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10 MWe Solar Thermal Central Receiver Pilot Plant Remote Operation Feasibility Study

McDonnell Douglas Astronautics Company

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10 MWe SOLAR THERMAL CENTRAL RECEIVER PILOT PLANT REMOTE OPERATION FEASIBILITY STUDY

Contract Report Prepared
Under SNLL Contract 91-1907

McDonnell Douglas Astronautics Company

ABSTRACT

This report describes the results of a feasibility study for remote operation of the 10 MWe Solar Thermal Central Receiver Pilot Plant located near Barstow, California. The plant, called Solar One, is a cooperative activity between the Department of Energy and the Associates: Southern California Edison, the Los Angeles Department of Water and Power, and the California Energy Commission. This report provides a description of the changes required to the plant and a rough cost estimate for the changes.

SOLAR THERMAL TECHNOLOGY
FOREWORD

The research and development described in this document was conducted within the U.S. Department of Energy's (DOE) Solar Thermal Technology Program. The goal of the Solar Thermal Technology Program is to advance the engineering and scientific understanding of solar thermal technology, and to establish the technology base from which private industry can develop solar thermal power production options for introduction into the competitive energy market.

Solar thermal technology concentrates solar radiation by means of tracking mirrors or lenses onto a receiver where the solar energy is absorbed as heat and converted into electricity or incorporated into products as process heat. The two primary solar thermal technologies, central receivers and distributed receivers, employ various point and line-focus optics to concentrate sunlight. Current central receiver systems use fields of heliostats (two-axis tracking mirrors) to focus the sun's radiant energy onto a single tower-mounted receiver. Parabolic dishes up to 17 meters in diameter track the sun in two axes and use mirrors or Fresnel lenses to focus radiant energy onto a receiver. Troughs and bowls are line-focus tracking reflectors that concentrate sunlight onto receiver tubes along their focal lines. Concentrating collector modules can be used alone or in a multi-module system. The concentrated radiant energy absorbed by the solar thermal receiver is transported to the conversion process by a circulating working fluid. Receiver temperatures range from 100°C in low-temperature troughs to over 1500°C in dish and central receiver systems.

The Solar Thermal Technology Program is directing efforts to advance and improve promising system concepts through the research and development of solar thermal materials, components, and subsystems, and the testing and performance evaluation of subsystems and systems. These efforts are carried out through the technical direction of DOE and its network of national laboratories who work with private industry. Together they have established a comprehensive, goal directed program to improve performance and provide technically proven options for eventual incorporation into the Nation's energy supply.

To be successful in contributing to an adequate national energy supply at reasonable cost, solar thermal energy must eventually be economically competitive with a variety of other energy sources. Components and system-level performance targets have been developed as quantitative program goals. The performance targets are used in planning research and development activities, measuring progress, assessing alternative technology options, and making optimal component developments. These targets will be pursued vigorously to insure a successful program.

This report describes the results of a feasibility study for remote operation of the 10 MWe Solar Thermal Central Receiver Pilot Plant (Solar One). This is part of the continuing evaluation of the pilot plant for the Solar Thermal Technology Program.

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I. INTRODUCTION

This report describes a feasibility study for remote operation of the Solar I Pilot Plant from the Southern California Edison's Coolwater Generating Station. The primary objective of remote operation would be to reduce Solar I operating costs which would increase plant revenue. This study identifies changes required to existing plant hardware and software and provides rough cost and schedule estimates for accomplishing the work.

At the beginning of this study a set of objectives, guidelines and ground rules were agreed to between the parties involved. These are delineated in Section II. Section III describes the baseline scenario to be used for the study. This scenario follows the operating procedures and automatic operation which is currently used daily at Solar I.

Two alternate concepts for remote operations were developed and are described in Section IV. Both concepts provide for a remote operator station for the Heliostat System and the Operational Control System (OCS-Supervisory Control). Alternate concept 1 also provides for a System Distributed Process Control (SDPC) remote operator station. This allows direct manual operation of various plant components and subsystems without need for OCS operation. The two remote system hardware configurations are discussed as well as required Solar I modifications.

Section V presents a work plan and proposed time-phased schedule for the remoting effort. Construction and development work packages are defined and the schedule shows the period of performance and major outputs of these tasks.

Section VI presents the estimated cost of the project for Alternates 1 and 2.

II. OBJECTIVES, GUIDELINES AND GROUND RULES

A. Objectives

The objectives for remoting the controls of Solar I to the SCE Coolwater generating plant, located approximately two miles from Solar I, is three fold:

1. Utilize the operating personnel at the Coolwater Generating Plant to monitor and control the Solar I Plant remotely and thereby significantly reduce or eliminate specific on-site operating staff requirements which in turn reduces plant operating costs.
2. Obtain remote operating information, following the implementation of the remote operations at the Coolwater Generating Plant, that can be used to evaluate and determine remote operation feasibility and requirements for future solar central receiver generating plants.
3. Provide the remote operation of Solar I from the Coolwater Generating Plant in a cost effective manner.

Demonstration of the first objective requires a high degree of automatic control of plant equipment for all phases of power production. Since Solar I was not designed initially for fully automatic operations, especially during startup and shutdown, some tradeoffs will be required between objectives 1 and 3.

B. <u>Guidelines and Ground Rules</u>

The general guidelines and ground rules for the remote operation feasibility study of Solar I were derived from several informal meetings and presentations conducted between MDAC, SNLL and SCE to benefit the first and third objectives. These can be arranged into five categories consisting of: 1) operating guidelines/ground rules; 2) performance guidelines/ground rules; 3) facility guidelines/ground rules; 4) hardware guidelines/ground rules; and 5) software guidelines/ground rules.

A general requirement was followed that directed the feasibility study to use the existing Solar I control and monitoring resources to the extent possible, extending these resources as required to meet the objectives.

1. <u>Operating Guidelines and Ground Rules</u>

The operating guidelines and ground rules relate to the permissable operating allowances between the remote and local operations. The following operating requirements were agreed to for this study:

a. Local Solar I operating capabilities shall not be compromised.
b. Remote operation of Solar I shall lockout local operation of Solar I and vice versa.
c. Configuration switching from local to remote operation or vice versa shall be performed only at the Coolwater remote site.
d. The operating procedures and man-machine interface differences between local and remote Solar I operation shall be minimal.
e. The OCS and HAC software shall remain transparent to local or remote operation

2. <u>Performance Guidelines and Ground Rules</u>

The performance guidelines and ground rules relate to the operating scaler differences allowed between local and remote operation. The following performance requirements were agreed to:

a. The effectiveness of the Solar I plant operation (e.g. mode transition, startup, steady state, etc.) shall not be degraded when operating remotely.

b. Remote operation shall be limited to Mode 8 to Mode 9 to Mode 1 and the return sequence of events.

c. The thermal storage subsystem (TSS) shall only provide auxillary steam to the other subsystems during remoting operation. Charging the TSS and discharging the TSS for power generation shall be controlled and monitored from the Solar I control room only.

3. <u>Facility Guidelines and Ground Rules</u>

The facility guidelines and ground rules are derived from utility (SCE) practices pertaining to the automation and remote control of plant systems. The following facility related requirements were reviewed and agreed to:

a. The work functions between Solar I and Coolwater utility personnel are to be consolidated, but without combining or integrating SCE job classifications.

b. The work methods structure (e.g. clearance procedures, preoperational equipment inspections, etc.) of SCE shall be maintained.

c. The control room at the Coolwater Generating plant shall be used to house the Solar I remoting equipment.

4. <u>Hardware Guidelines and Ground Rules</u>

The hardware guidelines and groundrules relate to the variations in operating plant equipment that affect remote operation. The following hardware ground rules and guidelines were agreed to:

a. The turbine-generator controls are to be operated remotely from the Coolwater site.
b. Hardware end elements (e.g. pumps, motors, valves, switchgear, etc.) that are manually operated at local stations away from the Solar I control room are not to be reconfigured for remote operation.
c. Hand switch functions that are manually operated in the Solar I control room for emergency shutdown of a subsystem shall be provided at the remote Coolwater control room site.
d. Only the TSS components required to supply auxillary steam for conditioning equipment used in Mode 8 to Mode 9 to Mode 1 shall be controlled remotely.

5. <u>Software Guidelines and Ground Rules</u>

The software guidelines and ground rules define the basis for implementing software to accommodate remote operation activities. The following rules were agreed to:

a. The development of new software to support the remoting operation shall be minimal.
b. Software systems startup (i.e. boot strap loading) shall be accomplished at Solar I.

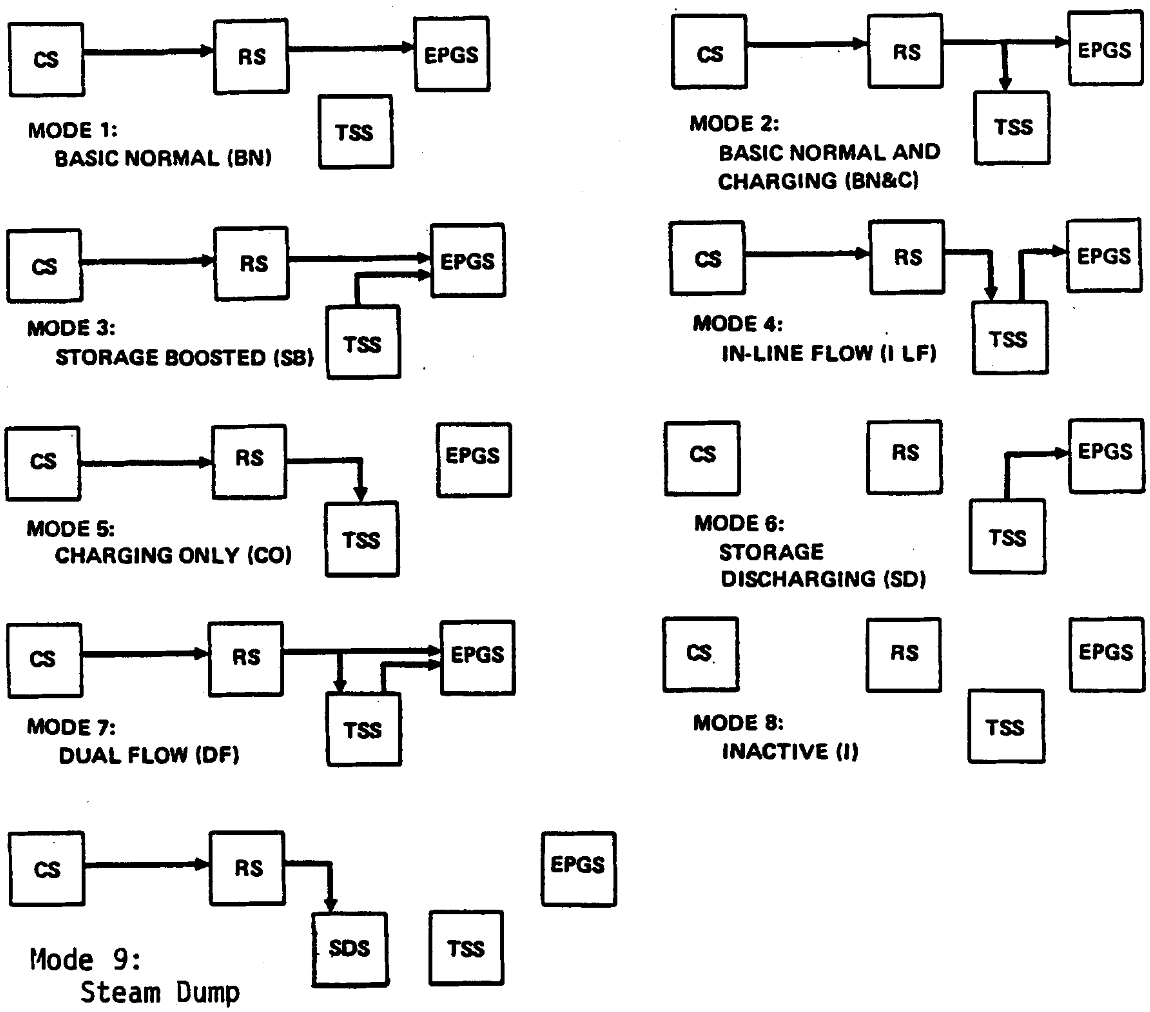
c. The HAC and OCS computers shall be placed in the "RUN" mode from the Solar I facility.

III. BASELINE OPERATING SCENARIO

In order to develop design alternatives for remoting Solar I operation, a baseline operating scenario was required from whence an evaluation of the tasks necessary for remoting could be identified. Using this baseline scenario two design alternatives were considered for remoting, each of which met the objectives, guidelines, and ground rules criteria outlined in Section II. This section defines the baseline scenario. The two conceptual design alternatives are defined in Section IV.

It had been established in the guidelines and ground rules that there would be one operating scenario from the Coolwater remoting site (See section II, B, 2, b). This scenario transitions the plant daily from an inactive status (Mode 8), where major systems are in standby, through receiver startup to the steam dump (Mode 9), where receiver steam is routed directly to the condenser, and then to the turbine (Mode 1) for power production. During shutdown the transitions are essentially the reverse: Mode 1 to Mode 9 to receiver shutdown and Mode 8. This scenario was selected from the variety of acceptable operating steady state modes of the Solar I plant shown in Figure 1. The following rationale prevailed for selecting this baseline:

1. Mode 8 to Mode 9 to Mode 1 scenario is the most used scenario at Solar I and constitutes the modes and mode transitions used for the OCS automatic "clear day scenario."



Mode 1 Turbine Direct:	Receiver-generated steam directly powers the turbine.
Mode 2 Turbine Direct and Charging:	Receiver-generated steam powers the turbine and charges storage.
Mode 3 Storage Boosted:	Steam from the receiver and storage powers the turbine.
Mode 4 In-line Flow:	Receiver steam charges storage, while storage steam is simultaneously discharged powering the turbine.
Mode 5 Storage Charging:	Receiver steam charges the storage system.
Mode 6 Storage Discharging:	Steam generated by the storage system is used to power the turbine.
Mode 7 Charging and Storage Boosted:	A combination of Modes 2 and 3 (probably only achieved during transitions).
Mode 8 Inactive:	Major systems are standing by for operation.
Mode 9 Steam Dump:	Receiver steam routed directly to the Condenser (used for startup, shutdown, and trips).

Figure 1. Steady State Operating Modes

2. This scenario contains representative hardware currently controlled and monitored from the Solar I control room.
3. Extensive software has been developed for automatic operation of this scenario.
4. This scenario provides a lower software and control hardware implementation cost for remoting.
5. The logic, controls, and monitor systems required to operate the plant within this scenario manually represents all of the major systems of the Master Control Subsystem.

The Mode 8 to Mode 7 to Mode 1 or Mode 2 or Mode 8 to Mode 2 or Mode 4 scenarios for plant operation would appear more representative since all of these scenarios include the Thermal Storage System (TSS) operation. However, the transition modes to and from the TSS require longer startup times, are not used every day because they provide a less efficient use of the steam resources, and are not as effectively automated as the Mode 8 to Mode 1 and return scenario. Consequently, you could expect less power to be produced and less revenue, which is contrary to the first objective for remoting Solar I operation: reducing fixed costs so as to improve net revenues.

Typically, the baseline scenario requires use of eight major operating sequences to transition from shutdown (Mode 8) to steady state receiver steam to turbine (Mode 1) and return to Mode 8. These sequences are:

- Initial Plant Startup
- Initial Fluids Circulation
- Collector Field Startup
- Receiver Startup
- Turbine Activation

- Plant Steady State Operation
- Turbine/Receiver Shutdown
- Plant Shutdown

These operating sequences are shown in a time phased order in Figure 2.

Each time phased operation requires a series of Control Operator (CO) activities with the Master Control Subsystem in the control room and, in addition, a series of non-control room related activities performed by the Plant Equipment Operator (PEO). A summary of the baseline scenario CO and PEO activities is presented in Figure 3. An examination of these activities clearly points up the requirement for a plant equipment operator on the premises at Solar I throughout the plant operating period. Also, the PEO must have frequent communications with the control operator at the remote Coolwater control room. It is also apparent that there is an appreciable amount of equipment that must be operated or attended to that is not controlled or monitored from the Solar I control room with the current configuration.

The baseline scenario as described above was used for the development of concepts for remote operation of Solar I from the Coolwater Generating Plant. The remoting concepts defined in this report require specific Solar I on-site personnel during remote operation. No attempt was made in this feasibility study to determine the engineering mechanization requirements for placing noncontrol room functions into the Master Control Subsystem and the costing to implement the mechanizations.

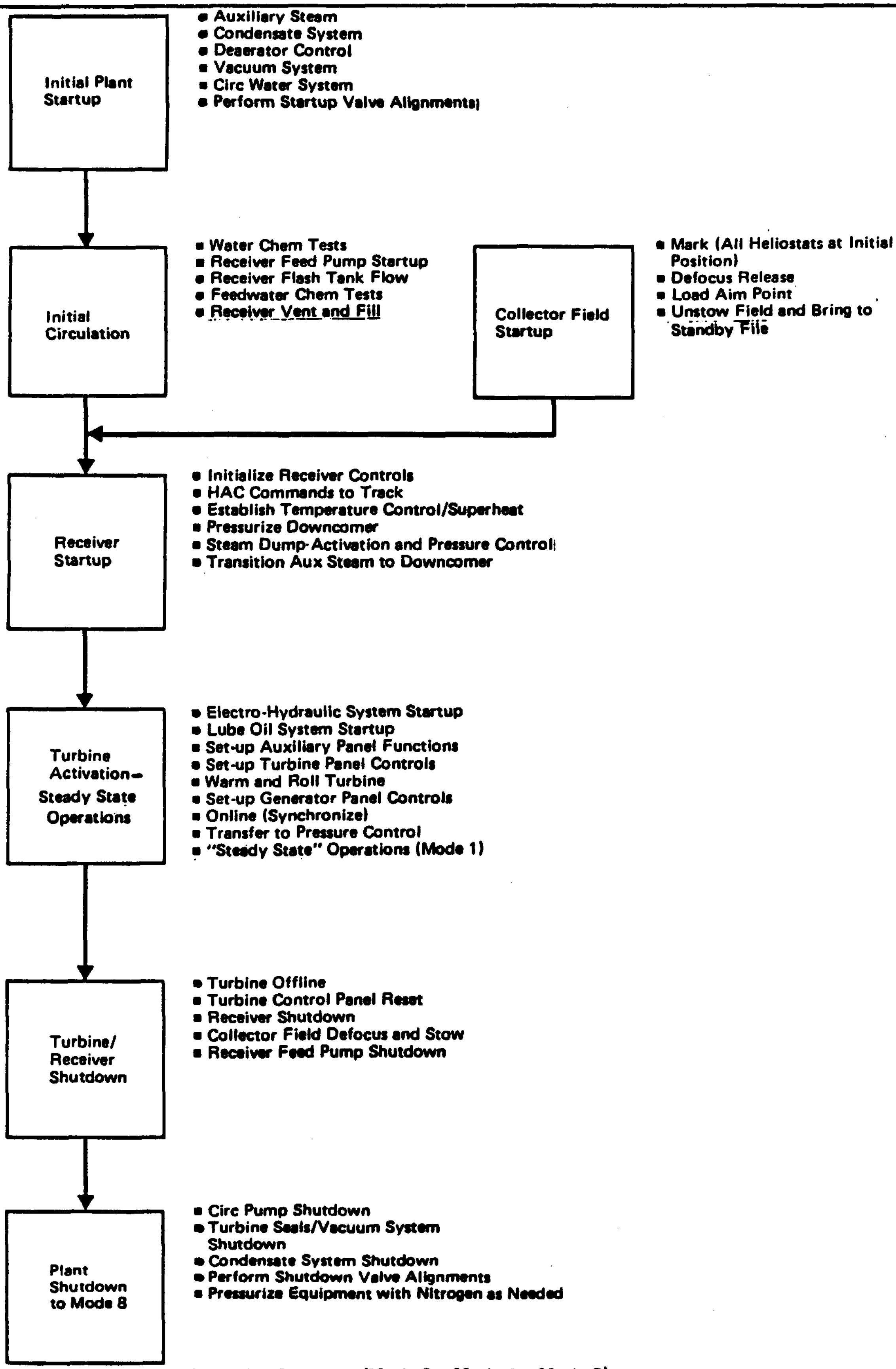


Figure 2. Typical Solar I Operating Sequence (Mode 8→Mode 1→Mode 8)

INITIAL PLANT STARTUP - 1

CONTROL ROOM RELATED OPERATOR (CO) ACTIONS	EQUIP.	NON-CONTROL ROOM RELATED OPERATOR (PEO) ACTIONS
AUX STEAM (T.S. STEAM GEN)		
• VERIFY PROPER BOILER WATER LEVEL	SDPC	• CHECK SELECTED TRAIN VALVE ALIGNMENT (TRAINS ALTERNATED)
		• OPEN GN_2 SUPPLY TO P-305
		• OPEN BLOCK VALVES ON LEAKY CONTROL VALVES (LV3505 & LV3605)
• FILL BOILER (IF REQ'D)	SDPC	• DRAIN BOILER LEVEL DOWN (IF REQ'D)
• TOGGLE EXTRACTION BOILER TO "AUX STEAM" MODE	SDPC	
• VERIFY PROPER OPERATION OF P305 (OIL), P904 (WATER), AND CONTROL VALVES	SDPC	
AUX STEAM (ELECTRIC BOILER)		
		• DRAIN DOWN TO NORMAL LEVEL (LEAK THRU)
		• VALVE CHECK (GN_2 - OFF, STEAM TRAP-IN SERVICE)
		• SWITCH TO "PREHEAT MODE" FOR 1/2 HR
		• SWITCH TO "RUN MODE"
CONDENSATE SYSTEM		
• CLOSE DEAERATOR FILL VALVE (LV83B)	SDPC	• BYPASS INLINE POLISHER
• PLACE CONDENSER LEVEL VALVES (LV146 A & B) IN AUTO	SDPC	• THROTTLE PUMP DISCHARGE BLOCK VALVE
		• VALVE OUT RECEIVER FEED PUMP SEALS
• START CONDENSATE PUMP (P907)	HARDWIRE (STOP/AUTO) +	• OPEN DISCHARGE BLOCK VALVE
	SDPC	• PLACE INLINE DEMINERALIZER IN SERVICE

Figure 3. Summary of Operating Activities

INITIAL PLANT STARTUP - 2

CONTROL ROOM RELATED OPERATOR (CO) ACTIONS	EQUIP.	NON-CONTROL ROOM RELATED OPERATOR (PEO) ACTIONS
DEAERATOR CONTROL		
• CHECK AND ADJUST DEAERATOR LEVEL (LV83B AUTO CONTROL)	SDPC	• APPLY GN_2 TO DEAERATOR
VACUUM SYSTEM		
• CLOSE CONDENSER GN_2 SUPPLY-MOV660	SDPC	• CLOSE GN_2 CONDENSER HAND VALVES
		• RACK IN BREAKERS
		• VALVE IN SPRAY WATER TO GLAND SEAL EXHAUSTER
		• CHECK VALVING
• START GLAND SEAL EXHAUSTER	SDPC	
• APPLY AUX STEAM TO TURBINE SEALS	SDPC	
• START AIR REMOVAL PUMP	SDPC	
CIRC WATER SYSTEM		
		• VALVE IN MAKEUP WATER SUPPLY LV210
		• VALVE IN CORROSION RACK
		• CHECK CIRC PUMP (OIL LEVEL)
		• RACK IN PUMP AND MOV BREAKERS
• START ONE CIRC PUMP	HARDWIRE (STOP/AUTO) + SDPC	
		• ADJUST RISER DISCHARGE VALVES (18PSI PUMP DISCHARGE PRESS)
		• VENT CONDENSER (TUBESIDE)
		• VENT BEARING COOLING WATER HEAT EXCHANGER
MISCELLANEOUS		
• VERIFY TURBINE DRAINS CLOSED	SDPC	• VALVE IN SPARGE LINE
• RESET STEAM DUMP	SDPC	
• MONITOR DEAERATOR LEVEL	SDPC	

Figure 3. Summary of Operating Activities (continued)

INITIAL CIRCULATION - 1

CONTROL ROOM RELATED OPERATOR (CO) ACTIONS	EQUIP.	NON-CONTROL ROOM RELATED OPERATOR (PEO) ACTIONS
WATER TESTS		
		• GATHER AND ANALYZE LOCAL SAMPLES CONDENSATE TANK DEMINERALIZED WATER TANK CIRC WATER SYSTEM (ADD ACID AS REQ'D)
		• ANALYZE LAB "PIPED IN" SAMPLES CONDENSATE SYSTEM
RECEIVER FEED PUMP		
		• OPEN SUCTION VALVE (BAD PUMP SEALS)
		• OPEN SEAL WATER
		• CHECK VALVE ALIGNMENT RECIRC MOV33 BYPASS
		• CHECK OIL LEVEL
		• VENT FEED PUMP (AFTER OUTAGE)
• VERIFY PROPER CONTROLLER STATUS	SDPC	
• RESET AND START REC. FEED PUMP	HARDWIRE + SDPC	
		• OPEN MOV33 BYPASS
		• OPEN LV74C BLOCK VALVE
• MONITOR PUMP DISCHARGE PRESSURE	SDPC	
• MONITOR PUMP LOGIC SEQUENCE (SCOOP-SPEED-PRESSURE CONTROL)	SDPC	
		• VENT FEEDWATER HEATERS
• OPEN MOV33	SDPC	• CLOSE MOV33 BYPASS

Figure 3. Summary of Operating Activities (continued)

INITIAL CIRCULATION - 2

CONTROL ROOM RELATED OPERATOR (CO) ACTIONS	EQUIP.	NON-CONTROL ROOM RELATED OPERATOR (PEO) ACTIONS
RECEIVER FLASH TANK FLOW		
• ADJUST PV2002, LV74A, & LV74C AS REQ'D	SDPC	
• APPLY GN_2 TO FLASH TANK	SDPC	
• MONITOR FLASH TANK LEVEL	SDPC	
FEEDWATER TESTS		
		• FEEDWATER CHEMISTRY TESTS
		• FILL AMMONIA AND HYDRAZINE DAY TANKS
RECEIVER VENT AND FILL		
• ESTABLISH FLOW TO THE RECEIVER	SDPC	
• OPEN PREHEAT VENT (AOV2007)	SDPC	• OBSERVE VENT
• CLOSE PREHEAT VENT (AOV2007) AND OPEN BOILER VENT (AOV2903)	SDPC	• OBSERVE VENT
• CLOSE BOILER VENT (AOV2903) AND PRESSURIZE THE RECEIVER	SDPC	• INSPECT RECEIVER FOR LEAKS
		• THROTTLE CONDENSATE PUMP RECIRC

Figure 3. Summary of Operating Activities (continued)

COLLECTOR FIELD STARTUP - 1

CONTROL ROOM RELATED OPERATOR (CO) ACTIONS	EQUIP.	NON-CONTROL ROOM RELATED OPERATOR (PEO) ACTIONS
MARK		
• VERIFY FIELD IS MARKED OR MARK IS REQUIRED	HAC CONSOLE	
DEFOCUS RELEASE		
• RELEASE THE DEFOCUS TO PERMIT THE HAC TO ACCEPT COMMANDS	HAC CONSOLE	
AIM POINT FILE		
• SELECT AND ENTER DESIRED AIM POINT FILE	HAC CONSOLE OR OCS	
UNSTOW		
		• VERIFY COLLECTOR FIELD IS CLEAR OF OBJECTS (e.g., TRUCKS, DEBRIS, ETC)
• ISSUE UNSTOW COMMAND	HAC CONSOLE	
• CORRECT ABNORMALITIES (TIMEOUTS, LOST POWER, LOST COMMUNICATON)	HAC CONSOLE	• FREE STUCK LIMIT SWITCHES (1 PER DAY) • CYCLE POWER HELIOSTAT (1 PER DAY) • REPORT HELIOSTAT ORIENTATION - ENCODER PROBLEMS (2 PER DAY)
"BACKROOM" FUNCTIONS		
• UPDATE OFFLINE COLLECTOR FIELD FILE	HAC TERMINAL	
• REBOOT HAC COMPUTER (MAY BE REQUIRED PRIOR TO ANY COLLECTOR FIELD STARTUP TASKS)	HAC TERMINAL	

Figure 3. Summary of Operating Activities (continued)

RECEIVER STARTUP - 1

CONTROL ROOM RELATED OPERATOR (CO) ACTIONS	EQUIP.	NON-CONTROL ROOM RELATED OPERATOR (PEO) ACTIONS
INITIALIZATION		
• EXECUTE RECEIVER INITIALIZATION SEQUENCE	SDPC OR OCS	
• VERIFY PROPER CONTROLLER STATUS AND RECEIVER FLOWS	SDPC OR OCS	
HAC COMMANDS		
• BEGIN TRACKING THE RECEIVER	HAC CONSOLE OR OCS	
INITIAL STEAMING		
• MONITOR RECEIVER PANELS SWITCHING TO FLOW CONTROL	SDPC OR OCS	
• MONITOR RECEIVER PANELS SWITCHING TO TEMP CONTROL	SDPC OR OCS	
• MONITOR RECEIVER TEMPERATURE RAMP TO SUPERHEAT AND MOISTURE SEPARATOR LEVEL FALL OFF	SDPC OR OCS	
PRESSURIZE DOWNCOMER		
• MONITOR GRADUAL OPENING OF UV2905 AND DOWNCOMER PRESSURIZATION PROCESS	SDPC OR OCS	
• MONITOR OPERATION OF DOWNCOMER BOOTLEG DRAINS	SDPC OR OCS	
• MONITOR DOWNCOMER PRESSURE AND TEMPERATURES	SDPC OR OCS	
STEAM DUMP ACTIVATION		
• MONITOR REALIGNMENT OF AUXILIARY STEAM VALVES	SDPC OR OCS	
• MONITOR STEAM DUMP COMING INTO SERVICE	SDPC OR OCS	
• MONITOR RECEIVER FLASH TANK BEING REMOVED FROM SERVICE	SDPC OR OCS	
• SECURE THERMAL STORAGE BOILER FROM AUXILIARY STEAM SERVICE	SDPC	• SHUTOFF GN_2 TO AUXILIARY OIL PUMP P305
		• SHUTDOWN ELECTRIC BOILER IF REQUIRED

Figure 3. Summary of Operating Activities (continued)

TURBINE ACTIVATION

CONTROL ROOM RELATED OPERATOR (CO) ACTIONS	EQUIP.	NON-CONTROL ROOM RELATED OPERATOR (PEO) ACTIONS
ELECTROHYDRAULIC (EH) SYSTEM		
		• CHECK EH SYSTEM (FLUID LEVEL, LEAKS, GENERAL CONDITIONS)
• START EH SYSTEM	SDPC	• OBSERVE EH SYSTEM (LEAK CHECK)
FIELD GROUND TEST		
• CONDUCT GENERATOR FIELD GROUND TEST	TURBINE PANEL	
LUBE OIL SYSTEM		
		• CHECK LUBE OIL SYSTEM
• VERIFY RECEIPT OF DC LUBE OIL PUMP ALARM	SDPC	• CONDUCT LUBE OIL PUMP SEQUENCE TEST
"BACK ROOM" CONTROL CABINET		
• VERIFY DC VOLTAGE DEVIATION METER READINGS	TURBINE CABINET	
• VERIFY STANDBY POWER SUPPLY VOLTAGE	TURBINE CABINET	
• VERIFY V1 AND V2 DIAL SETTINGS	TURBINE CABINET	
TURBINE PANEL		
• CONDUCT LAMP AND METER CHECKS	TURBINE PANEL	
• ADJUST DIALS AND SWITCHES TO STARTUP POSITIONS	TURBINE PANEL	
• CONDUCT EMERGENCY TRIP TEST	TURBINE PANEL	• RESET BREAKERS
WARM AND ROLL TURBINE		
• OPEN MAIN STEAM BLOCK VALVE (MOV1031)	SDPC	• PRESSURIZE STEAM LINE WITH MOV1031 BYPASS
• ALIGN STEAM LINE AND TURBINE DRAINS	SDPC	
• WARM STEAM CHEST, MONITOR TURBINE TEMPERATURES	SDPC	

Figure 3. Summary of Operating Activities (continued)

TURBINE ACTIVATION

CONTROL ROOM RELATED OPERATOR (CO) ACTIONS	EQUIP.	NON-CONTROL ROOM RELATED OPERATOR (PEO) ACTIONS
• ROLL TURBINE AND HOLD AT 1000 RPM	TURBINE PANEL	• SOUND TURBINE
• MONITOR TURBINE SPEED, TEMPERATURES AND VIBRATIONS	SDPC	
• ROLL TURBINE TO SYNCHRONOUS SPEED	TURBINE PANEL	
ON LINE		
• SYNCHRONIZE GENERATOR	TURBINE	
• NOTIFY DISPATCHER	PANEL	
TRANSFER TO PRESSURE CONTROL		
• INCREASE LOAD TO CLOSE STEAM DUMP VALVE	TURBINE PANEL OR SDPC	
• "ENABLE" STEAM DUMP	SDPC	
• ADJUST TURBINE PRESSURE CONTROL DIALS	TURBINE PANEL OR SDPC	
• PLACE TURBINE EXTRACTIONS IN SERVICE	SDPC	• VERIFY NON RETURN VALVES OPEN • CONDUCT NON RETURN VALVE TEST
"STEADY STATE" OPERATIONS		
• ADJUST STEAM TEMPERATURE AND PRESSURE SET POINTS (AS REQ'D)	SDPC	• CONDUCT WATER/STEAM CHEMISTRY CHECKS (CHEM TECH)
• SWITCH COLLECTOR AIM POINTS	HAC CONSOLE OR OCS	• CHECK TURBINE NON RETURN VALVES

Figure 3. Summary of Operating Activities (continued)

TURBINE/RECEIVER SHUTDOWN - 1

CONTROL ROOM RELATED OPERATOR (CO) ACTIONS	EQUIP.	NON-CONTROL ROOM RELATED OPERATOR (PEO) ACTIONS
<u>TURBINE OFFLINE</u>		
• "DISABLE" STEAM DUMP SYSTEM	SDPC	
• REDUCE LOAD	TURBINE PANEL OR SDPC	
• REMOVE GENERATOR FROM GRID (LOW LOAD CUTOFF OR OPERATOR ACTION) AND ADJUST CONTROL DIALS	TURBINE PANEL OR SDPC	• PLACE TURBINE ON TURNING GEAR (WHEN TURBINE STOPS SPINNING) • RACK OUT GENERATOR BREAKER • STOP SECOND LUBE OIL PUMP
• TRANSFER RECEIVER FLOW BACK TO FLASH TANK	SDPC AND HAC CONSOLE OR OCS	
• ADJUST RECEIVER TEMP SET POINT FOR COOLDOWN	SDPC	
• "DEFOCUS" COLLECTOR FIELD	HARDWIRE PUSH BUTTON	
• MONITOR RECEIVER TEMPERATURES DURING AMBIENT COOLDOWN	SDPC	
• STOP RECEIVER FEED PUMP	SDPC	• CLOSE SUCTION VALVE • SHUTOFF SEAL WATER • CLOSE LV73C BLOCK VALVE
• STOW COLLECTOR FIELD	HAC CONSOLE	

Figure 3. Summary of Operating Activities (continued)

PUMP SHUTDOWN TO MODE 8 - 1

CONTROL ROOM RELATED OPERATOR (CO) ACTIONS	EQUIP.	NON-CONTROL ROOM RELATED OPERATOR (PEO) ACTIONS
CIRC PUMP SHUTDOWN		
• SHUT DOWN ONE CIRC WATER PUMP	SDPC	• THROTTLE COOLING TOWER RISER LINE TO PUMP DISCHARGE PRESSURE TO 18PSI • CLOSE BLOCK VALVE ON COOLING TOWER FILL VALVE • SHUTOFF CIRC WATER FLOW TO CORROSION RACK
TURBINE SEALS/VACUUM SYS SHUTDOWN		
• STOP AIR REMOVAL PUMP	SDPC	
• OPEN GN_2 SUPPLY TO THE CONDENSER	SDPC	• VALVE IN GN_2 TO CONDENSER AND DEAERATOR
• SECURE TURBINE SEALS	SDPC	
• STOP GLAND SEAL EXHAUSTER	SDPC	
• STOP CONDENSATE PUMP	SDPC	• THROTTLE CONDENSATE PUMP DISCHARGE • OPEN CONDENSATE RECIRC. • SHUTOFF HOTWELL MAKEUP LINES • SHUTOFF CONTROL POWER TO ELECTRIC BOILER (IF REQ'D) • VALVE IN GN_2 TO FEEDWATER HEATERS • CLOSE CIRC WATER SUPPLY AND RETURN VALVES AT THE BEARING COOLING WATER HEAT EXCHANGER • ATTACH SERVICE WATER (HOSE) TO BEARING COOLING WATER HEAT EXCHANGER IF REQ'D (SUMMER)
• STOP LAST OPERATING CIRC WATER PUMP	SDPC	

Figure 3. Summary of Operating Activities (continued)

IV. CONCEPT DEFINITION

The remoting of Solar I monitor and control functions to the Coolwater Generating Plant, a distance of approximately two miles, was examined for each of the following two capabilities:

a. Alternate 1 - Provide SDPC, HAC and OCS stations at Coolwater with the required duplicated set of emergency trip hand-switches.

b. Alternate 2 - Provide only HAC and OCS stations at Coolwater with the required duplicated set of emergency trip hand-switches.

The Alternate 1 concept provides two levels of control and monitoring (automatic and manual) using displays, keyboards, switches identical to those found in the Solar I control room. The Alternate 2 concept provides two levels of plant control for the collector subsystem (OCS automatic and HAC manual) and one level of plant control (OCS automatic) for the other major subsystems (i.e. receiver, EPGS, TSS, BOP). The displays, keyboards and switches used in the Alternate 2 concept are also identical to those used in the Solar I control room.

Because the turbine-generator controls at Solar I are manual controls, the ability to perform the control and monitor functions through the SDPC at Solar I are required for both Alternate 1 and Alternate 2 concepts.

Command, monitor, and handswitch functions to and from the Coolwater remote control room and the Solar I plant will be transmitted over hardwire for both alternate concepts using appropriate line drivers, line receivers and modems as required.

A. Alternate 1 Concept Definition

The Alternate 1 concept provides the approach to remote monitor and control Solar I which deviates the least from the monitor and control system and operator practices now in use at Solar I. In order to implement this concept at least one Subsystem Distributed Process Control (SDPC) operator station with report logger, one Heliostat Array Controller (HAC) station, and an Operational Control System (OCS) station would be remoted at the Coolwater Generating Plant along with the appropriate emergency handswitches. The following paragraphs define the requirements for each station.

1. SDPC Operator Station

To understand the remoting requirements for an SDPC operator station an explanation of the SDPC hardware and functions at Solar I needs to be presented. The SDPC consists of three Beckman Model MV 8000 systems modified to allow any one, or combination, of up to four operator stations to communicate with each of the three MV 8000 systems. A schematic of this configuration is shown in Figure 4. The operator station, being micro processor organized, accomplishes this task via digital processors that communicate with each MV 8000 system in combination with a three position manual select switch (Console Access Processor or CAP) located at each operator station.

Each MV 8000 system data base is assigned to a specific control, monitoring and reporting function. One system data base is assigned to control and monitor the Receiver Subsystem, a second system and data base controls and monitors the Thermal Storage Subsystem, and the third MV8000 system and data base controls and monitors the Electrical Power Generation Subsystem and Balance of Plant (e.g. turbine-generator, water makeup, demineralization, etc.).

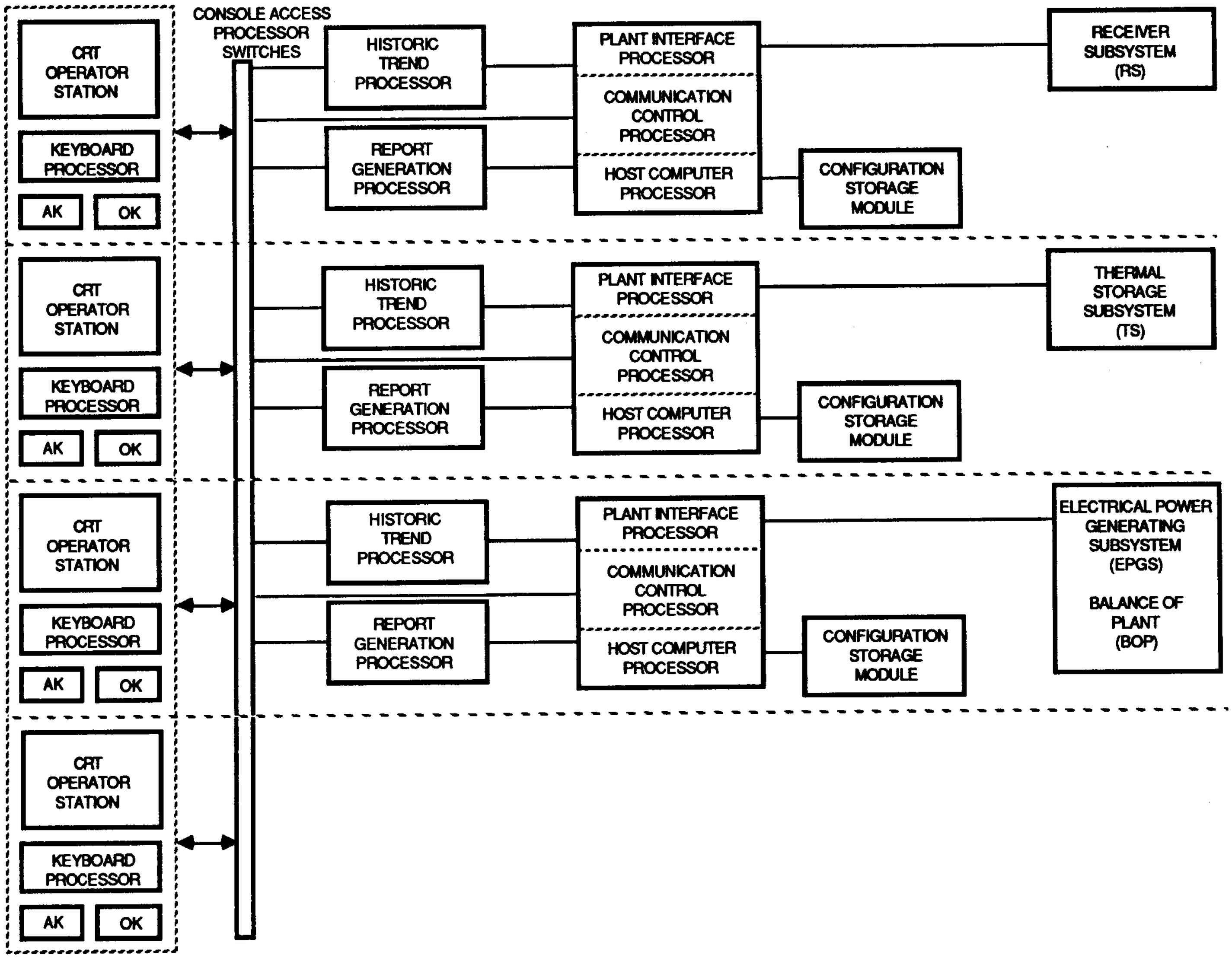


Figure 4. Simplified Subsystem Distributed Process Control Configuration – Solar 1

Usually one of the four operator stations services one of the three MV8000 system and the corresponding plant subsystem data base. The fourth operator station is used as a "Rover" station and provides: 1) an auxillary display monitor and control operator station for any one of the three MV8000 systems and 2) a backup station in the event one of the other stations becomes inoperative.

Each MV8000 system is supported by a logger/printer, used to record in hardcopy form the operator commands, system alarms and shift reports. Only one logger/printer can be physically and logically assigned to an MV8000 system. Hence, three logger/printer devices are connected to the SDPC at Solar I.

For the Alternate 1 remoting configuration, the SDPC system role would be a backup to the Operational Control System (OCS) and provide the operator adequate capability to monitor and control elements of a subsystem manually and semiautomatically, but in a manner less responsive than the local Solar I SDPC four station capability. The primary mode of operating Solar I remotely would be through the Operational Control System. Use of the SDPC would be in the event of an OCS failure. Acknowledging a reduction in control command and response performance to the operator, a minimum single operator station configuration is judged to be adequate. As a backup system, however, this configuration would probably not be adequate by itself to manage a plant emergency. The subsystem safety systems, the OCS and HAC software and/or local onsite Solar I personnel would have to support plant emergencies.

The SDPC is currently at the maximum capacity of four operator stations. Major modifications would be required to expand the operator station capacity. Consequently, the most cost effective approach is to move the "Rover" station from Solar I to the Coolwater remote site. A spare Plant Graphics Processor (PGP), currently not used at Solar I would be remoted with the operator station. In addition, a slave printer, interfacing with the Solar I SPDC, through the CAP switch, would require independent connections to each of the three Report Generator Processors for the transmission of operational messages, reports, alarms and diagnostic messages to a hard copy logger/printer.

To remote the rover station to the Coolwater remote site, the following additions would have to be provided to the SDPC System:

a. Hardware
   1. Add full duplex 9600 modem pairs to twelve (12) digital communications links between the remote station and the CCM, HTP, RGP and logger/printer output for each of three M8000 sytems.
   2. Manufacture a control console for the remote station that properly houses the SDPC remoted equipment and provides space to house the HAC and OCS operator stations.

b. Software

   No new software or existing software modifications are required.

A block diagram of the SDPC local and remote configuration is shown in Figure 5.

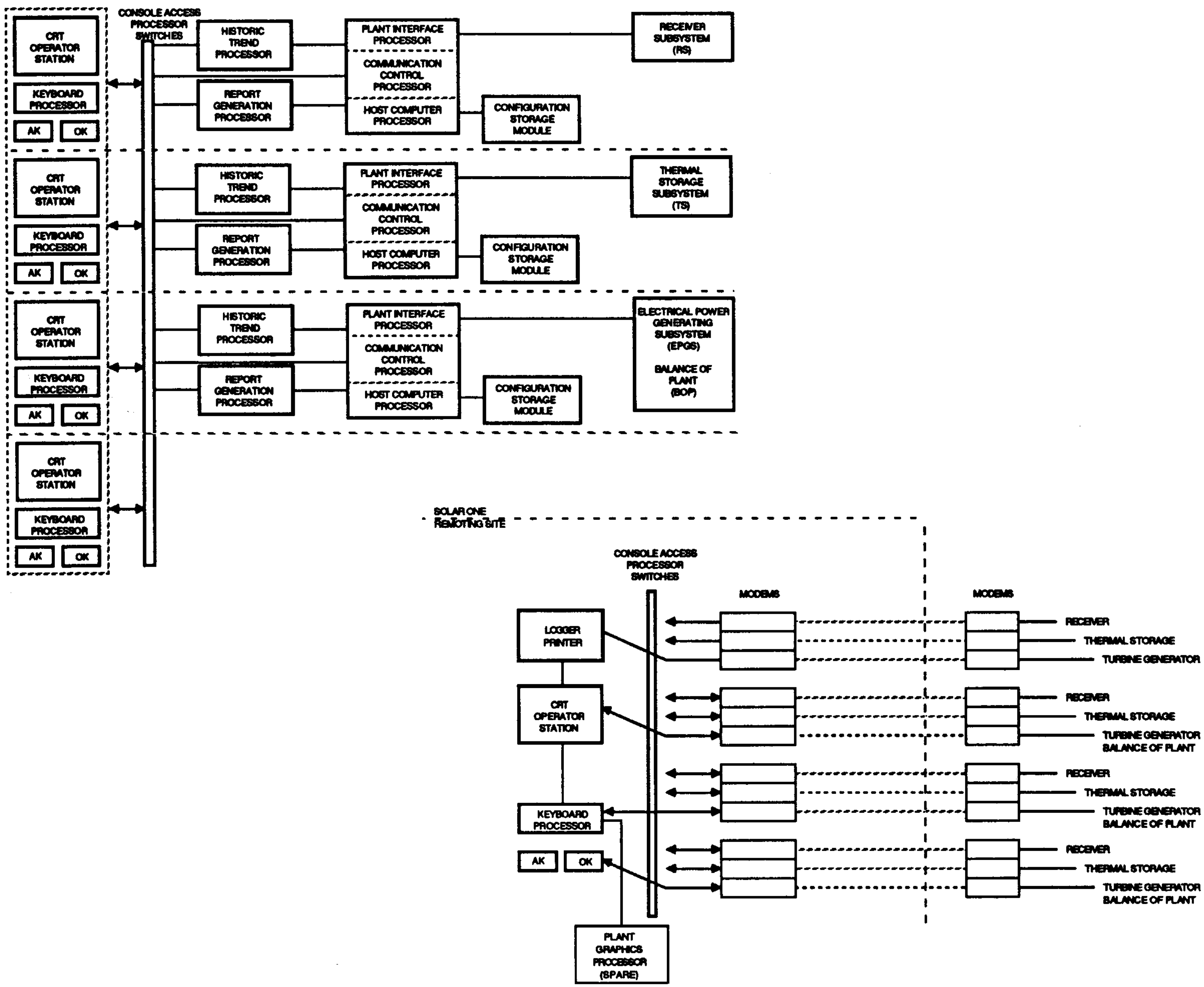


Figure 5. Simplified SDPC Local and Remote Configuration

2. <u>OCS Operator Station</u>

Primary operation of Solar I from the remoting site at Coolwater for Alternate 1 is through the Operational Control System. The OCS consists of a MODCOMP computer system Model 7863 digital computer with support peripherals. The computer interconnects to the SDPC, DAS and HAC computers for data and control and interacts with the operator(s) through two color display systems with keyboards supported by two logger/printers, and one additional color monitor for displaying trends. A block diagram of the OCS is shown in Figure 6.

The OCS contains applications software to perform near real time collector field control, supervisory control and automatic clear day operation. In all cases very little operator intervention is required to manage specific plant and subsystem operations. However, limited OCS control of the turbine-generator is currently available to the operator. A summary of plant automation functions and benefits is shown in Table 1.

To remote the OCS capability at the Coolwater Generating Plant and maintain the local OCS capability at Solar I the following changes must be incorporated into the OCS sytem:

a. Hardware

1. Add channel 3 and 4 electronics to the Aydin 5215 display generator for support of two additional OCS operator stations
2. Add two Aydin Model 5115A display editor keyboards.
3. Add two Aydin Model 5529 light pen assemblies.

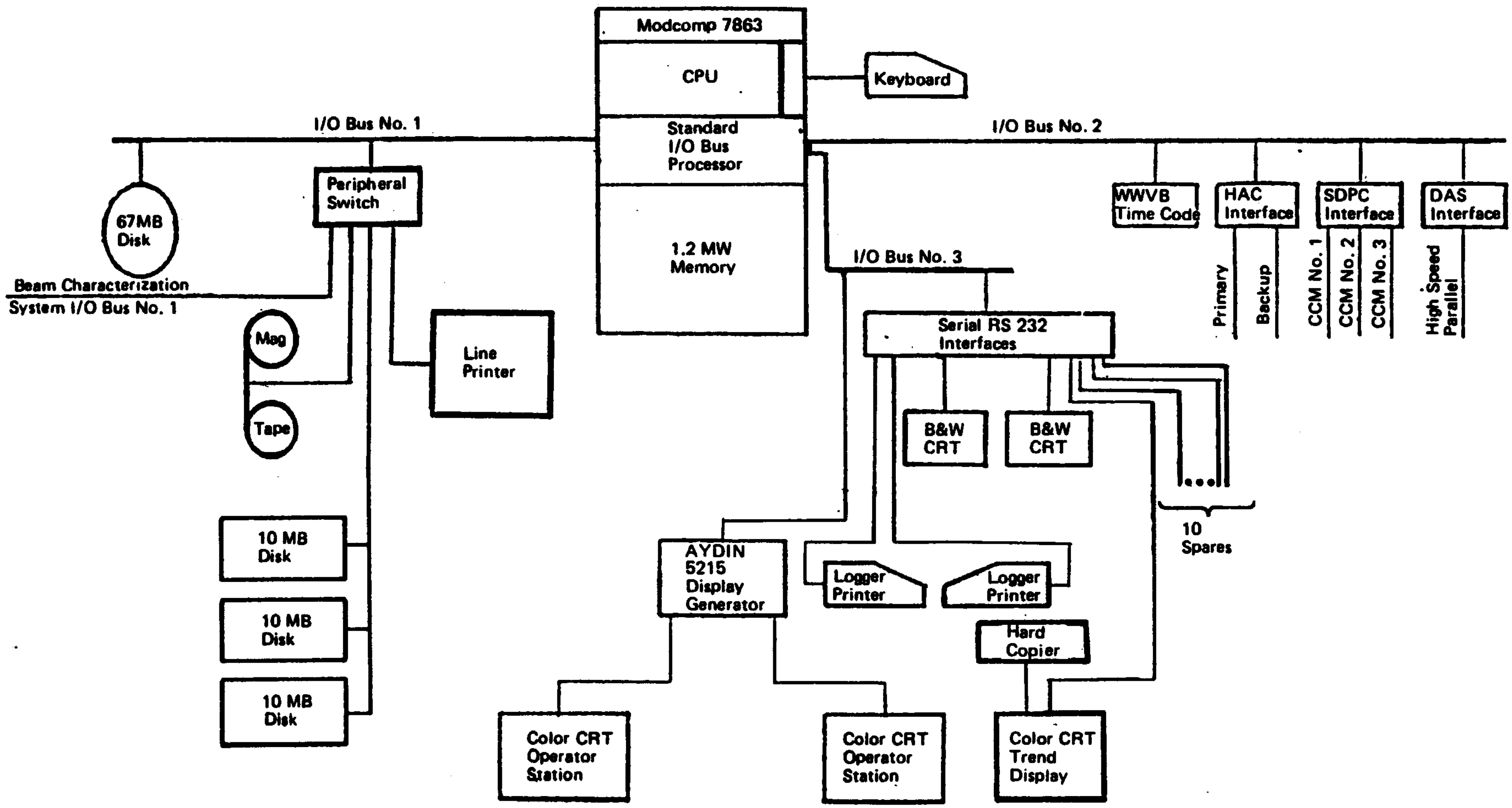


Figure 6. Operational Control System Block Diagram — Solar I

TABLE 1

PLANT AUTOMATION SUMMARY

Category	Description	Major Benefits
Supervisory Control	• Provides the operator with the capacity to automatically control and sequence the plant as desired for any one day with minimal real-time interaction by operator. • There are two levels of automation and control: clear day scenario and mode transitions.	• Decreases startup time of each system and plant compared to manual operation. • Improves the maximum operating performance of each system and plant. • Improves the net on-line operating time for each system and plant. • Reduces operator interaction with the plant. • Reduces operator workload. • Provides a uniform and consistent approach to plant operations.
Automatic Collector Aimpoint Control	• Provides the capability to control aimpoints in one of three modes: manual, semiautomatic, and automatic.	• Establishes required aimpoint set according to time of year and day. • Three modes of operation for flexibility. • Assures proper aimpoint set such that RS performance is maintained.
Plant Surveillance Functions	• Provides the operator with information regarding the current state of plant operation and operating efficiency in the form of alarm summaries, trends, operating status displays, and performance related displays.	• Provides operator visibility into all plant operations via one console. • Increases operator awareness of plant operating condition. • Provides visibility of automatic sequences in terms of major steps and which step is currently in progress.

TABLE 1 (continued)

PLANT AUTOMATION SUMMARY

Category	Description	Major Benefits
Plant Surveillance Functions (Continued)		• Provides high resolution trending of historical data. • Provides subsystem and overall plant efficiency measures which provide operator insight into ways of increasing efficiency. • Alarm summary consisting of all plant alarms which are color coded according to subsystem. • Allows operator to monitor and control the plant from an energy management and efficiency standpoint.
Man-Machine Interface (MMI)	• Provides the capability for the operator to monitor and control from one console all systems critical to overall plant operations. • Provides the capability for the operator to control the plant using OCS displays and application programs (supervisory control).	• Increase of display capability and display response time. • Operator access to all plant controls, alarms, and data via one console.
Automatic Collector Field Control	• Provides the capability to automatically regulate the collector field to achieve either startup full power, an intermediate power condition, a hot standby condition, or defocus of entire field.	• Decreases the RS startup time compared to manual operation. • Maintains RS flowrate within flash tank limit during startup. • Limits incremental power increases to minimize system disturbances.

TABLE 1 (continued)

PLANT AUTOMATION SUMMARY

Category	Description	Major Benefits
Automatic Collector Field Control (Continued)		• Rapidly transition back to acceptable flash tank operating power conditions in order to keep receiver on-line during disturbances. • Reduces the time and operator commands to achieve the desired power condition thereby improving output and performance.
SDPC Configuration Upload and Download	• Provides the capability to maintain the SDPC data base.	• Able to store current configuration for future reference or download. • Able to quickly verify the data base in case configurations are in question. • If data base gets "scrambled" for some reason, able to quickly download data base and resume operation. • Keep track of data base changes over periods of time.

4. Add two Aydin Model 8830 high resolution color monitors
5. Add interconnecting cabling between keyboards, monitors, light pens and display generator channels.
6. Add eight fiber optic cables with bidirectional signal line driving and receiving to providing remoting to 10,000 feet.
7. Add two logger/printers with RS 232 three wire cables and modems to remote terminals 10,000 feet.
8. Add one ISC Model 8001H color display system for parameter trending.
9. Add one printonix Model MVP to hardcopy the trend display.
10. Provide cabinets, cooling fans and racks to house and support the operator station hardware.

A block diagram of the OCS hardware system with remoted stations is shown in Figure 7.

b. Software

1. Modify existing OCS system software to accommodate two additional OCS operator stations and two additional logger printers.
2. Add applications software that allows control (e.g. warming, rolling, synchronizing, pressure or load control set point manipulation, generator power factor adjustment, and turbine shutdown) and monitoring of the automated turbine-generator functions.

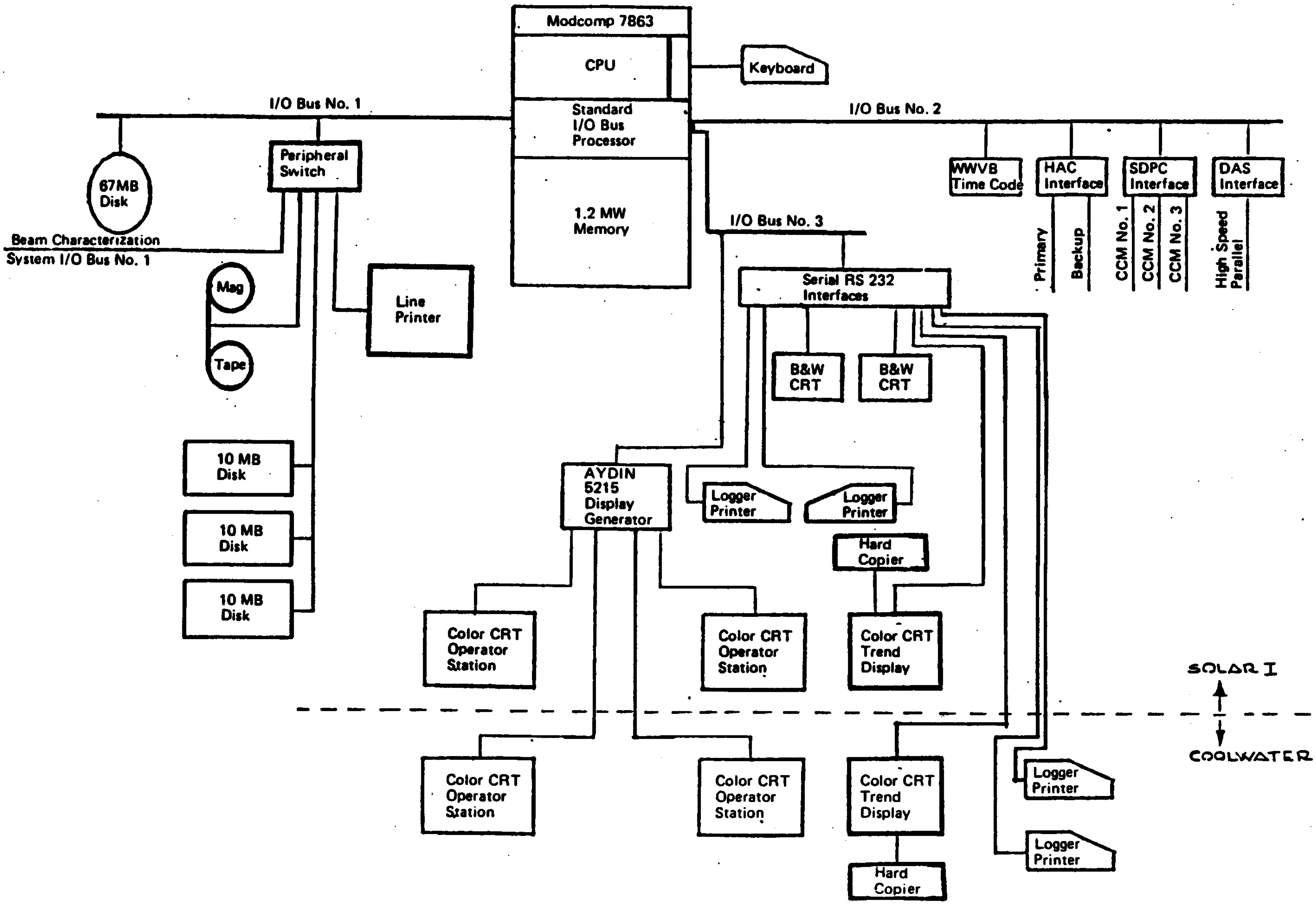


Figure 7. Operational Control System (OCS) with Remoted Station Block Diagram

3. Add protective software to the OCS that selects either remote or local operator stations for control access through the remote OCS operator station and provides a capability to determine and status of SDPC, OCS, DAS and HAC system availability before and during remote plant operation.

A pictorial chart of the OCS software with the additions and modifications for remoting is shown in Figure 8.

c. Operational Limitations

In keeping with the guideline to minimize new software development, the operation of the expanded OCS with the remoting capability will have limitations. These limitations are:

1. The "Bootstrap" loading of software into the OCS computer must be accomplished at Solar I. No capabilities will exist to bring the computer up and on line from a cold start at the Coolwater remote operator station.
2. The functional statusing of peripherals during operation must be accomplished from the Solar I site. Local equipment status lights (e.g. ready, offline, etc.) would not be remoted or conditioned to be monitored by a computer system. Equipment statusing would be limited to running the equipment diagnostics capabilities furnished as software by Modular Computer Systems Inc. before and during OCS operation.

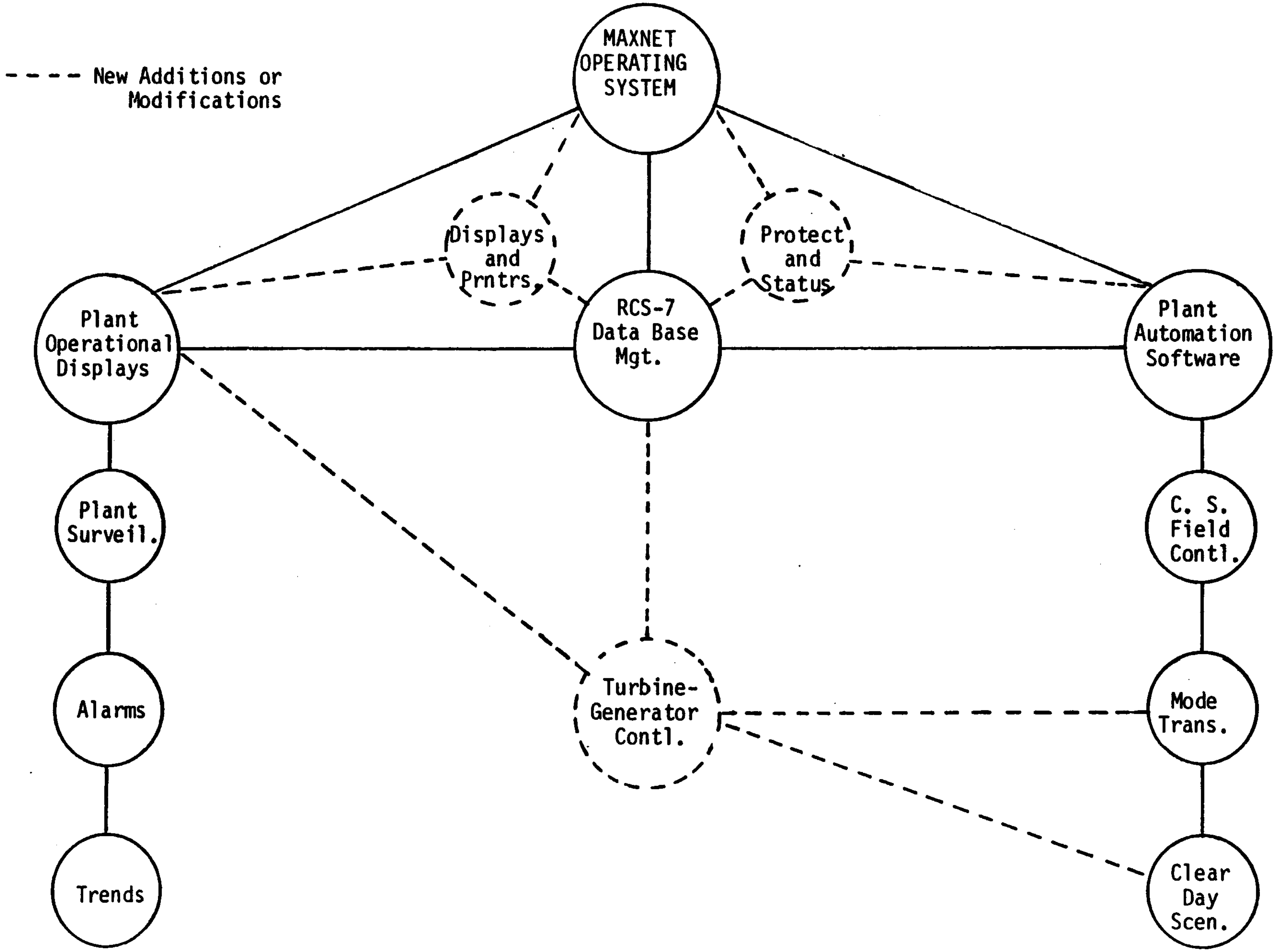


Figure 8. OCS Software Modifications for Remote Operation

3. Only the remote or local OCS operator stations will be active when OCS is operating. Selection of local or remote operation would be assigned from the remote Coolwater operator station.

4. The OCS uses DAS data to monitor plant functions. The DAS computer and associated data acquisition system front-end processors require initialization (booting up) occasionally. This operation would be done at the Solar I facility.

3. <u>Heliostat Array Controller Operator Station</u>

The operation of the collector fields can be accomplished from commands output by the OCS using OCS CRT displays with keyboards that communicate with the Operational Control System computer. However, direct control of the collector field from the Heliostat Array Controller (HAC) is required in the event the OCS to HAC communications link is lost.

The HAC is a redundant computer system comprised of two Modular Computer System Model 7861 minicomputers that communicate to the operator and between themselves via shared input and output hardware devices (i.e. peripheral control switches, shadow memory, and universal communications devices). A block diagram of the Dual-Redundant Heliostat Array Controller is shown in Figure 9.

One of the two HAC computers is declared by the operator as the prime controller and has the capability and capacity to control and monitor the collector field of 1818 heliostats as well as interact with the operator to accept field and heliostat commands and provide status information. The remaining HAC computer is designated as the backup controller. This computer, with the same capacity and capabilities as the prime HAC, mimics and monitors the primary HAC computer operations, but does not output commands or status information.

The switchover from the primary HAC to the backup HAC can occur one way automatically upon detection of a data base update latency that exceeds a preset time interval value. Reestablishing the redundancy following a fail over to the backup computer is an offline function that is accomplished with the collector field in the stow position.

Two modes of collector field control are available: One mode allows the plant operator to control the field and individual heliostats by typing commands at the HAC operator station; the second mode provides complete automatic control using time sequenced commands stored on computer disk memory and activated from the Operational Control System.

The applications software for the Heliostat Array Controller operates within the MAX IV/MAX NET operating system provided by Modular Computer Systems Inc. Memory resident routines interacting with external interfaces and a common data base, as shown in Figure 10, provide the intelligence for managing the collector field. The identical software configuration is resident in both HAC computers with only the data base differing in the backup HAC by a maximum time lag of one-half second.

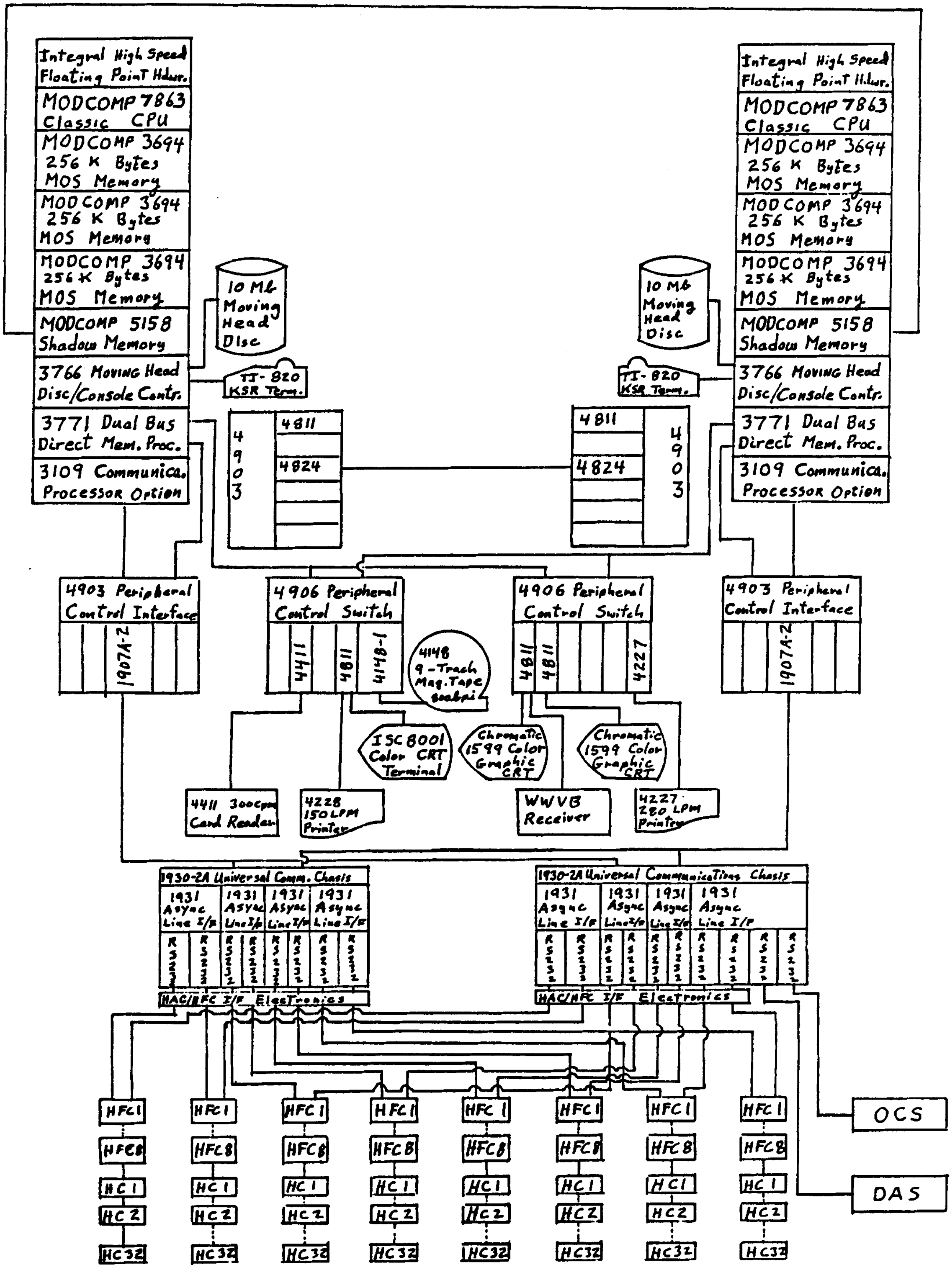


Figure 9. Redundant Heliostat Array Controller Block Diagram

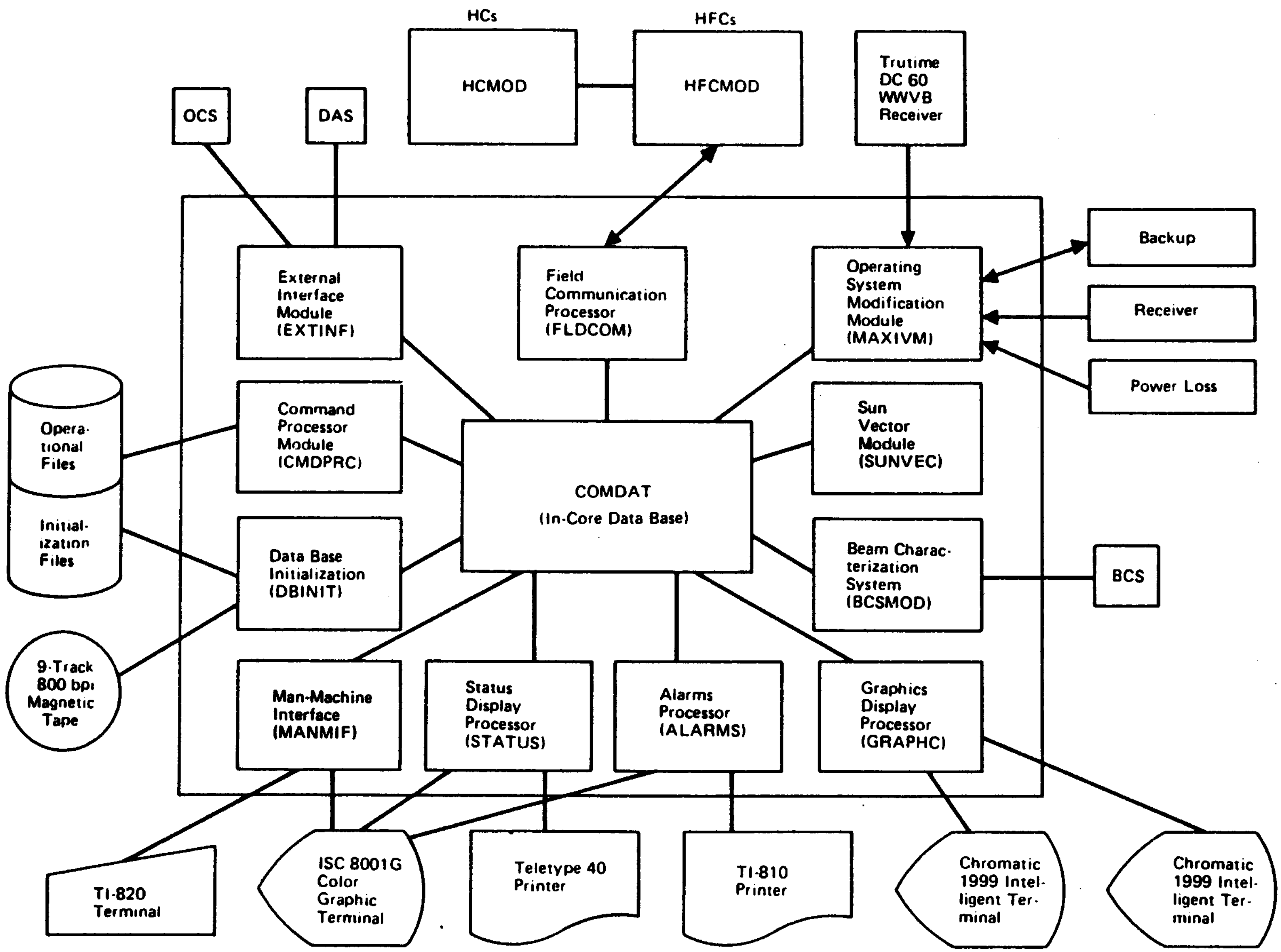


Figure 10. Heliostat Array Controller Software Structure

Remoting the Heliostat Array Controller monitor and controls capabilities for the Alternate 1 configuration requires hardware additions in the HAC. A duplicated HAC operator station would be provided at the remote Coolwater Generating Plant. The following changes and modifications would be required:

a. Hardware

1. Add an ISC 8001G color CRT display terminal to the HAC.
2. Add a TI-810 printer/logger to the HAC.
3. Relocate an existing redundant Chromatics 1599 color CRT monitor from Solar I to the remote Coolwater facility.
4. Add nine wires with modems for the remoted equipment from the HAC computers at Solar I to the control room at the Coolwater Generating Plant.
5. Provide an equipment rack for housing added communications equipment (i.e. modems, line drivers, line receivers, etc.) at Solar I.

A block diagram of the HAC hardware configuration with remoting capability is presented in Figure 11.

b. Software

1. Modify the HAC computer codes (MANMIF Software Module) to perform the operator station switching function between local (Solar I) and remote (Coolwater Generating Plant) operation.

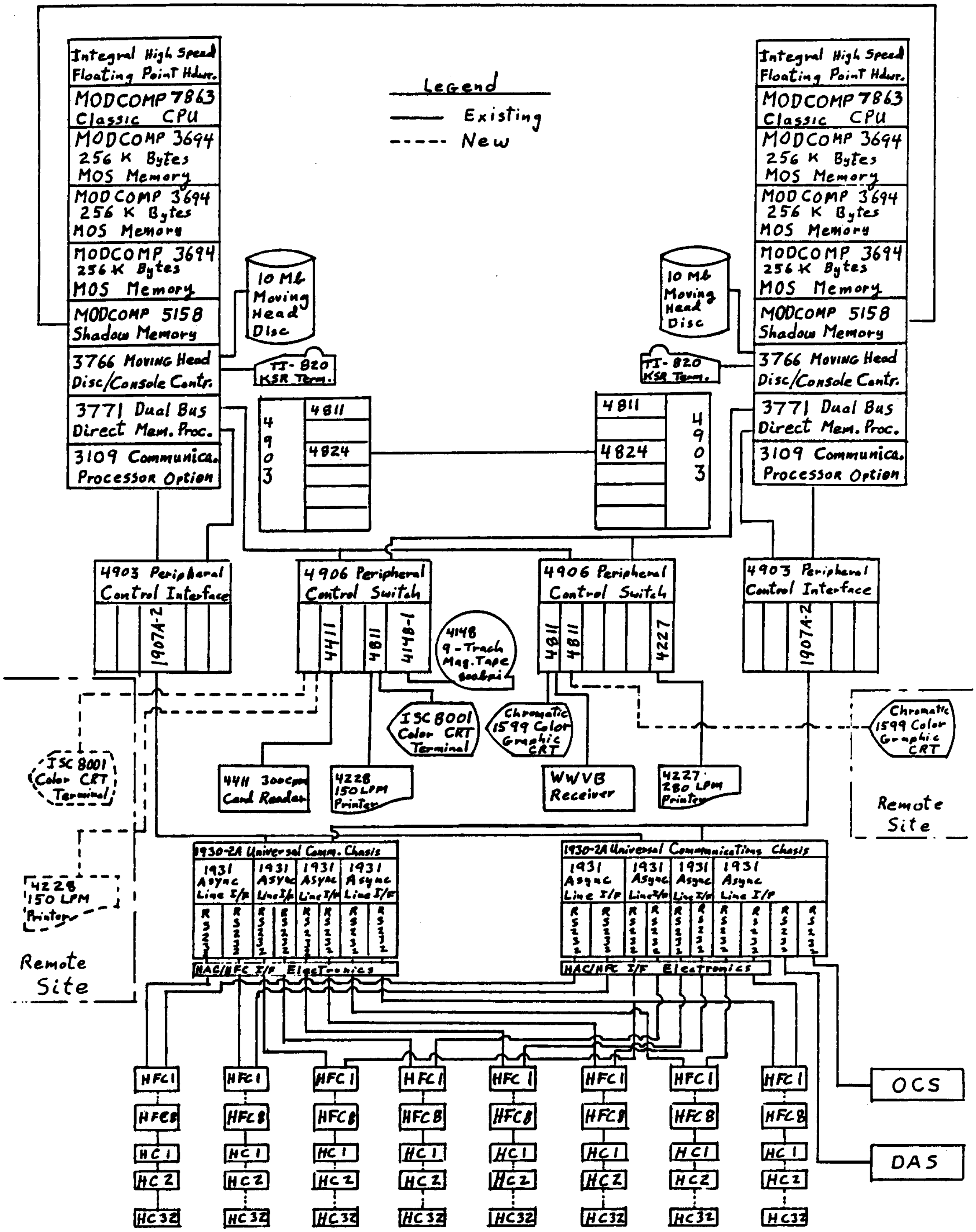


Figure 11. HAC Configuration with Remote Operator Station

2. Modify the MAX IV Operating System Generation to include the added ISC 8001G color CRT display terminal and the added TI 810 printer/logger terminal.

The HAC software structure concept that includes the software switching of operator stations is shown in Figure 12. A software switch designed into the HAC Computer Codes would perform the operator station switching function with software as proposed for the OCS operator station. This implementation method would reduce the wiring requirements between Solar I and the remoting site and on the surface appears simple to accomplish. However, even though the HAC software design is modular and the revisions required to select remote or local operation by a software switch are minor, there can be abnormal risk in modifying the software to perform the operator station switching. This is because adequate computer performance margins may not exist for program execution timing if major revisions are required. Software programs other than the MANMIF Modular (e.g. status, alarms, EXTINF, etc.) may require changes to implant the software switch. A proper assessment of the software change impact on HAC has not been conducted at this time.

c. Operational Limitations

There are limitations of operation associated with remoting the HAC operator station. These limitations are:

1. The collector field will only be monitored and controlled from one operator station as determined by the hardware or software switch selection position.

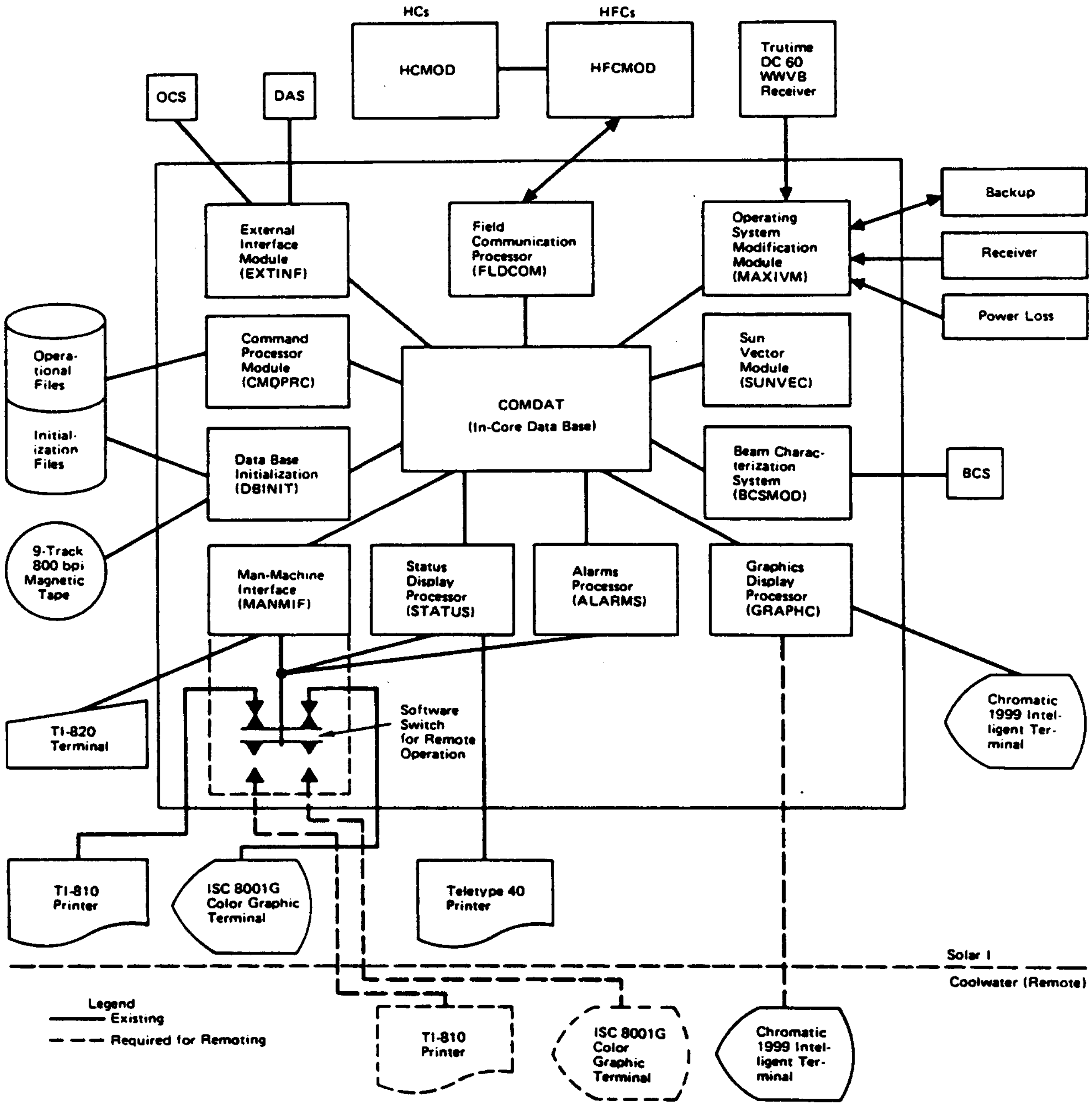


Figure 12. HAC Software Structure Concept with Remoting Capability

2. The hardware or software switching can only be done from the remote site.
3. The servicing of computer offline (e.g. command file update, source editing, computer rebooting, BCS candidate list entry, and running diagnostics) will be accomplished at Solar I.
4. The operation of the heliostat Beam Characterization System (BCS) in conjunction with the collector field will have to be initialized and started from the Solar I control room.
5. The statusing of HAC computer hardware (i.e. ready lights, power lights, etc.) will be accomplished at Solar I.

The HAC computers interface to the DAS, OCS and BCS computers. The operational integrity of the DAS and BCS interfaces with the HAC must be verified locally at Solar I. The OCS to HAC interface integrity will be verified running diagnostic tests that can be initialized through the remote OCS operator station and conducted by the OCS computer.

4. Turbine-Generator Control Operator Station

The operation of the turbine-generator system at Solar I is currently conducted from an operator analog manual panel board consisting of lighted indicators, push buttons, analog meters, and potentiometer adjustment knobs. Typical panels used in turbine-generator control are shown in Figure 13. Warmup rolling, sychronizing and loading the turbine-generator is accomplished manually by the control operator or assistant control operator from this large panel.

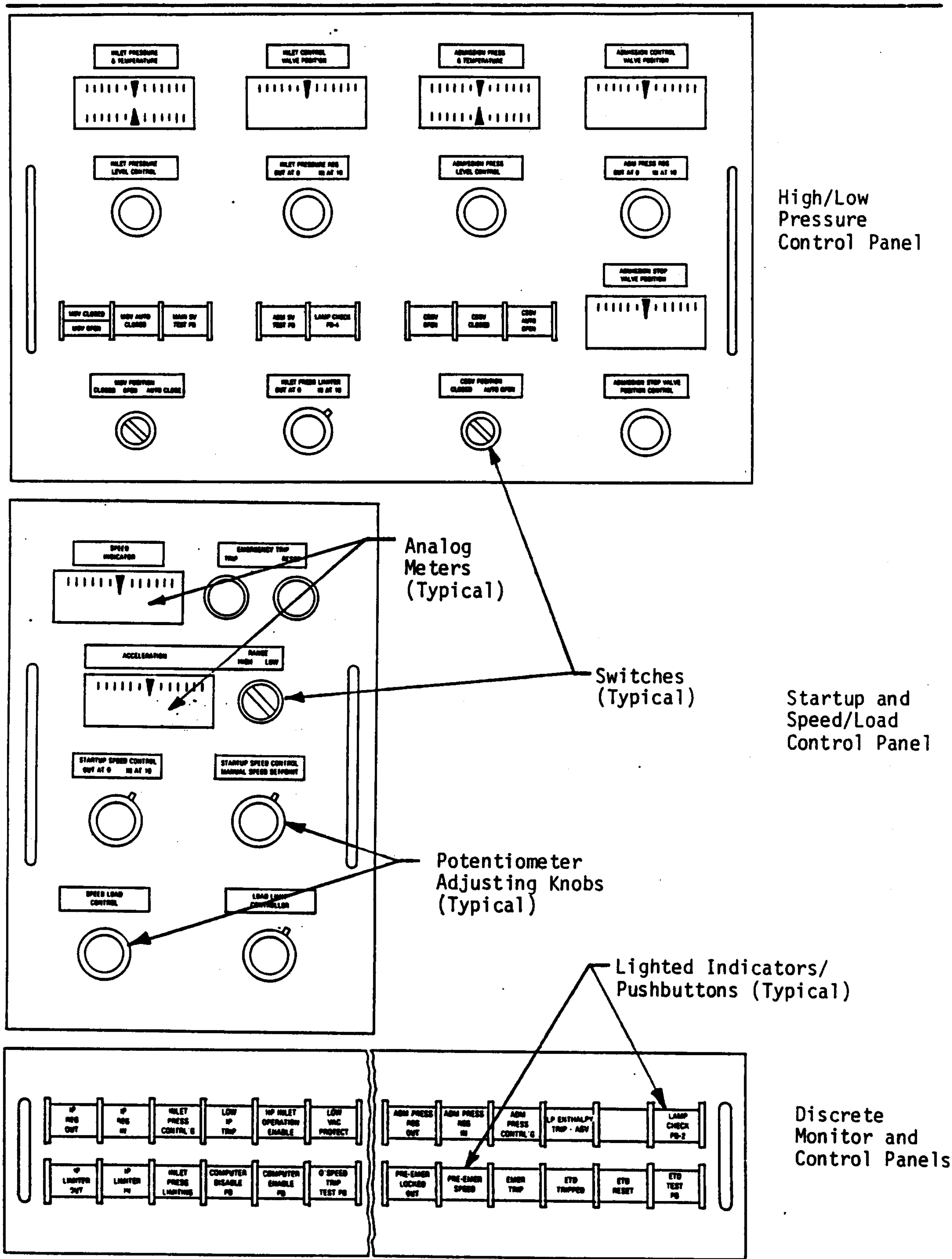


Figure 13. Solar I Turbine-Generator Monitor and Control Panels

A Plant Equipment Operator is sent to the turbine-generator set during startup to watch and listen for abnormalities (i.e. excessive vibration, seal leaks, verify local gage readings with panel readings, etc.) that could cause a hardware failure. Following generator sychronization, the turbine-generator can be controlled through the SDPC in the pressure control mode or manually at the turbine-generator panel in pressure control or load control modes.

The turbine-generator system is started manually from a cold, warm or hot condition following a prescribed procedure that includes defined metal soaking periods for each condition. The operator can manually select to warmup and roll the turbine from either the high pressure inlet (receiver subsystem) or the admission inlet (thermal storage subsystem) steam (above 500 PSIG). Turbine-generator shell temperatures, bearing oil pressures and steam pressures are monitored on the analog control panel and by the SDPC through an operator station color CRT display.

The basic functions for startup and speed control are shown in Figure 14. The Startup Speed Control (SSC) logic and generator sychronization with the utility grid system provided by the turbine-generator manufacturer are capable of automatic operation from the analog panel or Master Control (e.g. SDPC, ILS, OCS). However, the control wiring from the manual turbine-generator control panel switch, meter, and setpoint functions to the Master Control is not completed or checked out. Turbine-generator monitoring functions (e.g. shell temperatures, generator temperatures, etc.) are currently wired to Master Control and used by the SDPC and OCS color CRT displays, to characterize the operating status and alarm conditions of the turbine-generator system.

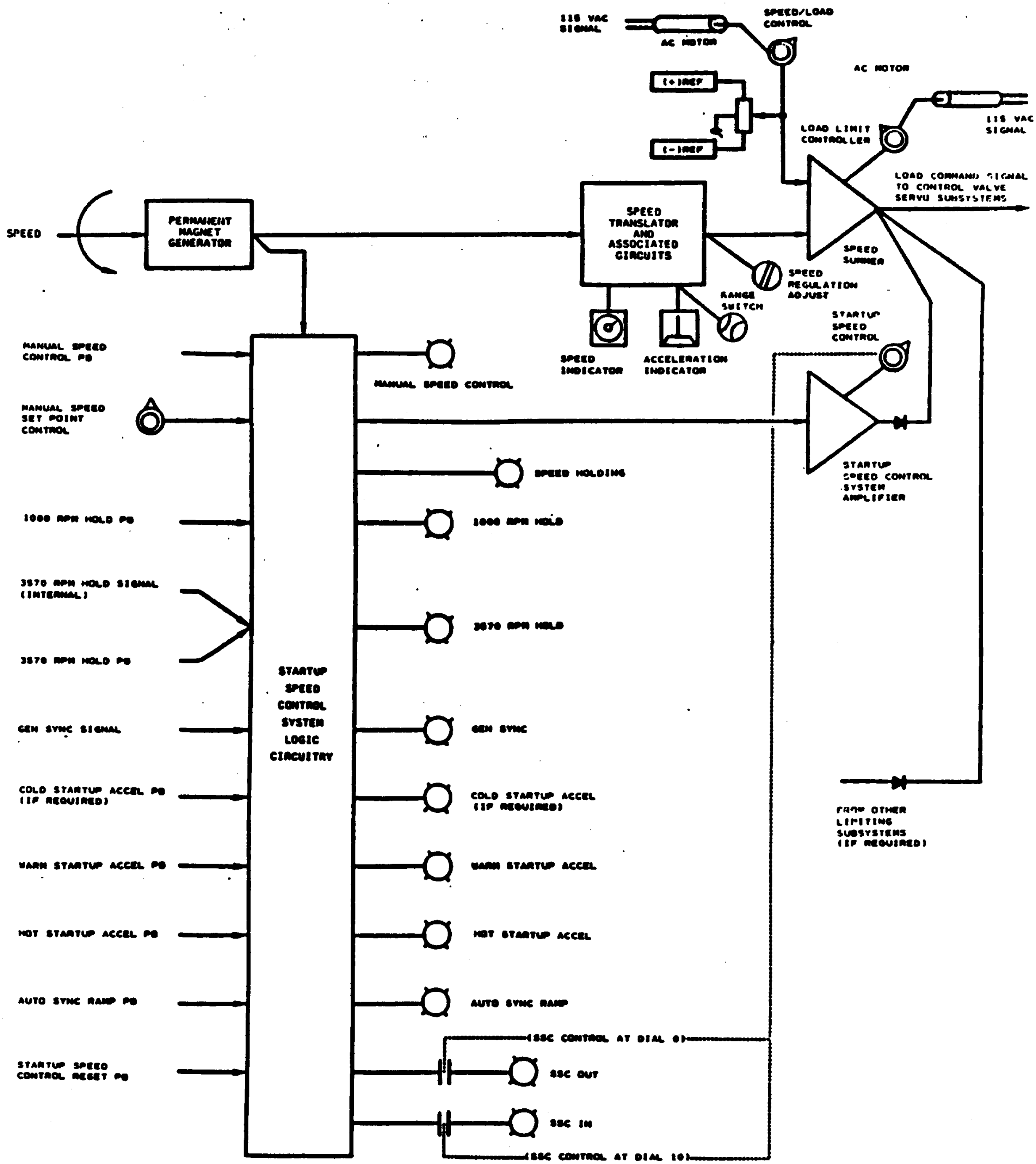


Figure 14. Turbine Startup Speed Control System Diagram

The following paragraphs describe the approach and changes or modifications which will be required to operate the turbine-genrator from a remote location through the SDPC and OCS.

a. Approach

The method selected for remote operation of the turbine-generator for the Alternate 1 concept is to establish the monitor and control in the SDPC and OCS instead of duplicating the present analog panels and functions at the remote site. This approach is considered the most feasible for the following reasons:

1. Duplicating the analog monitor and control panels at the remote site with the expectations of installing over 100 two wire functions a distance of approximately two miles would require: a) Significant design changes to existing turbine-generator logic to accommodate local/remote control sensing and switching and b) new design to provide long distance signal driving and receiving capabilities for the remoted turbine-generator monitor and control functions.
2. The turbine-generator monitor and control functions have been provided by the manufacturer that are adaptable to external control with automatic logic capabilities internally available for speed control and generator sychronization with the utility electrical grid.

3. A portion of the turbine-generator monitor functions have already been installed and used by the operators in the SDPC to monitor turbine-generator related activities. In addition, SDPC and ILS logic has been developed to operate the turbine-generator system in the pressure control mode following sychronization with the utility grid.
4. Cabling turbine-generator monitor and control functions to the SDPC and ILS requires short runs of several hundred feet all within the confines of the Solar I control building, substantially reducing long line communcations design and implementation costs.
5. Operating the turbine-generator through the OCS and SDPC as opposed to operating the machinery from the analog panels should reduce operator workload using automatic operating logic where possible.

b. Hardware

Provide hardware to completely control the turbine-generator from the SDPC.

1. Complete the wiring of the turbine-generator control monitor functions to the SDPC and ILS.
2. Procure and install the input/output hardware required in the ILS and SDPC to interface with the wiring to the turbine-generator panel and logic circuitry.

c. Software

Provide software to completely control the turbine-generator functions from the SDPC.

1. Establish the SDPC and ILS logic to safely operate the turbine-generator functions from an external source and conduct a checkout of the SDPC/ILS operation of the turbine-generator.
2. Design, code, and validate OCS supervisory software that integrates the turbine-generator automatic operation into the clear day scenario, mode transitions, and plant startup and shutdown capabilities.

A block diagram showing the remoting configuration for the turbine generator system is presented in Figure 15. The control and monitoring functions and their installation status in the ILS/SDPC systems to provide the basic remote automatic control capability for OCS are identified in Figure 16. There are an estimated sixty (60) control and monitor functions that need to be wired to the ILS/SDPC from the turbine-generator panel in order for the operator to manually (or automatically) perform the startup and turbine loading functions in the SDPC from the remote site.

5. <u>Trip Switch Panel</u>

There are seven trip switches and one reset switch located on four different panels within the Solar I operator control station. These panels and the switches are identified in Figure 17. The seven trip switches are comprised of: a) plant trip switch; b) receiver trip (RS) switch; c) Steam Dump (SDS) trip switch; d) thermal storage charging (charging trip) and thermal storage extraction (extraction trip) trip switches; e) turbine-generator (emergency trip) trip switch; and f) the collector field defocus trip switch. The reset switch is to reset a turbine-generator trip.

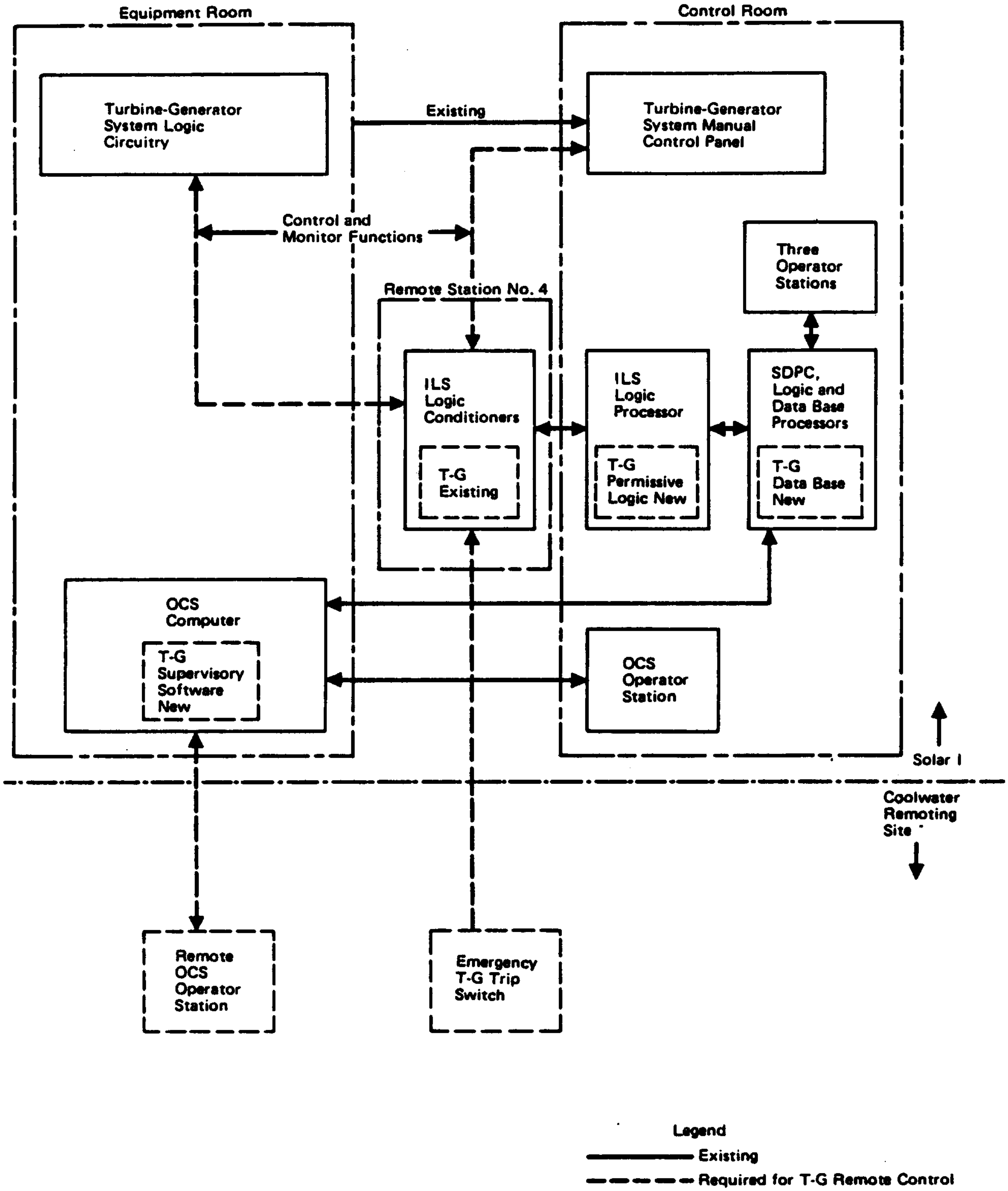


Figure 15. Turbine Generator Controls Remoting Configuration Block Diagram

STATUS
I = INSTALLED
N = NOT INSTALLED

PARAMETER NAME	FUNCTION	TYPE OF SIGNAL	MASTER CONTROL SYSTEM	STATUS
Remote/Local Control	Control	Digital	OCS/ILS	N
1000 RPM Hold PB	Control	Discrete	ILS	N
3570 RPM Hold PB	Control	Discrete	ILS	N
Cold Start Up Accel. PB	Control	Discrete	ILS	N
Warm Start Up Accel. PB	Control	Discrete	ILS	N
Hot Start Up Accel. PB	Control	Discrete	ILS	N
Auto Synch Ramp PB	Control	Discrete	ILS	N
Start Up Speed Control In/Out	Control	Analog	ILS	N
Speed/Load Control	Monitor	Analog	SDPC	I
Load Limit Controller Setpoint	Control	Analog	ILS	N
Start Up Speed Control Setpoint	Control	Discrete	ILS	N
Start Up Speed Control Range	Monitor	Discrete	ILS	N
1000 RPM Hold	Monitor	Discrete	ILS	N
3570 RPM Hold	Monitor	Discrete	ILS	N
Generator Synch	Monitor	Discrete	ILS	N
Cold Start Up Accel.	Monitor	Discrete	ILS	N
Warm Start Accel.	Monitor	Discrete	ILS	N
Hot Start Accel.	Monitor	Discrete	ILS	N
Auto Synch Ramp	Monitor	Discrete	ILS	N
Load Limit Control	Monitor	Analog	ILS	N
SSC Reset PB	Control	Discrete	ILS	N

Figure 16. Required T-G Control/Monitor Parameters for Remote Operation

STATUS
I = INSTALLED
N = NOT INSTALLED

PARAMETER NAME	FUNCTION	TYPE OF SIGNAL	MASTER CONTROL SYSTEM	STATUS
SCC Reset Lite	Monitor	Discrete	ILS	N
SCC Out	Monitor	Discrete	ILS	N
Speed Holding	Monitor	Discrete	ILS	N
Start Up Speed Control In Range	Monitor	Discrete	ILS	N
Speed	Monitor	Analog	SDPC	I
Computer Enable Switch	Control	ON/OFF	SDPC	I
Main Inlet Pressure Control	Control	Analog	SDPC	I
Admission Inlet Pressure Control	Control	Analog	SDPC	I
Generator Temperature Control	Control	Analog	SDPC	I
Turbine Lube Oil Cooling	Control	Analog	SDPC	I
Turbine Shell Temperatures	Monitor	Analog	SDPC	I
Main Inlet Pressure Regulator - IN/OUT	Control	Analog	SDPC	I
Admission Inlet Pressure Regulator - IN/OUT	Control	Analog	SDPC	I
Admission Stop Valve Position Control	Control	Analog	SDPC	I
Speed Load Control Setpoint	Control	Analog	SDPC	I
Inlet Pressure Limiter Control IN/OUT	Control	Analog	ILS	N
Inlet Pressure Limiter Control	Monitor	Analog	ILS	N

Figure 16. Required T-G Control/Monitor Parameters for Remote Operation (continued)

				STATUS
				I = INSTALLED
				N = NOT INSTALLED

PARAMETER NAME	FUNCTION	TYPE OF SIGNAL	MASTER CONTROL SYSTEM	STATUS
MSV Closed	Monitor	Discrete	ILS	N
MSV Open	Monitor	Discrete	ILS	N
MSV Auto Closed	Monitor	Discrete	ILS	N
MSV Position Control	Control	Discrete	ILS	N
CSBV Open	Monitor	Discrete	ILS	N
CSBV Closed	Monitor	Discrete	ILS	N
CSBV Auto Open	Monitor	Discrete	ILS	N
CSBV Position Control	Control	Discrete	ILS	N
V1 Speed/Load Contr. Limit	Monitor	Discrete	ILS	N
V2 Speed/Load Contr. Limit	Monitor	Discrete	ILS	N
+30 VDC Standby PS	Control	Discrete	ILS	N
+30 VDC Standby PS ON	Monitor	Discrete	ILS	N
-22 VDC Standby PS	Control	Discrete	ILS	N
-22 VDC Standby PS ON	Monitor	Discrete	ILS	N
+26 VDC Standby PS	Control	Discrete	ILS	N
+26 VDC Standby PS ON	Monitor	Discrete	ILS	N
Generator Field Breaker	Control	Discrete	ILS	N
Generator Field Breaker Position	Monitor	Discrete	ILS	N
Voltage Regulator	Control	Discrete	ILS	N
Voltage Regulator	Monitor	Discrete	ILS	N
Turbine Trip Reset	Control	Discrete	ILS	N

Figure 16. Required T-G Control/Monitor Parameters for Remote Operation (continued)

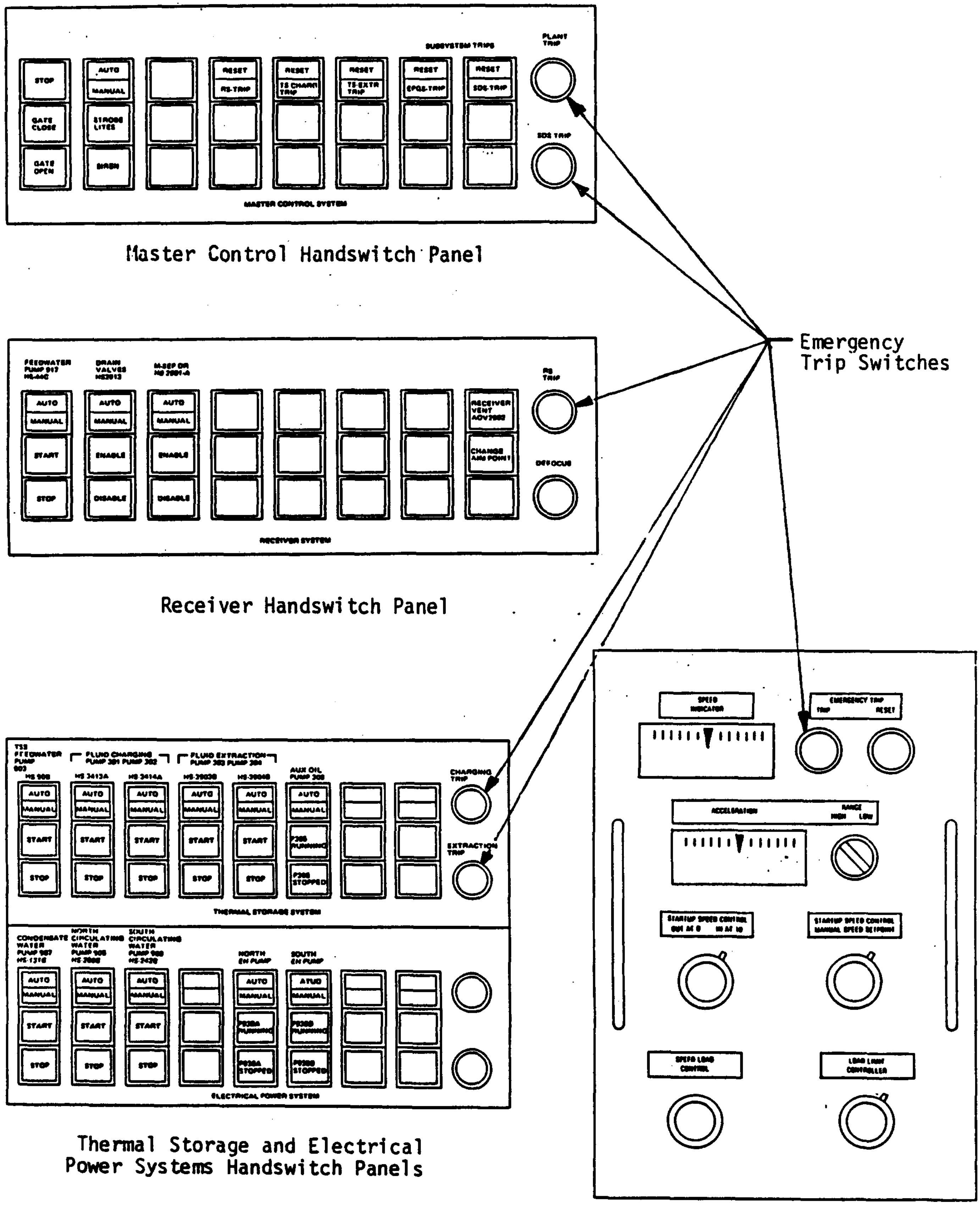


Figure 17. Solar I Handswitch Panel Layouts

The trip switches are hardwired to the plant trip box and also to the Interlock Logic system (ILS) where the functions are transformed to a digital form that is displayed within the SDPC and OCS systems. The switch functions cannot be activated from the SDPC or OCS with the current design implementation.

For remoting the seven trip functions, the following hardware and software tasks must be completed.

a. Hardware
   1. Provide a single panel that contains the eight function push buttons required for the seven trips defined above and one turbine-generator reset.
   2. Add ILS logic hardware at the Coolwater remote site to accommodate the activation of the trip functions.
   3. Add wiring and ILS logic hardware from the ILS at Solar I to the plant trip box and that allows activation of the seven trip functions and one reset from the ILS/SDPC system.
   4. Modify the plant trip logic box to add relays or relay contacts to accommodate parallel activating functions and provide adequate isolation of the remote inputs.

b. Software
   1. Add logic and data base in the ILS and SDPC systems that allows activation of the seven trip functions and one reset from the remote site.

2. Add software in the OCS to status the trip and reset functions transmitted from the remote site.

A diagram of the mechanization of the remote hand switch panel is shown in Figure 18. The Solar I hand switches are hardwired to the Plant Trip Box with status information fed back to the ILS and subsequently the SDPC and OCS systems. The remoting of the hand switches at Coolwater would be accomplished in a different way to minimize cabling over long distances (approximately two miles) and reduce the affects of electrical noise. The remote hand switch panel would be wired to ILS input and output conditioning equipment at the Coolwater remote location as an extension of the Solar I site ILS system. This extension would be connected to the main interlock logic system by a single coaxial cable. Added logic, data base, and software in the ILS, SDPC and OCS would provide the linkage between these systems. Additional wiring from existing ILS input and output conditioners in remote station 4 at Solar I to the plant trip box would complete the connections.

6. <u>Alternate 1 Concept Remote System Configuration</u>

a. Remote Site (Coolwater)

The remote system configuration for the Alternate 1 concept would consist of adding the following elements at Coolwater:

1. SDPC
    a. One Beckman MV8000 Operator Station Color CRT Display
    b. One Beckman MV8000 Operator Station Annunciator Keyboard
    c. One Beckman MV8000 Operator Station Touch Keyboard

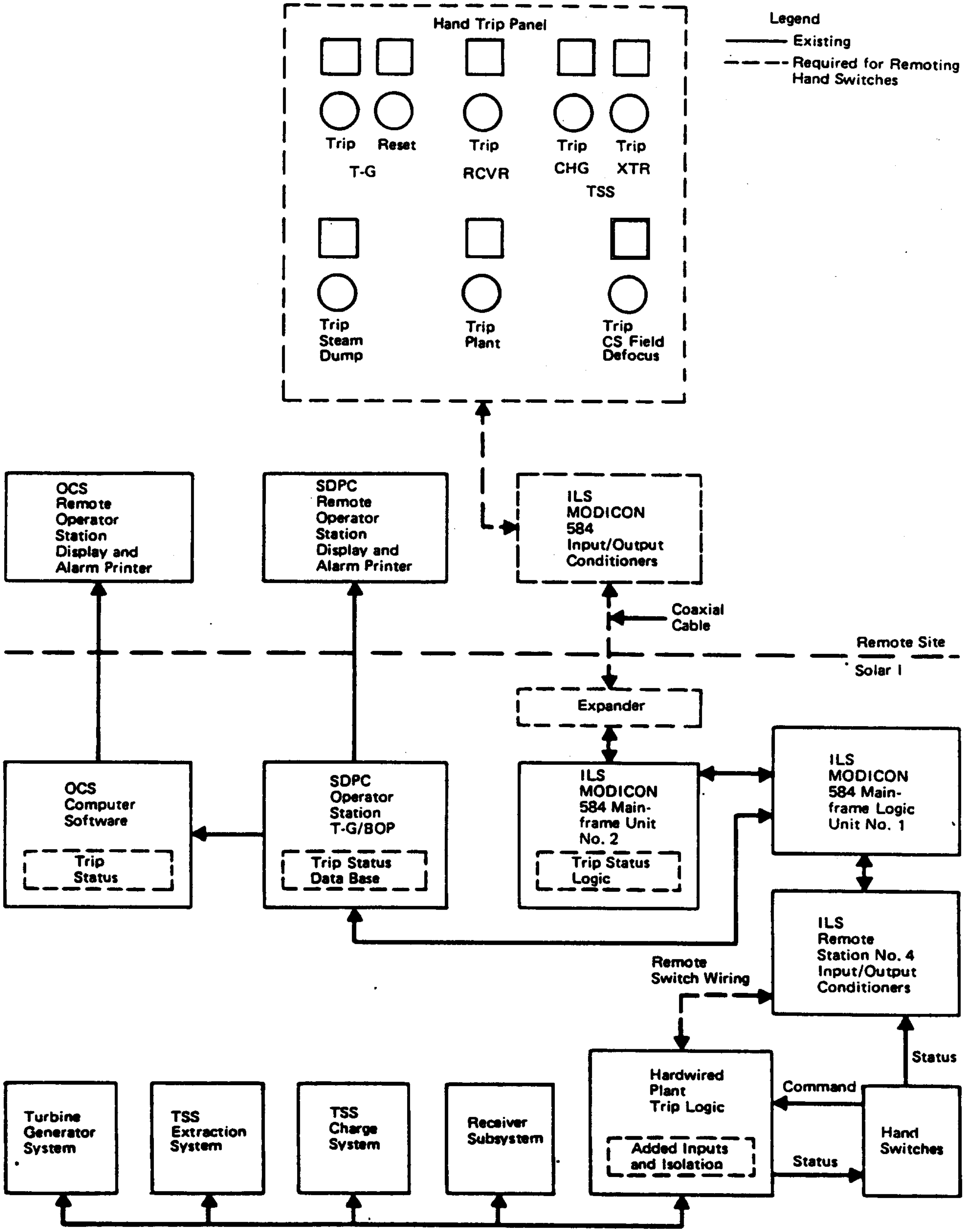


Figure 18. Remote Station Trip Hand Switch Mechanization

d. One Beckman MV8000 Operator Station Logger/Printer

e. One Beckman MV8000 Communications Access Processor switch

f. One Beckman MV8000 Light Pen

2. OCS

a. Two Operator station AYDIN 8830 Color CRT Displays

b. Two Operator Station AYDIN 5115A Keyboards

c. Two Operator Station AYDIN 5529 Light Pens

d. Two Texas Instruments 810 Logger/ Printers (or equivalent)

e. One ISC 8001G Color CRT Monitor

f. One Printonix MVP Hardcopier

3. HAC

a. One Operation Station ISC 8001G Color CRT Displays with Keyboards

b. One Operator Station Texas Instruments 810 Logger/Printer (or equivalent)

c. One Operator Station Chromatics 1599 Color Graphics CRT Display System

4. Trip Panel

One Custom Hand Switch Trip Panel consisting of Eight (8) switches and Eight (8) light indicators

5. Console

   One Operator Station Custom Console to accommodate the SDPC, OCS, HAC and trip panel hardware

6. Support Equipment

   a. One Modicon 584 I/O Module Housing with I/O wire terminals, MODBUS connectors and power supply to service the remote trip panel

   b. Two Modicon B260 analog output modules to service trip panel hand switches

   c. Two Modicon B243 Analog Input Modules to service trip panel light indicators

   d. Thirty (30) short haul RAD Model SRM-6D Modems to service two ISC 8001G color CRT displays, one SDPC operator station, and four TI 810 logger/printers over long distance

   e. One Wire Termination J-Box for communication wiring termination

   f. Two 19" x 24" x 60" closed cabinets to house support equipment

A block diagram of the remoting station hardware concept is shown in Figure 19.

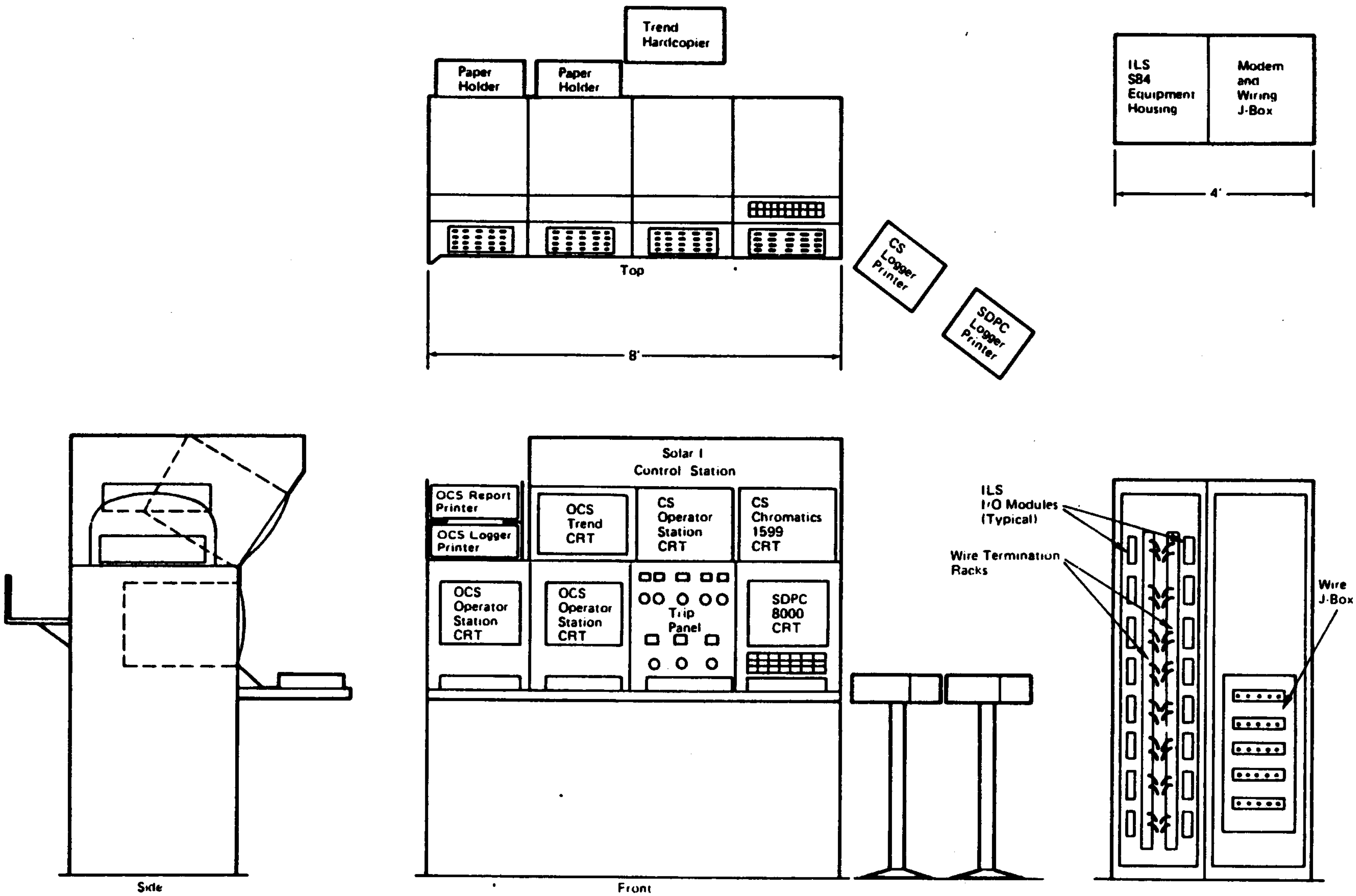


Figure 19. Remote Station Hardware Layout Alternate 1 Concept

b. Solar I Modifications

The configuration changes and additions within the monitor/control equipment at Solar I consists of the following elements:

1. SDPC/ILS
   a. Remove "Rover" operator station from the SDPC console for use at the remoting station and fill the vacated CRT display station with the receiver subsystem operation station.
   b. Cover annunciator keyboard and operator keyboards with metal plates.
   c. Add logic and data base to accommodate turbine-generator functions.
   d. Add eight (8) Modicon B260 Analog Output Modules and eight (8) Modicon B243 input Modules.
   e. Move OCS ISC 8001G CRT trend/x-y monitor to former Receiver Subsystem operator station location.
2. OCS
   a. Add two (2) AYDIN 5215A display generator circuit board channels to the existing four channel display generator controller.
   b. Add software to monitor and control the turbine-generator system.
   c. Add software to monitor and control receiver startup and shutdown functions.

d. Add software to incorporate the software switching function for remote or local terminal activation.

e. Generate a new system configuration to include the remote operator station hardware (e.g. three CRT display units and two logger/printers)

f. Add diagnostic software that appraises HAC, DAS, and SDPC availability.

g. Add software to status the remote trip functions.

h. Add one (1) Artel Communications Corporation Model 2016/2017 Fiber Optics Computer Graphics RGB Video and data interface module.

3. HAC

a. Remove Chromatics 1599 Color Graphics Terminal from DAS evaluation room (remoted at the Coolwater Generating Plant)

b. Relocate existing MODCOMP 4811 Asychronous Controller from a 4903 Peripheral Controller interface and place in vacant slot a 4906 Peripheral Control switch to service remote ISC 8001G CRT display terminal and logger/printer.

c. Modify system generation to include the added ISC 8001G CRT display terminal and the TI 810 logger/printer terminal.

d. Modify HAC software codes to incorporate a software switch for selecting remote or local HAC terminal activation.

4. Turbine-Generator

a. Wire an estimated sixty (60) turbine-generator functions from T-G logic circuitry and operator panel to SDPC and ILS input and output conditioning modules in remote station 4.

b. Add local/remote indicator light on turbine-generator control panel.

5. Trip Panel

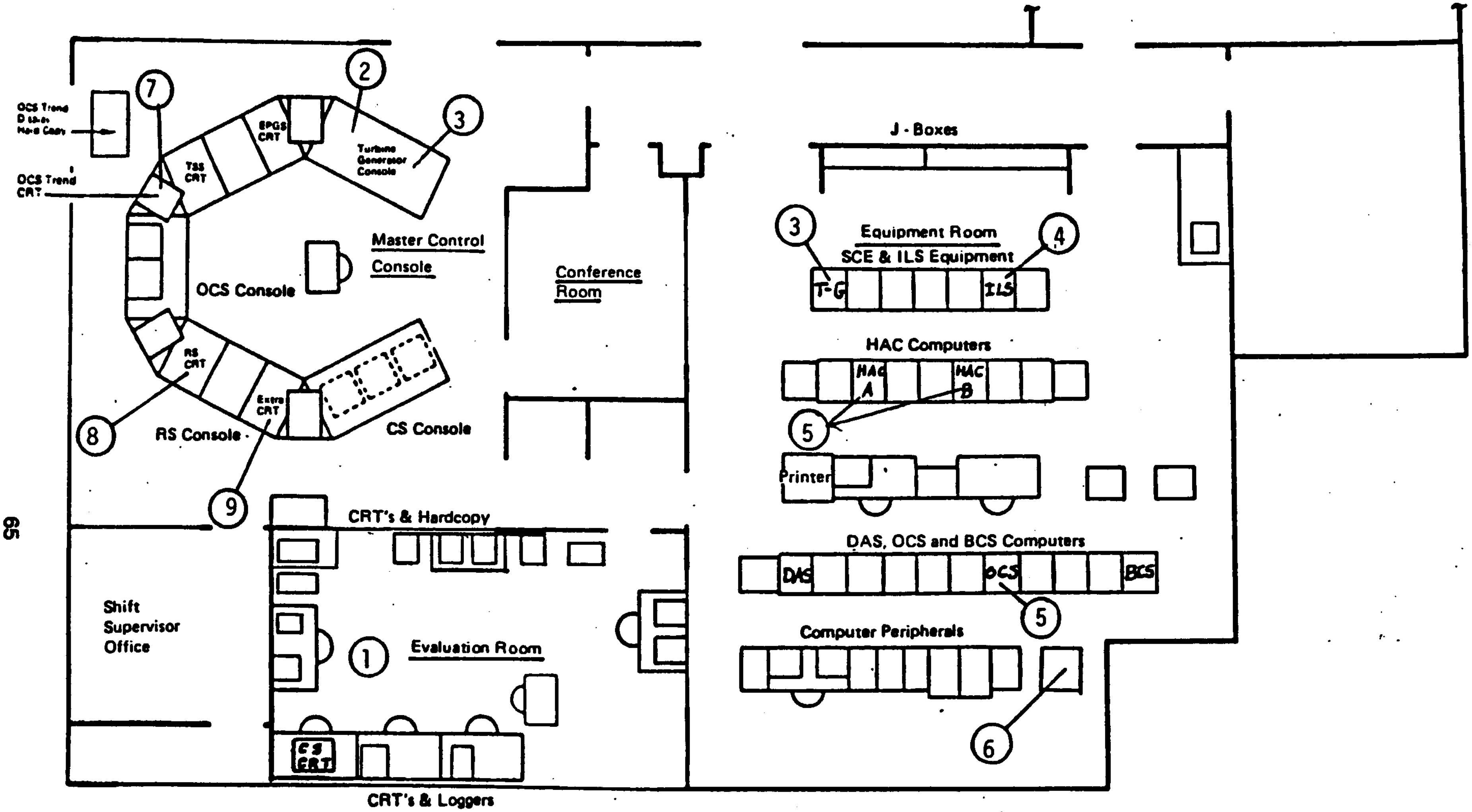
a. Add wiring between remote station #4 ILS and the Plant Trip Box.

b. Modify the Plant Trip logic to provide trip switch isolation and permit parallel wiring of trip functions (local and remote).

A diagram showing the areas of the control room that changes occured is shown in Figure 20.

B. <u>Alternate 2 Concept Definition</u>

The Alternate 2 concept provides an approach to monitoring and control of the Solar I Plant using the OCS, HAC and hand trip switch panel only. The SDPC and functions



Legend

(1) CS Chromatics CRT to Remote Site
(2) Install Local/Remote Indication
(3) T-G Wiring to Remote Station 4
(4) ILS Logic/Hardware Changes
(5) Hardware/Software Mods/Additions
(6) Comm. Cabinet for Modems
(7) OCS Trend CRT to (8)
(8) RS Station/CRT to (9)
(9) SDPC Station/CRT to Remote Site

Figure 20. Solar I Control Room Changes for Alternate 1 Concept

performed by the SDPC would remain at Solar I. This configuration allows the operator to monitor and control the plant within the categories defined in Table 1.

Manual manipulation of individual control loops would have to be accomplished at Solar I through the SDPC operator station. The control of Balance of Plant (BOP) and Thermal Storage Subsystem (TSS) operation would be most affected without an SDPC operator station at the remote site. However, under the guidelines and ground rules as defined in Section IIA and IIB, this alternate can provide adequate monitoring and control of the Solar I Plant as defined in the Operating Activities Summary shown in Figure 3 and providing the operator actions that use the SDPC are defined by software added to the OCS. The non-control room activities performed by a Plant Equipment Operator (PEO) would not be affected.

1. <u>OCS Operator Station</u>

The OCS operator station concept for the Alternate 2 plan would the same as for the Alternate 1 plan described in paragraph IV.A.2 (OCS Operator Station). A block diagram of the OCS hardware with the remoted stations is shown in Figure 7. The software modifications and changes are shown in Figure 8.

2. <u>Heliostat Array Controller Operator Station</u>

The Heliostat Array Controller (HAC) operating station for the Alternate 2 concept is identical to the HAC Operator Station defined for the Alternate 1 concept. The HAC hardware configuration block diagram with remoting capability is shown in Figure 11. Figure 12 shows a block diagram of the software structure/concept for remoting.

3. <u>Turbine-Generator Control Operator Station</u>

The turbine-generator monitor and control station for the Alternate 2 concept is identical to the turbine-generator operator station concept defined for the Alternate 1 concept, in paragraph IV.A.4.. The turbine-generator controls remoting configuration block diagram for the Alternate 2 concept is as shown in Figure 15.

4. <u>Trip Switch Panel</u>

The trip switch panel for the Alternate 2 concept is identical to the trip switch panel concept defined for the Alternate 1 concept, paragraph IV.A.5. The mechanization of this panel at the remote Coolwater Generating Plant site is as presented in Figure 18.

5. <u>Alternate 2 Concept Remote System Configuration</u>

a. Remote site (Coolwater)

The remote system configuration for the Alternate 2 concept would consist of adding the following elements.

1. SDPC
    a. No hardware elements required for the SDPC.
2. OCS
    a. Two operator station AYDIN 8830 Color CRT displays
    b. Two operator station AYDIN 5115A keyboards
    c. Two operator station AYDIN 5529 Light Pens
    d. Two Texas Instruments 810 Logger/ Printers (or equivalent)
    e. One ISC 8001G Color CRT monitor
    f. One Printonix MVP hardcopier

3. HAC

   a. One operator station ISC 8001G Color CRT display with keyboard

   b. One operator station Texas Instruments 810 Logger/Printer (or equivalent)

   c. One operator station chromatics 1599 color graphics CRT display system.

4. Trip Panel

   One custom hand switch trip panel consisting of eight (8) switches and eight (8) light indicators.

5. Console

   One operator station custom console to accommodate the OCS, HAC, and trip panel hardware

6. Support Equipment

   a. One MODICON 584 I/O Module housing with I/O wire terminals, MODBUS connectors and power supply to service the remote trip panel

   b. Two MODICON B260 ANALOG output modules to service trip panel hand switches

   c. Two MODICON B243 ANALOG input modules to service trip panel light indicators

   d. Seven (7) short haul RAD Model SRM-6D MODEMS to service two ISC 8001G Color CRT displays and two TI 810 Logger/ Printers over long distances.

e. One wire termination J-box for communication wiring termination

f. Two 19" x 24" x 60" closed cabinets to house support equipment

A block diagram of the remoting station hardware layout is shown in Figure 21.

b. Solar I Modifications

The configuration changes and additions within the monitor/control equipment at Solar I consist of the following elements:

1. OCS

a. Add two (2) AYDIN 5215A display generator circuit board channels to the existing four channel display generator controller

b. Add software to monitor and control the turbine-generator system

c. Add software to monitor and control receiver startup and shutdown functions

d. Add software to incorporate the software switching function for remote or local terminal activation

e. Generate a new system configuration to include the remote operator station hardware (e.g. three CRT display units and two logger/printers

f. Add diagnostic software that appraises HAC, DAS and SDPC availability

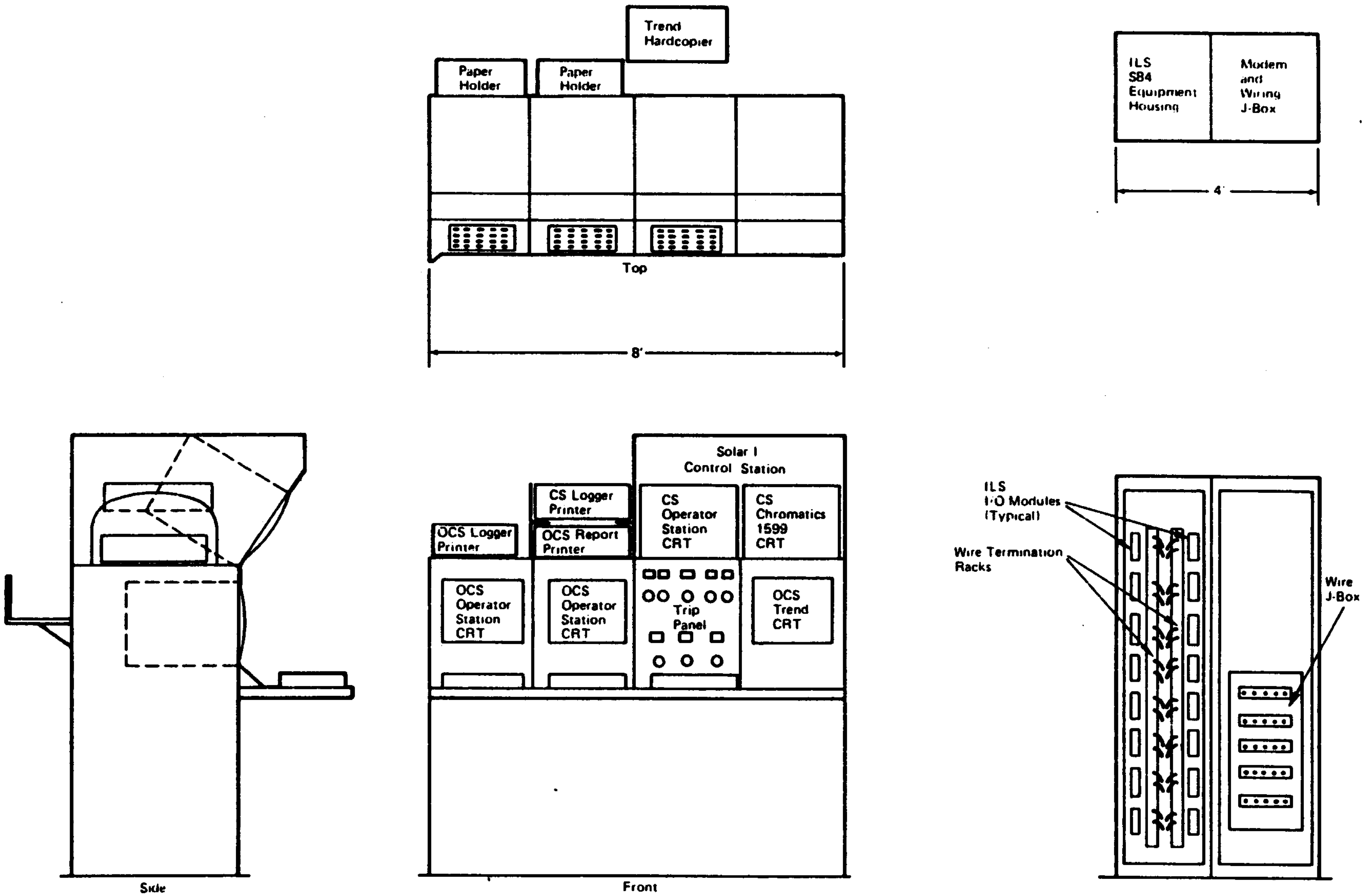


Figure 21. Remote Station Hardware Layout Alternate 2 Concept

g. Add software to status the remote trip functions.

h. Add one (1) Artel Communications Corporation Model 2016/2017 Fiber Optics Computer Graphics RGB Video and Data Interface Module.

2. HAC

a. Remove Chromatics 1599 Color Graphics Terminal from DAS evaluation room (remoted at the Coolwater Generating Plant)

b. Relocate existing MODCOMP 4811 Asychronous controller from a 4903 Peripheral Controller interface and place vacant slot in a 4906 Peripheral control switch to service remote ISC 8001G CRT display terminal and logger/printer

c. Modify system generation to include the added ISC 8001G CRT display terminal and the TI 810 logger/printer terminal

d. Modify HAC software codes to incorporate a software switch for selecting remote or local HAC terminal activation

3. Turbine-Generator

a. Wire an estimated sixty (60) turbine-generator functions from T-G logic circuitry and operator panel to SDPC and ILS input and output conditioning modules in remote station 4.

b. Add local/remote indicator light on turbine-generator control panel.

4. Trip Panel

   a. Add wiring between remote station #4 ILS and the Plant Trip box

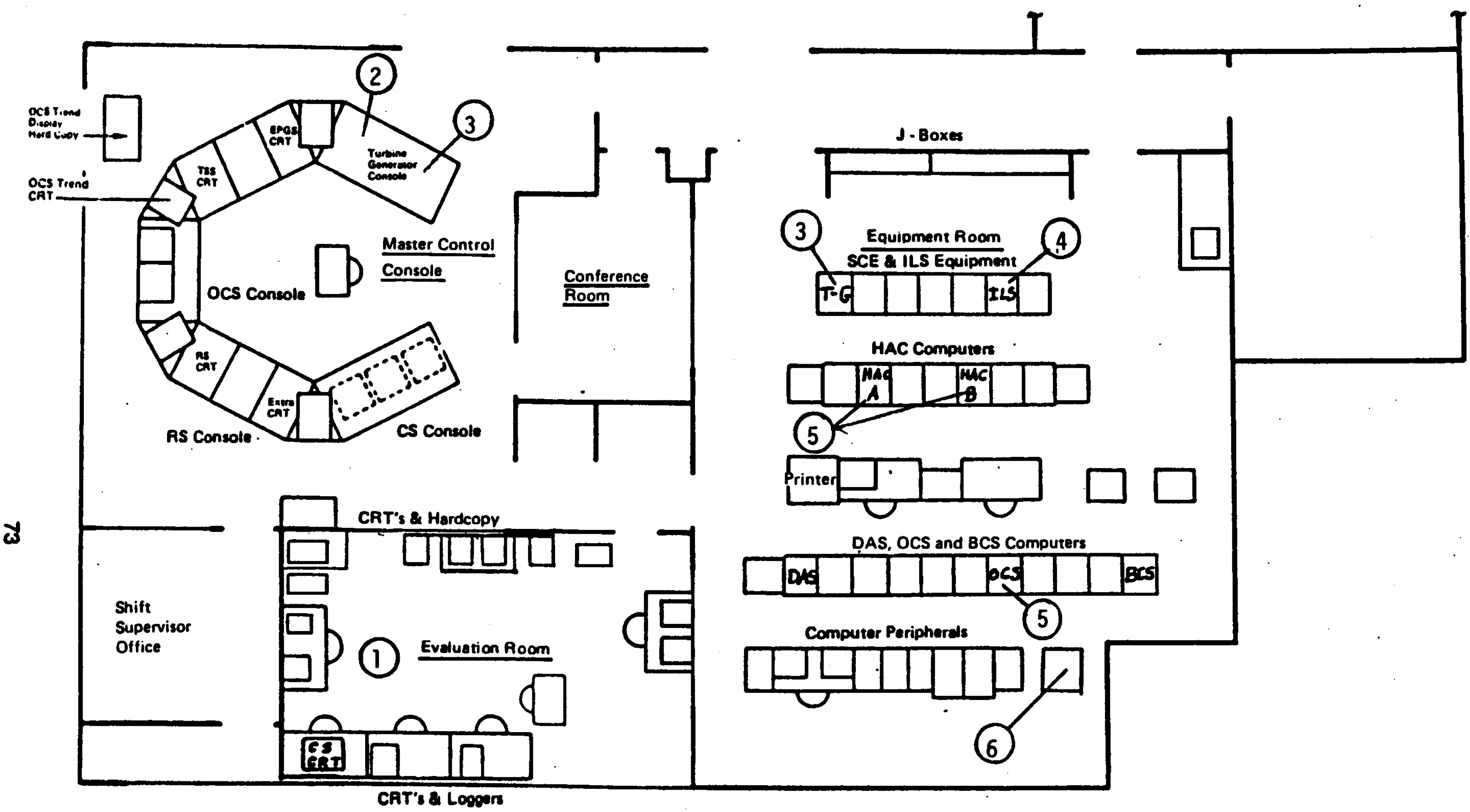
   b. Modify the Plant Trip logic to provide trip switch isolation and permit parallel wiring of trip functions (local and remote)

A diagram showing the areas of the control room where changes would occur is shown in Figure 22.

C. Remote Communications Concept Definition

The communications between the Solar I site and the Coolwater Generating Plant remoting site will be hardwire and fiber optic cable using MODEM line driving/line receiving devices to accomplish the long distance transmission of digital and analog signals. Both the Alternate 1 and Alternate 2 concepts will use the same communications design concept with the numbers of wire being the basic difference.

Wire and cables at the Solar I site for communication would be installed in existing underground conduits from the control room complex south to manhole number 7, the point along the southern plant perimeter near the Administration Building. At this point the cable would emerge and run on existing power poles above ground to the Coolwater facility. Within the Coolwater facility the cables and wires would run underground in existing conduit that go to Coolwater Generating Plants 1 and 2, emerging in the control/equipment building complex where the remote Solar I operator station would be located.



Legend

(1) CS Chromatics CRT to Remote Site
(2) Install Local/Remote Indication
(3) T-G Wiring to Remote Station 4
(4) ILS Logic/Hardware Changes
(5) Hardware/Software Mods/Additions
(6) Comm. Cabinet for Modems

Figure 22. Solar I Control Room Changes for Alternate 2 Concept

The wire and cable communications will span a distance estimated to be 9,700 feet. Approximately 1200 feet of this distance will be underground at Solar I and another 1200 feet will be underground at Coolwater. The remainder of the run, 7300 feet, will be above ground, strung on the existing power poles. A layout of the proposed wire route is presented in Figure 23.

It will be necessary to provide cable stress relief between the power pole spans. This will be done in the same manner used by the telephone industry, providing a wire rope between spans and typing the cables to this rope. A stainless steel 3/8" type 302 IWRC with a breaking strength of 17,500 pounds was selected for this application. A midline wire rope clamp of the variety that permits the attachment of a continuous cable will secure the cable to each pole.

The HAC, SDPC and the Trend CRT monitor from the OCS system will use RS232 Asychronous Digital Communications Hardwire techniques for long line transmission of commands and data. Consequently, telephonic MODEMS will be required. MODEM requirements for all three applications can use the "short haul" MODEM variety such as the RAD Computers Inc. Model SRM-6D which is packaged in a connector. This type of MODEM produces rate selection from 1200 BAUD to 19.2K BAUD.

The ILS Digital Communications will use the existing I/O channel capability for driving signals up to 15,000 feet. No additional hardware is required to perform this function.

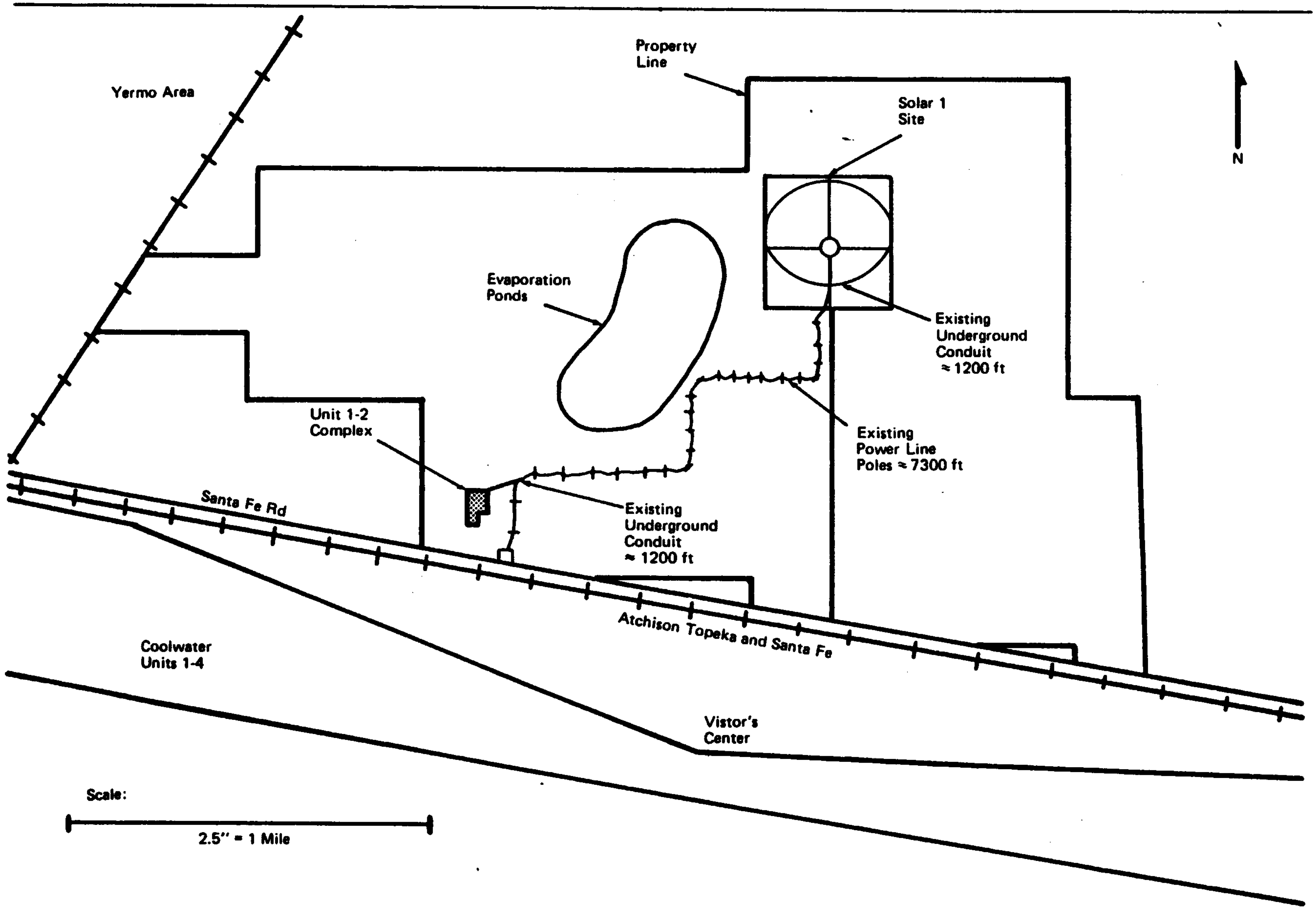


Figure 23. Proposed Wire Route – Solar I contols Remoting

The SDPC operator station requires four (4) wire transmission links between the remote station and Solar I. These links consist of: 1) the historic trend processor to keyboard processor; 2) the report generator processor to the keyboard processor; 3) the report generator to the remote logger/printer and 4) the console communications processor to the operator station CRT.

The AYDIN 5215 Color Display System requires a four (4) fiber optic cable with a standard 50 um core, graded index with a drop of less than 4 db/km. An Artel Communications Corp. model 2016/2017 video signal interface system will interface with the RGB computer generated RS170 composite signal as well as the keyboard/editor signals for the fiber optic cable.

One 75 conductor cable will provide the EIA RS232C type transmission line for the Alternate 1 concept. Sixty-six (66) of the wires in this cable will be used leaving nine (9) wires for spares. The Alternate 2 concept will require eighteen EIA RS232C type conductors that will be accommodated in a single twenty conductor cable that provides two (2) spare conductors. The ILS transmission link will use a single RG6-U Coaxial cable. A summary wire schedule is presented in Figure 24. The schedule identifies cable and connector types that would be satisfactory for the remoting wiring needs. There are other manufacturers and types that could be adequate substitutes. This schedule in no way implies the use of the products identified as mandatory requirements.

SYSTEM	FUNCTION	WIRE TYPE	NUMBER OF CONDUCTORS	LENGTH REQD	CONNECTOR TYPE
Trip Panel (Alternate Concepts 1 and 2)	1. MODICON Serial Comm. Data Hiway From 584 to Remote I/O	RG6-U	One (Belden 89120)	10,000 FT	GEROLD F Type
	2. Trip Function Analog Signal from Trip Panel to Remote ILS	16 AWG	32 (2 Belden 8621/9622)	100 FT	LUG
Turbine-Generator (Alternate Concepts 1 and 2)	1. Analog/Discrete Signals-60 I/O Functions T-G Panel and Logic Cabinet to ILS in Remote Station #4	16 AWG	2 Per Circuit (120 Total) 5 Belden 9622	200 FT	LUG
SDPC Alternate Concept (#1 only)	1. RS232C Digital Comm. for Links to CCM; HTP; RGP and Remote Logger Printer for Each of Three MV8000 Systems	18 AWG TSJ	4 Wires Per link (48 Total)	10,000 *	TB 25
MISCEL (Alternate Concepts 1 and 2)	1. Secure Communications Wire Between Power Pole Loops - Stress Relieve Communications Cables.	Wire Rope Type 302 Stainless Steel 3/8 Inch	1 McMaster-Carr (3458T940)	7,300	N/A
OSC	1. Video Signals-Two AYDIN 8830	Fiber Optics	3 Per CRT (6 Total)	10,000 FT	Amphenol 906

Figure 24. Connecting Wire Schedule

SYSTEM	FUNCTION	WIRE TYPE	NUMBER OF CONDUCTORS	LENGTH REQD	CONNECTOR TYPE
(Alternate Concepts 1 and 2)	CRT Displays to 5215A Display Generator				
	2. Keyboard Two 5115A Keyboards to 5215A Display Generator	Fiber Optics	1 Per CRT (2 Total)	10,000 FT	Amphenol 906
	3. RS232C Digital Comm. Two TI 810 Logger Printers to OCS Computer.	18 AWG TSJ	3 Per Logged (6 Total)	60,000 FT*	TB 25
	4. RS232C Digital Comm. One ISC 8001G CRT to OCS Computer	18 AWG TSJ	3 Per CRT (3 Total)	30,000 FT*	TB 25
	5. RS232 Parallel Digital Comm. ISC 8001G to Printronix MVP	22 AWG TSJ	9 (Centronics 324-3R3)	30 FT	Centronics
HAC (Alternate Concepts 1 and 2)	1. RS232C Digital Comm. One ISC 8001G CRT to HAC Computer	18 AWG TSJ	3 Per Crt (3 Total)	30,000 *	TB 25
	2. RS232C Digital Comm. One TI910 Logger Printer to HAC Computer	18 AWG TSJ	3 Per CRT (3 Total)	30,000 *	TB 25
	3. RS232C Digital Comm. One Chromatics 1599 CRT to HAC Computer	18 AWG TSJ	2 Per CRT (3 Total)	30,000 *	TB 25

*Single 10,000 FT Multi Conductor Cable
Alternate 1 - Alpha 25170/70
Alternate 2 - Alpha 25170/20

Figure 24. Connecting Wire Schedule (continued)

D. Solar I Equipment Layout Concept at the Coolwater Generating Plant

The Solar I Remote Console and the two equipment cabinets are to be located in the Coolwater Generating Plant Unit #1 and Unit #2 Control Room. This room is located on the second floor of building 502, above the Unit 1 and 2 wire switch gear room.

The control room layout, shown in Figure 25, is configured in a manner that positions the control equipment in a rectangle with the operators inside the rectangle. The Solar I controls are co-located with the Coolwater Unit #1 and Unit #2 controls using the packaging densities shown in Figures 19 and 21. No control room modifications are required to accommodate Solar I equipment cabinets and racks. All wiring can be layed in cable trays in the cable and switch gear room below the control room. Cables then penetrate the floor directly below the equipment cabinets.

V. PROJECT WORK PLAN AND SCHEDULE

A. Assumptions

For the purpose of managing and scheduling activities that lead to remoting the controls from Solar I to the Coolwater Generating Plant the following assumptions are made:

1. The work will be handled in a manner consistent with other construction projects at Solar I. This includes the development of construction packages, procurement specifications, competitive bidding where applicable, and construction management.

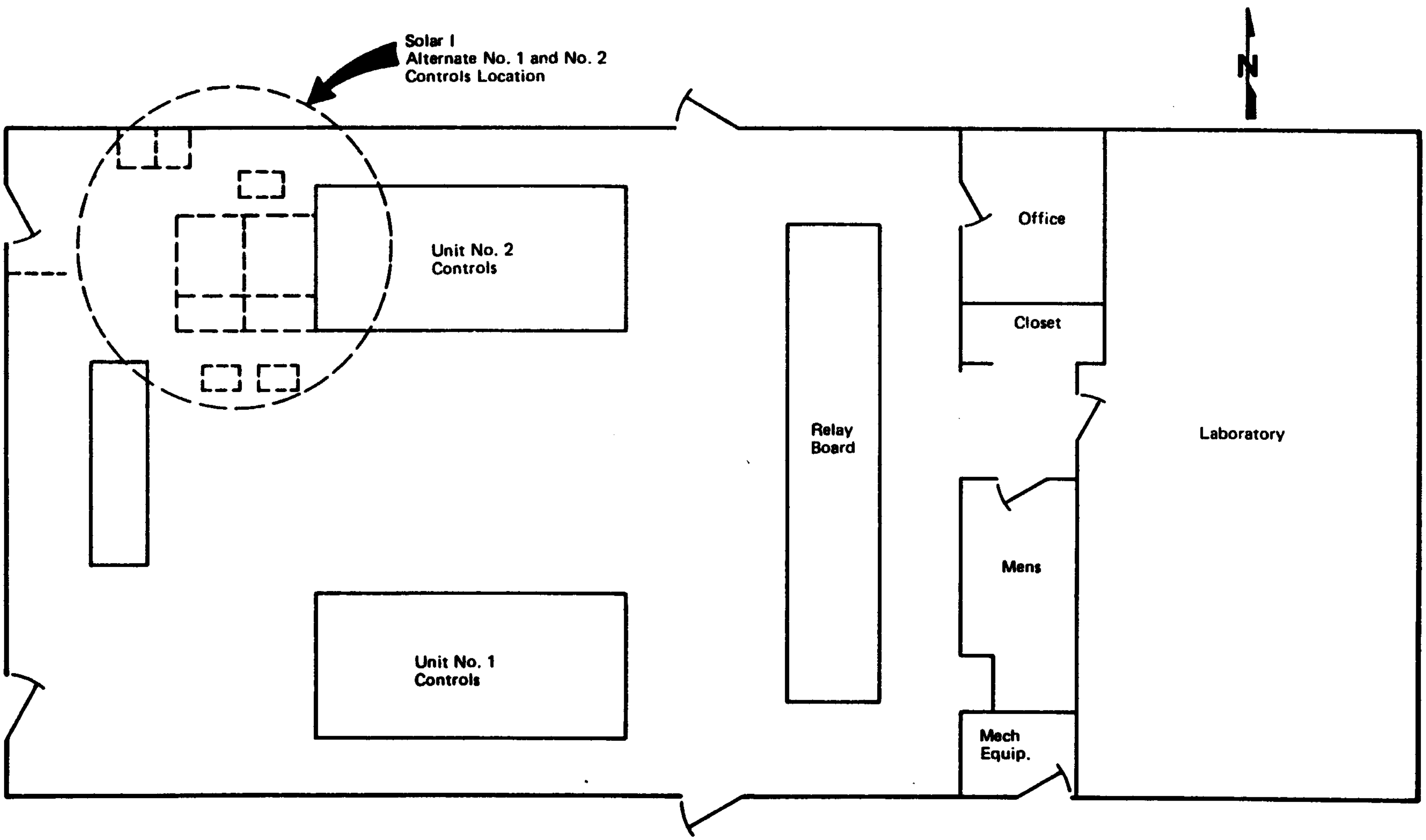


Figure 25. Proposed Solar I Equipment Layout at Coolwater

2. Where peculiar knowledge, skills or jurisdiction is apparent, the entities with the knowledge, skills or jurisdiction are assumed to be appropriate to accomplish the work. Learning curves are not factored into the plan and schedule.

3. Construction and access permits are not required for this project since this entire construction job takes place on Southern California Edison (SCE) property. SCE would dictate the regulations that the project must adhere to.

4. The documentation of the remoting project would follow the existing documentation guidelines used for construction of Solar I.

B. <u>Work Package Tasks</u>

The remoting of the monitor and controls functions at the Coolwater Generating Station 1 and 2 control room would have five (5) major tasks associated with the project. These tasks, defined as work packages would be:

- Remote station development work package
- Transmission link development work package
- Software and data base development work package
- Turbine-generator monitor and controls alterations work package
- System integration and test work package

Each work package would require detail design, hardware procurement, fabrication, installation and checkout as major subtasks of a package. In addition, each work package would envelop technical areas of expertise that can be effectively managed and worked.

1. <u>Remote Station Development Work Package</u>

The remote station development package would require the design, procurement, fabrication, installation, checkout and documentation of: 1) a console housing the remote operator station, CRTs, keyboards, logger/printers and trip panel; 2) two cabinets housing electrical wire termination panels and input/output electronics for the trip panel and log line information transmitting and receiving; and 3) a manual trip panel and 4) the preparation of the Coolwater Generating Station control room to receive the Solar one remote operator station. This package would output specifications for transmission line wire and cable and drawings of the Coolwater Generating Plant control room modification requirements.

2. <u>Transmission Link Development Work Package</u>

The transmission link development work package would require design, procurement, fabrication, installation checkout and documentation of the long line transmission system between Solar I control building and the Coolwater Generating Plant unit 1 & 2 control room. Wire and cable specifications for this package would be obtained from the remote station development work package.

3. <u>Software and Data Base Development Work Package</u>

The software and data base development work package would require design, coding checkout and documentation of the turbine-generator supervisory operations program, the protect and status program, software operator station switch and the systems generation for added displays and printers all of which is to be accomplished in the OCS computer. In addition, this package would modify the HAC computer codes to add the remote operator CRT terminal, logger/printer and the software operator station switch.

Data base and logic-additions and changes required in the SDPC and ILS to operate the turbine-generator would be accomplished in this task.

4. Turbine-Generator Monitor and Controls Alterations Work Package

The turbine-generator monitor and controls alterations work packages would require the design, procurement, fabrication, installation checkout and documentation that permits full operation of the turbine-generator system from the SDPC. This includes the wiring from T-G functions to the appropriate SDPC/ILS input/output module. This task also would output the SDPC and ILS logic, specifications, and algorithms used to design the SDPC, ILS and OCS turbine-generator operating functions.

5. System Integration and Test Work Package

The system integration and test work package would require the integrated test plan, test procedures, tests and test result reporting for the remoting operation system level testing. The output of this task would be the qualification of the remoting center for utility everyday operations use. Included in this task would be the detailed step by step operating procedures of the plant from the remote site.

C. Schedule

A projected over-all implementation schedule is presented in Figure 26. The remoting project is estimated to require about eighteen months from the ATP date to completion. The project organization would require the team selection, a project plan and a detailed time phased schedule prior to the authority to proceed (ATP) date. This activity is estimated to require no more than three months to complete.

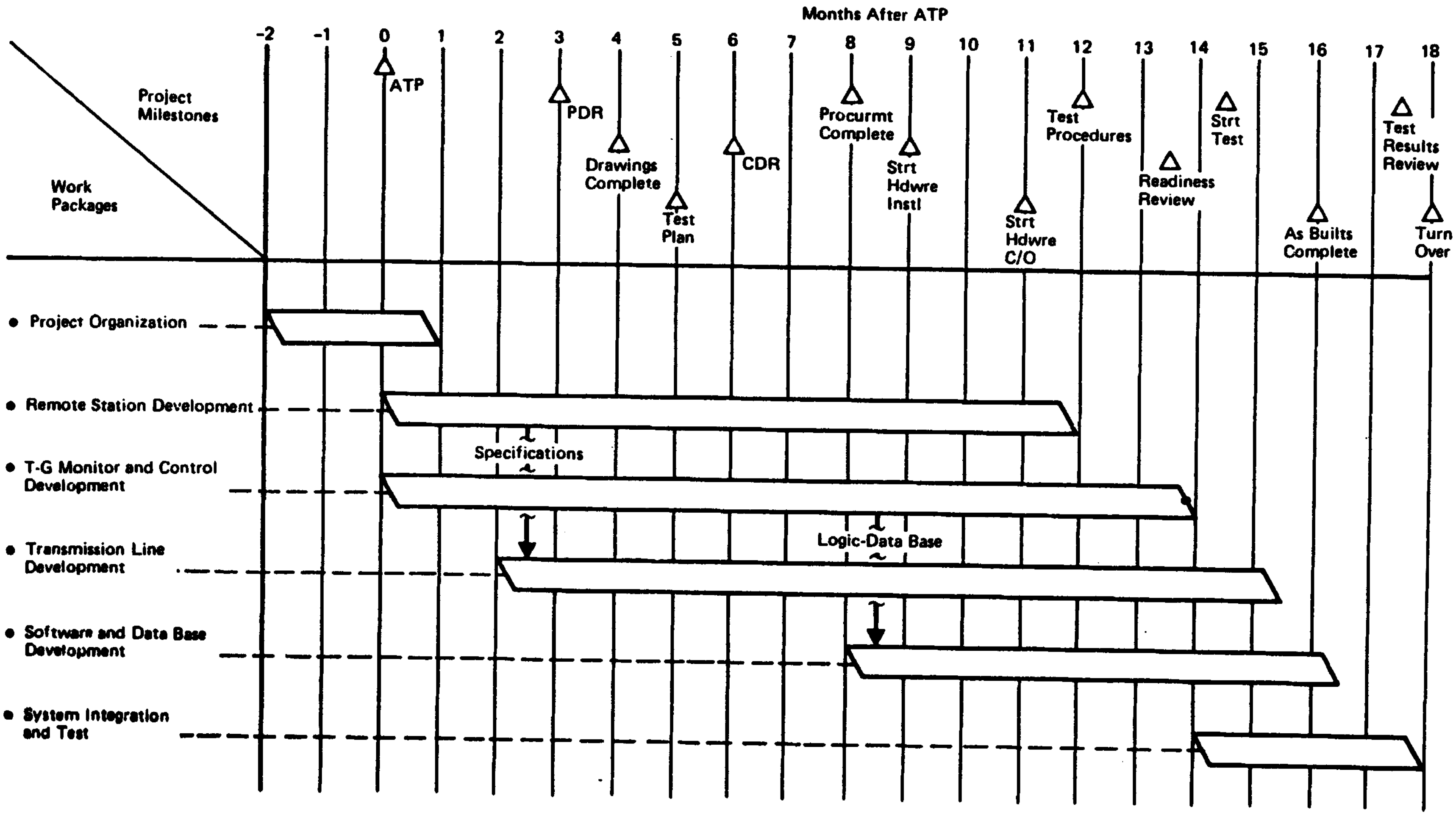


Figure 26. Solar I Remote Operation Implementation Schedule

The remote console build up, transmission cable procurements and the turbine-generator monitor and control alterations would be expected to be the pacing items.

The turbine-generator alteration requirements are the least understood and need to be surveyed before the ATP. It is expected that the alterations to the T-G controls would be done on a second or third shift or in a work-around basis on first shift, since it would not be practical to put the plant down for extended periods of time. It would be expected that upon completion of each alteration to the T-G controls a test would have to be conducted to assure proper system operation from the manual control panel. Some down time of the T-G can be expected to complete the auto sychronization system alterations. This could be scheduled to occur during a planned plant outage.

There appears to be negligible schedule change to implement either the Alternate 1 or Alternate 2 concept. The difference between Alternate 1 concept and the Alternate 2 concept is the remoting of the fourth ("Rover") SDPC operator station at Solar I into the alternate 1 remote concept. The SDPC station remoting would impact cable size, remote console design, and the integration and test which in our opinion would not add significant schedule growth.

The schedule reflects the utilization of skilled personnel who here-to-fore were involved in the design, construction and testing of the Solar I plant. To use other people unacquainted with the control and monitor system design, plant equipment and plant operation would extend the projected eighteen month schedule.

VI. ESTIMATED PROJECT COSTS

A. Cost Summary

Costs pertaining to the project of remoting controls from Solar I to the Coolwater Generating Plant can be summarized as follows:

Total Estimated Cost:

- Hardware

Alternate 1	$426,252.65
Alternate 2	284,983.95

- Labor

Alternate 1	52.8 man months
Alternate 2	52.3 man months

The costs do not include costs incurred by Southern California Edison personnel supporting the project nor do these costs include fees or profits that contractors would receive for their services.

The labor cost estimate is approximately the same for Alternate 1 and Alternate 2 concepts. The only difference is in the control console installation of one existing SDPC operator station for the Alternate 1 concept that is estimated to be approximately 80 man hours.

B. Cost Development

Material and labor estimates were made for the listed project breakdwon structures:

- Project/Construction/Business Management
- Engineering
- Construction
- Hardware

The management and engineering efforts were estimated by management and technical engineering personnel who worked in the specific disciplines at Solar I. Major construction and hardware costs were estimated from the 1985 Richardson Process Plant Construction Estimating Standards and supplier information (e.g. catalogs, quotations, etc.)

The following sections describe the rationale for costing the remoting of Solar I controls at the Coolwater Generating Plant units 1 and 2 control room. The Labor and material requirements are based on the technical approaches discussed in the previous sections of this report.

A time phased manload estimate is shown in Figure 27 and a summary list of major hardware costs is presented in Figure 28.

1. Project/Construction/Business Management

The managment of the Solar I controls remoting project would consist of a part-time project/construction manager and a part-time business manager. Both activities would start prior to the ATP date and the business managing activities to close out the work releases and accounts would continue one month following work completion.

This effort consists of project management, construction management, contract administration, and schedules, technical and financial progress reports. The project managing activities constitute approximately 28% of the project estimated cost.

Function	Labor - Man Months																					Total Man Mo.	
1. Project Management																							
a. Project/Constr. Manager	1.0	1.0	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.3	.2	.2		10.2	
b. Business Operations	.3	.3	.3	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.1	.1	.1	.1	.1	.1	.6	4.	
Sub Total	1.3	1.3	.8	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.6	.6	.6	.4	.3	.3	.6	14.5	28%
2. Engineering																							
a. Management			.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3		5.4	
b. Design			1.0	1.0	1.0	1.0	.5	.5	.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0				14.5	
c. Coordination-Supplier/Contractor						.5	.5	.5	.5			.2	.2	.2								2.6	
d. Test														.1	.2	.2	1.0	1.0	1.0	1.0		4.5	
e. Documentation				1.0	1.0	1.0	1.0								.5	.5	.5	.5	1.0	1.0		8.0	
Sub Total	θ	θ	1.3	2.3	2.3	2.8	2.3	1.3	1.3	1.3	1.3	1.5	1.5	1.6	2.0	2.0	2.8	2.8	2.3	2.3	θ	35.0	67%
3. Construction																							
a. Trip Panel												.5										0.5	
b. Transmission Link													1.0	.2								1.2	
c. Turbine-Generator Wiring												.3										0.3	
d. Remote Console Installation														.8								0.8	
Sub Total												.8	1.0	1.0								2.8	5%
Total	1.3	1.3	2.1	3.0	3.0	3.5	3.0	2.0	2.0	2.0	2.0	3.0	3.2	3.3	2.6	2.6	3.4	3.2	2.6	2.6	.6	52.3	

-2 -1 0 5 10 15 18 19

Months After ATP

Figure 27. Solar I Remoting Time-Phased Manload Estimate

Hardware Description	Supplier	Part Number	Quantity Required	Unit Cost	Total Cost	Reference
I. Remote Operator Station						
A. Console						
• Four CRT Bay with left and right long wings (Alternate 1 concept)	Beckman Instruments Division of Emerson Electronics	--	One	$114,800.00	$114,800.00	Budgetary List Price, Telecon
• Three Crt Bay with left and right long wings (Alternate 2 concept)	Beckman Instruments Division of Emerson Electronics	--	One	94,800.00	94,800.00	Budgetary List Price, Telecon
B. Remote ILS I/O and terminal board cabinet (Alternates 1 or 2)						
• Cabinet	Hoffman Engr. Co.	A60H36FLP	One	397.37	397.37	County Wholesale Electric - Orange, CA
• Panel	Hoffman Engr. Co.	A60P36	One	69.50	69.50	County Wholesale Electric - Orange, CA
• Mounting housing-8 module	Gould, Inc.-Modicon Program. Contr. Div.	B-240	One	225.00	225.00	Telecon
• Power Supply	Gould, Inc.-Modicon Program. Contr. Div.	P451-622	One	925.00	925.00	Telecon
• Discrete outputs	Gould, Inc.-Modicon Program. Contr. Div.	B232-501	One	445.00	445.00	Telecon
• Discrete inputs	Gould, Inc.-Modicon Program. Contr. Div.	B233-501	One	388.00	388.00	Telecon
C. Remote Wire Terminaton Cabinet (Alternate 1 or 2)						
• Cabinet	Hoffman Engr. Co.	DL722530	One	$1,135.40	$1,135.44	County Wholesale Electric - Orange, CA
• Terminal blocks/rail for 70 conductors	Reed Devices, Inc.	44F2745 44F2762 44F2763 44F2769	Seventy Two Seventy Two	0.50 5.80 0.58 0.66	35.00 11.60 40.60 1.32	Catalog (Newark)

Figure 28. Major Hardware Costs

Hardware Description	Supplier	Part Number	Quantity Required	Unit Cost	Total Cost	Reference
D. OCS Operator Station (Alternate 1 or 2)						
• CRT Display	Aydin Controls, Inc.	8830	Two	2,010.00	4,020.00	Aydin Controls Telecon Quote
• Keyboard/Editors	Aydin Controls, Inc.	5115A	Two	5,580.00	11,160.00	Aydin Controls Telecon Quote
• Video Cards	Aydin Controls, Inc.	TVD-190	Two	1,195.00	2,390.00	Aydin Controls Telecon Quote
• Edit Cards	Aydin Controls, Inc.	TVD-192	Two	1,245.00	2,490.00	Aydin Controls Telecon Quote
• Coax Cable	Aydin Controls, Inc.	RG59-20 ft	Eight	74.00	592.00	Aydin Controls Telecon Quote
• Coax Cable	Aydin Controls, Inc.	RG59-50 ft	Eight	134.00	1072.00	Aydin Controls Telecon Quote
• Trend CRT	Intelligence System, Inc.	8001G	One	3260.00	3260.00	Aydin Controls Telecon Quote
• Fiber Optics Interface Module	ARTEL, Inc.	2016/2017	Eight	1500.00	12,000.00	Artel Quote #86489
• Fiber Optics Power Supply	ARTEL, Inc.	SL2000	Two	990.00	1,980.00	Artel Quote #86489
• Fiber Optics Alarm Control Unit	ARTEL, Inc.	ACU2400	Two	750.00	1,500.00	Artel Quote #86489
• Patch Panel -	ARTEL, Inc.	12 fiber capacity	One	$200.00	$200.00	Artel Quote #86489
• Connectors (patch panel)	ARTEL, Inc.		Twelve	10.00	120.00	Artel Quote #86489
• CRT Hard Copier w/cable	PrinTronix, Inc.	MVP (centronics)	One	3,445.00	3,445.00	Catalog

Figure 28. Major Hardware Costs (continued)

Hardware Description	Supplier	Part Number	Quantity Required	Unit Cost	Total Cost	Reference
E. Trip Panel (Alternate 1 or 2)						
• Trip pushbuttons	Allen-Bradley Industrial Controls, Inc.	800MRQ12	Eight	48.00	384.00	Catalog
• Light Indicators	General Electric	CR103C2302	Eight	31.00	248.00	Catalog
• Panel-flat plate finished and engraved	TBD	TBD	One	695.00	695.00	Richardsons
II. Transmission Wire & Connectors						
A. RS232C Communications						
• Alternate 1 wire 18GTSJ 70 conductor cable	ALPHA, INC.	25170/20	10,000 ft.	8390/500 ft.	167,800.00	Catalog (Newark)
• Alternate 2 wire 18GTSJ 20 conductor cable	ALPHA, INC.	25170/20	10,000 ft.	2330/500 ft.	46,600.00	Catalog (Newark)
• Alternate 1 Connectors RS232 25 PIN	Cinch Connector Div. of TRW, Inc.	TB25	Forty-four	2.15 AVG.	94.60	Catalog (Newark)
• Alternate 2 Connectors RS232 25 pins	Cinch Connector Div. of TRW, Inc.	TB25	Twelve	2.15 AVG.	25.90	Catalog (Newark)
B. ILS Communications (Alternates 1 or 2)						
• Wire - RG6U	Belden-Division of Cooper Industries	8 9120	7300 ft.	1484/1000 ft.	$10,833.00	Catalog (Newark)
• Connector-Jerold Type	Belden-Division of Cooper Industries		Two	$50.00	100.00	Catalog (Newark)
C. OCS Terminal Communication Alternates (1 or 2)						
• Fiber Optic Cable	Artel, Inc.	12 Channel 50/125 micron	10,000 ft.	5.50 ft.	55,000.00	Artel, Inc. Quote #84489

Figure 28. Major Hardware Costs (continued)

Hardware Description	Supplier	Part Number	Quantity Required	Unit Cost	Total Cost	Reference
• Patch cords	Artel, Inc.	25 ft long	Eight	25.00	200.00	Artel, Inc. Quote #86489
• Connectors	Artel, Inc.	Amphenol 906	Sixteen	75.00	1,200.00	Artel, Inc. Quote #86489
III. Solar I ILS I/O and Terminal board cabinet (Alternates 1 or 2)						
• Cabinet	Hoffman Engr. Co.	A60H36FLP	One	397.37	397.37	County Wholesale Electric - Orange, CA
• Panel	Hoffman Engr. Co.	A60P36	One	69.50	69.50	
• Mounting Housing-4 module	Gould Inc. - Modicon Program. Contr. Div.	B240	Four	225.00	1,000.00	Telecon Gould-Modicon
• Power Supply	Gould Inc. - Modicon Program. Contr. Div.	P451-622	One	925.00	925.00	Telecon Gould-Modicon
• Discrete Outputs	Gould Inc. - Modicon Program. Contr. Div.	B232-501	Two	445.00	890.00	Telecon Gould-Modicon
• Discrete Inputs	Gould Inc. - Modicon Program. Contr. Div.	B233-501	Three	$388.00	$1,164.00	Telecon Gould-Modicon
• Analog Outputs	Gould Inc. - Modicon Program. Contr. Div.	B262-101 B258-101	One One	1,503.00 1,182.00	1,503.00 1,182.00	Telecon Gould-Modicon
• Analog Inputs	Gould Inc. - Modicon Program. Contr. Div.	B243-105	One	1,475.00	1,475.00	Telecon Gould-Modicon
• Connectors-Jerold Type	Gould Inc. - Modicon Program. Contr. Div.		Two	10.00	20.00	Telecon Gould-Modicon
• Splitter-Jerold Type	Gould Inc. - Modicon Program. Contr. Div.		One	100.00	100.00	Telecon Gould-Modicon
• Hookup Wire -						
- Turbine-Generator 168-25 conductor	Belden-Division of Cooper Industries	9622	1000 ft.	2775/1000 ft.	2,775.00	Catalog (Newark)

Figure 28. Major Hardware Costs (continued)

Hardware Description	Supplier	Part Number	Quantity Required	Unit Cost	Total Cost	Reference
- Trip panel 16G-25 conductor	Belden-Division of Cooper Industries	9622	100 ft.	2775/1000 ft.	277.50	Catalog (Newark)
16G-7 conductor	Belden-Division of Cooper Industries	8621	100 ft.	114.85/100 ft.	114.85	Catalog (Newark)
IV. Miscellaneous (Alternate 1 or 2)						
A. Power Pole Stress relief 3/8" IWRCE Wire rope	McMaster Carr Supply Company	TYP 302 3458T930	7300 ft.	2.04/ft.	14,892.00	Catalog McMaster Carr
B. Power Pole fasteners for wire rope			Seventy	30.00	210.00	
			Alternate 1 or 2 -	$143,558.05		
			Alt 1 Peculiar	282,694.60		
			Alt 2 Peculiar	141,425.90		
			Alt 1 Total -	$426,252.65	TOTAL COSTS	
			Alt 2 Total -	$284,983.95		

Figure 28. Major Hardware Costs (continued)

2. <u>Engineering</u>

Engineering estimates include the efforts to: 1) coordinate with suppliers and contractors; 2) perform the engineering work associated with the remote station design, turbine-generator control development, drawing development for the transmission lines; construction package development, software and data base development and support test, test data evaluation and documentation functions. This effort constitutes approximately 67% of the project estimated cost.

3. <u>Construction</u>

The construction estimates encompass the work to fabricate and wire the trip panel, install wires from the turbine-generator manual monitor and control panel to the ILS and SDPC input and output conditioners, install wire and cables from Solar I to the Coolwater Generating Plant, install the equipment in the Coolwater Generating Plant and install the wiring from the remote Solar I operating station in the Coolwater control room to the wiring junction boxes in the Coolwater control room. This effort constitutes approximately 5% of the estimated contract costs.

4. <u>Hardware</u>

All of the hardware is purchased from commercial suppliers. The summary of major hardware items and their costs is shown in Figure 28. Included in these costs is the cost to install the CRT equipment in the remote operator station console. This task would be done at the suppliers facility prior to shipping the console to the site.

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