

348
10-23-78
DR. 634
Send to M115 (25 Aug)

DOE/NASA CONTRACTOR REPORT

MASTER

DOE/NASA CR-150786

SOLAR HEATING AND COOLING SYSTEMS DESIGN AND DEVELOPMENT
(Quarterly Report)

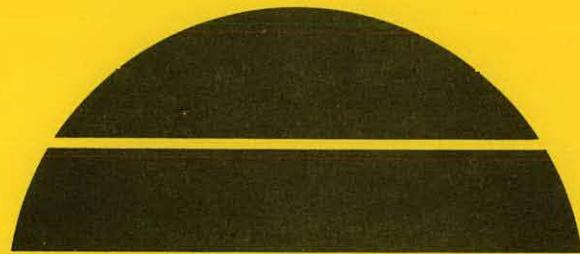
Prepared from documents furnished by

Honeywell - Energy Resource Center
2600 Ridgway Parkway
Minneapolis, Minnesota 55413

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

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

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

DISCLAIMER

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

NOTICE

This report was prepared to document work sponsored by the United States Government. Neither the United States nor its agents the United States Department of Energy, the United States National Aeronautics and Space Administration, nor any federal employees, nor any of their contractors, subcontractors or their employees, make any warranty, express or implied, or assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product or process disclosed, or represent that its use would not infringe privately owned rights.

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. DOE/NASA CR-150786	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.	
4. TITLE AND SUBTITLE Solar Heating and Cooling Systems Design and Development Quarterly Report		5. REPORT DATE July 1978	
7. AUTHOR(S)		6. PERFORMING ORGANIZATION CODE	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Honeywell - Energy Resource Center 2600 Ridgway Parkway Minneapolis, Minnesota 55413		8. PERFORMING ORGANIZATION REPORT #	
12. SPONSORING AGENCY NAME AND ADDRESS National Aeronautics and Space Administration Washington, D. C. 20546		10. WORK UNIT NO.	
		11. CONTRACT OR GRANT NO. NAS8-32093	
		13. TYPE OF REPORT & PERIOD COVERED Contractor Report 1 Apr 78 - 30 Jun 78	
15. SUPPLEMENTARY NOTES This work was done under the technical management of Al Krupnick, George C. Marshall Space Flight Center, Alabama.			
16. ABSTRACT Honeywell was awarded Contract NAS8-32093 by the George C. Marshall Space Flight Center (MSFC) effective 9 July 1976.			
The program calls for the development and delivery of eight (was 12) prototype solar heating and cooling systems for installation and operational test. Two (was 6) heating and six heating and cooling units will be delivered for single-family residences (SFR), multiple-family residences (MFR) and commercial applications.			
Lennox Industries, Marshalltown, Iowa, and Barber-Nichols Engineering Company, Arvada, Colorado, are supporting Honeywell in subcontractor roles.			
This document describes the progress of the program during the eighth program quarter, 1 April 1978 to 30 June 1978.			
17. KEY WORDS	18. DISTRIBUTION STATEMENT Unclassified-Unlimited  WILLIAM A. BROOKSBANK, JR. Mgr, Solar Heating and Cooling Project Office	UC-59c	
19. SECURITY CLASSIF. (of this report) Unclassified	20. SECURITY CLASSIF. (of this page) Unclassified	21. NO. OF PAGES 21	22. PRICE NTIS

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

TABLE OF CONTENTS

	<u>Page</u>
SECTION 1 COSTS	1-1
SECTION 2 SCHEDULES	2-1
SECTION 3 TECHNICAL STATUS	3-1
WILLIAM O'BRIEN - SFR HEATING ONLY	3-1
NEW CASTLE, PA - SFR HEATING ONLY	3-2
KANSAS UNIVERSITY - MFR HEATING AND COOLING	3-3
CARROLLTON, TX - COMMERCIAL HEATING AND COOLING	3-3
SACRAMENTO, CA - SFR HEATING AND COOLING	3-4
OCMULGEE NATIONAL MONUMENT, GEORGIA - LIGHT COMMERCIAL HEATING AND COOLING	3-4
RESIDENTIAL COOLING SUBSYSTEM	3-5
COMMERCIAL AND MULTI-FAMILY SUBSYSTEMS - 25 TON RANKINE CHILLER	3-5
SECTION 4 DATA SUBMISSIONS	4-1

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

78341

FEE

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1-1		1-2
1-2		1-3
1-3		1-4
1-4	Cost information has been deleted.	
1-5		1-5
1-5		1-6
2-1	Single-Family Residence (Heating Only) Stillwater, Minnesota (OTS #40)	2-2
2-2	Single-Family Residence (Heating Only) New Castle, Pennsylvania (OTS #39)	2-3
2-3	Kansas University Multiple-Family Residence (OTS #43)	2-4
2-4	Single-Family Residence Heating and Cooling Site -- Sacramento, CA (OTS #41)	2-5
2-5	Single-Family Residence Heating and Cooling Site, TVA (OTS #42)	2-6
2-6	Commercial Heating and Cooling (Ocmulgee) (OTS #44)	2-7
2-7	Commercial Heating and Cooling (50 Ton Lennox) (OTS #46)	2-8
2-8	Commercial Heating and Cooling (75 Ton Unidentified) (OTS #45)	2-9
4-1	Data Submissions Control Ledger	4-2

1-1

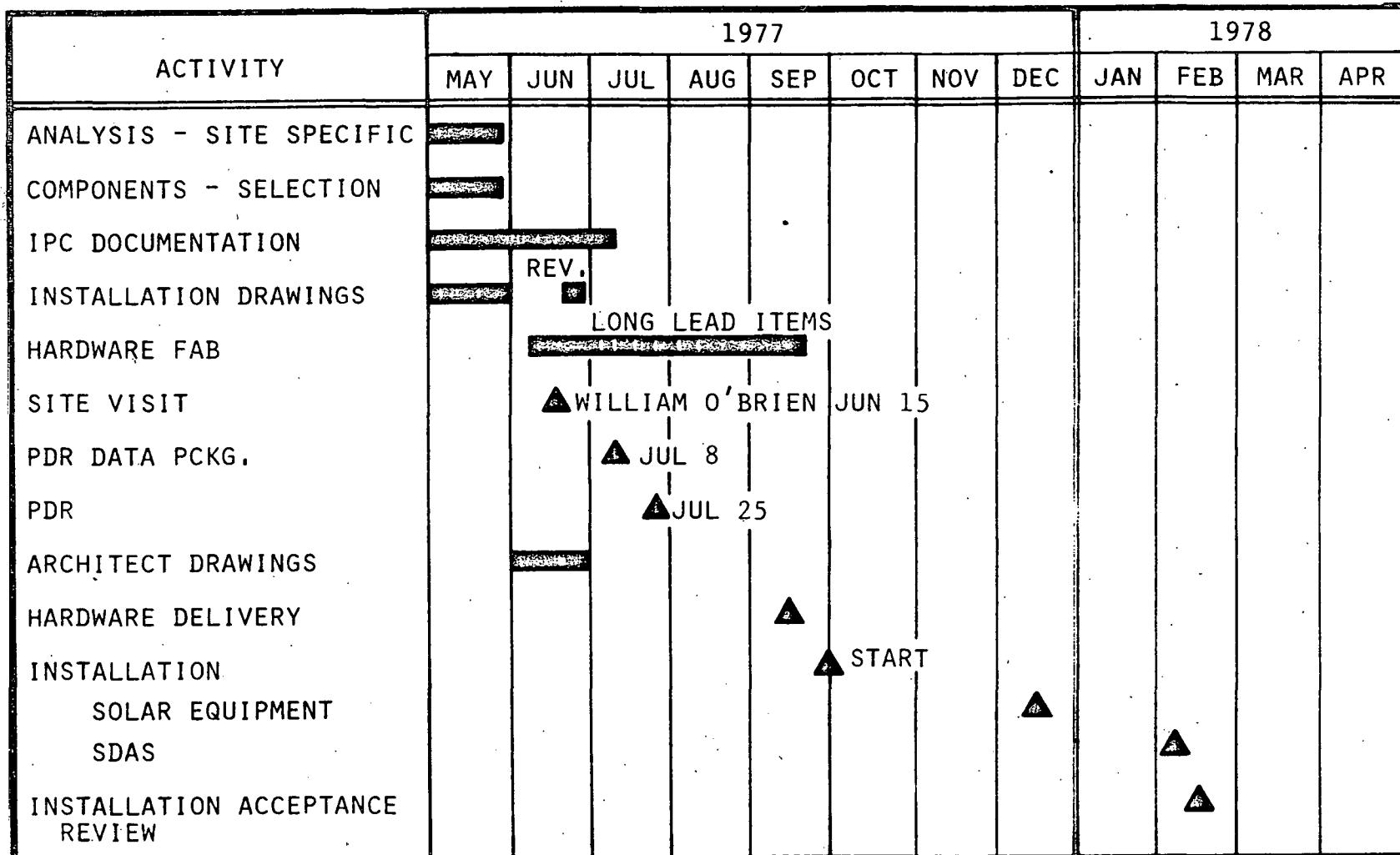
SECTION 1
COSTS

This section has been deleted.

78341

SECTION 2
SCHEDULES

Schedules for each deliverable hardware system are shown in Figures 2-1 through 2-8. Current status schedules for systems that have sites selected are depicted in Figures 2-1 through 2-4, 2-6 and 2-7. The schedules for the two unidentified sites, Figures 2-5 and 2-8 that were dependent on site selection by 1 August 1977 continue to be in a day-for-day slip. Future reports will continue to reflect this slippage on applicable schedules.



REVISED 6/30/78

Figure 2-1. Single-Family Residence (Heating Only) Stillwater, Minnesota (OTS #40)

78341

2-3

REVISED 6/30/78

Figure 2-2. Single-Family Residence (Heating Only) New Castle, Pennsylvania (OTS #39)

78341

ACTIVITY	1977							1978							
	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
ANALYSIS - SITE SPECIFIC															
COMPONENTS - SELECTION															
IPC DOCUMENTATION															
INSTALLATION DRAWINGS															
HARDWARE FAB															
SITE VISIT								▲							
PDR DATA PACKAGE										▲					
PDR										▲					
ARCHITECT DRAWINGS															
HARDWARE DELIVERY															
INSTALLATION															
INSTALLATION ACCEPT. REVIEW															△ 9/15

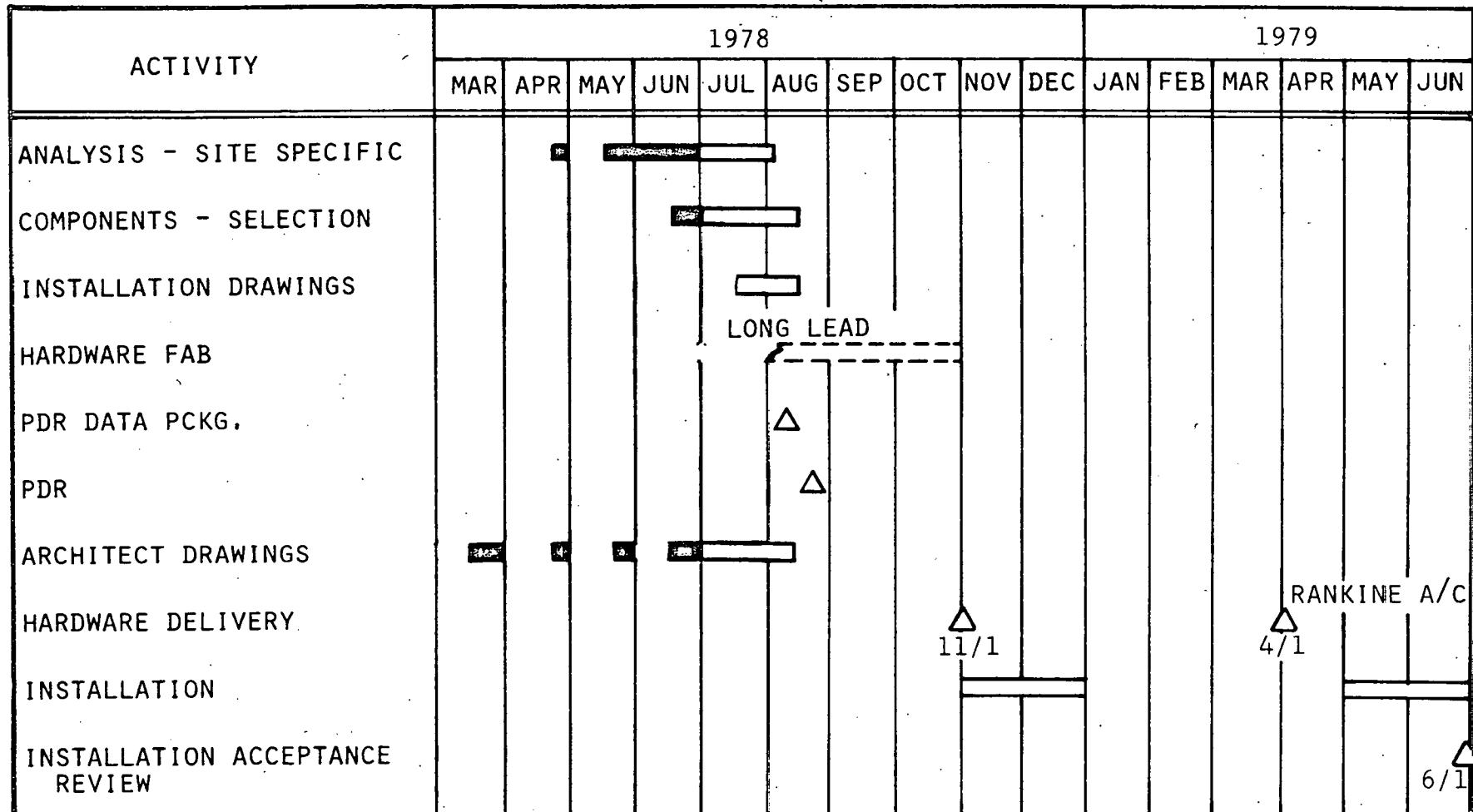
REVISED 6/30/78

Figure 2-3. Kansas University Multiple-Family Residence (OTS #43)

2-4

78341

2-5



REVISED BASED ON E.C.P. 005

REVISED 6/30/78

Figure 2-4. Single-Family Residence Heating and Cooling Site -- Sacramento, CA (OTS #41)

78341

2-6

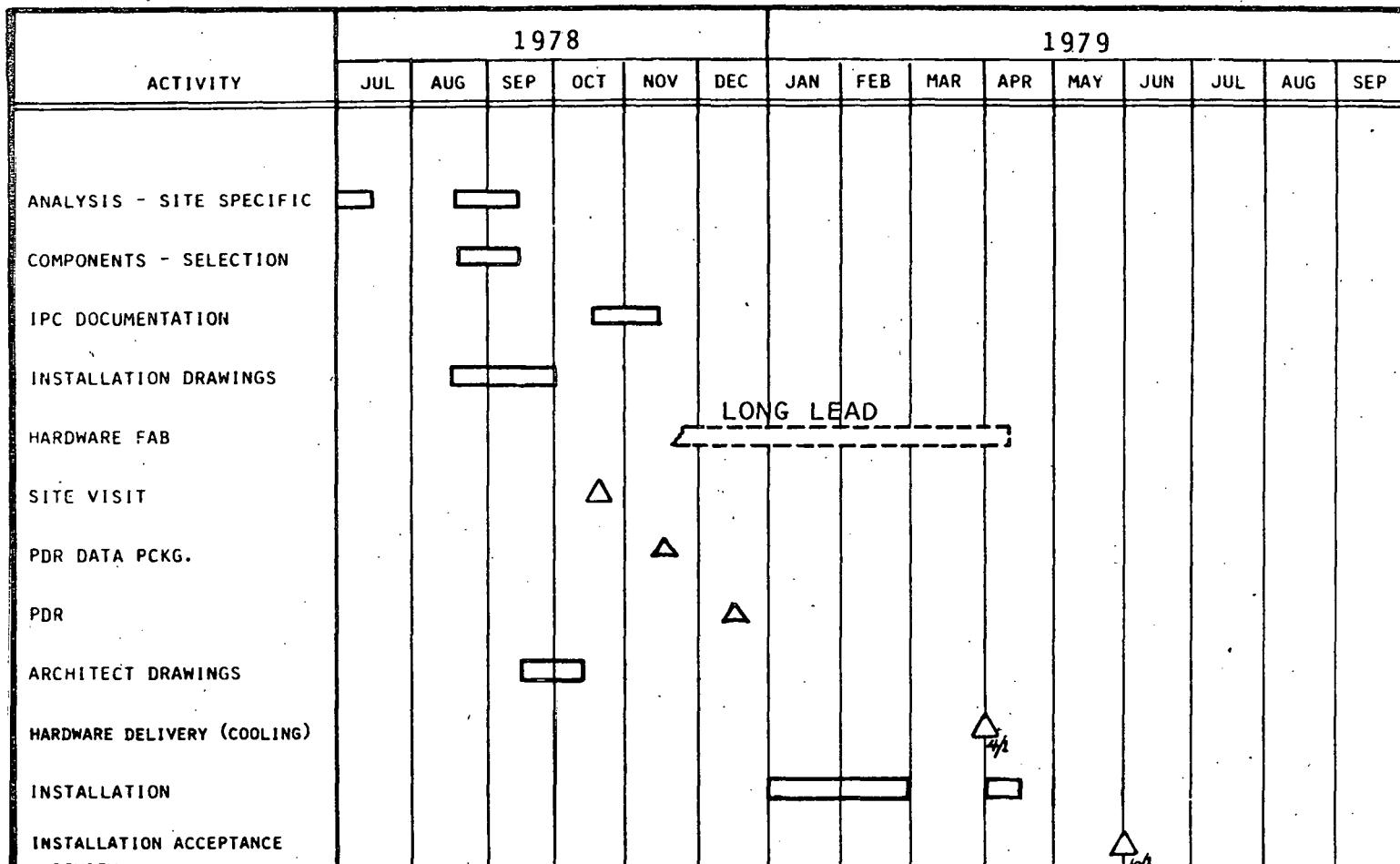


Figure 2-5. Single-Family Residence Heating and Cooling Site, TVA (OTS #42)

ACTIVITY	1978												1979	
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
ANALYSIS - SITE SPECIFIC														
INSTALLATION DRAWINGS														
HARDWARE FAB														
PDR DATA PCKG.														
PDR														
ARCHITECT DRAWINGS														
HARDWARE DELIVERY														
INSTALLATION														
INSTALLATION ACCEPTANCE														
REVIEW														

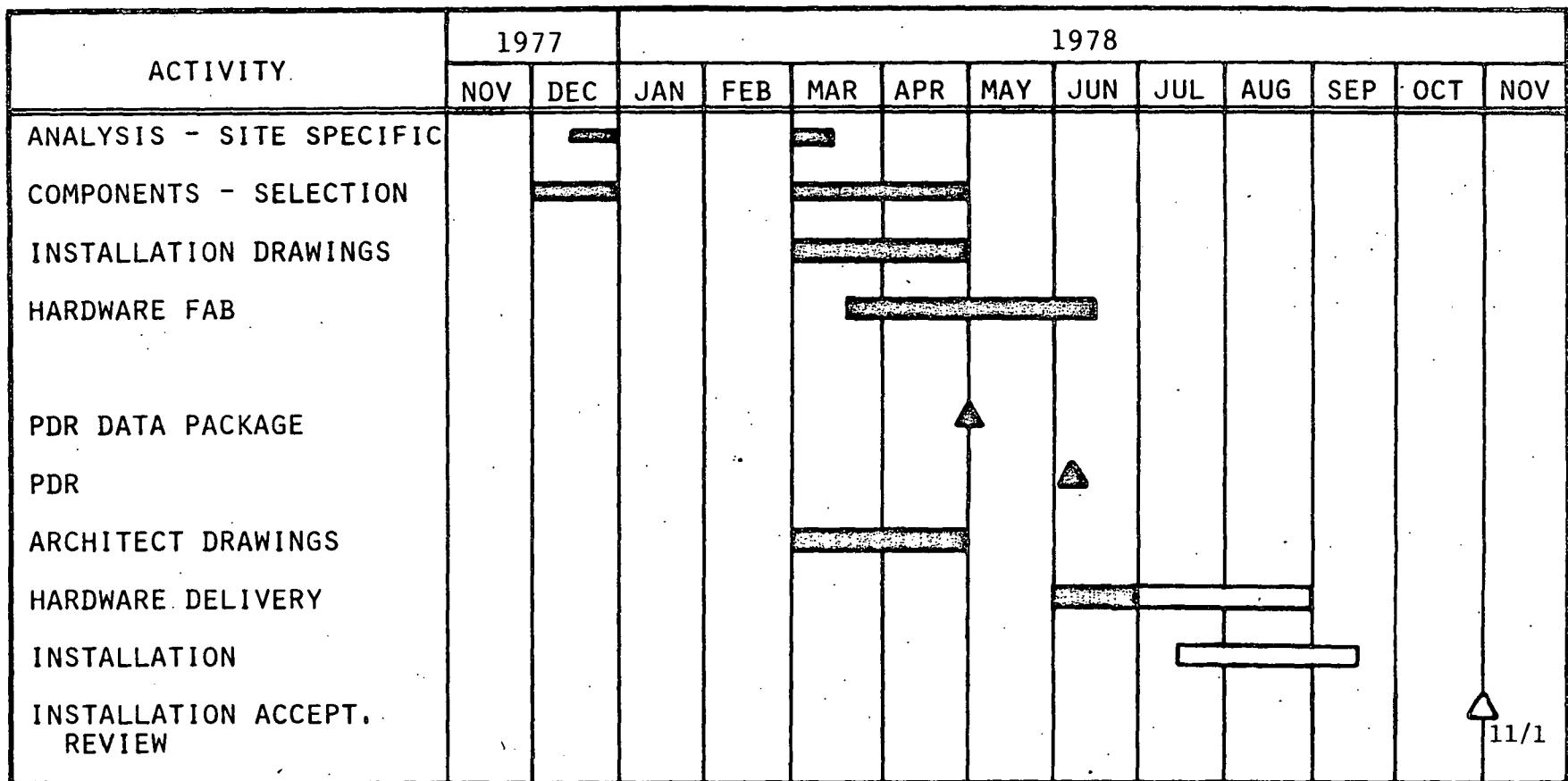
78341

2-7

REVISED BASED ON E.C.P. 005

REVISED 6/30/78

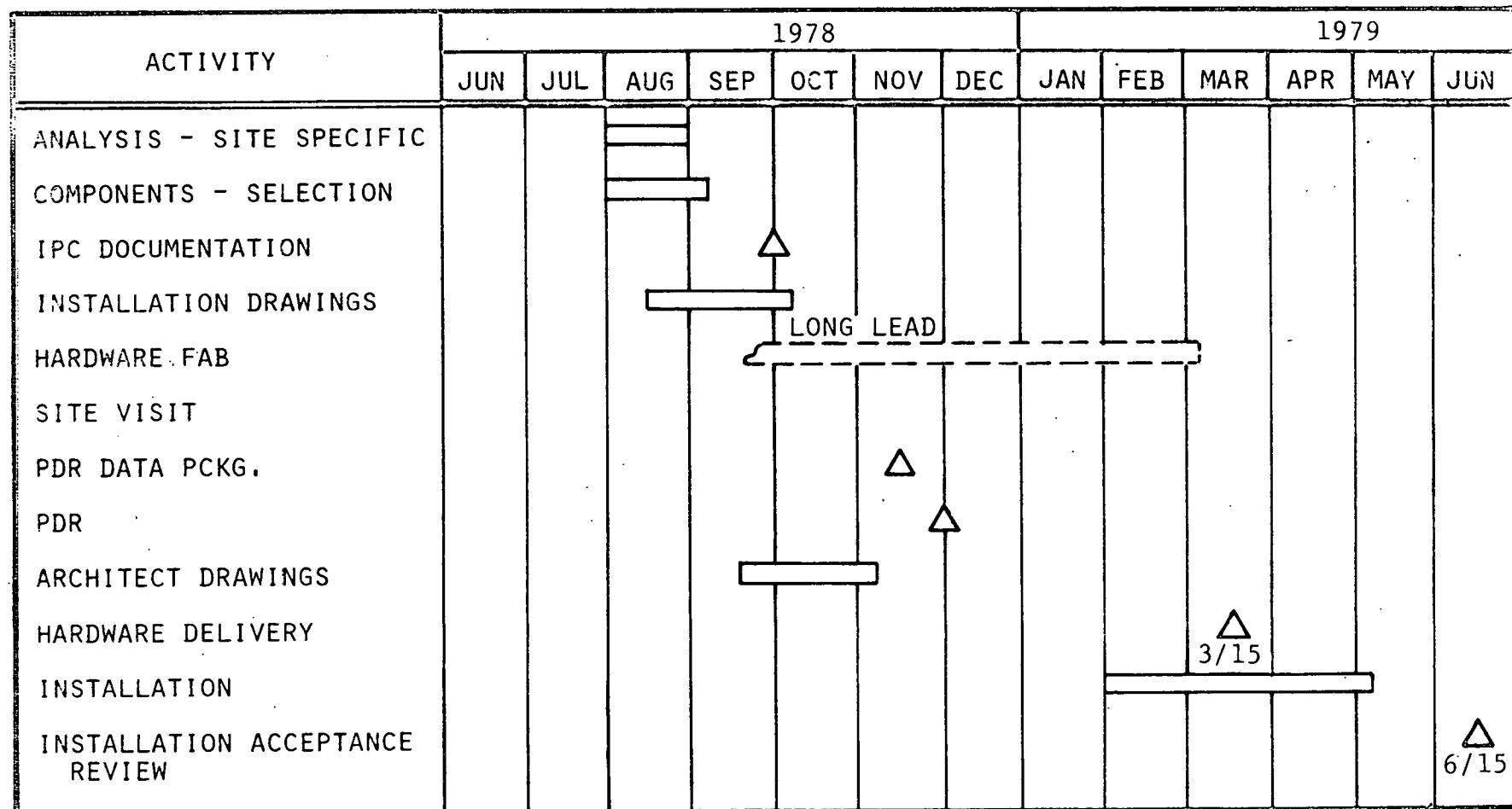
Figure 2-6. Commercial Heating and Cooling (Ocmulgee) (OTS #44)



REVISED BASED ON E.C.P. 005

REVISED 6/30/78

Figure 2-7. Commercial Heating and Cooling (50 Ton) (Lennox) (OTS #46)



REVISED BASED ON E.C.P. 005

REVISED 6/30/78

Figure 2-8. Commercial Heating and Cooling (75 Ton Unidentified) (OTS #45)

SECTION 3
TECHNICAL STATUS

WILLIAM O'BRIEN - SFR HEATING ONLY

The Certificate of Occupancy for the William O'Brien site has been received from Washington County, Minnesota. It states that all requirements of the Uniform Building Code and the various local ordinances regulating building construction for domestic use have been met. Prior to receipt of this certificate, the following tasks have been completed.

- Additional cellulose insulation was added to the top of the storage tank to maintain a cool environment temperature in the equipment room and to reduce heat transfer to the living quarters above.
- The ambient air temperature sensor (T001) was moved away from the collector field to the northeast corner of the garage roof. No heat given off by the collector field is sensed at this location.
- The pyranometer (I001) was moved from the east end of the collector field to the south side of the upper house roof. No early morning shading from trees is possible at this location.
- The air temperature sensor (T601) has been moved from the side of the furnace return air plenum to the back of the furnace near the solar water coil.
- The collector supply and return pipe in the sleeve through the south block wall of the equipment room was insulated, and the remaining space in the sleeves has been caulked.

- The exposed portion of the collector return line between the return header and building penetration has been weatherproofed.

A summertime cover for the 5 x 3 collector array is being investigated. Since only solar DHW preheating occurs during the summertime, such a cover would reduce both storage tank temperature and time spent in the purge mode. The transport fluid would still pass through the 9 x 2 and 5 x 3 arrays, but a lower temperature mixed flow would pass to the storage heat exchanger. As a result, the system would spend more time in an "idle energy transfer" state. The collector plate sensor on the 9 x 2 array would initiate collector fluid circulation. However, the mixed-fluid temperature in the return line would take longer to reach the "purge" state. Also, it would take longer to reach the "charge storage" state once the storage tank has been charged to a sufficiently high temperature. The benefits are as follows:

- Less time spent in the "charge storage mode" and, therefore, lower pumping power expenditure.
- Less time spent in the "purge mode" and, therefore, lower power expenditure since the purge fan is off.
- Lower summertime storage tank temperature and, therefore, a cooler equipment room. At design condition of 3 gpm DHW flow, a 175°F storage tank is sufficient to preheat the DHW to approximately 140°F.

NEW CASTLE, PA - SFR HEATING ONLY

Construction at the site is nearly complete. Final SDAS wiring and miscellaneous items are yet to be completed. System startup and control checkout were completed in mid-June. All work should be completed by mid-July to provide for an Installation Acceptance Review in early August.

KANSAS UNIVERSITY - MFR HEATING AND COOLING

The site was visited on 28 and 29 June. The following items were noted:

- All piping has been properly installed in the building, including SDAS components.
- Furnaces have been removed from the apartments.
- Contractor A poured the cement for the cooling complex on 29 June.
- The Rankine chiller was delivered to the site.
- Tank insulation did not meet specification. This condition will be corrected by applying an additional coat of insulation and by painting it green.

Contractor A is two weeks behind schedule causing contractor B to vacate the job while waiting for site preparation. However, contractor B still intends to complete his work by 31 July. He would have to be installing collectors by 10 July to accomplish this.

CARROLLTON, TX - COMMERCIAL HEATING AND COOLING

Although the basic system design is complete, some architectural modifications have been made so the detail control subsystem design is continuing. Some pipe lines in the mechanical building and adjacent solar equipment complex

have been rerouted. Provisions have been incorporated for thermal expansion of the heating/cooling supply and return lines between the mechanical building and the plant.

Some additions and deletions were made in the SDAS instrumentation. All instrumentation for the DHW subsystem was deleted since it is completely independent of the solar system that supplies heating and cooling to the plant. Flow meters and temperature sensors have been added to the condensing water return lines for both Rankine engines and chillers.

SACRAMENTO, CA - SFR HEATING AND COOLING

The SFR heating and cooling system schematic is finalized. The simulations conducted for this 34-collector array indicate acceptable solar contribution if collectors are mounted flush on the eight-degree sloping roof. The decision was made to roof mount the collectors since performance is minimally affected, installation costs are reduced, and aesthetics are enhanced.

The furnace/heat coil/direct expansion coil configuration has been determined, as well as the sizing of headers and piping. A H/C Energy Transport Module configuration has evolved and is ready for an internal design review. The storage tank is sized at 1,000 gallons. The Mechanical Room, R/CA/C and purge layout agreed upon by Honeywell and the site architect remains unchanged. Detailed system design continues, and controls and SDAS design will begin next month. No major problems are anticipated; work progresses on schedule.

OCMULGEE NATIONAL MONUMENT, GEORGIA - LIGHT COMMERCIAL HEATING AND COOLING

Detailed system design work continues with preparation of construction drawings and bidding documents. Coordination with the A/E firm representing the NPS will result in a single combined bid package for the Visitor Center project.

The 90 percent package will be ready for the NPS on 8 August; the remainder will be ready by 28 August.

RESIDENTIAL COOLING SUBSYSTEM

Lennox and Barber-Nichols continue to work the detailed design of the components for the three-ton unit. Honeywell has conducted several technical and cost coordination meetings to assure design continuity and control expenditures.

The compressor has been selected and meets the recent COP goals presented at the PDR.

The regeneration is designed and in fabrication at the Fort Worth Lennox facility.

Evaporative condenser initial development tests are complete, and final sizing has been determined. Fabrication will be complete by mid-August for total subsystem development testing at Marshalltown, Iowa.

Boiler/demister design continues through the final packaging phase. One configuration has been determined. The outer shell design will be complete in early August.

Gearbox testing continues in an effort to define the final gear and lubrication configuration.

COMMERCIAL AND MULTI-FAMILY SUBSYSTEMS - 25 TON RANKINE CHILLER

The development on the first 25-ton unit was completed. A complete series of off-design data was run, and a performance map was drawn up from the data. The design point data was better than expected. This unit was shipped to Lennox at Carrollton, Texas. The second unit was tested and shipped to Kansas Univ-

ersity at Lawrence, Kansas. The third unit is ready for the acceptance inspection. The fourth through sixth units are in assembly. Problems continue with off-the-shelf components. Chillers leaked requiring changes and repair. The balance of the chillers were checked, and leaks were repaired.

The operation and maintenance manual is in the final stages of preparation.

SECTION 4
DATA SUBMISSIONS

A current Data Submissions Control Ledger is presented in Figure 4-1.

LEGEND: P - PLANNED SUBMISSION DATE
 A - ACTUAL SUBMISSION DATE
 M - MULTI SUBMISSIONS

PAGE 1 OF 1
 REV. 21 DATE 7.10/78

CONTRACT DESCRIPTION: Solar Heating and Cooling				CUSTOMER: Geo. C. Marshall Space Flight Center												CONTRACT NUMBER: NAS8-32093			
ITEM SEC. NUMBER	ITEM DESCRIPTION	FIRST SUBMISSION DUE	FREQ.	SUBMISSION DATES															REMARKS
				JUL 77	AUG 77	SEP 77	OCT 77	NOV 77	DEC 77	JAN 78	FEB 78	MAR 78	APR 78	MAY 78	JUN 78	JUL 78			
*1	DEVELOPMENT PLAN		A/R																
*2	VERIFICATION PLAN		A/R																
*3	QUALITY ASSURANCE PLAN		Once																
*4	SYSTEM PERFORMANCE SPECIFICATION		A/R																
*5	SOURCE & SPEC. CONTROL DRAWINGS		A/R							15									
*6	CHANGE PROPOSAL & ASSOC. DATA		A/R																
7	PRELIMINARY DESIGN REVIEW DATA		A/R																
8	PROTOTYPE DESIGN REVIEW DATA (8)		A/R	6 (1)	7	9 (1)	10			10 (1)			13						
9	FIRST ARTICLE REVIEW DATA		A/R					21								22			
10	QUARTERLY REPORT		Qtrly	15	21				14	27			16	27		14	27		11
11	MONTHLY STATUS REPORT		Month			12	16	15	16		14	22	14	20		14	27	14	21
12	ACCEPTANCE DATA PACKAGE		A/R				21	12	15							22	12	15	
13	QUALIFICATION & ACCEPT. TEST. PROC.		Once																
14	QUALIFICATION TEST AND/OR ANALYSIS REPORT		Once																
15	SPECIAL HANDLING INSTALLATION AND MAINTENANCE - TOOL LIST		Once																
16	SPARE PARTS LIST		Once	7	7	9				10 (1)			15						
17	INSTALLATION, OPERATION AND MAINTENANCE MANUAL		A/R	18			1 (1)	1 (1)		1 (1)			19 (5)						
18	HAZARD ANALYSIS		Once																
19	DESIGN DATA BROCHURE		Once										30						
20	NON-CONFORMANCE REPORT		A/R																
21	OPERATIONAL TEST REVIEW DATA		Once																
22	LOGISTICS PLAN		Once																
23	SYSTEM PERFORMANCE REPORT		Month										28	31	30	31	30	31	
24	SAFETY & HEALTH PLAN		A/R																
25	NEW TECH. REPORTING PLAN		A/R																
*26	WORK BREAKDOWN STRUCTURE		A/R																
27	FINANCIAL MANAGEMENT REPORT 533M		Month		19	19	19	21		18	20	16	20		17	17	17	17	
	533Q		Qtrly	18	19				14	17			13	13		14	14		18
28	INSTALLATION ACCEPT. REVIEW(8)		A/R							15 (1)		17 (1)					15 (1)		Remaining five are scheduled in Aug. 78

Figure 4-1. Data Submissions Control Ledger