	1-C	3-I	

ITEM (NAME & PART NO.) Control Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.7

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 1.7.1 Installation and Maintenance	2,4 -C	2-C	3-I	
IPC 1.7.2 Manual Adjustment	2,4 -C	2-C	3-I	ORIGINAL PAGE IS OF POOR QUALITY
IPC 1.7.3 Inhabited Space Temp. Control	2,4 -C	2-C	3-I	
IPC 1.7.4 Hot Water Temp.	2,4 -C	2-C	3-I	
IPC 2.2.5 Thermal Changes	1-C	2-C	3-I	
IPC 2.5.1 Shutdown Multi Unit	1-C	2-C	3-I	
IPC 3.5.1 Design Provisions	1-C	2-C	3-I	
IPC 4.1.2 Electrical Codes	1-C	2-C	3-I	
IPC 4.2.1 System Failure Prevention	4-C	2-C	3-I	
IPC 4.3.1 Applicable Fire Standards	2-C	2-C	3-I	
IPC 4.3.2 Penetrations - Fire Rated Assemblies	2-C	2-C	3-I	

ITEM (NAME & PART NO.)
Control Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.7

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 4.5.2 Ident. and Location	2-C	2-C	3-I	
IPC 4.6.1 Contamination by Materials	1-C	2-C	3-I	
IPC 5.2.1 Thermal Degradation	1-C	2-C	3-I	
IPC 5.2.3 Thermal Cycling Stresses	1-C	2-C	3-I	
IPC 5.2.5 Deterioration of Gaskets and Sealants	1-C	2-C	3-I	
IPC 5.3.1 Materials/Transfer Fluid Compatibility	1-C	2-C	3-I	
IPC 5.3.2 Corrosion of Dis-similar Materials	1-C	2-C	3-I	
IPC 5.4.1 Wear and Fatigue	1-C	2-C	3-I	
IPC 6.1.1 Access for Maint.	1-C	2-C	3-I	
IPC 6.2.1 Install. Instructions	1-C	2-C	3-I	
IPC 6.2.2 Maintenance and Operation Instructions	1-C	2-C	3-I	

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ITEM (NAME & PART NO.) Control Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.7

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 6.2.3 Maintenance Plan	1-C	2-C	3-I	
IPC 6.2.4 Replacement Parts	1-C	2-C	3-I	
IPC 6.3.1 Servicing H & HC	1-C	2-C	3-I	
IPC 6.3.2 Servicing HW	1-C	2-C	3-I	

ITEM (NAME & PART NO.) Site Collection Date System

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.8

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
n/a				

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ITEM (NAME & PART NO.)

Electrical Subsystem

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.9

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 4.1.2 Electrical Codes	1-I	1-I	3-I	
IPC 8.3.2 Electrical Connections	1-I	1-I	3-I	
IPC 8.3.3 Lightning Protection	2-I	2-I	3-I	

ITEM (NAME & PART NO.) System Integration

VERIFICATION CROSS REFERENCE MATRIX

WBS 1.2.2.1.10

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 9.2.1. Loads	1-I	2-I	3-I	
IPC 9.2.2 Penetration of Structural Members	1-I	2-I	3-I	
IPC 9.3.1 Structural Connections	1-I	2-I	3-I	
IPC 9.3.3 Strength & Stiffness	1-I	2-I	3-I	

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ITEM (NAME & PART NO.)
System Development and Verification

VERIFICATION CROSS REFERENCE MATRIX

VERIFICATION METHOD: 1. [illegible] 2. [illegible] 3. [illegible] 4. [illegible] N/A [illegible]

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 1.1.1 Heating Design Temp.	N/A	N/A	3	
IPC 1.1.3 RH & Water Vapor Pressure	N/A	N/A	3	
IPC 1.1.4 Solar Contribution	N/A	N/A	4	
IPC 1.1.5 Operation Impairment	N/A	N/A	3	
IPC 1.2.1 Draw & Temperature Design O/P (HW)	N/A	N/A	3	
IPC 1.2.3 Solar Contribution	N/A	N/A	4	
IPC 1.5.1 Heat or Humidity Transfer Effects	N/A	N/A	3	
IPC 1.8.1 Design Heat Loads (Aux.)	N/A	N/A	3	
IPC 2.3.3 Air Transport Systems	N/A	N/A	3	
IPC 2.4.2 Mutual Shadowing	N/A	N/A	3	
IPC 2.6.2 Air Quality	N/A	N/A	3	
IPC 3.2.3 Vehicular Loads	N/A	N/A	3	

ITEM (NAME & PART NO.)
System Development and Verification

VERIFICATION CROSS REFERENCE MATRIX

VERIFICATION METHOD: 1. SIMILARITY 2. ANALYSIS 3. INSPECTION 4. TEST N/A NOT APPLICABLE

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
IPC 3.5.1 Design Provisions	N/A	N/A	3	
IPC 3.6.1 Deflection Limitations	N/A	N/A	3	
IPC 3.8.2 Foundation Settlement	N/A	N/A	3	
IPC 4.3.2 Penetrations	N/A	N/A	3	
IPC 4.5.1 Emergency Egress & Access	N/A	N/A	3	
IPC 6.1.5 Filters	N/A	N/A	3	
IPC 7.1 Design	N/A	N/A	3	
IPC 8.1 Interference with Mech. Operation	N/A	N/A	3	
IPC 9.1 Structural Integrity	N/A	N/A	3	
IPC 10.1 Safety	N/A	N/A	3	
IPC 11.1 Durability and Reliability	N/A	N/A	3	
IPC 12.1 Maintainability	N/A	N/A	3	

3.0 DRAWINGS AND HONEYWELL/GOVERNMENT FURNISHED EQUIPMENT LIST

Installation drawings of all single family heating subsystems are included in appendices A through F. Appendix A is entitled System Integration and serves as a top drawing for the subsystem designed by Honeywell; it lists the requirements for integration of the subsystems into the site and dwelling.

The installation drawings included in appendices A through F delineate the material needed to install the Solar Heating System. Only part of the material shown on these drawings will be furnished by Honeywell for NASA.

To assist the architect in preparation of the request for bids, the list of Honeywell/Government furnished equipment was compiled. This list is shown in the following table.

HONEYWELL-GOVERNMENT FURNISHED EQUIPMENT

REF.: NAS8-32093
TOP DWG. NO.: SK- 142057
DATE: June 27, 1977
REVISED: June 29, 1977

Single Family Residence

SYSTEM: Solar Heating LOCATION: Wm. O'Brien State Park, Stillwater, Minn.

SUBSYSTEM	QUANTITY	UNIT DESCRIPTION	PART NO.	MANUFACTURER
Collector	33	Solar Collector	LSC-18-1S	Lennox Industries
	6	Header Assembly	SK-142064-2C	Honeywell
	2	Header Assembly	SK-142064-1C	Honeywell
	2	Header Assembly	SK-142064-1B	Honeywell
	19	Hose Assembly	SK-142066	Honeywell
	28	3/8 npt Coupling	4738-6-6	Aeroquip
	38	3/8 npt Coupling	FF1162-0606B	Aeroquip
	1	Purge Cooling Unit	CBHW3-1	Lennox Industries
Storage	1	Tank-Hot Water Storage	SK 14200	Honeywell
Auxiliary Energy & Space Heat	1	Furnace-Gas	G11Q3-82V	Lennox Industries
	1	Space Heat Coil	CW3-45	Lennox Industries
Domestic Hot Water	1	Heater-Hot Water	40-GK35C	Lochinvar
	1	Valve-Mixing	70 A - 3/4"	Watts Req.
Energy Transport	1	Module-Energy Transport	SK-142065	Honeywell
	20 gal.	Dowtherm SR-1		
Control	1	Aquastat	L6008C1065	Honeywell
	1	Aquastat	L4008B1013	Honeywell
	1	Thermostat	T872C1004	Honeywell
	1	Sub Base	Q672B1004	Honeywell
	1	Valve	V4331A1003	Honeywell
	1	Sensor shield	SK-142067	Honeywell

HONEYWELL-GOVERNMENT FURNISHED EQUIPMENT

REF.: NAS8-32093
TOP DWG. NO.: SK- 142057
DATE: June 27, 1977
REVISED:

Single Family Residence

SYSTEM: Solar Heating LOCATION: Wm. O'Brien State Park, Stillwater, Minn.

SUBSYSTEM	QUANTITY	UNIT DESCRIPTION	PART NO.	MANUFACTURER
Control	2	Sensor	C773B1005	Honeywell
	2	Wells	122555B	Honeywell
	1	Case assembly	112892F	Honeywell
Site Data Acqu.	1	Site Data Acq. Module		
	1	Junction Box		
	1	Sensor - Total Radiation	(I001)	
	1	Sensor - Outdoor Ambient	(T001)	
	1	Sensor - Collect Inlet	(T100)	
	1	Sensor - Collector Diff.	(TD101)	
	1	Sensor - HX Solar Inlet	(T102)	
	1	Sensor - HX Solar Diff.	(TD103)	
	1	Sensor - HX Hot Water	(T200)	
	1	Sensor - HX Hot Water Diff.	(TD201)	
	1	Sensor - Storage Tank Top	(T202)	
	1	Sensor - Storage Tank M	(T203)	
	1	Sensor - Storage Tank B	(T204)	
	1	Sensor - Domestic Cold Water	(T300)	
	1	Sensor - Solar DHW Preheat	(TD301)	
	1	Sensor - Heating Coil HW	(T400)	
	1	Sensor - Heating Coil Diff.	(TD401)	
	1	Sensor - Heating Coil Air	(T600)	
	1	Sensor - Heating Coil Diff.	(TD601)	
	1	Sensor - Collector Flow Rate	(W100)	
	1	Sensor - Storage Flow Rate	(W200)	
	1	Sensor - DHW Flow Rate	(W300)	

HONEYWELL-GOVERNMENT FURNISHED EQUIPMENT

REF.: NAS8-32093
TOP DWG. NO.: SK- 142057
DATE: June 27, 1977
REVISED:

Single Family Residence

SYSTEM: Solar Heating LOCATION: Wm. O'Brien State Park, Stillwater, Minn.

SUBSYSTEM	QUANTITY	UNIT DESCRIPTION	PART NO.	MANUFACTURER
Site Data Acq.	1	Sensor - Heating Coil Flow	(W400)	
	1	Sensor - Collector Pump Pwr	(EP100)	
	1	Sensor - Storage Pump Pwr	(EP200)	
	1	Sensor - Heating Pump Pwr	EP400)	
	1	Sensor - Furnace Fan Pwr	(EP401)	
	1	Sensor - Natural Gas Flow	(F400)	
	1	Sensor - Heat Rej. Fan Pwr	(EP101)	
	1	Junction Box & Cable Ass'y		

SECTION 2

SYSTEM PERFORMANCE SPECIFICATIONS

Honeywell

ENERGY RESOURCES CENTER CODE IDENTIFICATION NO. 55513

HONEYWELL REQUIREMENTS SPECIFICATION NO. | HRS SK-140021

THIS HONEYWELL REQUIREMENTS SPECIFICATION IS FOR:

System Performance Specifications

SIGNATURES	DATE
PREPARED BY A. M. Klidzejs	7-1-77
APPROVED BY PROJECT ENGINEER Glen L Merrill	7-1-77

REVISIONS

LTR	DESCRIPTION	DATE	APPROVAL	LTR	DESCRIPTION	DATE	APPROVAL
A	Madison, WI to Stillwater, MN	6-30-77					

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HH-64

SYSTEM PERFORMANCE SPECIFICATION

Specification No. SFRH-1
Page Date 6 February, 1976
Page 1 of 4
Revised June 30, 1977

SYSTEM IDENTIFICATION

This section defines the performance and installation drawings for Residential Heating System, Honeywell Inc., System Model Number SFR-756H-1.

SYSTEM PERFORMANCE SHEETS

Site-
The system shall be installed in a residence in the William O' Brien State Park, in the county of Washington, state of Minnesota.

Heating Capacity -
The system will provide solar energy for 45% of the average total heating load[1] during the heating season[2] based on an average total heating load of 6.6×10^6 BTU/Month[3] and a peak heating load of 45,220 BTU/hr. on February 16, 1958 (-12°F).

Footnotes:

1. Yearly heating (or cooling) load minus auxiliary supplied for heating (or cooling) divided by the yearly total heating (or cooling) load.

2. Based on the number of months that have a heating (or cooling) load.

3. Total yearly heating (or cooling) load divided by the number of months that have a heating (or cooling) load.

Auxiliary Energy -

The average rate of auxiliary energy used for heating shall be no greater than 6.1×10^6 BTU/Month of the total energy required for heating, including hot water.[4] This shall be no greater than 6% of the total energy required for heating.[5]

Footnotes:

4. Average monthly auxiliary energy is the total auxiliary for heating and hot water (or cooling) divided by the number of months that have auxiliary for heating and hot water (or cooling).

5. Average monthly auxiliary energy divided by total yearly load for heating and hot water (or cooling).

SYSTEM PERFORMANCE SPECIFICATION

Specification No. SFRH-1
Page Date 6 February 1976
Page 2 of 4
Revised 30 June 1977

Hot Water -

40 gallons of potable (or usable) hot water shall be delivered at no less than 3 gal/min at temperatures no less than $140^{o}F$. Recovery time shall be no greater than .75 hours. The average hot water heating load will be 1.9×10^{6} BTU/Month of which 26% is provided by auxiliary energy.

Operating Requirements -

The maximum electrical energy required to drive only the solar portion of the system at its rated capacity shall be no greater than .5 K.W. The maximum electrical energy required to drive the complete system shall be no greater than 1.0 K.W. The average yearly electrical energy required to drive the system shall be no greater than 2200 K.W.H.

Physical Data - Table III

The following subsystems shall have:

	Expected life no less than:	Weight (filled) no greater than	Installation dimensions:
Heating	10 yrs.	34 lbs.	23" x 18" x 8"
Cooling	NA yrs.	NA lbs.	NA
Auxiliary Energy	10 yrs.	194 lbs.	49"x21 1/4"x22"
Storage	10 yrs.	9500 lbs.	64" xia. x72" long
Potable Water Preheat	10 yrs.	40 lbs.	7 3/4" dia. x 30" long
Potable Water	10 yrs.	475 lbs.	20"dia. x 50 3/16" high
Collector	10 yrs.	9.0 lbs/ft^2	3' x 6' x 6 1/2" ea.
Energy Transport	10 yrs.	TBD	NA
Controls	10 yrs.	TBD	NA

Performance Analysis Summary for William O'Brien State Park residence in Washington County, Minnesota.

	Load (10^6 Btu)		Auxiliary (10^6 Btu)	
Month	Heating	Hot Water	Heating	Hot Water
1	13.8	1.9	10.0	1.2
2	15.1	1.8	8.3	1.0
3	10.2	2.1	5.8	0.8
4	4.9	2.0	0.8	0.4
5	1.8	2.0	0.0	0.1
6	1.3	1.9	0.0	0.0
7	0.4	1.8	0.0	0.0
8	0.4	1.7	0.0	0.0
9	1.2	1.7	0.0	0.0
10	3.4	1.7	0.2	0.2
11	8.4	1.7	4.3	0.7
12	17.7	1.9	13.9	1.3
TOTAL	78.6	22.2	43.4	5.7

SYSTEM PERFORMANCE SPECIFICATION

INSTALLATION DRAWING SHEETS

SK-142057	SINGLE FAMILY RESIDENCE SYSTEM INTEGRATION

SUBSYSTEM DRAWING SCHEDULE

SK-142049	Collector Subsystem
SK-142050	Storage Subsystem
SK-142051	Auxiliary Energy and Space Heating Subsystems
SK-142052	Hot Water Subsystem
SK-142053	Energy Transport Subsystem
SK-142054	Control Subsystem
SK-142055	Site Data Aquisition Subsystem
SK-142056	Electrical Subsystem

SECTION 3

Document F3437-F-102
28 June 1977

SOLAR HEATING AND COOLING DEVELOPMENT PROGRAM

SPECIAL HANDLING INSTALLATION AND MAINTENANCE

TOOL LIST
for
Operational Site at
Wm. O'Brien State Park
Stillwater, Minnesota

A
Single Family Residence
Heating System

Contract NAS8-32093

Honeywell Inc.
Energy Resources Center
2600 Ridgway Parkway
Minneapolis, Minnesota 55413

Prepared By

Allen J Baldwin

Approved By

Glen L Merrill

SPECIAL HANDLING INSTALLATION AND MAINTENANCE TOOL LIST

1.0 Analysis

An analysis of the subsystem installations was conducted to determine if special handling or installation tools are required for a single family heating solar system.

A tool or piece of equipment is assumed to be special if a typical HVAC contractor does not have the tool or equipment or that he cannot obtain an infrequently used tool or equipment through local hire. To assure complete analysis, the matrix presented in Figure 1 was used. Those blocks marked in the matrix with a note represent items deemed unusual or questionable as to their status as standard equipment; each item has been investigated in more detail. The results of this further investigation and the availability of tools or equipment is presented in the notes following the matrix.

2.0 Conclusions

The conclusion of this analysis is that there are no special purpose tools or equipment required in a single family solar heating system. All tools or equipment required would be possessed by a typical HVAC contractor or be available through local hire.

TITLE	LIFTING OR PLACING EQUIPMENT	SPECIAL FITTINGS	INSTALLATION	VACUUM OR PRESSURE TESTING	FLUID INSTALLATION	PERFORMANCE MEASUREMENTS	RECOMMENDATIONS
COLLECTOR SUBSYSTEM	NOTE 1	N/A	N/A	NOTE 2	NOTE 3	NOTE 4	
ENERGY STORAGE	NOTE 1	N/A	N/A	N/A	N/A	N/A	
SPACE HEATING	N/A	N/A	N/A	N/A	N/A	N/A	
AUXILIARY ENERGY SUBSYSTEM	N/A	N/A	N/A	N/A	N/A	N/A	
HOT WATER SUBSYSTEM	N/A	N/A	N/A	N/A	N/A	N/A	
ENERGY TRANSPORT SUBSYSTEM	N/A	N/A	N/A	N/A	N/A	N/A	
CONTROLS SUBSYSTEM	N/A	N/A	N/A	N/A	N/A	N/A	
ELECTRICAL SUBSYSTEM	N/A	N/A	N/A	N/A	N/A	N/A	
INTEGRATION HARDWARE	N/A	N/A	N/A	N/A	N/A	N/A	

Figure 1. Special Tools and Handling Equipment Analysis

3.0 Notes

Note 1:
Collector and storage tank installation will require a crane or lift truck. This is available for local hire in any location.

Note 2:
Pressure testing will require an air compressor, which is either in the inventory of an HVAC contractor or is available on a daily rental basis.

Note 3:
Fluid installation in the collector loop will require a positive displacement pump and fittings. This is standard HVAC equipment used for filling hydronic heating systems.

Note 4:
Measurements made during system balancing will require pressure gauges and differential pressure gauges. These gauges are the same as those used for hydronic heating system balancing and should be in the possession of a typical HVAC contractor.

SECTION 4

Document F3437-M-105
28 June 1977

SOLAR HEATING AND COOLING DEVELOPMENT PROGRAM

Spare Parts List
for
Operational Site at
Wm. O'Brien State Park
Stillwater, Minnesota

Single Family Residence
Heating System

Contract NAS8-32093

Honeywell Inc.
Energy Resources Center
2600 Ridgway Parkway
Minneapolis, Minnesota 55413

Prepared By

Approved By

1.0 INTRODUCTION

This spare parts list is submitted under Data Item 16 for the Single Family Residential Solar Heating System being installed in Wm O'Brien State Park, Stillwater, Minnesota.

2.0 DEFINITIONS

a) Spare parts are those repair parts NASA/MSFC should procure and have on hand in case of subsystem/component failure because the item is a "non-standard" device or "one of a kind" device and repair parts would probably not be available.

b) Replacement parts are those repair parts that the component supplier could be expected to provide normally as HVAC industry standard practice. These replacement parts are normally available for all standard/catalog items.

3.0 BASIS

This spare parts list was determined utilizing a support philosophy that relies upon the HVAC dealer/distributor/factory to provide replacement parts when required. Only in those subsystems/components where it is not a "standard" component will replacement parts be recommended as spare parts.

3.0 BASIS (continued)

The screening criteria used, classified all componetns that were passive, i.e. pipes, tanks, heat exchangers, coils, cabinetry, etc. with "P." Only active (A) components were reviewed to determine if the item was "standard/catalog" (std) or "special" (sp). Table 1 lists all the solar heating components and their classification and type.

4.0 RECOMMENDATIONS

There are no items recommended as spare parts for the SFR Solar Heating System at Wm. O'Brien State Park, Stillwater, Minnesota.

TABLE 1. SPARE PARTS LIST

HONEYWELL FURNISHED EQUIPMENT - SPARES SELECTION ANALYSIS

SINGLE FAMILY RESIDENCE

SYSTEM: Solar Heating

LOCATION: Wm. O'Brien State Park, Stillwater, Minn.

SUBSYSTEM	QUANTITY	UNIT DESCRIPTION	PART NO	MANUFACTURER	CLASSIFICATION	TYPE	EXPECTED LIFE (IN YEARS)	SPARES RECOMMENDED
COLLECTOR	33	Solar Collector	LSC-18-1S	Lennox Industries	P			
	6	Header Assembly	SK-142064-2C	Honeywell	P			
	2	Header Assembly	SK-142064-1C	Honeywell	P			
	2	Header Assembly	SK-142064-1B	Honeywell	P			
	19	Hose Assembly	SK-142066	Honeywell	P			
	28	3/8 npt Coupling	4738-6-6	Aeroquip	P			
	38	3/8 npt Coupling	FF1162-0606B	Aeroquip	P			
	1	Purge Cooling Unit	CBHW3-1	Lennox Industries	A	STD	>10	0
STORAGE	1	Tank-Hot Water Storage	SK-14200	Honeywell	P			
		includes Hot Water Coil	SK-142008A	Honeywell	P			
AUXILIARY ENERGY AND SPACE HEAT	1	Furnace-Gas	G11Q3-82V	Lennox Industries	A	STD	>10	0
	1	Space Heat Coil	CW3-45	Lennox Industries	P			
DOMESTIC HOT WATER	1	Heater-Hot Water	40-GK35C	Lochinvar	P			
	1	Valve-Mixing	70A-3/4"	Watts Req.	A	STD	>10	0
ENERGY TRANSPORT	1	Module-Energy Transport as Listed Below	SK-142065	Honeywell				
	1	Pump 1/4 hp	Series 60-11S	Bell and Gossett	A	STD	>10	0
	2	Pumps 1/16 hp	Series PR-1	Bell and Gossett	A	STD	>10	0
	1	Heat Exchanger	SK-140184	Honeywell	P			
	1	Tank-Expansion	Model 30 Extrol	Amtrol	P			
	1	Seperator-Air	Model 451	Amtrol	P			
	1	Vent-Air	Model 690	Amtrol	P			
	1	Valve-Air	1/8" Radiator Air	Hammond	P			
	1	Valve-Relief	Model 480-36	Bell and Gossett	P			
	1	Valve-Dual	V4331-A1003	Honeywell	A	STD	>10	0
	1	Valve-Balancing	Model CB-1 1/4	Bell and Gossett	P			
	2	Valve-Balancing	Model CB-1	Bell and Gossett	P			
	1	Valve-Lift Check	Model BA-1 1/4	Bell and Gossett	A	STD	>10	0
	2	Valve-Swing Check	Model B-309	Stockham	A	STD	>10	0
	[illegible]	Valve-Drain/Fill	Model 7111-1/2	Hammond	P			
		Drain-Coupling	701-D-1	Nibco	P			
	[illegible]	Strainer-Pipeline	Style S-1 1/4	Strong	P			
	1	Switch-Low Pressure	P/N 3815936	General Motors	A	STD	>10	0
	1	Panel - Solar Control	Model W968A	Honeywell	A	STD	>10	0
	1	Cabinet-ETM	LR-1950	LeRae	P			
CONTROL	1	Aquastat	L6008C1065	Honeywell	A	STD	>10	0
	1	Aquastat	L4008B1013	Honeywell	A	STD	>10	0
	1	Thermostat	T872C1004	Honeywell	A	STD	10	0
	1	Sub Base	Q672B1004	Honeywell	P			
	1	Valve	V4331A1003	Honeywell	A	STD	>10	0
	1	Sensor Shield	SK-142067	Honeywell	P			
	2	Sensor	C773B1005	Honeywell	A	STD	>10	0
	2	Wells	122555B	Honeywell	P			
	1	Case Assembly	112892F	Honeywell	P			

SECTION 5

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Document F3437-IOM-101
29 June 1977

SOLAR HEATING AND COOLING DEVELOPMENT PROGRAM

Installation, Operation and Maintenance Manual Outline
for
Operational Site at
Wm. O'Brien State Park
Stillwater, Minnesota

A
Single Family Residence
Heating System

Contract NAS8-32093

Honeywell Inc.
Energy Resources Center
2600 Ridgway Parkway
Minneapolis, Minnesota 55413

Prepared by: Allen J Baldini

Approved by: Glen L Merrill

MANUAL OUTLINE

Operation

I. System Function
II. System Components
(Refer to Appendices)

Maintenance

I. System Monitoring
II. Periodic Maintenance Schedule
III. System Components
(Refer to Appendices)

Installation Instructions

I. General
II. Subsystems and Components
(Refer to Appendices)
III. Start-up and Check-out
IV. Balancing

Appendices

Appendix A.	Manual - Solar Collector
Appendix B.	Manual - Purge Cooling Unit
Appendix C.	Manual - Furnace, Gas
Appendix D.	Specification - Space Heat Coil
Appendix E.	Catalog Sheet Manual - Domestic Hot Water Heater
Appendix F.	Manual - Energy Transport Module
Appendix G.	Manual - Control

SECTION 6

Document F3437-P-103
9 September, 1976
Revised 6/29/77

HEATING SYSTEMS HAZARD ANALYSIS

Contract NAS8-32093

Honeywell Inc.
Energy Resources Center
2600 Ridgway Parkway N. E.
Minneapolis, Minnesota 55413

Document F3437-P-103
9 September, 1976
Revised 6/29/77

HEATING SYSTEMS HAZARD ANALYSIS

	Signatures	Date
Prepared by	[illegible]	Aug 25, 1976
Approved by	[illegible]	Aug 25 1976
	[illegible]	Aug 26 1976
Reviewed by	[illegible]	July 27, 1976

Revisions			
Test	Description	Date	Approval
	Additions to Hazard Corrective Action Matrix	6-29-77	[illegible]

1.0 INTRODUCTION

This document has a twofold purpose:

- To identify and categorize actual or potential hazards or hazardous conditions in single-family, multiple-family, and commercial solar heating systems.
- To identify, rationalize, and document measures to eliminate or mitigate these hazards.

These precautionary activities will continue through system development, and this document will be revised as necessary to ensure its completeness prior to the heating systems Prototype Design Review. All revisions will be approved by the program manager and will be recorded in the revision log.

2.0 DICTIONARY

Hazard - A hazard is any actual or potential condition that could cause injury or death to persons, or damage to or loss of equipment or property.

Hazard Level - A qualitative categorization of hazards in terms of potential consequences.

The following hazard levels which pertain in this program result from conditions such that user error, environment, design characteristics, procedural deficiencies, or component or subsystem failure could cause these types of damage:

Category I - Negligible - Will not result in injury to persons or damage to the system.

Category II - Marginal - Can, if not controlled, result in minor injury to persons or damage to equipment or structures.

Category III - Critical - Can if not controlled, result in serious injury to persons or major damage to equipment or structures.

Category IV - Catastrophic - Can, if not controlled cause death to persons or destruction of equipment or structures.

Hazard Control - Actions that eliminate or mitigate hazards. The hazard control techniques below are in descending order of preference. The highest level of practical action will be taken in a given case, with the goal in all cases being to reduce the hazard to the Category I level, or below, i.e., minimize it even further.

(1) Design for Minimum Hazard - The major effort during the design phases will be directed toward selecting appropriate design safety features, e.g., failsafe, redundancy.

(2) Safety Devices - Known hazards that cannot be eliminated from the design will be reduced to an acceptable level through use of appropriate safety devices.

(3) Warning Devices - When it is not practical to preclude the existence or occurrence of an identified hazard, a device that will detect it and provide timely warning will be used.

(4) Special Procedures - When none of the above is feasible, special operating procedures will be developed to reduce the hazards.

3.0 IDENTIFICATION AND CONTROL OF HAZARDS

This process will, as stated, be continuous during system development, with the goal being to reduce all hazards to the Category I level or below.

Table 1 is a list of identified hazards, the levels to which they are hazards, elements exposed to them [persons (p), equipment (e), and structures (s)], and corrective actions to eliminate or minimize them.

4.0 RATIONALE FOR CORRECTIVE ACTION

Class (2), (3) and (4) corrective actions leave residual hazard potential associated with failure of a safety device, failure of or failure to heed a warning device, or failure to follow procedures properly. The rationale for accepting this residual hazard rather than striving for a fail-safe design in all of its aspects is set forth below.

(Will be provided in a future revision).

TABLE 1. HAZARDS AND CORRECTIVE ACTION

Revised 6/29/77

Source of Hazard	Level	Exposure	Corrective Action: Type	Corrective Action: Description	Reference
Plumbing defects	III	p, e, s	(1)	Design to Code	Drawing SK 142057
Electrical defects	IV	p, e, s	(1)	Design to Code	Drawing SK 142057
Controls					
Excessive temperatures	II	e, s	(1)	Purge coil removes excess heat preventing temperature buildup.	Drawing SK 142049
Excessive pressures	II	p, e	(1)	Pressure relief valves and expansion tanks provided on pressurized loops.	Drawing SK 142053
Fire					
Increased fire hazard due to solar systems	IV	p, e, s	(1)	Heat transfer fluids are non-flammable	Drawing SK 142053
Reduced building fire resistance due to installation	IV	p, e, s	(1)	No unsealed penetrations of fire retarding members or walls.	Drawing SK 142057
Toxic and Flammable Fluids					
Drainage of overflow	IV, II	p, s	(1)	Overflow protection provided	Drawing SK 142053
Undetected leaks	IV, II	p, s	(1)	The collector loop is protected by a pressure sensor to warn occupants of leaks.	Drawing SK 142053
Emergency Conditions					
Blocked emergency exits	IV	p	(1)	Solar equipment does not block any portals or windows	
Blocked emergency access	IV	e, s	(1)		Drawing SK 142057
Inconspicuous/inaccessible controls	III	e, s	(1)	Controls conspicuously marked and located in accessible area	Drawing SK 142054 Drawing SK 142057
Protection of Water & Air					
Contamination of potable water	IV	p	(1)	Double point of failure between toxic fluid and potable water	Drawing SK 142050 Drawing SK 142057
Excessive Surface Temperatures					
Personnel burns	II	p	(1)	All surfaces in human occupied spaces are insulated to prevent temperatures in excess of 160°F.	Drawing SK 142053
Facility and Site					
Falling Snow and Ice	III	p	(1)	Site integration precludes falling snow or ice in walkways or occupied areas.	Drawing SK 142057

C-2

TABLE 1. HAZARDS AND CORRECTIVE ACTION

Revised 6/29/77

Source of Hazard	Level	Exposure	Corrective Action		Reference
			Type	Description	
Plumbing defects	III	p, e, s	(1)	Design to Code	Drawing SK 142057
Electrical defects	IV	p, e, s	(1)	Design to Code	Drawing SK 142057
Controls					
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Emergency Conditions					
Blocked emergency exits	IV	p	(1)	Solar equipment does not block any portals or windows	
Blocked emergency access	IV	e, s	(1)		Drawing SK 142057
Inconspicuous/inaccessible controls	III	e, s	(1)	Controls conspicuously marked and located in accessible area	Drawing SK 142054 Drawing SK 142057
Protection of Water & Air					
Contamination of potable water	IV	p	(1)	Double point of failure between toxic fluid and potable water	Drawing SK 142050 Drawing SK 142057
Excessive Surface Temperatures					
Personnel burns	II	p	(1)	All surfaces in human occupied spaces are insulated to prevent temperatures in excess of 160°F.	Drawing SK 142053
Facility and Site					
Falling Snow and Ice	III	p	(1)	Site integration precludes falling snow or ice in walkways or occupied areas.	Drawing SK 142057

C-2

APPENDIX A

SYSTEM INTEGRATION

DRAWING NO. SK 142057

APPENDIX A

SYSTEM INTEGRATION

DRAWING NO. SK 142057

PART NO.

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

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SUBSYSTEM DRAWING SCHEDULE

DRAWING TITLE	DRAWING NUMBER
COLLECTOR SUBSYSTEM	SK- 142049
STORAGE SUBSYSTEM	SK- 142050
AUXILIARY ENERGY & SPACE HEATING SUBSYSTEMS	SK- 142051
HOT WATER SUBSYSTEM	SK- 142052
ENERGY TRANSPORT SUBSYSTEM	SK- 142053
CONTROL SUBSYSTEM	SK- 142054
SITE DATA AQUISITION SUBSYSTEM	SK- 142055
ELECTRICAL SUBSYSTEM	SK- 142056

UNRELEASED DRAWING – NOT SUBJECT TO E.C.O. CONTROL

NEXT ASSY | USED ON | APPLICATION

TOLERANCES UNLESS NOTED OTHERWISE

MATERIAL

FINISH–SEE NOTE

DRAFTSMAN 6/6/77
CHECKER
DEV ENGR
ENGRG MGT
CONTRACT NO.

WILLIAM O'BRIEN

HONEYWELL INC. | ENERGY RESOURCES CENTER, MINNEAPOLIS, MINN. 55413

SINGLE FAMILY RESIDENCE SYSTEM INTEGRATION

SIZE	CODE IDENT NO.	DRAWING NO.
C	55513	SK-142057

SCALE NONE | SHEET 1 OF 3

A-1

PART NO.

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

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SUBSYSTEM DRAWING SCHEDULE	
DRAWING TITLE	DRAWING NUMBER
COLLECTOR SUBSYSTEM	SK-142049
STORAGE SUBSYSTEM	SK-142050
AUXILIARY ENERGY & SPACE HEATING SUBSYSTEMS	SK-142051
HOT WATER SUBSYSTEM	SK-142052
ENERGY TRANSPORT SUBSYSTEM	SK-142053
CONTROL SUBSYSTEM	SK-142054
SITE DATA AQUISITION SUBSYSTEM	SK-142055
ELECTRICAL SUBSYSTEM	SK-142056

UNRELEASED DRAWING ... E.C.O. CONTROL

NEXT ASSY	USED ON
APPLICATION	

TOLERANCES UNLESS NOTED OTHERWISE

MATERIAL

FINISH—SEE NOTE

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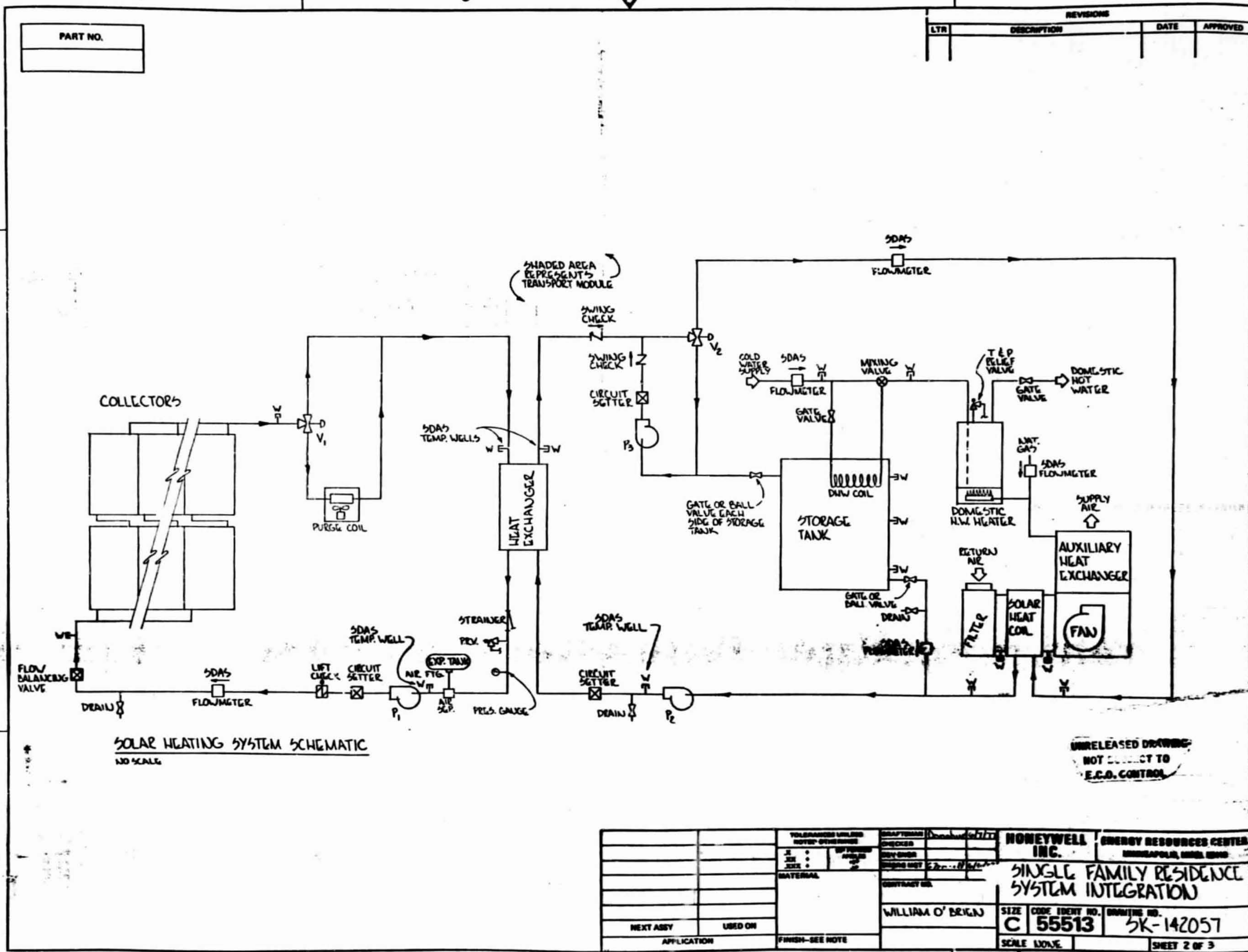
SINGLE FAMILY RESIDENCE SYSTEM INTEGRATION

SIZE	CODE IDENT NO.	DRAWING NO.
C	55513	SK-142057

SCALE NONE SHEET 1 OF 3


SOLAR HEATING SYSTEM SCHEMATIC
NO SCALE
COLLECTORS
PURGE COIL
HEAT EXCHANGER
SDAS TEMP. WELLS
SHADED AREA REPRESENTS TRANSPORT MODULE
SWING CHECK
CIRCUIT SETTER
STORAGE TANK
DHW COIL
GATE OR BALL VALVE EACH SIDE OF STORAGE TANK
COLD WATER SUPPLY
FLOWMETER
MIXING VALVE
GATE VALVE
T & P RELIEF VALVE
DOMESTIC HOT WATER
DOMESTIC H.W. HEATER
NAT. GAS
SUPPLY AIR
AUXILIARY HEAT EXCHANGER
RETURN AIR
FILTER
SOLAR HEAT COIL
FAN
STRAINER
PRV
EXP. TANK
AIR FTG.
AIR SEP.
PRES. GAUGE
LIFT CHECK
FLOW BALANCING VALVE
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UNRELEASED DRAWING NOT SUBJECT TO E.C.O. CONTROL
HONEYWELL INC.
ENERGY RESOURCES CENTER
SINGLE FAMILY RESIDENCE SYSTEM INTEGRATION
WILLIAM O' BRIEN
SIZE C
CODE IDENT NO. 55513
DRAWING NO. SK-142057
SCALE NONE
SHEET 2 OF 3
PART NO.
REVISIONS
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APPLICATION
CONTROL A

IPC SYSTEM INTEGRATION CRITERIA

2.1 Requirement — System Design Conditions. The systems for heating (H) and combined heating and cooling (HC) and the domestic hot water (DHW) system/subsystem shall be capable of functioning at their designed flow rates, pressures and temperatures.

2.1.5 Criterion — Entrapped Air. When liquid heat transfer fluids are used, the system shall provide suitable means for air removal.

2.2 Requirement — Mechanical Stresses. Mechanical stresses that arise within the system shall not cause damage or malfunction of the system or its components.

2.2.1 Criterion — Vibration Stress Levels. Vibrations in piping, ducts, instrumentation lines, and control devices shall be controlled to reduce stress levels below those that could cause fatigue and subsequent component damage.

2.2.5 Criterion — Thermal Changes. The system components and assemblies shall be designed to allow for the thermal contraction and expansion that would occur over the service temperature range.

2.2.6 Criterion — Flexible Joints. All systems employing heat transfer fluids shall be designed to be capable of accommodating flexing of plumbing and fittings.

2.3 Requirement — Leakage Prevention. System assemblies containing heat transfer fluids shall not leak to an extent greater than that specified in the design when operated at the design conditions.

2.3.1 Criterion — Pressure Test: Nonpotable Fluids. Those portions of the H, HC and DHW systems which contain heat transfer fluids (other than air) and are not directly connected to the potable water supply shall not leak when pressures of not less than 1-1/2 times their working pressure are imposed for a minimum of 15 minutes.

2.3.2 Criterion — Pressure Test: Potable Water. Those portions of the H, HC and DHW systems that are directly connected to the potable water supply system shall not leak when tested in accordance with the code having jurisdiction in the area where the system is used. In areas having no building code, a nationally recognized model code shall be used.

2.7 Requirement — Piping Supports. Pipe hangars, pipe trenches, and other supports shall carry the static and operational loads normally imposed without impairing system function.

2.7.1 Criterion — Applicable Plumbing Standards. Piping shall be installed in accordance with Section 615 of the MPS (4900.1 and 4910.1).

3.2 Requirement — Failure Loads and Load Capacity. The structural elements and connections of the H, HC and DHW systems shall not fail under ultimate loads expected during the service life of the system.

3.2.1 Criterion — Ultimate Load Combinations. Non-conventional elements and connections shall comply with this criterion. (Conventional elements and connections are deemed to satisfy this criterion).

Structural components, connections and supporting elements shall be designed to withstand a uniform load of 50 psf.

3.5 Requirement — Cutting of Structural Elements. Cutting of structural elements for the installation of H, HC and DHW system components shall not reduce the required load capacity of structural elements.

3.5.1 Criterion — Design Provisions. The effect on the size, shape or engineering properties of a load-bearing element resulting from holes, cuts, notches, etc., shall be determined to insure that required safety margins against failure have been maintained.

3.6 Requirement — Constraint Loads. The structural elements and connections of H, HC and DHW systems shall comply with Criterion 3.2.1 while simultaneously subjected to constraint loads expected during the service life.

3.6.1 Criterion — Foundation Settlement, Contraction and Expansion. Non-conventional elements and connections shall comply with this criterion. (Conventional elements and connections are deemed to satisfy this criterion).

4.1 Requirement — Plumbing and Electrical Installation. The design and installation of the systems for heating (H), combined heating and cooling (HC) and the domestic hot water (DHW) system/subsystem and their components shall be in accordance with nationally recognized plumbing and electrical codes and standards for health and safety, where applicable.

4.1.1 Criterion — Plumbing Codes and Standards. Plumbing materials and equipment and their installation shall be in accordance with Sections 515 and 615 of the MPS (4900.1 and 4910.1).

4.1.2 Criterion — Electrical Codes and Standards. Electrical materials and equipment and their installation shall be in accordance with Sections 516 and 616 of the MPS (4900.1 and 4910.1).

4.3 Requirement — Fire Safety. The design and installation of the H, HC and DHW systems and their components shall provide a minimum level of fire safety consistent with applicable codes and standards.

4.3.2 Criterion — Penetrations through Fire-Rated Assemblies. Penetrations through fire rated walls, partitions, floors, roofs, etc. shall not reduce the fire resistance below the levels specified in Section 605 of the MPS (4900.1 and 4910.1) (1), where applicable.

4.5 Requirement — Safety Under Emergency Conditions. In the event of emergencies, the H, HC and DHW systems shall not unduly hinder the movement of occupants of the building or emergency personnel. Life safety hazards which could occur as a result of failures of the above systems shall not be greater than those imposed by conventional systems.

4.5.1 Criterion — Emergency Egress and Access. The design and installation of the H, HC and DHW systems shall not impair the emergency movement of occupants of the building or emergency personnel to an extent greater than that allowed by Sections 402 and 405 of the MPS (4900.1 and 4910.1) (1) and NFPA 101 (3), where applicable.

6.1 Requirement — Accessibility for Maintenance and Servicing. The systems for heating (H), combined heating and cooling (HC) and the domestic hot water (DHW) system/subsystem shall be designed, constructed, and installed to provide sufficient access for general maintenance, convenient servicing and monitoring of system performance.

6.1.1 Criterion — Access for System Maintenance. All individual items of equipment and components of the H, HC and DHW systems which may require periodic examination, adjusting, servicing and/or maintenance shall be accessible for inspection, service, repair, removal or replacement without dismantling of any adjoining major piece of equipment or subsystem.

6.1.5 Criterion — Filters. Filters shall be designed and located so that they can be cleaned or replaced with minimum disruption to the system and adjacent equipment. Cleaning frequencies shall be specified by the system manufacturer in the maintenance manual.

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HONEYWELL INC.	ENERGY RESOURCES CENTER
Title	SINGLE FAMILY RESIDENCE SYSTEM INTEGRATION
Drawn by	WILLIAM O'BRIEN
Size	C
Code Ident No.	55513
Drawing No.	SK-142057
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Sheet	3 OF 3
Control	A

PART NO.

APPENDIX B

COLLECTOR SUBSYSTEM
DRAWING NO. SK 142049

SOLAR COLLECTORS
LSC18-1S AND LSC18-1

The Lennox LSC18 solar collector is a development of the Lennox Research Laboratory Solar Design department, Lennox Manufacturing group and the Solar Research group of Honeywell Inc. The LSC18 is a glass cover, selective absorber, solar collector adaptable to any type and size solar system. Lennox collectors are available with single (LSC18-1S) or two-glass (LSC18-1) covers and utilized to accumulate solar energy which may be used in systems for heating residences, commercial areas, domestic hot water, swimming pool water, etc. The LSC18 collector is a high thermal efficiency, flat plate collector applicable to new or retrofit installations. Collectors are designed for easy installation in separate supports or frames constructed of wood or metal. The solar collector structural framing system may be installed on a roof or at ground level. Collectors can be installed individually or in multiple banks end to end and/or side by side and assembled in parallel, series or series parallel combination. When collectors are installed the thermal expansion of each absorber plate is approximately 0.125 inch for a temperature difference of 300°F. Since the inlet and outlet from each collector are on opposite sides of the modules, the inter connection forms an expansion loop relieving thermal expansion forces. Service access to each collector may be accomplished without removing the entire module or disturbing the adjacent modules. All piping connections are located external to the collector enclosure. The high output-to-insolation ratio of the collector is accomplished primarily in the design of the steel absorber plate which captures solar energy and transfers it to usable heat. The plate is formed around the copper flow tubes and sealed with a solder filler. The wrap-around contact of plate to tubes provides maximum heat transfer and the tubes, permanently sealed against oxide corrosion, have continuing high efficiency. In addition, the entire plate is given a special black chrome coating for high absorptivity and low re-radiation loss. The absorber plate is completely isolated on rubber pads within the enclosure, eliminating metal-to-metal contact that would result in conductivity loss. Surfaces of the glass cover(s) have acid etched surface lines that increase light transmission by reducing reflection. Tempered, low iron glass is abrasion resistant and structurally strong. In case of breakage, the weather tight aluminum cover frame can be easily dismantled for glass replacement. The collector enclosure is constructed of galvalume steel with a electrostatically dip-painted finish. Enclosure is completely lined with high temperature fiberglass insulation both beneath and around the absorber plate. Two-position mounting brackets on each corner of the enclosure permits installation either vertically or on flat surfaces. Collectors are shipped individually and factory assembled. The installer has only to mount collector in type of framing structure desired and make connections to system supply and return lines.

NOTE: Specifications, Ratings and Dimensions subject to change without notice.

FEATURES

Translucent Cover — Composed of one or two sheets of 1/8 inch thick tempered low iron glass. Both surfaces of the glass sheet are anti-reflection surface etched to increase transmission. The glass sheet has a PVC (Poly Vinyl Chloride) weatherstrip seal around the edges and is enclosed in an extruded aluminum frame which may be disassembled for replacement of the glass. Vent holes are provided in the aluminum frame. The rugged glass cover is structurally strong enough to withstand heavy wind, rain and snow loads. The glass cover system provides transmission of the maximum amount of incident solar energy.

Absorber Plate — The solar absorber is an assembly of parallel copper flow tubes bonded to a formed steel plate and electroplated with a solar selective coating. [illegible]

Insulation — The solar collector has 3 1/2 inch thick insulation beneath the absorber plate and 1 inch around the sides of the collector enclosure. The insulation is a semi-rigid fiberglass board without facing and is capable of withstanding unlikely temperatures up to 350°F without outgassing.

Collector Enclosure — The weather-tight enclosure is constructed of corrosion resistant heavy gauge galvalume steel with a special Lennox "Electro Deposition" process paint finish. Extruded aluminum cover frame is anodized for maximum protection against corrosion. Cover frame is easily removed for complete service access to interior of enclosure. Weep holes are furnished in the enclosure for ventilation and moisture removal in case of any condensation. The absorber plate is mounted on silicone rubber pads isolating the plate from metal to metal contact with the enclosure that would result in any conductivity loss. Two-position mounting brackets on each corner of the enclosure provide flexibility of installation. Piping connections are located external to the enclosure and are equipped with piping collars which reinforce the pipe fittings and allows force to be applied to the connection without stressing the manifolds.

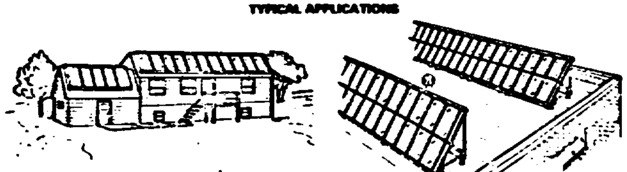
Collector (Transport or Cooling) Fluid — The heat transfer fluid used in the solar collector can range from water to various oils. However, the fluid should exhibit the following properties: low viscosity over the range of ambient temperatures encountered, noncorrosive (with inhibitors if necessary), chemically stable over 15-20 year life, good heat transfer properties, high heat capacity and low freezing point if low ambient temperatures are anticipated. Lennox recommends the use of ethylene glycol based antifreeze (Dowtherm SR-1, produced by the Dow Chemical Company). Mixed with water in a 50-50 ratio by volume, SR-1 yields a fluid capable of providing efficient heat transfer over a temperature range of -40°F to 300°F. Dowtherm should be analyzed once per year and inhibitors added if needed.

Specifications —

- Collector Model Numbers:
  - Single Glass Cover LSC18-1S
  - Double Glass Cover LSC18-1
- Nominal Collector Area — 18 sq. ft.
- Effective Absorber Area — 15.4 sq. ft.
- Ratio Of Usable Absorber Area To Total Surface Covered — 86%
- Glass Cover(s):
  - 1/8 in. Thick
  - Tempered Low Iron Clear
  - Transmittance — .96
- Absorber Coating Black Chrome On Bright Nickel:
  - Absorptivity — .95
  - Emissivity — .16
  - Stable To [illegible]

Absorber Construction:
  - Steel Plate
  - Copper Flow Tubes — [illegible] 1/4 in. o.d. (.194 in. i.d.)
  - Tube Spacing — [illegible] On Center
  - [illegible]
  - Manifold — 1-1/8 in. o.d. (1.079 in. i.d.)
  - Tube Connections To Manifold ASTM BCuP-5 Brazing Material
  - Bond Between Tubes & Steel Plate — 95-5 Solder
  - Piping Connections (inlet outlet) — 3/8-18 fpt
  - Manifolds & Tubes Pressure Tested: To 150 psig Working Pressure
- Recommended Flow Rate Thru Collector — .3 to .7 gpm
- Collector Fluid Capacity — .3 gal
- Collector Fluid (50-50 Dowtherm SR-1 or Equivalent): SR-1 Data:
  - Density — 1.065 gm/ml (at 160°F)
  - Viscosity — 1.4 centipoise (at 160°F)
  - Thermal Conductivity — 0.23 Btu/h-°F (at 160°F)
  - Specific Heat — 0.86 Btu/lb °F (at 160°F)
  - Boiling Point — 232°F
  - Freezing Point — -34°F
- Insulation — Semirigid Fiberglass Board:
  - Density — 3.0 lb/ft³
  - Thermal Conductivity — 0.28 Btu in./hr-ft² (at 300°F) (R = 12.8)
  - Specific Heat — .16 Btu/lb °F
  - Maximum Temperature — 350°F (without outgassing)
- Collector Shipping Weight (lbs.) — (1 - Package)
  - LSC18-1S — 143
  - LSC18-1 — 170
- Collector Net Weight (lbs.)
  - LSC18-1S — 123
  - LSC18-1 — 150

TYPICAL APPLICATIONS



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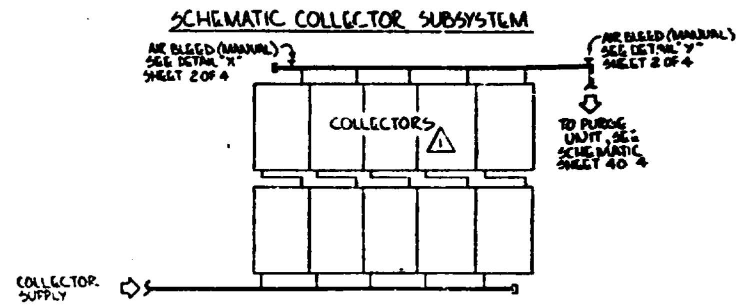
SCHEMATIC COLLECTOR SUBSYSTEM



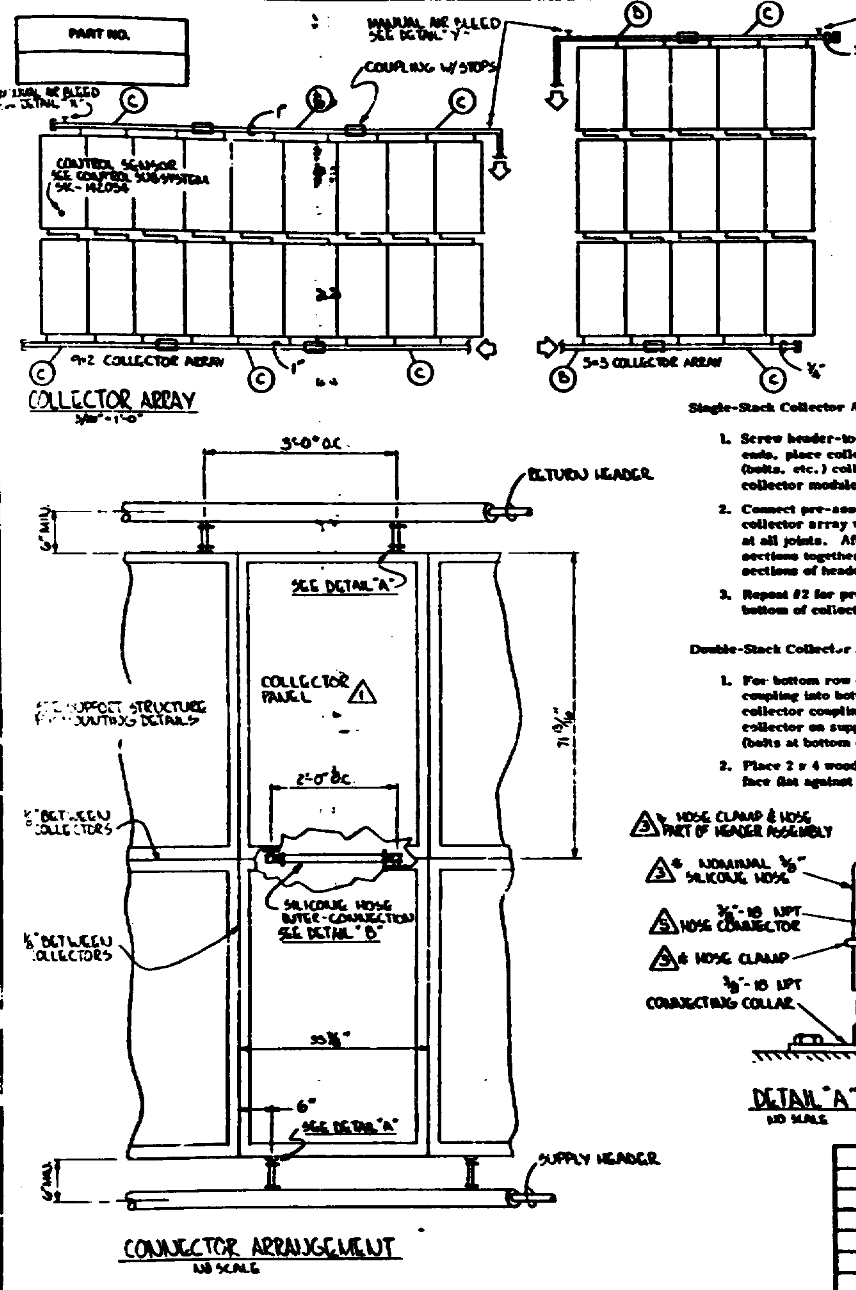
MATERIAL SCHEDULE

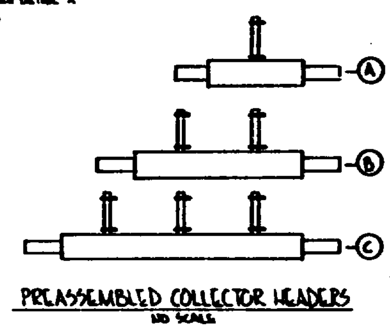
ITEM NO.	ITEM	MANUFACTURER	TYPE / PART NO.	QUAN.
1	COLLECTOR	LENNOX IND.	LSC-18-1S	33
2	PURGE COOLING UNIT	LENNOX IND.	CBHW3-41	1
3	HEADER ASSEMBLY (PRE ASSEMBLED)	HONEYWELL	SK-142064	
4	HOSE KIT	HONEYWELL	SK-142066	19
5	COUPLING NOM. 3/8 NPT × 3/8" (HOSE TO COLLECTOR)	AEROQUIP	4738-6-6 ([illegible])	28
[illegible]	COUPLING NOM. 3/8 NPT × 3/8" (COLLECTOR TO CLTR)	AEROQUIP	FF1462-0606[illegible]	38
[illegible]	INSULATION NOM. (3/4" THICK)	ARMSTRONG CORK CO.	ARMAFLEX	[illegible]
[illegible]	COPPER END CAPS NOM. 1"	NIBCO	617-1	4
[illegible]	INSULATION ADHESIVE	ARMSTRONG CORK CO	520	[illegible]
[illegible]	INSULATION WEATHERPROOFING	ARMSTRONG CORK CO.	ARMAFLEX FINISH	[illegible]
[illegible]	FLOW BALANCING VALVE	BELL & GOSSETT	CB-1 (CB-3/4)	1 EA
[illegible]	TEMPERATURE WELLS	PETERSON EQUIP. CO.	[illegible]	
[illegible]	FITTING REDUCER NOM. [illegible]	NIBCO	600-2-1×3/4	1
[illegible]	VENT ELBOW NOM. 1"	NIBCO	705-D-1	1
[illegible]	FITTING DRAIN COUPLING NOM. 3/4"	NIBCO	701-2-D-3/4	2
16	FITTING PLUG NOM. 3/4"	NIBCO	616-3/4	2
17	VENT ELBOW NOM. 3/4"	NIBCO	705-D-3/4	1
18	BALL VALVE	NIBCO	S-580-1 (S-580-3/4)	1 EA.
19				

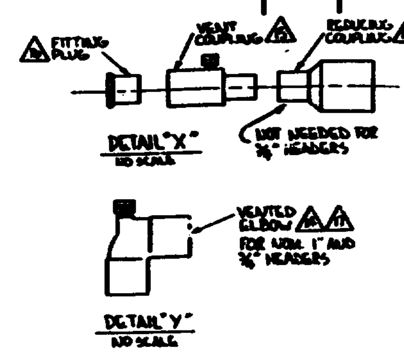
UNRELEASED DRAWING - NOT [illegible] TO E.C.O. CONTROL

NEXT ASSY	USED ON	TOLERANCES UNLESS NOTED OTHERWISE	DRAFTSMAN / CHECKER / DEV ENGR / DESIGN UNIT	HONEYWELL INC.	ENERGY RESOURCES CENTER
APPLICATION		MATERIAL / FINISH—SEE NOTE	WILLIAM O'BRIEN	SINGLE FAMILY RESIDENCE COLLECTOR SUBSYSTEM	
				SIZE C · CODE IDENT NO. 55513 · DRAWING NO. SK-142049	SCALE NONE · SHEET 1 OF 4

CONTROL A







INSTALLATION NOTES

Single-Stack Collector Array

1. Screw header-to-collector coupling into both collector ends, place collector on support structure, and fasten (bolts, etc.) collector to structure. Repeat for all collector modules.
2. Connect pre-assembled return header sections to top of collector array with section-to-section couplings placed at all joints. After proper alignment braze header sections together. Insulate and weatherproof uninsulated sections of header. Strap header to support structure.
3. Repeat #2 for pre-assembled supply header sections at bottom of collector array.

Double-Stack Collector Array

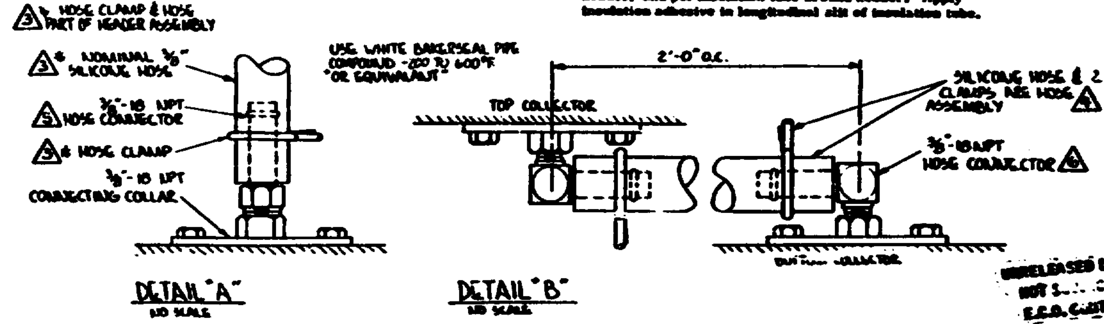
1. For bottom row collector screw header-to-collector coupling into bottom end of collector and collector-to-collector coupling into top end of collector. Place collector on support structure and fasten to structure (bolts at bottom end and insert clips at top end).
2. Place 2 x 4 wood stud at top end of collector with wide face flat against support structure.
3. For second stack collector screw collector-to-collector coupling into bottom end of collector and header-to-collector coupling into top end of collector.
4. Lower collector down structure until it rests against wood stud, and connect fluid lines with 24 in. silicone hose clamping each end to coupling.
5. Remove 2 x 4 wood stud and lower collector such that mounting brackets slide into clips. Fasten top mounting brackets (bolts) to structure.
6. Repeat #1 - #5 for entire collector array.
7. Connect pre-assembled return header sections same as #2 for single-stack array.
8. Connect pre-assembled supply header sections same as #2 for single-stack array.

Triple-Stack Collector Array

The procedure is an extension of the double-stack collector array installation notes.

INSULATION NOTES

Apply insulation adhesive to surface of uninsulated portion of header, and put insulation tube around header. Apply insulation adhesive to longitudinal slit of insulation tube.



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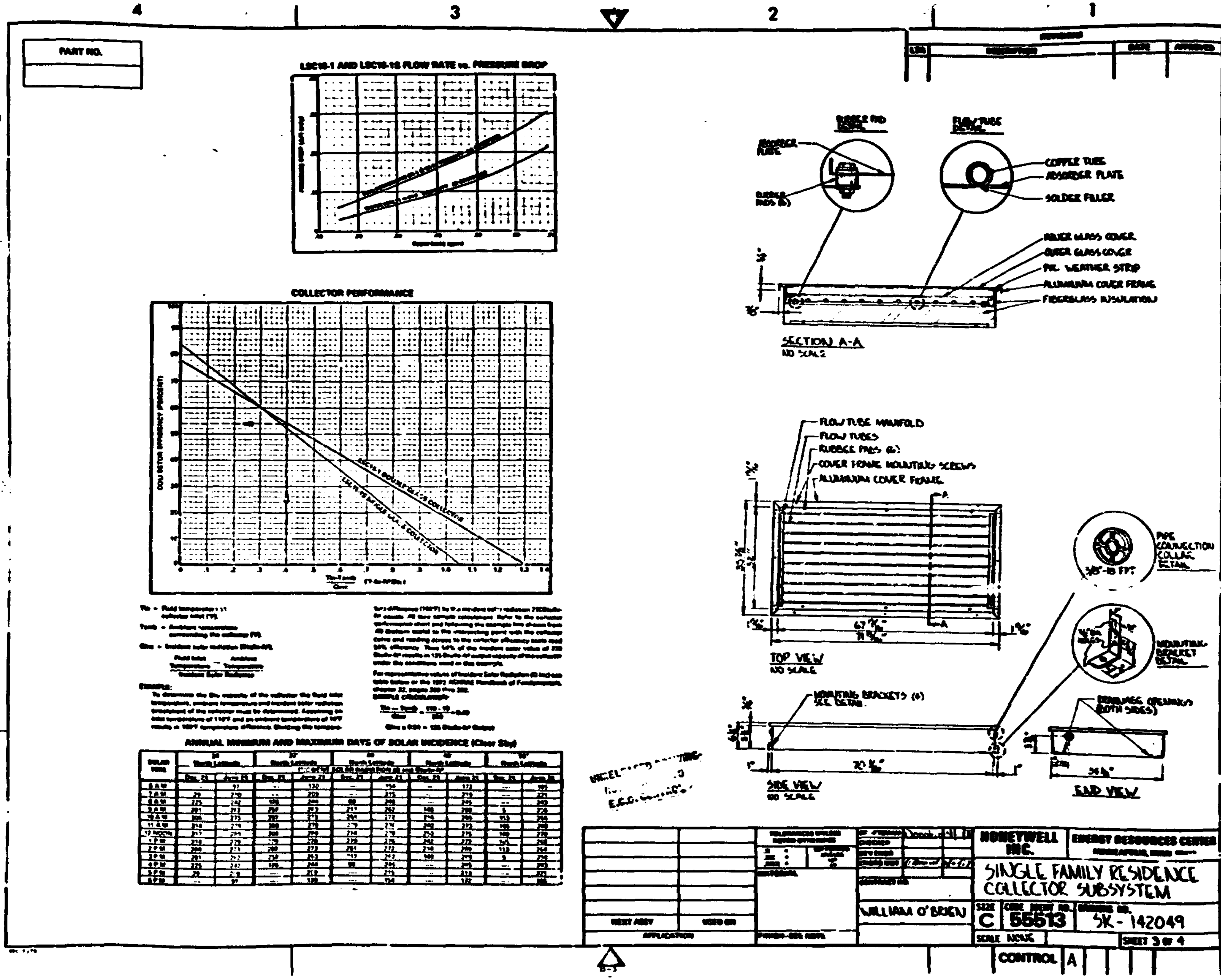
HONEYWELL INC.	ENERGY RESOURCES CENTER
Title	SINGLE FAMILY RESIDENCE COLLECTOR SUBSYSTEM
Drawn	WILLIAM O'BRIEN
Size	C
Code Ident No.	55513
Drawing No.	SK-142049
Scale	AS INDICATED
Sheet	2 OF 4
Control	A
Next Assy / Used On	APPLICATION



PART NO.
LSC18-1 AND LSC18-1S FLOW RATE vs. PRESSURE DROP
COLLECTOR PERFORMANCE
ANNUAL MINIMUM AND MAXIMUM DAYS OF SOLAR INCIDENCE (Clear Sky)
RUBBER PAD DETAIL
ABSORBER PLATE
RUBBER PADS (6)
FLOW TUBE DETAIL
COPPER TUBE
ABSORBER PLATE
SOLDER FILLER
INNER GLASS COVER
OUTER GLASS COVER
PVC WEATHER STRIP
ALUMINUM COVER FRAME
FIBERGLASS INSULATION
SECTION A-A
NO SCALE
FLOW TUBE MANIFOLD
FLOW TUBES
RUBBER PADS (6)
COVER FRAME MOUNTING SCREWS
ALUMINUM COVER FRAME
TOP VIEW
NO SCALE
PIPE CONNECTION COLLAR DETAIL
MOUNTING BRACKET DETAIL
MOUNTING BRACKETS (4) SEE DETAIL
SIDE VIEW
NO SCALE
DRAINAGE OPENINGS (BOTH SIDES)
END VIEW
HONEYWELL INC.
ENERGY RESOURCES CENTER
SINGLE FAMILY RESIDENCE
COLLECTOR SUBSYSTEM
WILLIAM O'BRIEN
SIZE C
55513
SK-142049
SCALE NONE
SHEET 3 OF 4
CONTROL A
NEXT ASSY
USED ON
APPLICATION

B-3

PART NO.

PURGE COIL DESCRIPTION

Heat Capacity and Pressure Drop

Height of the coil	= 25"
Length of the coil	= 20"
No. of rows	= 2
No. of fins/inch	= 15
Outer dia. of tubes	= 1/2"
No. of circuits	= 10
Air flow rate	= 2000 CFM
HP of fan motor	= 1/5

Assumed air temp. at the suction side of the fan = 60-120°F

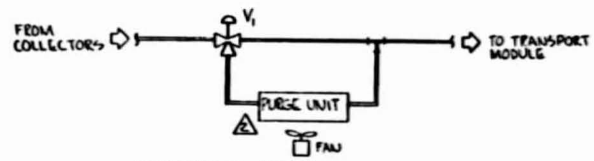
Calculated heat dissipated/hr = 101,000-15_,000 Btu/hr. (Inlet Fluid Temp. = 230°F 50% glycol solution)

Pressure drop (calculated) in the Purge coil = 9.0 ft.

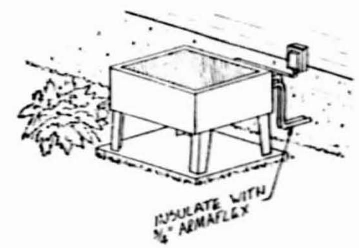
INSTALLATION NOTES

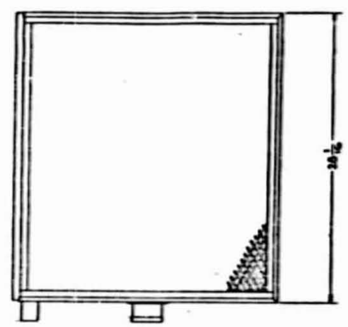
PLUMBING: Connect the inlet and outlet manifolds (1 5/8", O.D., copper tube) of the purge coil to the desired pipes in the collector loop.

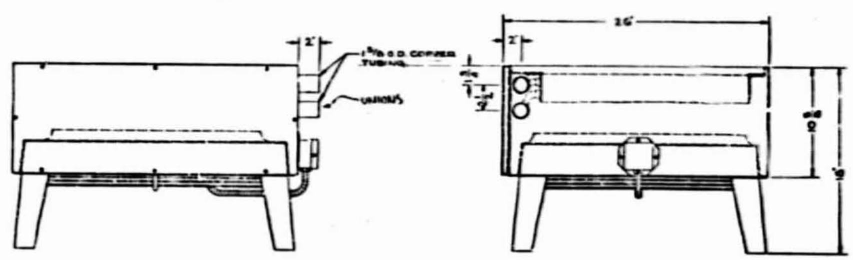
ELECTRICAL: Connect the motor of the purge coil fan to the control panel.



SCHEMATIC - PURGE
NO SCALE







PURGE COIL UNIT (HEAT REJECTOR)
1½" = 1'-0"

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REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

NEXT ASSY	USED ON
APPLICATION	
TOLERANCES UNLESS NOTED OTHERWISE	
MATERIAL	
FINISH—SEE NOTE	
DRAFTSMAN / CHECKER / DEV ENGR / ENGR	
CONTRACT NO.	
WILLIAM O'BRIEN	

HONEYWELL INC. ENERGY RESOURCES CENTER

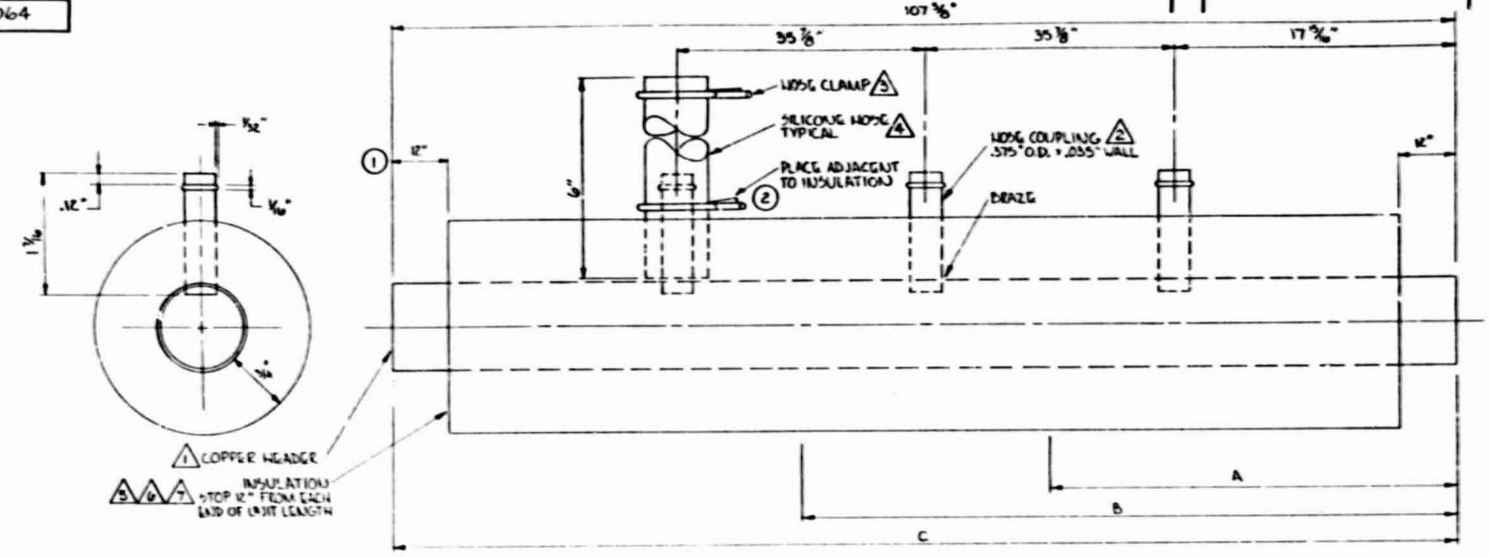
SINGLE FAMILY RESIDENCE COLLECTOR SUBSYSTEM

SIZE	CODE IDENT NO.	DRAWING NO.
C	55513	SK-142049

SCALE 1½" = 1'-0" SHEET 4 OF 4

CONTROL A

PART NO.
SK-142064



FABRICATION NOTES

1. 12" LEFT UNINSULATED ON EACH END OF UNIT LENGTH IN TABULATION
2. HOSE CLAMP LOCATED ADJACENT TO OUTER SURFACE OF INSULATION

HEADER SIZES

		DIAMETER			
		-1	-2	-3	
		3/4"	1"	1 1/4"	
LENGTH	A	35 7/8"	35 7/8"	35 7/8"	
	B	71 3/4"	71 3/4"	71 3/4"	
	C	107 7/8"	107 7/8"	101 3/8"	

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UNRELEASED DRAWING ... E.C.O. CONTROL

MATERIAL SCHEDULE

ITEM #	ITEM	MANUFACTURER	TYPE/PART NO.	QUAN.
1	COPPER HEADER	REVERE	M	
2	NOM. 3/8" COUPLING	BAUER WELDING & METAL	CUSTOM MADE	
3	NOM. 3/4" HOSE CLAMP	EATON CORP	R-12	
4	NOM. 3/8" SILICONE HOSE	AEROQUIP	FC252-6	
5	INSULATION (3/4" THICK)	ARMSTRONG CORK CO.	ARMAFLEX	
6	INSULATION ADHESIVE	ARMSTRONG CORK CO	520 ADHESIVE	
7	INSULATION FINISH	ARMSTRONG CORK CO	ARMAFLEX FINISH	

TOLERANCES UNLESS NOTED OTHERWISE

MATERIAL

FINISH-SEE NOTE

NEXT ASSY | USED ON

APPLICATION

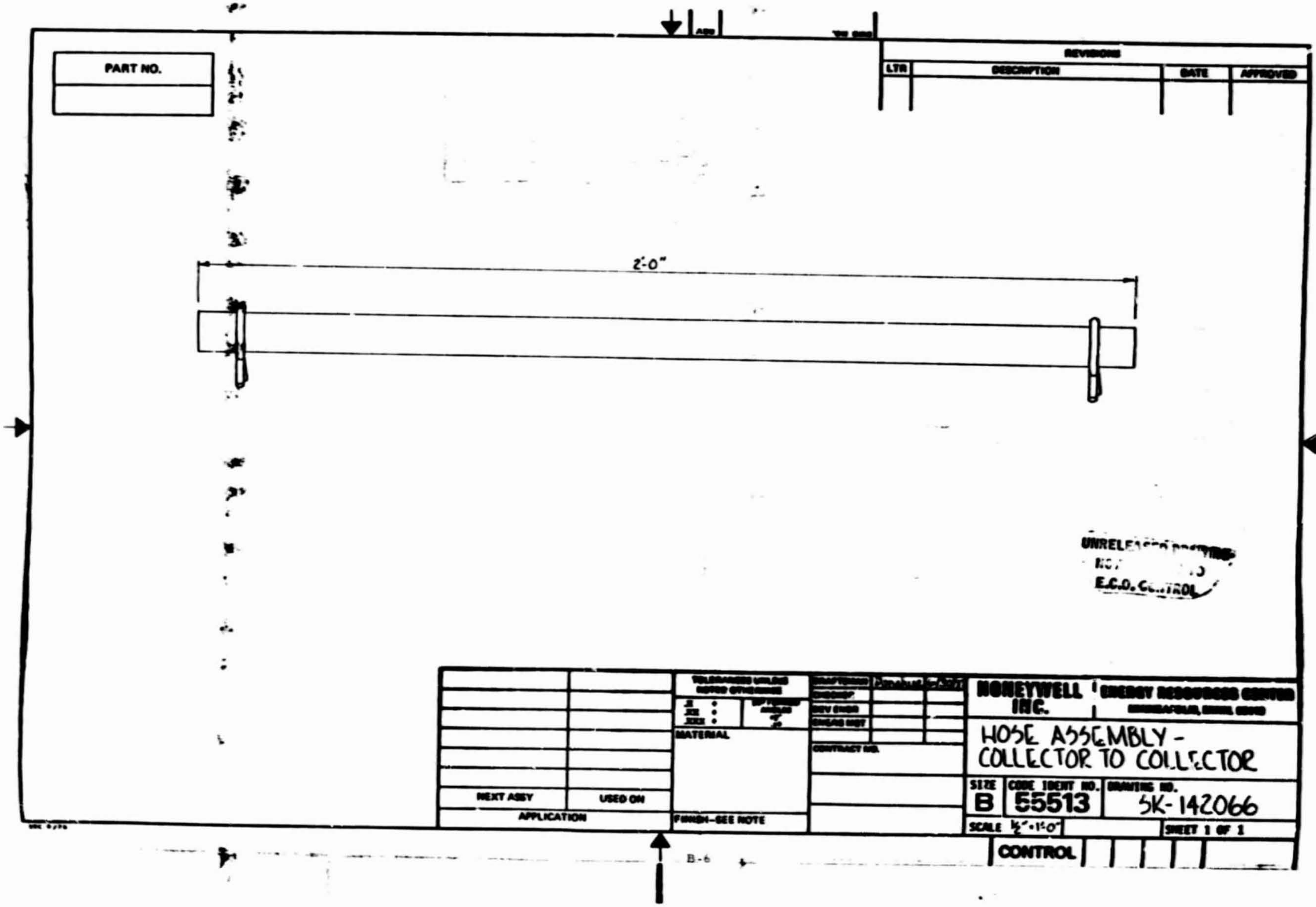
HONEYWELL INC. | ENERGY RESOURCES CENTER, MINNEAPOLIS, MINN.

HEADER ASSEMBLY - COLLECTOR

SIZE C | CODE IDENT NO. 55513 | DRAWING NO. SK 142064

SCALE NONE | SHEET 1 OF 1

CONTROL


PART NO.
REVISIONS
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DESCRIPTION
DATE
APPROVED
2'-0"
UNRELEASED
E.C.O. CONTROL
NEXT ASSY
USED ON
APPLICATION
MATERIAL
FINISH—SEE NOTE
CONTRACT NO.
HONEYWELL INC.
ENERGY RESOURCES CENTER
HOSE ASSEMBLY - COLLECTOR TO COLLECTOR
SIZE
B
CODE IDENT NO.
55513
DRAWING NO.
SK-142066
SCALE ½"=1'-0"
SHEET 1 OF 1
CONTROL
B-6

APPENDIX C

STORAGE SUBSYSTEM
DRAWING NO. SK142050

PART NO.

STORAGE SUBSYSTEM

The solar energy which cannot be used for space heating/cooling is stored for future use. This stored energy will be available for domestic hot water heating and space heating at nite or on cloudy days. This energy is stored in water, contained in a lined and insulated steel tank. The capacity of the tank is 1000 gallons. It should be installed at the residence above ground. Valves activated by the control system permit charging or discharging.

Specifications

Nominal capacity - 1000 gallons
Material #10 gauge cold rolled steel
Size, 64" diameter x 72" long
Domestic hot water coil included in tank
Lining, coal tar epoxy
Exterior painted with primer and shop coat of enamel
Tank empty weights approx. 860 lbs.
Filled tank weights approx. 9,205 lbs.
18" manhole provided for internal access
11 penetrations are provided for inlets/outlets and temperature sensor installations.

Installation Notes

(1/1) Above grade installation should be enclosed with partition and tank engulfed in blown fiberglass insulation.

(2/1) Tank should be filled with 1500 mg/l sodium nitrite corrosion inhibitor, Norman Chemical, Product No. 234 or equivalent.

(3/1) All sweat connections shall use only 95-5 solder.

MATERIAL SCHEDULE

INSTALLATION NOTE NO.	ITEM #	ITEM	MANUFACTURER	TYPE / PART NO.	QUAN.
2/1	1	TANK - SOLAR H.W. STORAGE	HONEYWELL	SK-142008	1
1/1	2	TANK INSULATION (BLOWN FIBERGLASS)	CONWED CORP.	BW-0010	AS REQ'D
	3	INSULATING REDWOOD BOARDS	ANY	—	1
	4	DRAIN VALVE W/ HOSE BIB	NIBCO	BOILER DRAIN 74 - 3/4	1
3/1	5	COPPER ADAPTER NOM. 1"	NIBCO	604 - 1	2
	6	COPPER PIPE NOM. 1"	REVERE	M	AS REQ'D
	7	PIPE INSULATION NOM. 1" (1" THICK)	OWENS CORNING	CERTAINTEED	AS REQ'D
	8	INSULATION ADHESIVE	CHICAGO-MASTIC CO.	17-465	AS REQ'D
	9	PIPE INSULATION NOM. 3/4" (3/4" THICK)	ARMSTRONG	ARMAFLEX STANDARD	AS REQ'D
	10	INSULATION ADHESIVE	ARMSTRONG	520	AS REQ'D
	11	VENT CAP NOM. 1½"	CLAY & BAILEY	300 - 3/4	1
3/1	12	COPPER PIPE NOM. 1½"	REVERE	M	AS REQ'D
	13	COPPER ELBOW NOM. 1½" × 1½"	NIBCO		1
	14	CAST BRONZE ADAPTER 1½" C × 3/4" MPT	NIBCO	704 - 1½ × 3/4	2

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

NEXT ASSY	USED ON	TOLERANCES UNLESS NOTED OTHERWISE .X ± .XX ± .XXX ± 90° FORMED ANGLES ±2° ±1°	DRAFTSMAN / CHECKER / DEV ENGR / ENGRG MGT
APPLICATION		MATERIAL / FINISH-SEE NOTE	CONTRACT NO. WILLIAM O'BRIEN

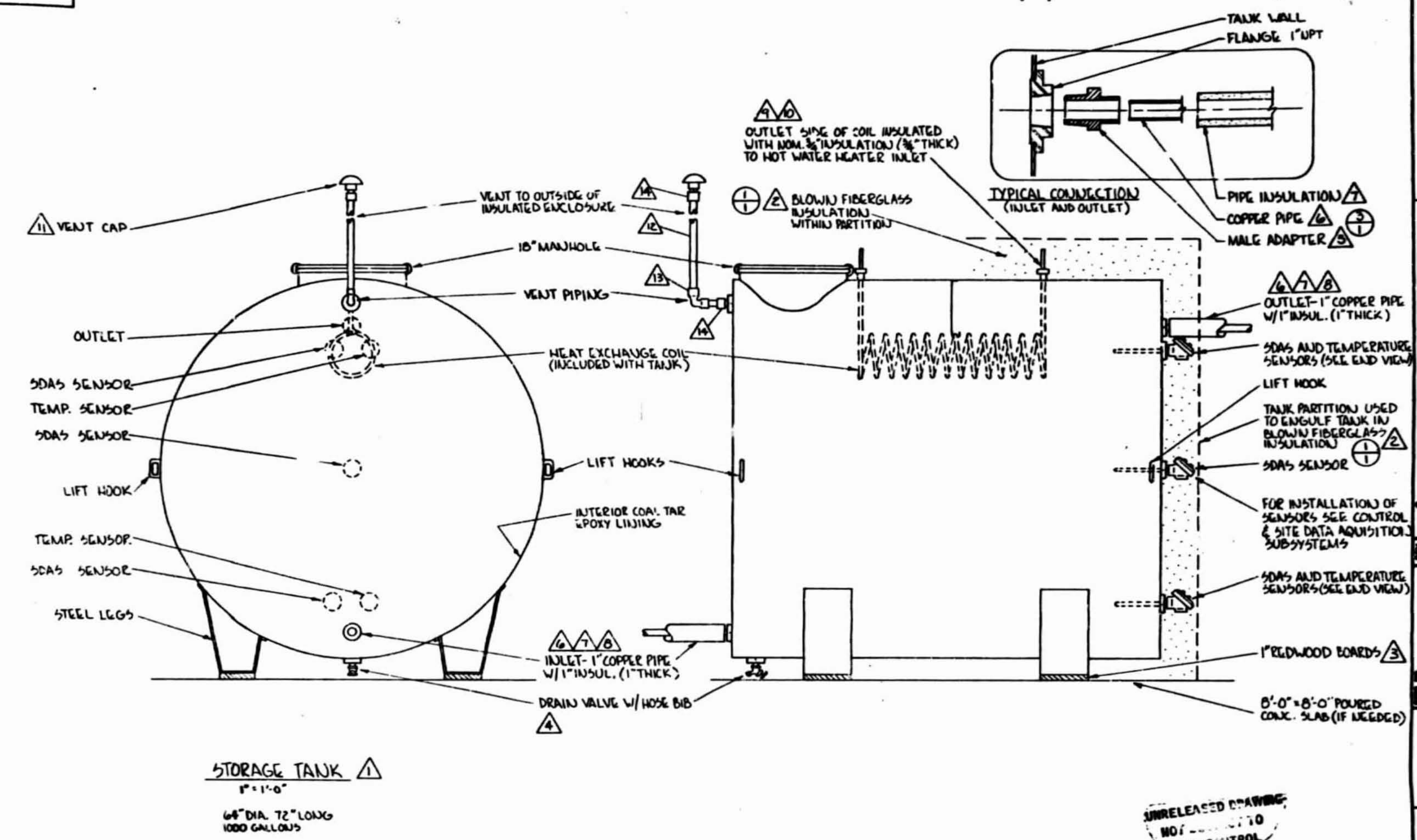
HONEYWELL INC. — **ENERGY RESOURCES CENTER**, MINNEAPOLIS, MINN. 55413

SINGLE FAMILY RESIDENCE STORAGE SUBSYSTEM

SIZE C | CODE IDENT NO. 55513 | DRAWING NO. SK-142050

SCALE NONE | SHEET 1 OF 2

CONTROL A



PART NO.

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

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NEXT ASSY	USED ON
APPLICATION	

TOLERANCES UNLESS NOTED OTHERWISE

MATERIAL

FINISH—SEE NOTE

DRAFTSMAN	Donahue	6/25/77
CHECKER		
DEV ENGR	[illegible]	[illegible]
ENGRG MGT	[illegible]	[illegible]

CONTRACT NO.

WILLIAM O'BRIEN

HONEYWELL INC. — ENERGY RESOURCES CENTER, MINNEAPOLIS, MINN. 55413

SINGLE FAMILY RESIDENCE STORAGE SUBSYSTEM

SIZE	CODE IDENT NO.	DRAWING NO.
C	55513	SK-142050

SCALE 1" = 1'-0" — SHEET 2 OF 2

CONTROL A

C-2

Honeywell

ENERGY RESOURCES CENTER CODE IDENTIFICATION NO. 55513

HONEYWELL REQUIREMENTS SPECIFICATION NO. HRS SK 142008

THIS HONEYWELL REQUIREMENTS SPECIFICATION IS FOR:

Tank, Solar Hot Water Storage

SIGNATURES	DATE
PREPARED BY W. H. Berry *(signed)* W H Berry	5/5/77
APPROVED BY PROJECT ENGINEER Al Baldwin *(signed)* Al Baldwin Aleks Klidzejs *(signed)* Aleks M. Klidzejs	5/5/77
Ron Ness, Quality Engineer *(signed)* 5/5/77	
Glen Merrill, Program Manager *(signed)* Glen L Merrill	5/5/77

REVISIONS

LTR	DESCRIPTION	DATE	APPROVAL	LTR	DESCRIPTION	DATE	APPROVAL
A	Increased size added 3 openings	6-21-77	*(signed)* Glen Merrill				

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PAGE	1	2	3	6	7
REVISION	A	A	A	A	A
PAGE					
REVISION					

PAGE 1 OF 7

HRS SK 142008

HH-64

1.0 SCOPE

This specification covers the material, design, construction and quality requirements for a 1000 gallon capacity shop-welded steel hot water storage tank to operate at less than 15 psi. This tank is intended to be used as an unattended long term storage of a water and rust inhibiture mixture. It may be installed above or buried underground.

2.0 REQUIREMENTS

2.1 Material

Shell and end plates shall be a minimum of number 10 gauge SAE 1020 cold rolled carbon steel.

2.2 Construction

The tank shall be sized for a capacity of 1000 gallons and be approximately 64 inches in diameter and 72 inches long. The shell and end plate joints shall be continuous double welded joints with complete penetration.

2.3 Integrity

The tank shall not leak fluid in normal use, nor deform such as to preclude normal use for intended purpose.

2.4 Openings

Tanks shall be furnished with an 18 inch nominal manhole located as shown on the Storage Tank drawing Figure 1. Pipe tapping's or NPT flanges shall be attached with butt welds. Coupling threads must be clean and free from defects after installation. Minimum length of thread shall conform to ANSI B2.1 for tapered pipe thread for the size specified in Figure 1.

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVAL
A	Tank size & capacity	6-21-77	

2.5 Appurtances

Four tie down lugs also used as lift hooks shall be provided. They shall be made of the same material as the tank shell and sized and located approximately as shown on Figure 2. They shall be attached with continuous double welded joints full length of the lug. Four support saddles shall be fabricated and welded at the tank 1/4 points. The saddles shall be capable of supporting the tanks when filled to capacity with water at 8.3 lbs/gallon.

2.6 Internals

A rod of 1/8" min diameter shall be formed as shown in Figure 2 and welded to the top of the tank to support the heat coil. It should be installed prior to applying the interior lining. The heat coil, Honeywell SK 142047, shall be furnished by buyer and installed by the tank manufacturer. It should be installed <u>after</u> the interior lining is applied.

2.7 Finishes

After final testing the tank shall be dried and cleaned thoroughly inside and outside to remove grease, loose scale, rust, and foreign material.

The interior shall be sandblasted and then a coal tar epoxy (Chem-mastic 2203 or equivalent) shall be applied for a minimum thickness of 0.012".

The exterior shall be primed and painted with a coat of enamel for rust protection.

All welds shall be cleaned of welding slag prior to priming and painting.

REVISIONS

LTR	DESCRIPTION	DATE	APPROVAL
A	Heat Coil P/N	6-21-77	

3.0 INSPECTION & TESTING

3.1 Drawings

The tank manufacturer, after receipt of purchase order, shall furnish shop drawings to the buyer for approval. These drawings, as well as the Purchase Order and specification, may be used by the buyer to inspect the tank during or after fabrication. An "as built" drawing will be required if changes are authorized during tank fabrication.

3.2 Workmanship

The tank manufacturer shall assure that a) all welds show no evidence of poor workmanship such as porosity, inclusions, cracks, lack of fill, blow holes, incompleteness, etc. b) the location and size of all appurtances,openings, threads and internals meet the print requirements, c) the diameter, length and wall thickness meet the print requirements.

3.3 Inspections

The tank manufacturer shall visually inspect each tank 100% both inside and outside after cleaning and before applying the finishes.

a. After finishing and installation of the heat coil the tank shall be reinspected visually for lack of evidence of use of incorrect materials or poor workmanship such as incomplete coverage, cracks, thin spots, lack of adhesion,runs, etc.

b. Verify that the minimum thickness of the coal tar epoxy is 0.012 inches at random points inside the tank and on the hook or measure the build-up on witness plugs used in the threaded openings and the change in diameter of the hook.

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVAL

3.4 Testing

The tank shall be pressure tested for leaks using air pressure or vacuum and a suitable material such as soap suds or linseed oil for the detection of leaks. All leaks shall be corrected and retested for not less than 15 minutes. The test pressure shall be 3 psi (min) and shall be held for an adequate time to permit thorough inspection in any case not less than 30 minutes.

3.5 Records

The tank manufacturer shall record the results of the inspections and tests of paragraphs 3.3, 3.4. These records shall be mailed to the Buyer at the time of shipment. Each tank shall be identified for record purposes including Purchase Order number and item number.

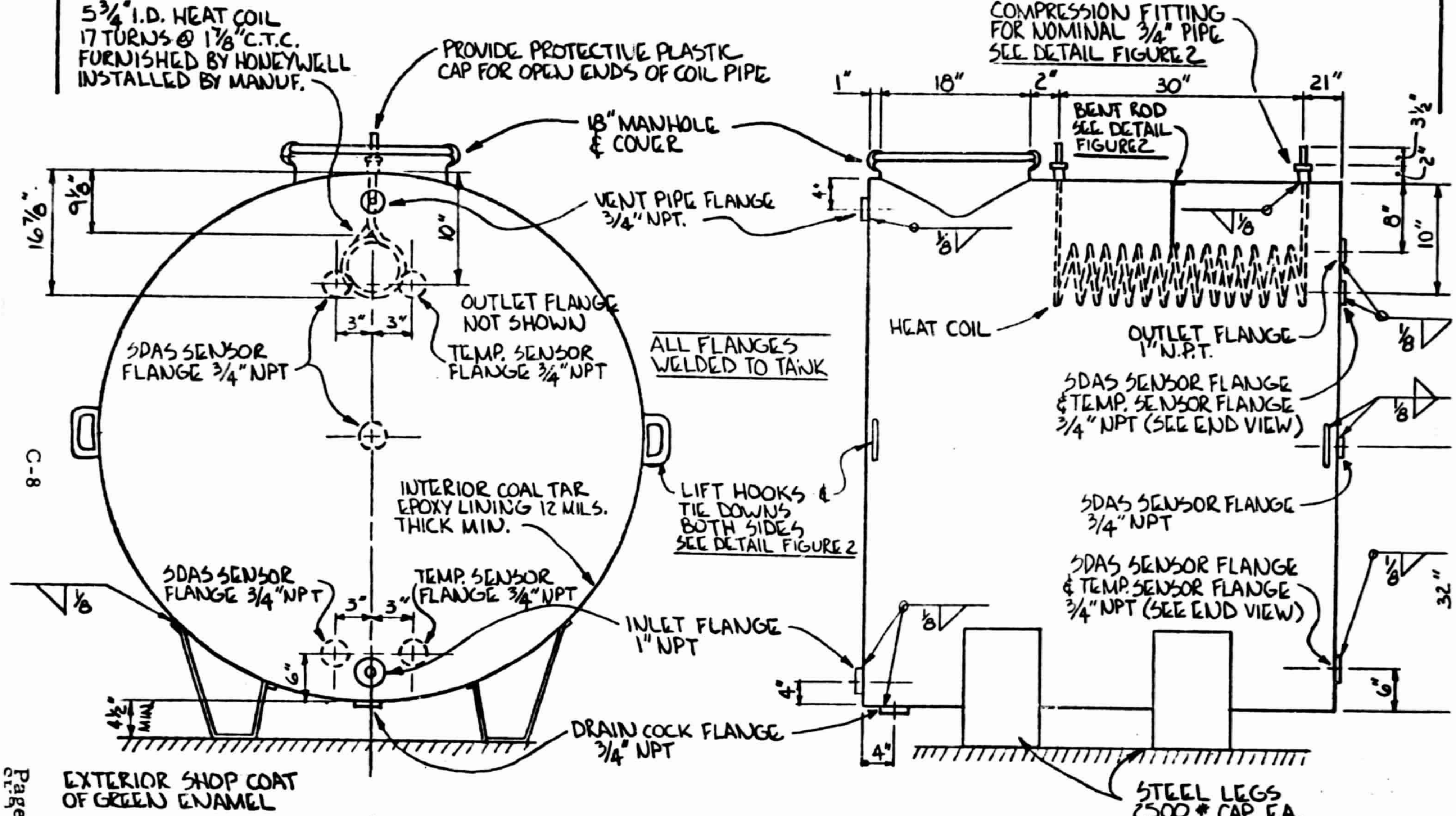
4.0 PREPARATION FOR SHIPMENT

All finished surfaces not otherwise protected shall be coated with rust preventive. Threaded opening shall be plugged and pipes extending beyond tank shall be capped and suitably supported to avoid damages during shipment. Tank shall be clearly identified with purchase order number and item number.

5.0 GUARANTEE

Manufacturer guarantees that the vessel fulfills all conditions as stated in this Specification and that it is free from fault in design, construction, workmanship and material. Should any defect develop during the first year of operation, the manufacturer agrees to make all necessary alterations, repairs and replacements free of charge.

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVAL



STORAGE TANK

3/4" = 1'-0"

64" DIA. 72" LONG (± 1")
10 GAUGE 1000 GAL.

ALL TOLERANCES ± 1/4"
UNLESS OTHERWISE NOTED

FIGURE 1

REVISION A

SK 142008

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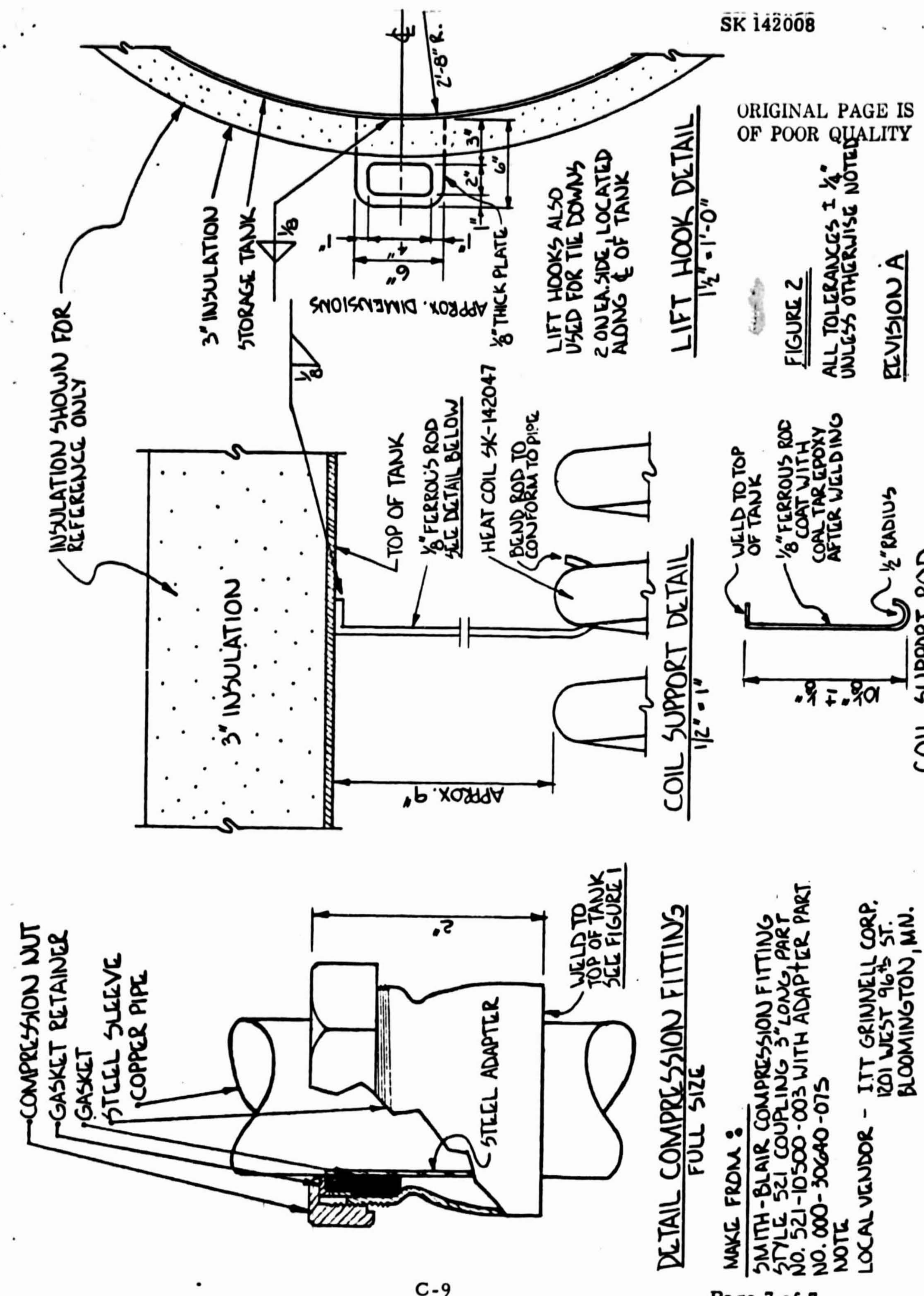


REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

PART NO.
SK-142047

Specifications

Material - copper alloy - ASTM-B359-B111
Length - approx. 33 feet
No. of Coils - 17
Coil I.D. - 5 3/4" (± 1/8")
Tubing Diam. - nom. 3/4"

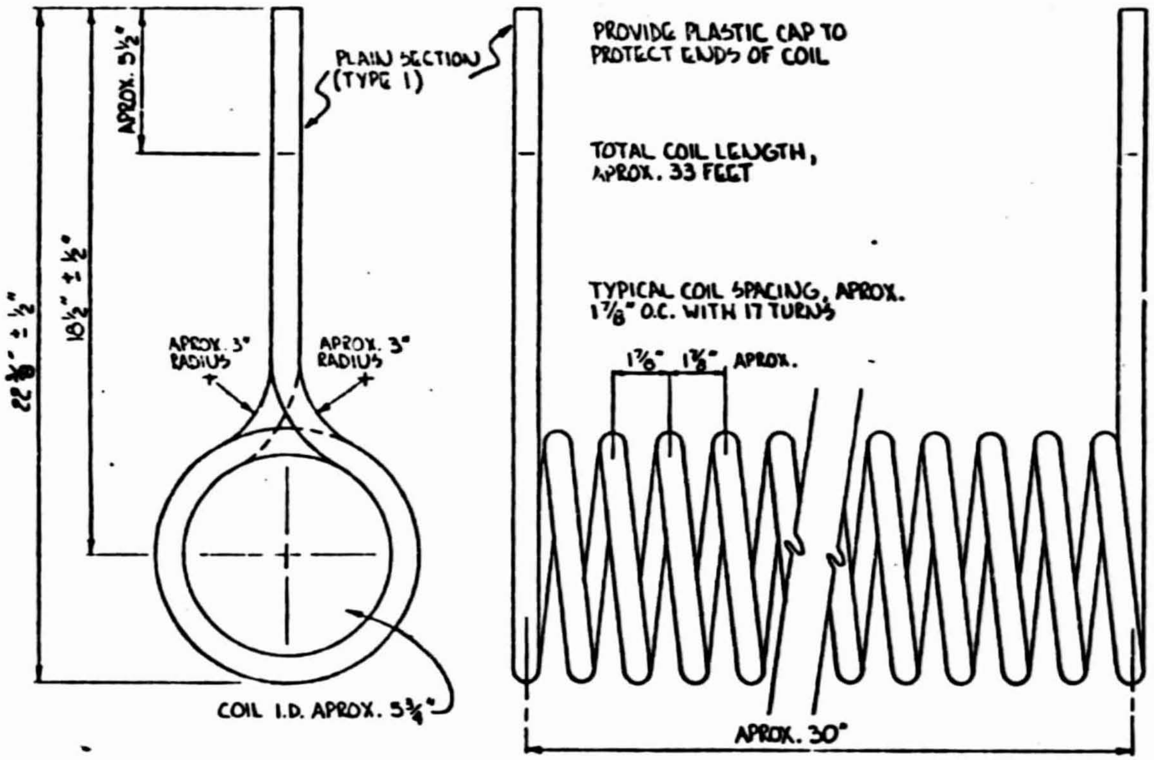
NOTES

1) The seller will inspect each coil to the requirements of this specification and for evidence of poor workmanship.
2) The heat coils shall be packaged in suitable protective containers that prevent damage to coil when shipped by United Parcel Service.

Approved Source

Vender/PN
Wolverine Tube Division
17200 Southfield Rd.
Allen Park, Michigan 48101

Truffin Type W/H
Catalog No. 66-116038-01
With type 1 ends



C-10

		TOLERANCES UNLESS NOTED OTHERWISE		DRAFTSMAN	Donahue	6/16/77	HONEYWELL INC.	ENERGY RESOURCES CENTER MINNEAPOLIS, MINN. 55413
		.X ± .XX ± .XXX ±	90° FORMED ANGLES +2° -1°	CHECKER				
				DEV ENGR	?. Klidzei?	6/29/77		
				ENGRG MGT	G. Morr?:ll	6/30/77		
		MATERIAL		CONTRACT NO.			HOT WATER COIL	
				SOURCE CONTROL			SIZE A	CODE IDENT NO. 55513	DRAWING NO. SK-142047
NEXT ASSY	USED ON						SCALE NONE	SHEET 1 OF 1
APPLICATION		FINISH—SEE NOTE						

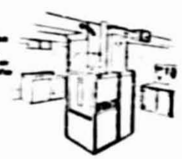
ERC 9/76

APPENDIX D

AUXILIARY ENERGY AND SPACE HEATING SUBSYSTEM
DRAWING NO. SK 142051

PART NO.

FORCED AIR GAS FURNACES—UP-FLO
G11Q SERIES
DIRECT DRIVE BLOWERS
82,000 Btuh Input



A.G.A. INSTALLATION CLEARANCES

Sides	1 inch
Rear	1 inch
Top	1 inch
Front	6 inches
Floor	Combustible
*Flue	[illegible]

HIGH ALTITUDE DERATE

SPECIFICATIONS

BLOWER DATA
WITHOUT SPACE HEAT COIL
G11Q3-82V BLOWER PERFORMANCE

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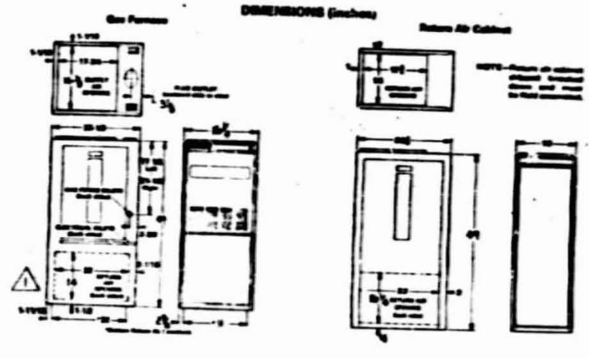


MATERIAL SCHEDULE				
ITEM #	ITEM	MANUFACTURER	TYPE/PART NO.	QUANTITY
1	FURNACE	LENNOX IND.	G11Q3-82V	1
2	HEAT COIL	LENNOX IND.	CW3-45	1

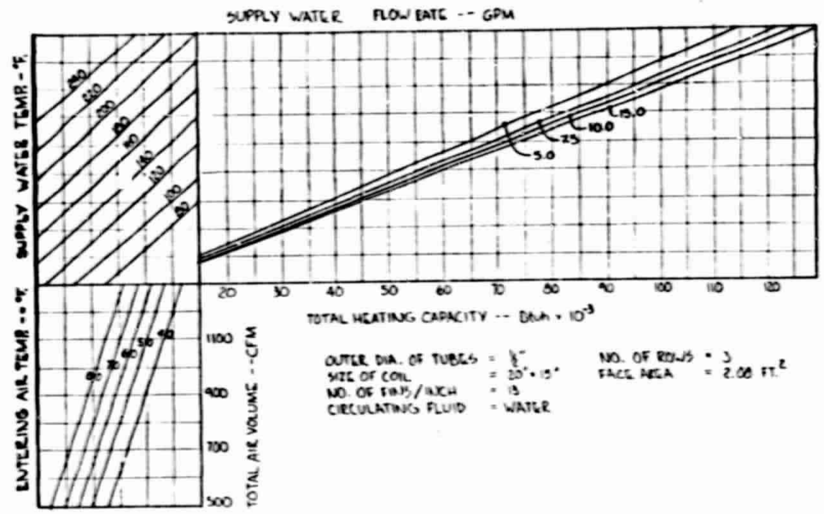
BLOWER DATA
WITH CW3-45 SPACE HEAT COIL
G11Q3-82V BLOWER PERFORMANCE

EXTERNAL STATIC PRESSURE (IN. H2O)	AIR VOLUME (CFM) @ VARIOUS SPEEDS HIGH	MEDIUM HIGH	MEDIUM LOW	LOW
0.00	1291	1185	995	888
0.05	1270	1166	977	836
0.10	1245	1144	960	819
0.15	1219	1121	940	807
0.20	1190	1096	920	796
0.25	1160	1070	898	780
0.30	1128	1043	875	765
0.40	1060	984	827	721
0.50	985	915	770	666
0.60	905	855	705	597
0.70	825	750	640	523
0.80	740	668	575	440

NOTE - ALL CFM MEASURED EXTERNAL TO THE UNITS W/ THE AIR FILTER IN PLACE

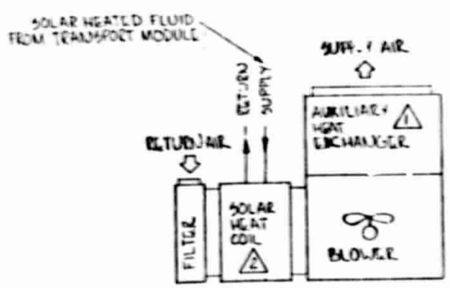
HONEYWELL INC.	ENERGY RESOURCES CENTER
DRAFTSMAN	WILLIAM O'BRIEN
TITLE	SER. AUXILIARY ENERGY AND SPACE HEATING SUBSYSTEMS
SIZE	C
CODE IDENT NO.	55513
DRAWING NO.	SK-142051
SCALE	NONE
SHEET	1 OF 3
CONTROL	A

NEXT ASSY | USED ON | APPLICATION | FINISH—SEE NOTE



Space Heating Subsystem Description

Space heating for residential use is provided using a forced-air recirculating system. The fan is integral to the commercially available auxiliary energy furnace. Heating of the air from the solar energy source occurs through heat exchange in a hot-water coil which is installed in the return-air cabinet.



SPACE HEATING SCHEMATIC
NO SCALE

D-2

HONEYWELL INC.	ENERGY RESOURCES CENTER, MINNEAPOLIS, MINN. 55413
DRAWING TITLE	SFR. AUXILIARY ENERGY AND SPACE HEATING SUBSYSTEMS
SIZE	C
CODE IDENT NO.	55513
DRAWING NO.	SK-142051
SCALE	NONE
SHEET	2 OF 3
CONTRACT NO.	WILLIAM O'BRIEN
CONTROL	A

PART NO.

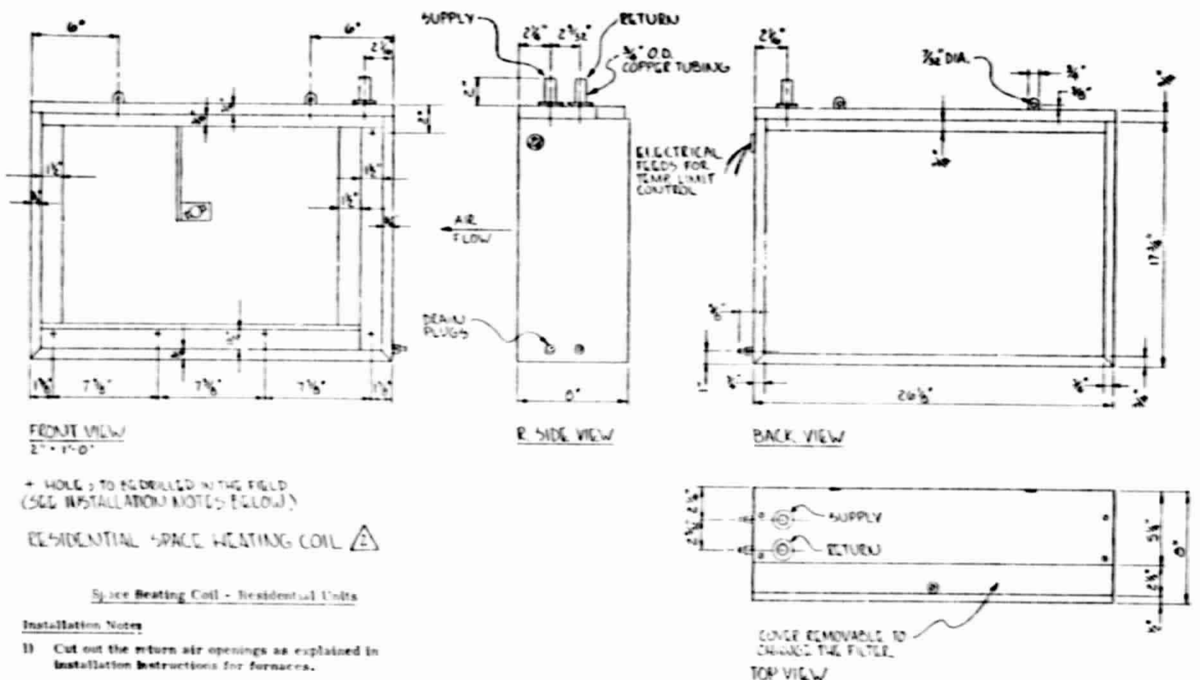
REVISIONS: LTR | DESCRIPTION | DATE | APPROVED

NEXT ASSY | USED ON | APPLICATION

MATERIAL | FINISH—SEE NOTE | TOLERANCES UNLESS NOTED OTHERWISE

DRAFTSMAN | CHECKER | DEV ENGR | ENGRG MGT

E.C.C. CONTROL



+ HOLES TO BE DRILLED IN THE FIELD
(SEE INSTALLATION NOTES BELOW)

RESIDENTIAL SPACE HEATING COIL

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Space Heating Coil - Residential Units

Installation Notes

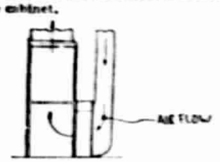
1) Cut out the return air openings as explained in installation instructions for furnaces.

2) Remove bottom four screws on the cut outside.

3) Align the coil with return air opening.

4) Mark the location of the four holes on the front of the space heating coil (indicated by + marks on front view this sheet).

5) Mark the location of the two holes to be drilled in the furnace cabinet.



UP-FLO, SIDE INSTALLATION

6) Drill the various holes and fasten the coil to the furnace cabinet with sheet metal screws.

7) Drill one more hole on the side of the coil (indicated by + marks on front view this sheet) and the furnace cabinet at the same time. Fasten with a sheet metal screw.

Electrical

For wiring information see control subsystem.

HONEYWELL INC. — ENERGY RESOURCES CENTER, MINNEAPOLIS, MINN.

SFR. AUXILIARY ENERGY AND SPACE HEATING SUBSYSTEMS

SIZE C | CODE IDENT NO. 55513 | DRAWING NO. SK-142051

SHEET 3 OF 3

CONTROL A

WILLIAM O'BRIEN

ITEM	DESCRIPTION	PART NO.	QTY	PART NO.	QTY	PART NO.	QTY	PART NO.	QTY	PART NO.	QTY	PART NO.	QTY	PART NO.	QTY	PART NO.	QTY	ITEM
	CATALOG NO.																	
	UNIT MODEL NO.																	
	ASS'Y. CONTROL NO.	25-530AA																
1	CABINET S.A.	LB-32675BA	1															1
2	COIL S.A.	LB-32691BA	1															2
3	FILTER	P-8-4956	1															3
4	COIL SEAL	LB-32698D	1															4
5	TOP PANEL	LB-32699DA	1															5
6	FILTER ACCESS PANEL	LB-32699DB	1															6
7	GROMMET	P-8-1026	2															7
8	LIMIT CONTROL	P-8-7091	1															8
9	#7 X 1/2" S.M.S.	P-8-3994	6															9
10	#8 X 1 1/2" S.M.S.	P-8-5970	4															0
11	#10-24 X 1 1/4" R.H.M.S.	P-8-4099	1															1
12	1/4-20 X 1/2" H.H.M.S.	P-8-5222	4															2
13	STAKE NUT	P-8-3701	4															3
14	WIRE TIE	P-8-7085	2															4
15	SNAP BUSHING	P-8-7102	1															5
16	STRAIN RELIEF	P-8-4934	1															6
17	SPRING CLIP	P-8-5720	1															7
18	FLAT WASHER 1/2"	P-8-3951	2															8
19	1/2-20 JAM NUT	P-8-3891	2															9
20	1/4-20 X 1/4" SOC SET S	P-8-4038	2															0
21	WIRE	W013602036	2															1
22	TAPE - MASKING 3/4"	299011011	6															2
23	1/4 LOCKWASHER	P-8-5249	4															3
24	INSULATING SLEEVE	P-8-965	2															4
25	CARTON (REF ONLY)	77A2201																5
26	CARTON BODY	LB-32674C	1															6
27	CORNER POST	LB-32708C	4															7
28	STAPLE	P-8-6126	20															8

D-4

ALTERATIONS

2-16-77

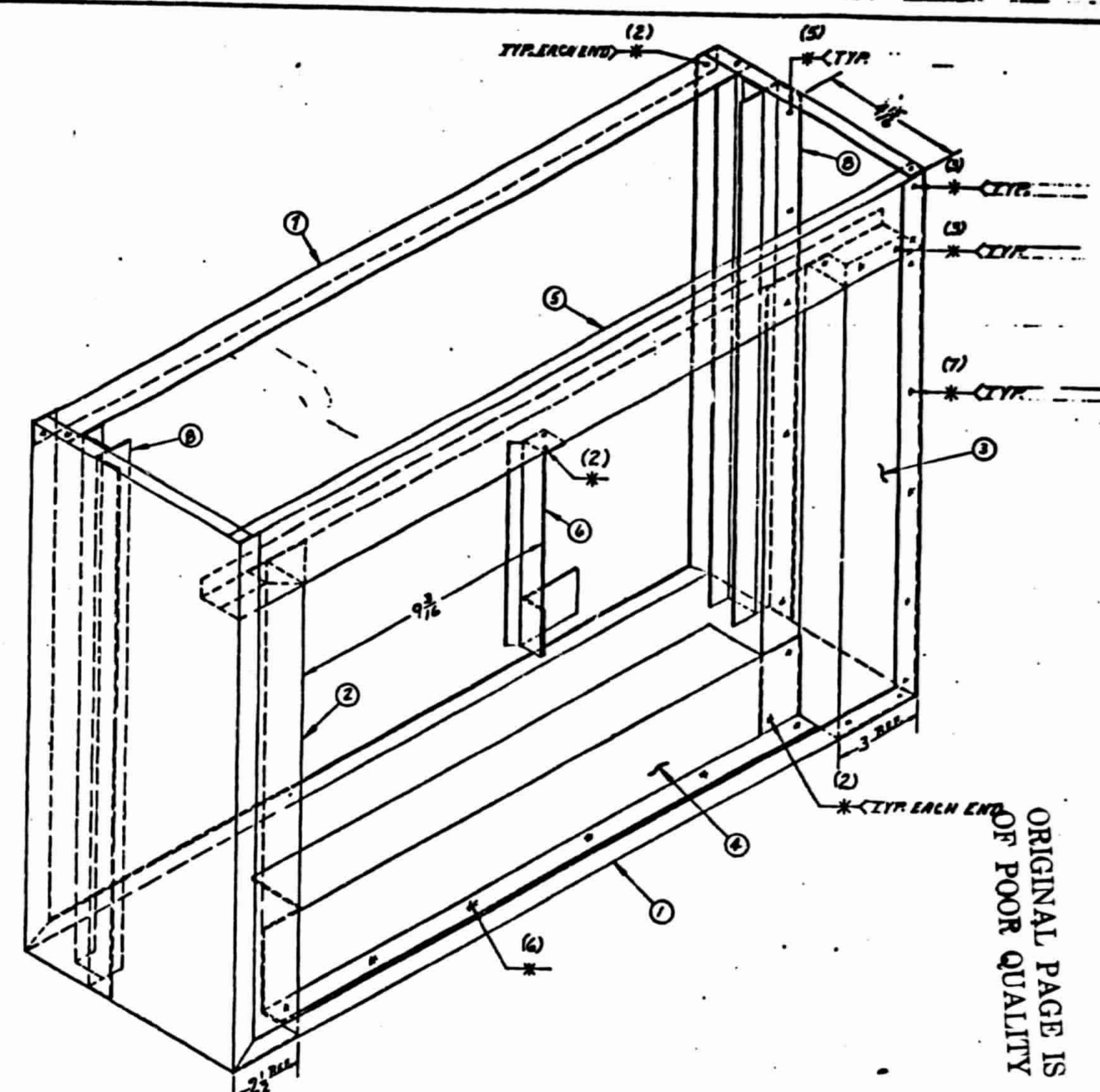
LENNOX

FINAL ASSY

25-530A

JUNE 23, 1977

ITEM	DESCRIPTION	PART NO.	QTY.
	UNIT MODEL NO.		
	S.A. CONTROL NO.	LB-32677AA	
1	WRAPPER	LB-32678B	1
2	MTG. ANGLE L.-COIL	LB-32679C	1
3	MTG. ANGLE R.-COIL	LB-32680C	1
4	SEAL BOTTOM	LB-32681C	1
5	SEAL TOP	LB-32682C	1
6	MTG. BRKT. S.A.-LIMIT	LB-32683CA	1
7	ANGLE-CABINET	LB-32686DA	1
8	FILTER SUPPORTS.A.	LB-32688CA	2



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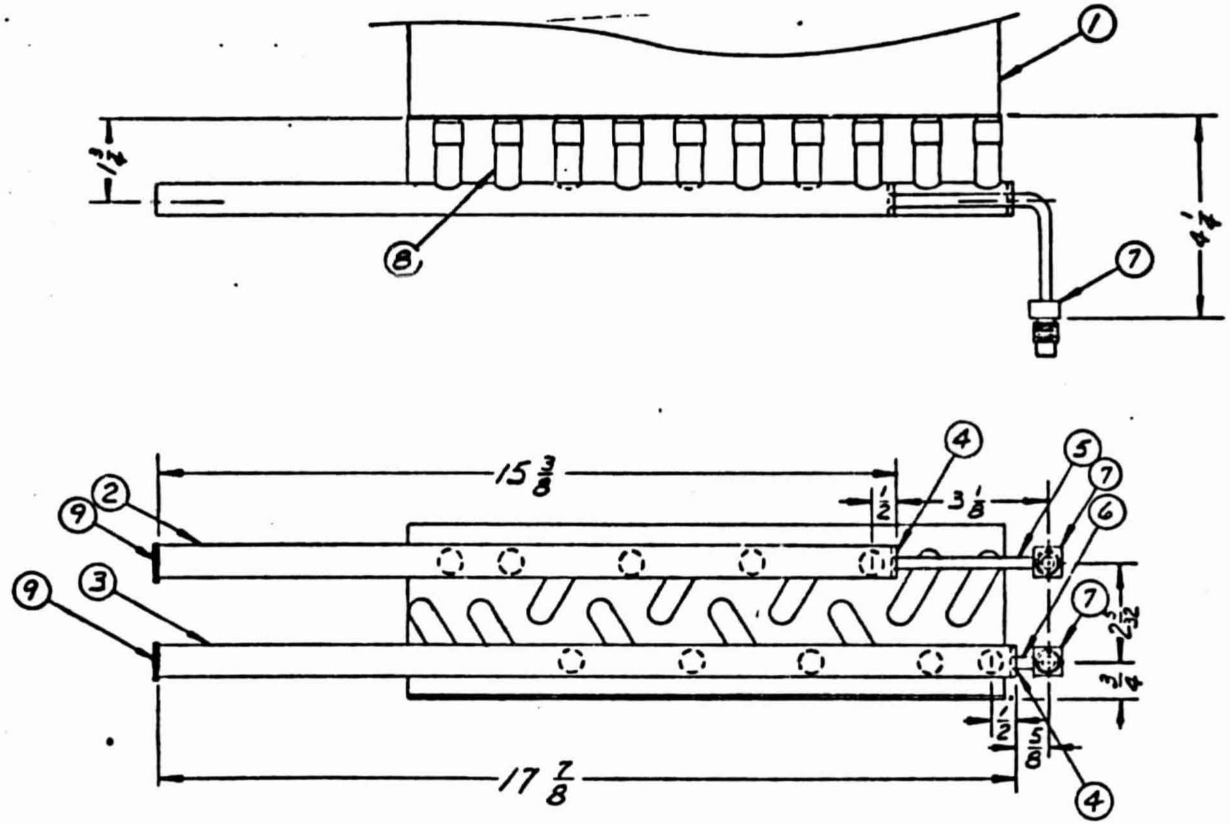
ALTERATIONS	ALTERATIONS	ALTERATIONS	ALTERATIONS	ALTERATIONS

LB-32675B

LENNOX Industries Inc
RESEARCH LABORATORY
CABINET S.A. SP
LB-3267

ITEM	DESCRIPTION	PART NO.	QTY.
	CATALOG NO.		
	UNIT MODEL NO.		
	S. A. CONTROL NO.	LB-32691BA	
1	COIL SUB. ASS'Y.	LB-32692C	1
2	INLET MANIFOLD	LB-32693C	1
3	OUTLET MANIFOLD	LB-32694C	1
4	END PLUG	LB-32695D	2
5	VENT LINE INL. MAN.	LB-32696D	1
6	VENT LINE OUTL. MAN.	LB-32697D	1
7	LIQUID VENT VALVE	LB-8026	2
8	OUTLET TUBE	LB-41827DF	10
9	CAP PLUG	P-8-1006	2



Change Record Sheet

ALTERATIONS	ALTERATIONS	ALTERATIONS	USAGE	REF. PRINT
				25-530A

LENNOX Industries Inc.
RESEARCH LABORATORY

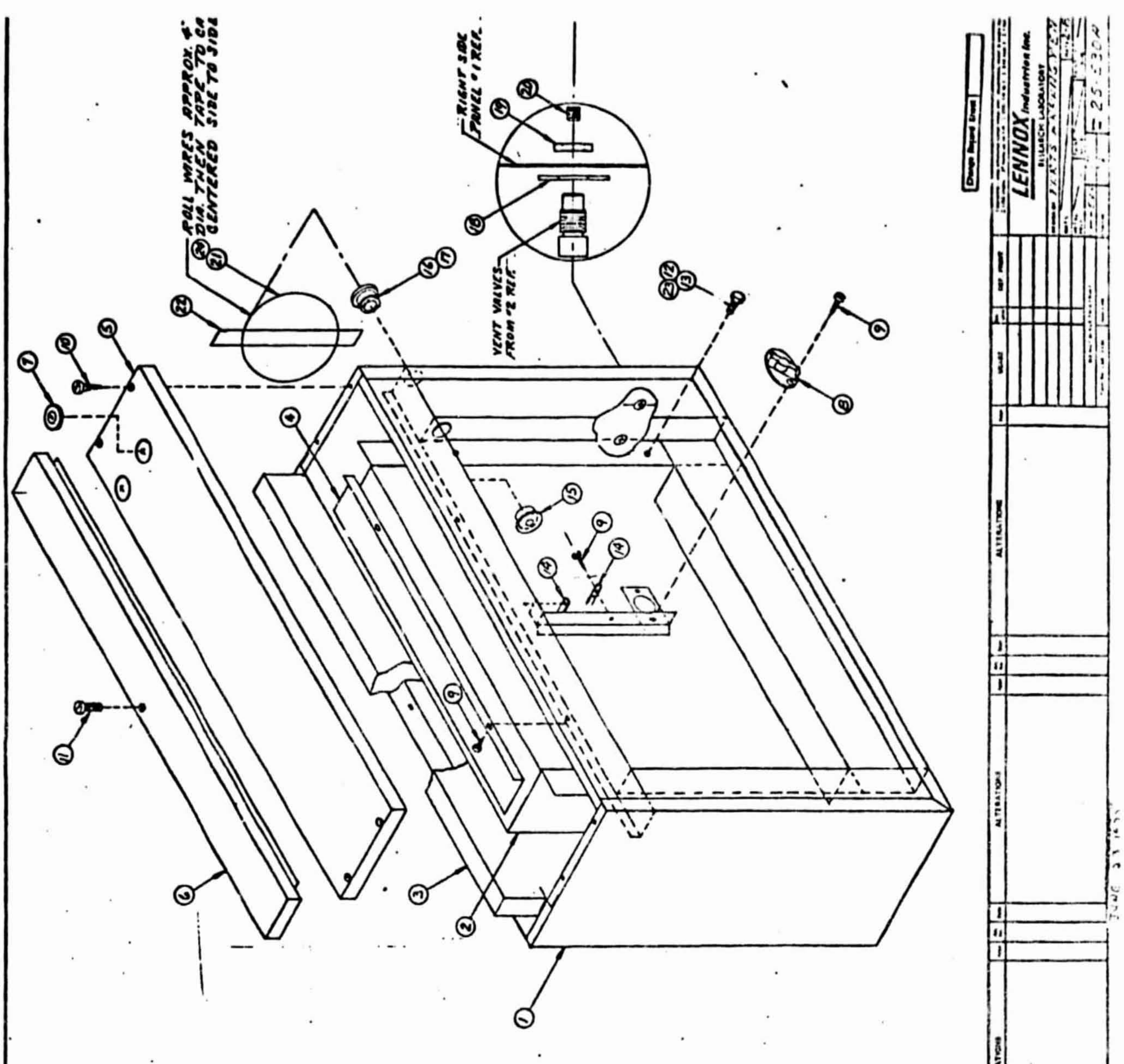
DESIGN OF COIL ASS'Y.

DATE 2-11

DO NOT SCALE THIS PRINT

DRAWN BY EJH

DWG NO. LB-32691B



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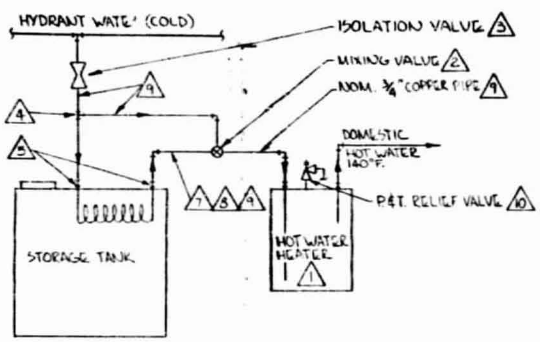
APPENDIX E

HOT WATER SUBSYSTEM

DRAWING NO. SK 142052

PART NO.



SCHEMATIC H.W. SUBSYSTEM
NO SCALE

ALL ITEMS LISTED "OR EQUIVALANT"

MATERIAL SCHEDULE

ITEM#	ITEM	MANUFACTURER	TYPE / PART NO.	QUAN.
1	HOT WATER HEATER	LOCHINVAR	40 GK3TC	1
2	3-WAY MIXING VALVE	WATTS REGULATOR CO.	70A - 3/4"	1
3	BALL VALVE	NIBCO	S-580 - 3/4"	1
4	COPPER TEE NOM. 3/4" x 3/4" x 3/4"	NIBCO	611 - 3/4	1
5	COPPER COUPLING W/ STOP NOM 3/4	NIBCO	600 - 3/4	2
6	COPPER ELBOW NOM. 3/4" x 3/4"	NIBCO	607 - 3/4	AS REQ'D
7	INSULATION 3/4 NOM. (3/4" THICK)	ARMSTRONG CORK CO.	ARMAFLEX STANDARD	AS REQ'D
8	INSULATION ADHESIVE	ARMSTRONG	520	AS REQ'D
9	COPPER PIPE 3/4" NOM.	REVERE	M	AS REQ'D
10	PRESSURE & TEMP RELIEF VALVE	WATTS PLUMBING SPEC.	40 XL	1

INSTALLATION INFORMATION

1. Put DHW preheat coil in storage tank through manhole and run ends through appropriate penetrations at top of tank.
2. Support the coil inside tank by hook at midpoint location of coil.
3. Tighten adapter on compression fitting.
4. Connect coil ends to copper tubing by coupling (W/O stops) and braze.

INSULATION INFORMATION

Insulate copper tubing from storage tank outlet to hot water heater inlet.

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UNRELEASED DRAWING NO. ... E.C.O. CONTROL

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

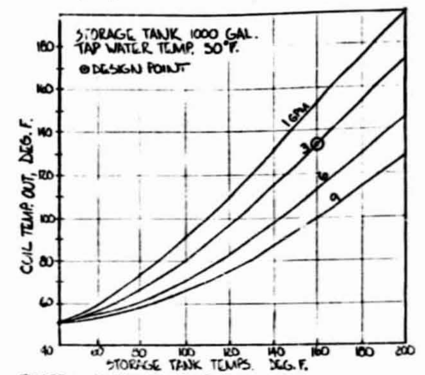

FIGURE 1. HEATING COIL PERFORMANCE

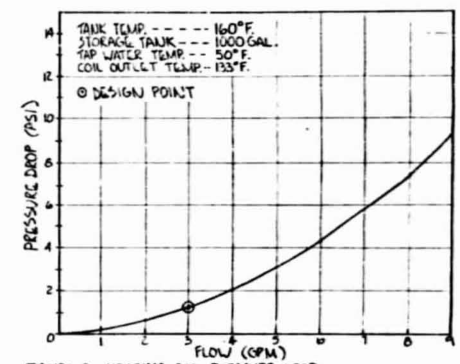

FIGURE 2. HEATING COIL PRESSURE DROP

DOMESTIC HOT WATER (DHW)
Subsystem

The DHW subsystem consists of two hot water heaters in series. The 1st heater is the coil immersed in the storage tank, and the 2nd heater is a conventional domestic hot water heater. The storage tank is heated with the surplus solar energy not required for space heating. This stored heat is transferred to city water via a coil which preheating the water before it goes to the conventional hot water heater. When the storage tank is at it's maximum temperature 200°F no additional heat will be required from the conventional heater at flow rates of 7 gpm or less. The capacity of preheat coil is shown in Figure 1 and 2. To limit the output of the heaters to 140° a self contained 3 way mixing valve tempers the hot water to the user with city water.

NEXT ASSY	USED ON	TOLERANCES UNLESS NOTED OTHERWISE	DRAFTSMAN	HONEYWELL INC.	ENERGY RESOURCES CENTER MINNEAPOLIS, MINN.
APPLICATION		MATERIAL / FINISH—SEE NOTE	CHECKER / DEV ENGR / ENGRG MGT / CONTRACT NO. WILLIAM O'BRIEN	SINGLE FAMILY RESIDENCE HOT WATER SUBSYSTEM	

SIZE C | CODE IDENT NO. 55513 | DRAWING NO. SK-142052

SCALE NONE | SHEET 1 OF 1

CONTROL A

E-1

APPENDIX F

ENERGY TRANSPORT SUBSYSTEM

DRAWING NO. SK 142053

F-1

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REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

ENERGY TRANSPORT MODULE (ETM) - SOLAR HEATING

The Energy Transport Module is a fully-assembled, pre-wired unit which provides the pumping power, control logic, and interface between subsystems in a residential hydronic solar heating system. It has a sturdy, rolled steel cabinet with an attractive, durable finish for installation within a building. Four large, easily removable, vented access panels are provided.

The main pump is capable of 12 gpm flow of water/ethylene glycol (mixture percentage is site-specific) through collector arrays of 200-450 ft². Two smaller pumps move water through the heating and storage subsystems. Separating the freeze-protected collector loop from the water loop is a high efficiency, water-to-water heat exchanger. Other hydronic components are included in the ETM, resulting in an efficient, quietly running system which requires minimal maintenance. An integrally mounted W988A Honeywell Solar Control Panel provides system operation control. For on-site handling, the ETM is 28" x 72" x 43" and weighs 420 pounds (operating weight is 500 pounds).

Application Criteria

- Position ETM on level surface (adjustable legs are provided).
- ETM is insulated; cabinet operating temperature is less than 140°F.
- Location near walls must not restrict heat ventilation through front, back and side louvers.
- Servicing access is through front, sides and top.
- Suggested orientation is with back of ETM toward wall. Location, determined by system designer or architect, should be near storage and solar heat coil subsystems. Consult manufacturer when location of ETM above a subsystem is considered.

Installation

- Description and location of required plumbing connections to subsystems are noted on this drawing and on SK-142085. Insure holding pan is connected to pressure relief valve.
- Collector subsystem fill/drain valve and ETM drain plugs are accessible inside the cabinet.
- No isolation/shutoff valves are contained within the ETM. Install them and air bleeds in supply lines as needed.

- Electrical - ETM is internally pre-wired
  - 115 volt AC main power line must be connected from a circuit breaker to Control Panel.
  - Detailed wiring of 115 volt power lines and external control wiring is described in the Controls Subsystem.

Specifications

Pumps: Single phase, 115 volt, 60 cycle, 1725 rpm, built-in overload protection, centrifugal impeller.

Subsystem	Motor	Capacity (Flow @ Head)	Full load Current	Full load Power Factor	Locked Impeller Current
Collector	1/4 hp	12 gpm @ 20 ft.	4.2 amp	.84	27 amp
Heating	1/6 hp	4 gpm @ 2[illegible]	1.7 amp	.67	20 amp
Storage	1/6 hp	5 gpm @ 17 ft.	3.1 amp	.67	20 amp

Pressure drop within ETM (can be increased by adjusting circuit setter):

Collector Loop (40% ethylene glycol) @ 4.7 psig

Direct Heating Loop (water) @ 3.8 psig

Charge Storage (water) @ 3.1 psig

Heat from Storage (water) @ 2.4 psig

Conditions

Pressure (pump inlet)	Operating	Maximum	Minimum
Collector Loop	3-12 psig	76 psig	
Storage/Heating	atmospheric		—
Temperature (liquid)			
Collector Loop	90-200°F	210°F	outside ambient
Storage/Heating	90-200°F	200°F	inside ambient

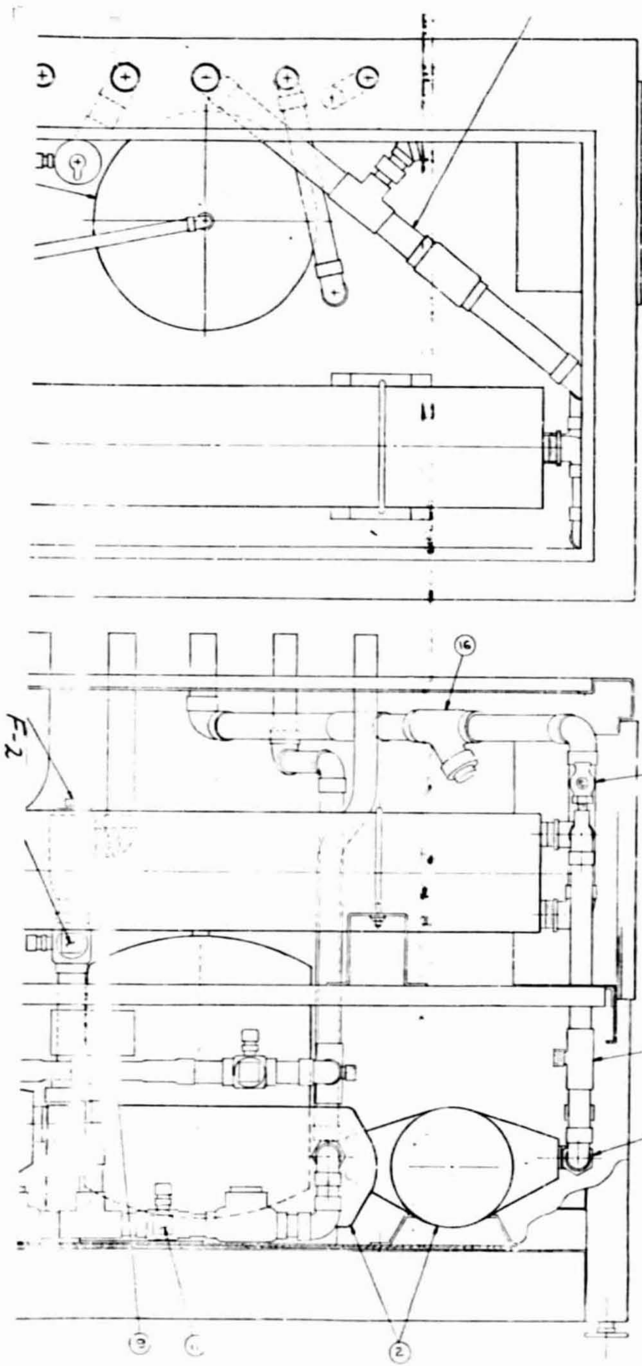
NOTE: Refer to National Electrical Code manual to determine wire, fuse and disconnect size requirements. For power supply wiring, use wires suitable for at least 90°C (194°F).

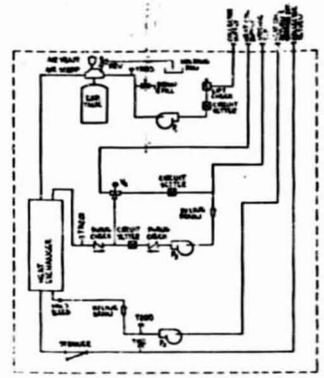
		TOLERANCES UNLESS NOTED OTHERWISE	DRAFTSMAN	HONEYWELL INC.	ENERGY RESOURCES CENTER MINNEAPOLIS, MINN. 55413
		X ± / XX ± / XXX ± / ANGLES	CHECKER		
			DEV ENGR		
		MATERIAL	ENGRG MGT		
			CONTRACT NO		
NEXT ASSY	USED ON			SIZE C	CODE IDENT NO. 55513	DRAWING NO.
APPLICATION		FINISH - SEE NOTE		SCALE	SHEET 1 OF

PART NO.

CONTROL A

F-1

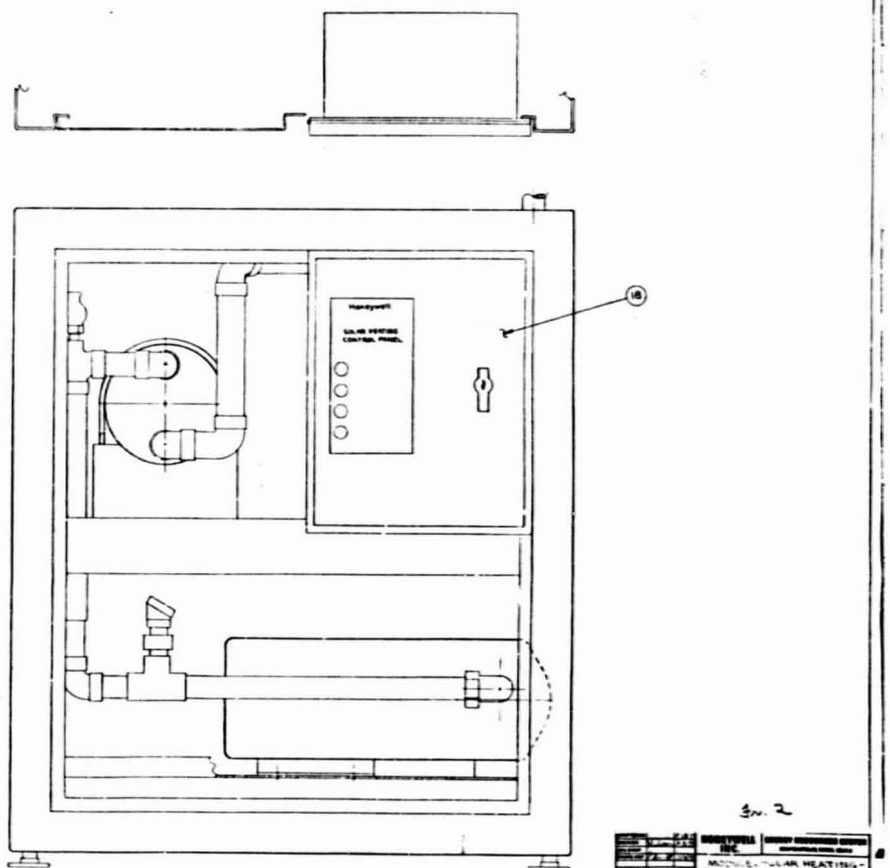




SCHEMATIC - TRANSPORT MODULE

MATERIAL SCHEDULE

No.	Item	Manufacturer	Type/Part	Quantity
1	Pump 1	Bell & Gossett	[illegible]	1
2	Pump 2 & 3	Bell & Gossett	[illegible]	2
3	Heat Exchanger	[illegible]	[illegible]	1
4	Expansion Tank	Amtrol, Inc.	[illegible], Diaphragm	1
5	Air Separator	Amtrol, Inc.	[illegible]	1
6	Air Vent	Amtrol, Inc.	[illegible]	1
7	Air Vent	[illegible]	[illegible]	1
8	Relief Valve	Bell & Gossett	[illegible]	1
9	Control Valve - 3 way	Honeywell	[illegible]	1
10	Circuit Setter Balancing Valve	Bell & Gossett	[illegible]	1
11	Circuit Setter Balancing Valve	Bell & Gossett	[illegible]	[illegible]
12	Lift Check Valve	Bell & Gossett	[illegible]	1
13	Swing Check Valve	[illegible]	[illegible]	[illegible]
14	[illegible] Valve	[illegible]	[illegible]	1
15	Drain	[illegible]	[illegible]	[illegible]
16	Strainer	[illegible]	[illegible]	1
17	Low Level Indicator	[illegible]	[illegible]	1
18	Solar Control Panel	Honeywell	[illegible]	1
19	[illegible]	[illegible]	[illegible]	1
20	[illegible]	[illegible]	[illegible]	1
21	Insulation, [illegible]	[illegible]	[illegible]	[illegible]
22	Insulation, Pipe	Armstrong Cork	[illegible]	[illegible]
23	Copper Tubing Type "L"	[illegible]	[illegible]	[illegible]
24		[illegible]	1	[illegible]
25		[illegible]	1/2	[illegible]
26	[illegible], Copper	[illegible]	[illegible]	[illegible]
27	Fittings and Adaptors	[illegible]	Copper/Bronze	



HONEYWELL INC.	
MODULE - SOLAR HEATING - SINGLE FAMILY RESIDENCE	
NASA	
C	56513
SK142063	
CONTROL	

F-2

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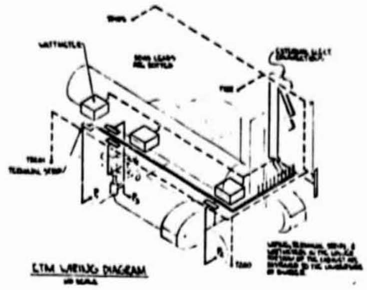
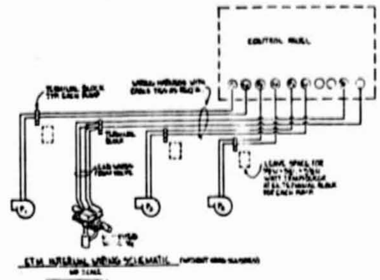
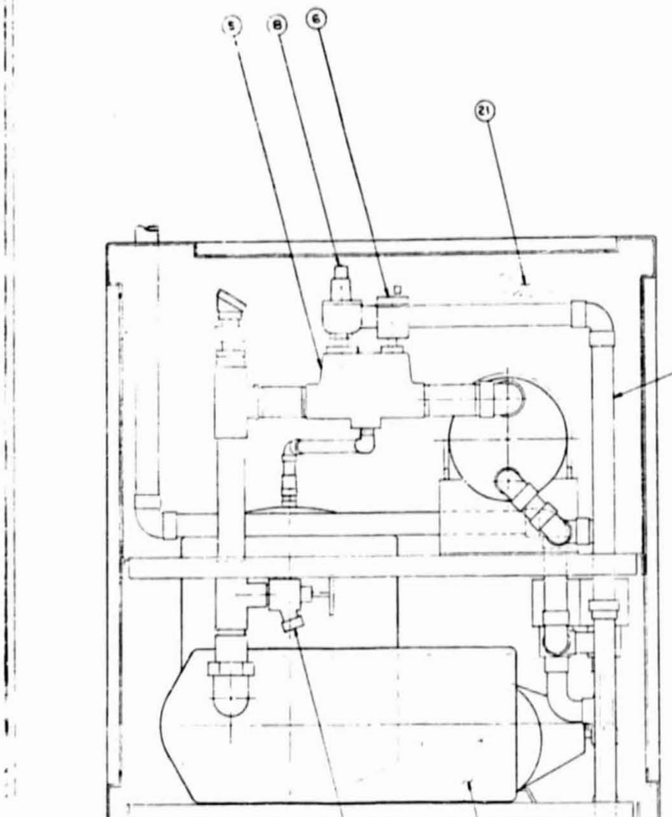
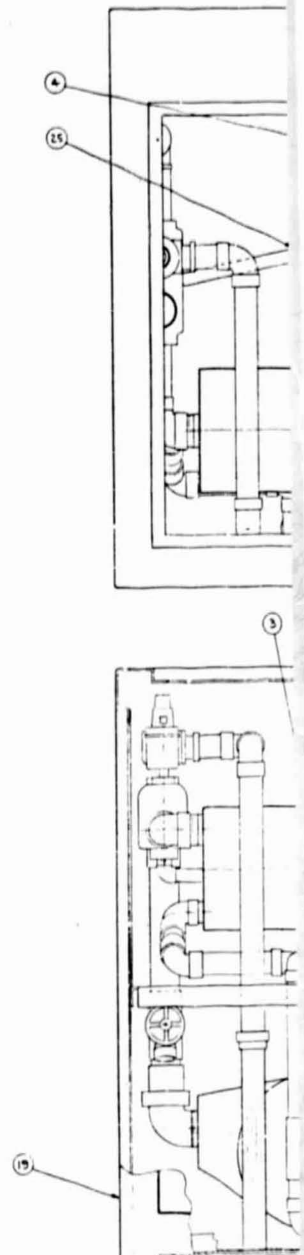


ETM WIRING DIAGRAM
NO SCALE



ETM INTERNAL WIRING SCHEMATIC
NO SCALE





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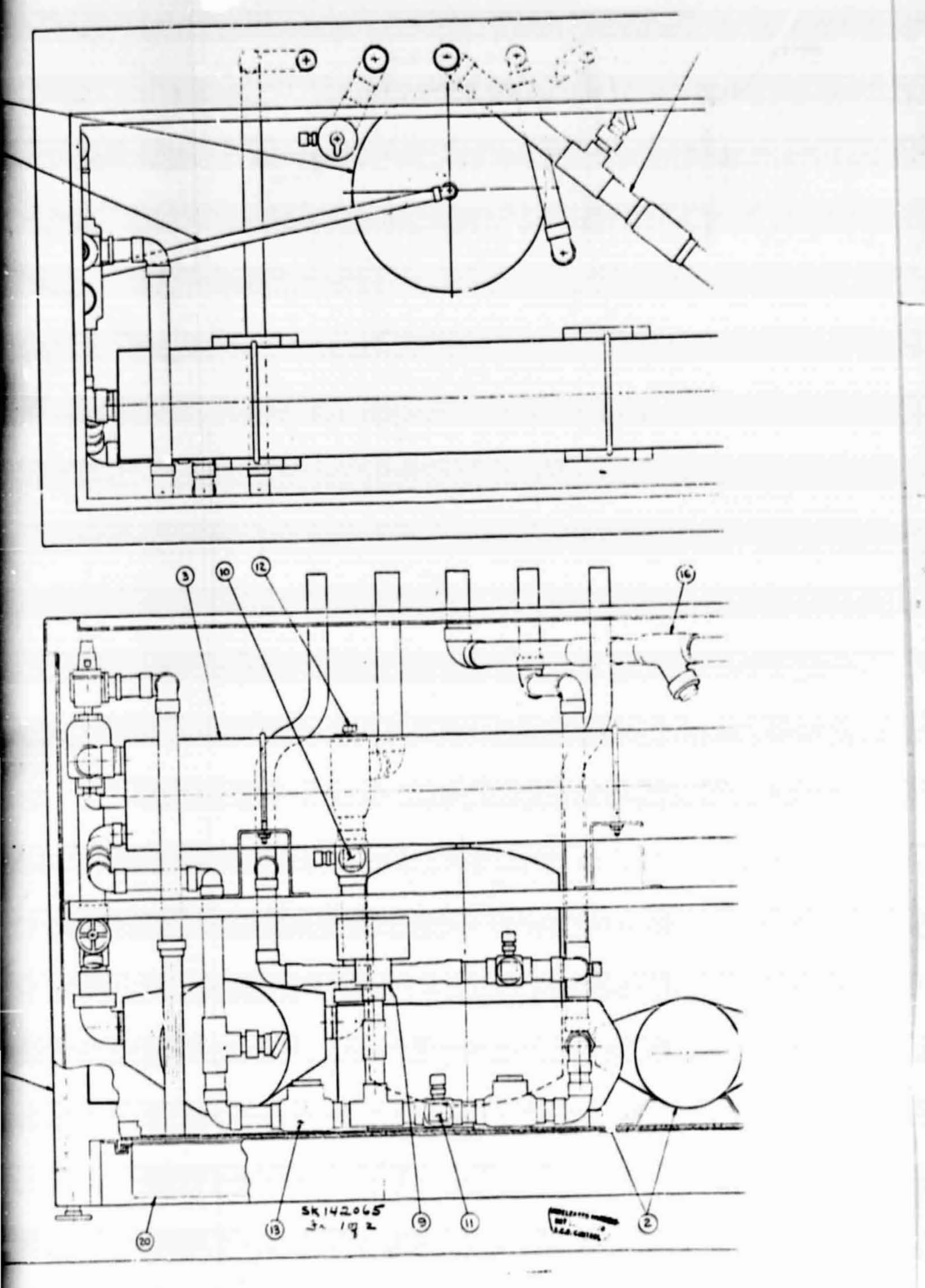

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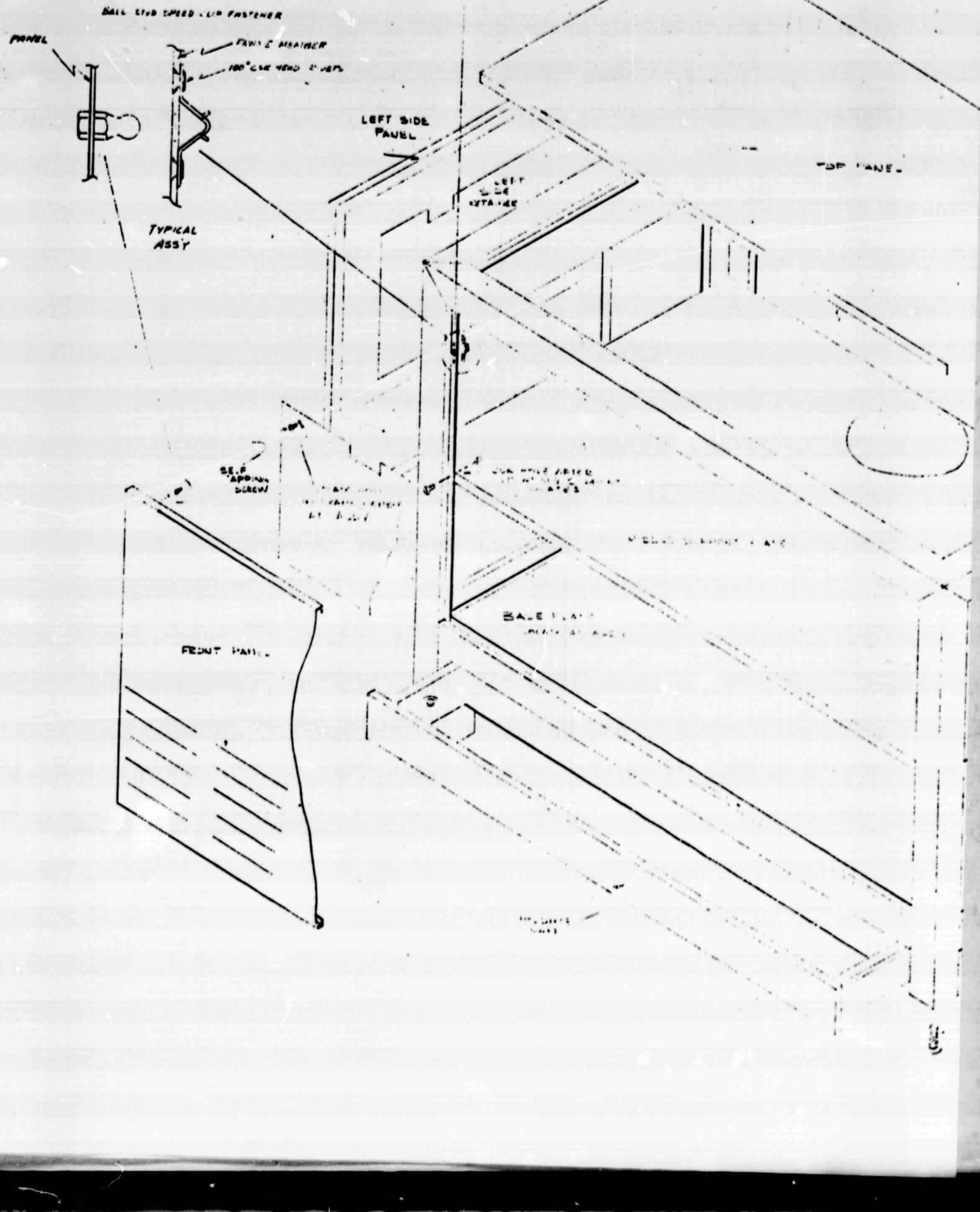

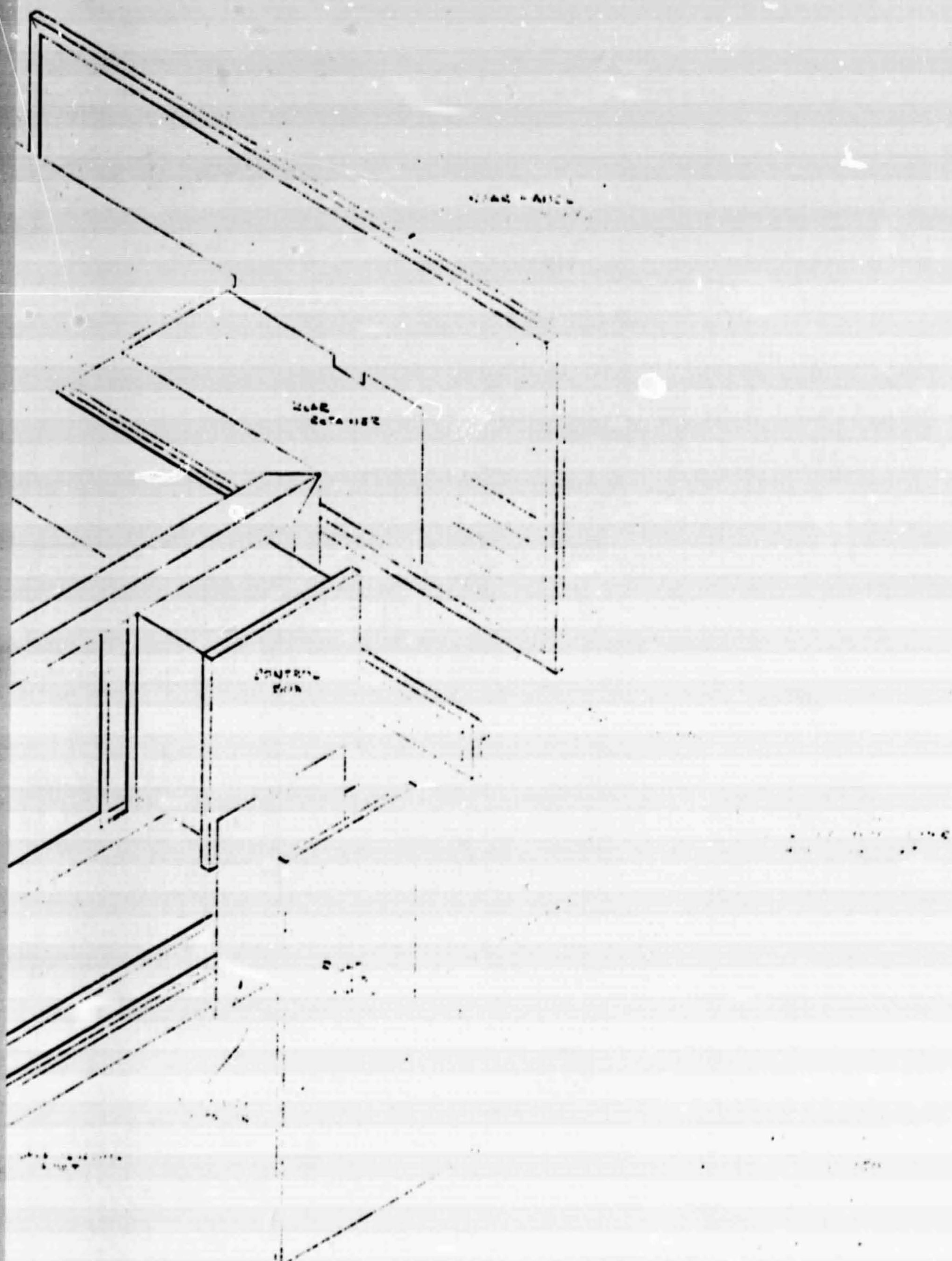

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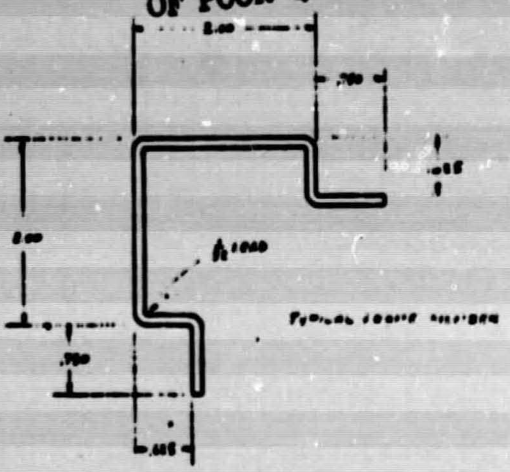
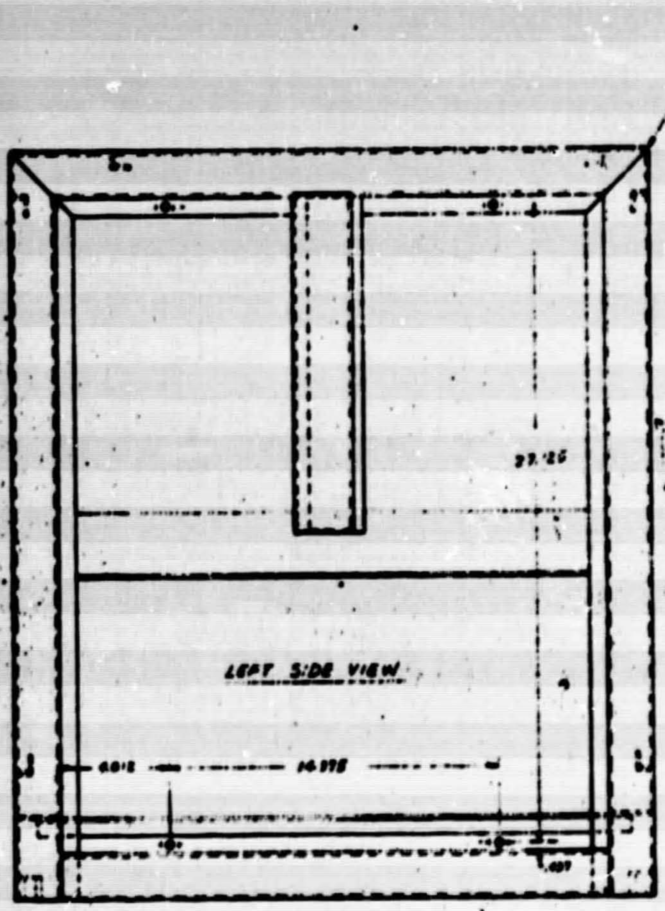
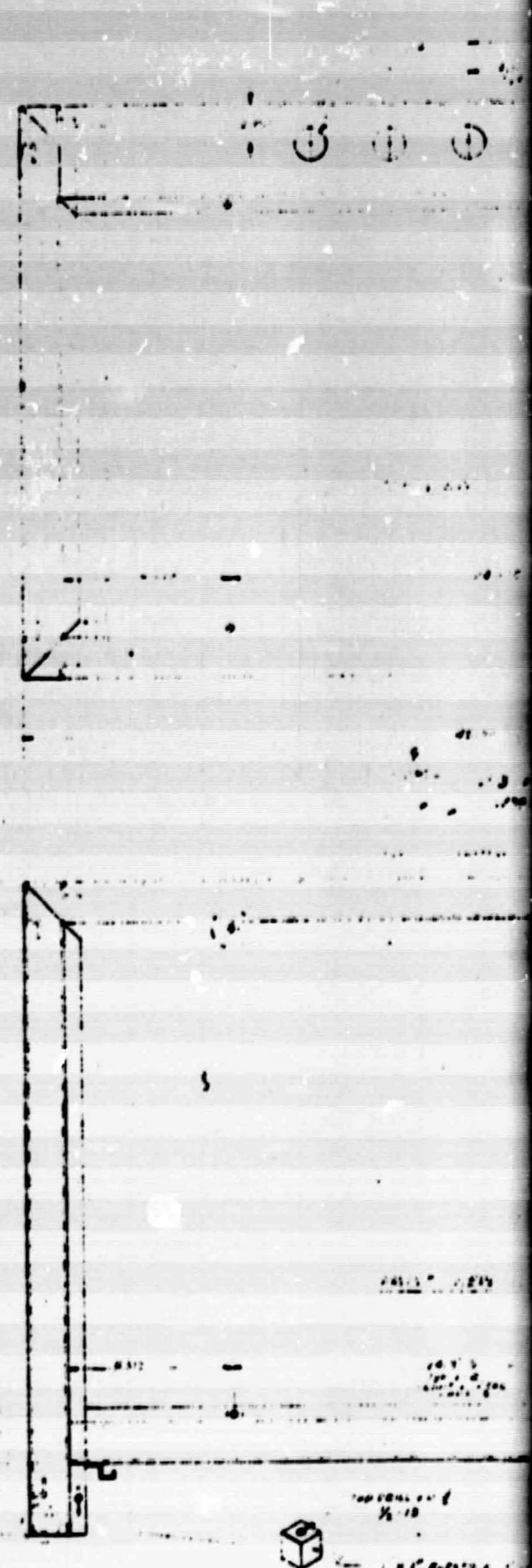
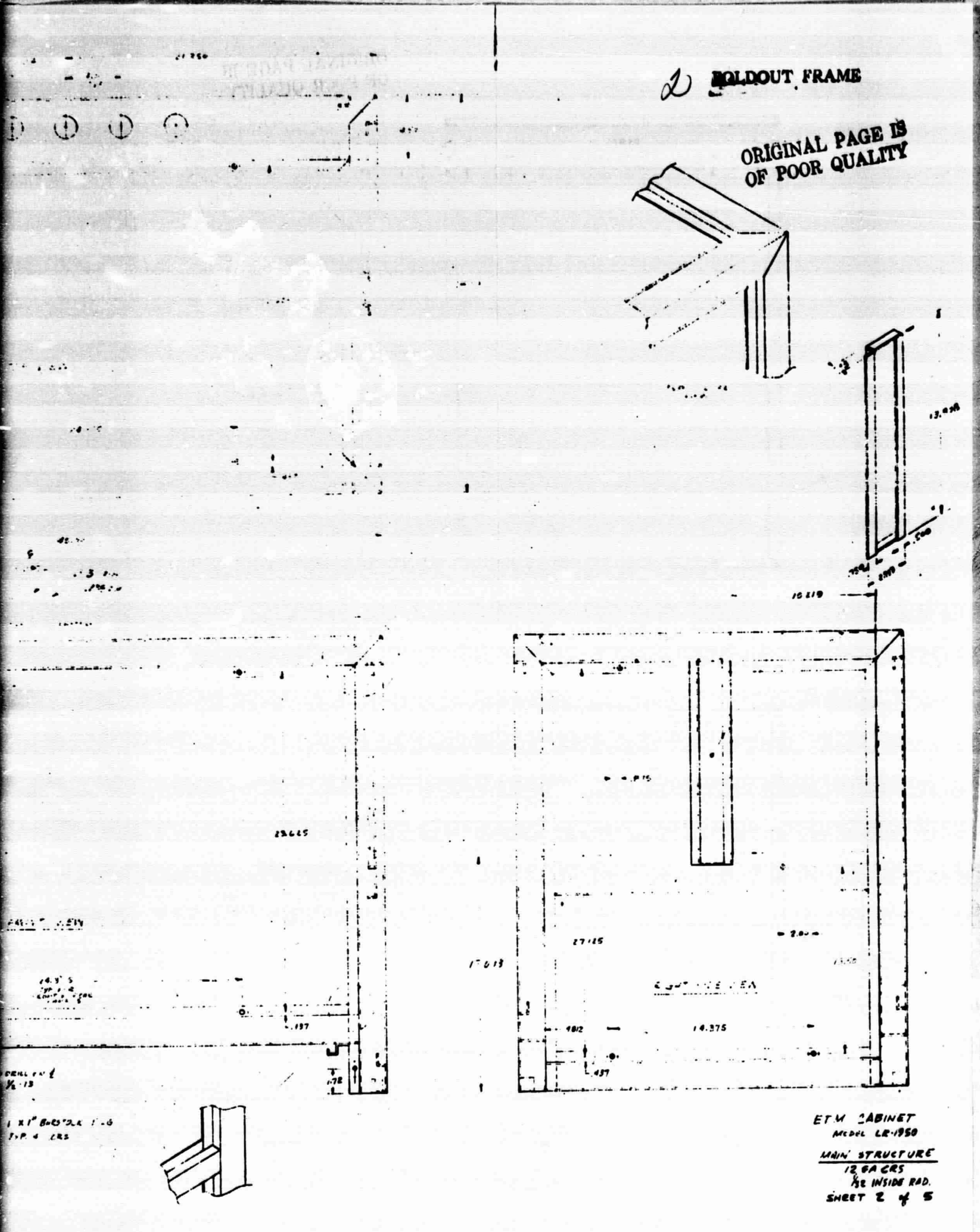
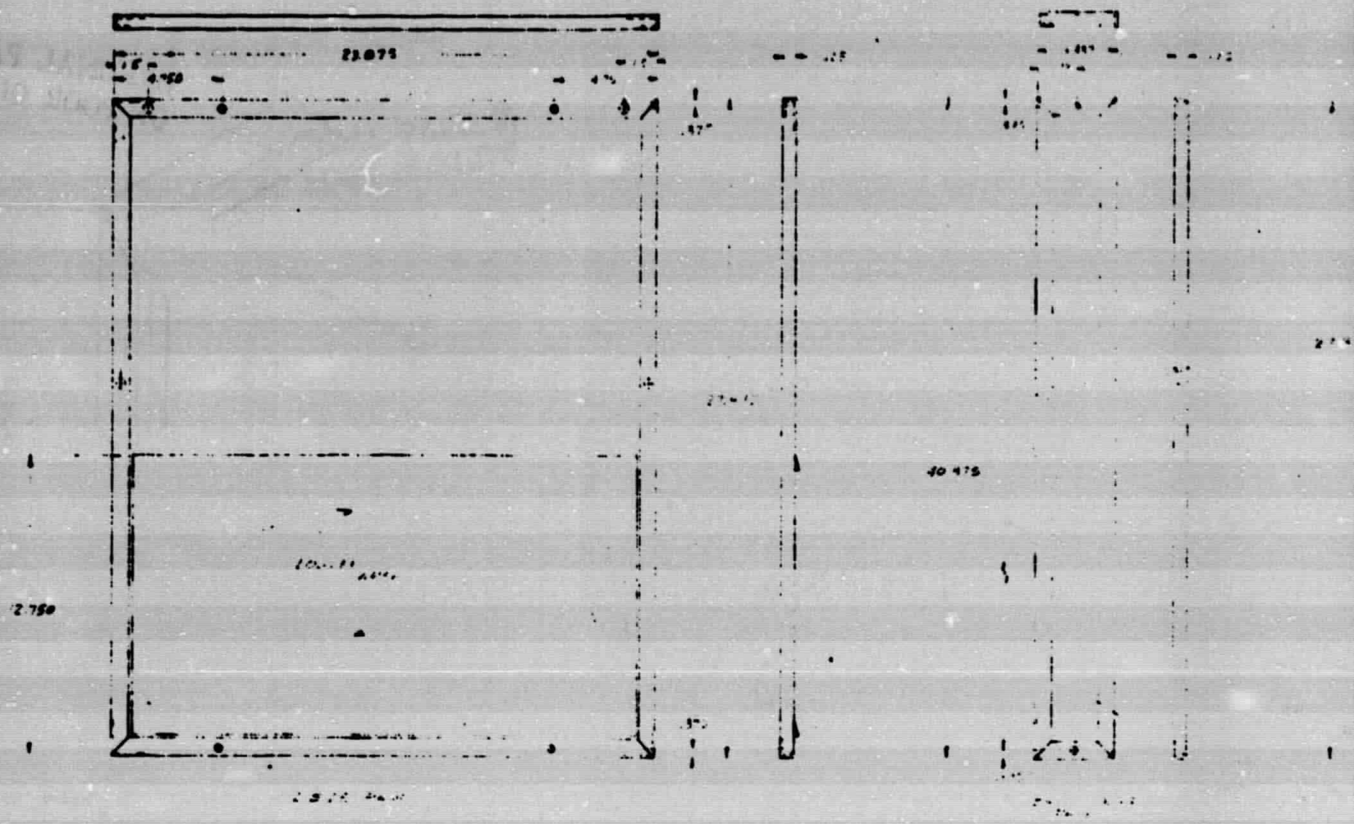
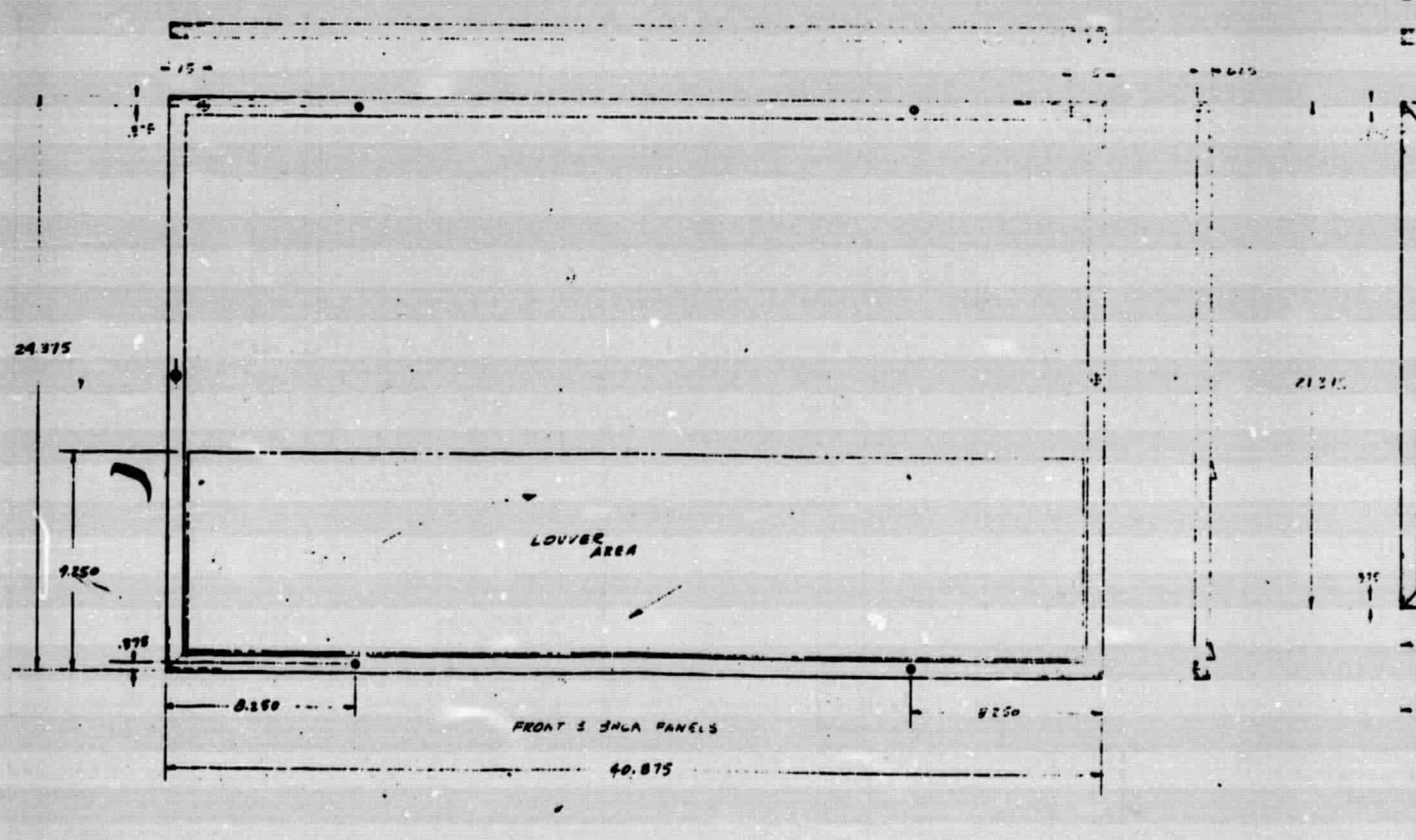







23.625
27.125
17.813
14.375
.437
.137
.812
2.00
ETM CABINET
MODEL LR-1950
MAIN STRUCTURE
12 GA CRS
1/32 INSIDE RAD.
SHEET 2 of 5




24.375
9.250
LOUVER AREA
8.250
FRONT & BACK PANELS
40.875

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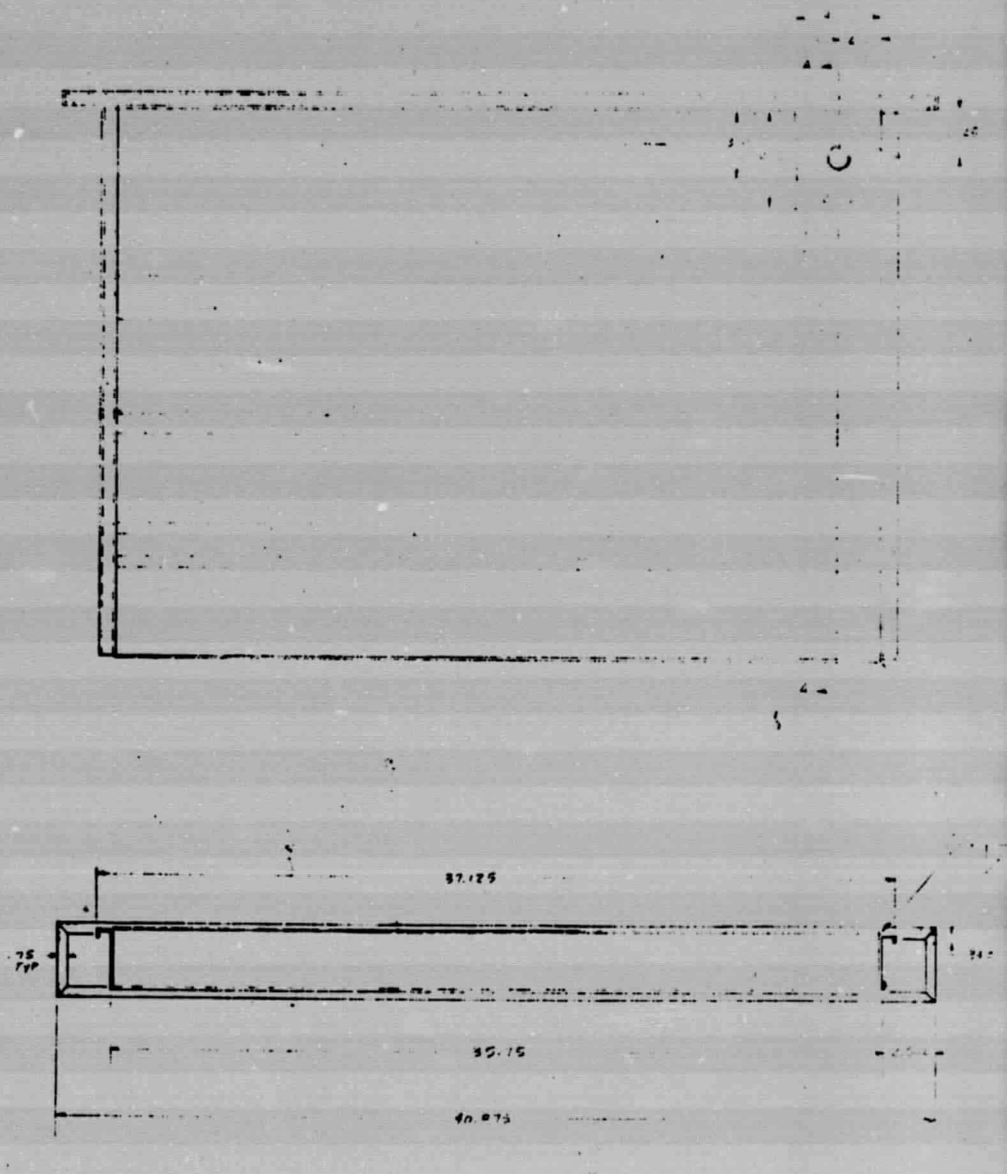
F-7



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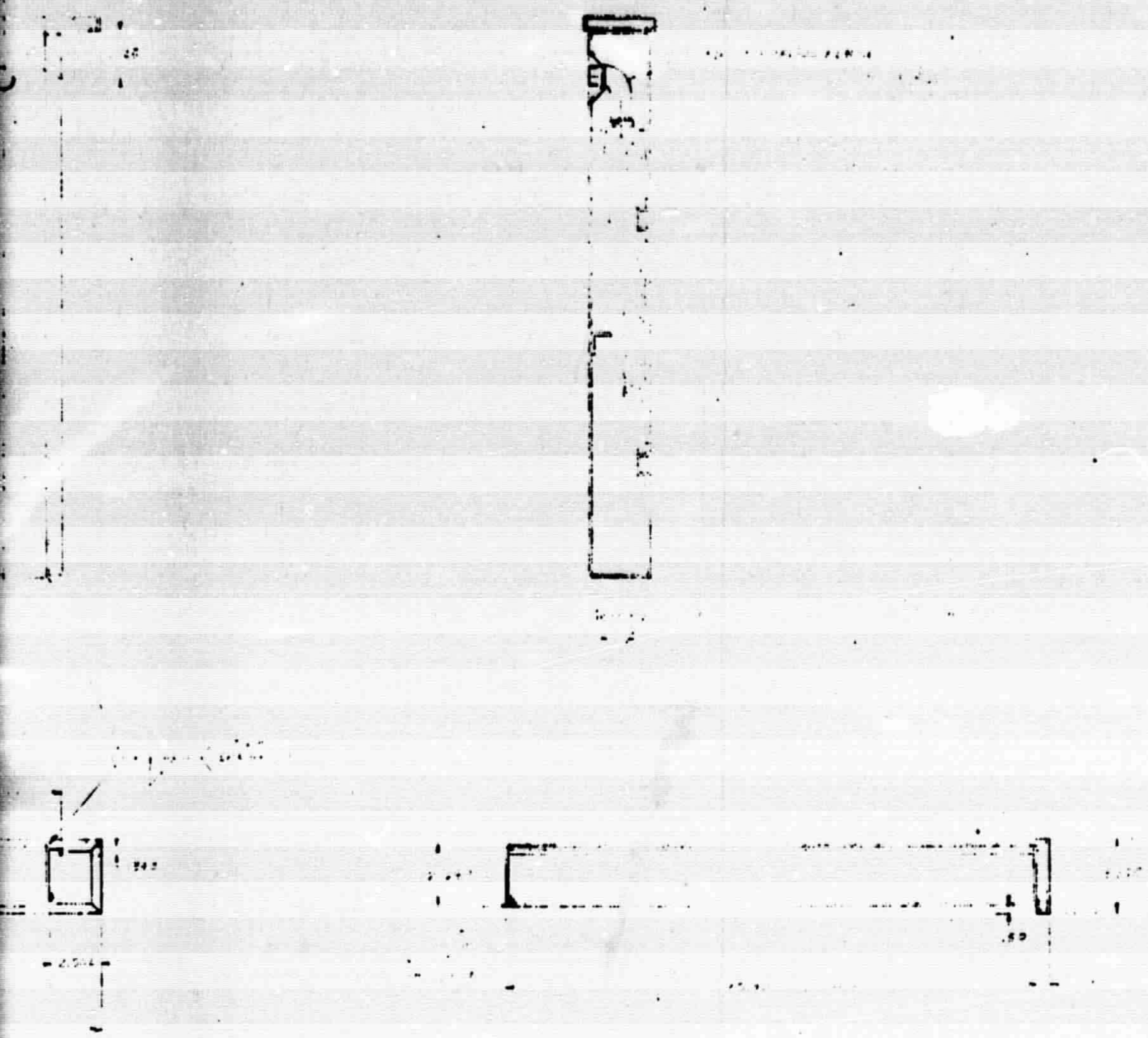
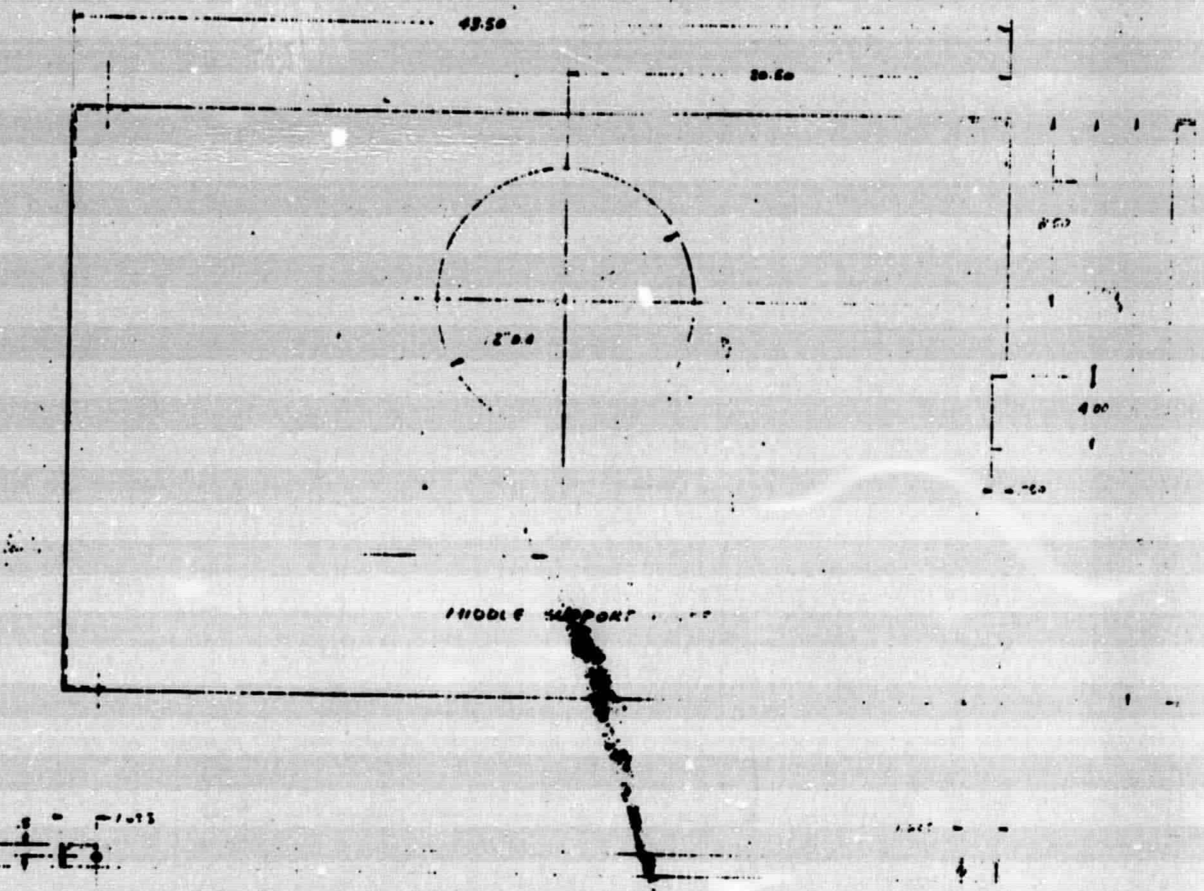
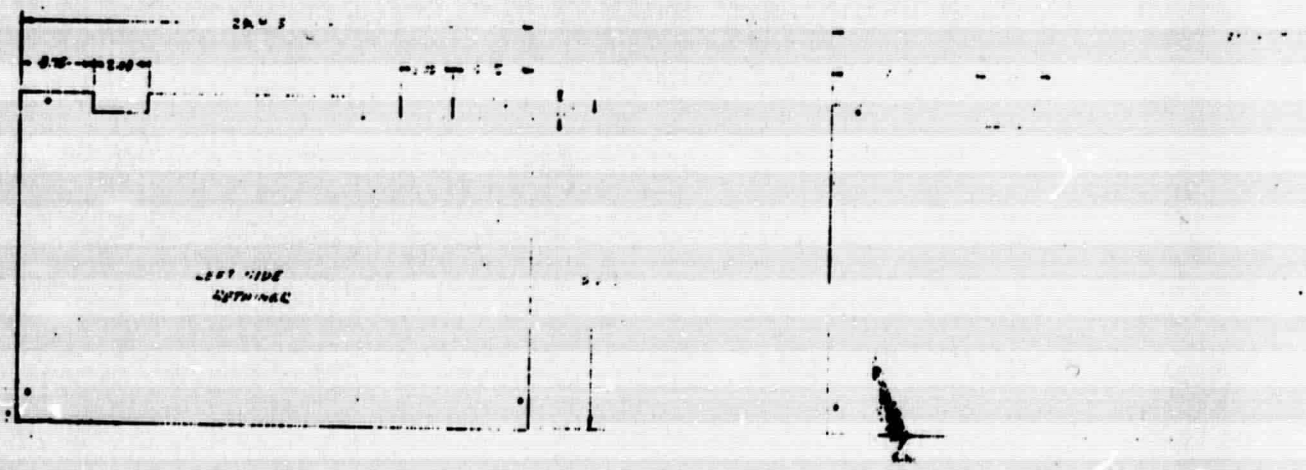
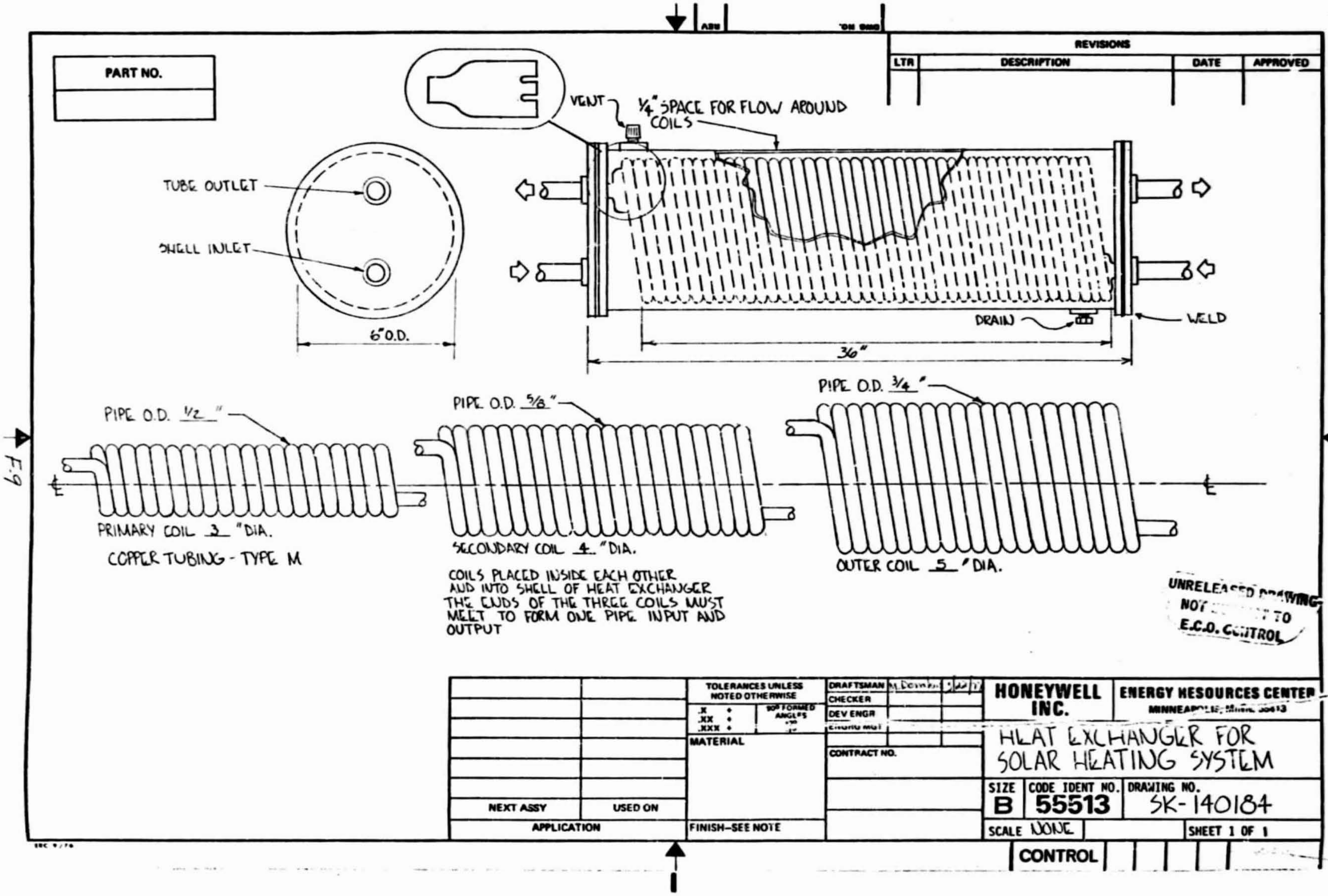



43.50
20.50





F.9

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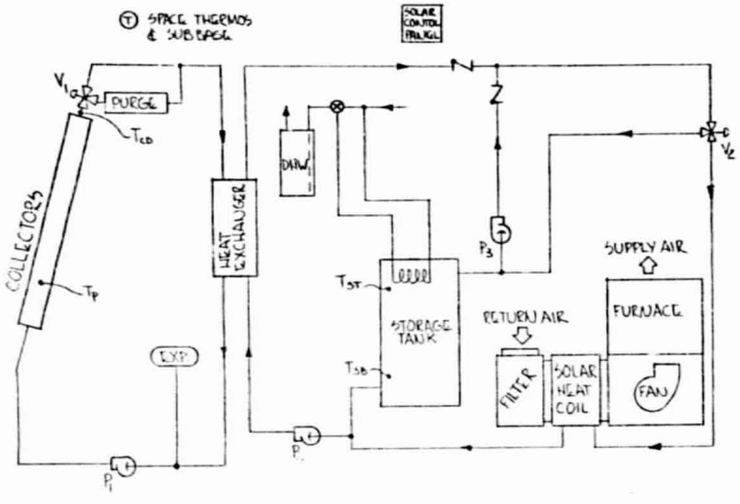
PART NO.



SOLAR HEATING SYSTEM CONTROL SCHEMATIC
NO SCALE

MATERIAL LIST			
ITEM	QUAN.	DESCRIPTION	HONEYWELL MODEL NO.
	1	SOLAR CONTROL PANEL	W968A1009
T_{ST}	1	AQUASTAT CONTROLLER	L6008C1065
T_{CD}	1	AQUASTAT CONTROLLER	L4008B1013
	1	MULTISTAGE THERMOSTAT	T872C1004
	1	THERMOSTAT SUBBASE	Q672B1004
V_1	1	MOTORIZED VALVE	V4331A1003
V_2	1	MOTORIZED VALVE	V4331A1003
	2	IMMERSION WELL	122555B
	1	CASE ASSEMBLY	112892F
T_P & T_{SB}	2	SENSOR	C773B1005
	1	COLLECTOR SENSOR SHIELD	SK-142067

REFERENCE ONLY REMOUNTED ON TRANSPORT MODULE - SK- 142053

REFERENCE ONLY MOUNTED IN TRANSPORT MODULE SK-142053

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REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

Solar Heating System - Single Family Residence

SEQUENCE OF OPERATION

GENERAL

Space heating is controlled by the two stage heating thermostat. First stage heating is set to utilize solar energy if available while second stage heating will supply the auxiliary energy if solar is not adequate. The system control logic is as follows:

- Collect solar energy when available
  - Store energy under no load conditions
  - Provide energy directly to load on demand
- Use direct solar energy before stored energy
- Use stored energy when direct solar energy is not available
- Use direct or stored solar energy before auxiliary energy

DIRECT HEATING FROM COLLECTORS

Whenever plate temperature T_p is greater than 105°F (adjustable) and there is a call for heating from the space thermostat pumps P_1 and P_2 are activated. Valve V_2 is positioned to direct flow to the heating coil. The furnace fan is activated to provide warm air to the space. A heating coil leaving air high limit controller will cause valve V_2 to direct flow to the storage tank if the heating coil leaving air temperature exceeds 140°F ~~(adjustable)~~. Direct heating operation will continue until the space thermostat is satisfied or until the collector plate temperature has dropped to 90°F.

HEATING FROM STORAGE

Whenever T_p is less than 105°F (adjustable), T_{ST} is greater than 90°F (adjustable), and there is a call for space heat, pump P_3 is activated to discharge the storage tank for space heating. Valve V_2 is positioned to direct flow to the heating coil. The furnace fan is activated to provide warm air to the space. Pumps P_1 and P_2 are not allowed to operate during this mode. The heating coil leaving air high limit controller functions as described above.

STORAGE CHARGING

Storage charging is accomplished whenever T_p is greater than T_{SB} by 18°F (adjustable). Pumps P_1 and P_2 are activated and valve V_2 is positioned to direct flow to the storage tank. If the above temperature difference falls to less than 3°F (adjustable), the storage charge mode is terminated.

HEAT REJECTOR CONTROL

Whenever the collector discharge temperature exceeds 210°F (adjustable) as sensed by T_{CD}, valve V_1 is positioned to direct collector loop flow through the heat rejector, and the heat rejector fan is activated.

AUXILIARY HEATING

Whenever solar heating is being utilized, either direct or stored, auxiliary gas-fired heating will be available as controlled by the second heating stage of the space thermostat. When solar heating is not available, auxiliary gas-fired heating will be available as first stage heating. Auxiliary heating is provided by a conventional gas furnace utilizing conventional controls.

DOMESTIC HOT WATER HEATING

Whenever domestic hot water is drawn from the water heater it is replaced by preheated water from a coil in the storage tank. A thermostatic mixing valve is used to regulate the hot water supply temperature to 140°F.

UNRELEASED DRAWING NOT SUBJECT TO E.C.O. CONTROL

NEXT ASSY	USED ON
APPLICATION	

TOLERANCES UNLESS NOTED OTHERWISE
MATERIAL
FINISH-SEE NOTE

DRAFTSMAN / CHECKER / DEV ENGN / ENGRG MGT
CONTRACT NO.
WILLIAM O'BRIEN

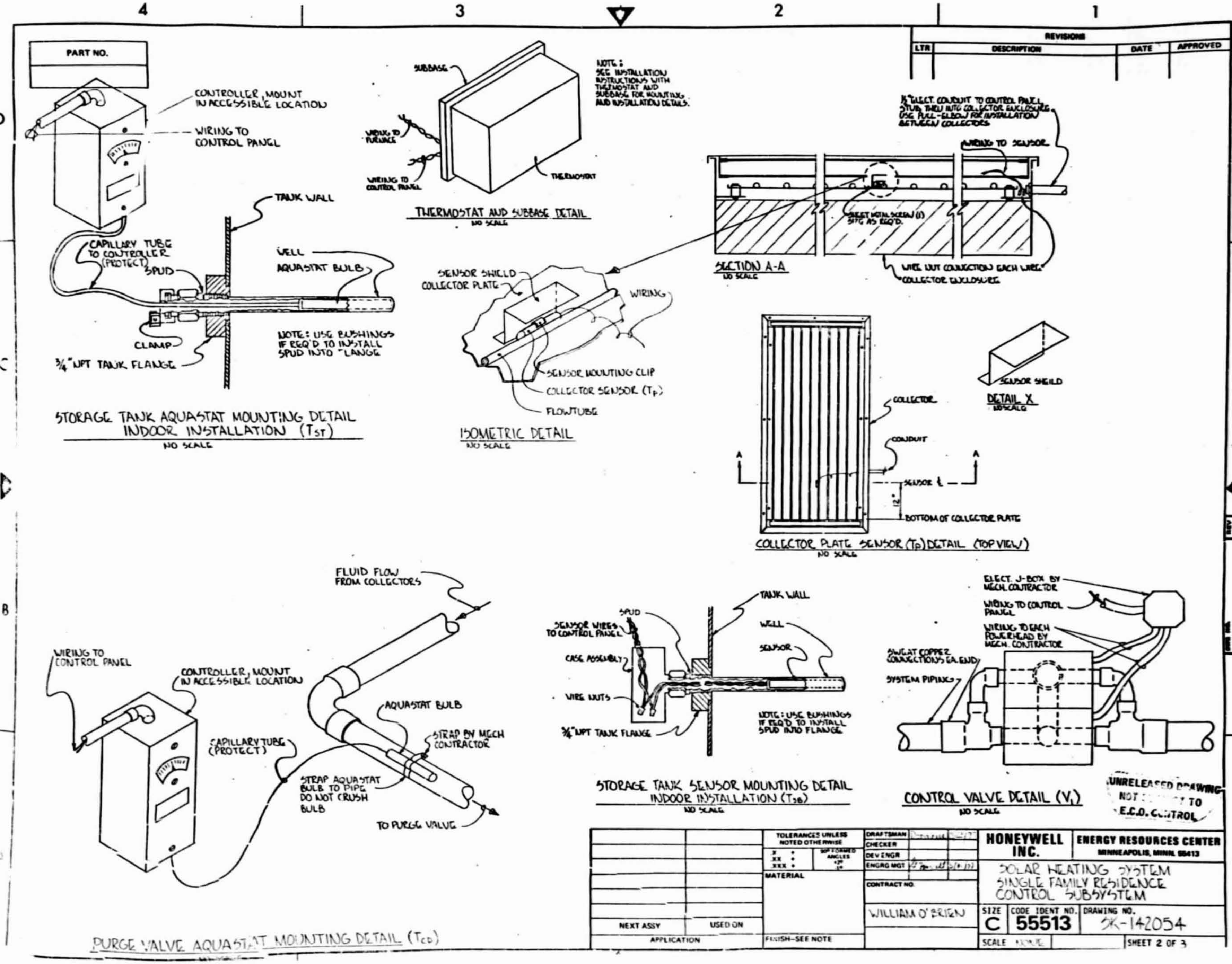
HONEYWELL INC. — ENERGY RESOURCES CENTER, MINNEAPOLIS, MINN. 55413

SOLAR HEATING SYSTEM
SINGLE FAMILY RESIDENCE
CONTROL SUBSYSTEM

SIZE	CODE IDENT NO.	DRAWING NO.
C	55513	SK-142054
SCALE NONE		SHEET 1 OF 3

CONTROL A

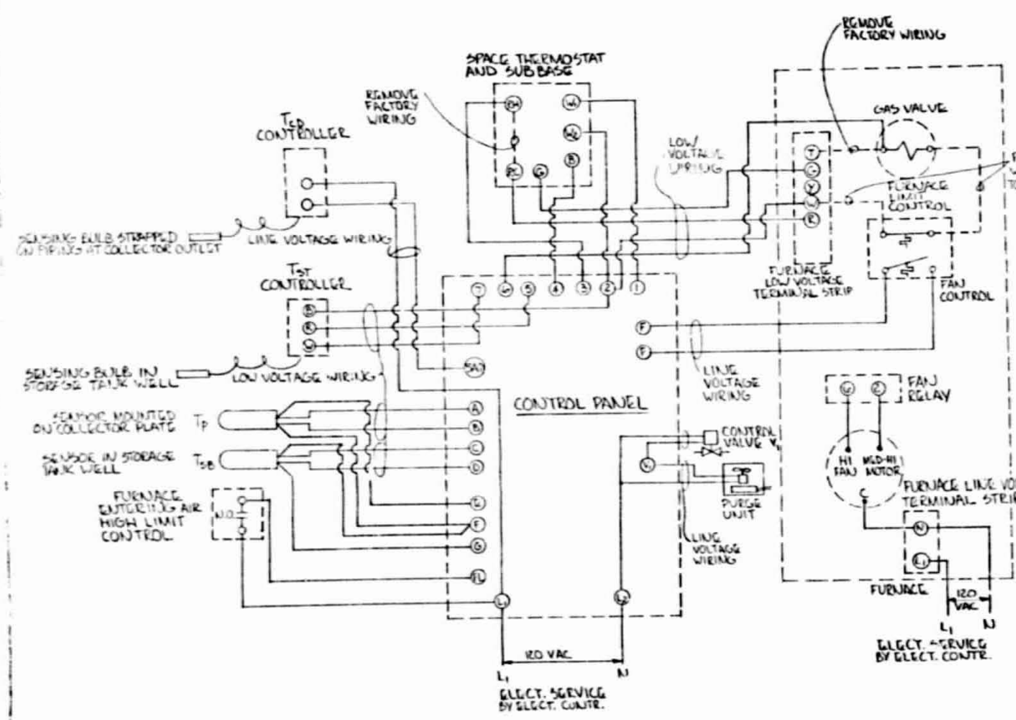
G-2



PART NO.
CONTROLLER, MOUNT IN ACCESSIBLE LOCATION
WIRING TO CONTROL PANEL
TANK WALL
CAPILLARY TUBE TO CONTROLLER (PROTECT)
SPUD
WELL
AQUASTAT BULB
CLAMP
3/4" NPT TANK FLANGE
NOTE: USE BUSHINGS IF REQ'D TO INSTALL SPUD INTO FLANGE
STORAGE TANK AQUASTAT MOUNTING DETAIL INDOOR INSTALLATION (TST)
NO SCALE
SUBBASE
WIRING TO FURNACE
WIRING TO CONTROL PANEL
THERMOSTAT
NOTE: SEE INSTALLATION INSTRUCTIONS WITH THERMOSTAT AND SUBBASE FOR MOUNTING AND INSTALLATION DETAILS.
THERMOSTAT AND SUBBASE DETAIL
NO SCALE
SENSOR SHIELD
COLLECTOR PLATE
WIRING
SENSOR MOUNTING CLIP
COLLECTOR SENSOR (TP)
FLOWTUBE
ISOMETRIC DETAIL
NO SCALE
REVISIONS
LTR
DESCRIPTION
DATE
APPROVED
WIRING TO SENSOR
SECTION A-A
NO SCALE
WIRE NUT CONNECTION EACH WIRE COLLECTOR ENCLOSURE
COLLECTOR
CONDUIT
SENSOR
BOTTOM OF COLLECTOR PLATE
COLLECTOR PLATE SENSOR (TP) DETAIL (TOP VIEW)
NO SCALE
SENSOR SHEILD
DETAIL X
NO SCALE
FLUID FLOW FROM COLLECTORS
WIRING TO CONTROL PANEL
CONTROLLER, MOUNT IN ACCESSIBLE LOCATION
AQUASTAT BULB
CAPILLARY TUBE (PROTECT)
STRAP BY MECH CONTRACTOR
STRAP AQUASTAT BULB TO PIPE DO NOT CRUSH BULB
TO PURGE VALVE
PURGE VALVE AQUASTAT MOUNTING DETAIL (TCO)
SPUD
SENSOR WIRES TO CONTROL PANEL
CASE ASSEMBLY
WIRE NUTS
3/4" NPT TANK FLANGE
TANK WALL
WELL
SENSOR
NOTE: USE BUSHINGS IF REQ'D TO INSTALL SPUD INTO FLANGE
STORAGE TANK SENSOR MOUNTING DETAIL INDOOR INSTALLATION (TSB)
NO SCALE
ELECT. J-BOX BY MECH. CONTRACTOR
WIRING TO CONTROL PANEL
WIRING TO EACH POWERHEAD BY MECH. CONTRACTOR
SWEAT COPPER CONNECTIONS EA. END
SYSTEM PIPING
CONTROL VALVE DETAIL (V1)
NO SCALE
UNRELEASED DRAWING
E.C.O. CONTROL
TOLERANCES UNLESS NOTED OTHERWISE
DRAFTSMAN
CHECKER
DEV ENGR
ENGRG MGT
MATERIAL
CONTRACT NO.
NEXT ASSY
USED ON
APPLICATION
FINISH–SEE NOTE
HONEYWELL INC.
ENERGY RESOURCES CENTER
MINNEAPOLIS, MINN.
SOLAR HEATING SYSTEM
SINGLE FAMILY RESIDENCE
CONTROL SUBSYSTEM
WILLIAM O'BRIEN
SIZE C
CODE IDENT NO. 55513
DRAWING NO. SK-142054
SCALE NONE
SHEET 2 OF 3

PART NO.

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



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SOLAR HEATING SYSTEM - SINGLE FAMILY RESIDENCE
CONTROL SUBSYSTEM

1.0 GENERAL CONDITIONS

1.1 Scope: The Control Subsystem will include all controls necessary for operation of the solar heating system.

1.2 Required Work: The Mechanical Contractor will install and wire all controls as shown on control subsystem wiring schematic. This will include all line voltage wiring required.

1.3 Procurement of Control Devices: Control devices listed in Material List, (i.e., Solar Control Panel, Aquastats, Thermostat, etc.) will be provided by Honeywell ERC. This will include the control devices only, all materials necessary for a complete installation will be provided by the Mechanical Contractor.

2.0 BASIC MATERIALS AND METHODS

2.1 Basic Materials:

2.1.1 Control sensor wiring (T_p and T_{SB}): Wiring from solar control panel to control sensors T_p and T_{SB} shall be run in conduit in outdoor areas and shall be Belden #8762 or equal.

2.1.2 Power and control wiring: All line and low voltage wiring shall be of size and type required by applicable codes. and supplied by Mechanical Contractor.

2.1.3 Other Materials: All other materials required for a complete installation of the Control Subsystem shall be supplied by the Mechanical Contractor.

2.2 Basic Methods:

2.2.1 Control device installation methods: As per applicable details and/or instructions included with equipment.

2.2.2 Electrical wiring: As per all applicable codes.

UNRELEASED DRAWING- NOT ... TO E.C.O. CONTROL

NEXT ASSY	USED ON
APPLICATION	

TOLERANCES UNLESS NOTED OTHERWISE
MATERIAL
FINISH—SEE NOTE

DRAFTSMAN
CHECKER
DEV ENGR
ENGRG MGT
CONTRACT NO.
WILLIAM O'BRIEN

HONEYWELL INC. **ENERGY RESOURCES CENTER** MINNEAPOLIS, MINN. 55413

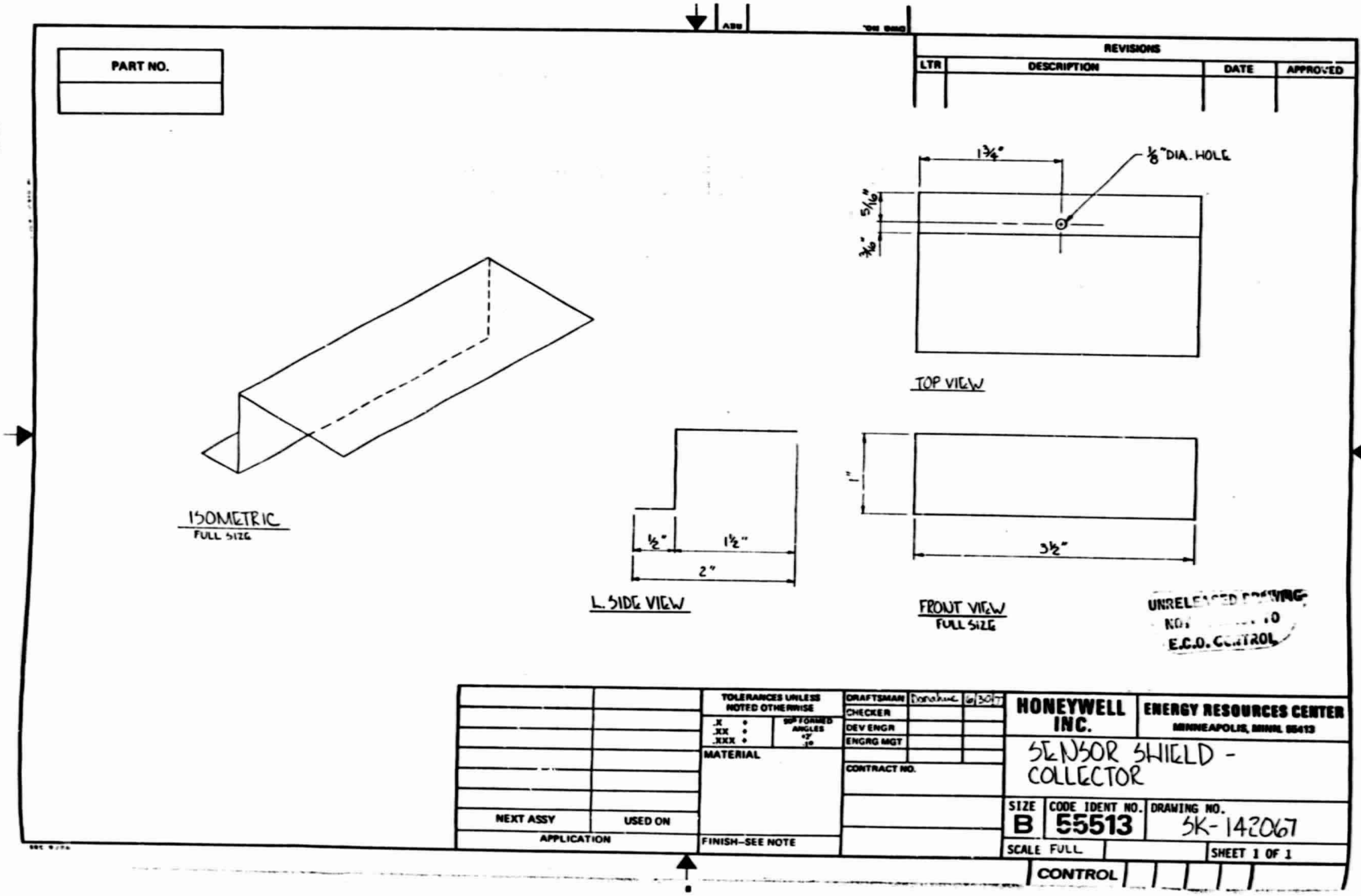
SOLAR HEATING SYSTEM SINGLE FAMILY RESIDENCE CONTROL SUBSYSTEM

SIZE	CODE IDENT NO.	DRAWING NO.
C	55513	SK-142054

SCALE NONE | SHEET 3 OF 3

CONTROL A

G-3


PART NO.
REVISIONS
LTR
DESCRIPTION
DATE
APPROVED
1/8" DIA. HOLE
1 3/4"
5/16"
3/16"
TOP VIEW
ISOMETRIC
FULL SIZE
1/2"
1 1/2"
2"
L. SIDE VIEW
1"
3 1/2"
FRONT VIEW
FULL SIZE
TOLERANCES UNLESS NOTED OTHERWISE
MATERIAL
FINISH-SEE NOTE
NEXT ASSY
USED ON
APPLICATION
DRAFTSMAN
CHECKER
DEV ENGR
ENGRG MGT
CONTRACT NO.
HONEYWELL INC.
ENERGY RESOURCES CENTER
MINNEAPOLIS, MINN. 55413
SENSOR SHIELD - COLLECTOR
SIZE
B
CODE IDENT NO.
55513
DRAWING NO.
SK-142067
SCALE FULL
SHEET 1 OF 1
CONTROL

APPENDIX H

SITE DATA ACQUISITION SUBSYSTEM DRAWING

DRAWING NO. SK 142055

PART NO.

Single Heating System - Single Family Residence

SITE DATA ACQUISITION SUBSYSTEM

1.0 GENERAL CONDITIONS

1.1 Purpose:
A Site Data Acquisition Subsystem (SDAS) will be installed to evaluate the performance of the solar heating system as well as determine the contribution of collected solar energy in reducing the consumption of conventional energy. The Site Data Acquisition Subsystem components will be furnished by NASA, consisting of instrumentation sensors, junction box, Site Data Acquisition Subsystem Module and a telephone interface, as shown in detail.

1.2 Required Work

1.2.1 Instrumentation Installation - The Mechanical Contractor [illegible] the instrumentation schedule. [illegible] Contractor shall [illegible] the sensors in the locations shown so as to [illegible] of cavitating.

1.2.2 [illegible] - The Mechanical Contractor shall perform all electrical wiring from each sensor back to the Junction Box as shown on details and described below.

1.2.3 Watt Transducer Installation Mechanical Contractor shall [illegible] and rewire factory wiring as required. See Watt Transducer detail.

1.2.4 Site Data Acquisition Subsystem Module - The Site Data Acquisition Subsystem Module will be furnished by NASA, and installed by the Mechanical Contractor. The installation location will be [illegible] mechanical plans.

1.2.5 SDAS Telephone Interface - NASA will [illegible] the telephone installation required [illegible] the SDAS.

1.2.6 SDAS Electrical Interface - The SDAS will interface with a standard [illegible] phase, 3 amp service. A standard 3 wire [illegible] safety ground, power and returned with a [illegible] twist lock outlet, located within approximately six feet of the SDAS, shall be provided by the Mechanical Contractor. NASA shall provide a three pin twist lock connector and cable to interface the SDAS with the power outlet.

1.2.7 Junction Box - NASA shall provide a Junction Box to the Mechanical Contractor for installation in a location as shown on the [illegible] plans. The Junction Box shall be located so that it is accessible for wiring connections from the sensors into the top and is within four feet of the SDAS location. At the required mounting location, the Junction Box shall be mounted using the four mounting feet located at the top and bottom of the unit. Depending on the characteristics of the mounting surface, [illegible] bolts, wood screws or bolt/nut combinations will be used to mount the unit. The Junction Box shall be installed in a top-up orientation.

1.2.8 Junction Box/Sensor Interface - NASA will establish the wire run list which identifies where each sensor wire attaches to the Junction Box. The Junction Box will be prewired from the terminal strips to output connectors by NASA prior to delivery to the site. Each applicable sensor detail illustrates the sensor to Junction Box wiring. The Mechanical Contractor shall connect sensor wires to Junction Box terminals according to a wiring diagram to be provided by NASA.

1.2.9 Junction Box/SDAS Module Interface Cables - NASA will install the cables between the Junction Box and the SDAS Module.

1.3 Restrictions on Use of Instrumentation

No monitoring, indicating or readout devices are to be connected to the instrumentation sensors, i.e., paralleled with the Site Data Acquisition Subsystem, without prior approval of NASA.

1.4 Failed Sensor Replacement

Defective sensors will be [illegible] identified by NASA as a part of the performance analysis research.

The improperly operating sensor will be identified to Honeywell ERC. After examination of the sensor for signs of physical damage such as broken wires, loose connections, loose terminals, etc. If no physical damage is apparent in the inspection, NASA shall be notified for further instructions. If such [illegible] damage is apparent, the sensor shall be replaced [illegible] with a sensor supplied by NASA. The defective sensor [illegible] shall be returned to NASA for failure analysis.

2.0 SDAS MATERIALS

2.1 Instrumentation Wiring

Wiring from the sensors to the Junction Box shall be performed by the Mechanical Contractor utilizing wire supplied by the Mechanical Contractor. The wire size and number of conductors required for each sensor type is specified in list below and each sensor detail. The sensor-to-Junction Box wire shall be UL approved, color-coded, audio and instrumentation grade cable of the following manufacture or equal.

Alpha P/N 2421-18 gauge, 2 conductor
Dearborn P/N 872202-18 gauge, 2 conductor
Alpha P/N 2424-18 gauge, 4 conductor
Dearborn P/N 778404-18 gauge, 4 conductor

All externally exposed wire in the outdoor environment or buried will be in conduit.

Wire nuts will be utilized for terminations at the following sensors:

Temperature Sensors	3 each (single element)
	6 each (dual element)

It is recommended that the wire nuts be replaced with a "butt splice" in areas where the connections are exposed to vibration.

Ring terminals will be used to terminate the wires at the following sensors:

Gas Meter	2 each
Flow Meter	5 each
Watt Transducer	2 each

If terminations conflict with local codes, local codes shall be applicable.

2.2 All other material necessary for installation of the sensors shall be provided by the Mechanical Contractor. This would include but not be limited to, weld-on fittings, pipe flanges, valves, pipe fittings, fasteners, electrical enclosures, terminal blocks, electrical wiring, electrical conduit and any other materials necessary for a complete installation of all sensors.

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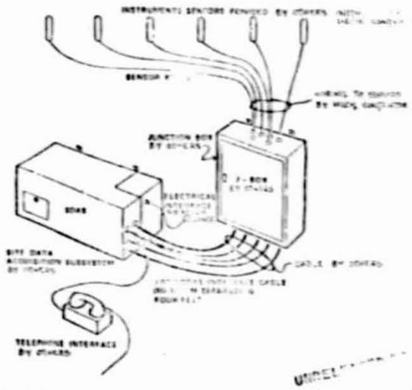


SITE DATA ACQUISITION SUBSYSTEM COMPONENTS
NO SCALE

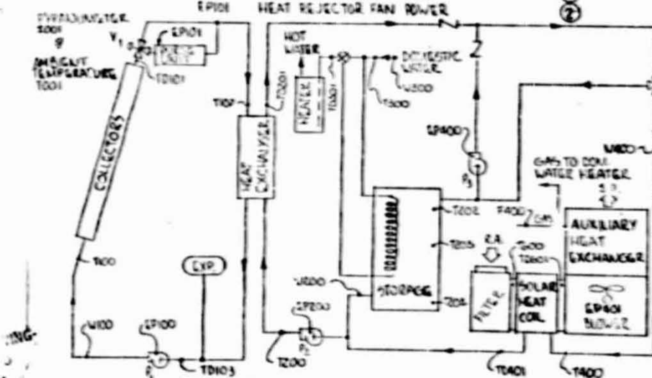
REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

SITE DATA ACQUISITION SUBSYSTEM

MATERIAL LIST

Site Data Aquisition Subsystem Module
Junction Box and interface cable.
Instrumentation Sensors as follows:

Sensor	Function	Detail
I001	Total Radiation	1
T001	Outdoor Ambient DB Temperature	3
T100	Collector Inlet Temperature	10
TD101	Collector Differential Temperature	9
T102	HX Solar Inlet Temperature	10
TD103	HX Solar Differential Temperature	9
T200	HX Hot Water Inlet Temperature	10
TD201	HX Hot Water Differential Temperature	9
T202	Storage Tank Temperature - Top	8
T203	Storage Tank Temperature - Middle	8
T204	Storage Tank Temperature - Bottom	8
T300	Domestic Cold Water Temperature	10
TD301	Solar DHW Preheat Differential Temperature	9
T400	Heating Coil HW Inlet Temperature	10
TD401	Heating Coil HW Differential Temperature	9
T600	Heating Coil Air Inlet Temperature	7
TD601	Heating Coil Air Differential Temperature	6
W100	Collector Flow Rate	5
W200	Storage Flow Rate	5
W300	DHW Flow Rate	5
W400	Heating Coil Flow Rate	5
EP100	Collector Pump Power	2
EP200	Storage Pump Power	2
EP400	Heating Pump Power	2
EP401	Furnace Fan Power	2
F400	Natural Gas Auxiliary Energy	4
EP101	HEAT REJECTOR FAN POWER	2



SINGLE FAMILY RESIDENTIAL SOLAR HEATING SYSTEM
SITE DATA ACQUISITION SUBSYSTEM SCHEMATIC

NEXT ASSY	USED ON	TOLERANCES UNLESS NOTED OTHERWISE	DRAFTSMAN / CHECKER / DEV ENGR / ENGRG MGT
APPLICATION		MATERIAL	CONTRACT NO.
		FINISH-SEE NOTE	WILLIAM O'BRIEN

HONEYWELL INC. | ENERGY RESOURCES CENTER, MINNEAPOLIS, MINN. 55413

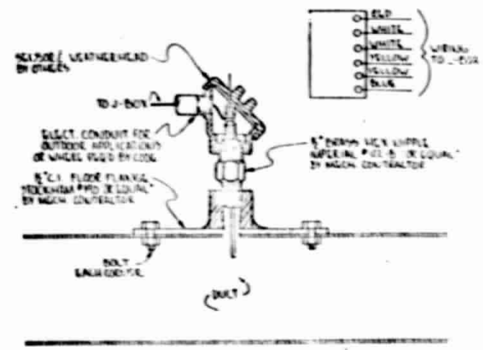
SOLAR HEATING SYSTEM - SFR
SITE DATA ACQUISITION SUBSYSTEM

SIZE	CODE IDENT NO.	DRAWING NO.
C	55513	SK-142055

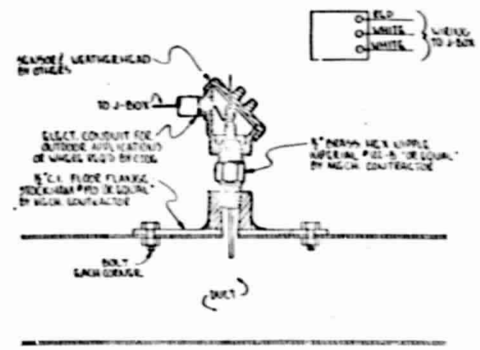
SCALE NONE | SHEET 1 OF 3

CONTROL A

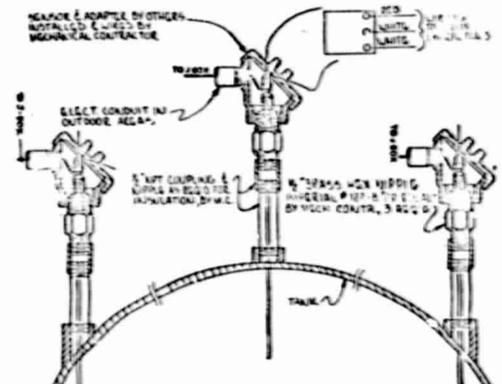
PART NO.



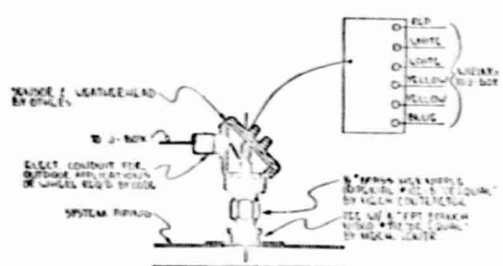
(6) DUAL ELEMENT TEMPERATURE SENSOR
NO SCALE



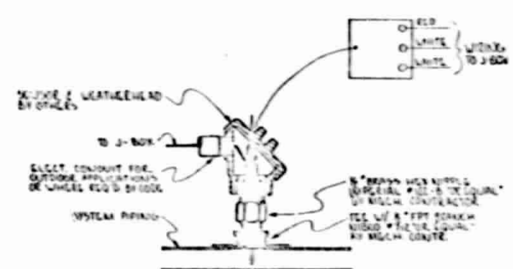
(7) SINGLE ELEMENT TEMPERATURE SENSOR
NO SCALE



(8) TEMPERATURE SENSORS AT TANK
NO SCALE



(9) DUAL ELEMENT TEMPERATURE SENSOR
NO SCALE



(10) SINGLE ELEMENT TEMPERATURE SENSOR
NO SCALE

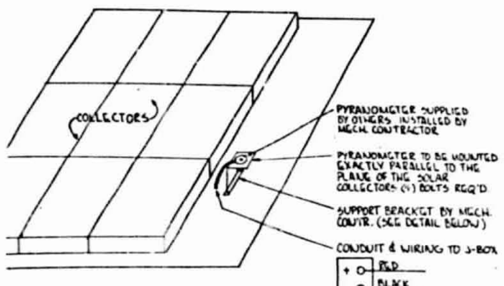
TEMPERATURE SENSOR INSTALLATION

1. All temperature sensors shall be located so as to avoid accidental damage to the sensor head assembly.
2. Dow Corning DC-340 heat transfer grease shall be applied to the bottom of the temperature probe prior to insertion into the thermowell.
3. In areas where there is a mixing of flows, the temperature sensor shall be mounted a minimum of twenty (20) pipe diameters downstream of the point of mixing.
4. All temperature sensors shall be identified with a brass tag.

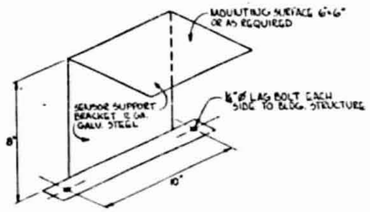
HONEYWELL INC.	ENERGY RESOURCES CENTER MINNEAPOLIS, MINN. 55413
SOLAR HEATING SYSTEM - SFR. SITE DATA ACQUISITION SUBSYSTEM	
SIZE C	CODE IDENT NO. 03513
DRAWING NO. 5K-147055	SHEET 2 OF 3
DRAFTSMAN	WILLIAM O'BRIEN
TOLERANCES UNLESS NOTED OTHERWISE	MATERIAL
CONTRACT NO	FINISH - SEE NOTE
NEXT ASSY	USED ON
APPLICATION	
SCALE NONE	CONTROL

PART NO.

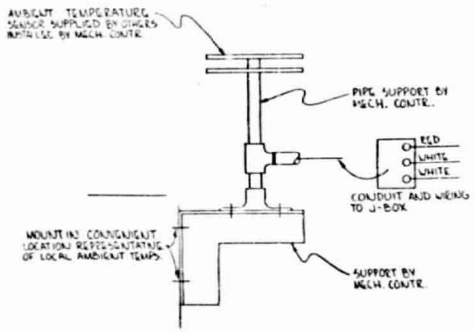
REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



(1) PYRANOMETER DETAIL
NO SCALE



SUPPORT BRACKET DETAIL
NO SCALE



(3) AMBIENT TEMPERATURE SENSOR
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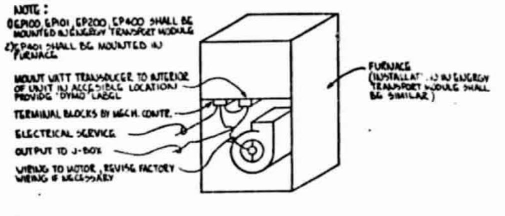
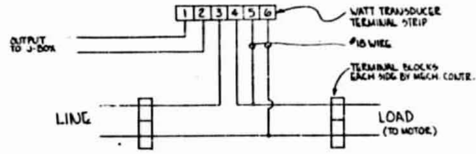
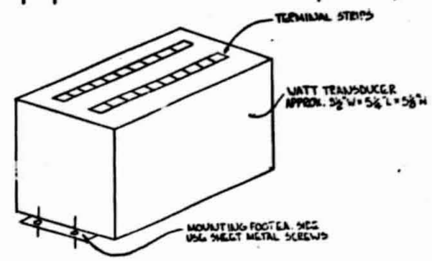


INSTALLATION
NO SCALE



WIRING DIAGRAM

(2) WATT TRANSDUCER
NO SCALE



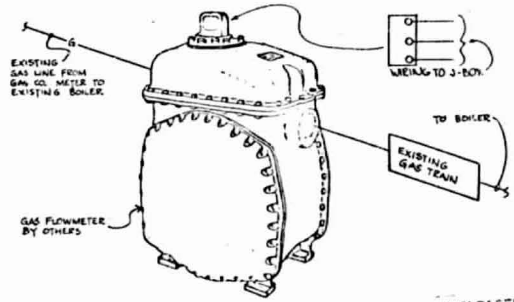
WATT TRANSDUCER
NO SCALE

FLOWMETER INSTALLATION INSTRUCTIONS

1. Flowmeters shall be preceded by a minimum of twenty (20) pipe diameters of uninterrupted flow line upstream, and followed by a mimimum of ten (10) pipe diameters of uninterrupted flow line downstream. These sections shall have no elbows, valves, thermometers or temperature sensors, or other obstructions.

2. Flowmeters shall be located in the horizontal position.

3. All flowmeters shall be identified with a brass tag.



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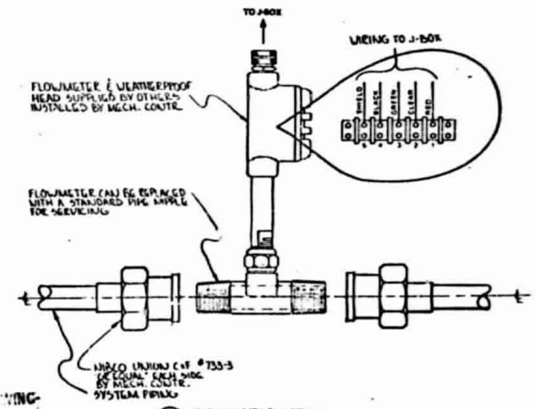

(5) FLOWMETER DETAIL
NO SCALE

UNRELE... DRAWING
NO... TO
E.C.O. CONTROL

		TOLERANCES UNLESS NOTED OTHERWISE	DRAFTSMAN Donat... 5/20/77	HONEYWELL INC.	ENERGY RESOURCES CENTER MINNEAPOLIS, MINN. 55413
		.X ± .XX ± .XXX ± / 90° FORMED ANGLES ±2° ±1°	CHECKER	SOLAR HEATING SYSTEM - S.F.R. SITE DATA ACQUISITION SUBSYSTEM	
		MATERIAL	DEV ENGR		
			ENGRG MGT ... 6/3/77		
			CONTRACT NO.		
			WILLIAM O'BRIEN	SIZE C / CODE IDENT NO. 55513	DRAWING NO. SK-142055
NEXT ASSY	USED ON			SCALE NONE	SHEET 3 OF 3
APPLICATION		FINISH-SEE NOTE			

CONTROL A

APPENDIX I

ELECTRICAL SUBSYSTEM

DRAWING NO. SK 142056

PART NO.

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

SOLAR HEATING SYSTEM - SINGLE FAMILY RESIDENCE
ELECTRICAL SUBSYSTEM

1.0 GENERAL CONDITIONS

1.1 Scope: The Electrical Subsystem will involve all field electrical wiring necessary to complete the solar heating system and make it ready for operation.

1.2 **Required Work:** The Electrical Contractor shall provide a separate 120V single phase circuit of size indicated (minimum) to each of the following:

a.) Transport Module: 15 amp

b.) Furnace: 10 amp

Each of the above circuits shall serve only that particular load. Each circuit shall have a circuit breaker or fuse at the main electrical panel and a separate disconnect switch at unit if required by code.

2.0 BASIC MATERIALS AND METHODS

2.1 **Basic Materials:** All materials shall be supplied by the Electrical Contractor. All materials shall be as specified by the Architect and required by all applicable codes.

2.2 Basic Methods: All work shall conform with all applicable codes.

UNRELEASED DRAWING NOT SUBJECT TO E.C.O. CONTROL

TOLERANCES UNLESS NOTED OTHERWISE: .X ± / .XX ± / .XXX ± ; ANGLES ±°	DRAFTSMAN: Donahue 6/3	HONEYWELL INC.	ENERGY RESOURCES CENTER MINNEAPOLIS, MINN. 55413
MATERIAL	CHECKER: 1977	SOLAR HEATING SYSTEM S.F.R. ELECTRICAL SUBSYSTEM	
	DEV ENG: 6/30/77		
	ENGRG MGT: 6/ /77		
	CONTRACT NO. WILLIAM O'BRIEN	SIZE C / CODE IDENT NO. 55513	DRAWING NO. SK-142056
FINISH--SEE NOTE		SCALE	SHEET 1 OF 1

NEXT ASSY	USED ON
APPLICATION	

CONTROL A

APPENDIX J

RESIDENTIAL SOLAR HEATING SYSTEM INSTALLATION

FILE NO. P 049.14.24

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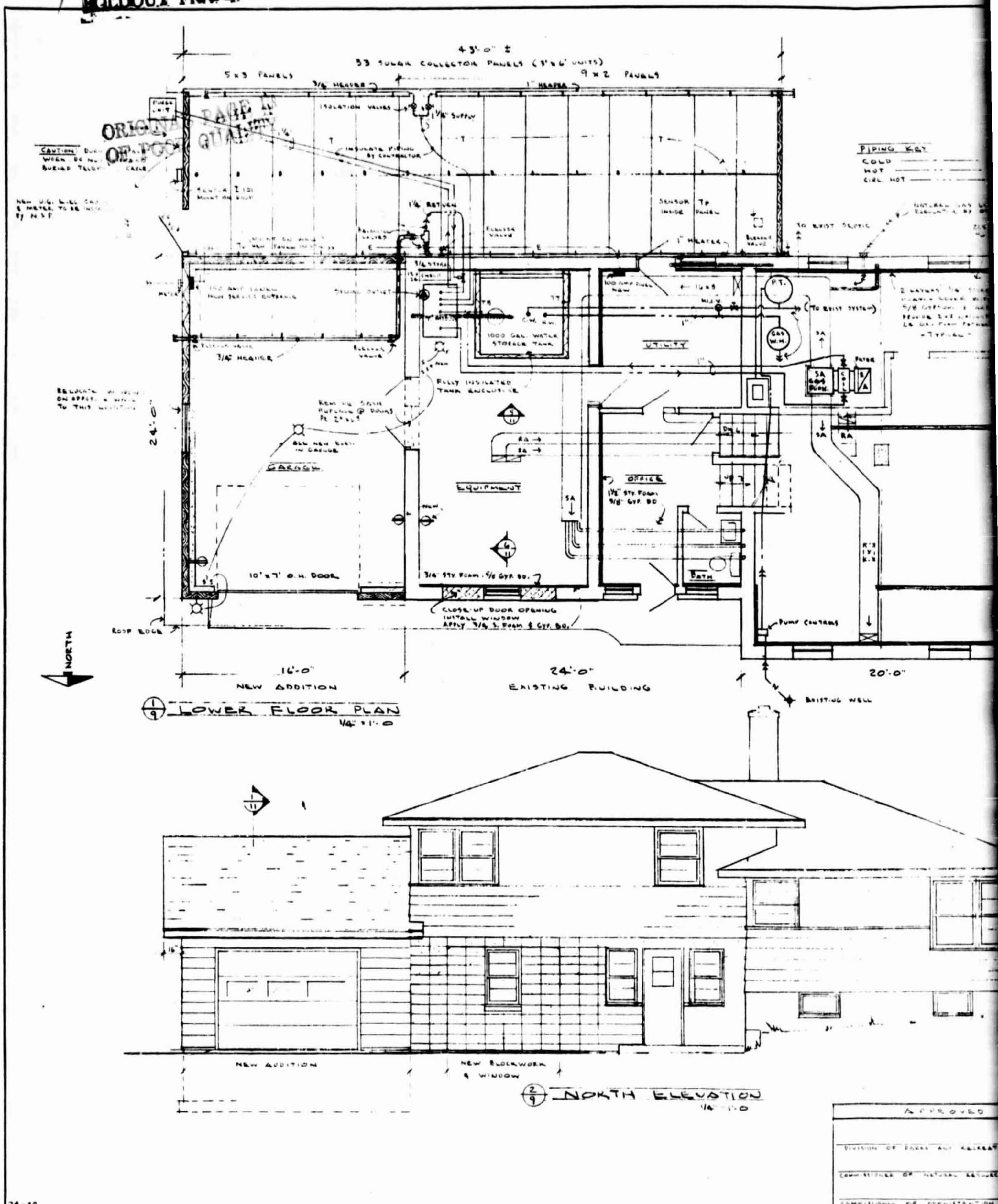

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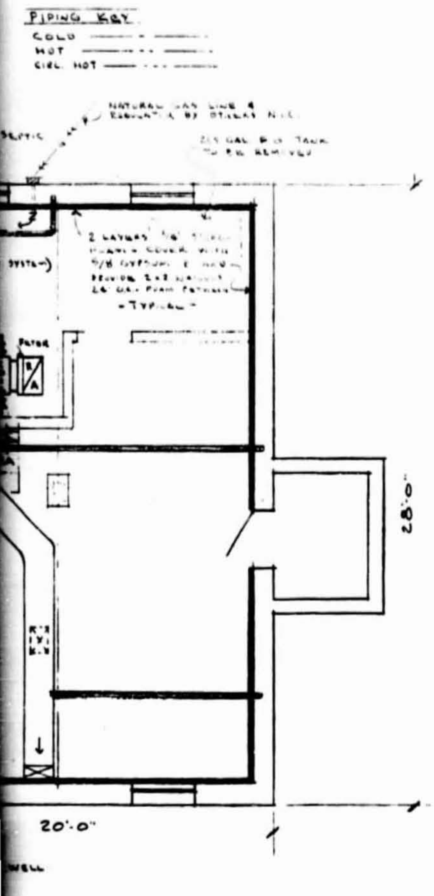
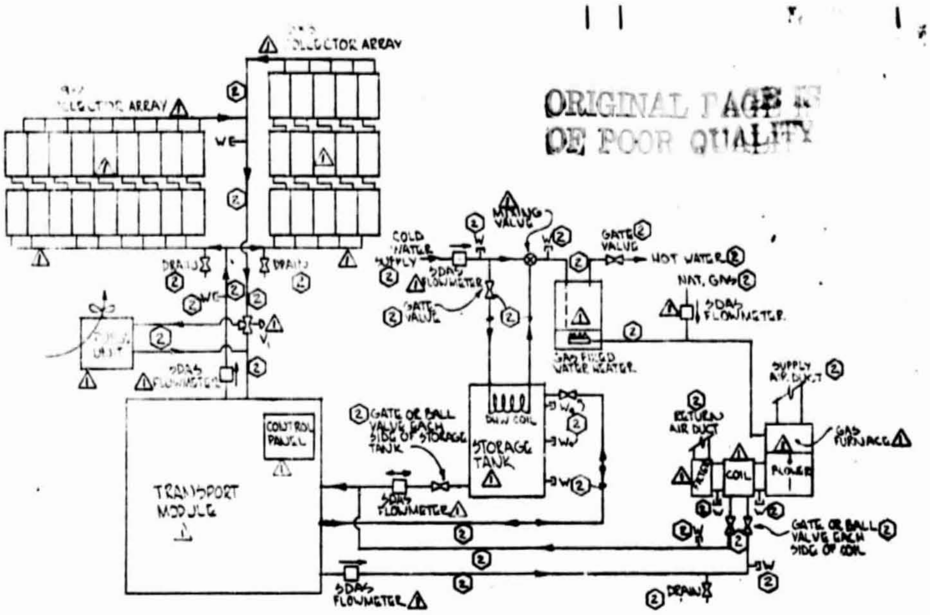
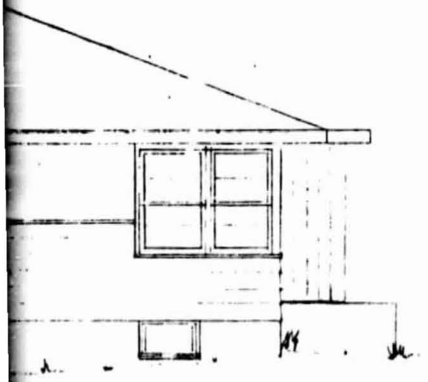
FOLDOUT FRAME

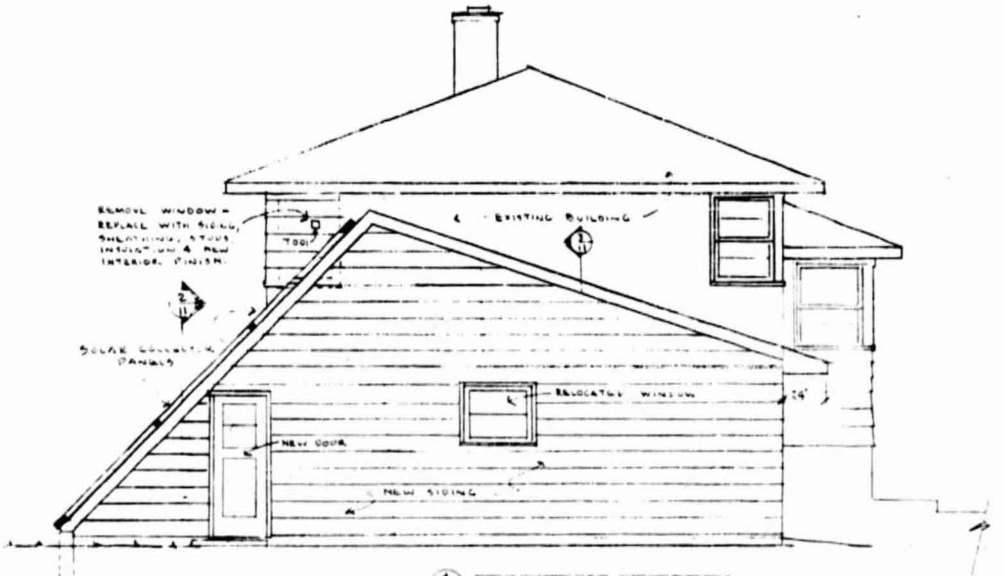




3/9 SFR - HEATING SYSTEM SCHEMATIC
NO SCALE

KEY:
△ FURNISHED BY OTHERS AND INSTALLED BY THIS CONTRACT.
② FURNISHED AND INSTALLED UNDER THIS CONTRACT.





4/9 EAST ELEVATION
1/4" = 1'-0"

JUN 30 1977

APPROVED	
DIVISION OF PARKS AND RECREATION	DATE
COMMISSIONER OF NATURAL RESOURCES	DATE
COMMISSIONER OF ADMINISTRATION	DATE

No.	Date	Revision	By	Chkd.	Appr.
Reference Drawings	P049.14.24 - SH 1-8 N.I.C. - SH. NOS. 10 THRU 17				

MINNESOTA DEPARTMENT OF NATURAL RESOURCES
BUREAU OF ENGINEERING
DIVISION OF PARKS AND RECREATION
PLAN - ELEVATIONS - SCHEMATIC
RESIDENTIAL SOLAR HEATING SYSTEM INSTALLATION
WM. O'BRIEN STATE PARK
WASHINGTON CO.

Designed 6-77 JWN | Drawn 5-24-77 | Checked 6-77
Date 6-30-77 Administrator (signature)
Sec. 31 | T. 32 | R. 19 W
Dept. Code 325845 | Reg. 77-70 | Sheet 9 | File P049.14.24

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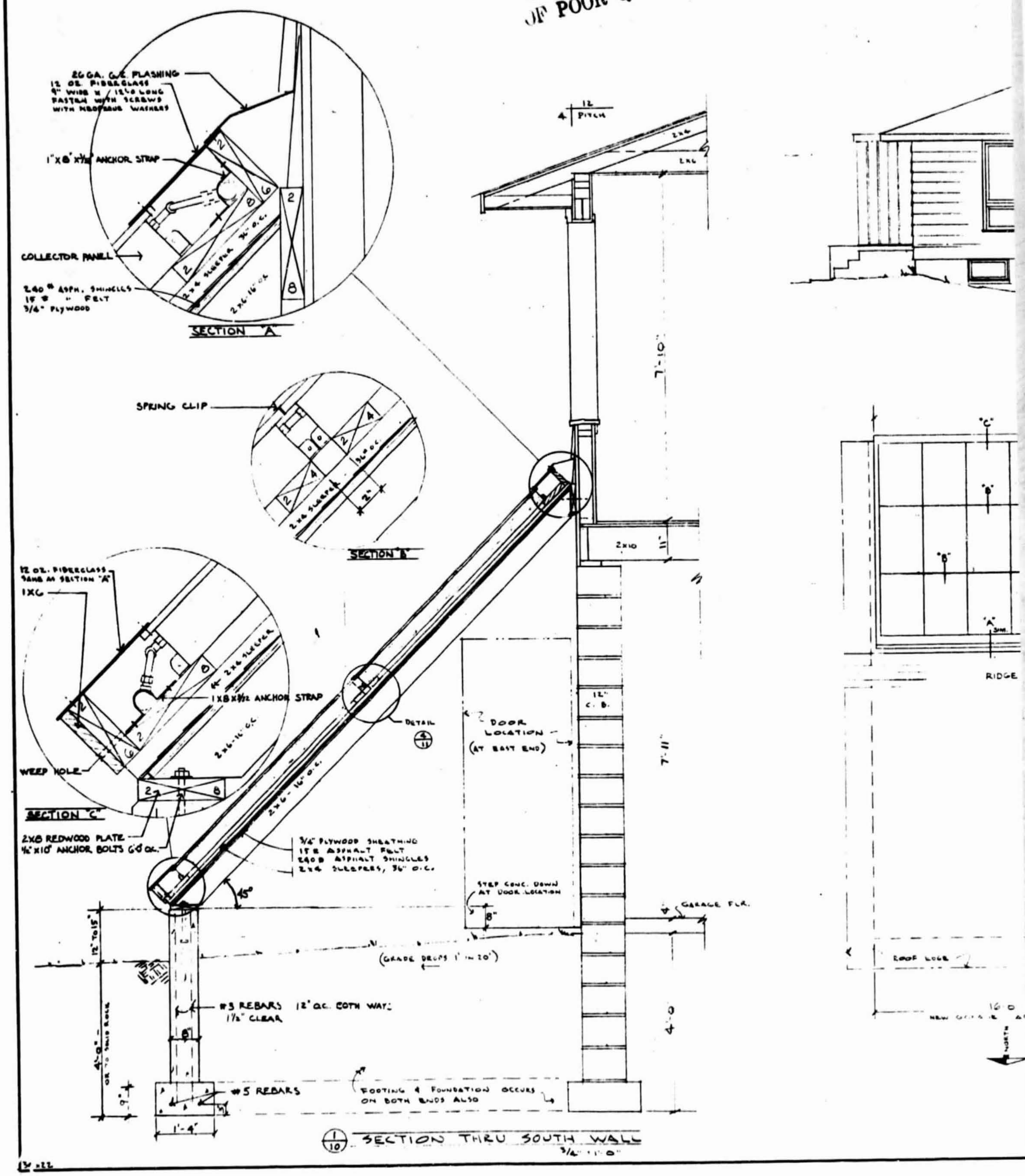

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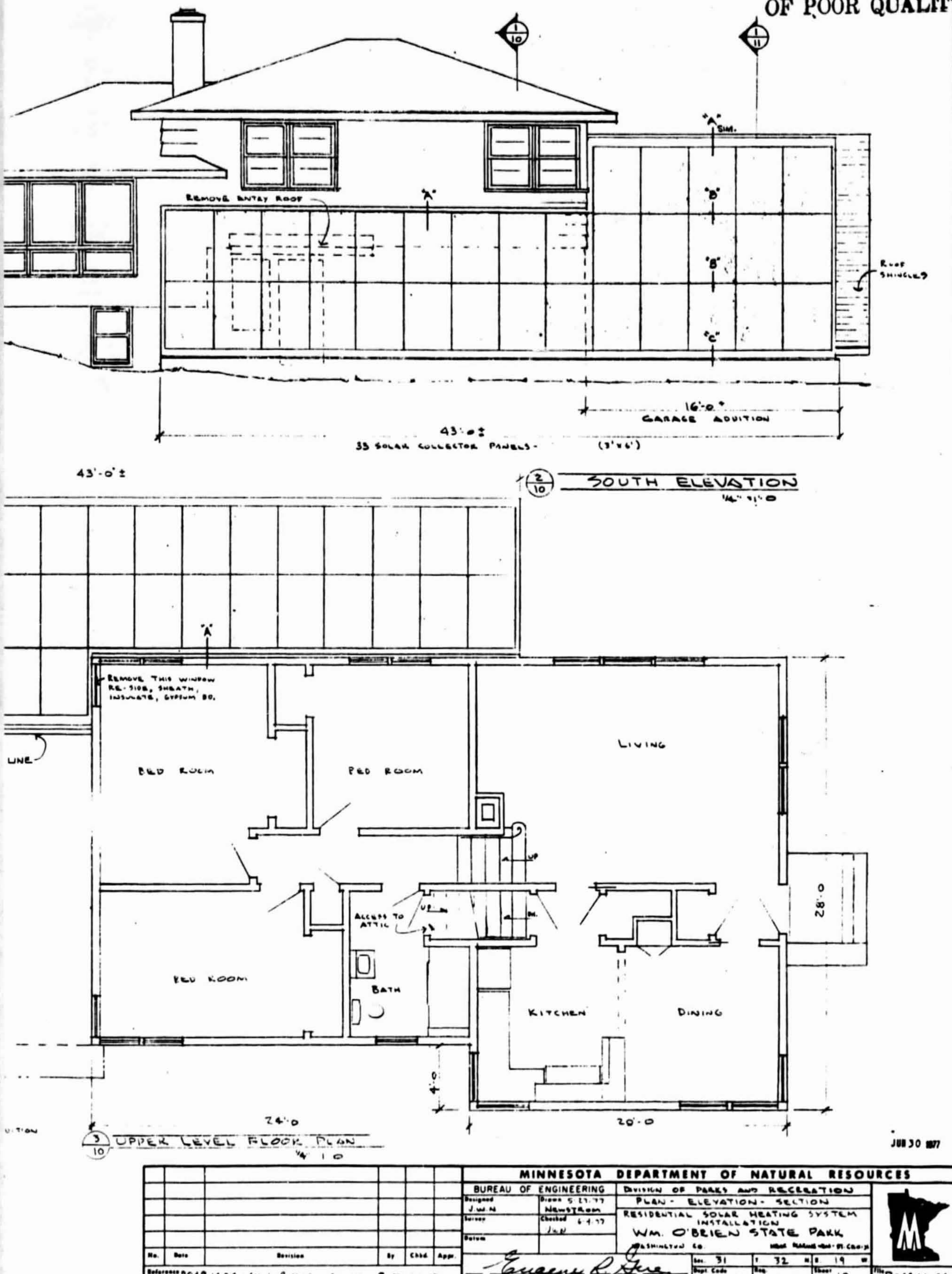

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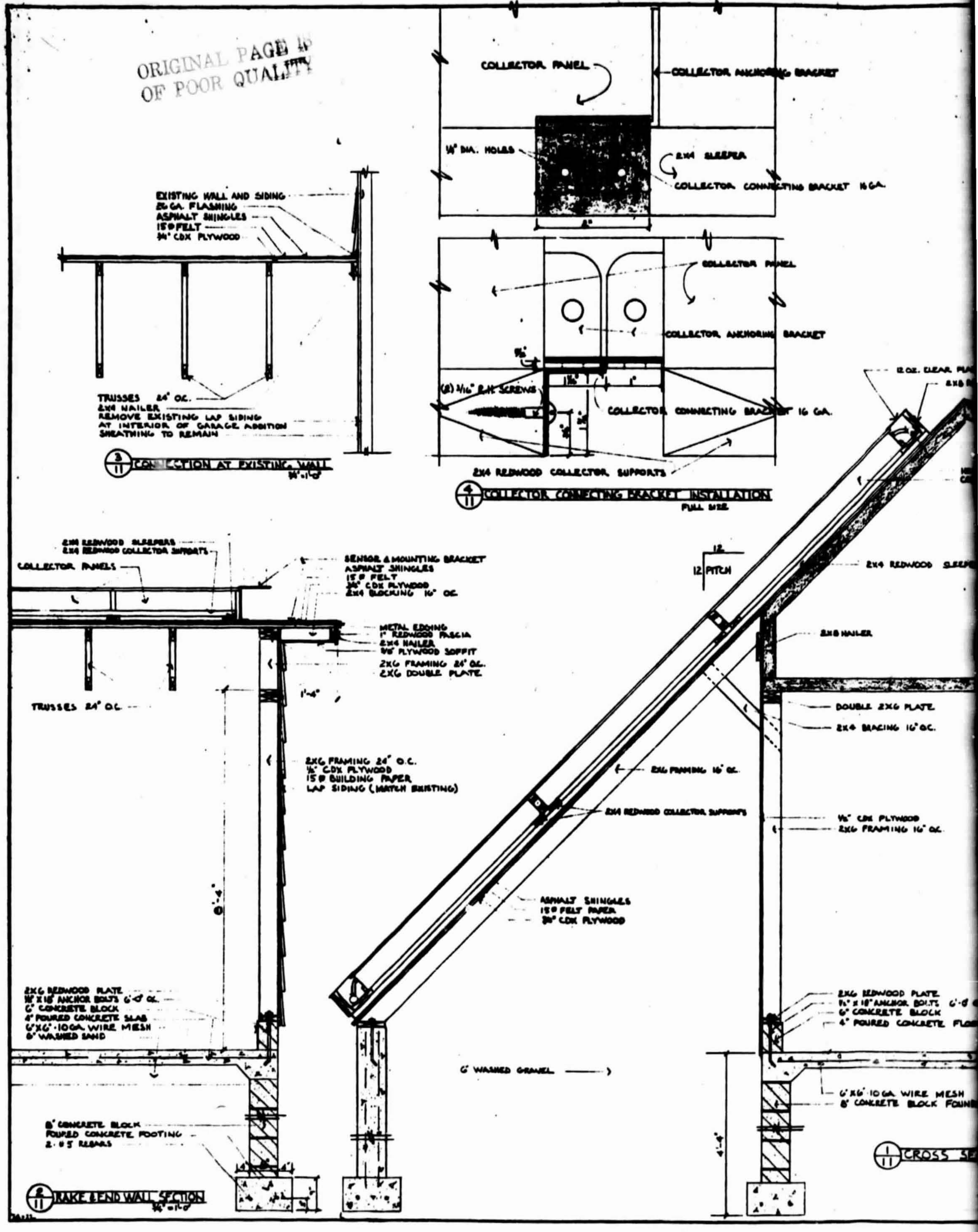

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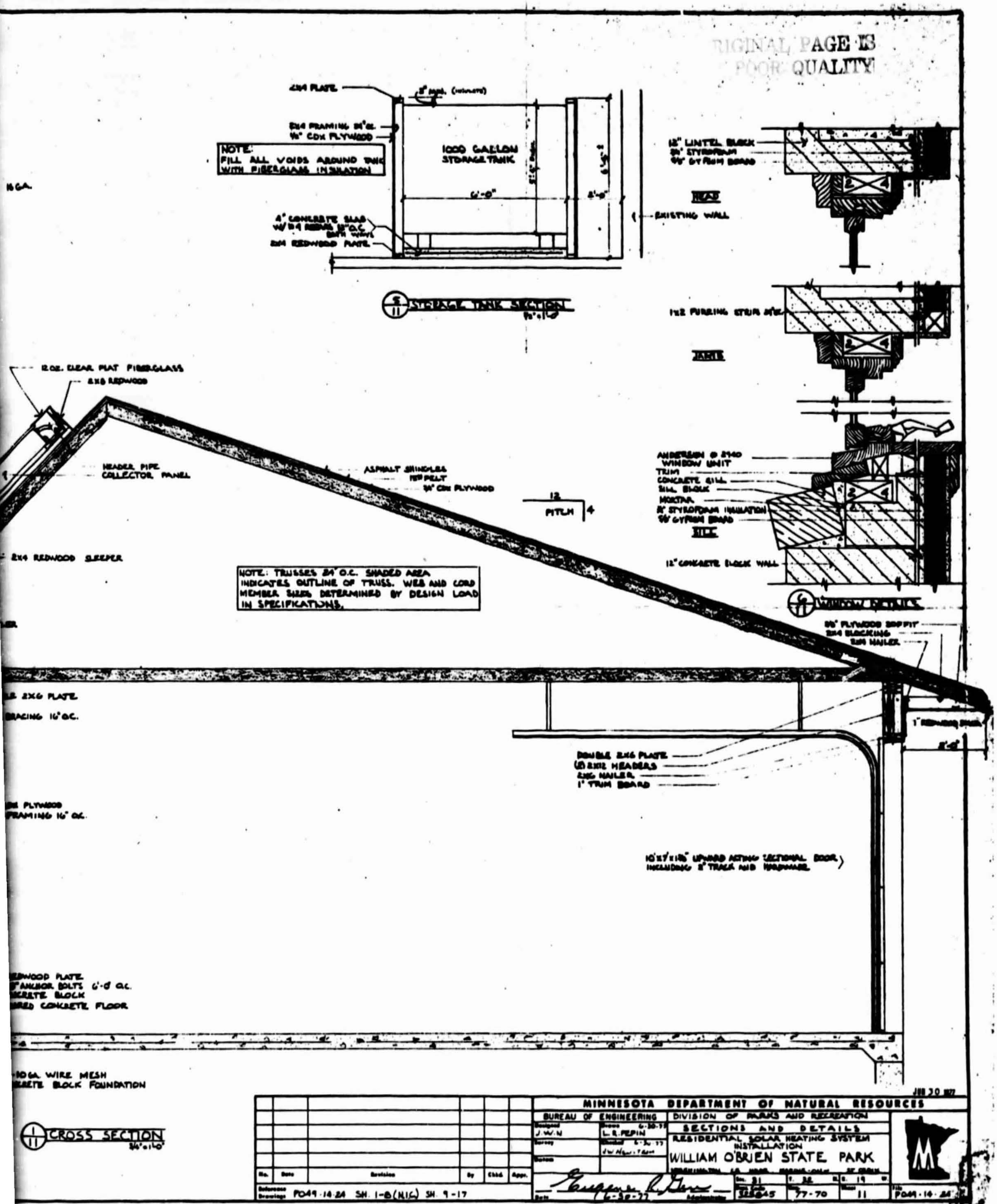

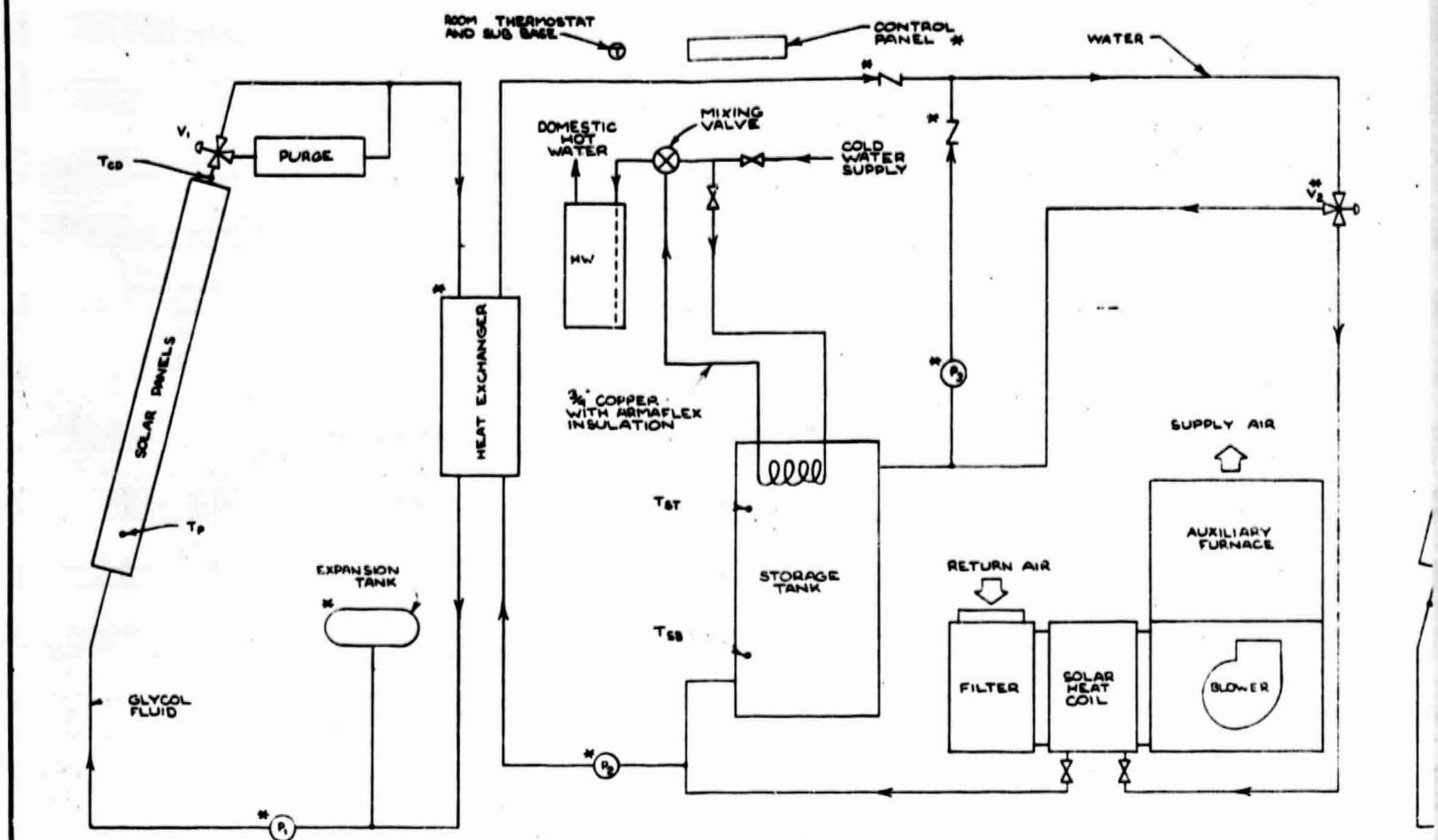

SOLAR HEATING SYSTEM CONTROL SCHEMATIC

NO SCALE

* THESE COMPONENTS ARE INCLUDED IN THE TRANSPORT MODULE.

(P) PUMPS

MATERIAL LIST				
ITEM	QUAN.	DESCRIPTION	HONEYWELL MODEL NO.	OTHER MFG. NO.
	1	CONTROL PANEL	W968A1009	
T_{ST}	1	AQUASTAT	L6008C1065	
T_{CD}	1	AQUASTAT	L4008B1013	
T	1	2-STAGE THERMOSTAT	T872C1004	
	1	SUB BASE	Q672B1004	
V_1	1	MOTORIZED VALVE	V4331A1003	
V_2	1	MOTORIZED VALVE	V4044A1191	
	1	COLLECTOR SENSOR CLIP WIRE	137096	
	1	COLLECTOR SENSOR SHIELD	—	
	1	MIXING VALVE		WATTS REGULATOR COMPANY # 70A - 3/4"
HW	1	HOT WATER HEATER		LOCHINVAR #40GK3TC

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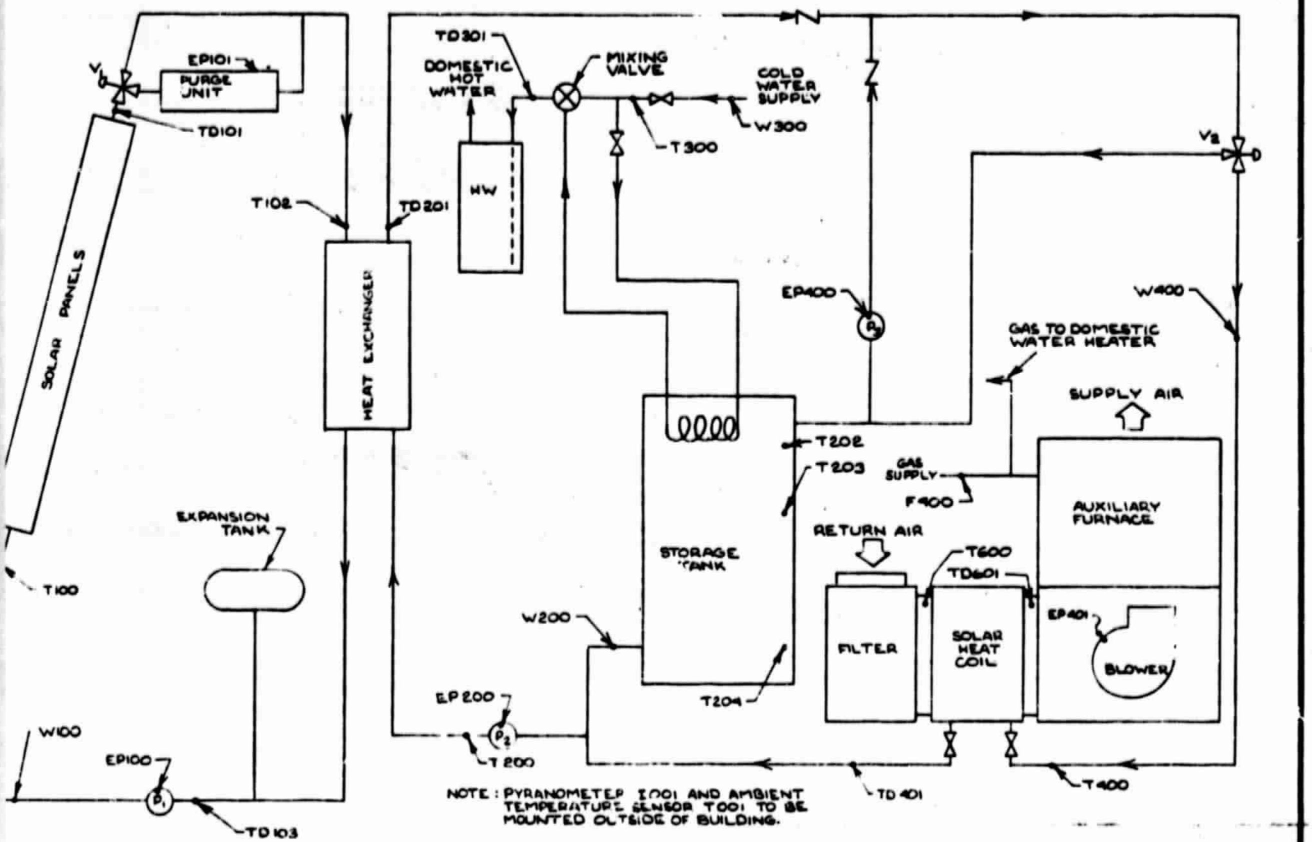
34x16



SITE DATA ACQUISITION SUBSYSTEM SCHEMATIC

NO SCALE

SITE DATA ACQUISITION SUBSYSTEM

MATERIAL LIST

Site Data Aquisition Subsystem Module
Junction Box
Instrumentation Sensors as follows:

Sensor	Function	Detail
I001	Total Radiation	1
T001	Outdoor Ambient DB Temperature	3
T100	Collector Inlet Temperature	10
TD101	Collector Differential Temperature	9
T102	HX Solar Inlet Temperature	10
TD103	HX Solar Differential Temperature	9
T200	HX Hot Water Inlet Temperature	10
TD201	HX Hot Water Differential Temperature	9
T202	Storage Tank Temperature - Top	8
T203	Storage Tank Temperature - Middle	8
T204	Storage Tank Temperature - Bottom	8
T300	Domestic Cold Water Temperature	10
TD301	Solar DHW Preheat Differential Temperature	9
T400	Heating Coil HW Inlet Temperature	10
TD401	Heating Coil HW Differential Temperature	9
T600	Heating Coil Air Inlet Temperature	7
TD601	Heating Coil Air Differential Temperature	6
W100	Collector Flow Rate	5
W200	Storage Flow Rate	5
W300	DHW Flow Rate	5
W400	Heating Coil Flow Rate	5
EP100	Collector Pump Power	2
EP101	Heat Rejector Fan Power	2
EP200	Storage Pump Power	2
EP400	Heating Pump Power	2
EP401	Furnace Fan Power	2
F400	Natural Gas Auxiliary Energy	4

JUN 30 1977

No.	Date	Revision	By	Chkd	Appr

Reference Drawings

MINNESOTA DEPARTMENT OF NATURAL RESOURCES
BUREAU OF ENGINEERING
DIVISION OF PARKS AND RECREATION
PIPING AND CONTROL SCHEMATICS
RESIDENTIAL SOLAR HEATING SYSTEM INSTALLATION
WILLIAM OBRIEN STATE PARK
WASHINGTON CO. - NEAR MARINE ON ST. CROIX

Designed
Drawn 6-7-77 S.J. OGORMAN
Survey
Checked 6-10-77 H.F. KOEGLER
Datum

Date 6-30-77 — Administrator

Sec. 31 T. 32 R. 19 W.
Dept. Code 325845
Year 77-70
Sheet 12
File P049.14 24

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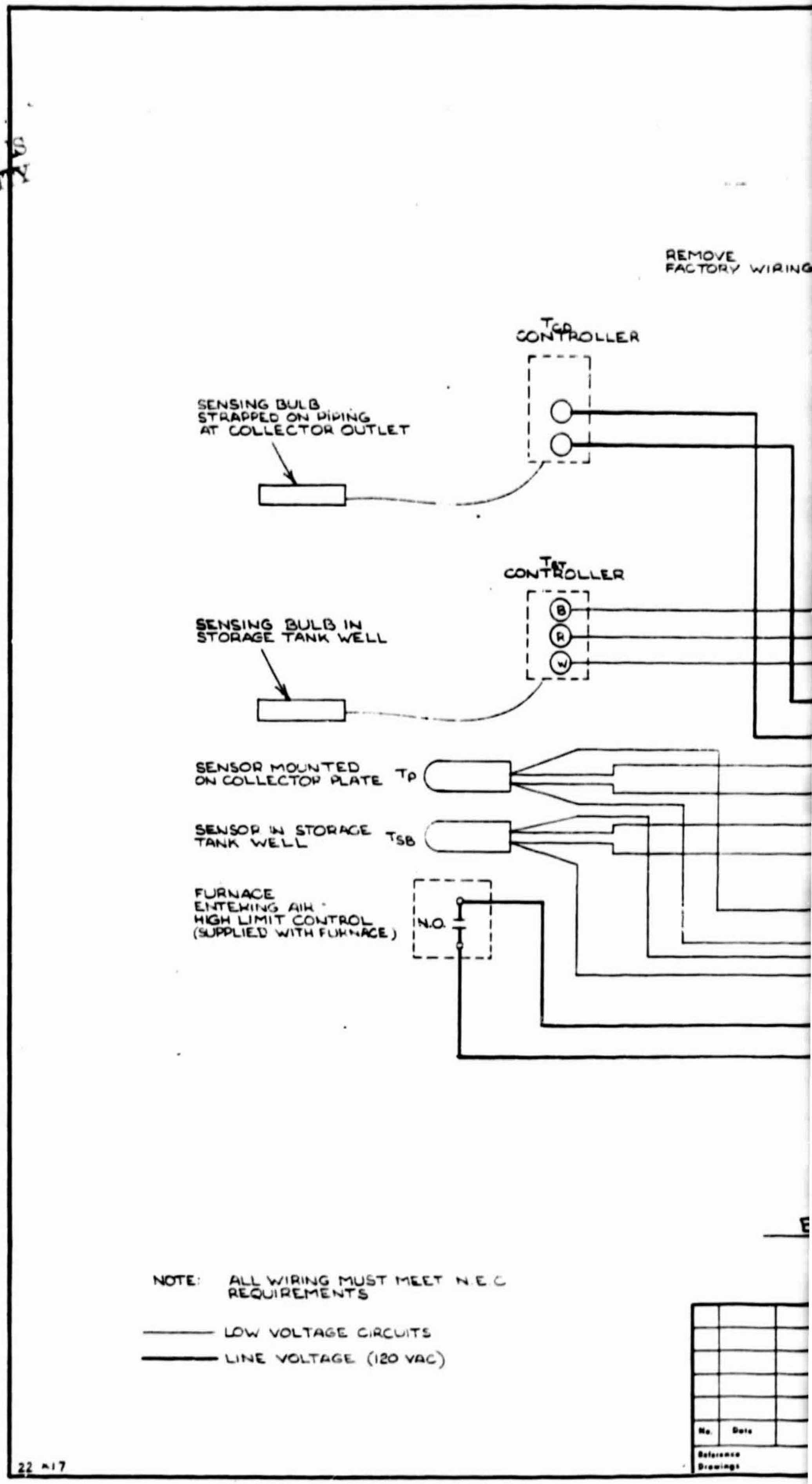
REMOVE
FACTORY WIRING
T_{CP} CONTROLLER
SENSING BULB
STRAPPED ON PIPING
AT COLLECTOR OUTLET
T_{ST} CONTROLLER
B
R
W
SENSING BULB IN
STORAGE TANK WELL
SENSOR MOUNTED
ON COLLECTOR PLATE
TP
SENSOR IN STORAGE
TANK WELL
TSB
FURNACE
ENTERING AIR
HIGH LIMIT CONTROL
(SUPPLIED WITH FURNACE)
N.O.
NOTE: ALL WIRING MUST MEET N.E.C
REQUIREMENTS
LOW VOLTAGE CIRCUITS
LINE VOLTAGE (120 VAC)
No.
Date
Reference
Drawings
22 417

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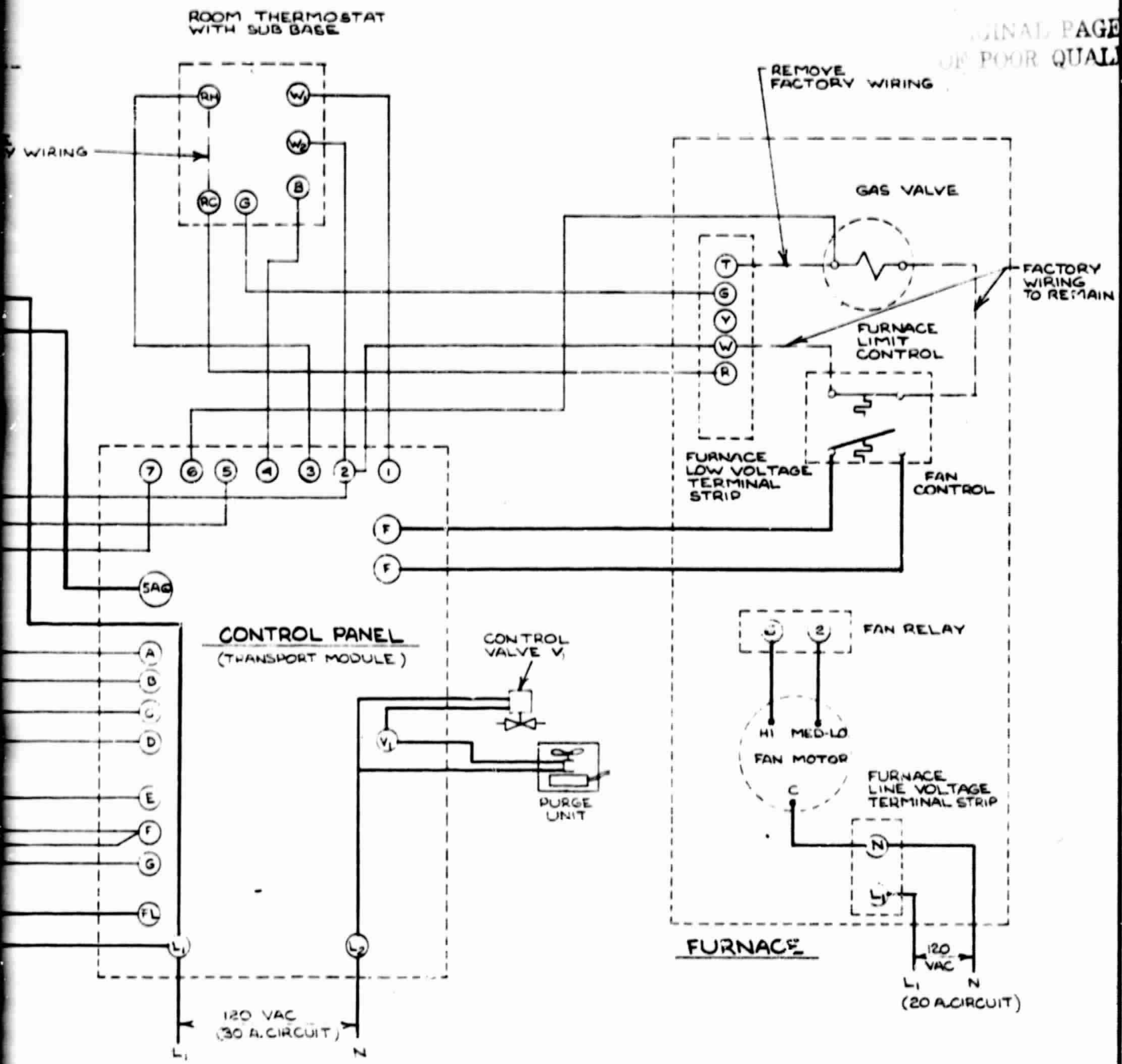


ELECTRIC CONNECTING SCHEMATIC

JUN 30 1977

Date	Revision	By	Chkd.	Appr.

MINNESOTA DEPARTMENT OF NATURAL RESOURCES

BUREAU OF ENGINEERING

DIVISION OF PARKS AND RECREATION

Designed — Drawn 6-8-77 S. J. O'GORMAN

Survey — Checked 6-10-77 H. F. KOEGLER

Datum

ELECTRIC CONNECTING SCHEMATIC

RESIDENTIAL SOLAR HEATING SYSTEM INSTALLATION

WILLIAM O'BRIEN STATE PARK

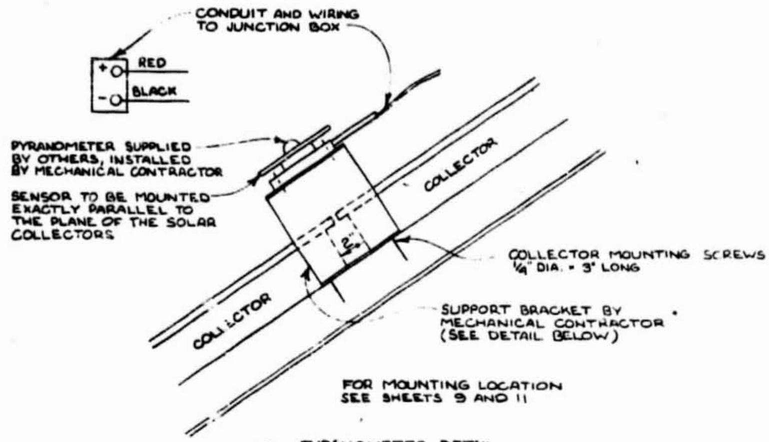
WASHINGTON CO. - NEAR MARINE ON ST. CROIX

Eugene R. Gere (signature) — Date 6-30-77 — Administrator

Sec. 31 | T. 32 N | R. 19 W

Dept Code 325845 | Reg. 77-70 | Sheet 13 | File P.049.14.24

J-5



① PYRANOMETER DETAIL
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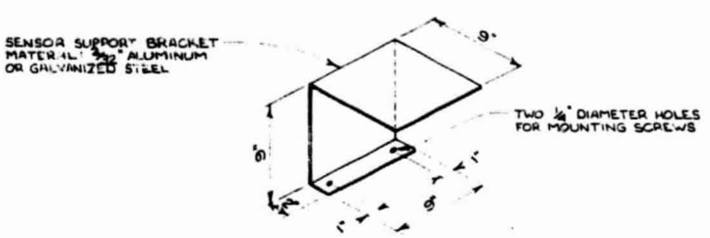

SUPPORT BRACKET DETAIL
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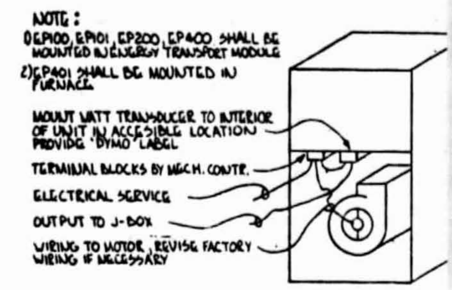

INSTALLATION
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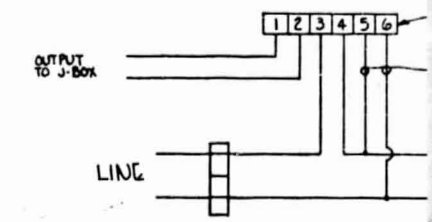
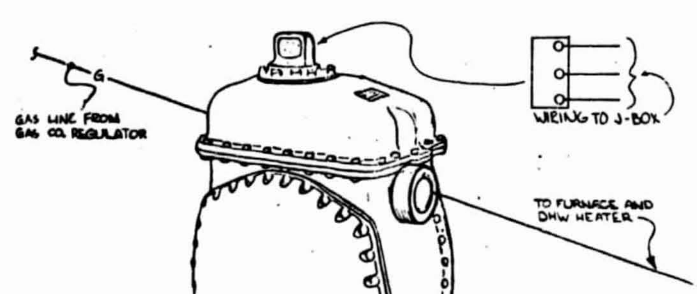


WIRING DIAGRAM

② WATT TRANSDUCER
NO SCALE



④ GAS METER DETAIL
NO SCALE

⑤ FLOWMETER DETA
NO SCALE

34 × 22

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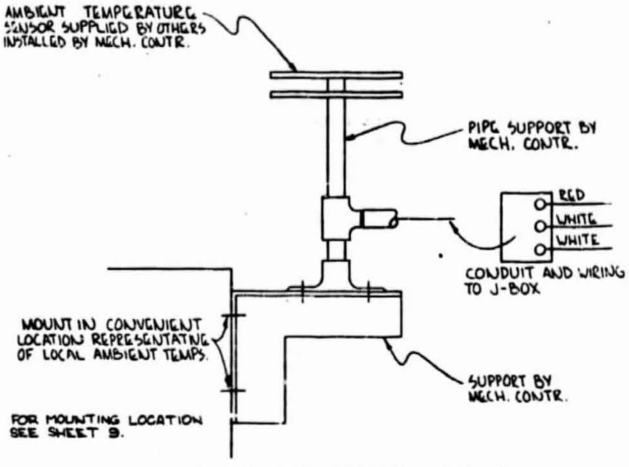

(3) AMBIENT TEMPERATURE SENSOR
NO SCALE

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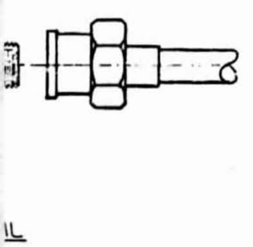

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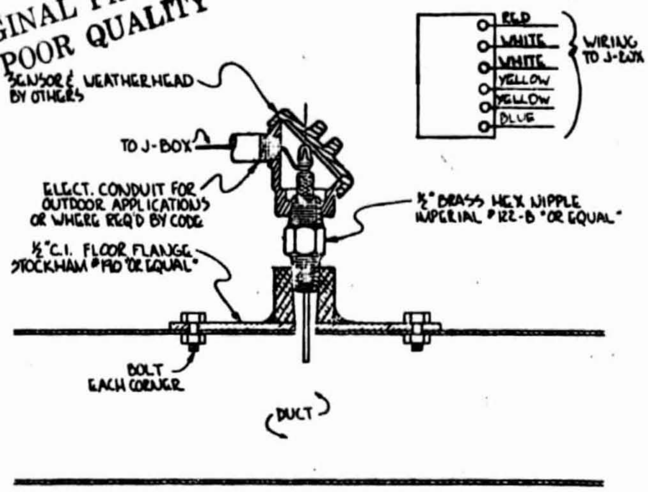
JUN 30 1977

MINNESOTA DEPARTMENT OF NATURAL RESOURCES
BUREAU OF ENGINEERING — DIVISION OF PARKS AND RECREATION
Designed — Drawn 6-27-77 S.J. O'GORMAN — S.D.A.S. SENSOR MOUNTING DETAILS
Survey — Checked 6-27-77 H.F. KOEGLER — RESIDENTIAL SOLAR HEATING SYSTEM INSTALLATION
Datum — WILLIAM OBRIEN STATE PARK
WASHINGTON CO. - NEAR MARINE ON ST. CROIX
Sec. 31 | T. 32 N. | R. 19 W.
Dept Code 325845 | Reg. 77-70 | Sheet 14 | File P049.14.24
Date 6-30-77 — Eugene R. Gere — Administrator

No.	Date	Revision	By	Chkd.	Appr.

Reference Drawings



⑥ DUAL ELEMENT TEMPERATURE SENSOR
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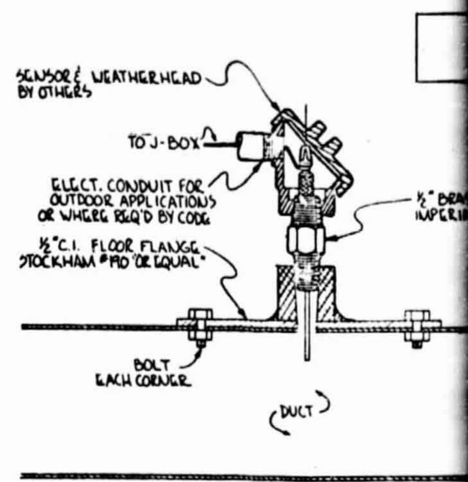

⑦ SINGLE ELEMENT TEMPERATURE SENSOR
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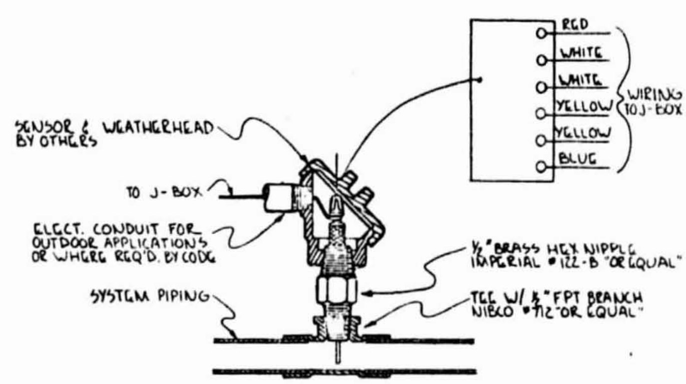
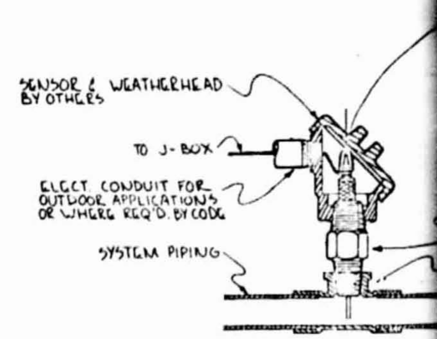


⑨ DUAL ELEMENT TEMPERATURE SENSOR
NO SCALE



⑩ SINGLE ELEME
TEMPERATURE SEN
NO SCALE

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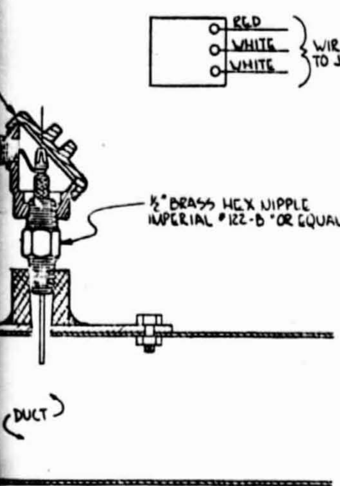
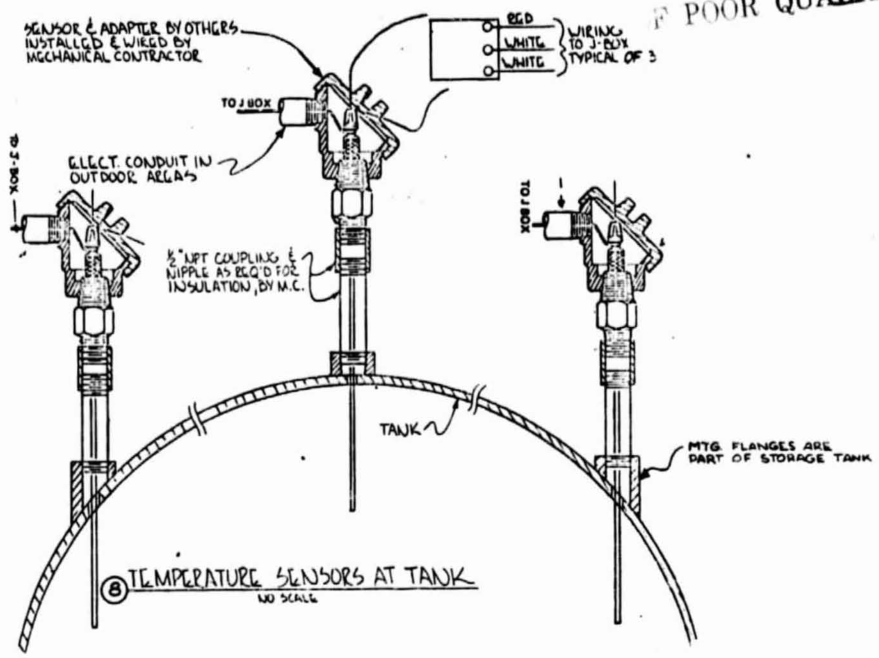
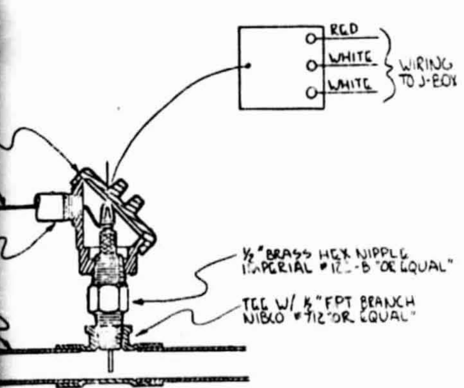


...E ELEMENT ...RATURE SENSOR
NO SCALE



(8) TEMPERATURE SENSORS AT TANK
NO SCALE



(10) SINGLE ELEMENT TEMPERATURE SENSOR
NO SCALE

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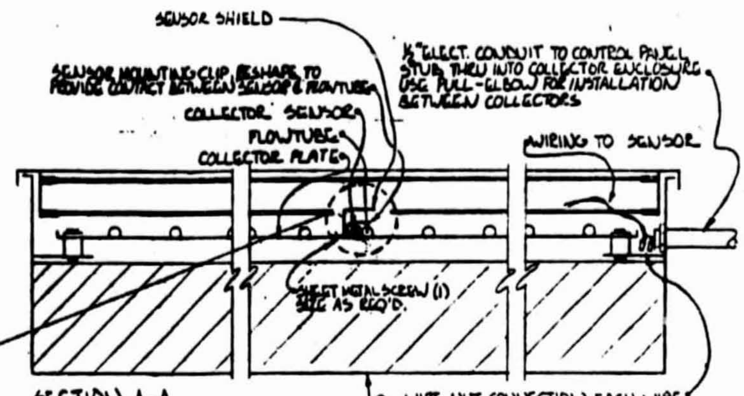
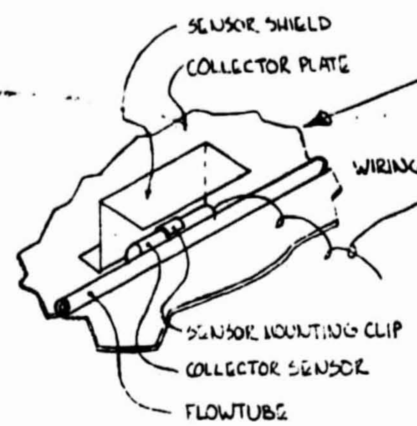
JUN 30 1977

MINNESOTA DEPARTMENT OF NATURAL RESOURCES
BUREAU OF ENGINEERING
DIVISION OF PARKS AND RECREATION
SDAS SENSOR MOUNTING DETAILS
RESIDENTIAL SOLAR HEATING SYSTEM INSTALLATION
WILLIAM OBRIEN STATE PARK
WASHINGTON CO. - NEAR MARINE ON ST. CROIX
Designed | Drawn 6-24-77 S.J. O'GORMAN
Survey | Checked 6-29-77 H.F. KOEBLER
Datum
Date 6-30-77 Administrator
Sec. 31 | T. 32 | R. 19
Dept Code 325945 | Req 77-70 | Sheet 15 | File P049 14 24
No. | Date | Revision | By | Chkd | Appr
Reference Drawings

B DOUT FRAME

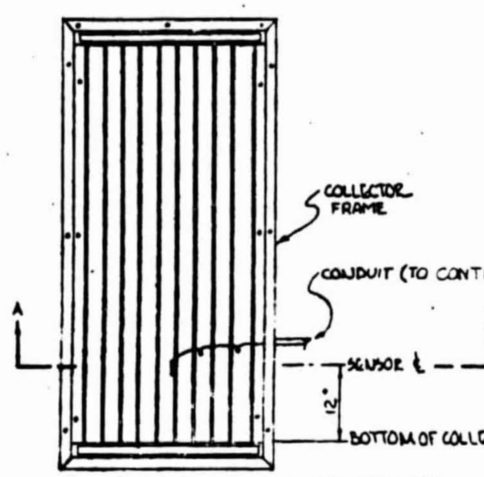


SECTION A-A
NO SCALE

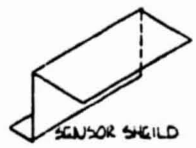


ISOMETRIC DETAIL
NO SCALE

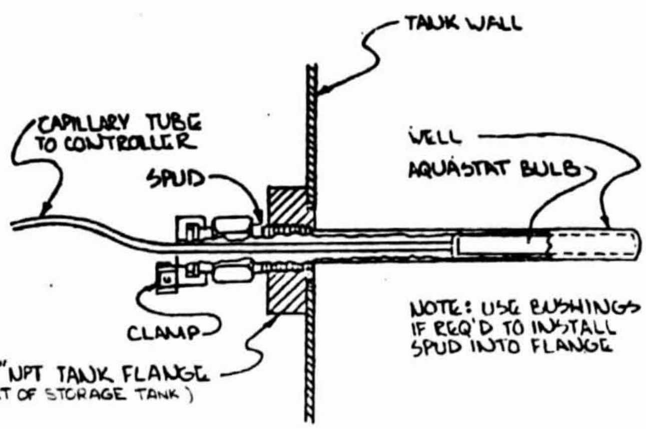
FOR MOUNTNG LOCATION SEE SHEET 9



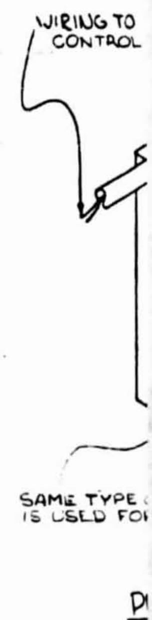
COLLECTOR PLATE SENSOR (T_P) DETAIL (TOP VIEW)
NO SCALE



DETAIL X
NO SCALE



STORAGE TANK AQUASTAT MOUNTING DETAIL - (T_{ST})
INDOOR INSTALLATION
NO SCALE



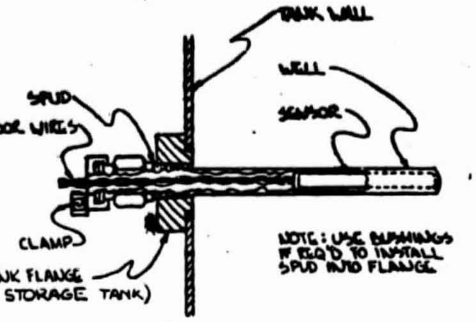
No	Date	Revision	By	Chkd	Appr

Reference Drawings

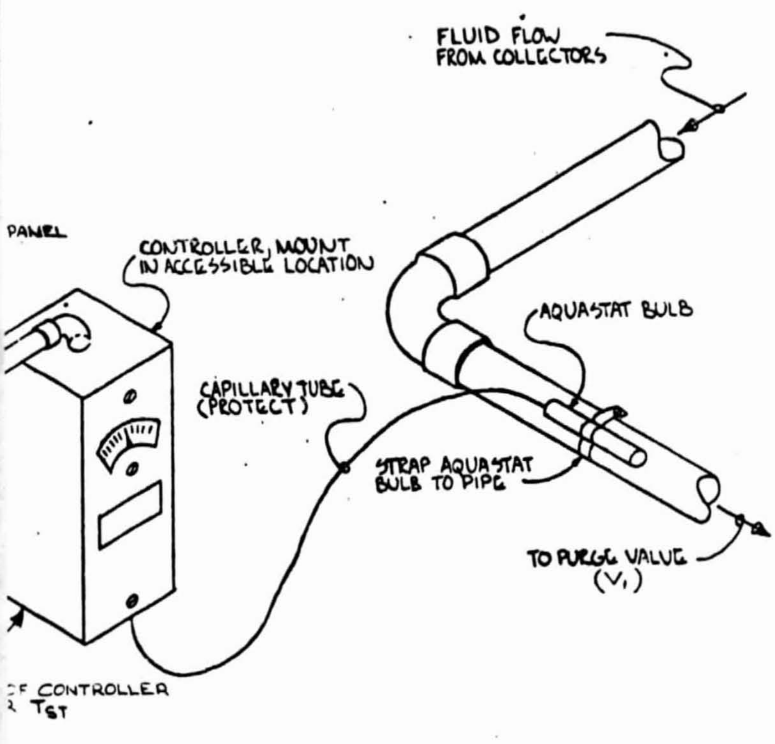
BURI
Designed
Survey
Datum
Date

22 x 17

2 FOLDOUT FRAME



STORAGE TANK SENSOR MOUNTING DETAIL - (T_{SB})
INDOOR INSTALLATION
NO SCALE



URGE VALVE AQUASTAT MOUNTING DETAIL - (T_{CD})

JUN 30 1977

MINNESOTA DEPARTMENT OF NATURAL RESOURCES				
EAU OF ENGINEERING	DIVISION OF PARKS AND RECREATION			
Drawn	CONTROL SENSOR MOUNTING DETAILS			
Checked	RESIDENTIAL SOLAR HEATING SYSTEM INSTALLATION			
	WILLIAM OBRIEN STATE PARK			
Administrator	Sec. 31	T. 32	R. 19 W	
	Dept Code	Req.	Sheet 16	File P049.14 24

J-8