Contract No.: NAS9-14311
DRL No.: T-974
Line Item No.: 4
DRD No.: MA 183T
AiResearch Report No.: 75-11994

NASA CR-
144432

FINAL REPORT
FOR
ELECTRICAL DISTRIBUTION SYSTEM (EDS)
AND
CAUTION AND WARNING SYSTEM (CWS)

SEPTEMBER 23, 1975

(NASA-CR-144432) ELECTRICAL DISTRIBUTION SYSTEM (EDS) AND CAUTION AND WARNING SYSTEM (CWS) Final Report (AiResearch Mfg. Co., Los Angeles, Calif.) 90 p HC $4.75 CSCL 06K
N75-32760
Unclas
G3/54 35073

GARRETT

AIRESEARCH MANUFACTURING COMPANY
OF CALIFORNIA

Contract No.:	NAS9-14311
DRL No.:	T-974
Line Item No.:	4
DRD No.:	MA 183T
AiResearch Report No.:	75-11994

FINAL REPORT FOR ELECTRICAL DISTRIBUTION SYSTEM (EDS) AND CAUTION AND WARNING SYSTEM (CWS)

SEPTEMBER 23, 1975

Author T. McClung, Development Engineer

Approved R. Ichikawa, Project Engineer

GARRETT

AIRESEARCH MANUFACTURING COMPANY OF CALIFORNIA

DISTRIBUTION LIST

FOUR (4) COPIES

NASA Lyndon B. Johnson Space Center
Extravehicular Equipment Branch
Attn: Bill Burton, Mail Code EC6
Houston, Tx 77058

ONE (1) COPY

NASA Lyndon B. Johnson Space Center
Management Services Division
Attn: John T. Wheeler, Mail Code AT3
Houston, Tx 77058

FOUR (4) COPIES

NASA Lyndon B. Johnson Space Center
Technical Library Branch
Attn: Retha Shirkey, Mail Code JM6
Houston, Tx 77058

ONE (1) COPY

NASA Lyndon B. Johnson Space Center
R & T Procurement Branch
Attn: Charley D. Stamps, Mail Code BC721(2)
Houston, Tx 77058

ABSTRACT

This final report provides a technical summary of a concept study, design and development program designed to achieve improvements in the operation of electrical subsystems utilized by an astronaut life support system.

The primary focus of this report is a discussion of an astronaut Caution and Warning System (CWS). The CWS monitors various life support system parameters and will detect out-of-range parameter conditions. Upon detection of a malfunction condition the CWS will generate a warning tone and the malfunction condition is displayed to the astronaut. The CWS will then proceed to display, in sequence, the proper corrective action procedures required of the astronaut, based upon the current status of life support system operational parameters.

Key words are:

- Caution and Warning System
- Life Support System
- Malfunction Detection
- Corrective Action Procedures

CONTENTS

SECTION		PAGE
	DISTRIBUTION LIST	ii
	ABSTRACT	iii
	CONTENTS	iv
	SUMMARY	1
	PROGRAM RESULTS	3
	CONCLUSIONS	3
	RECOMMENDATIONS	4
1.	INTRODUCTION	1-1
2.	STATEMENT OF WORK (SOW)	2-1
	2.1 Design Phase	2-1
	2.2 Fabrication Phase	2-2
	2.3 Test Phase	2-2
	2.4 Delivery and Documentation	2-2
3.	CWS SYSTEM FEATURES	3-1
4.	SYSTEM DESCRIPTION	4-1
	4.1 Hardware Description	4-1
	4.2 Hardware Operation	4-3
	4.3 Software Description	4-7
	4.4 Test Equipment	4-12
	4.5 Fabrication	4-13
	4.6 Production Package Study	4-16
5.	DEVELOPMENT TESTING	5-1

ILLUSTRATIONS

Figure		Page

FIGURE

1.	Breadboard Caution and Warning System	2
4-1	CWS Block Diagram	4-2
4-2	PROM Field Definition	4-4
4-3	Excerpt from Program Flow Chart	4-8
4-4	CWS Software Cycle	4-11
4-5	CWS Front Panel	4-14
4-6	CWS Breadboard Internal Construction	4-15

TABLE

1.	CWS Features	3-2
2.	Parameters Monitored	3-3
3.	Status Check Parameters	3-3
4.	Messages	4-6
5.	Test Equipment Features	4-12

APPENDIXES

A	AiResearch Report Number 75-11206	A-1
B	Logic Program Flow Chart	B-1
C	Software Translation Program	C-1

SUMMARY

This final report provides a technical synopsis of all job tasks performed by the AiResearch Manufacturing Company of California for the National Aeronautics and Space Administration Manned Spacecraft Center at Houston, Texas under NASA contract number NAS 9-14311.

The objective of this program was to develop and demonstrate improvements in the design of two electrical subsystems currently utilized in Astronaut Life Support Systems. The two subsystems under consideration were the Electrical Distribution System (EDS) and the Caution and Warning System (CWS).

The program objectives were achieved by successfully performing the following job tasks which were specified by the contract Statement of Work (SOW).

Job Task	SOW Paragraph
1. Concept Study and Evaluation of EDS	3.2.1
2. Design of a CWS	3.2.2
3. Fabrication of CWS Breadboard	3.2.3
4. Development Testing of CWS	3.2.4
5. Delivery of Breadboard CWS	3.2.5

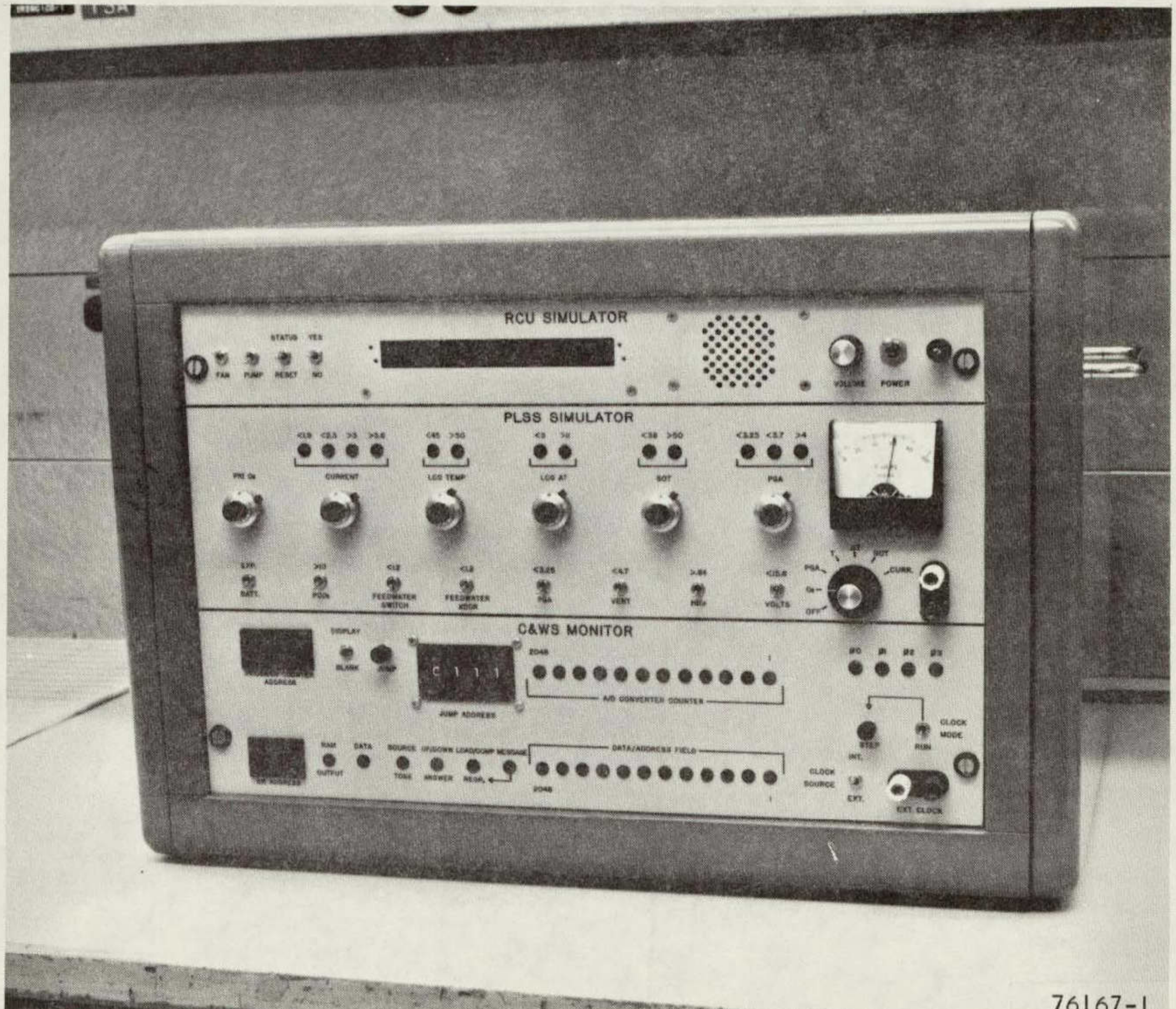
The EDS engineering study task included the identification and evaluation of various alternate concepts of providing an electrical distribution system. Criteria utilized in the evaluation of the candidate approaches included: performance, reliability, maintainability, expected life, size, weight, cost, development risk, and development lead time. Results of this study concluded that an EDS with the following features would be most suitable for futher consideration; Breakout boxes should be replaced by connectors, external harnesses should be foil wrapped, internal harnesses could be either flat cable or wire, and in order to completely eliminate all solder connections, internal interconnections should utilize either wire wrap or stitch-wire terminations.

Complete details and results of the electrical distribution system concept study were presented to NASA in a final report that was included with the February 6, 1975 monthly progress report, and is included for reference as Appendix (A) of this report. A formal presentation of the EDS concept study results was made to NASA personnel at the Johnson Space Center during the course of the Caution and Warning System Design Review.

The major portion of resources expended under this contract and the main body of this final report deals exclusively with the Caution and Warning System designed, developed and tested during this program.

The end product of this contractual effort is a breadboard Caution and Warning System as specified by the Statement of Work. This breadboard includes the Caution and Waning System, test equipment designed to simulate all parameter sensor inputs of a Life Support System, and circuitry to monitor, control and display breadboard operating parameters. The breadboard system is shown in Figure 1.

AIRESEARCH MANUFACTURING COMPANY
OF CALIFORNIA



76167-1

FIGURE 1. BREADBOARD CAUTION AND WARNING SYSTEM

All design objectives were met or exceeded by the CWS system design and were demonstrated by development testing of the breadboard system.

The main body of this final report presents a background of the operation of contemporary Caution and Warning Systems and points out areas where design improvement is required. System features to achieve this improvement are incorporated into the CWS developed under this contract and are summarized. Detailed descriptions of the hardware and software (logic programming) of the breadboard CWS are presented. Details of breadboard fabrication are described and a preliminary production packaging philosophy is discussed. The report concludes with a discussion of the development testing that was performed.

PROGRAM RESULTS

The program objective of designing, developing, and testing an improved Caution and Warning System was met and resulted in a breadboard system as shown in Figure 1.

The CWS developed under this contract represents a substantial improvement in sophistication over earlier systems.

Life Support System parameters are continually monitored. If a Life Support System malfunction occurs, the CWS will detect and display the out-of-range condition. Proper corrective procedures based upon Life Support System operation and present status are automatically presented to the crewman. Earlier electromechanical flags and lights are replaced by a 16 character alphanumeric solid state electronic display which provides the crewman with an easily readable and understandable presentation of malfunction conditions and corrective procedures.

All CWS functional logic is permanently stored on miniature solid state electronic memory integrated circuits which relieves the crewman of the responsibility of memorizing Life Support System operational minutiae and eliminates extensive checklists.

System flexibility is enhanced by the functional logic memories which can be altered, allowing CWS operation to be tailored to any one of a number of available life support systems or developed to accommodate future life support systems by simple integrated circuit replacement.

Development tests performed during the course of this contract demonstrated the ease and accuracy by which life support system malfunction procedures could be incorporated into a functioning Caution and Warning System.

CONCLUSIONS

It is concluded that the objective of demonstrating the design principles of an improved Caution and Warning System suitable for use in an Astronaut Life Support System has been achieved.

A system that would ultimately be used for space application would require small size, long life, low maintainance, and high reliability. These features, although not incorporated into the deliverable breadboard, can be readily designed into a production system.

The Caution and Warning System developed during this effort would reduce the amount of training and engineering evaluation required of an astronaut in the event that a life support system malfunction should occur. Considering the increasing complexity and workloads of future space application programs and the increasing time span during which Life Support Systems will be in use, an automatic Caution and Warning System such as the system presented in this final report would help to maximize crewman safety and efficiency.

RECOMMENDATIONS

The following recommendations are based upon the results of engineering concept studies, design effort and development testing performed during the course of this program.

1. A Caution and Warning System similar to the system that resulted from this contractual effort should be utilized on the Life Support Systems of future space application programs.

2. Based upon the extreme flexibility incorporated into the design of the Caution and Warning System, application for use with systems other than Life Support Systems should be considered. Any system that requires extensive parameter monitoring, complex operating logic or procedures and excessive crewman knowledge, training and memorization could be a candidate for an automatic, adaptive, monitoring and display system. The Caution and Warning System developed for this program could monitor other diverse systems by altering its functional logic through a simple integrated circuit replacement.

3. Alternate CWS annunciation techniques should be investigated. An oral annunciator could be utilized in addition to, or in conjunction with the visual display.

4. A second CWS breadboard system could be fabricated and maintained at AiResearch so that ongoing functional logic programming studies could be performed and CWS operation with various life support systems could be tested in conjunction with NASA efforts in these areas.

1. INTRODUCTION

Caution and warning systems have been utilized on the Apollo PLSS (Portable Life Support System) and the Skylab ALSA (Astronaut Life Support Assembly). These caution and warning systems consisted of instrumentation designed to trigger a warning tone in the crewman's headset and actuate a visual indicator on the chest-mounted display unit when a critical Life Support System parameter went out of its operational range. Ground monitoring of telemetered parameter information was used in conjunction with the caution and warning systems to detect system anomalies and maintain crew safety.

Experience gained during the Apollo and Skylab programs has pointed out areas in which improvement of caution and warning system operation is required.

The Apollo PLSS caution and warning system response to transient conditions could result in warning tones without the visual display (electromechanical flag); or the flag, if triggered, not remaining on long enough for the crewman to observe which parameter had gone out of specification. An occurance of this situation required the crewman to stop his activity and go through a complex system check to verify that it was safe to continue the EVA (Extra Vehicular Activity). The Skylab ALSA replaced the electromechanical flags with lights and did not experience problems of transient actuation of warning tones without displays.

Both the PLSS and the ALSA caution and warning systems presented the crewman with a visual indication of which parameter had gone out of specification range. In order to select the proper corrective action, the crewman had to know (or have checklists available) which system malfunctions could cause the out of specification condition. This method of operation depends on extensive crewman knowledge and/or a time consuming checklist run-down during the high stress period between the warning tone actuation and the selection of the proper corrective action.

Another problem due to the present method of caution and warning system operation is one of unnecessary abort of an EVA due to an inadvertant switch actuation, transient condition, or sensor-only failure.

The primary objective of this contractual effort has been to design, develop and demonstrate an improved Caution and Warning System (CWS).

In order to achieve a reduction in dependence on crew training the CWS presents (in addition to the warning tone) a visual indication of which parameter has gone out of specification as well as the proper corrective action required.

The electromechanical flags and lights of the earlier systems have been replaced with a sixteen character, Alpha-Numeric, LED (Light Emitting Diode) display. This display allows the CWS to present messages of up to sixteen characters in length to the crewman. Message characters can be selected from the full 64 symbol ASCII character font. These include the 26 letters of the alphabet, numerals 0 through 9 and 27 special symbols including the question mark, equal sign and blank. This display allows great flexibility in the visual presentation made to the crewman.

The simple combinatorial logic fault detection circuitry of the earlier caution and warning systems has been replaced by a special purpose digital logic processor. This type of caution and warning system implementation contains both a memory section and a decision making element.

Input information from the life support system sensors is monitored to detect malfunctions, the decision making element then directs the display presentation of the malfunctioning parameter followed by the corrective action sequence. Safety-critical parameters are assigned priority over non-safety critical malfunctions. The memory element allows the CWS to adapt to multiple malfunction conditions and to detect and accommodate sensor-only failures without unnecessarily terminating an EVA. The CWS will also interact with the crewman by means of display questions and push button answers so that inadvertant switch closures and malfunctioning sensors can be detected and corrected. Life support system expendables are monitored by comparing actual parameter values during the course of an EVA against preprogrammed parameter profiles, and proper corrective commands can be displayed to control excessive use rates.

All of the Caution and Warning System functional logic is stored in solid state electronic memory so that alterations in the number and manner of parameters monitored, parameter priority assignments, messages displayed, and corrective action sequences can be readily achieved by a simple integrated circuit replacement. This feature allows for changes in fault isolation logic as a result of increased understanding of life support system operation, or the CWS function can be totally changed to accommodate various life support systems while still using the same CWS hardware.

2. STATEMENT OF WORK

In order to demonstrate that the principles and concepts utilized in the design of an improved caution and warning system will produce a subsystem acceptable for use in a space application program the contract statement of work (SOW) described the effort required to perform the engineering design, development, testing and demonstration of a CWS breadboard system including both the CWS, and test equipment.

The SOW defined a four-phase program. The phases and corresponding SOW paragraph numbers are as follows:

1. Design Phase	SOW Paragraph 3.2.2
2. Fabrication Phase	SOW Paragraph 3.2.3
3. Test Phase	SOW Paragraph 3.2.4
4. Delivery and Documentation Phase	SOW Paragraph 3.2.5

The four-phase program has been successfully completed and all associated job tasks have or will be completed within the time and budget constraints of this contract.

A brief technical summary of the purpose and scope of each SOW job task is included to highlight program accomplishments.

2.1 DESIGN PHASE

The design phase began with a system study of the Apollo Operations Handbook Extra-Vehicular Mobility Unit, Volume II (CSD-A-789-(2)). This study consisted of an analysis of all pre-EVA and EVA Extravehicular Mobility Unit (EMU) conditions and resulted in a logic flow diagram detailing malfunction conditions, priority assignments, logic to cope with multiple malfunction conditions and definition of proper corrective actions.

The logic flow diagram was then used to develop a circuit design concept. The circuit mechanization was designed to a stage suitable for fabrication into a breadboard system, less the pre-EVA logic.

All EVA fault conditions are displayed and five faults, including one expendable parameter, have complete corrective procedure sequences programmed.

Test equipment to simulate input sensors and circuitry to monitor CWS opration was designed and integrated with the CWS in the same breadboard chassis.

At the conclusion of the design phase, a formal presentation of the logic flow diagram, hardware features, circuit design and fabrication details was made to NASA personnel at the Johnson Space Center.

2.2 FABRICATION PHASE

After NASA review, approval was given to proceed with the next program phase and the fabrication of the breadboard and test equipment was completed.

A software program designed to check out the hardware was developed and installed in the CWS memory so that all CWS operating modes could be exercised to verify proper machine operation prior to installation of the final system memory.

2.3 TEST PHASE

Upon the successful completion of the hardware checkout, the final system software program was finalized and installed in the CWS memory. This program consists of approximately 750 program steps and includes system initialization logic, monitoring of all simulated Apollo Portable Life Support System (PLSS) sensor inputs, complete malfunction procedure subroutines for five malfunction conditions including one expendable check, and a special procedures section to enable reinitialization of the CWS memory.

This software program was then exercised to verify that the CWS did indeed function as programmed and sufficient testing was performed to fully debug the program memory and thoroughly verify the machine performance.

2.4 DELIVERY AND DOCUMENTATION PHASE

Upon completion of the development testing, a demonstration of CWS operatio was given to NASA personnel.

Documentation of program results include this final report, a drawing set detailing circuit schematics and breadboard layouts, a logic flow chart of the CWS software malfunction program, a listing of the machine codes stored in the CWS memory, and a test instruction and procedure document to verify proper CWS operation.

3. CAUTION AND WARNING SYSTEM FEATURES

A summary of the Caution and Warning System features is presented in Table 1.

Eleven different life support system parameters are monitored for sixteen different out-of-range conditions. Some of these parameters are input to the CWS as sensor switch closures and the others are input as analog voltages from sensor transducers. The parameters monitored, the out-of-range conditions detected and the corresponding Apollo Operations Handbook Extravehicular Mobility Unit (EMU) numbers are presented in Table (2).

The parameters are monitored approximately thirty times per second in the sequence given in Table (2). The first five parameter conditions are assigned high priority, and if detected, will override lower order parameter malfunctions.

In addition to the continuous parameter monitoring, the crewman can request a status check at any time, to periodically monitor an additional five system parameters. These parameters and their EMU numbers are listed in Table (3). In the event that the crewman has not requested a status check for a fixed time lapse (10 minutes in the breadboard system), the CWS will remind the crewman that a status check is in order by displaying "STATUS CHECK" and the crewman may initiate the check procedure at his discretion.

Caution and Warning System outputs to the crewman include the message display as well as two different warning tones. Crewman inputs to the CWS are in the form of pushbutton switches for "yes" and "no" responses, a button to request a status check and a button to shut off the warning tone. For a production version system, the status request could be incorporated as a Yes or No response, and the tone reset deleted.

The system circuit design is based upon a digital, bus oriented architecture, with its accompanying simplicity, flexibility and noise immunity advantages. The CWS functional ligic is completely contained within a solid state, electronic PROM (Programmable Read Only Memory). This allows the CWS to be 100 percent reprogrammable; that is, its operating functional logic can be completely changed by the substitution of new PROMS for the existing PROMS.

The system design is such that the operation can be easily expanded. As designed, the system can accommodate up to 4096 discrete program steps and up to 256 individual 16 character messages. As a base line, it is estimated that the functional logic required by the complete Apollo operations handbook malfunction procedures (excluding communication checks and post-EVA procedures) would require approximately 1000 to 1200 program steps for the EVA and 600-700 program steps for the pre-EVA procedures. The corresponding number of messages required would be approximately 75 for the EVA and 100 for the pre-EVA conditions.

TABLE 1

C&WS FEATURES

I SYSTEM FUNCTION

- Continuous Monitoring of Alsa Parameters
- Detection of Out-of-Range Parameters
- Display Presentation of Proper Corrective Action
- Accomodates Multiple ALSA Failures
- Priority Assigned to Critical Parameters

II SYSTEM INPUT-OUTPUT

- ALSA Parameters from sensor inputs
- Simple Crewman Interface

  Outputs: Message display, 2 discrete tones

  Inputs: "Yes" response, "No" response, status request, tone reset

III SYSTEM DESIGN

- Bus Oriented Digital System
- PROM Controlled-100 Percent Reprogrammable
- Expandable

  4096 program steps

  256 16-character messages

- Oral Output by Message Module Replacement
- Low Power CMOS Logic (EST <16 Watts)

TABLE 2

PARAMETERS MONITORED

33.9 Times Per Second

Program Control

*	PGA Pressure	< 3.25	Psid	EMU	2
*	Battery Volts	<16.0	Volts	EMU	30
*	Vent Flow	< 4.0	ACFM	EMU	1
*	PCO_2	>10.0	MM	EMU	33
*	O_2 Flow	> 0.5	Lb/Hr	EMU	3
	O_2 Temperature	>50	F	EMU	32
	Feedwater Pressure	< 1.45	Psia	EMU	4 and 5
	PGA Pressure	< 3.7	Psid	EMU	21
	PGA Pressure	> 4.0	Psid	EMU	22
	O_2 Pressure	<Predicted	Psia	EMU	23
	Feedwater Pressure	< 1.2	Psia	EMU	24 and 25
	LCG H_2O Temperature	>50	°F	EMU	26
	LCG H_2O T	>11	°F	EMU	27
	Battery Current	> 3.0	AMP	EMU	28
	Battery Current	< 2.3	AMP	EMU	29
	O_2 Temperature	<38	°F	EMU	31

* Priority critical parameters

TABLE 3

STATUS CHECK PARAMETERS

PGA Gage	<3.7	Psid	EMU	7
O_2 Quantity Indicator Abnormal			EMU	8
PGA Gage	>4.0	Psid	EMU	9
Loss of Pump Noise			EMU	10
Inadequate Cooling			EMU	11
Depleted Battery Capacity			---	

Crewman may request status check at any time

CWS will remind crewman if no status check has been requested for 10 minutes

STATUS CHECK ?

An advantage of the bus-oriented circuit design architecture is that the display output section could be easily replaced or supplemented by an oral output module.

One of the design goals of the circuit design was to minimize CWS power consumption since CWS power is derived from the life support system battery. This goal was met by utilizing an extremely low power digital logic family throughout the sytem. The logic family is known as CMOS (Complementary Metal Oxide Silicon) which is a mature technology with multiple suppliers, full military specification components and a broad functional range, all readily available. The breadboard CWS system consumes approximately 13 watts and most of that power is utilized to light the LED display. Standby power consumption without the display operating is in the neighborhood of 1 to 2 watts.

4. SYSTEM DESCRIPTION

The next sections of this report will provide detailed descriptions of the CWS hardware and software.

The hardware description includes a detailed presentation of the circuit architecture and function. The software description describes how the system operational logic is programmed into the CWS.

4.1 HARWARE DESCRIPTION

The CWS circuit block diagram is shown in Figure 4-1. Functional descriptions of each of the major blocks follow:

PROM: The PROM (Programmable Read Only Memory) is a solid state electronic memory that contains the CWS functional logic program. This memory is installed into the CWS at the time of manufacture and cannot be altered during system operation. System function can be changed by removing this PROM and installing a new PROM with the different functional Program.

RAM: The RAM (Random Access Memory) is a 64-bit memory that stores information concerning system status, and its contents are changed during the course of CWS operation. For example, if the CWS functional logic determines that a sensor has failed, this bit of information is written into the RAM so that the CWS will take into account the failed sensor status every time the CWS interrogates that sensor. This memory gives the CWS the ability to "Learn" about CWS status during system operation. The RAM can be reinitialized under crewman control, and will relearn the current CWS status at the time of the reinitialization.

CPU: The CPU (Central Processing Unit) is the "brain" of the CWS. It selects the next functional logic program step (i.e., PROM information address) based upon data given by sensor inputs, analog-to-digital conversions, time delays, and RAM status data. The CPU is also constantly on the alert for an interrupt signal generated by one of the five critical priority parameter inputs. Upon receipt of a priority interrupt, the CPU initiates a branch in the functional logic software to a priority service subroutine.

MESSAGE MODULE: This section of the CWS can store up to 256 sixteen-character messages in its own PROM. The module will output these messages and all display drive signals when it is addressed by the CPU.

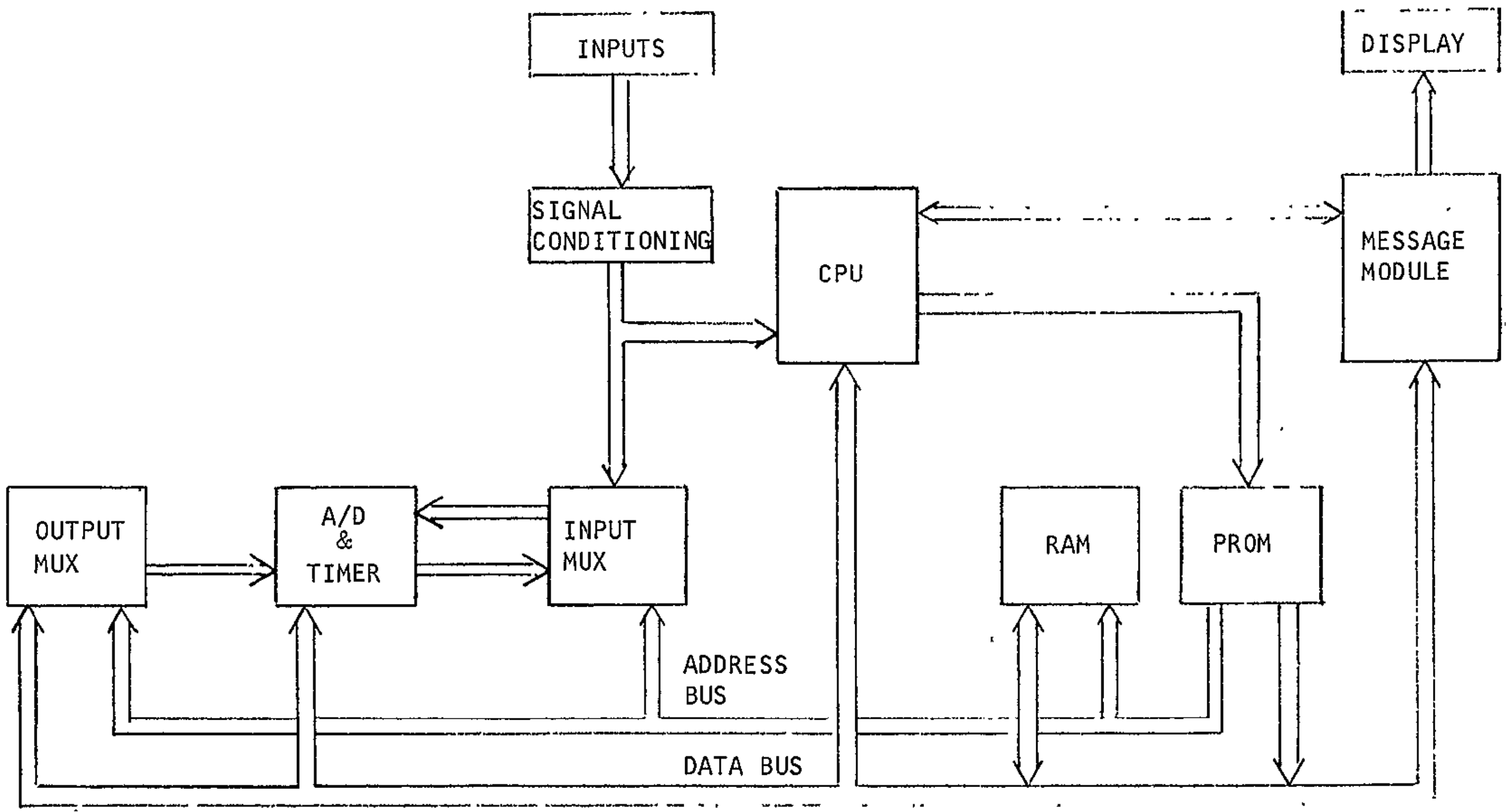


FIGURE 4-1. CWS BLOCK DIAGRAM

DISPLAY: The display consists of a 16-character, light-emitting-diode (LED) display. Each character is formed by lighting the proper leds which are arrayed in a 5 x 7 dot matrix. This type of display was selected for the breadboard system from among several possible display technologies suitable for a production version CWS. Led displays are extremely rugged and reliable, but are relatively inefficient considering light output from electrical power input. A study performed to determine the optimum display technology for use in a production CWS considering efficiency, reliability, availability, cost and environment would be a suitable subject for a future effort.

SIGNAL CONDITIONING: This section of the CWS converts sensor and switch inputs into binary logic levels compatible with the CWS internal circuitry. This section also buffers sensor transducer inputs for the analog-to-digital converter and provides out-of-range parameter level detection.

A/D CONVERTER AND TIMER: This section performs all analog-to-digital (A/D) conversions required by the CWS functional logic. It also generates all of the various time delays required. The type of A/D conversion (up, down, differential and offset), as well as the lengths of the various time delays generated are specified by data bits stored in the PROM (i.e., the system functional logic program)

INPUT/OUTPUT MUX: The input and output multiplexers (MUX) connect up to 64 various input and output signals onto the system data bus, and analog signals into the A/D converter.

ADDRESS BUS: This bus contains seven bits of information and originates from the PROM. This allows the program stored in the PROM to select any one of 128 input, output or RAM locations as the source or destination of data.

DATA BUS: this bus consists of seventeen bits of information and is common to all sections of the CWS (except the signal conditioner). Five bits of the data bus are used as control bits and determine the CWS operating mode (loading data, checking data or displaying a message). The remaining twelve bits of the data bus contain either program jump address information, or A/D converter data.

4.2 HARDWARE OPERATION

As discussed in the previous section, the CWS functional logic program is stored in the PROM memory. Each step in the functional logic program addresses one word in the PROM. Each PROM word consists of 24 bits of data which are divided into 3 sub-words or fields. The PROM field definitions are illustrated in Figure 4-2.

PROM bits 1-12 comprise the data bit field, bits 13-17 comprise the control bit field, and bits 18-24 comprise the address bit field.

Interpretation of the PROM data is controlled by bit 13, the message bit.

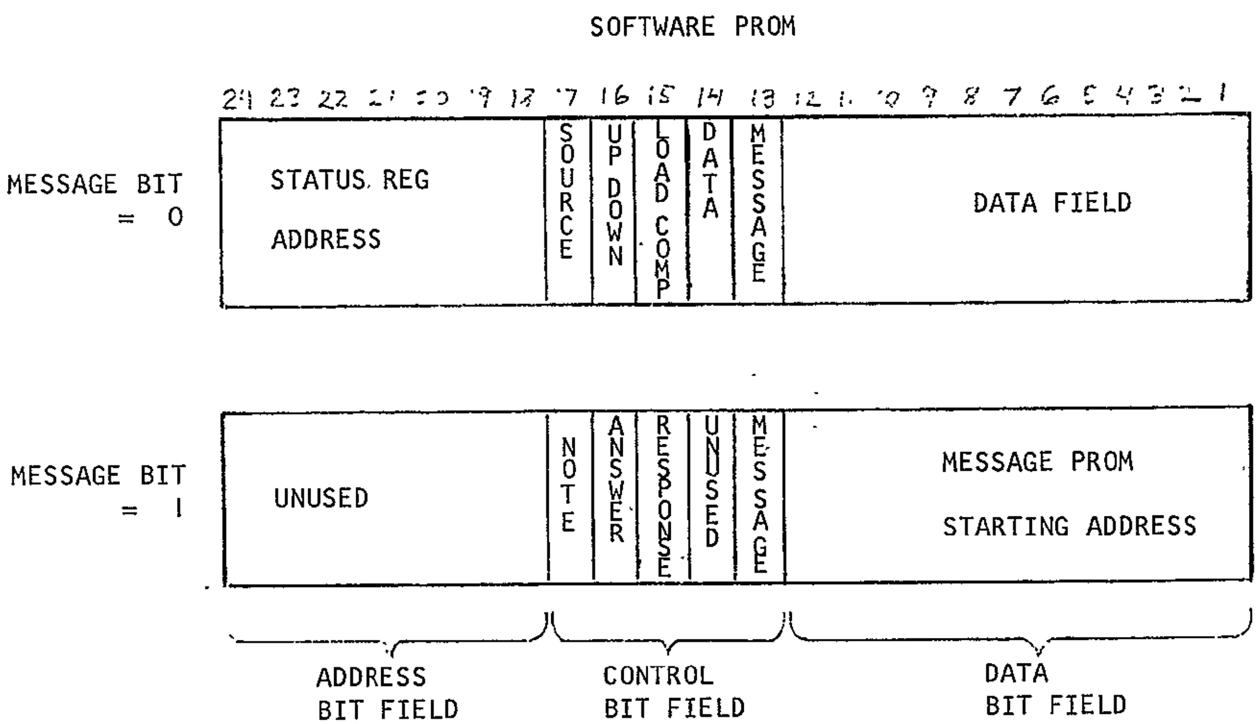


FIGURE 4-2. PROM FIELD DEFINITION

If the message bit equals "0", the program step is not a message step, and the PROM fields are intepreted as shown in the top part of Figure 4-2. The address field (bits 18-24) specifies which one of 128 locations is the source or destination of data. The load/compare bit (bit 15) determines whether the CWS is to store a piece of information, or to compare an input variable to a predetermined value (the data bit, bit 14). Bits 16 and 17 control the source of data and mode of operation of the A/D converter. The data field (bits 1-12) contains data that can be used in two ways. When the CWS is comparing an input variable with its predetermined value, a match in the two pieces of information will cause the PROM to increment to the next sequential step in the functional logic program; a mismatch in the two pieces of information causes the PROM to jump to the program step whose number is stored in the PROM data field. For example, if the functional logic program is checking on the status of a certain input sensor, it will compare the condition of that sensor against its normal value. If the two pieces of data match, the PROM is incremented one step and checks the next sensor input. If the data does not match, the PROM program is jumped to a program step (PROM location) where the corrective action procedure subroutine for the malfunctioning sensor is stored. The second function of the data field is to store predetermined values of analog to digital converter results so that analog sensor inputs can be checked similar to the procedure just described for switch sensor inputs.

If the message bit equals a logic "1", the program step is to output a display message, and the PROM fields are interpreted as shown in the bottom part of Figure 4-2. The data field (bits 1-24) contains the address of the particular message that is required. The messages are stored in a small PROM within the message module section of the CWS. A list of the various messages stored in the breadboard message module is included in Table 4. This list contains the starting address and text of each message. Bits 18-24 are unused, and bits 15-17 control the type of warning tone that is to be generated, whether or not a crewman response is required, and if a response is required, whether a yes only or a yes-or-no answer is acceptable.

The PROM is stepped through the functional logic program at a rate of 2000 steps per second. At this program operating speed, each input parameter listed in the Apollo operations handbook EMU conditions is checked 33.9 times per second. The input parameters are polled in sequence, and in the event that an input parameter is detected to be out of range, the program stored in the PROM is jumped to a subroutine that services the particular malfunctioning input condition.

The 2000 Hz PROM clock is derived from a four-phase, 8000 Hz system clock so that each PROM program step is controlled by four separate clock pulses, simplifying the PROM control logic design and eliminating any potential logic race conditions. During the second phase of each PROM program step, the priority critical input parameters are checked (independant of the functional logic program). This provides continuous monitoring of the priority inputs and is completely transparent to the PROM sequencing. If a priority input is detected, the normal PROM sequence is interrupted and the PROM is jumped to the address location which contains the first step of the priority interrupt subroutine.

TABLE 4

MESSAGES

0 AIRESEARCH MFG !	196 D/V MAX ?	401 PR102 = 75% ?	606 REINITIALIZE ?
14 START EVA	203 INCREASE D/V	411 PR102 = 80% ?	619 REPEAT PREEVA ?
22 TURN FAN ON	214 LOW WATER PRESS	421 PR102 = 85% ?	632 GO TO EMU2-1A
31 FAN SW ON ?	227 HIGH SUIT PRESS	431 PR102 = 90% ?	643 USING AUX H20 ?
39 TURN PUMP ON	240 HIGH LCG TEMP	441 PR102 = 100% ?	655 GO TO EMU 4
49 PUMP SW ON ?	251 PR102 EMPTY ?	452 HIGH DELTA T	662 GO TO EMU 5
58 LOW SUIT PRESS	262 PR102 = 5% ?	462 CURRENT > 3 AMP	671 PR102 = 95% ?
70 CONTINUE ?	271 PR102 = 10% ?	474 CURRENT < 2.3 A	681 THANK YOU
79 TURN FAN OFF	281 PR102 = 15% ?	488 SOT TEMP < 38	689 ENTER "YES"
89 FAN SW OFF ?	291 PR102 = 20% ?	498 STATUS CHECK ?	699 MESSAGE
98 OPEN OPS	301 PR102 = 25% ?	510 BATT DEPLETED	
105 PURGE LOW	311 PR102 = 30% ?	522 SPECIAL PROC ?	
113 LOW BATT VOLTS	321 PR102 = 35% ?	534 PGA < 3.7 ?	
125 POSTEVA C/O REQD	331 PR102 = 40% ?	542 PR102 ABNORMAL ?	742 TURN PR102 ON
140 LOW VENT FLOW	341 PR102 = 45% ?	556 PGA > 4 PSI ?	753 SOT > 50
151 HIGH PC02	351 PR102 = 50% ?	565 HEAR PUMP ?	759 AND RISING
159 REST 5 MIN	361 PR102 = 55% ?	574 RCVNG SIDETONE ?	768 COMFORTABLE ?
167 CLOSE PURGE	371 PR102 = 60% ?	588 PGA > 3.7 ?	780 HI 02 USE RATE
177 CLOSE OPS	381 PR102 = 65% ?	596 CLOSE PR102	791 PART REINITIAL ?
185 HIGH PR102 FLOW	391 PR102 = 70% ?		

4.3 SOFTWARE DESCRIPTION

The CWS functional logic is contained in the program stored in the PROM memory. The purpose of the CWS software is to enable the system designer to develop a functional logic program based upon any particular life support system, to develop this program into a logic flow diagram and then to code the resulting logic flow diagram into the CWS machine language so that the correct pattern of logical "1's" and "0's" can be stored in the PROM memory.

For the breadboard CWS the functional logic is organized in a flow chart consisting of a mainline program and supporting subroutines. An excerpt from the complete flow diagram is shown in Figure 4-3.

The mainline program consists of a string of decision blocks designed to check the status of all input sensor parameters in sequence. The CWS constantly cycles around this mainline program loop, polling sensor status (plus some overhead program steps) until one or more of the input sensors indicate a malfunction.

Referring to Figure 4-3, a section of the flow chart corresponding to Apollo Operations Handbook EMU condition number 27 is shown. Program step 53 is a diamond shaped decision block that tests the LCG (Liquid Cooled Garment) ΔT sensor to see if it indicates a delta temperature of greater than 11°F. If the sensor reading is normal, the program will advance to Step 54 which tests the battery current level (corresponding to EMU 28). If, however, the LCG ΔT sensor indicates an out-of-range condition, the program will jump to Step 533, which is the first step of the LCG ΔT service subroutine.

The number to the right, above each decision block, indicates the address assigned to the parameter that is tested by the decision. The decision blocks can test sensor input parameters directly, or they can test CWS status information stored in the CWS RAM. For example, the first step (533) in the LCG ΔT subroutine tests to see if the CWS has previously determined that the LCG ΔT sensor has failed, this bit of information is stored in RAM location 080. If the LCG ΔT sensor is failed, LCGDT will equal "1" and the subroutine logic will ignore the failed sensor and return to the mainline program at Step 54.

The complete functional logic program flow chart for the breadboard CWS consists of slightly more than 700 program steps and is included as Appendix (B) of this report. The flow chart is in the form of a paper roll 18 inches wide by approximately 50 feet in length and is transmitted separately from this report.

The three basic modes of CWS operation are illustrated in the flow chart example of Figure 4-3. The diamond shaped decision blocks represent operation of the "compare" mode. In this mode the CWS compares input data or internal status data against predetermined values stored in the software PROM, and based upon the results of the comparison will either advance one program step, or branch (jump) to any specified program location.

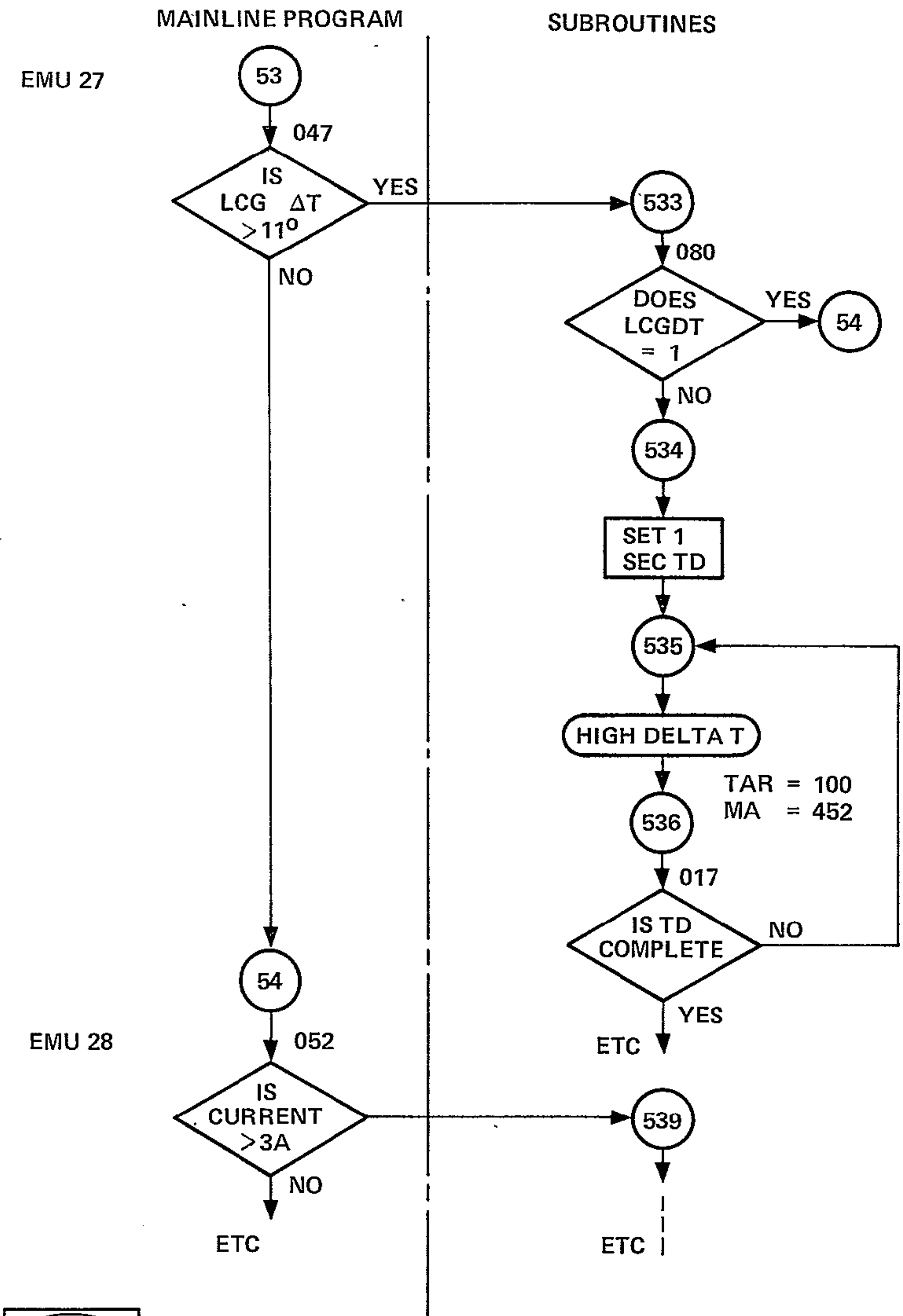


FIGURE 4-3. EXCERPT FROM PROGRAM FLOW CHAR.

S-98426

The rectangular action block shown as Step 534 (load 1-sec time delay) illustrates CWS operation in the "load" mode. In this mode the CWS will load data into the specified CWS module. In this case the machine code representing a one-second time interval will be loaded into the time delay counter. Action blocks can be used to start A/D conversions or to load CWS status information into the RAM.

The third machine mode of operation is illustrated by the message bubble shown as Step 535. The message to be displayed ("High Delta T") is shown in the bubble. The starting address of the message (MA = 452) and the three bit message control code (TAR = 100) are shown adjacent to the bubble. Definition of the three bit message control code is given in the following table.

MESSAGE CONTROL CODE

	T	A	R
	TONE BIT	ANSWER BIT	RESPONSE BIT
"1"	Produces continuous emergency tone	Either a "Yes" or "No" answer will be accepted	Crewman must push either the "Yes" or "No" answer switch
"0"	Produces modulated attention tone	Only a "Yes" answer will be accepted	No response is required. Message is displayed for 1/2 second

Many subroutines are utilized by more than one EMU malfunction condition. Rather than duplicate complete subroutines for each EMU condition, subroutines can be written and stored once (saving PROM memory capacity) and called from many points in the mainline program. Subroutines can also be nested; that is, one subroutine can call on another subroutine. Seventeen storage locations in the CWS RAM are set aside for subroutine control. If a subroutine is to be called upon from more than one entry point, a data location in the RAM, unique to the calling program step, is set to a logical "1". Upon completion of the subroutine, the RAM data is checked to find the logical "1" flag which identifies the proper return point in the main program or calling subroutine.

The program flow chart provides the system designer with the link between the life support system malfunction procedure logic and the CWS machine language pattern of "1's" and "0's" stored in the PROM. The system designer translates the desired malfunction procedures into a flow chart using the three symbols described earlier; decision blocks, action blocks, and message blocks. With only these three simple tools at his command, a flow chart is easily constructed; yet they provide the capability of monitoring input sensors, monitoring CWS system status, identifying and accommodating failed sensors and multiple malfunctions, and provides an extremely flexible output display presentation and direct interaction with the crewman.

Once the flow chart is constructed, the next task is to translate the flow chart logic into the CWS machine language code. Conceptually, this is a simple procedure. For each program step a PROM address is coded with 24 bits of data in three separate fields (address, control and data fields). The code definitions have been explained in the hardware operation section of this report.

Since a CWS application program might require 2000 program steps, approximately 50,000 (2000 words X 24 bits) discrete bits of information must be loaded into the CWS PROM. In order to eliminate the task of manually translating the program flow chart into CWS machine language code a computer program was developed and written to automate this task.

This software translation program allows the system designer to use familiar decimal notation during the coding operation. Standard IBM-type computer-coding forms are used. For each step on the flow chart, three numbers are written. An address field (0-128), a data field (0-4096) and a control field (00000-11111). Computer cards are keypunched from the coding sheets and entered into the computer along with the software translation program card deck. The computer will then process the coding information and provides a computer printout that lists all of the flow chart program steps in sequence, the input information in decimal notation and the corresponding binary machine language PROM code patterns. The computer also provides a paper tape with the PROM bit pattern suitable for use with automated PROM data storage equipment.

A listing of the PROM software translation program as well as the computer printout for the flow chart of the breadboard CWS is included as appendix C of this report.

This program was written and operated on the AiResearch IBM model 370/158 computer. The program is written in standard Fortran IV computer code suitable for any computer with a Fortran compiler.

The Caution and Warning System software is designed to provide a simple, efficient and fast procedure for developing CWS PROMS from the life support system malfunction procedures.

The software cycle is shown in Figure 4-4. System malfunction procedures are used to define a functional logic flow diagram. The flow chart is coded in simple decimal format onto computer keypunch cards. The cards are used as input for the software PROM translation program which generates a computer printout listing of the flow chart and the binary PROM code. A paper tape of the binary PROM code is also automatically produced. These tapes are used with automated equipment to "blow" the PROMS which can then be inserted directly into the CWS breadboard.

The efficiency and flexibility of this software system was amply demonstrated to NASA personnel during the development testing phase of this program when modifications, additions, and deletions to the malfunction procedure functional logic could be incorporated into the breadboard hardware within a three-hour time span.

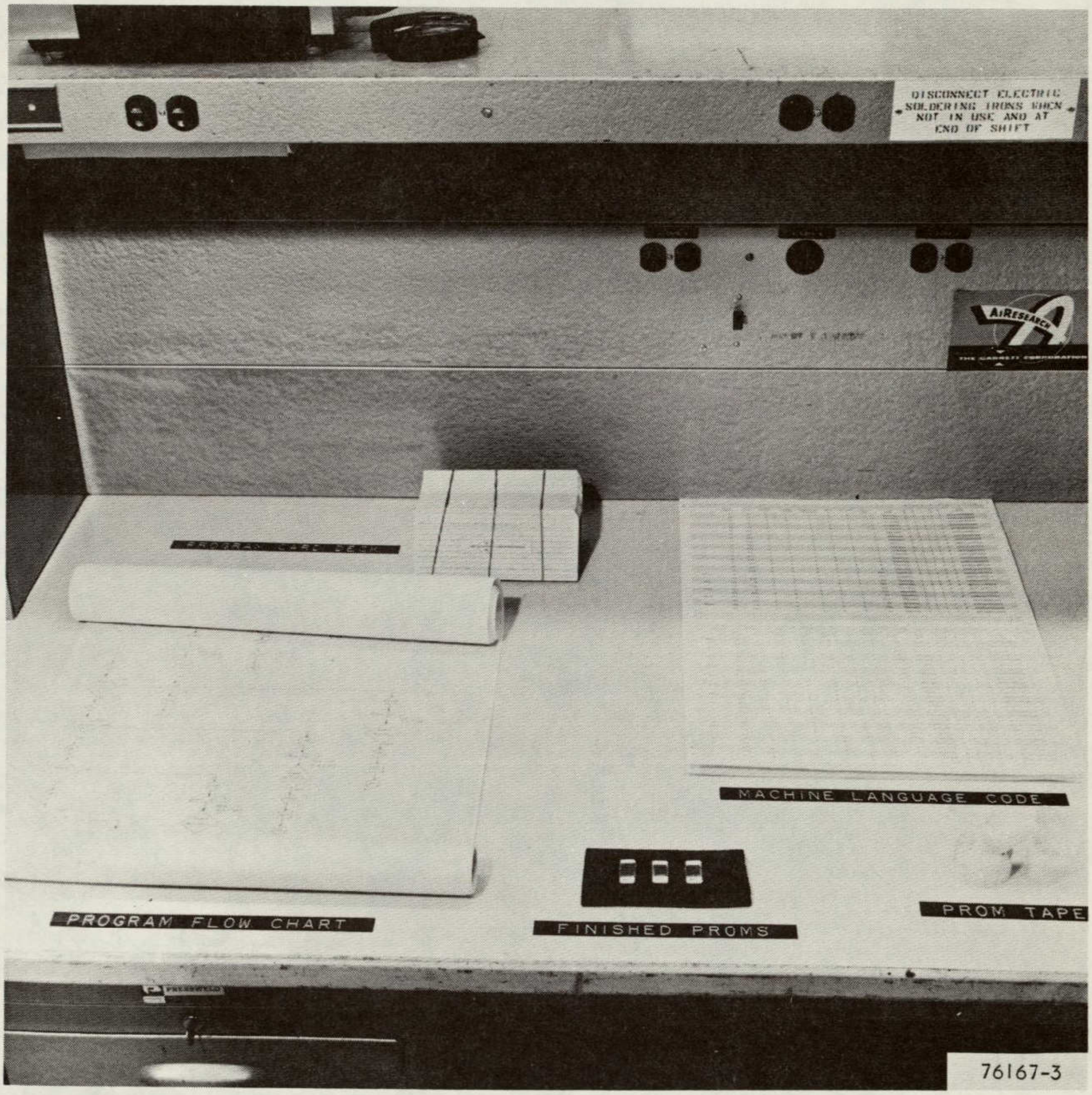


FIGURE 4-4. CWS SOFTWARE CYCLE

4.4 TEST EQUIPMENT

In order to provide meaningful data from development testing of the CWS, it was necessary to simulate a life support system so that various malfunction condition problems could be set up and proper operation of the Caution and Warning System verified.

Life support system sensors were simulated by switches, and potentiometers were used to provide analog transducer inputs.

In order to facilitate checkout of the Caution and Warning System itself, test equipment designed to monitor the internal operation of the CWS was also developed and fabricated.

The CWS breadboard and all associated test equipment and displays were integrated into one cabinet for ease of operation and transportation. A summary of the test equipment features is presented in Table 5.

TABLE 5

TEST EQUIPMENT FEATURES

- o INTERFACES WITH 115 VAC LINE ONLY
- o EXTERNAL CLOCK CAPABILITY
- o SINGLE STEP CAPABILITY FOR PROGRAM COUNTER
- o DECIMAL READOUTS FOR
    1) PROGRAM COUNTER OUTPUT
    2) STATUS REGISTER ADDRESS
- o LED READOUTS FOR
    1) PROM BIT OUTPUTS
    2) A/D COUNTER
    3) CLOCK PHASES (1 THROUGH 4)
- o SPEAKER FOR AUDIO TONE AND SWITCHES FOR CREWMAN INTERFACE
- o PLSS INPUTS ARE SIMULATED BY SWITCHES AND POTS
- o INTEGRATED WITH C&WS IN ONE CABINET

A close-up view of the hardware front panel is shown in Figure 4-5.

The top section of the front panel is labeled RCU (remote control unit) simulator and simulates the crewman interface to the system. Pump, fan, status and "yes"/"no" switches are provided. The display and a speaker simulating the crewman's headset is also provided. A single power on-off switch for the system is in the upper right hand corner of the front panel.

The center section is labeled PLSS simulator and provides all of the life support system inputs. A selector switch and meter is available so that all analog inputs can be read as a percent of full scale on the meter as potentiometers are varied. Light emitting diodes (LED's) are provided above the analog sensor potentiometers so that out-of-range conditions are immediately apparent as the potentiometers are adjusted.

The lower section of the front panel is used to monitor, control and display the operation of the caution and warning system. LED's are provided for the PROM data field, control bit field, and A/D converter contents. The address field and program step number are converted from binary to decimal with seven segment decimal readouts so that manual decoding of binary bit patterns is not required. Clock mode control is provided so that the CWS internal clock can be stopped and the system manually stepped one clock phase at a time. Provision for an external clock input is also provided. Thumbwheel switches are available so that any program step number can be set in the switches and a "jump" button will load this address into the CWS program counter. This feature allows the user to reset the CWS to any point on the flow chart without the necessity of following the normal flow chart program sequence.

4.5 FABRICATION

The Caution and Warning System breadboard, the life support system simulator and all associated test equipment was integrated into one cabinet. The size of the cabinet was chosen to accommodate the large front panel and is not indicative of a production system. The large cabinet facilitated system integration and checkout since ample room was available to mount the electronic circuit cards. Rather than devote program resources to the design and development of efficient power supplies to simulate operation with life support system batteries, an economical, commercial power supply was purchased and installed. This also allows system operation from readily accessible 115 volt power outlets.

A view of the internal construction of the hardware is shown in Figure 4-6. All of the circuitry (except the display drive section) are mounted on prefabricated logic panels specifically designed for use with standard dual-in-line integrated circuit packages. Signal interconnections on each board use standard back panel point-to-point wirewrap. Interconnections between boards use prefabricated, flexible flat ribbon cable and connectors. The logic boards are mounted free standing and the top board will pivot upwards to provide easy access to the PROM circuit packages which are installed on the lower board. The display drive circuitry was mounted on a custom printed circuit card and mounted on the right side wall of the cabinet (visible at the rear of Figure 4-6).

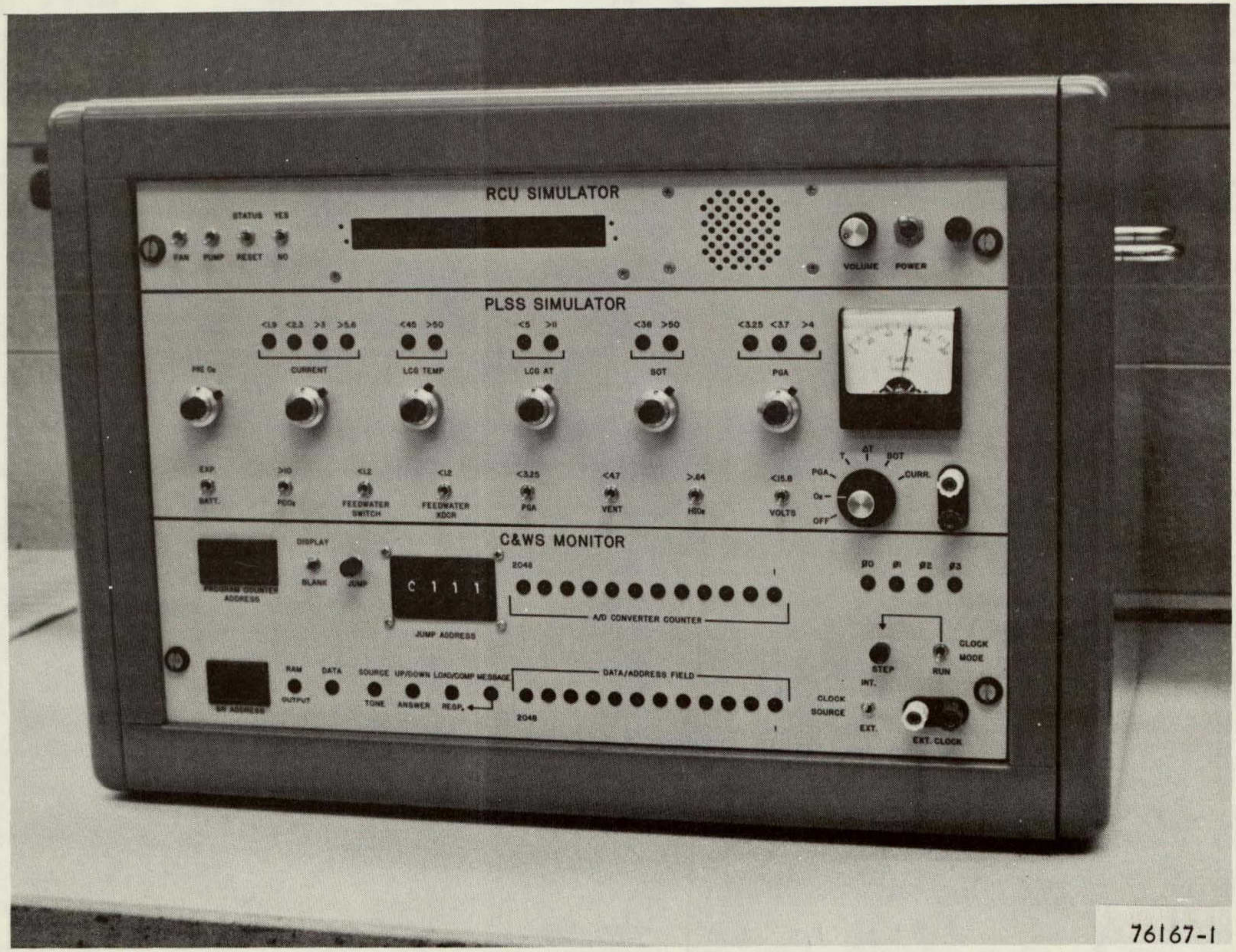


FIGURE 4-5. CWS FRONT PANEL

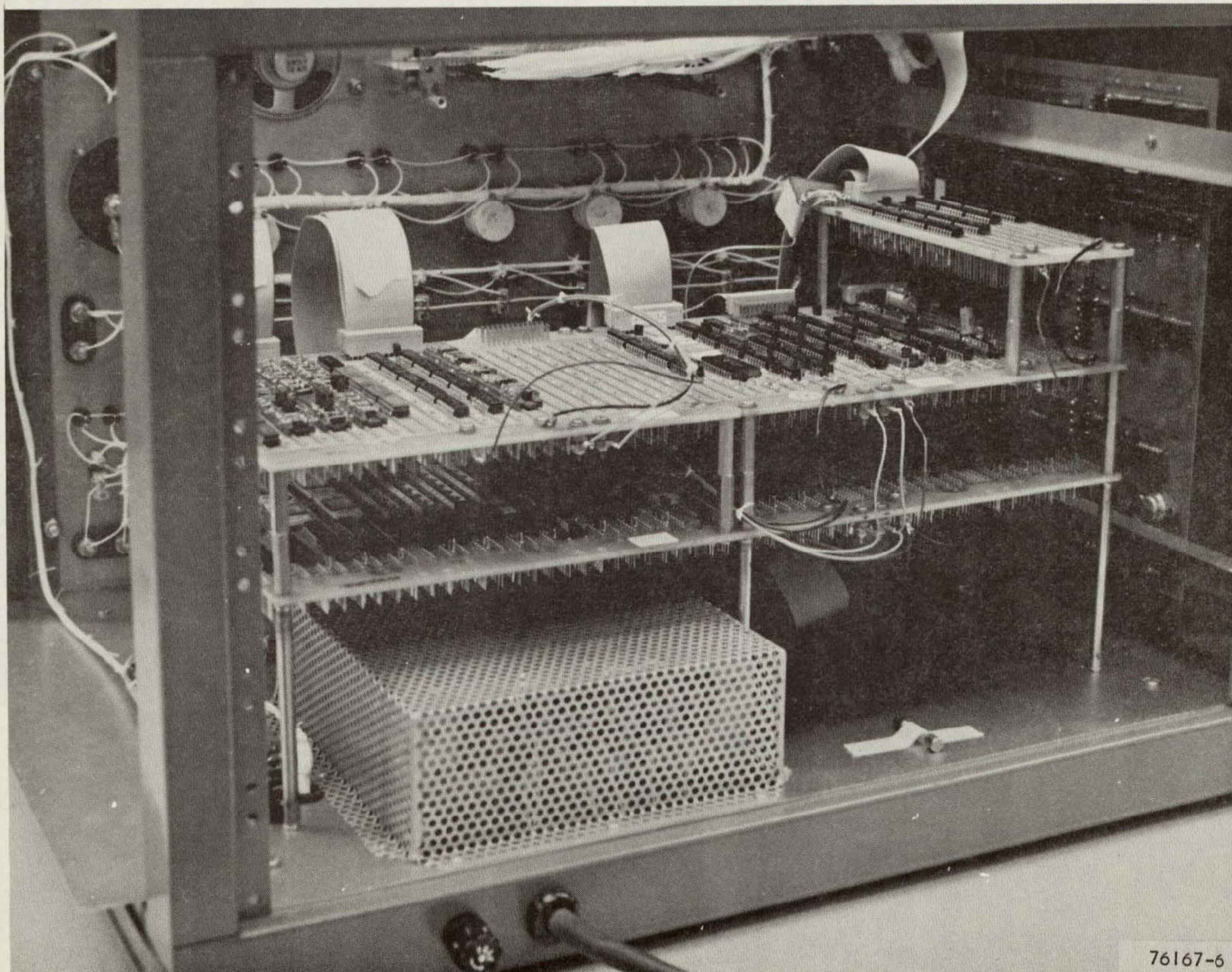


FIGURE 4-6. CWS BREADBOARD INTERNAL CONSTRUCTION

Approximately 50 percent of the circuitry shown in Figure 4-6 is utilized for the required test equipment and monitoring displays.

The PROMs used in the breadboard are erasable-programmable-read-only-memories (EPROMs). These integrated circuits are manufactured with a quartz window in the top of the package. Application of ultraviolet light completely erases the information stored in the internal memory circuits of these PROMs so that they can be reprogrammed and used many times. This feature is cost effective during the development phase of a CWS system design, then when the functional logic is completely developed, the memories can be replaced with less expensive permanent PROMs.

A point of interest concerning PROM technology deals with the rapidly advancing state of the art in the achievement of increasing PROM bit densities. Each PROM used in the CWS breadboard contains 8192 (8K) bits of information so that the breadboard 700 step program requires six PROM packages. Since the beginning of this effort the Intel Corporation has marketed PROMs containing 16,384 (16K) bits of data in the same size package. Bit packaging density will continue to increase in the future. The CWS circuit design implements some of its operational decision making with hardware, rather than software in an attempt to minimize the amount of memory required. With smaller memories becoming available, the built-in hardware control could be redesigned (and simplified) while allowing the software (PROMs) to assume the control tasks. This would cause a further increase in CWS flexibility; particularly in the manner in which messages are displayed and crewman responses are interpreted.

4.6 PRODUCTION PACKAGE STUDY

The original statement of work required that a study be made for a package to house the electronics in a production version of the Caution and Warning System. Before much work was done on this phase, it was decided by NASA that the time and funding would be better spent on the hardware rather than on the study. However, a preliminary study was made but it was not investigated in any detail and no tradeoff was made. The areas of investigation were:

- Component package technique
- System package technique
- System package size
- Display package review

4.6.1 Component Package Technique

There are basically three technologies that can be used. They are 1) discrete, 2) hybrid, and 3) custom large scale integration (LSI). Although there was no tradeoff made, the most logical approach that should be taken is a combination of discrete and hybrid technologies. This conclusion is based on size, reliability, ability to change, lead time for delivery and cost.

4.6.2 System Package Techniques

There are several approaches that were to be considered for packaging the system. The approaches are: 1) soldered printed circuit cards, 2) stitchweld printed circuit cards, 3) wire wrap, 4) welded modules, and 5) combinations thereof. The welded module approach would minimize the size but would be impractical to package multi-leaded devices with such techniques. Soldered printed cards would be smaller and less costly than stitchwelded cards but not as reliable. Wire wrap is larger than stitch-welded cards and not as reliable; however, it is the easiest for maintainability. The recommended approach would be a combination of stitchwelded p.c. cards for the integrated circuits with welded modules for components with few leads such as resistors, capacitors, diodes and transistors.

4.6.3 System Package Size

Based on using hybrid packages and a combination of stitchweld cards and welded modules, the size of the package is approximately 80 cubic inches.

4.6.4 Display Package Review

The display for annunciating the caution and warning is visual. Investigation of other types of displays to be used was started but no conclusion was reached. The package for the display would be approximately 16 cubic inches. It should be located where it would not interfere with the mobility of the crewman while being easily seen and read.

5. DEVELOPMENT TESTING

Upon completion of hardware fabrication, the hardware was checked to verify that all circuitry functioned as designed. A special PROM memory was programmed with a system checkout program. This test program was designed to test all of the operating modes of the CWS breadboard and test equipment. All sensor inputs were checked, various types of message displays and responses were tested. The analog to digital converter was calibrated and tested in all of its operating modes. Assorted time delays were programmed and checked, and the CWS monitor, single step clock and program jump control were tested. During this phase of the system testing various and sundry hardware quirks were discovered and corrected. This phase of the testing also verified the software programming rule structure, so that experience and confidence were gained in the ability to construct a functional logic flow chart diagram and translate the flow chart into operating hardware.

The next phase of the development testing consisted of developing and testing a functional logic program based upon an existing life support system. Malfunction procedures utilized were based upon extravehicular mobility unit conditions as specified in Apollo Operations Handbook CSD-A-789-(2), Volume II.

All input sensors are monitored for out-of-range conditions, and complete corrective action subroutines were programmed for six malfunction conditions, including an expendable parameter. Corrective action procedure subroutines are included for low battery voltage, low vent flow, high sublimator outlet temperature, high carbon dioxide partial pressure and high pressure garment assembly pressure conditons. Primary oxygen (an expendable) is also monitored for abnormal use rates.

Upon completion of the functional logic flow chart, PROM memories were programmed and installed in the breadboard. The flow chart was completely checked and the breadboard CWS performed as ordained by the flow chart.

The development testing performed on the breadboard CWS confirmed and verified the design and development phases of this contractual effort, demonstrated the operation of the breadboard CWS with two separate functional logic programs and demonstrated the flexibility and ease of adapting this CWS to any present or future astronaut life support system.

An additional comment can be made. The CWS operating speed is orders-of-magnitude faster than the human response time and it was necessary to stop the machine operation from time to time during the development testing, so that simulated life support system parameters could be modified to emulate the parameter responses that a real life support system would provide. A future program to modify the CWS to accept sensor inputs from a real-time life support system simulator (or an actual life support system) would provide meaningful test data.

APPENDIX A

"CONCEPT STUDY OF THE ELECTRICAL DISTRIBUTION SYSTEM"

AiResearch Report Number 75-11206

PRECEDING PAGE BLANK NOT FILMED

AIRESEARCH MANUFACTURING COMPANY
OF CALIFORNIA

CONCEPT STUDY

OF

THE ELECTRICAL DISTRIBUTION SYSTEM

(EDS)

75-11206 February 6, 1975

Number of pages 18

Original date February 6, 1975

Prepared by R. Ichikawa

Edited by M. W. Castle

Approved by R. Ichikawa

Revision	Date	Pages Affected (Revised, Added, Eliminated)

CONCEPT STUDY OF THE ELECTRICAL DISTRIBUTION SYSTEM (EDS)

Sections I thru VII describe the alternative concepts or approaches considered for use in the E. D. S. Table 1 shows the ranking of each concept to aid in the selection of an optimum design. Items were rated on a scale of 0 to 10. An "0" rating indicates that particular item is unknown at this time and testing will be required.

When first considered, a breakout box appears to be an ideal method for simplified system modification. However, the additional housing, cover, connectors, wire, etc., that are required will result in an increase in the system volume, weight and cost. The system reliability will be decreased because of the additional interconnections involved. In most cases. when systems are modified, components as well as wiring must be changed. This requires modifying the individual units as well as the breakout box. If the methods covered in this study are used for system design, modifications can be accomplished in the most economical manner and the system can be packaged into the least volume. AiResearch Manufacturing strongly suggests that the EVLSS be built without using a breakout box.

"Scoop-proofing" is a feature of a series of connectors designed to eliminate the possibility of bent contacts. These connectors in all cases are larger and cost more than the standard I/O connectors. In compact systems where weight and volume are critical it is doubtful if the protection provided is worth this increase.

A survey conducted by a major aircraft company found that approximately 10% of contact damage is caused by incorrect mating while the remainder of damage is caused by careless techniques during the handling, assemblying or testing phases. Tight manufacturing procedures such as using protectors during test, not using alligator clips or other tools as probes, covering connectors when not in use and pre-alignment of contacts before mating will eliminate the possibility of bent contacts.

In many cases, connectors are located in the same general area. When using round connectors of varying diameters in adverse assemblying conditions it is highly probable that an attempt at cross mating can occur. Whenever a smaller plug enters the inside of a larger receptacle, even the "scoop-proofing" feature will not always provide adequate contact protection. Using better connector separation, similar shell diameters and eliminating blind installations will permit use of standard connectors.

If the above design guides are followed a reliable, more lightweight unit is possible and this method is recommended for use in the EVLSS.

Regardless of which external harness is selected, modification is doubtful since some destruction would be required. Of the three, molded, heat shrinkable tubing and foil wrapped, the molded assembly would be the least desirable. If the harness could be made on one plane a mold can easily be made. Past experiences on space applications has shown that to effectively utilize the allotted volume and meet weight restrictions the harness will have to be formed to go around components within the assembly. The mold then would have to be a complex shape and the cost would be quite expensive for the low quantities generally associated with space applications. Some unit modifications can be achieved however by providing spare contacts and conductors within the harness assembly.

Flexible circuitry will not be selected for use in this application. Although a high level of reliability is possible, assembly is generally done by soldering and does not meet this EVLSS design goal. The remaining 2 types, flat cable and wire are equal in the overall scale and selection will be based on the final design criteria.

Wirewrapping and stitchwiring are efficient, reliable systems that can reduce or eliminate the need for solder. Comparison between the two indicates that both should be used for the EVLSS.

The wirewrap technique presents the greatest versatility for unit modification but it also requires the most volume for packaging. Discrete components are not available with wire wrap leads. This method therefore cannot be utilized throughout the entire unit unless welded modules with wrap terminals are used.

Stitchwiring assemblies are available by welding discrete components to stainless steel pins. This assembly, with conductors welded to both sides can have the same density as that of a six to eight layer printed wiring board. This higher density will aid in reducing the total number of boards required and will result in a lesser volume and lower weight.

Modification at the present time is limited to in-house operations but portable equipment is being developed and is expected to be ready for use in the spring of 1975. Field modifications can be accomplished using solder or by complete board replacement.

The MIL-W-81381 wire is selected for use on the EVLSS because of its lightweight construction, mechanical strength, and electrical properties. It can be used with wire wrap applications and flat cables are available using the same insulation material. It cannot be used with stitchwiring since the cut-through strength of the wire is greater than the pressure that can be exerted by the stitchwiring equipment.

In circuit boards, component leads must be stress relieved to lessen the possibility of cracked solder joints. Some form of stress relief should be provided for when using solder for a hermetic seal between rigid mechanical parts. The Control Module used in the Skylab ALSA was stress relieved by pre-positioning the cover into the housing with hardware prior to soldering. This method would be utilized should solder be selected for this application.

Preliminary testing was conducted on the Skylab ALSA Control Module using RTV with a tear seal. The specimen could not maintain a pressure seal and failed the water leak test prior to temperature and pressure cycling. To determine the merits of RTV as an effective seal more extensive tests will be necessary. The previous test was limited to the type of groove used since the envelop size could not be exceeded. Future tests should be conducted on the following:

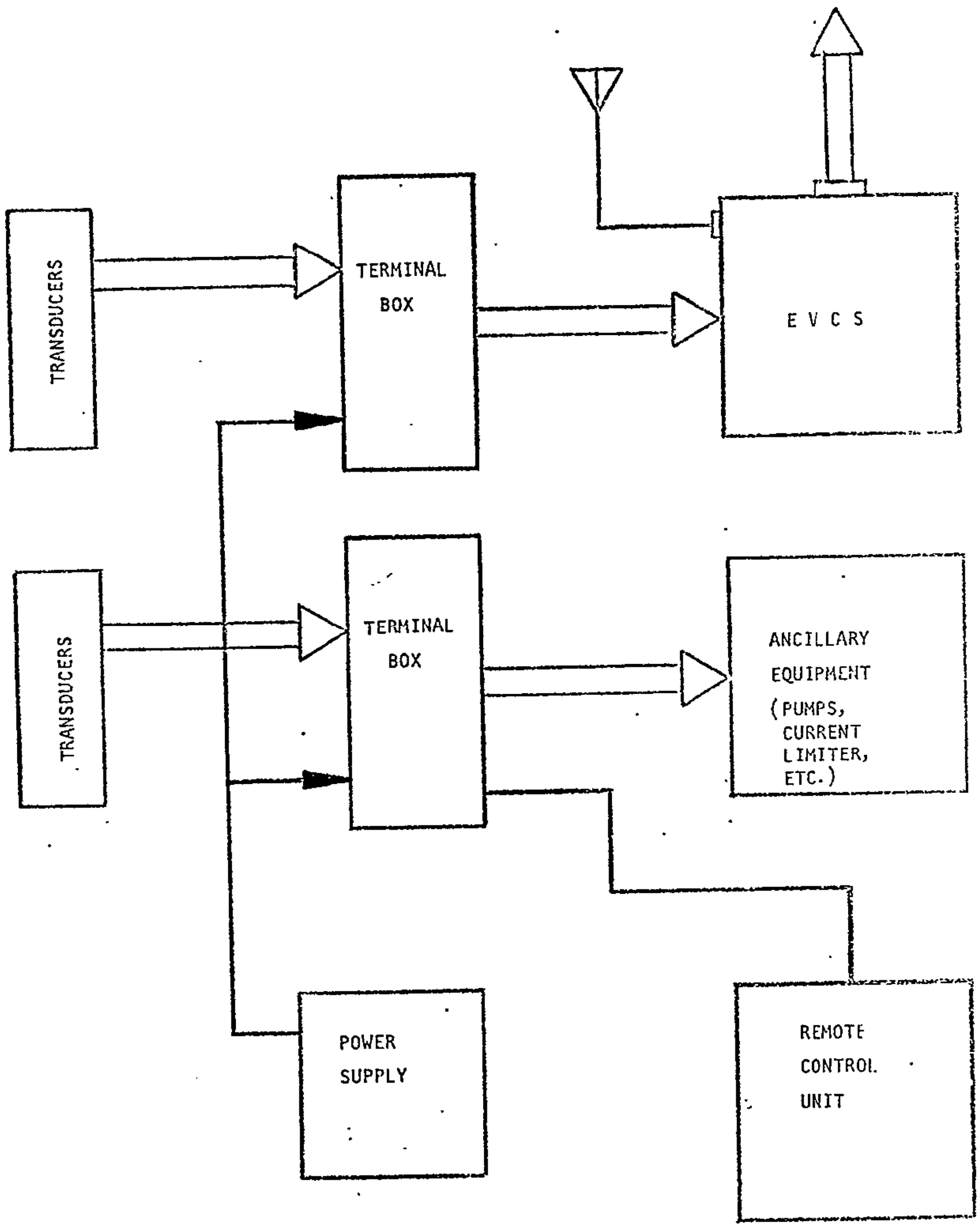
1) Should a groove or a flat surface be used
2) Size of groove or flange necessary
3) "Tear-wire" or solvent for entry into unit
4) Maintenance of seal with or without hardware

If the groove is not effective and a flange is necessary the size required would probably be similar to that used with the "O" ring or "gask-o-seal" and would not offer any size or weight advantage for use in this application.

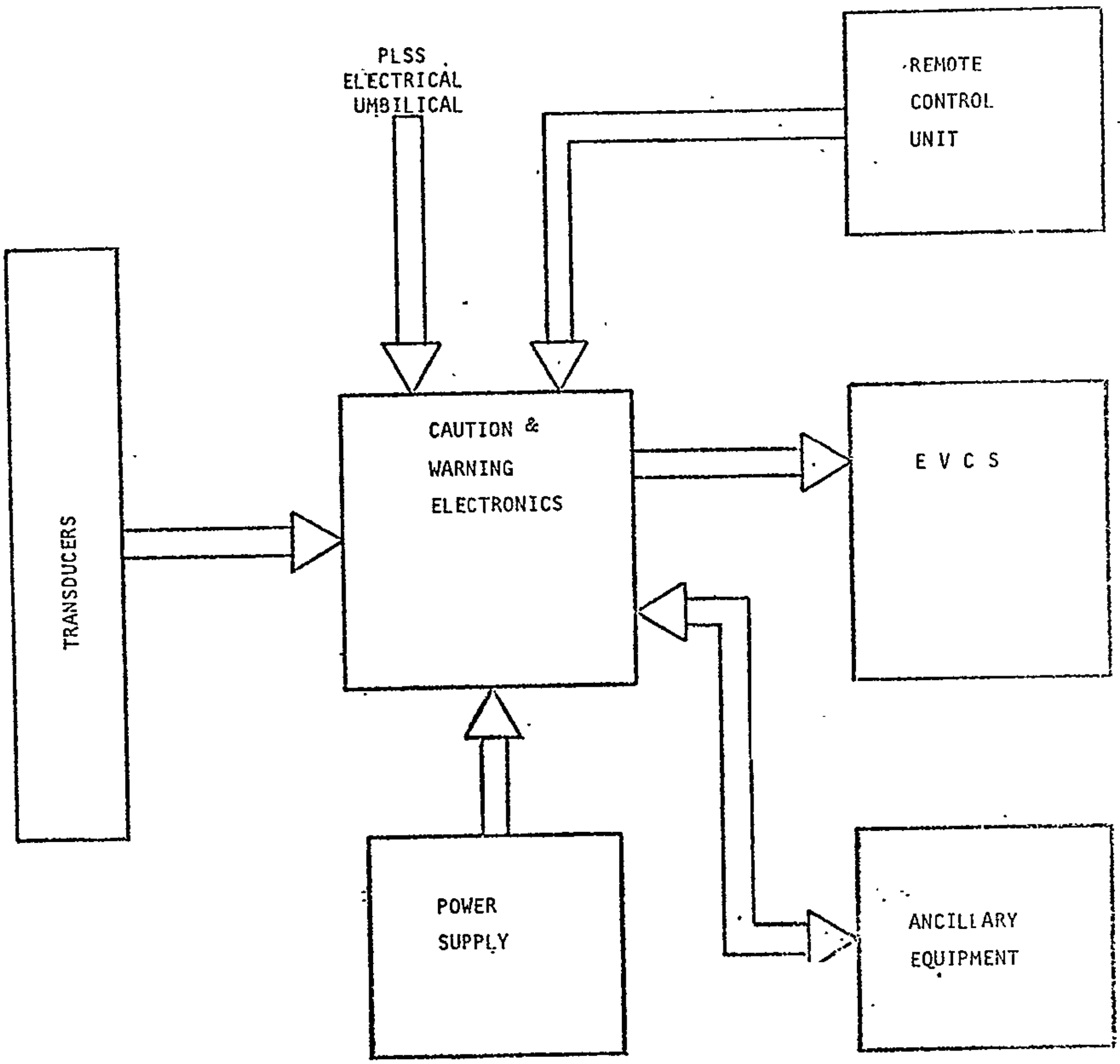
In consideration of the above, the elastomers seem to be the most ideal method for sealing. The flange thickness required for sealing is greater than that required for soldering but the reliability is greatly increased and entry into the unit is much easier. Of the 2 elastomers, the "O" ring in the dovetail groove is preferred. The "gask-o-seal" requires a bonding operation for retention of the seal into the groove and if damaged the entire cover would require replacement. With the "O" ring this is not necessary and as a precaution could be replaced each time the unit is opened for modification or repair.

TABLE 1

	PERFORMANCE	RELIABILITY	MAINTENANCE	SERVICING	EXPECTED LIFE	SIZE	WEIGHT	COST	IMPACT TO EVLSS
I. BREAKOUT BOX:									
A. YES	6	4	8	8	8	2	2	4	42
B. NO	8	8	8	8	8	8	8	6	62
II. I/O CONNECTORS:									
A. "SCOOP-PROOF"	8	8	8	8	8	4	4	4	52
B. "NON-SCOOP-PROOF"	8	6	8	8	8	6	6	6	56
III. HARNESS EXTERNAL:									
A. MOLDED	8	8	2	2	8	4	4	2	38
B. HEAT SHRINKABLE TUBING	8	8	5	6	8	6	6	5	52
C. FOIL WRAPPED	8	8	5	6	8.	6	6	6	53
IV. HARNESS INTERNAL:									
A. FLAT CABLE	8	8	8	6	8	8	8	6	60
B. FLEXIBLE CKTY	8	8	6	4	8	8	8	4	54
C. WIRE	8	8	8	8	8	6	6	8	60
V. INTERCONNECTION:									
A. WIRE WRAP	8	9	9	9	8	3	4	6	56
B. STITCHWIRE	9	9	6	6	9	9	6	2	56
VI. TRANSMISSION LINE:									
A. MIL-W-16878	8	8	8	8	6	6	5	6	55
B. MIL-W-22759	8	8	8	8	6	6	5	6	55
C. MIL-W-81044	4	2	8	8	3	8	10	4	47
D. MIL-W-81381	8	8	8	8	8	8	10	4	62
VII. UNIT SEALING									
A. ELASTOMER:									
1. "Gask-o-Seal"	9	8	7	9	8	4	4	4	53
2. "O" Ring	9	9	9	9	8	4	4	4	56
B. RTV:									
1. With tear-seal	0	0	0	5	0	7	6	5	23
2. Without tear-seal	0	0	0	3	0	7	6	5	21
C. SOLDER:									
1. With tear-seal	6	7	6	4	7	8	7	6	51
2. Without tear-seal	5	6	5	3	7	8	7	6	47



PRESENT SYSTEM



OPTIMIZED SYSTEM
WITH CAUTION AND WARNING

I BREAKOUT BOX

The purpose of the breakout box is to provide for easy access should unit modification become necessary. For this system it is anticipated that approximately 300 I/O connections would be required for interface with all subassemblies.

Using this figure, a preliminary design was instigated using five, 100% "scoop-proof" connectors having 61 crimp contacts each. They are assembled to the cover plate and use conventional round wire, terminated at the opposite end with crimp contacts and assembled into 8 AMP Mod IV or equal connectors. These connectors have 44 contacts each and will provide for a total of 352 wraposts. The internal connectors are assembled to a space bar, which in turn is assembled to the cover plate. The wire wrap board will be unclad epoxy glass and assembled with the wrap side of the post exposed to view, permitting access for wiring modification when this assembly is removed from the housing. An "O" ring is installed into a dovetail groove in the cover plate and this assembly is then placed into the housing.

The housing is a drawn aluminum can with a brazed flange to provide for hermetic sealing. The hardware, number 6-32 screws on 1.0 inch centers will be properly torqued to provide for the necessary leak rate.

The 352 wraposts, if provided with 3 levels, will allow for 1056 wraps. A 2 level post will provide for 704 possibilities. If an assembly with approximately 300 I/O contacts and the 3 level post is required the unit, including the "scoop-proof" connectors will require approximately 100 in^3. Another design, using 2 level wraposts and having 264 I/O contacts would require approximately 80 in^3 including the same I/O connectors. If a "scoop-proof" type connector and the unit hermiticity are not required, then the necessary volume in both examples could be decrease 10 to 20%.

II I/O CONNECTORS

One of the primary objectives in this study is the selection of reliable components that can be assembled without solder. For Space Shuttle applications, North American Rockwell is using a connector to the NASA specification 40M39569. This was given prime consideration for the ALSA. The hermetic connectors covered in the specification are not obtainable with crimp contacts. Connectors now available from Bendix, Deutsch and Malco (Microdot), although not manufactured to military specifications, will meet some of the applicable requirements of MIL-C-5015, MIL-C-22992, MIL-C-26482, MIL-C-26500, MIL-C-27599, MIL-C-38300, MIL-C-38999, and NAS 1599. Deutsch has designed an hermetic connector with crimp contacts that will meet the requirements of the new Navy Spec MIL-C-0026482. The user will be required to meet the costs for tooling and qualification testing.

A. "SCOOP-PROOF"

A method by which a series of connectors can be designed to prevent inadvertent electrical contact and to provide contact protection during mating is referred to as "scoop-proofing". This can be accomplished using a 50% or a 100% "scoop-proof". The 50% will prevent damage provided the pin contacts are used in the receptacle while the 100% will provide protection with the pins used in either the plug or receptacle. In all cases, the connectors with built-in protection are approximately 30% greater in size than the standard non-scoop-proof style.

B. BENDIX CONNECTORS

The Bendix connector is bayonet coupled and obtainable as a "scoop-proof" or "non-scoop-proof". It is assembled into a single hole using an "O" ring and jam nut. It has an additional feature in that to insure hermeticity it can be torqued to the proper setting and then lockwired in place. The barrel is crimped to the wire and using an MS insertion/removal tool is assembled into the insert. Spring clips retain the barrel in the insert and the same tool is used to remove the contact, should modifications be required. This connector will meet the applicable requirements of MIL-C-38999, except that this specification does not have provisions for an hermetic connector with crimp contacts.

C. DEUTSCH CONNECTORS

Deutsch has available a "non-scoop-proof" hermetic connector with crimp contacts. It is bayonet coupled and can be mounted into a single hole using an "O" ring and jam nut or soldered in place. It is also available with a standard or wide flange to permit assembly with hardware. The contact is crimped to a conventional round wire which is assembled into the connector using an MS style insertion/removal tool. This connector will also meet environmental requirements of Mil Specs.

The MIL-C-0026482 connector is also a "non-scoop-proof" type, but it is provided with a hard plastic interface that prevents assembly if a contact is bent beyond a pre-established limit. The pin contacts are surrounded by conical shaped risers which fit into the chamered lead-in of the socket thus assuring individual contact sealing at the connector interface.

D. MALCO (MICRODOT) CONNECTORS

The Malco connector (Marc 63) is a bayonet coupled 100% "scoop-proof" connector. It is supplied with a silicone "O" ring for sealing and is mounted into a single hole and held in place with a jam nut. An interfacial seal is provided using fluorosilicone rubber per MIL-R-3065. Of the three types found, this connector had the most positive means of retaining the contacts. It is supplied with a retaining nut, a follower grommet and a rear insert. The wires are passed through these parts, stripped and crimped into a barrel contact and pulled back into a cavity in the rear insert. Keyways are provided to assure proper alignment of the assembly to double-ended contacts fused with lead-free vitreous glass insert in the shell. The assembly is held in place with the follower grommet and the retaining nut. The connector is field serviceable and does not require special tools for maintainability. If the plug is not completely engaged, the coupling ring cannot be turned to the safety lock position. Consequently, under blind mating conditions, it is always possible to determine if the plug is properly engaged without visual reference, damage, or accidental engagement.

III HARNESS, EXTERNAL

For external interconnection on the ALSA three methods of harnessing were considered.

A. METHOD 1

A molded cable is the first type of harness to be considered for interconnection and can be designed for use with round and/or rectangular connectors and use conventional round wire or flat cable. A flourocarbon elastomer per MIL-R-83248, Type II, Class 2 will be used. Rework of a molded harness would be impossible since complete destruction is required to the outer covering to change or add additional conductors. Spare conductors, however, could be provided to permit some limited unit modification.

B. METHOD 2

The second type available is constructed using heat shrinkable tubing. Design configurations are unlimited since fittings are available for single or multiple breakouts at various angles. Numerous materials are available including PTFE, and can be readily used in temperatures encountered in space environments. Wall thickness, varying from .040 to .300 in. will permit lightweight, durable assemblies. The temperature required for shrinking ranges from +275°F to +310°F and shrinking occurs as soon as the parts reach the required temperature. Very little heat is transferred to the internal components and units can be safely assembled even though the wires are soldered to the connector.

C. METHOD 3

The final type of harness to be considered was successfully used on the Gemini ELSS Chestpack and the Skylab ALSA. The connectors used were non-hermetic and were encapsulated after soldering. Encapsulated areas were wrapped with aluminum foil backed pressure-sensitive tape. Where possibility of abrasion occurred, the harness was wrapped with teflon tape and the terminating ends were wrapped with the same pressure-sensitive tape to prevent unraveling.

IV HARNESS, INTERNAL

Three methods of interconnection were researched for use in the ALSA, again the design goal being a solderless unit that would permit ease of modification. The methods considered were flat cable, flexible circuitry and conventional wire.

The first two, from the standpoint of weight and volume requirements would be preferred but both have drawbacks. The main difficulties to overcome is the transition from a flat to a round configuration and modification capabilities. Rectangular hermetic connectors would be best for this application, but they are not available with crimp contacts.

A. FLAT CABLE

Flat cable can be adapted for use with circular connectors by soldering or resistance welding a round wire to the flat conductor, which then must be provided with a means of strain relief and electrical insulation. This wire would be terminated with a crimp contact and inserted into the connector. The encapsulation required to provide strain relief and insulation would reduce the number of terminations for circuit modification since the contacts could only be removed at the I/O connector. If the Malco connector (See Secion III) is selected, rework would not be possible without wire splicing. The rear insert used in this connector requires that the contact be removed before the wire can be disassembled.

Flat cable can be modified at the connector level by slitting and relocating conductors. The cable can also be modified by splicing, crimping, welding, or soldering, but in most cases special tools are required and encapsulation of the modified area is recommended for sealing and physical strength.

Many rectangular connectors with crimp contacts are available for use with flat cable. These can be terminated by staking, crimping or welding but can only be modified by splicing externally along the cable.

B. FLEXIBLE CIRCUITRY

Flexible circuitry is similar to the standard printed circuit board except it is a thinner flexible material which can be designed to go around corners or be folded. It can be multilayer and unlike flat cable, the circuitry is not required to be paralled. At present the most common method of attachment to the connector is by soldering. On connectors having a low number of contacts, assembly is easily accomplished. For connectors with a high number of contacts multiple layers of circuits will be required. To remove the bottom layer all layers above it must also be removed. A special non-hermetic connector with stepped pins is available which will in some instances permit easier disassembly. One manufacturer is presently developing an eyelet which can be crimped to the flexible circuitry and is then assembled to a contact and is retained by spring tension. Availability is projected for April, 1975 but extensive testing would be required to determine its reliability.

C. CONVENTIONAL ROUND WIRE

Conventional round wire offers the most versatility for transition from the I/O connectors to the interconnection board or chassis. It also eliminates the additional interface required by the necessity of adding a wire to the flat cable or flexible circuitry. Conventional wire is available in a broad range of conductors and jacket materials and sizes (See Section VI). Many types of contacts are available and adaptation to any application can be easily accomplished. Crimp contacts permit assembly or disassembly with the same tool and modification or repair is a simple matter of replacing, deleting or adding a conductor. In the previous methods, extra conductors should be available for required modifications. With wire, connectors can be supplied with a few spare pins and all that is required is to add additional wires for modification.

Wire is easily stripped with a standard tool which is relatively inexpensive and readily available for field modification. The thin insulation on the flat cable makes stripping more difficult and numerous techniques and operations have been developed. The method of stripping is dictated by the conductor style and the insulation material used. Stripping does not present a problem on flexible circuitry since it can be accomplished in the process of producing the circuitry.

The length of the circuit runs will be short, therefore the conventional wiring method would be preferred for the transition from the I/O connectors to the circuit board or chassis. Flat cable could however be used for other interconnections.

V INTERCONNECTION

The methods of interconnection have been narrowed to 2 types to enable meeting the requirements of a solderless assembly with ease of modification.

A. WIRE WRAP

Wire wrapping was developed to eliminate the ever-increasing demand for more compact circuitry. As more and more circuitry was being put into smaller volume, the number of interconnections increased to the point where multilayer boards were required. This not only presented manufacturing problems, but also practically eliminated circuit modification without costly redesign and replacement of these boards.

A completely solderless interconnect board can be produced by pressing 0.025 in. square posts into an epoxy glass board or insulated posts can be assembled into a metal chassis. Connectors with wraposts are also available which can be used instead of the board or chassis. Posts are available which will allow for 3 wrap levels but are recommended for development only where modifications are done on the third level. This will require a clearance of 0.60 in. behind the board. Posts which permit 2 wraps will require a 0.35 in clearance. Modifications can be accomplished by unwrapping wires and rewrapping new ones to the desired points. Portable equipment is available, permitting modifications to be done in the field. If posts should be damaged, new ones can be replaced without distribing adjacent posts or circuitry.

B. STITCHWIRE

Two methods of stitchwiring are possible. The first method considered would be the lightest, but soldering is required for assembly. It uses an epoxy glass board which is clad on both sides with 0.005 in. thick stainless steel. The board is etched and the holes plated through with copper. To insure continuity, copper is also deposited on the stainless steel in the vicinity of these holes. Components are assembled to the board by either hand or flow soldering. The nickel wire is welded to the exposed stainless steel portion of the pad.

Modification is accomplished by removing the wire and replacing with another by welding or soldering. Since the conductor is only 0.005 in. thick, it is doubtful if the wire could be easily removed without some damage, therefore rework or modification on this board should be done by soldering.

The other method of stitchwiring permits for less use or complete elimination of solder. Stainless steel pins are pressed into an epoxy glass board. These pins vary in weight from 20 grams to 45 grams per 1000 pieces. One side of the pin is used for resistance welding a teflon coated nickel wire, while the other side is used for component leads. The behind the board clearance is 0.20 in. The components selected for this type of assembly will require parts having weldable leads. Hybrid circuits would be ideal for this type assembly in that they have kovar leads which are highly compatible for the welding process.

The system of stitchwiring has a drawback in that connectors with weldable leads are not available. Edge card connectors or connectors which will require soldering are presently used. Since crimp contact connectors are available for wire-wrapped posts, a combination of the wirewrap and stitchwire was considered to enable keeping within our design goals.

The first method was to resistance weld the nickel wire used for stitchwiring to 0.025 in wraposts. The welds were then given pull tests and results obtained were equal to similar type of welds as used in the Skylab ALSA welded modules.

The second method was to wrap the nickel wire around the post to the requirements of MIL-STD-1130A. Testing was conducted to the above specifications and the requirements for strip-force limits, gas tight area and pull tests were within the requirements of this specification.

The tests conducted were preliminary. Care was taken to insure that the tests specimens were made as though they were to be installed into a production unit and the number of specimens tested was low. Before selection of this method of assembly, it is suggested that more extensive testing be conducted. Stitchwiring at present is limited to in-house assembly. Two manufacturers have indicated that they will have units available approximately March, 1975 which will permit repairs and modifications in the field.

VI TRANSMISSION LINE

Four types of wire were considered for use in the ALSA. Two of these, MIL-W-16878 and MIL-W-22759 were used in the Skylab ALSA and would be acceptable for use in this application. The other two types are covered by MIL-W-81044 and MIL-W-81381.

The MIL-W-81044 wire is a high strength copper alloy with an extruded polyarylene insulation. This wire was considered because its thin wall construction would allow a reduction in unit weight and volume required over the normally used conductors. Data received from the manufacturer proved the wire to be excellent in terms of temperature range, cut-through strength and radiation hardening. The wire could be assembled using standard crimping and soldering methods. The only drawback to using this type is that it has an oxygen index of 36 as determined by ASTM D2863 and because of this could only be utilized in an hermetically sealed or encapsulated unit.

The MIL-W-81381 wire is available using a high strength copper alloy conductor. The primary insulation is 2 layers of polyimide film, each side of which is coated with an FEP-flurocarbon resin. To provide a well bonded insulation it is then passed thru an oven within a temperature range of 600°F to 900°F for a period of from 10 to 60 seconds. This construction is etched and given a dip coat of a modified polyimide resin coating. The thicknesses most commonly used in wire construction are 1, 1.5, and 2 mil and this permits significant weight and space savings over wire normally used in aerospace applications. Dielectric breakdown strength is in excess of 15 KV with the dielectric constant varying, depending upon construction, in the range of 2.3 to 2.7.

Insulation resistance will be in excess of 10,000 megohms per thousand feet. Polyimide film has excellent heat aging characteristics. Testing to the requirements of MIL-W-22759B show a thermal life in excess of 2000 hours at 250°C and 600 hours at 275°C. Insulated wires, after exposure to these temperatures were still flexible and had dielectric breakdown strengths greater than 10 KV.

When exposed to the hot section of a Bunsen burner per the requirements of MIL-W-22759 and MIL-W-16878 there was no after flame when the source was removed and the burning of the insulation was confined only to the area in direct contact with the flame. In a pure oxygen atmosphere the conductor temperature was raised by electrical overload and ignition occured well above 600°C.

Thermal cut-through was tested using a chisel having a .011 inch radius and loaded with a 4000 gram weight. The test was performed in an oven heated at a rate of 2°C/minute. Cut-through occured at approximately 530°C for the specimen insulated with polyimide while other wires normally used in aerospace applications experienced cut-through at temperatures below 250°C and in most cases below 100°C.

Wire insulated with polyimide can be used in cryogenic applications since it remains flexible at liquid helium temperature (-269°C). At this temperature a 16 AWG wire can be bent around a 0.75 inch mandrel (10X) without cracking. Dielectric tests can still be met even after exposure in a Van de Graaff generator to 10^9 Rads. Breakdown strength remained in excess of 10 KV.

Weight loss versus time studies of polyimide film at 200°C and 3×10^{-6} Torr pressure, reveal no decomposition of the film. There is an initial weight loss of about 0.7% for insulation precondition at 50% relative humidity which corresponds to moisture removal. Subsequently no further weight loss was observed.

Mechanical stripping is satisfactory and can be accomplished with commercial precision tools to avoid nicking the conductor. Because of the infusable nature of polyimide film thermal stripping is more difficult to accomplish but strippers are available if required. It is suggested that since the above indicate the toughness and reliability of this wire that it be selected for use in the ALSA.

VII UNIT SEALING

Four methods of sealing are considered for use on the ALSA. Two, using an elastomer, will require a greater flange width to provide a good seal. The other 2 methods, solder and RTV, can be accomplished using thin walls but they present a greater problem of disassembly for unit modification.

A. METHOD 1

"Gask-o-seal" is an elastomer, molded into a groove in the cover or housing. The material is a 70 shore ethylene propylene, with a temperature range of -65° to +300°F. To meet the required leakage rate, a minimum flange width of 0.20 inch is required with additional material required to assemble the cover to the housing. For this seal #10-32 screws on a 2.0 to 2.5 inch pitch is necessary. Elevated temperatures and frequent disassembly will decrease repeatability of the gasket, but the temperature range that the EDS and the CWS are exposed to will not present a problem. If, however, the elastomer is damaged, it can only be replaced by returning the part to the supplier to have a new seal bonded in place. This would require sparing covers to replace any parts damaged in the field.

B. METHOD 2

This method will use an "O" ringe assembled into a dovetail groove in the cover or housing. This groove not only provides an area for the elastomer when compressed but it will also retain the "O" ring when the unit is disassembled. The recess design also provides for the correct amount of squeeze and sufficient volume to house the "O" ring completely without extrusion as is experienced with a standard "O" ring groove. It can be replaced without the expense, time and trouble of returning parts to the factory to have a new seal bonded in place.

The "O" ring seal requires a flange width of 0.20 inch. Additional material will be required to assemble the cover and housing. For this seal, #6-32 screws on a 0.75 to 1.00 inch pitch will be necessary. The material used should be a 70 shore Ethylene Propylene having a temperature range of -65°F to +300°F.

The manufacturer of the "O" ring seal has supplied test data for units manufactured by other users substantiating its effectiveness in Space applications. AiResearch has previously used this type of seal on the Apollo program with good success. Actual test data has not been received covering "gask-o-seal". The manufacturer has indicated that successful results have been obtained from usage in the Mercury Space Capsule, Ranger IV, Gemini, Mariner IV Fly-by and Skylab programs.

The "Gask-o-seal" or "O" ring method can be used only if ample space is provided. If the unit volume available is 300 cc, approximately 25% would be required for sealing. This percentage will decrease however as unit volume increases. If a solder or RTV were to be used, approximately 13% of the volume would be required for sealing purposes.

C. METHOD 3

In earlier space applications, RTV has been used for sealing around windows and similar applications where proper compressions can be applied to effect a seal. Information is not available from suppliers of RTV which would indicate that these materials, applied into a groove would provide a good hermetic seal. Therefore, extensive testing would have to be conducted to determine the groove size, material and method of application required to enable meeting the necessary leakage rate. This testing would be conducted to determine use of RTV with and without a tear wire.

D. METHOD 4

The most widely used method of hermetic sealing in the past has been by soldering. A considerable amount of knowledge exists on ways of accomplishing this type of seal. The method also creates a maintainability problem which can be overcome by the use of a tear seal. A tear seal is accomplished by wrapping a beryllium copper wire around the cover prior to soldering and then solder it in place with a tang left free of solder for disassembly. The cover is then assembled into the housing and solder sealed by induction heating.

A quartz sensor manufactured by AiResearch is assembled in this manner and upon completion is required to pass a leak rate of 1×10^{-6} SCC/Sec of helium when exposed to helium for a minimum of 1 minute.

APPENDIX B

BREADBOARD CAUTION AND WARNING SYSTEM FUNCTIONAL LOGIC PROGRAM FLOW CHART

The flow chart is physically large and is submitted under separate cover.

NOTE

TWO COPIES OF THIS FLOW CHART (18 inches X 50 feet) ARE PROVIDED TO THE NASA TECHNICAL MONITOR (MR. BILL BURTON). ADDITIONAL COPIES ARE AVAILABLE UPON REQUEST TO MR. RALPH ICHIKAWA, DEPARTMENT 93091, AiRESEARCH MANUFACTURING COMPANY OF CALIFORNIA, 2525 WEST 190 STREET, TORRANCE, CALIFORNIA 90509.

APPENDIX C

Software Translation Program

A computer listing of the PROM software translation program and a computer printout for the breadboard Caution and Warning System.

```
 COMPILER OPTIONS - NAME=NASACW,OPT=02,LINECNT=57,SIZE=0000K,
                    SOURCE,BCD,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
C
C
C
C         TITLE---NASA CAUTION AND WARNING SYSTEM (NASACW),VERSION 2
C                   DATE 8-22-75
C
C         PROGRAM DESCRIPTION---ALLOWS USER TO ENTER DATA IN DECIMAL
C                   FORMAT DIRECTLY FROM CWS FLOWCHART.  THE PROGRAM
C                   CONVERTS THE INPUT DATA TO THE BINARY BIT PATTERN
C                   REQUIRED TO PROGRAM 6, 8 BIT X 512 WORD PROMS (24
C                   BITS X 512 WORDS).  THE DATA IS OUTPUTTED, 1)TO A
C                   PRINTER WHICH LISTS THE INPUT DATA AND THE OUTPUT
C                   BIT PATTERNS, AND 2)TO A PAPER TAPE WHICH IS USED
C                   TO PROGRAM THE PROMS.  THE PROGRAM IS WRITTEN IN
C                   FORTRAN IV, LEVEL H.
C
C         EQUIPMENT UTILIZED---
C                   1)GARRETT IBM 370/158 COMPUTER
C                   2)COPE 1280 READER/PRINTER
C                   3)IBM 3772 PAPER TAPE READER/PUNCH
C                   4)DATA I/O CORP, ROM PROGRAMMER 1
C
C         PROM TYPE---NATIONAL SEMICONDUCTOR MM5204Q
C
C         INPUT---ALL DATA IS ENTERED BY CARDS AS FOLLOWS
C                   1)DATA CARD 1, SPECIFIES THE NUMBER OF LINES TO BE
C                        PRINTED AND IS RIGHT JUSTIFIED TO COLUMN 3 (999
C                        MAX).
C                   2)BALANCE OF DATA CARDS (999 MAX) NEED NOT BE IN
C                        ORDER.
C                        A. FIELD 1-SPECIFIES INTEGER NUMBER OF PROM
C                             ADDRESS.  RIGHT JUSTIFIED TO COLUMN 4 (0-
C                             1024, BASE 10).
C                        B. FIELD 2-SPECIFIES INTEGER NUMBER OF STATUS
C                             REGISTER ADDRESS.  RIGHT JUSTIFIED  TO
C                             COLUMN 17 (0-127,BASE 10).
C                        C. FIELD 3-SPECIFIES BINARY BIT PATTERN FOR
C                             MESSAGE AND DATA CONTROL.  LEFT JUSTIFIED
C                             TO COLUMN 30.
C                        D. FIELD 4-SPECIFIES INTEGER NUMBER OF DATA,
C                             JUMP ADDRESS, OR MESSAGE ADDRESS.  RIGHT
C                             JUSTIFIED TO COLUMN 48 (-255-0-+255 FOR
C                             DATA, 0-511 FOR JUMP ADDRESS, AND 0-1023
C                             FOR MESSAGE ADDRESS).  NEGATIVE VALUES OF
C                             DATA INPUT MUST HAVE MINUS SIGN PLACED IN
C                             COLUMN 44, NO MATTER WHERE THE DATA IS
C                             LOCATED.
C
C
C         OUTPUT---
C              1) LINE PRINTER
C              2) PUNCHED TAPE
C
```

GARRETT AIRESEARCH MANUFACTURING COMPANY OF CALIFORNIA

ORIGINAL PAGE IS OF POOR QUALITY

```
C                         NOTE***
C                            A PUNCHED HOLE IN THE TAPE WILL CAUSE THE PROM
C                            PROGRAMMER TO CHANGE AN ERASED PROM '0' TO A '1'.
C
C
ISN 0002          INTEGER NUM,A,C,H,EM,EN,O,P,R,S,U,W,EQUAL,RO,Z,LOOP,DG,Q,MM
ISN 0003          INTEGER  M,N,NN,SUM,J,K,PRBIN,MESS,PAGE,MS,B,USED,ADDRBN
ISN 0004          DIMENSION NPROM(1024),NBITS(1024),NADDR(1024),IO(3,560),NFLAG(8)
ISN 0005          DIMENSION B(5),MESS(2),USED(1024),PRBIN(7),ADDRBN(12)
ISN 0006          DIMENSION NUM(3,7),A(7),C(7),H(7),EM(7),EN(7),O(7),P(7),R(7),S(7),
                 *U(7),W(7),EQUAL(7),RO(7)
ISN 0007          DATA MESS/'    ','MESS'/
ISN 0008          DATA NUM/132,194,129,130,161,137,255,145,145,128,137,165,128,134,6
                 *6,0,0,0,0,0,0/,A/254,17,17,17,254,0,0/,C/126,129,129,129,129,0,0/,
                 *H/255,16,16,16,255,0,0/,EM/255,4,8,4,255,0,0/,EN/255,2,8,32,255,0,
                 *0/,O/126,129,129,129,126,0,0/,P/255,9,9,9,6,0,0/,R/255,9,25,41,198
                 *,0,0/,S/134,137,129,145,97,0,0/,U/127,128,128,128,127,0,0/,W/255,6
                 *4,32,64,255,0,0/,EQUAL/36,36,36,36,36,0,0/,RO/255,255,255,255,255,
                 *0,0/,Z/0/
ISN 0009      398 FORMAT(1H1,8X,'*',29X,'I',3X,'N',3X,'P',3X,'U',3X,'T',30X,'*',12X,
                 1'O',3X,'U',3X,'T',3X,'P',3X,'U',3X,'T',12X,'*',/)
ISN 0010      399 FORMAT(1H0,8X,'      PROM        S/R     SOURCE   UP/DOWN   LOAD/COMP
                 1 DATA    MESSAGE    DATA',8X,'S/R        B    B    B    B    B',7X,'DATA')
ISN 0011      400 FORMAT(11X,'ADDRESS    ADDR.     TONE      ANSWER    RESPONSE     *',
                 18X,'*',6X,'FIELD',6X,'ADDR.     1    2    3    4    5',6X,'FIELD')
ISN 0012      405 FORMAT(1H0,1X,A4,7X,I4,5X,I4,7X,I1,8X,I1,10X,I1,8X,I1,8X,I1,6X,I5,
                 15X,7I1,5(3X,I1),3X,12I1)
ISN 0013      410 FORMAT(1H0,12X,I4)
ISN 0014      415 FORMAT(A3,77A1,/,7A1,A4,42A1,6A4,A3,/,49A1,5A4,A3,8A1)
ISN 0015      420 FORMAT( 80A1 )
ISN 0016      425 FORMAT( I3)
ISN 0017      430 FORMAT(I4,10X,I3,12X,I5,9X,I5)
ISN 0018          READ(5,425)MM
ISN 0019          LOOP=0
ISN 0020          PAGE=0
ISN 0021          DG=1
ISN 0022          Q=1
ISN 0023          DO 2  N=1,1024
ISN 0024        2 USED(N)=0
ISN 0025        5 READ(5,430,END=10)N,NPROM(N+1),NBITS(N+1),NADDR(N+1)
ISN 0026          USED(N+1)=1
ISN 0027          GO TO 5
ISN 0028       10 N=1+LOOP
ISN 0029       15 IF(PAGE)20,20,25
ISN 0030       20 PAGE=27
ISN 0031          WRITE(6,398)
ISN 0032          WRITE(6,399)
ISN 0033          WRITE(6,400)
ISN 0034       25 PAGE=PAGE-1
ISN 0035          NX=N-1
ISN 0036       30 IF(USED(N))35,40,35
ISN 0037       35 J = NPROM(N)
ISN 0038          K = NADDR(N)
ISN 0039          CALL BINARY(J,6,PRBIN)
ISN 0040          CALL BINARY(K,11,ADDRBN)
```

```
ISN 0041          SUM = NBITS(N)
ISN 0042          DO 45 NN=1,5
ISN 0043          MS = 6 - NN
ISN 0044          B(MS) = MOD(SUM,10)
ISN 0045       45 SUM = SUM / 10
ISN 0046          IF (B(5))50,50,55
ISN 0047       50 MS=1
ISN 0048          GO TO 60
ISN 0049       55 MS = 2
ISN 0050       60 WRITE(6,405) MESS(MS),NX,J,B,K,PR,IN,B,ADDRBN
ISN 0051          GO TO 65
ISN 0052       40 WRITE(6,410)NX
ISN 0053          MS = 2**24
ISN 0054          IO(1,Q) = 0
ISN 0055          IO(2,Q) = 0
ISN 0056          IO(3,Q) = 0
ISN 0057          GO TO 70
ISN 0058       65 MS = 2**24
ISN 0059          IO(1,Q) = MS*(J*2+B(1))
ISN 0060          IO(2,Q) = MS*(128*B(2)+64*B(3)+32*B(4)+16*B(5)+8*ADDRBN(1)+
                 *4*ADDRBN(2)+2*ADDRBN(3)+ADDRBN(4))
ISN 0061          IO(3,Q) = MS*(ADDRBN(12)+2*ADDRBN(11)+4*ADDRBN(10)+8*ADDRBN
                 *(9)+16*ADDRBN(8)+32*ADDRBN(7)+64*ADDRBN(6)+128*ADDRBN(5))
ISN 0062       70 N = N+1
ISN 0063          Q=N-LOOP
ISN 0064          IF(512-Q)76,72,72
ISN 0065       72 IF (MM-N) 75,15,15
ISN 0066       75 LOOP=512
ISN 0067       76 IF(DG-2)77,83,77
ISN 0068       77 DO 80 N=1,8
ISN 0069       80 NFLAG(N) = MS*(2**N - 1)
ISN 0070          DO  81  N=1,5
ISN 0071          NUM(1,N)=NUM(1,N)*MS
ISN 0072          NUM(2,N)=NUM(2,N)*MS
ISN 0073          NUM(3,N)=NUM(3,N)*MS
ISN 0074          A(N)=A(N)*MS
ISN 0075          C(N)=C(N)*MS
ISN 0076          H(N)=H(N)*MS
ISN 0077          EM(N)=EM(N)*MS
ISN 0078          EN(N)=EN(N)*MS
ISN 0079          O(N)=O(N)*MS
ISN 0080          P(N)=P(N)*MS
ISN 0081          R(N)=R(N)*MS
ISN 0082          S(N)=S(N)*MS
ISN 0083          U(N)=U(N)*MS
ISN 0084          W(N)=W(N)*MS
ISN 0085          EQUAL(N)=EQUAL(N)*MS
ISN 0086       81 RO(N)=RO(N)*MS
ISN 0087       83 DO  82 N=Q,560
ISN 0088          IO(1,N) = 0
ISN 0089          IO(2,N) = 0
ISN 0090       82 IO(3,N) = 0
ISN 0091          NN = 1
ISN 0092       85 WRITE(7,415) Z,RO,RO,RO,RO,RO,EN,A,S,A,C,W,S,Z,P,R,O,EM,(NUM(DG,MS
                 *),MS=1,7),(NUM(NN,MS),MS=1,7),Z,Z,Z,Z,Z,Z,Z,P,U,EN,C,H,EQUAL,(NUM(
```

AIRESEARCH MANUFACTURING COMPANY OF CALIFORNIA

ORIGINAL PAGE IS OF POOR QUALITY

```
                   *1,MS),MS=1,7),Z,Z,Z,Z,Z,Z,NFLAG
   ISN 0093           DO 90  M =1,560,80
   ISN 0094           MS = M+79
   ISN 0095        90 WRITE(7,420) (IO(NN,N),N=M,MS)
   ISN 0096           NN = NN+1
   ISN 0097           IF (NN-4) 85,95,95
   ISN 0098        95 DG=2
   ISN 0099           Q=1
   ISN 0100           IF (512-LOOP) 110,110,100
   ISN 0101       100 LOOP=512
   ISN 0102           GO TO 10
   ISN 0103       110 CALL EXIT
   ISN 0104           STOP
   ISN 0105           END

*OPTIONS IN EFFECT*      NAME=NASACW,OPT=02,LINECNT=57,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,BCD,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =      104 ,PROGRAM SIZE =     26606

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                  41K BYTES OF CORE NOT USED
```

```
LEVEL 21.7 ( JAN 73 )                    OS/360  FORTRAN H                         DATE  75.254/17.01.22

          COMPILER OPTIONS - NAME=NASACW,OPT=02,LINECNT=57,SIZE=0000K,
                             SOURCE,BCD,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF
  ISN 0002             SUBROUTINE BINARY(DEC,LENGTH,ARRAY)
  ISN 0003             INTEGER ARRAY,DEC,LENGTH,SIZE,T,SUB
  ISN 0004             DIMENSION ARRAY(1),I(2),J(2)
  ISN 0005             DATA I,J/1,0,0,1/
  ISN 0006             T = LENGTH
  ISN 0007             K = 1
  ISN 0008             SIZE = 2**LENGTH
  ISN 0009             L = DEC
  ISN 0010             IF (L) 96,98,98
  ISN 0011          96 SUB = 2
  ISN 0012             L = -1*(L+1)
  ISN 0013             GO TO 100
  ISN 0014          98 SUB = 1
  ISN 0015         100 M = L/SIZE
  ISN 0016             IF (M) 110,120,110
  ISN 0017         110 ARRAY(K) = I(SUB)
  ISN 0018             L = L-SIZE
  ISN 0019             GO TO 130
  ISN 0020         120 ARRAY(K) = J(SUB)
  ISN 0021         130 IF (LENGTH) 150,150,140
  ISN 0022         140 K = K+1
  ISN 0023             LENGTH = LENGTH-1
  ISN 0024             SIZE = SIZE/2
  ISN 0025             GO TO 100
  ISN 0026         150 LENGTH = T
  ISN 0027             RETURN
  ISN 0028             END
*OPTIONS IN EFFECT*      NAME=NASACW,OPT=02,LINECNT=57,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,BCD,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =      27 ,PROGRAM SIZE =      482

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                  69K BYTES OF CORE NOT USED

*STATISTICS*  NO  DIAGNOSTICS THIS STEP
```

	INPUT							OUTPUT						
PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
0	55	0	0	1	1	0	0	0110111	0	0	1	1	0	000000000000
1	57	0	0	1	1	0	0	0111001	0	0	1	1	0	000000000000
2	59	0	0	1	1	0	0	0111011	0	0	1	1	0	000000000000
3	61	0	0	1	1	0	0	0111101	0	0	1	1	0	000000000000
4	63	0	0	1	1	0	0	0111111	0	0	1	1	0	000000000000
5	111	0	0	1	0	0	0	1101111	0	0	1	0	0	000000000000
6	112	0	0	1	0	0	0	1110000	0	0	1	0	0	000000000000
7	113	0	0	1	0	0	0	1110001	0	0	1	0	0	000000000000
8	114	0	0	1	0	0	0	1110010	0	0	1	0	0	000000000000
9	115	0	0	1	0	0	0	1110011	0	0	1	0	0	000000000000
10	116	0	0	1	0	0	0	1110100	0	0	1	0	0	000000000000
11	117	0	0	1	0	0	0	1110101	0	0	1	0	0	000000000000
12	118	0	0	1	0	0	0	1110110	0	0	1	0	0	000000000000
13	119	0	0	1	0	0	0	1110111	0	0	1	0	0	000000000000
14	120	0	0	1	0	0	0	1111000	0	0	1	0	0	000000000000
15	121	0	0	1	0	0	0	1111001	0	0	1	0	0	000000000000
16	122	0	0	1	0	0	0	1111010	0	0	1	0	0	000000000000
17	123	0	0	1	0	0	0	1111011	0	0	1	0	0	000000000000
18	124	0	0	1	0	0	0	1111100	0	0	1	0	0	000000000000
19	125	0	0	1	0	0	0	1111101	0	0	1	0	0	000000000000
20	126	0	0	1	0	0	0	1111110	0	0	1	0	0	000000000000
21	127	0	0	1	0	0	0	1111111	0	0	1	0	0	000000000000
22	26	0	0	0	0	0	60	0011010	0	0	0	0	0	000000111100
23	90	0	0	0	1	0	10	1011010	0	0	0	1	0	000001101110
24	86	0	0	0	0	0	29	1010110	0	0	0	0	0	000000011101
25	87	0	0	0	0	0	29	1010111	0	0	0	0	0	000000011101
26	32	0	0	0	0	0	55	0100000	0	0	0	0	0	000010011011

AIRESEARCH MANUFACTURING COMPANY
OF CALIFORNIA

	INPUT							OUTPUT						
PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
27	87	0	0	0	0	0	29	1010111	0	0	0	0	0	000000011101
28	54	0	0	1	1	0	0	0110110	0	0	1	1	0	000000000000
29	49	0	0	0	0	0	214	0110001	0	0	0	0	0	000011010110
30	89	0	0	1	0	0	0	1011001	0	0	1	0	0	000000000000
31	67	0	0	0	0	0	33	1000011	0	0	0	0	0	000000100001
32	56	0	0	1	1	0	0	0111000	0	0	1	1	0	000000000000
33	34	0	0	0	0	0	232	0100010	0	0	0	0	0	000011101000
34	100	0	0	0	0	0	36	1100100	0	0	0	0	0	000000100100
35	58	0	0	1	1	0	0	0111010	0	0	1	1	0	000000000000
36	31	0	0	0	0	0	259	0011111	0	0	0	0	0	000100000011
37	85	0	0	0	0	0	39	1010101	0	0	0	0	0	000000100111
38	60	0	0	1	1	0	0	0111100	0	0	1	1	0	000000000000
39	35	0	0	0	0	0	719	0100011	0	0	0	0	0	001011001111
40	79	0	0	0	0	0	42	1001111	0	0	0	0	0	000000101010
41	62	0	0	1	1	0	0	0111110	0	0	1	1	0	000000000000
42	43	0	0	0	0	0	284	0101011	0	0	0	0	0	000100011100
43	33	0	0	0	0	0	350	0100001	0	0	0	0	0	000101011110
44	39	0	0	0	0	0	356	0100111	0	0	0	0	0	000101100100
45	40	0	0	0	0	0	362	0101000	0	0	0	0	0	000101101010
46	79	0	0	0	0	0	51	1001111	0	0	0	0	0	000000110011
47	116	0	0	1	1	0	0	1110100	0	0	1	1	0	000000000000
48	102	0	0	0	1	0	380	1100110	0	0	0	1	0	000101111100
49	68	0	0	0	1	0	739	1000100	0	0	0	1	0	001011100011
50	68	0	0	1	0	0	0	1000100	0	0	1	0	0	000000000000
51	42	0	0	0	0	0	368	0101010	0	0	0	0	0	000101110000
52	45	0	0	0	0	0	374	0101101	0	0	0	0	0	000101110110
53	47	0	0	0	0	0	533	0101111	0	0	0	0	0	001000010101

			I N P U					O U T P U T						
PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
54	52	0	0	0	0	0	539	0110100	0	0	0	0	0	001000011011
55	51	0	0	0	0	0	545	0110011	0	0	0	0	0	001000100001
56	44	0	0	0	0	0	551	0101100	0	0	0	0	0	001000100111
57	21	0	0	0	0	0	567	0010101	0	0	0	0	0	001000110111
58	23	0	0	0	0	0	557	0010111	0	0	0	0	0	001000101101
59	102	0	0	0	1	0	0	1100110	0	0	0	1	0	000000000000
60	22	0	0	1	1	0	0	0010110	0	0	1	1	0	000000000000
61	90	0	0	1	0	0	0	1011010	0	0	1	0	0	000000000000
62	74	0	0	1	1	0	0	1001010	0	0	1	1	0	000000000000
63	96	0	0	1	1	0	0	1100000	0	0	1	1	0	000000000000
64	84	0	0	1	1	0	0	1010100	0	0	1	1	0	000000000000
65	68	0	0	1	0	0	0	1000100	0	0	1	0	0	000000000000
66	69	0	0	1	0	0	0	1000101	0	0	1	0	0	000000000000
67	70	0	0	1	0	0	0	1000110	0	0	1	0	0	000000000000
68	71	0	0	1	0	0	0	1000111	0	0	1	0	0	000000000000
69	72	0	0	1	0	0	0	1001000	0	0	1	0	0	000000000000
70	73	0	0	1	0	0	0	1001001	0	0	1	0	0	000000000000
71	65	0	0	1	0	0	0	1000001	0	0	1	0	0	000000000000
72	75	0	0	1	0	0	0	1001011	0	0	1	0	0	000000000000
73	76	0	0	1	0	0	0	1001100	0	0	1	0	0	000000000000
74	77	0	0	1	0	0	0	1001101	0	0	1	0	0	000000000000
75	78	0	0	1	0	0	0	1001110	0	0	1	0	0	000000000000
76	79	0	0	1	0	0	0	1001111	0	0	1	0	0	000000000000
77	80	0	0	1	0	0	0	1010000	0	0	1	0	0	000000000000
78	81	0	0	1	0	0	0	1010001	0	0	1	0	0	000000000000
79	82	0	0	1	0	0	0	1010010	0	0	1	0	0	000000000000
80	83	0	0	1	0	0	0	1010011	0	0	1	0	0	000000000000

INPUT								OUTPUT						
PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
81	67	0	0	1	0	0	0	1000011	0	0	1	0	0	000000000000
82	85	0	0	1	0	0	0	1010101	0	0	1	0	0	000000000000
83	86	0	0	1	0	0	0	1010110	0	0	1	0	0	000000000000
84	87	0	0	1	0	0	0	1010111	0	0	1	0	0	000000000000
85	88	0	0	1	0	0	0	1011000	0	0	1	0	0	000000000000
86	89	0	0	1	0	0	0	1011001	0	0	1	0	0	000000000000
87	64	0	0	1	0	0	0	1000000	0	0	1	0	0	000000000000
88	91	0	0	1	0	0	0	1011011	0	0	1	0	0	000000000000
89	92	0	0	1	0	0	0	1011100	0	0	1	0	0	000000000000
90	93	0	0	1	0	0	0	1011101	0	0	1	0	0	000000000000
91	94	0	0	1	0	0	0	1011110	0	0	1	0	0	000000000000
92	95	0	0	1	0	0	0	1011111	0	0	1	0	0	000000000000
93	66	0	0	1	0	0	0	1000010	0	0	1	0	0	000000000000
94	97	0	0	1	0	0	0	1100001	0	0	1	0	0	000000000000
95	98	0	0	1	0	0	0	1100010	0	0	1	0	0	000000000000
96	99	0	0	1	0	0	0	1100011	0	0	1	0	0	000000000000
97	100	0	0	1	0	0	0	1100100	0	0	1	0	0	000000000000
98	101	0	0	1	0	0	0	1100101	0	0	1	0	0	000000000000
99	102	0	0	1	0	0	0	1100110	0	0	1	0	0	000000000000
100	103	0	0	1	0	0	0	1100111	0	0	1	0	0	000000000000
101	104	0	0	1	0	0	0	1101000	0	0	1	0	0	000000000000
102	105	0	0	1	0	0	0	1101001	0	0	1	0	0	000000000000
103	106	0	0	1	0	0	0	1101010	0	0	1	0	0	000000000000
104	107	0	0	1	0	0	0	1101011	0	0	1	0	0	000000000000
105	108	0	0	1	0	0	0	1101100	0	0	1	0	0	000000000000
106	109	0	0	1	0	0	0	1101101	0	0	1	0	0	000000000000
107	110	0	0	1	0	0	0	1101110	0	0	1	0	0	000000000000

	INPUT								OUTPUT						
	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
	108	28	0	0	1	1	0	0	0011100	0	0	1	1	0	000000000000
	109	102	0	0	0	1	0	23	1100110	0	0	0	1	0	000000010111
	110	19	0	0	1	1	0	5	0010011	0	0	1	1	0	000000000101
MESS	111	0	0	0	0	0	1	0	0000000	0	0	0	0	1	000000000000
	112	17	0	0	0	1	0	111	0010001	0	0	0	1	0	000001101111
	113	115	0	0	1	1	0	0	1110011	0	0	1	1	0	000000000000
	114	102	0	0	0	1	0	129	1100110	0	0	0	1	0	000010000001
	115	115	0	0	1	0	0	0	1110011	0	0	1	0	0	000000000000
	116	118	0	0	1	1	0	0	1110110	0	0	1	1	0	000000000000
	117	102	0	0	0	1	0	141	1100110	0	0	0	1	0	000010001101
	118	118	0	0	1	0	0	0	1110110	0	0	1	0	0	000000000000
MESS	119	0	0	0	0	0	1	14	0000000	0	0	0	0	1	000000001110
	120	19	0	0	1	1	0	1	0010011	0	0	1	1	0	000000000001
	121	17	0	0	0	1	0	121	0010001	0	0	0	1	0	000001111001
	122	33	0	0	0	0	0	119	0100001	0	0	0	0	0	000001110111
	123	14	0	1	1	1	0	-10	0001110	0	1	1	1	0	111111110110
	124	19	0	1	1	1	0	0	0010011	0	1	1	1	0	000000000000
	125	18	0	0	0	1	0	125	0010010	0	0	0	1	0	000001111101
	126	20	0	0	1	1	0	0	0010100	0	0	1	1	0	000000000000
	127	90	0	0	1	1	0	0	1011010	0	0	1	1	0	000000000000
	128	102	0	0	0	1	0	24	1100110	0	0	0	1	0	000000011000
	129	73	0	0	0	0	0	137	1001001	0	0	0	0	0	000010001001
	130	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	131	0	0	0	0	0	1	22	0000000	0	0	0	0	1	000000010110
	132	17	0	0	0	1	0	131	0010001	0	0	0	1	0	000010000011
	133	36	0	0	0	0	0	137	0100100	0	0	0	0	0	000010001001
MESS	134	0	0	1	1	0	1	31	0000000	0	1	1	0	1	000000011111

	INPUT								OUTPUT						
	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
	135	25	0	0	0	1	0	130	0011001	0	0	0	1	0	000010000010
	136	73	0	0	1	1	0	0	1001001	0	0	1	1	0	000000000000
	137	74	0	0	1	0	0	0	1001010	0	0	1	0	0	000000000000
	138	115	0	0	0	0	0	115	1110011	0	0	0	0	0	000001110011
	139	125	0	0	0	0	0	209	1111101	0	0	0	0	0	000011010001
	140	114	0	0	0	0	0	254	1110010	0	0	0	0	0	000011111110
	141	95	0	0	0	0	0	149	1011111	0	0	0	0	0	000010010101
	142	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	143	0	0	0	0	0	1	39	0000000	0	0	0	0	1	000000100111
	144	17	0	0	0	1	0	143	0010001	0	0	0	1	0	000010001111
	145	37	0	0	0	0	0	149	0100101	0	0	0	0	0	000010010101
MESS	146	0	0	1	1	0	1	49	0000000	0	1	1	0	1	000000110001
	147	25	0	0	0	1	0	142	0011001	0	0	0	1	0	000010001110
	148	95	0	0	1	1	0	0	1011111	0	0	1	1	0	000000000000
	149	96	0	0	1	0	0	0	1100000	0	0	1	0	0	000000000000
	150	118	0	0	0	0	0	570	1110110	0	0	0	0	0	001000111010
	151	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
	152	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
	153	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
	154	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
	155	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	156	0	1	0	0	0	1	58	0000000	1	0	0	0	1	000000111010
	157	17	0	0	0	1	0	156	0010001	0	0	0	1	0	000010011100
MESS	158	0	0	1	1	0	1	70	0000000	0	1	1	0	1	000001000110
	159	25	0	0	0	1	0	155	0011001	0	0	0	1	0	000010011011
	160	102	0	0	0	1	0	27	1100110	0	0	0	1	0	000000011011
	161	74	0	0	0	0	0	171	1001010	0	0	0	0	0	000010101011

	INPUT								OUTPUT						
	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
	162	59	0	0	1	1	0	0	0111011	0	0	1	1	0	000000000000
	163	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	164	0	0	0	0	0	1	79	0000000	0	0	0	0	1	000001001111
	165	17	0	0	0	1	0	164	0010001	0	0	0	1	0	000010100100
	166	36	0	0	0	1	0	170	0100100	0	0	0	1	0	000010101010
MESS	167	0	0	1	1	0	1	89	0000000	0	1	1	0	1	000001011001
	168	25	0	0	0	1	0	163	0011001	0	0	0	1	0	000010100011
	169	73	0	0	1	1	0	0	1001001	0	0	1	1	0	000000000000
	170	74	0	0	1	1	0	0	1001010	0	0	1	1	0	000000000000
	171	124	0	0	0	0	0	188	1111100	0	0	0	0	0	000010111100
	172	125	0	0	0	0	0	206	1111101	0	0	0	0	0	000011001110
	173	114	0	0	0	0	0	249	1110010	0	0	0	0	0	000011111001
	174	63	0	0	1	1	0	0	0111111	0	0	1	1	0	000000000000
	175	83	0	0	0	0	0	178	1010011	0	0	0	0	0	000010110010
MESS	176	0	1	0	1	0	1	98	0000000	1	0	1	0	1	000001100010
	177	83	0	0	1	1	0	0	1010011	0	0	1	1	0	000000000000
	178	98	0	0	0	0	0	181	1100010	0	0	0	0	0	000010110101
MESS	179	0	1	0	1	0	1	105	0000000	1	0	1	0	1	000001101001
	180	98	0	0	1	1	0	0	1100010	0	0	1	1	0	000000000000
	181	114	0	0	0	0	0	241	1110010	0	0	0	0	0	000011110001
	182	115	0	0	0	0	0	269	1110011	0	0	0	0	0	000100001101
	183	124	0	0	0	0	0	195	1111100	0	0	0	0	0	000011000011
	184	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
	185	34	0	0	0	0	0	202	0100010	0	0	0	0	0	000011001010
	186	124	0	0	1	1	0	0	1111100	0	0	1	1	0	000000000000
	187	102	0	0	0	1	0	161	1100110	0	0	0	1	0	000010100001
	188	124	0	0	1	0	0	0	1111100	0	0	1	0	0	000000000000

AIRESEARCH MANUFACTURING COMPANY
OF CALIFORNIA

		INPUT						OUTPUT						
PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
189	19	0	0	1	1	0	3	0010011	0	0	1	1	0	000000000011
190	17	0	0	0	1	0	190	0010001	0	0	0	1	0	000010111110
191	34	0	0	0	0	0	197	0100010	0	0	0	0	0	000011000101
192	100	0	0	1	1	0	0	1100100	0	0	1	1	0	000000000000
193	124	0	0	1	1	0	0	1111100	0	0	1	1	0	000000000000
194	102	0	0	0	1	0	174	1100110	0	0	0	1	0	000010101110
195	124	0	0	1	0	0	0	1111100	0	0	1	0	0	000000000000
196	114	0	0	0	0	0	226	1110010	0	0	0	0	0	000011100010
197	73	0	0	1	1	0	0	1001001	0	0	1	1	0	000000000000
198	114	0	0	0	0	0	226	1110010	0	0	0	0	0	000011100010
199	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
200	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
201	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
202	114	0	0	0	0	0	196	1110010	0	0	0	0	0	000011000100
203	117	0	0	0	0	0	196	1110101	0	0	0	0	0	000011000100
204	125	0	0	1	1	0	0	1111101	0	0	1	1	0	000000000000
205	102	0	0	0	1	0	161	1100110	0	0	0	1	0	000010100001
206	19	0	0	1	1	0	5	0010011	0	0	1	1	0	000000000101
207	17	0	0	0	1	0	207	0010001	0	0	0	1	0	000011001111
208	102	0	0	0	1	0	129	1100110	0	0	0	1	0	000010000001
209	125	0	0	1	0	0	0	1111101	0	0	1	0	0	000000000000
210	19	0	0	1	1	0	5	0010011	0	0	1	1	0	000000000101
211	17	0	0	0	1	0	0	0010001	0	0	0	1	0	000000000000
212	34	0	0	0	1	0	198	0100010	0	0	0	1	0	000011000110
213	102	0	0	0	1	0	196	1100110	0	0	0	1	0	000011000100
214	67	0	0	0	0	0	33	1000011	0	0	0	0	0	000000100001
215	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010

	INPUT								OUTPUT						
	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
MESS	216	0	1	0	0	0	1	113	0000000	1	0	0	0	1	000001110001
	217	17	0	0	0	1	0	216	0010001	0	0	0	1	0	000011011000
	218	44	0	0	0	0	0	220	0101100	0	0	0	0	0	000011011100
	219	47	0	0	0	1	0	228	0101111	0	0	0	1	0	000011100100
	220	46	0	0	0	0	0	223	0101110	0	0	0	0	0	000011011111
	221	52	0	0	0	0	0	223	0110100	0	0	0	0	0	000011011111
	222	51	0	0	0	1	0	228	0110011	0	0	0	1	0	000011100100
	223	67	0	0	1	1	0	0	1000011	0	0	1	1	0	000000000000
	224	114	0	0	1	1	0	0	1110010	0	0	1	1	0	000000000000
	225	102	0	0	0	1	0	185	1100110	0	0	0	1	0	000010111001
	226	114	0	0	1	0	0	0	1110010	0	0	1	0	0	000000000000
	227	102	0	0	0	1	0	33	1100110	0	0	0	1	0	000000100001
	228	89	0	0	1	1	0	0	1011001	0	0	1	1	0	000000000000
MESS	229	0	0	0	1	0	1	125	0000000	0	0	1	0	1	000001111101
MESS	230	0	0	0	1	0	1	70	0000000	0	0	1	0	1	000001000110
	231	102	0	0	0	1	0	33	1100110	0	0	0	1	0	000000100001
	232	100	0	0	0	0	0	36	1100100	0	0	0	0	0	000000100100
	233	74	0	0	0	0	0	36	1001010	0	0	0	0	0	000000100100
	234	73	0	0	0	0	0	36	1001001	0	0	0	0	0	000000100100
	235	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	236	0	1	0	0	0	1	140	0000000	1	0	0	0	1	000010001100
	237	17	0	0	0	1	0	236	0010001	0	0	0	1	0	000011101100
	238	36	0	0	0	1	0	252	0100100	0	0	0	1	0	000011111100
	239	114	0	0	1	1	0	0	1110010	0	0	1	1	0	000000000000
	240	102	0	0	0	1	0	174	1100110	0	0	0	1	0	000010101110
	241	114	0	0	1	0	0	0	1110010	0	0	1	0	0	000000000000
	242	52	0	0	0	0	0	247	0110100	0	0	0	0	0	000011110111

	INPUT								OUTPUT						
	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
	243	44	0	0	0	0	0	249	0101100	0	0	0	0	0	000011111001
	244	51	0	0	0	0	0	249	0110011	0	0	0	0	0	000011111001
	245	49	0	0	0	0	0	29	0110001	0	0	0	0	0	000000011101
	246	102	0	0	0	1	0	736	1100110	0	0	0	1	0	001011100000
	247	114	0	0	1	1	0	0	1110010	0	0	1	1	0	000000000000
	248	102	0	0	0	1	0	161	1100110	0	0	0	1	0	000010100001
	249	114	0	0	1	0	0	0	1110010	0	0	1	0	0	000000000000
	250	73	0	0	1	1	0	0	1001001	0	0	1	1	0	000000000000
	251	102	0	0	0	1	0	36	1100110	0	0	0	1	0	000000100100
	252	114	0	0	1	1	0	0	1110010	0	0	1	1	0	000000000000
	253	102	0	0	0	1	0	129	1100110	0	0	0	1	0	000010000001
	254	114	0	0	1	0	0	0	1110010	0	0	1	0	0	000000000000
	255	73	0	0	0	0	0	239	1001001	0	0	0	0	0	000011101111
	256	19	0	0	1	1	0	5	0010011	0	0	1	1	0	000000000101
	257	17	0	0	0	1	0	257	0010001	0	0	0	1	0	000100000001
	258	102	0	0	0	1	0	33	1100110	0	0	0	1	0	000000100001
	259	85	0	0	0	0	0	39	1010101	0	0	0	0	0	000000100111
	260	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	261	0	1	0	0	0	1	151	0000000	1	0	0	0	1	000010010111
	262	17	0	0	0	1	0	261	0010001	0	0	0	1	0	000100000101
MESS	263	0	0	0	1	0	1	159	0000000	0	0	1	0	1	000010011111
	264	19	0	0	1	1	0	147	0010011	0	0	1	1	0	000010010011
	265	17	0	0	0	1	0	265	0010001	0	0	0	1	0	000100001001
	266	31	0	0	0	1	0	38	0011111	0	0	0	1	0	000000100110
	267	115	0	0	1	1	0	0	1110011	0	0	1	1	0	000000000000
	268	102	0	0	0	1	0	174	1100110	0	0	0	1	0	000010101110
	269	115	0	0	1	0	0	0	1110011	0	0	1	0	0	000000000000

	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
	INPUT								OUTPUT						
	270	19	0	0	1	1	0	147	0010011	0	0	1	1	0	000010010011
	271	17	0	0	0	1	0	271	0010001	0	0	0	1	0	000100001111
	272	31	0	0	0	0	0	282	0011111	0	0	0	0	0	000100011010
MESS	273	0	0	0	1	0	1	167	0000000	0	0	1	0	1	000010100111
	274	98	0	0	1	0	0	0	1100010	0	0	1	0	0	000000000000
MESS	275	0	0	0	1	0	1	177	0000000	0	0	1	0	1	000010110001
	276	102	0	0	0	1	0	713	1100110	0	0	0	1	0	001011001001
	277														
	278	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	279	0	1	0	0	0	1	185	0000000	1	0	0	0	1	000010111001
	280	17	0	0	0	1	0	279	0010001	0	0	0	1	0	000100010111
	281	102	0	0	0	1	0	687	1100110	0	0	0	1	0	001010101111
	282	85	0	0	1	1	0	0	1010101	0	0	1	1	0	000000000000
	283	102	0	0	0	1	0	39	1100110	0	0	0	1	0	000000100111
	284	77	0	0	0	0	0	43	1001101	0	0	0	0	0	000000101011
	285	116	0	0	1	1	0	0	1110100	0	0	1	1	0	000000000000
	286	102	0	0	0	1	0	608	1100110	0	0	0	1	0	001001100000
	287	116	0	0	1	0	0	0	1110100	0	0	1	0	0	000000000000
	288	68	0	0	0	1	0	43	1000100	0	0	0	1	0	000000101011
	289	68	0	0	1	0	0	0	1000100	0	0	1	0	0	000000000000
	290	42	0	0	0	0	0	303	0101010	0	0	0	0	0	000100101111
	291	114	0	0	1	1	0	0	1110010	0	0	1	1	0	000000000000
	292	102	0	0	0	1	0	324	1100110	0	0	0	1	0	000101000100
	293	114	0	0	1	0	0	0	1110010	0	0	1	0	0	000000000000
	294	81	0	0	0	1	0	301	1010001	0	0	0	1	0	000100101101
	295	81	0	0	1	0	0	0	1010001	0	0	1	0	0	000000000000
	296	33	0	0	0	0	0	299	0100001	0	0	0	0	0	000100101011

GARRETT

AIRESEARCH MANUFACTURING COMPANY
OF CALIFORNIA

ORIGINAL PAGE IS
OF POOR QUALITY

	INPUT								OUTPUT						
	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
	297	76	0	0	1	1	0	0	1001100	0	0	1	1	0	000000000000
	298	102	0	0	0	1	0	676	1100110	0	0	0	1	0	001010100100
	299	75	0	0	1	1	0	0	1001011	0	0	1	1	0	000000000000
	300	102	0	0	0	1	0	43	1100110	0	0	0	1	0	000000101011
	301	77	0	0	1	1	0	0	1001101	0	0	1	1	0	000000000000
	302	102	0	0	0	1	0	39	1100110	0	0	0	1	0	000000100111
	303	33	0	0	0	0	0	305	0100001	0	0	0	0	0	000100110001
	304	76	0	0	1	1	0	0	1001100	0	0	1	1	0	000000000000
	305	102	0	0	0	1	0	43	1100110	0	0	0	1	0	000000101011
	306	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
	307	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
	308	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
	309	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
	310	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
	311	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
	312	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
	313	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
MESS	314	0	0	1	1	0	1	196	0000000	0	1	1	0	1	000011000100
	315	25	0	0	0	0	0	689	0011001	0	0	0	0	0	001010110001
MESS	316	0	0	0	1	0	1	203	0000000	0	0	1	0	1	000011001011
	317	71	0	0	1	0	0	0	1000111	0	0	1	0	0	000000000000
	318	19	0	0	1	1	0	30	0010011	0	0	1	1	0	000000011110
	319	17	0	0	0	1	0	319	0010001	0	0	0	1	0	000100111111
	320	124	0	0	0	0	0	326	1111100	0	0	0	0	0	000101000110
	321	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
	322	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
	323														

	I N P U T							O U T P U T						
PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
324	124	0	0	1	1	0	0	1111100	0	0	1	1	0	000000000000
325	102	0	0	0	1	0	314	1100110	0	0	0	1	0	000100111010
326	124	0	0	1	0	0	0	1111100	0	0	1	0	0	000000000000
327	70	0	0	0	1	0	42	1000110	0	0	0	1	0	000000101010
328	45	0	0	0	1	0	331	0101101	0	0	0	1	0	000101001011
329	48	0	0	0	1	0	331	0110000	0	0	0	1	0	000101001011
330	81	0	0	1	1	0	0	1010001	0	0	1	1	0	000000000000
331	114	0	0	0	0	0	293	1110010	0	0	0	0	0	000100100101
332	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
333	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
334	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
335	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
336	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
337	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
338	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
339	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
340	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
341	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
342	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
343	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
344	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
345	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
346	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
347	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
348	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
349	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
350	76	0	0	0	0	0	44	1001100	0	0	0	0	0	000000101100

GARRETT

AIRESEARCH MANUFACTURING COMPANY
OF CALIFORNIA

	INPUT								OUTPUT						
	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
	351	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	352	0	1	0	0	0	1	214	0000000	1	0	0	0	1	000011010110
	353	17	0	0	0	1	0	352	0010001	0	0	0	1	0	000101100000
MESS	354	0	0	0	1	0	1	70	0000000	0	0	1	0	1	000001000110
	355	102	0	0	0	1	0	44	1100110	0	0	0	1	0	000000101100
	356	88	0	0	0	0	0	45	1011000	0	0	0	0	0	000000101101
	357	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	358	0	1	0	0	0	1	58	0000000	1	0	0	0	1	000000111010
	359	17	0	0	0	1	0	358	0010001	0	0	0	1	0	000101100110
MESS	360	0	0	0	1	0	1	70	0000000	0	0	1	0	1	000001000110
	361	102	0	0	0	1	0	45	1100110	0	0	0	1	0	000000101101
	362	88	0	0	0	0	0	46	1011000	0	0	0	0	0	000000101110
	363	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	364	0	1	0	0	0	1	227	0000000	1	0	0	0	1	000011100011
	365	17	0	0	0	1	0	364	0010001	0	0	0	1	0	000101101100
MESS	366	0	0	0	1	0	1	70	0000000	0	0	1	0	1	000001000110
	367	102	0	0	0	1	0	46	1100110	0	0	0	1	0	000000101110
	368	75	0	0	0	0	0	52	1001011	0	0	0	0	0	000000110100
	369	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	370	0	1	0	0	0	1	214	0000000	1	0	0	0	1	000011010110
	371	17	0	0	0	1	0	370	0010001	0	0	0	1	0	000101110010
MESS	372	0	0	0	1	0	1	70	0000000	0	0	1	0	1	000001000110
	373	102	0	0	0	1	0	52	1100110	0	0	0	1	0	000000110100
	374	82	0	0	0	0	0	53	1010010	0	0	0	0	0	000000110101
	375	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	376	0	1	0	0	0	1	240	0000000	1	0	0	0	1	000011110000
	377	17	0	0	0	1	0	376	0010001	0	0	0	1	0	000101111000

INPUT								OUTPUT						
PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
378	0	0	0	1	0	1	70	0000000	0	0	1	0	1	000001000110
379	102	0	0	0	1	0	53	1100110	0	0	0	1	0	000000110101
380	14	1	0	0	0	0	0	0001110	1	0	0	0	0	000000000000
381	19	1	0	1	1	0	0	0010011	1	0	1	1	0	000000000000
382	18	0	0	0	1	0	382	0010010	0	0	0	1	0	000101111110
383	16	0	0	0	1	0	385	0010000	0	0	0	1	0	000110000001
384	68	0	0	1	1	0	0	1000100	0	0	1	1	0	000000000000
385	117	0	0	0	0	0	0	1110101	0	0	0	0	0	000000000000
386	118	0	0	0	0	0	0	1110110	0	0	0	0	0	000000000000
387	116	0	0	0	0	0	711	1110100	0	0	0	0	0	001011000111
388	14	0	0	0	0	0	19	0001110	0	0	0	0	0	000000010011
389	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
390	18	0	0	0	1	0	390	0010010	0	0	0	1	0	000110000110
391	16	0	0	0	1	0	471	0010000	0	0	0	1	0	000111010111
392	14	0	0	0	0	0	28	0001110	0	0	0	0	0	000000011100
393	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
394	18	0	0	0	1	0	394	0010010	0	0	0	1	0	000110001010
395	16	0	0	0	1	0	476	0010000	0	0	0	1	0	000111011100
396	14	0	0	0	0	0	37.	0001110	0	0	0	0	0	000000100101
397	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
398	18	0	0	0	1	0	398	0010010	0	0	0	1	0	000110001110
399	16	0	0	0	1	0	479	0010000	0	0	0	1	0	000111011111
400	14	0	0	0	0	0	46	0001110	0	0	0	0	0	000000101110
401	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
402	18	0	0	0	1	0	402	0010010	0	0	0	1	0	000110010010
403	16	0	0	0	1	0	482	0010000	0	0	0	1	0	000111100010
404	14	0	0	0	0	0	54	0001110	0	0	0	0	0	000000110110

	INPUT							OUTPUT						
PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
405	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
406	18	0	0	0	1	0	406	0010010	0	0	0	1	0	000110010110
407	16	0	0	0	1	0	485	0010000	0	0	0	1	0	000111100101
408	14	0	0	0	0	0	63	0001110	0	0	0	0	0	000000111111
409	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
410	18	0	0	0	1	0	410	0010010	0	0	0	1	0	000110011010
411	16	0	0	0	1	0	488	0010000	0	0	0	1	0	000111101000
412	14	0	0	0	0	0	72	0001110	0	0	0	0	0	000001001000
413	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
414	18	0	0	0	1	0	414	0010010	0	0	0	1	0	000110011110
415	16	0	0	0	1	0	491	0010000	0	0	0	1	0	000111101011
416	14	0	0	0	0	0	81	0001110	0	0	0	0	0	000001010001
417	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
418	18	0	0	0	1	0	418	0010010	0	0	0	1	0	000110100010
419	16	0	0	0	1	0	494	0010000	0	0	0	1	0	000111101110
420	14	0	0	0	0	0	89	0001110	0	0	0	0	0	000001011001
421	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
422	18	0	0	0	1	0	422	0010010	0	0	0	1	0	000110100110
423	16	0	0	0	1	0	497	0010000	0	0	0	1	0	000111110001
424	14	0	0	0	0	0	98	0001110	0	0	0	0	0	000001100010
425	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
426	18	0	0	0	1	0	426	0010010	0	0	0	1	0	000110101010
427	16	0	0	0	1	0	500	0010000	0	0	0	1	0	000111110100
428	14	0	0	0	0	0	107	0001110	0	0	0	0	0	000001101011
429	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
430	18	0	0	0	1	0	430	0010010	0	0	0	1	0	000110101110
431	16	0	0	0	1	0	503	0010000	0	0	0	1	0	000111110111

GARRETT
AIRESEARCH MANUFACTURING COMPANY
OF CALIFORNIA

	INPUT							OUTPUT						
PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
432	14	0	0	0	0	0	116	0001110	0	0	0	0	0	000001110100
433	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
434	18	0	0	0	1	0	434	0010010	0	0	0	1	0	000110110010
435	16	0	0	0	1	0	506	0010000	0	0	0	1	0	000111111010
436	14	0	0	0	0	0	125	0001110	0	0	0	0	0	000001111101
437	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
438	18	0	0	0	1	0	438	0010010	0	0	0	1	0	000110110110
439	16	0	0	0	1	0	509	0010000	0	0	0	1	0	000111111101
440	14	0	0	0	0	0	132	0001110	0	0	0	0	0	000010000100
441	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
442	18	0	0	0	1	0	442	0010010	0	0	0	1	0	000110111010
443	16	0	0	0	1	0	512	0010000	0	0	0	1	0	001000000000
444	14	0	0	0	0	0	142	0001110	0	0	0	0	0	000010001110
445	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
446	18	0	0	0	1	0	446	0010010	0	0	0	1	0	000110111110
447	16	0	0	0	1	0	515	0010000	0	0	0	1	0	001000000011
448	14	0	0	0	0	0	150	0001110	0	0	0	0	0	000010010110
449	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
450	18	0	0	0	1	0	450	0010010	0	0	0	1	0	000111000010
451	16	0	0	0	1	0	518	0010000	0	0	0	1	0	001000000110
452	14	0	0	0	0	0	160	0001110	0	0	0	0	0	000010100000
453	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
454	18	0	0	0	1	0	454	0010010	0	0	0	1	0	000111000110
455	16	0	0	0	1	0	521	0010000	0	0	0	1	0	001000001001
456	14	0	0	0	0	0	168	0001110	0	0	0	0	0	000010101000
457	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
458	18	0	0	0	1	0	458	0010010	0	0	0	1	0	000111001010

AIRESEARCH MANUFACTURING COMPANY
OF CALIFORNIA

ORIGINAL PAGE IS
OF POOR QUALITY

		INPUT							OUTPUT						
	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
	459	16	0	0	0	1	0	524	0010000	0	0	0	1	0	001000001100
	460	14	0	0	0	0	0	177	0001110	0	0	0	0	0	000010110001
	461	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
	462	18	0	0	0	1	0	462	0010010	0	0	0	1	0	000111001110
	463	16	0	0	0	1	0	527	0010000	0	0	0	1	0	001000001111
	464	14	0	0	0	0	0	185	0001110	0	0	0	0	0	000010111001
	465	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
	466	18	0	0	0	1	0	466	0010010	0	0	0	1	0	000111010010
	467	16	0	0	0	1	0	530	0010000	0	0	0	1	0	001000010010
MESS	468	0	0	1	1	0	1	441	0000000	0	1	1	0	1	000110111001
	469	0	0	0	0	0	0	0	0000000	0	0	0	0	0	000000000000
	470	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	471	0	1	1	1	0	1	251	0000000	1	1	1	0	1	000011111011
	472	25	0	0	0	1	0	474	0011001	0	0	0	1	0	000111011010
	473	68	0	0	1	1	0	0	1000100	0	0	1	1	0	000000000000
	474	114	0	0	0	0	0	630	1110010	0	0	0	0	0	001001110110
	475	102	0	0	0	1	0	0	1100110	0	0	0	1	0	000000000000
MESS	476	0	0	1	1	0	1	262	0000000	0	1	1	0	1	000100000110
	477	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	478	102	0	0	0	1	0	472	1100110	0	0	0	1	0	000111011000
MESS	479	0	0	1	1	0	1	271	0000000	0	1	1	0	1	000100001111
	480	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	481	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	482	0	0	1	1	0	1	281	0000000	0	1	1	0	1	000100011001
	483	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	484	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	485	0	0	1	1	0	1	291	0000000	0	1	1	0	1	000100100011

	INPUT								OUTPUT						
	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
	486	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	487	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	488	0	0	1	1	0	1	301	0000000	0	1	1	0	1	000100101101
	489	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	490	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	491	0	0	1	1	0	1	311	0000000	0	1	1	0	1	000100110111
	492	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	493	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	494	0	0	1	1	0	1	321	0000000	0	1	1	0	1	000101000001
	495	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	496	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	497	0	0	1	1	0	1	331	0000000	0	1	1	0	1	000101001011
	498	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	499	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	500	0	0	1	1	0	1	341	0000000	0	1	1	0	1	000101010101
	501	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	502	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	503	0	0	1	1	0	1	351	0000000	0	1	1	0	1	000101011111
	504	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	505	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	506	0	0	1	1	0	1	361	0000000	0	1	1	0	1	000101101001
	507	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	508	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	509	0	0	1	1	0	1	371	0000000	0	1	1	0	1	000101110011
	510	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	511	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	512	0	0	1	1	0	1	381	0000000	0	1	1	0	1	000101111101

AIRESEARCH MANUFACTURING COMPANY
OF CALIFORNIA

	INPUT								OUTPUT						
	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
	513	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	514	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	515	0	0	1	1	0	1	391	0000000	0	1	1	0	1	000110000111
	516	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	517	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	518	0	0	1	1	0	1	401	0000000	0	1	1	0	1	000110010001
	519	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	520	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	521	0	0	1	1	0	1	411	0000000	0	1	1	0	1	000110011011
	522	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	523	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	524	0	0	1	1	0	1	421	0000000	0	1	1	0	1	000110100101
	525	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	526	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	527	0	0	1	1	0	1	431	0000000	0	1	1	0	1	000110101111
	528	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	529	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
MESS	530	0	0	1	1	0	1	671	0000000	0	1	1	0	1	001010011111
	531	25	0	0	0	0	0	474	0011001	0	0	0	0	0	000111011010
	532	102	0	0	0	1	0	473	1100110	0	0	0	1	0	000111011001
	533	80	0	0	0	0	0	54	1010000	0	0	0	0	0	000000110110
	534	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	535	0	1	0	0	0	1	452	0000000	1	0	0	0	1	000111000100
	536	17	0	0	0	1	0	535	0010001	0	0	0	1	0	001000010111
MESS	537	0	0	0	1	0	1	70	0000000	0	0	1	0	1	000001000110
	538	102	0	0	0	1	0	54	1100110	0	0	0	1	0	000000110110
	539	69	0	0	0	0	0	55	1000101	0	0	0	0	0	000000110111

		INPUT							OUTPUT						
	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
	540	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	541	0	1	0	0	0	1	462	0000000	1	0	0	0	1	000111001110
	542	17	0	0	0	1	0	541	0010001	0	0	0	1	0	001000011101
MESS	543	0	0	0	1	0	1	70	0000000	0	0	1	0	1	000001000110
	544	102	0	0	0	1	0	55	1100110	0	0	0	1	0	000000110111
	545	69	0	0	0	0	0	56	1000101	0	0	0	0	0	000000111000
	546	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	547	0	1	0	0	0	1	474	0000000	1	0	0	0	1	000111011010
	548	17	0	0	0	1	0	547	0010001	0	0	0	1	0	001000100011
MESS	549	0	0	0	1	0	1	70	0000000	0	0	1	0	1	000001000110
	550	102	0	0	0	1	0	56	1100110	0	0	0	1	0	000000111000
	551	77	0	0	0	0	0	57	1001101	0	0	0	0	0	000000111001
	552	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	553	0	1	0	0	0	1	488	0000000	1	0	0	0	1	000111101000
	554	17	0	0	0	1	0	553	0010001	0	0	0	1	0	001000101001
MESS	555	0	0	0	1	0	1	70	0000000	0	0	1	0	1	000001000110
	556	102	0	0	0	1	0	57	1100110	0	0	0	1	0	000000111001
	557	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	558	0	0	0	0	0	1	498	0000000	0	0	0	0	1	000111110010
	559	17	0	0	0	1	0	558	0010001	0	0	0	1	0	001000101110
	560	38	0	0	0	1	0	564	0100110	0	0	0	1	0	001000110100
	561	19	0	0	1	1	0	3	0010011	0	0	1	1	0	000000000011
MESS	562	0	1	0	0	0	1	510	0000000	1	0	0	0	1	000111111110
	563	17	0	0	0	1	0	562	0010001	0	0	0	1	0	001000110010
	564	24	0	0	1	1	0	0	0011000	0	0	1	1	0	000000000000
	565	22	0	0	1	1	0	0	0010110	0	0	1	1	0	000000000000
	566	102	0	0	0	1	0	0	1100110	0	0	0	1	0	000000000000

	INPUT								OUTPUT						
	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
MESS	567	0	0	1	1	0	1	522	0000000	0	1	1	0	1	001000001010
	568	25	0	0	0	0	0	748	0011001	0	0	0	0	0	001011101100
	569	102	0	0	0	1	0	653	1100110	0	0	0	1	0	001010001101
	570	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	571	0	0	0	0	0	1	681	0000000	0	0	0	0	1	001010101001
	572	17	0	0	0	1	0	572	0010001	0	0	0	1	0	001000111100
	573	102	0	0	0	1	0	715	1100110	0	0	0	1	0	001011001011
	574														
MESS	575	0	0	1	1	0	1	556	0000000	0	1	1	0	1	001000101100
	576	25	0	0	0	1	0	589	0011001	0	0	0	1	0	001001001101
	577	115	0	0	1	1	0	0	1110011	0	0	1	1	0	000000000000
	578	102	0	0	0	1	0	596	1100110	0	0	0	1	0	001001010100
	579	115	0	0	1	0	0	0	1110011	0	0	1	0	0	000000000000
	580	68	0	0	0	0	0	586	1000100	0	0	0	0	0	001001001010
	581	68	0	0	1	0	0	0	1000100	0	0	1	0	0	000000000000
	582	116	0	0	1	1	0	0	1110100	0	0	1	1	0	000000000000
	583	102	0	0	0	1	0	721	1100110	0	0	0	1	0	001011010001
	584	116	0	0	1	0	0	0	1110100	0	0	1	0	0	000000000000
	585	102	0	0	0	1	0	588	1100110	0	0	0	1	0	001001001100
	586	35	0	0	0	0	0	582	0100011	0	0	0	0	0	001001000110
	587	40	0	0	0	1	0	733	0101000	0	0	0	1	0	001011011101
	588	99	0	0	1	1	0	0	1100011	0	0	1	1	0	000000000000
MESS	589	0	0	1	1	0	1	565	0000000	0	1	1	0	1	001000110101
	590	25	0	0	0	0	0	592	0011001	0	0	0	0	0	001001010000
MESS	591	0	0	0	1	0	1	70	0000000	0	0	1	0	1	000001000110
MESS	592	0	0	1	1	0	1	768	0000000	0	1	1	0	1	001100000000
	593	25	0	0	0	0	0	560	0011001	0	0	0	0	0	001000110000

ORIGINAL PAGE IS OF POOR QUALITY

	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
		INPUT							OUTPUT						
MESS	594	0	0	0	1	0	1	70	0000000	0	0	1	0	1	000001000110
	595	102	0	0	0	1	0	560	1100110	0	0	0	1	0	001000110000
	596	14	0	0	0	0	0	-4	0001110	0	0	0	0	0	111111111100
	597	19	0	1	1	1	0	147	0010011	0	1	1	1	0	000010010011
	598	17	0	0	0	1	0	598	0010001	0	0	0	1	0	001001010110
	599	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
	600	18	0	0	0	1	0	600	0010010	0	0	0	1	0	001001011000
	601	16	0	0	0	1	0	603	0010000	0	0	0	1	0	001001011011
	602	68	0	0	1	1	0	0	1000100	0	0	1	1	0	000000000000
	603	114	0	0	0	0	0	0	1110010	0	0	0	0	0	000000000000
	604	115	0	0	0	0	0	579	1110011	0	0	0	0	0	001001000011
	605	116	0	0	0	0	0	0	1110100	0	0	0	0	0	000000000000
	606	42	0	0	0	1	0	615	0101010	0	0	0	1	0	001001100111
	607	43	0	0	0	1	0	615	0101011	0	0	0	1	0	001001100111
	608	15	0	0	0	0	0	17	0001111	0	0	0	0	0	000000010001
	609	19	0	1	1	1	0	30	0010011	0	1	1	1	0	000000011110
	610	17	0	0	0	1	0	610	0010001	0	0	0	1	0	001001100010
	611	19	0	0	1	1	0	0	0010011	0	0	1	1	0	000000000000
	612	18	0	0	0	1	0	612	0010010	0	0	0	1	0	001001100100
	613	16	0	0	0	1	0	615	0010000	0	0	0	1	0	001001100111
	614	68	0	0	1	1	0	0	1000100	0	0	1	1	0	000000000000
	615	117	0	0	0	0	0	0	1110101	0	0	0	0	0	000000000000
	616	115	0	0	0	0	0	0	1110011	0	0	0	0	0	000000000000
	617	116	0	0	0	0	0	723	1110100	0	0	0	0	0	001011010011
	618	114	0	0	0	0	0	0	1110010	0	0	0	0	0	000000000000
	619														
	620														

AIRESEARCH MANUFACTURING COMPANY
OF CALIFORNIA

	INPUT								OUTPUT						
	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
	621	39	0	0	0	1	0	624	0100111	0	0	0	1	0	001001110000
	622	41	0	0	0	0	0	668	0101001	0	0	0	0	0	001010011100
	623	102	0	0	0	1	0	667	1100110	0	0	0	1	0	001010011011
	624	40	0	0	0	0	0	638	0101000	0	0	0	0	0	001001111110
	625	35	0	0	0	0	0	668	0100011	0	0	0	0	0	001010011100
MESS	626	0	0	1	1	0	1	588	0000000	0	1	1	0	1	001001001100
	627	25	0	0	0	1	0	632	0011001	0	0	0	1	0	001001111000
	628	114	0	0	1	1	0	0	1110010	0	0	1	1	0	000000000000
	629	102	0	0	0	1	0	388	1100110	0	0	0	1	0	000110000100
	630	114	0	0	0	0	0	0	1110010	0	0	0	0	0	000000000000
	631	102	0	0	0	1	0	730	1100110	0	0	0	1	0	001011011010
	632	88	0	0	1	1	0	0	1011000	0	0	1	1	0	000000000000
	633	72	0	0	1	1	0	0	1001000	0	0	1	1	0	000000000000
	634	118	0	0	1	1	0	0	1110110	0	0	1	1	0	000000000000
	635	102	0	0	0	1	0	644	1100110	0	0	0	1	0	001010000100
	636	118	0	0	1	0	0	638	1110110	0	0	1	0	0	001001111110
	637	102	0	0	0	1	0	745	1100110	0	0	0	1	0	001011101001
	638	35	0	0	0	0	0	640	0100011	0	0	0	0	0	001010000000
	639	79	0	0	1	1	0	0	1001111	0	0	1	1	0	000000000000
	640	115	0	0	1	1	0	0	1110011	0	0	1	1	0	000000000000
	641	102	0	0	0	1	0	721	1100110	0	0	0	1	0	001011010001
	642	115	0	0	1	0	0	0	1110011	0	0	1	0	0	000000000000
	643	102	0	0	0	1	0	745	1100110	0	0	0	1	0	001011101001
	644	63	0	0	1	0	0	0	0111111	0	0	1	0	0	000000000000
	645	83	0	0	0	0	0	648	1010011	0	0	0	0	0	001010001000
MESS	646	0	1	0	1	0	1	98	0000000	1	0	1	0	1	000001100010
	647	83	0	0	1	1	0	0	1010011	0	0	1	1	0	000000000000

	INPUT								OUTPUT						
	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
	648	84	0	0	0	0	0	651	1010100	0	0	0	0	0	001010001011
MESS	649	0	1	0	1	0	1	596	0000000	1	0	1	0	1	001001010100
	650	84	0	0	1	1	0	0	1010100	0	0	1	1	0	000000000000
	651	102	0	0	0	1	0	691	1100110	0	0	0	1	0	001010110011
	652														
MESS	653	0	0	1	1	0	1	534	0000000	0	1	1	0	1	001000010110
	654	25	0	0	0	0	0	658	0011001	0	0	0	0	0	001010010010
MESS	655	0	0	1	1	0	1	542	0000000	0	1	1	0	1	001000011110
	656	25	0	0	0	0	0	660	0011001	0	0	0	0	0	001010010100
	657	102	0	0	0	1	0	575	1100110	0	0	0	1	0	001000111111
MESS	658	0	0	0	1	0	1	70	0000000	0	0	1	0	1	000001000110
	659	102	0	0	0	1	0	655	1100110	0	0	0	1	0	001010001111
MESS	660	0	0	0	1	0	1	70	0000000	0	0	1	0	1	000001000110
	661	102	0	0	0	1	0	575	1100110	0	0	0	1	0	001000111111
MESS	662	0	0	1	1	0	1	606	0000000	0	1	1	0	1	001001011110
	663	25	0	0	0	0	0	60	0011001	0	0	0	0	0	000000111100
MESS	664	0	0	1	1	0	1	619	0000000	0	1	1	0	1	001001101011
	665	25	0	0	0	0	0	110	0011001	0	0	0	0	0	000001101110
	666	102	0	0	0	1	0	694	1100110	0	0	0	1	0	001010110110
	667	35	0	0	0	1	0	730	0100011	0	0	0	1	0	001011011010
	668	72	0	0	1	1	0	0	1001000	0	0	1	1	0	000000000000
MESS	669	0	1	0	1	0	1	98	0000000	1	0	1	0	1	000001100010
	670	84	0	0	1	1	0	0	1010100	0	0	1	1	0	000000000000
	671	19	0	0	1	1	0	3	0010011	0	0	1	1	0	000000000011
MESS	672	0	0	0	0	0	1	632	0000000	0	0	0	0	1	001001111000
	673	17	0	0	0	1	0	672	0010001	0	0	0	1	0	001010100000
MESS	674	0	0	1	1	0	1	70	0000000	0	1	1	0	1	000001000110

	I N P U T							*	O U T P U T						
	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
	675	102	0	0	0	1	0	745	1100110	0	0	0	1	0	001011101001
MESS	676	0	0	1	1	0	1	643	0000000	0	1	1	0	1	001010000011
	677	25	0	0	0	0	0	683	0011001	0	0	0	0	0	001010101011
	678	19	0	0	1	1	0	3	0010011	0	0	1	1	0	000000000011
MESS	679	0	0	0	0	0	1	655	0000000	0	0	0	0	1	001010001111
	680	17	0	0	0	1	0	679	0010001	0	0	0	1	0	001010100111
MESS	681	0	0	0	1	0	1	70	0000000	0	0	1	0	1	000001000110
	682	102	0	0	0	1	0	43	1100110	0	0	0	1	0	000000101011
	683	19	0	0	1	1	0	3	0010011	0	0	1	1	0	000000000011
MESS	684	0	0	0	0	0	1	663	0000000	0	0	0	0	1	001010010111
	685	17	0	0	0	1	0	684	0010001	0	0	0	1	0	001010101100
	686	102	0	0	0	1	0	681	1100110	0	0	0	1	0	001010101001
MESS	687	0	0	0	1	0	1	70	0000000	0	0	1	0	1	000001000110
	688	102	0	0	0	1	0	40	1100110	0	0	0	1	0	000000101000
	689	70	0	0	1	1	0	0	1000110	0	0	1	1	0	000000000000
	690	102	0	0	0	1	0	320	1100110	0	0	0	1	0	000101000000
	691	116	0	0	0	0	0	584	1110100	0	0	0	0	0	001001001000
	692	118	0	0	0	0	0	636	1110110	0	0	0	0	0	001001111100
	693	115	0	0	0	0	0	642	1110011	0	0	0	0	0	001010000010
	694	19	0	0	1	1	0	3	0010011	0	0	1	1	0	000000000011
MESS	695	0	0	0	0	0	1	689	0000000	0	0	0	0	1	001010110001
	696	17	0	0	0	1	0	695	0010001	0	0	0	1	0	001010110111
	697	19	0	0	1	1	0	1	0010011	0	0	1	1	0	000000000001
	698	106	0	0	1	0	0	0	1101010	0	0	1	0	0	000000000000
	699	17	0	0	0	0	0	653	0010001	0	0	0	0	0	001010001101
	700	25	0	0	0	0	0	698	0011001	0	0	0	0	0	001010111010
	701	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010

AIRESEARCH MANUFACTURING COMPANY
OF CALIFORNIA

	INPUT								OUTPUT						
	FROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD	S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
MESS	702	0	0	0	0	0	1	706	0000000	0	0	0	0	1	001011000010
	703	17	0	0	0	1	0	702	0010001	0	0	0	1	0	001010111110
	704	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	705	0	0	0	0	0	1	719	0000000	0	0	0	0	1	001011001111
	706	17	0	0	0	1	0	705	0010001	0	0	0	1	0	001011000001
	707	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	708	0	0	0	0	0	1	732	0000000	0	0	0	0	1	001011011100
	709	17	0	0	0	1	0	708	0010001	0	0	0	1	0	001011000100
	710	102	0	0	0	1	0	653	1100110	0	0	0	1	0	001010001101
	711	116	0	0	1	0	0	0	1110100	0	0	1	0	0	000000000000
	712	102	0	0	0	1	0	49	1100110	0	0	0	1	0	000000110001
	713	83	0	0	1	0	0	0	1010011	0	0	1	0	0	000000000000
	714	102	0	0	0	1	0	37	1100110	0	0	0	1	0	000000100101
MESS	715	0	1	0	1	0	1	742	0000000	1	0	1	0	1	001011100110
	716	84	0	0	1	0	0	0	1010100	0	0	1	0	0	000000000000
	717	102	0	0	0	1	0	118	1100110	0	0	0	1	0	000001110110
	718														
	719	83	0	0	0	0	0	42	1010011	0	0	0	0	0	000000101010
	720	102	0	0	0	1	0	277	1100110	0	0	0	1	0	000100010101
	721	99	0	0	1	1	0	0	1100011	0	0	1	1	0	000000000000
	722	102	0	0	0	1	0	644	1100110	0	0	0	1	0	001010000100
	723	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	724	0	1	0	0	0	1	753	0000000	1	0	0	0	1	001011110001
	725	17	0	0	0	1	0	724	0010001	0	0	0	1	0	001011010100
	726	19	0	0	1	1	0	2	0010011	0	0	1	1	0	000000000010
MESS	727	0	1	0	0	0	1	759	0000000	1	0	0	0	1	001011110111
	728														

	INPUT								*	OUTPUT						
	PROM ADDRESS	S/R ADDR.	SOURCE TONE	UP/DOWN ANSWER,	LOAD/COMP RESPONSE	DATA *	MESSAGE *	DATA FIELD		S/R ADDR.	B 1	B 2	B 3	B 4	B 5	DATA FIELD
	729	102	0	0	0	1	0	287		1100110	0	0	0	1	0	000100011111
MESS	730	0	0	0	1	0	1	125		0000000	0	0	1	0	1	000001111101
MESS	731	0	0	0	1	0	1	70		0000000	0	0	1	0	1	000001000110
	732	102	0	0	0	1	0	745		1100110	0	0	0	1	0	001011101001
MESS	733	0	0	0	1	0	1	125		0000000	0	0	1	0	1	000001111101
MESS	734	0	0	0	1	0	1	70		0000000	0	0	1	0	1	000001000110
	735	102	0	0	0	1	0	589		1100110	0	0	0	1	0	001001001101
MESS	736	0	0	0	1	0	1	125		0000000	0	0	1	0	1	000001111101
MESS	737	0	0	0	1	0	1	70		0000000	0	0	1	0	1	000001000110
	738	102	0	0	0	1	0	34		1100110	0	0	0	1	0	000000100010
	739	19	0	0	1	1	0	2		0010011	0	0	1	1	0	000000000010
MESS	740	0	1	0	0	0	1	780		0000000	1	0	0	0	1	001100001100
	741	17	0	0	0	1	0	740		0010001	0	0	0	1	0	001011100100
	742	55	0	0	1	1	0	0		0110111	0	0	1	1	0	000000000000
	743	63	0	0	1	1	0	0		0111111	0	0	1	1	0	000000000000
	744	102	0	0	0	1	0	621		1100110	0	0	0	1	0	001001101101
	745	54	0	0	1	1	0	0		0110110	0	0	1	1	0	000000000000
	746	62	0	0	1	1	0	0		0111110	0	0	1	1	0	000000000000
	747	102	0	0	0	1	0	51		1100110	0	0	0	1	0	000000110011
MESS	748	0	0	1	1	0	1	791		0000000	0	0	1	1	1	001100010111
	749	25	0	0	0	0	0	65		0011001	0	0	0	0	0	000001000001
	750	102	0	0	0	1	0	662		1100110	0	0	0	1	0	001010010110
	751															
	752															
	753															
	754															
	755															