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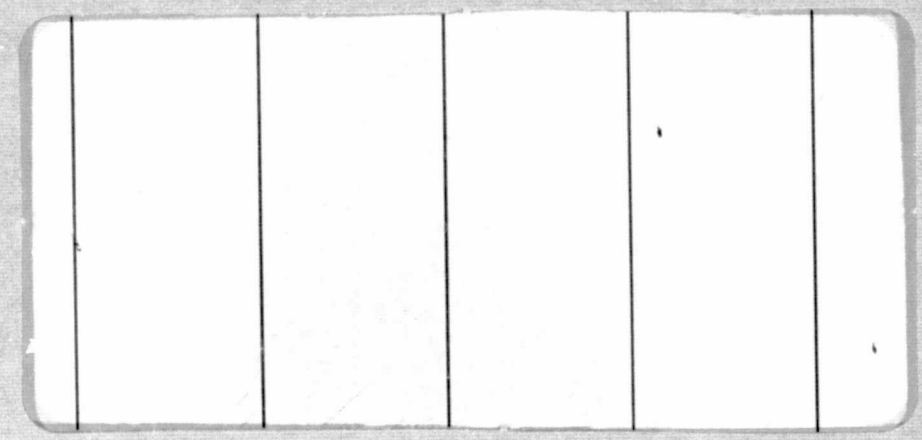

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TRILATERATION RANGE AND RANGE RATE SYSTEM

VOLUME I. CDA SYSTEM MANUAL

FEBRUARY 1976

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CONTENTS

		Page
1.	INTRODUCTION	
1.1	Scope of Document	1-1
1.2	General Description of TRRR System	1-1
1.2.1	Physical Description of TRRR System	1-1
1.2.2	Functional Description of TRRR System	1-2
1.3	General Description of CDA	1-7
1.3.1	Physical Description of CDA Equipment	1-7
1.4	Equipment Required	1-10
1.4.1	Major Equipment	1-10
2.	INSTALLATION	
2.1	Introduction	2-1
3.	OPERATION	
3.1	Introduction	3-1
3.2	Preparation for Use	3-1
3.3	Location and Function of CDA Controls and Indicators	3-1
3.4	Power Turn-On	3-7
3.5	System Operation	3-7
3.5.1	Ranging Operations	3-7
3.5.2	Orderwire Operations	3-9
3.6	Power Shutdown	3-10
4.	THEORY OF OPERATION	
4.1	Introduction	4-1
4.2	Functional Description of CDA Equipment	4-1
4.2.1	Range Tone Generation and Modulation	4-2
4.2.2	Range Tone Reception and Demodulation	4-2
4.2.3	Command Tone Generation	4-2
4.2.4	Orderwire Operations	4-5
4.2.5	Computer Operations	4-5
4.3	Unit Operation	4-7
4.3.1	Orderwire Unit Theory of Operation	4-7
4.3.2	Switch Unit Theory of Operation	4-7
4.3.3	Range Unit Theory of Operation	4-17
4.3.4	Tone Modulator Unit Theory of Operation	4-37
5.	TRRR SOFTWARE SYSTEM	
5.1	TRRR Software System Loading	5-1
5.2	Data Word Allocation	5-2
5.3	TRRR Program and Computer Printouts	5-2
APPENDICES		
A	TRRR Operational Modes	A-1
B	TARS Antenna Alignment Procedures	B-1

ILLUSTRATIONS

		Page
1-1	Trilateration Range and Range Rate System	1-2
1-2	TRRR Simplified Block Diagram	1-5
1-3	CDA Terminal	1-9
2-1	CDA Trilateration Cable Diagram	2-2
3-1	CDA Equipment Rack	3-2
3-2	Orderwire Unit	3-3
3-3	Switch Unit	3-4
3-4	Range Unit	3-5
3-5	Tone Modulator Unit	3-6
4-1	CDA Overall Functional Diagram	4-3
4-2	Orderwire Unit Functional Block Diagram	4-6
4-3	Switch Unit Modem Interface Section Functional Block Diagram	4-8
4-4	Receiver Antenna/Test Loop/Computer Test Switch Functional Diagram	4-11
4-5	Range Tone/Orderwire/Computer Select Functional Diagram	4-11
4-6	TARS Command Tone Interface	4-12
4-7	Receiver Assignment Function	4-13
4-8	Computer Selected Count Period Functional Diagram	4-15
4-9	Range Unit Functional Diagram	4-16
4-10	Mode Select Switch Logic	4-18
4-11	Range Tone Frequency Generation	4-19
4-12	Transmit Section Functional Diagram	4-23
4-13	Received Tone Detection	4-30
4-14	Reference Tone Selection	4-35
4-15	Tone Modulator Functional Diagram	4-36

TABLES

1-1	SMS Satellite Parameters	1-3
1-2	CDA Station Parameters	1-4
1-3	TARS Station Parameters	1-4
1-4	TRRR RF Carrier Utilization	1-6
1-5	CDA Receive Band Baseband Frequencies	1-8
1-6	CDA Supplied Major Equipment	1-10
3-1	CDA Equipment Operational Configuration	3-11
3-2	TRRR Range Procedure	3-13
3-3	Teleprinter Input Definition	3-16
4-1	CDA Receiver Frequency Assignments	4-14
5-1	Data Word Allocations	5-3
5-2	TRRR Core Map	5-12

1. INTRODUCTION

1.1 SCOPE OF DOCUMENT

This document is one of a series of manuals designed to provide the information required to operate and maintain the Command and Data Acquisition (CDA) equipment of the Trilateration Range and Range Rate (TRRR) System, as furnished by Hughes Aircraft Company to the National Aeronautics and Space Administration under Contract No. NAS 5-21629. The function of each manual is as follows:

1) Volume I, Command and Data Acquisition (CDA) System Manual contains information pertaining to the equipment in the Trilateration Range and Range Rate System which is designed to interface with existing NASA equipment located at Wallops Island, Virginia.

2) Volume II, Turn-Around Ranging Station (TARS) System Manual contains information pertaining to the equipment located in the Turn-Around Ranging Station

1.2 GENERAL DESCRIPTION OF TRRR SYSTEM

The Trilateration Range and Range Rate System is described in the following paragraphs.

1.2.1 Physical Description of TRRR System

The TRRR System consists of three basic units that are physically independent of each other. (See Figure 1-1.) These units are as follows:

1) The Master Range Station of the Command and Data Acquisition (CDA) System for the Synchronous Meteorological Satellite (SMS) located in the NASA facility at Wallops Island, Virginia

2) The Turn-Around Ranging Station located at the NASA facility at Oahu, Hawaii, designated TARS 1

3) The Turn-Around Ranging Station located near Santiago, Chile, designated TARS 2

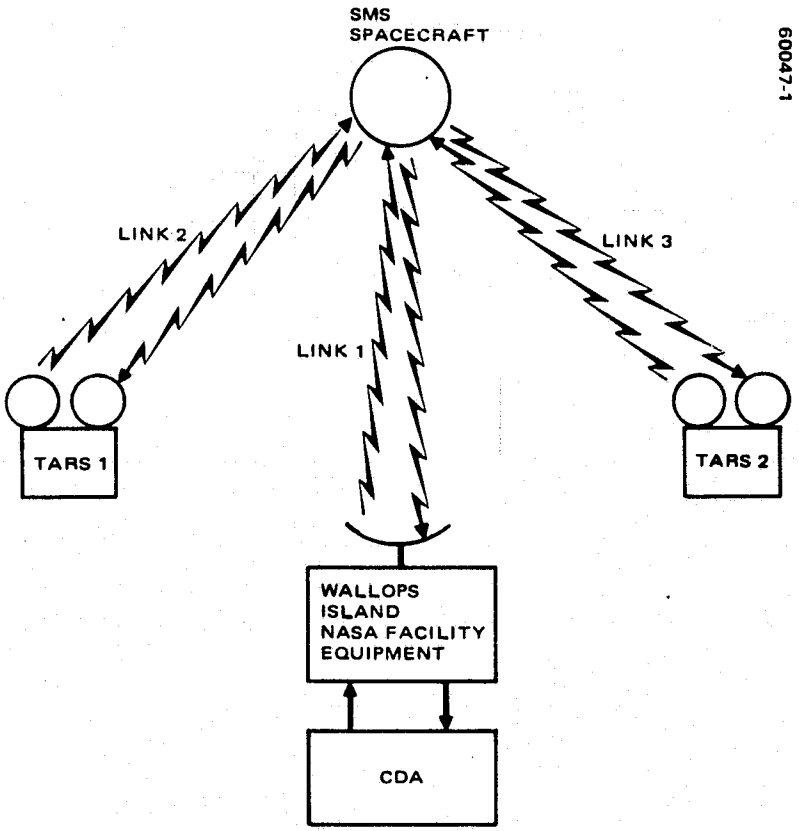

FIGURE 1-1. TRILATERATION RANGE AND RANGE RATE SYSTEM

All Master Station (CDA) electronic equipment is located in two standard racks within the Operations Area of the NASA facility. All TARS electronic equipment is located within a weatherproof shelter, while antennas and associated equipment are mounted on the exterior of the shelter.

1.2.2 Functional Description of TRRR System

The TRRR System contains transmitters, receivers, and other equipment (Tables 1-1 through 1-3) that provide the capability of simultaneous range and range rate information for the SMS. This information, derived from data acquired from the CDA and the two TARS, is gathered at the CDA for additional analysis.

In general, the range and range rate information is derived in the following manner. (See Figure 1-2.) A ranging signal is developed in the CDA and transmitted to the NASA Wallops Island Station modulator and upconverter for frequency conversion. This signal is then amplified and transmitted to the SMS at the proper frequency and power levels. When the

TABLE 1-1. SMS SATELLITE PARAMETERS

Transmitter power (hard limited), dBm	43.0
Transmitter feed loss, dB	-3.4
Transmit antenna gain, dB	19.1
Transmit off-beam center loss, dB (at 9 degrees)	-2.5
Transmit off-beam center loss, dB (at 7 degrees)	-1.6
Receive antenna gain, dB	13.4
Receive feed loss, dB	-4.5
Receive off-beam center loss, dB (at 9 degrees)	-2.8
Receive off-beam center loss, dB (at 7 degrees)	-1.4
Receive noise temperature (TE = 1630°K), dB/°K	32.1
Bandwidth, MHz	8.2
Polarization loss, dB	-0.2
Antenna polarization	Linear
Local oscillator stability	
Long term, per year	1.0×10^{-6}
Short term, per 1/2 second	1×10^{-9}
Synchronous orbit, degrees	2 inclined

signal is received by the satellite, it is automatically downconverted and retransmitted through the satellite antennas back to earth to be received at the CDA, TARS 1, and TARS 2. When the signal is received, each TARS reacts by transponding a signal, again at the proper frequency and power levels, back to the SMS, which again downconverts and retransmits the signal back to the CDA. Although they receive the newly transmitted signal, each TARS is mechanized to respond only to transmissions initiated at the CDA. In addition, sufficient guard bands have been engineered into the system to ensure isolation between the TARS. (See Table 1-4.)

TABLE 1-2. CDA STATION PARAMETERS

Transmitter power, dBm	48.0
Transmitter feed loss, dB	-1.6
Transmitter antenna gain, dB	48.0
Transmit off-beam center loss, dB (at 0.25 degree)	-1.0
Receive antenna gain, dB	48.0
Receive off-beam center loss, dB (at 0.25 degree)	-0.7
Receive feed loss, dB	-0.4
Receive noise temperature (Te = 100°K), dB/°K	20.0
Polarization loss, dB	-0.2
Transmit frequency, MHz	2026.000
Receive IF, MHz	70.2; 68.0; 64.0
Transmit IF, MHz	66.0

TABLE 1-3. TARS STATION PARAMETERS

Transmit power, dBm	46.0
Transmit loss, dB	-1.7
Transmit antenna gain (8 foot diameter), dB	31.8
Transmit off-beam center loss, dB (at 2.2 degrees)	-3.0
Transmit frequency, MHz	
TARS 1	2030.200
TARS 2	2032.200
Receive antenna gain (8 foot diameter), dB	30.4
Receive off-beam center loss, dB (at 2.2 degrees)	-2.4
Receive feed loss, dB	-0.7
Receive noise temperature, dB/°K (630°K)	28.0
Receive frequency, MHz	1684.000
Local oscillator stability	
Long term, per year	1×10^{-6}
Short term, per 1/2 second	2×10^{-10}
Polarization loss, dB	-0.2

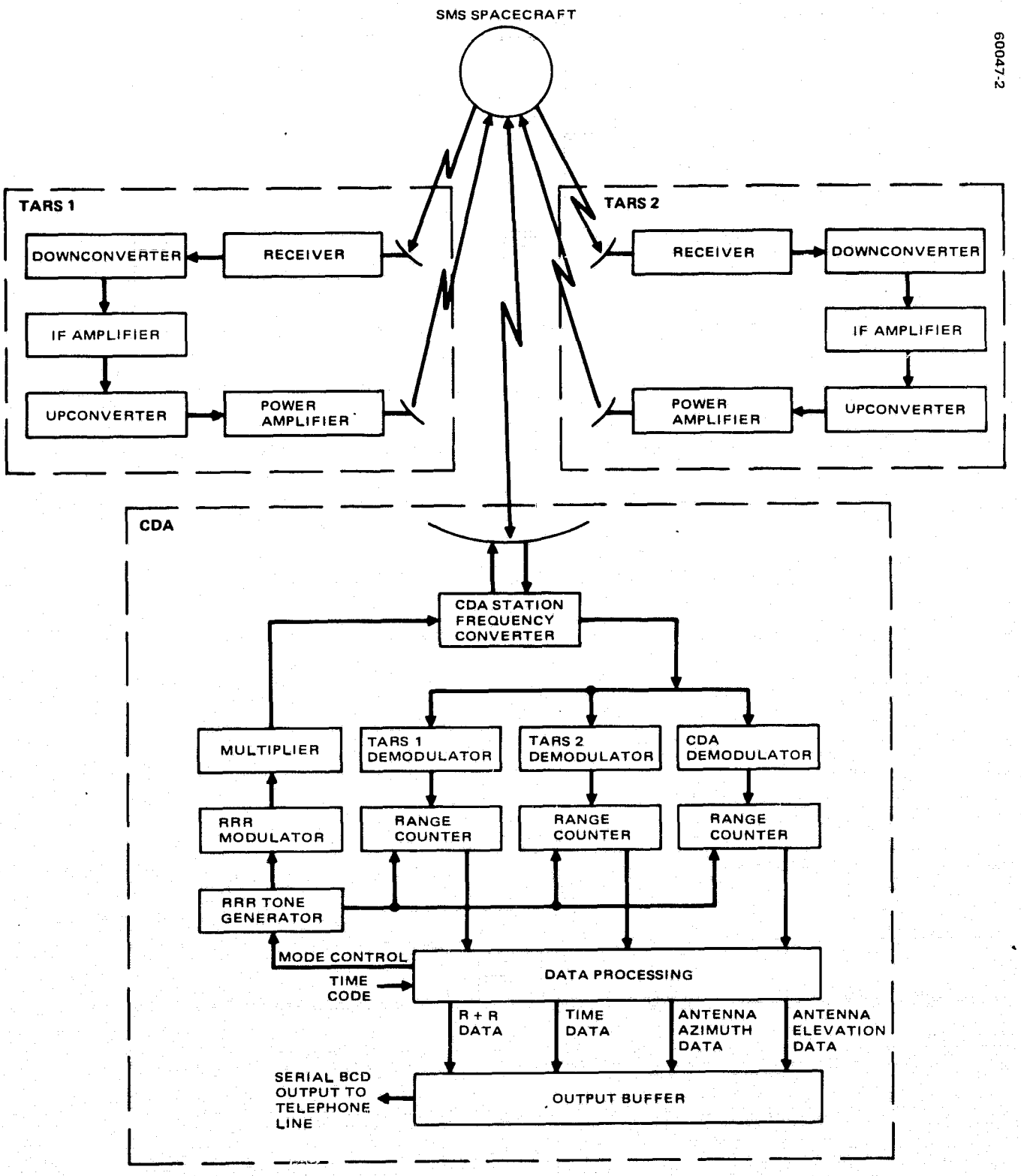

FIGURE 1-2. TRRR SIMPLIFIED BLOCK DIAGRAM

TABLE 1-4. TRRR RF CARRIER UTILIZATION

Links		Frequency, MHz
CDA Link		
Uplink	(CDA to SMS)	2026.0
Downlink	(SMS to CDS)	1684.0
TARS 1 Link		
Uplink	(CDA to SMS)	2026.0
Downlink	(SMS to TARS 1)	1684.0
Uplink	(TARS 1 to SMS)	2030.2
Downlink	(SMS to CDA)	1688.2
TARS 2 Link		
Uplink	(CDA to SMS)	2026.0
Downlink	(SMS to TARS 2)	1684.0
Uplink	(TARS 2 to SMS)	2032.2
Downlink	(SMS to CDA)	1690.2

On receipt of the transmissions from the TARS, three range/time intervals can be measured and stored by a computer at the CDA:

1) CDA to SMS to CDA

2) CDA to SMS to TARS 1 to SMS to CDA

3) CDA to SMS to TARS 2 to SMS to CDA

By measuring successive range/time intervals, the system is capable of resolving range rate information of the SMS in addition to range.

Upon receipt of the above data, the CDA assembles the following information into a serial data format suitable for transmissions on demand over a standard telephone line:

1) Range/time interval

2) Range rate

3) Wallops Island facility antenna azimuth and elevation angle

4) Time of year in days, hours, minutes, and seconds

5) Data source identification (CDA, TARS 1, TARS 2, and SMS)

6) SMS housekeeping telemetry (spacecraft temperature, SMS system delay)

7) CDA delay

The entire TRRR operation, including spacecraft acquisition, multiple data measurement, data multiplexing, and transmission, is designed not to exceed 11 minutes with the total spacecraft time allocation for the operation not to exceed 10 minutes.

An orderwire function is provided between the CDA and each TARS to ensure a coordinated operation in the event that field alignment or repair of TARS is required.

1.3 GENERAL DESCRIPTION OF CDA

The CDA receive band baseband frequencies are listed in Table 1-5, and CDA equipment is described in the following paragraph.

1.3.1 Physical Description of CDA Equipment

The principal units that comprise the CDA are as follows:

1) Three nominal 70 MHz receiver units

2) One range unit

3) One switch unit

4) One tone modulator

5) One orderwire unit

6) Three computing counter units

7) Three computing counter unit patch panels

8) One digital computer

9) One teleprinter unit

10) One cassette unit

11) One power supply

All the above units are mounted in racks equipped with air circulating blowers. (See Figure 1-3.)

TABLE 1-5. CDA RECEIVE BAND BASEBAND FREQUENCIES

Tones	Frequency
Ranging Tones	
Mode A	35.4 Hz
	283.4 Hz
	3.968 kHz
	27.777 kHz
	200.00 kHz
Mode B	283.4 Hz
	3.968 kHz
	27.777 kHz
	200.000 kHz
Mode C	3.968 kHz
	27.777 kHz
	200.000 kHz
Command Tones	
TARS 1	2940 Hz
TARS 2	3180 Hz
Orderwire Ringing Tone	4525 Hz

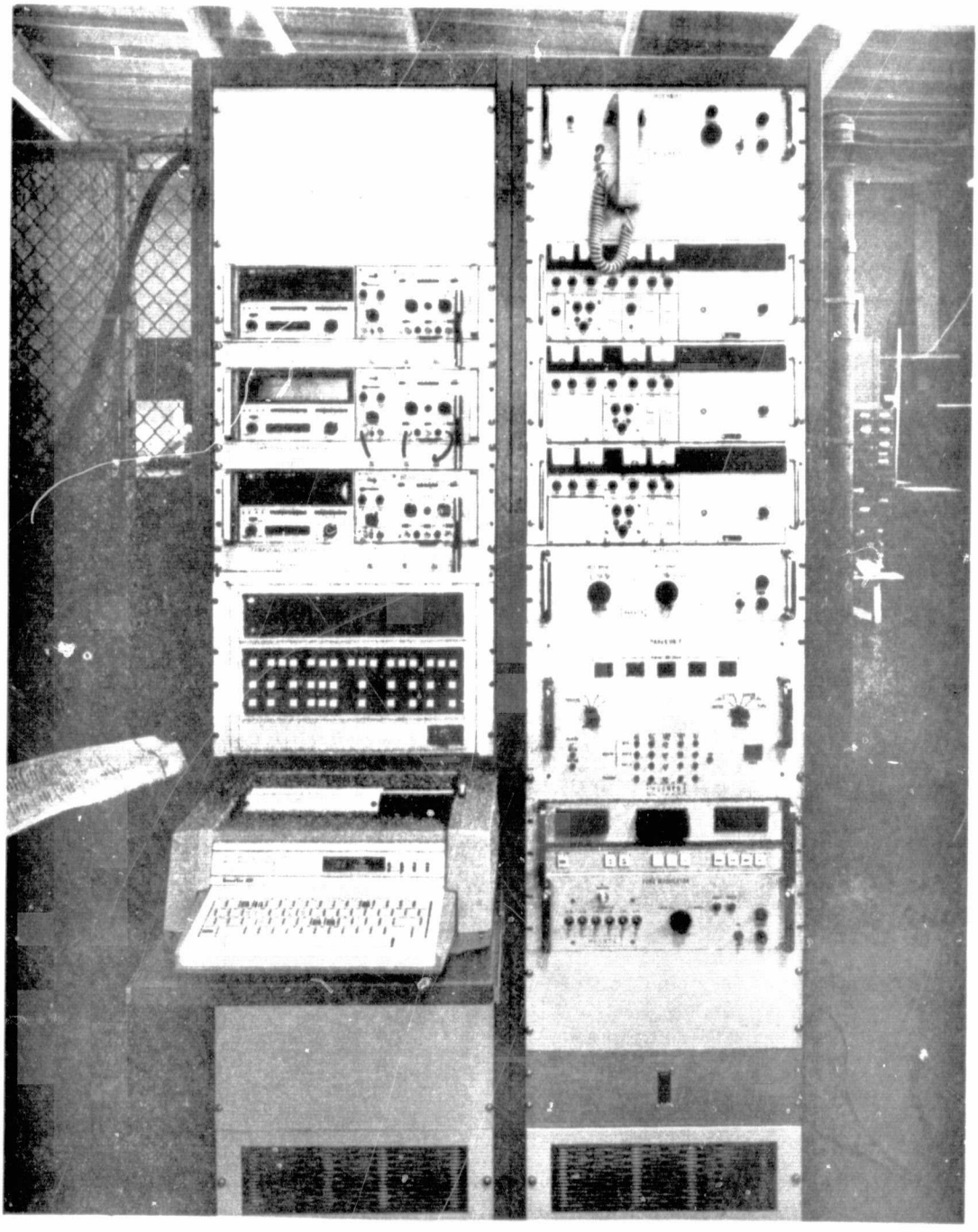

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FIGURE 1-3. CDA TERMINAL (PHOTO 4R7083)

1.4 EQUIPMENT REQUIRED

The equipment required in the CDA to conduct the ranging function and provide interfacing with the TARS and SMS is described in the following paragraph.

1.4.1 Major Equipment

Table 1-6 lists the major equipment supplied with the CDA.

TABLE 1-6. CDA SUPPLIED MAJOR EQUIPMENT

Equipment	Manufacturer	Part Number
Computing counter (three supplied)	Hewlett-Packard	Model 5360A
Computing counter patch panel (three supplied)	Hughes	3029323
Computer	Hewlett-Packard	Model 2100A
Teleprinter	General Electric	Terminet 300
Power supply	Acopian	Model 21PT10
Orderwire unit	Hughes	3029309
Receiver (three supplied)	Scientific Atlanta	Model 410A
Switch unit	Hughes	3029322
Range unit	Hughes	3029304
Cassette unit	DICOM	Model 344
Tone modulator	Hughes	3029324
Blower (two supplied)	McLean	Model 2E409A

2. INSTALLATION

2.1 INTRODUCTION

This section provides information designed to illustrate the manner in which the Command and Data Acquisition (CDA) equipment is configured for ranging operations. This information is provided in the following order:

1) CDA Trilateration Cable Diagram	See Figure 2-1
2) Computer Programming	See Section 5, TRRR Software System

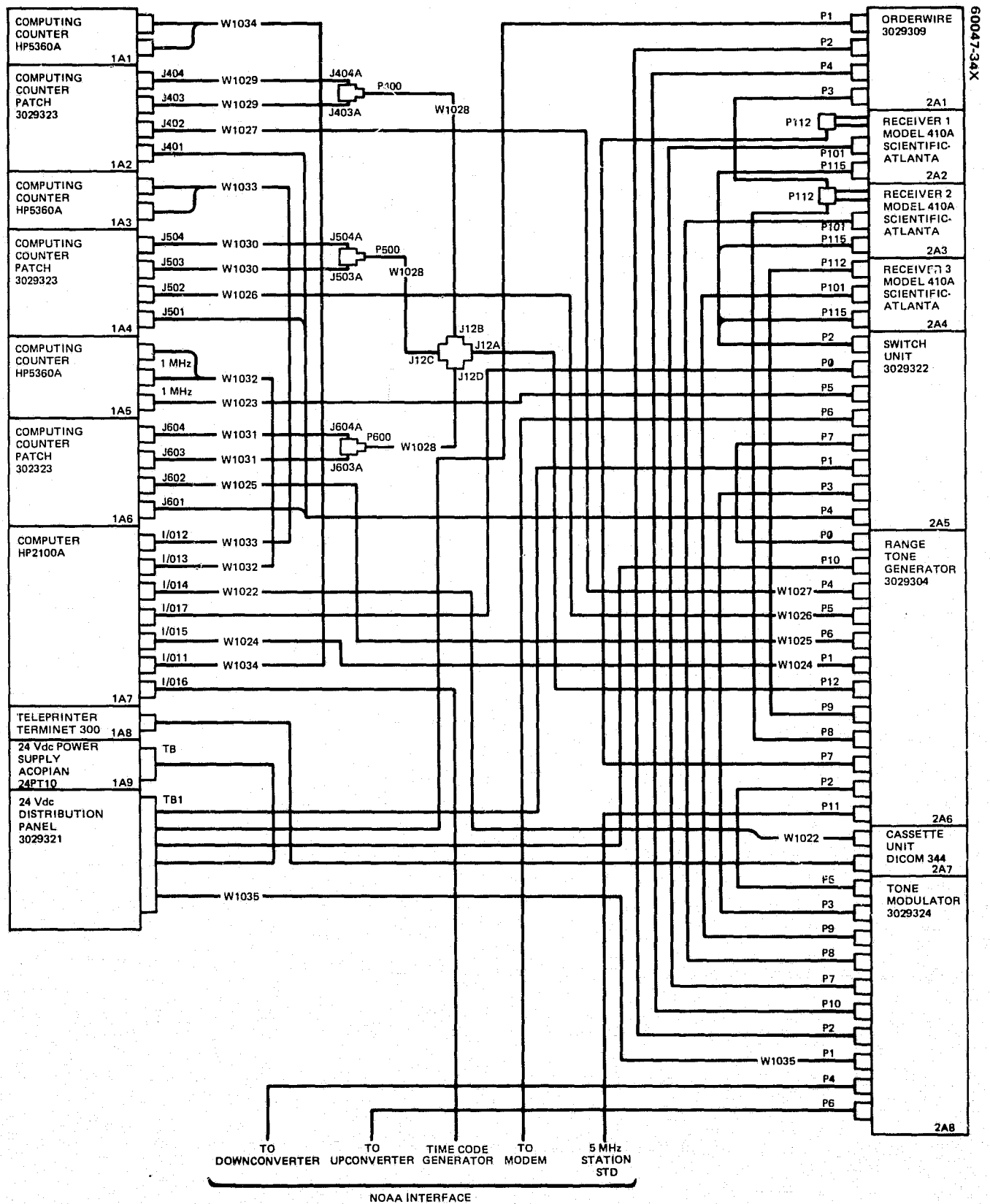


FIGURE 2-1. CDA TRILATERATION CABLE DIAGRAM

3. OPERATION

3.1 INTRODUCTION

This section provides a description of the location and function of each of the controls and indicators that will be used in the normal operation of the CDA equipment. In addition, this section provides all procedures required for the normal operation of the equipment in the terminal, including equipment preparation for use, power turn-on, and power turn-off.

3.2 PREPARATION FOR USE

No special procedures are required to convert the CDA equipment from a standby (or power off) condition to an operational configuration.

3.3 LOCATION AND FUNCTION OF CDA CONTROLS AND INDICATORS

All CDA equipment used in the TRRR System are mounted in either of two racks which are Government-furnished equipment (GFE) (See Figure 3-1). The location and function of the controls and indicators for the commercially available units are contained in the appropriate commercial handbook included in this series of manuals. The location and function of the units unique to the CDA terminal are presented in the following order:

Unit	Figure
Orderwire unit, Hughes P/N 3029309	3-2
Switch unit, Hughes P/N 3029322	3-3
Range unit, Hughes P/N 3029304	3-4
Tone modulator unit, Hughes P/N 3029324	3-5

The location and function of controls and indicators on units that are not listed above are included in the appropriate commercial manual.

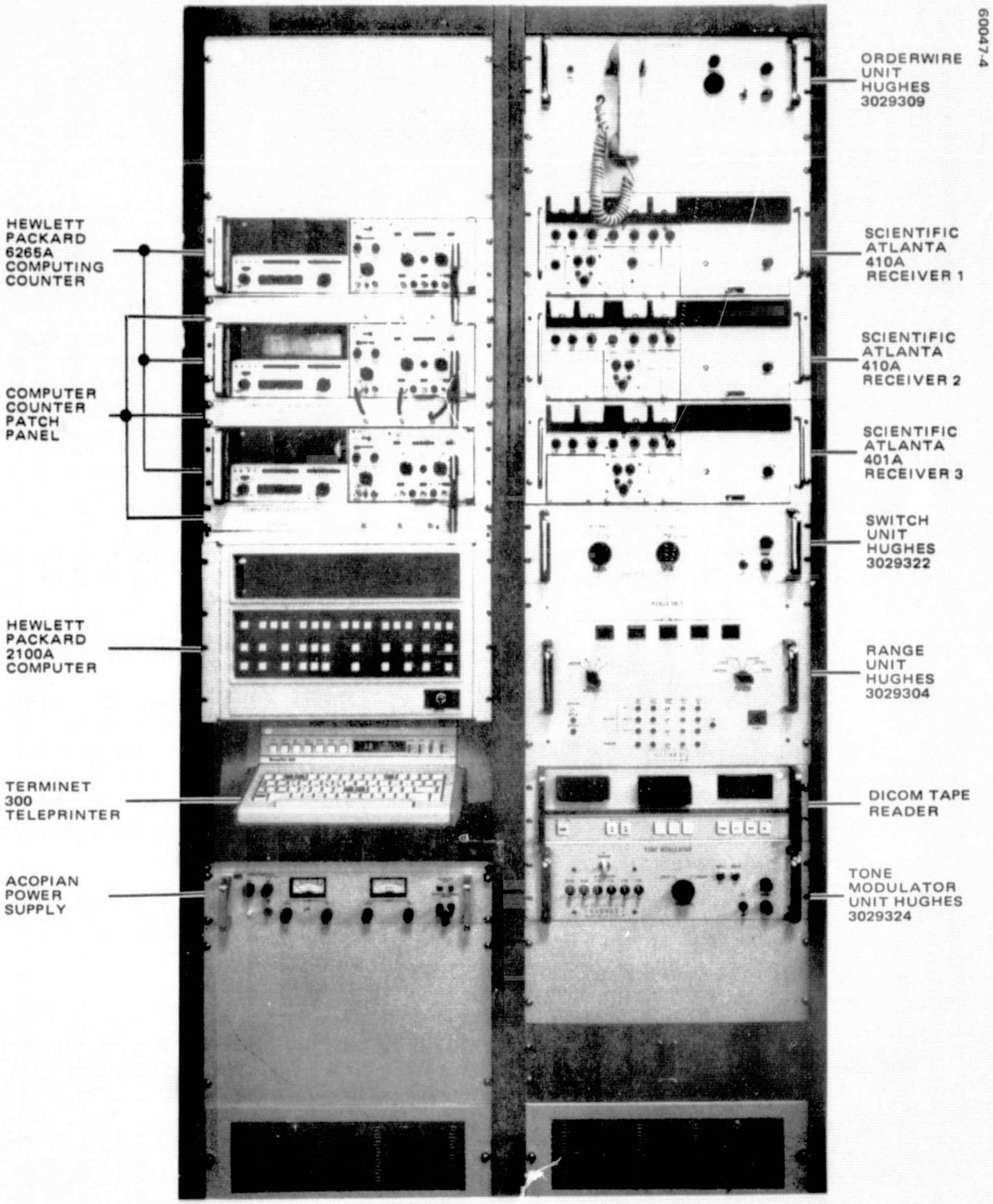
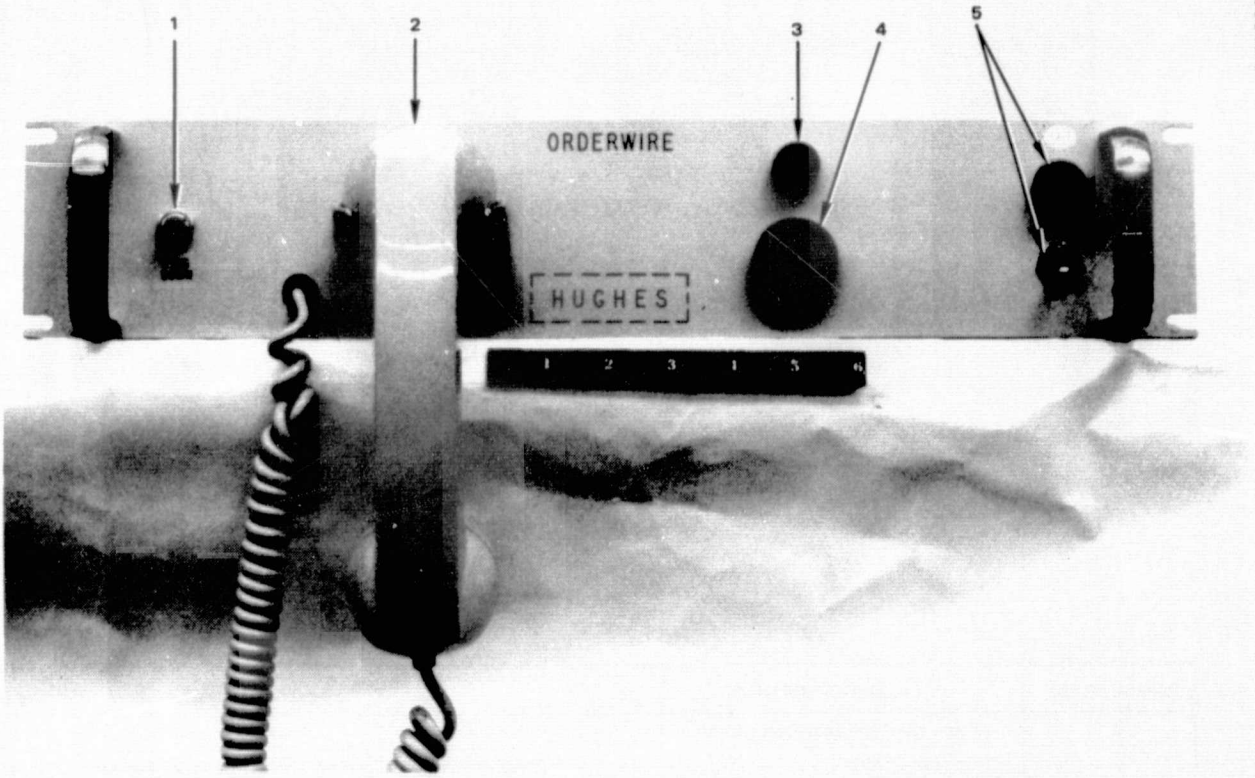
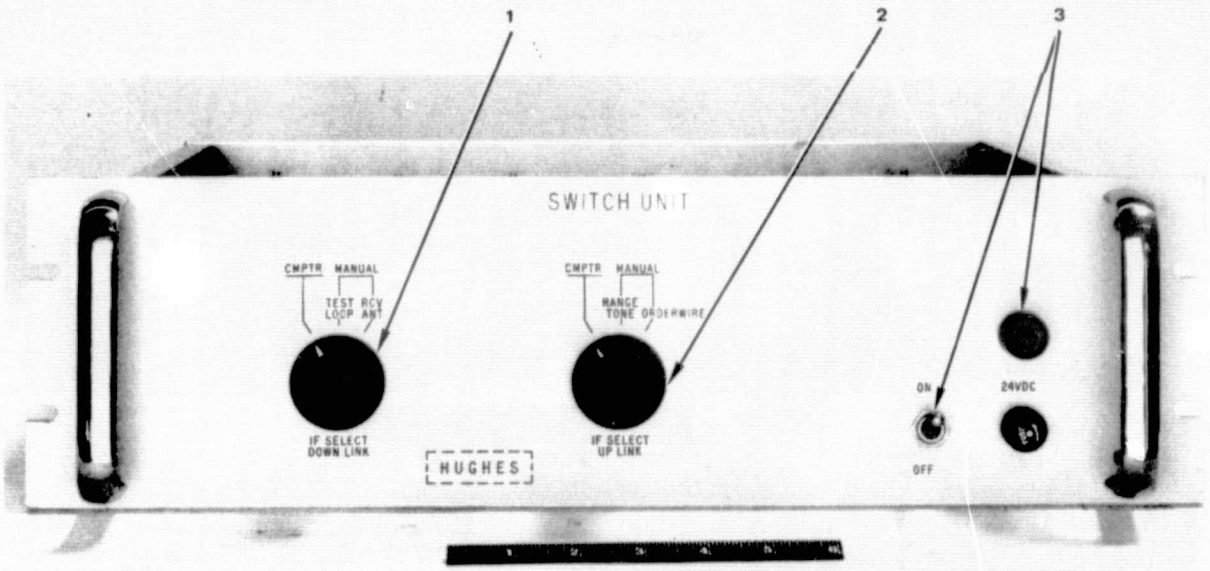


FIGURE 3-1. CDA EQUIPMENT RACK (PHOTO 4R27084)



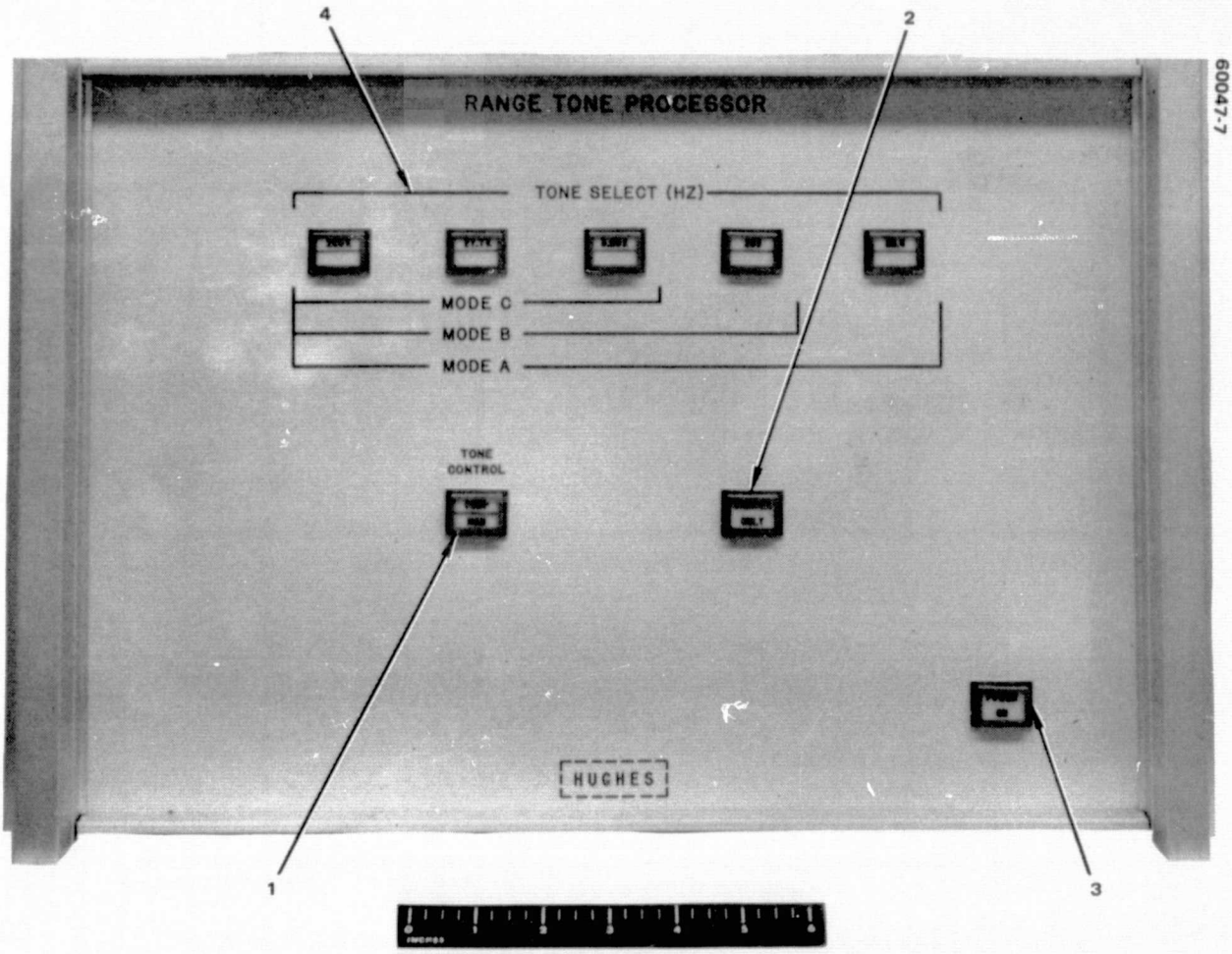
PANEL ITEM	DESCRIPTION	FUNCTION
1	RING DOWN	USED TO SIGNAL TARS 1 AND 2 WHEN ORDERWIRE SELECTED ON SWITCH UNIT
2	HANDSET	VOICE TRANSMITTER AND RECEIVER WHEN ORDERWIRE SELECTED ON SWITCH UNIT
3	ORDERWIRE SIGNALING LIGHT	PROVIDES VISUAL INDICATION OF TARS TO CDA ORDERWIRE SIGNALING
4	SIGNALING BUZZER	PROVIDES AURAL INDICATION OF TARS TO CDA ORDERWIRE SIGNALING
5	POWER ON/OFF SWITCH AND INDICATOR	PROVIDES CONTROL AND MONITORING OF PRIMARY POWER TO UNIT

FIGURE 3-2. ORDERWIRE UNIT (PHOTO 4R25723)



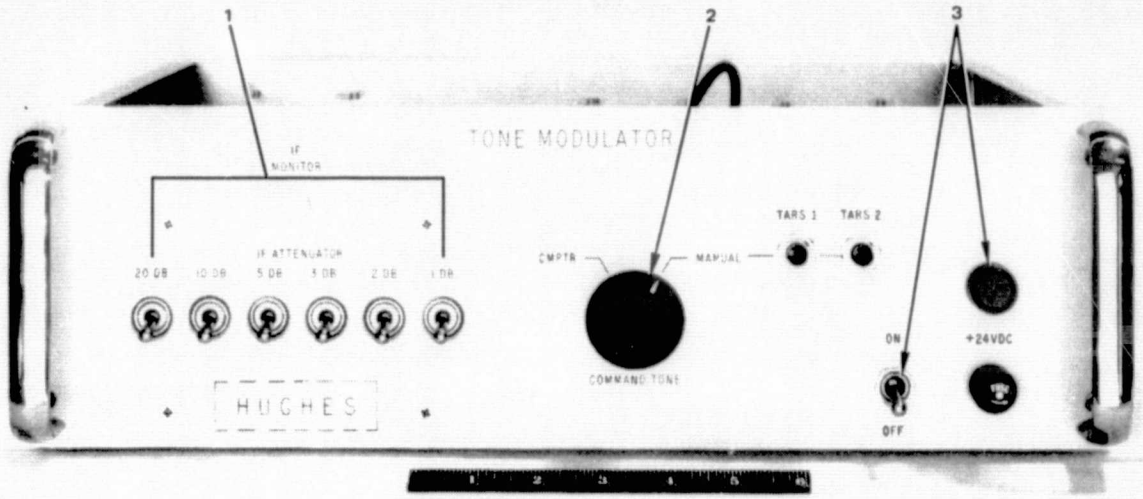
PANEL ITEM	DESCRIPTION	FUNCTION
1	IF SELECT DOWNLINK SWITCH	
	COMPUTER	COMPUTER CONTROLS CONFIGURATION OF EQUIPMENT FOR RANGING OR TEST OPERATIONS
	MANUAL-TEST LOOP	CONFIGURES SYSTEM FOR PROCESSING i - f UPLINK IN DOWNLINK RECEIVERS FOR CLOSED LOOP TEST
	MANUAL-RECEIVER ANTENNA	DOWNLINK RECEIVERS PROVIDED i - f SIGNALS FROM STATION DOWNCONVERTERS FOR NORMAL OPERATIONS
2	IF SELECT UPLINK SWITCH	
	COMPUTER	COMPUTER CONTROLS SELECTION OF RANGE TONES TO UPCONVERTER
	MANUAL RANGE TONE	SELECTS RANGE TONE OPERATION
	MANUAL OVERWIRE	SELECTS ORDERWIRE OPERATION
3	ON/OFF 24 vdc	CONTROLS AND MONITORS APPLICATION OF PRIME POWER TO UNIT

FIGURE 3-3. SWITCH UNIT (PHOTO 4R27062)



PANEL ITEM	DESCRIPTION	FUNCTION
1	TONE CONTROL	SELECT MANUAL OR COMPUTER CONTROLLED MODE
2	CARRIER ONLY SWITCH	DELETES ALL MODULATION ON THE CARRIER. USEFUL FOR LOCKUP OF THE SCIENTIFIC ATLANTA RECEIVERS
3	POWER ON	CONTROLS APPLICATION OF POWER TO RANGE UNIT
4	TONE SELECT	MANUALLY ENABLES WHICH TONE IS MODULATED ON CARRIER

FIGURE 3-4. RANGE UNIT (PHOTO 75-35080)



PANEL ITEM	DESCRIPTION	FUNCTION
1	IF ATTENUATOR	PROVIDES SELECTION OF FROM 0 TO 41 dB TO ATTENUATE i - f SIGNAL TO UPCONVERTER
2	COMMAND TONE	
	COMPUTER	COMPUTER CONTROLS TRANSMISSION OF RANGING COMMAND TONES TO TARS 1 AND TARS 2
	MANUAL-TARS 1/TARS 2	PROVIDES THE MANUAL CONTROL OF TRANSMISSION OF COMMAND TONE TO TARS 1 AND TARS 2
3	ON/OFF +24 vdc	CONTROLS AND MONITORS THE APPLICATION OF PRIME POWER TO UNIT

FIGURE 3-5. TONE MODULATOR UNIT (PHOTO 4R27063)

3.4 POWER TURN-ON

All electrical power to the units in the CDA is supplied and controlled by GFE functions. Other than setting all switches to ON, no special procedural instructions are required for applying power to any of the units in the CDA terminal.

3.5 SYSTEM OPERATION

The CDA terminal equipment can be configured for three basic modes of operation.

1) Ranging operations

2) Orderwire operation

3) System testing

The procedures to be used for each of these functions are contained in the following paragraphs.

3.5.1 Ranging Operations

Ranging operations can be conducted automatically by addressing the HP 2100A computer through the Terminet teleprinter. The procedures for automatic ranging operations, including range link selection and range tone mode selection, are presented in the following order:

1)	Range Link Manual Selection	Paragraph 3.5.1.1
2)	Range Tone Mode Selection	Paragraph 3.5.1.2
3)	Automatic Ranging Operations	Paragraph 3.5.1.3

3.5.1.1 Range Link Manual Selection

To manually select the range link, perform the following:

1) On the receivers 1 through 3, set frequency select switch to FREQ 1, FREQ 2, and FREQ 3, respectively. With this selection, tune receiver 1 to 64 MHz IF for CDA/CDA operation, tune receiver 2 to 68.2 MHz IF for CDA/TARS 1 operation, and tune receiver 3 to 70.2 MHz IF for CDA/TARS 2 operation.

2) Set the switches on receivers 1 through 3 to the following positions:

Response	AC
Bandwidth	BYPASS
AGC To	1 SEC

Second local oscillator mode	VFO
Wideband phase demodulator mode	PM
Bandwidth, Hz	100
Phase lock loop	LONG
IF filter	500 MHz
Volume	To maximum CW position

3) Set second local oscillator mode switch to APC. Receivers are now tuned for automatic phase control operation.

4) On switch unit, set switches to the following positions:

IF select downlink	RCV ANT
IF select uplink	RANGE TONES

Receivers are now prepared to receive IF inputs from the NASA Station equipment downconverters.

5) On tone modulator unit, set command tone switch to MANUAL and momentarily press TARS 1 or 2 in accordance with desired range link operation. The appropriate receiver phase lock loop light indicates when receiver is locked to the IF signal. If the IF is not locked, proceed with the following.

6) Push and tune FINE TUNE control until a low frequency note is heard from the receiver speaker.

Note

If no beat note is heard, the IF signal is out of the tuning range of the loop. Set second local oscillator mode switch to VFO and repeat steps 3, 4, and 5.

7) Continue tuning FINE TUNE control until loop locks and phase lock loop indicator lights. With loop locked, tuning meter reads approximately zero. To continue ranging operations, continue to paragraph 3. 5. 1. 2.

3. 5. 1. 2 Range Tone Mode Selection

To manually select a range mode, perform the following:

1) On the range unit, set transmit mode select switch to mode A, B, or C in accordance with the desired transmit tone frequency and modulation index as follows:

	Frequency	Modulation Index
Mode A	200.00 kHz	1.5
	27.777 kHz	1.5
	3.968 kHz	1.5
	283.4 Hz	1.5
	35.46 Hz	0.8

	Frequency	Modulation Index
Mode B	200.000 kHz	1.5
	27.777 kHz	1.5
	3.968 kHz	1.5
	283.4 Hz	1.5
Mode C	200.000 kHz	1.5
	27.777 kHz	1.5
	3.968 kHz	1.5

2) Set transmit tone select switches such that only the applicable frequency lamps are lighted as determined in step 1.

3) Set reference tone select switch to the range tone frequency to be processed in accordance with the mode selection as set in step 1. The range unit is prepared to transmit and detect selected range tones.

3.5.1.3 Automatic Ranging Operations

To perform automatic ranging operations, using the HP 2100 computer, perform the following:

1) Configure the CDA units as shown in Table 3-1.

2) Proceed with computer operations as shown in Table 3-2 for automatic ranging operations as required. Additional computer operations are provided in Table 3-3.

3.5.2 Orderwire Operations

In order to utilize the orderwire, the CDA ranging equipment must be configured as described in the following paragraphs.

3.5.2.1 Scientific-Atlanta Receiver for TARS 1

This receiver is the second receiver down from the top of the equipment rack and shall be set as follows:

1) Demodulator select to FM demod

2) IM filter to 12 kHz

3) FM demodulator to 20 kHz

4) Frequency select to frequency 2 or 3

(Note: Frequency 2 when desired communication to TARS 1, frequency 3 for TARS 2.)

3.5.2.2 Switch Unit

The switch unit shall be set as follows:

1) IF select uplink to orderwire

2) IF select downlink to range tone

3.5.2.3 Procedure

After configuring the system for orderwire operation, push the ring down button on orderwire unit and pick up the telephone receiver. The ring (4525 Hz) will be heard at both TARS. Personnel at the TARS must configure their system for orderwire in order to respond.

3.5.2.4 Command Modulator

There are two phase modulators in the CDA equipment rack. One modulator is used for the orderwire ring down and command signals to the TARS. The other modulator, located in the tone modulator unit, is used to impose the ranging tone on the carrier.

3.6 POWER SHUTDOWN

No formal equipment shutdown procedures are required.

TABLE 3-1. CDA EQUIPMENT OPERATIONAL CONFIGURATION (AUTOMATIC RANGING OPERATIONS)

Range Unit	
Tone control	**Comp**
Tone Modulator	
On/Off	ON
Command tone	CMPTR
Switch Unit	
On/Off	ON
IF select downlink	CMPTR
IF select uplink	CMPTR
SA Model 410A Receiver 1 and 3	
Level	As required
Response	AC
Bandwidth	BYPASS
Volume	As required
AGC To	1 SEC
Second local oscillator mode	APC
Second local oscillator tuning	As required
Wideband phase demodulator	
Mode	PM
Bandwidth, Hz	100
Loop	LONG
Phase lock light	ON
500 kHz IF filter	ON
Frequency select	As required
SA Model 410A Receiver 2	
Level	As required
Response	AC
Bandwidth	BYPASS
Volume	As required
AGC To	1 SEC
Second local oscillator mode	APC
Second local oscillator tuning	As required

Table 3-1 (continued)

Wideband phase demodulator	
Mode	PM
Bandwidth, Hz	100
Loop	LONG
Phase lock light	ON
12 kHz IF filter	OFF
500 kHz IF filter	ON
Frequency select	As required

HP 5360A Computing Counter

Arm/count/compute/display	FAST
Cycle rate	HOLD
Digits displayed	10
Clear reset/self-check/etc.	EXT
Measurement time	3
Multiplier	100 ms

HP 5365A Input Module

Function	PERIOD
Input	A
Preset (A)	Approximately 60% CW
Preset (B)	OFF (full CCW)
Sensitivity multiplier (black)	X1
Sensitivity multiplier (red)	Not used
DC/AC	AC

HP 5379A Time Interval Module

Slope (T1)	↑
Slope (T2)	↑
Arming	AUTO/+T
T1 (black)	X1
Level	1K
T2 (black)	X1
AC/DC (T1)	AC
DC/AC (T2)	AC
Sep/Com	SEP

Patching Requirements

Computing counter patch panel REF TONE to A INPUT on HP 5365A;
Computing counter patch panel REF TONE to T1 INPUT on HP 5379A;
Computing counter patch panel RCV TONE to T2 INPUT on HP 5379A;
Computing counter patch panel multipin connector to multipin connector on HP 5379A.

TABLE 3-2. TRRR RANGE PROCEDURE

1.	Operator types in run command: R, N, A. N number of minutes of ranging (1 to 15) and A = range mode (which can be either A, B, or C). Then computer program proceeds as follows:
	Loop Calibration (Mode A)
2.	Command both TARS ON
3.	Switch all receivers to 66 MHz IF
4.	Switch receive signal to loop calibration
5.	Receive 200 kHz tone
6.	Computer responds with "Lockup?"
7.	Operator checks or tunes receivers for lockup and types "OK" on teletype
8.	Transmit 200 kHz tone
9.	Software program hesitates 3 seconds before count begins
10.	Count 100 axis crossings of the 200 kHz tone
11.	Receive 27.7 kHz
12.	Software program hesitates 3 seconds
13.	Count 1000 axis crossings of 27.7 kHz
14.	Receive 3.98 kHz
15.	Wait 3 seconds before count begins
16.	Count 1000 axis crossings of 3.98 kHz
17.	Receive 283 Hz
18.	Wait 3 seconds before count begins
19.	Count 1000 axis crossings of 283 Hz tone
20.	Receive 35.5 Hz tone
21.	Wait 3 seconds before count begins
22.	Count 100 axis crossing of 35.5 Hz tone
	Ambiguity Removal
23.	Switch receiver 1 to 63 MHz, receiver 2 to 68.2 MHz, receiver 3 to 70.2 MHz
24.	Switch receive signal from loop to receive antenna
25.	Computer responds with "Lockup?"

Table 3-2 (continued)

26.	Operator checks or tunes receiver for lockup and types "OK" on teletype
27.	Receive 35.5 Hz tone
28.	Wait 3 seconds before count begins
29.	Count 100 axis crossings of the 35.5 Hz tone
30.	Receive 283 Hz tone
31.	Wait 3 seconds before countbegins
32.	Count 1000 axis crossings of the 283 Hz tone
33.	Receive 3.98 kHz tone
34.	Wait 3 seconds before count begins
35.	Count 1000 axis crossings of the 3.98 kHz tone
36.	Receive 27.7 kHz tone
37.	Wait 3 seconds before count begins
38.	Count 1000 axis crossings of 27.7 kHz tone
	Ranging
39.	Record next 1 second mark via the time code generator from which all timing signals shall be measured
40.	Receive 200 kHz tone
41.	Wait 3 seconds before count begins
42.	Count 3000 axis crossings of the 200 kHz tone
	Endpoint Check
43.	Receive 27.7 kHz tone
44.	Wait 3 seconds before count begins
45.	Count 1000 axis crossings of 27.7 kHz tone
46.	Receive 3.98 kHz tone
47.	Wait 3 seconds before count begins
48.	Count 1000 axis crossings of 3.98 kHz tone
49.	Receive 283 Hz tone
50.	Wait 3 seconds before count begins
51.	Count 1000 axis crossings of 283 Hz tone

Table 3-2 (continued)

52. Receive 35.5 Hz tone

53. Wait 3 seconds before count begins

54. Count 100 axis crossings of 35.5 Hz tone

55. Command both TARS OFF

56. Ranging complete

57. If operator desires transmission of data to Suitland, type *M on the teletype

58. Before or after transmission, operator can command data output to teletype by typing E,N and carriage return (where N = number of range points to skip during printout). All points are one-way ranges.

NOTE

Ranging with mode C is identical to that with mode A except the 35.5 and 283.3 Hz tones are not utilized. Mode B is identical to that with mode A except the 35.5 Hz tone is not utilized.

TABLE 3-3. TELEPRINTER INPUT DEFINITION

1. There are eight input commands available using the teleprinter. To begin operation: Load Address 2 (press P, clear, SW 1 of Display Register, S). Press internal preset, external present, then press RUN. The teleprinter will respond with:

   Time: DDD HH:MM:SS:Y Where: DDD = day
   HH = hours
   MM = minute
   SS = second
   Y = year

   If this does not occur, verify hardware and begin again.

2. Data can now be input as at any time after the teleprinter has responded:

   **

3. The commands available are:

R, N, MODE	"RUN" Where: N = number of minutes to range (from 1 to 15) Mode = A, B, C ex: R, 10, B causes operation to begin and range for 10 minutes
S, V, VALUE	"SET" Where: V = variable Value - decimal number ex: S, TEMP, 128.0 causes "TEMP" to be set to 128.0 S, ALLX causes all variables to be set to 0
D, V	"DUMP Where: V = variable ex: D, SPCN causes spacecraft number to be displayed on teleprinter

Table 3-3 (continued)

	D, ALLX causes all data to be displayed
*A	"ABORT" Causes ranging to cease, accompanied by automatic return to start
**	Same as *A
*M	"MODEM" Causes computer to output all range data over modem
OK	"RESPONSE" operator must respond "OK" or *A to computer generated "LOCK-UP"
E, N	"ERUPT" Where: N = number of points to skip ex: E, 10 causes every tenth range point to be printed on teleprinter "ERUPT" may only be commanded after ranging has completed and teleprinter has displayed: "RANGING COMPLETE". All points are "ONE WAY" ranges.
Y, XX	Input Year
S1, X	SYSTEM 1 Where: X = number of links X = 1: CDA only X = 2: CDA, TARS 1 only X = 3: CDA, TARS 1 and TARS 2
I, XX	INITIALIZE MODEM BUFFER Where: XX = number in each 8 bit word for modem test; if 'XX' is not typed, buffer will be set to 1, 2, 3, ... 17, 0 ...
T, X	MODEM TEST Where: X = number of consecutive executions
C, X	Set culling number Where: X = number of nanoseconds between ranges allowed

Table 3-3 (continued)

4. Variables identified in "SET" and "DUMP" functions are four letters long as follows: (All range estimates are "one way" range)

TEMP	3 digit temperature of spacecraft	
RECD	Range estimate in meters CDA	
RET1	Range estimate in meters TARS 1	
RET 2	Range estimate in meters TARS 2	
SPCN	Spacecraft number (1 digit)	
1DT1	TARS 1 35 Hz	Fixed delay
2DT1	TARS 1 283 Hz	Fixed delay
3DT1	TARS 1 3.9 kHz	Fixed delay
4DT1	TARS 1 27 kHz	Fixed delay
5DT1	TARS 1 200 kHz	Fixed delay
1DT2	TARS 2 35 Hz	Fixed delay
2DT2	TARS 2 283 Hz	Fixed delay
3DT2	TARS 2 3.9 kHz	Fixed delay
4DT2	TARS 2 27 kHz	Fixed delay
5DT2	TARS 2 200 kHz	Fixed delay
1DSP	SPACECRAFT 35 Hz	Fixed delay
2DSP	SPACECRAFT 283 Hz	Fixed delay
3DSP	SPACECRAFT 3.9 kHz	Fixed delay
4DSP	SPACECRAFT 27 kHz	Fixed delay
5DSP	SPACECRAFT 200 kHz	Fixed delay
1DTR	TRANSMITTER 35 Hz	Fixed delay
2DTR	TRANSMITTER 283 Hz	Fixed delay
3DTR	TRANSMITTER 3.9 kHz	Fixed delay
4DTR	TRANSMITTER 27 kHz	Fixed delay
5DTR	TRANSMITTER 200 kHz	Fixed delay

Table 3-3 (continued)

5. Data has been accepted if teleprinter responds:

**

Check and resubmit data if teleprinter responds:

ERROR

**

4. THEORY OF OPERATION

4.1 INTRODUCTION

This section provides a concise description of the principles of operation of the Master Range Station of the CDA equipment as a system and supplies the operating principles of units that are unique to the terminal. The principles of operation of units that are commercially available can be located in the appropriate document within this series of manuals.

The order in which the information is presented in this section is as follows:

1) Functional Description of CDA Equipment Paragraph 4.2

2) Unit Operation Paragraph 4.3

Information pertaining to the TARS equipment may be found in Volume II of this series of manuals.

4.2 FUNCTIONAL DESCRIPTION OF CDA EQUIPMENT

The CDA equipment is designed to perform five functions in the TRRR System of operations. These functions are as follows:

1) Range tone generation and modulation

2) Range tone reception and demodulation

3) Phase Determination of range tones with respect to a reference tone

4) Command tone generation

5) Orderwire

6) Computer operations

These functions are described in the following paragraphs and shown in Figure 4-1.

4.2.1 Range Tone Generation and Modulation

The CDA contains baseband equipment that enables the extremely accurate satellite ranging information to approximately 1 foot and extremely accurate rate of change of range information to approximately 4×10^{-5} mps. In order to accomplish this function, the NASA station S band transmitting equipment is provided with ranging signals, or tones that are used to modulate the S band carrier frequency. These tones are generated in the range unit in the CDA, converted to the 66 MHz IF level and supplied to the NASA station upconverters and high power amplifiers for transmission to the SMS. These signals are transponded by the satellite and directed back to earth at a lower S band frequency. When the transponded signals are received at the CDA, they are compared in phase to a reference tone. The computer then determines the satellite range information from these data. Range rate information is derived from successive sampling of range data during measured time periods.

Prior to initiating any ranging operations, satellite range ambiguities must be nulled out. This is accomplished in the CDA by generating five ranging tones that are assembled into three operational modes. Note that the satellite range uncertainty is limited to one-quarter of the wavelength of the frequency selected. For example, the wavelength of the 200 kHz tone is 1.5×10^3 meters. As the range uncertainty must be within one-quarter of this value, the 200 kHz tone cannot be used if the range uncertainty is greater that 375 meters and the 35.46 Hz tone cannot be used if the range uncertainty is greater than 2.11×10^6 meters.

The operational modes available including the tone frequencies and their allowable range uncertainties are provided in the appendix.

4.2.2 Range Tone Reception and Demodulation

The CDA contains three receivers which detect the range tones received from the signals transponded from the SMS satellite, TARS 1, and TARS 2. These signals are received at IF frequencies from the NASA station downconverter, demodulated in the receiver units, and applied to the range unit for range tone detection. After the range tones are detected, they are supplied to the computer counter for range analysis.

4.2.3 Command Tone Generation

Each TARS is mechanized to operate upon receipt of command tones generated in the CDA tone modulator unit and transmitted through the SMS satellite to each TARS. Two command tone oscillators are provided in the CDA, one for each TARS. When the command tone receiver in the TARS detects the frequency assigned to it, the transponding function of that TARS is enabled. The reception of a second command tone disables the transponding function. Thus, the transponding function of the TARS is remotely controlled by successive transmissions of command tones from the CDA. The range equipment has a switch which indicates System I or System II. System I refers to command tones for the ascension and Chile TARS, while System II is for the Hawaii and Seattle TARS.

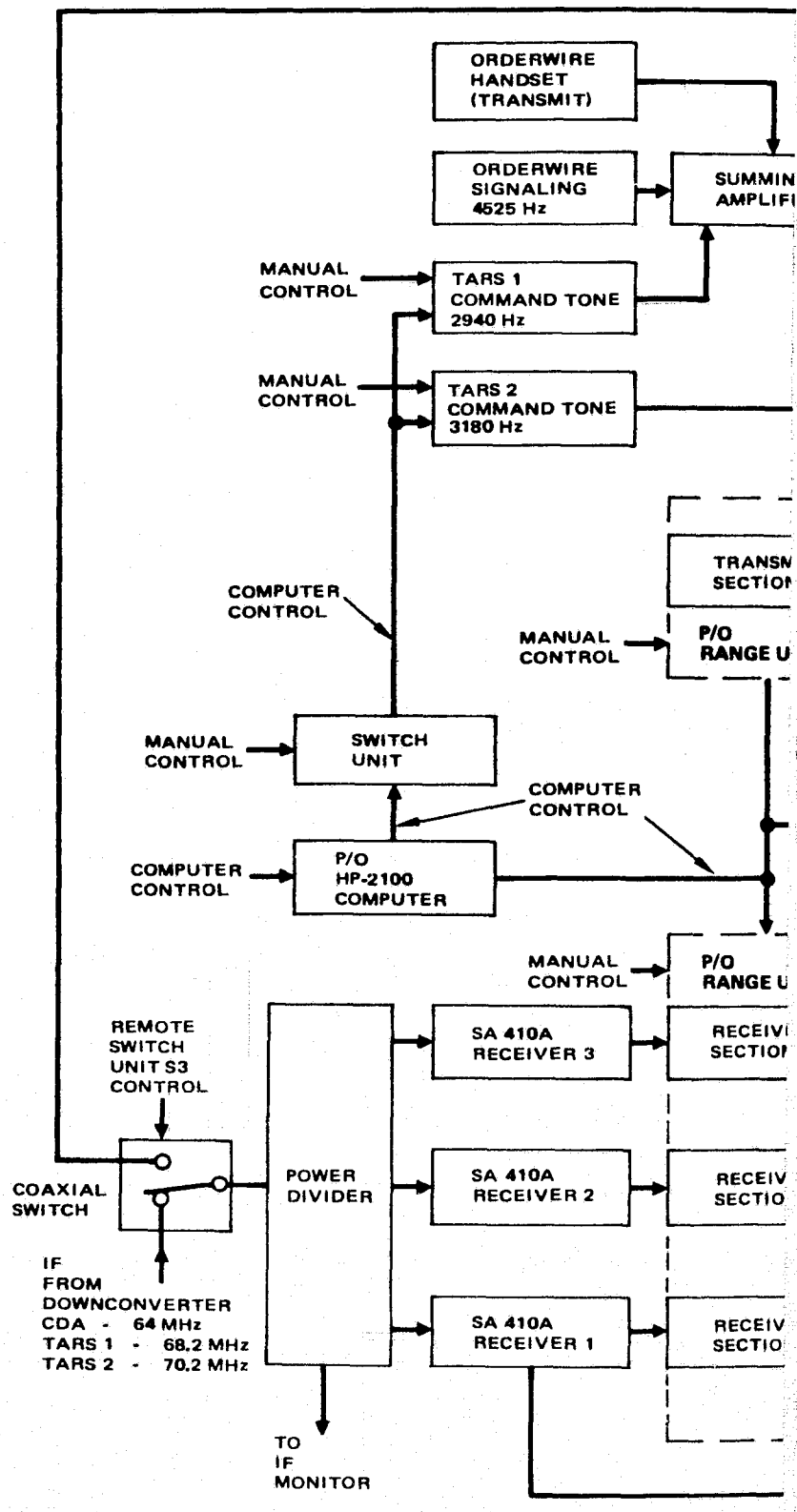
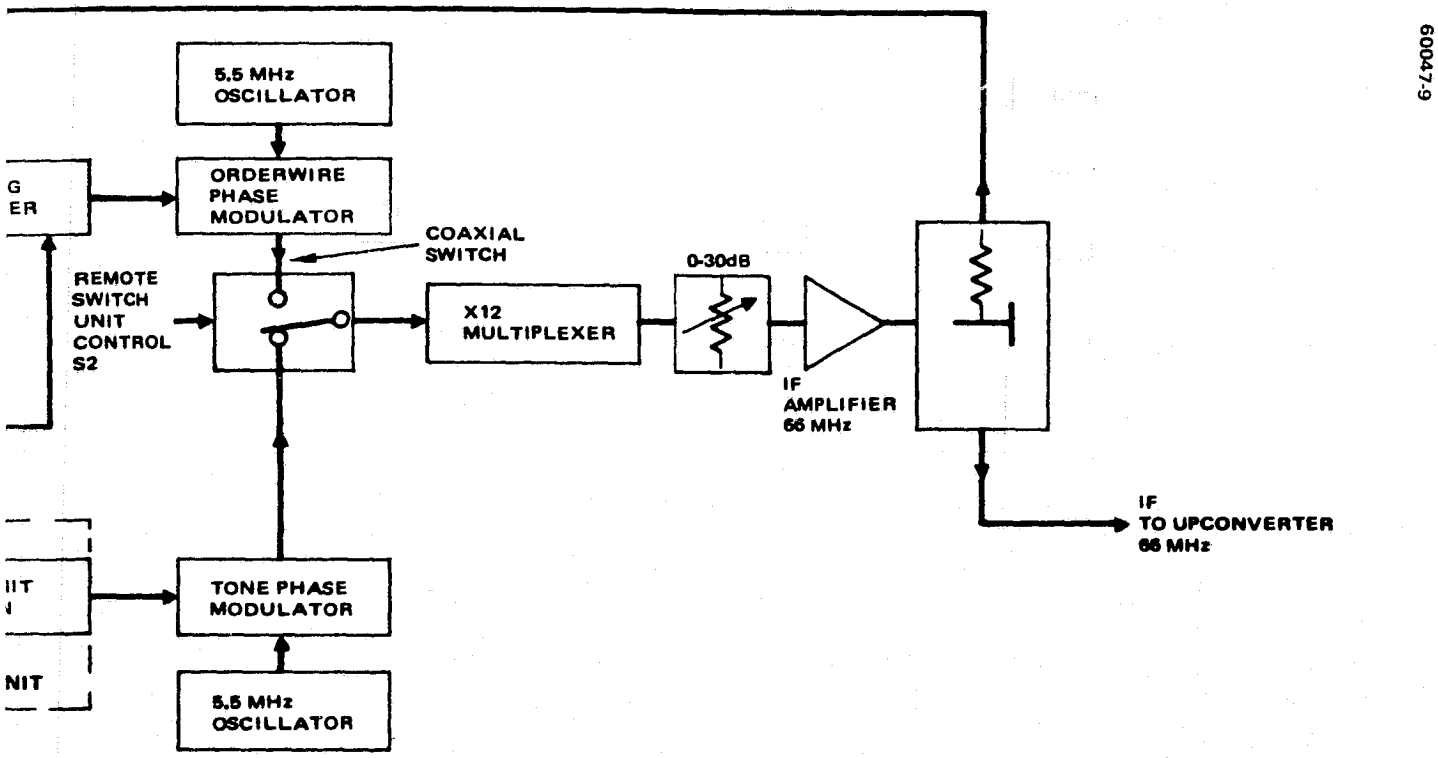
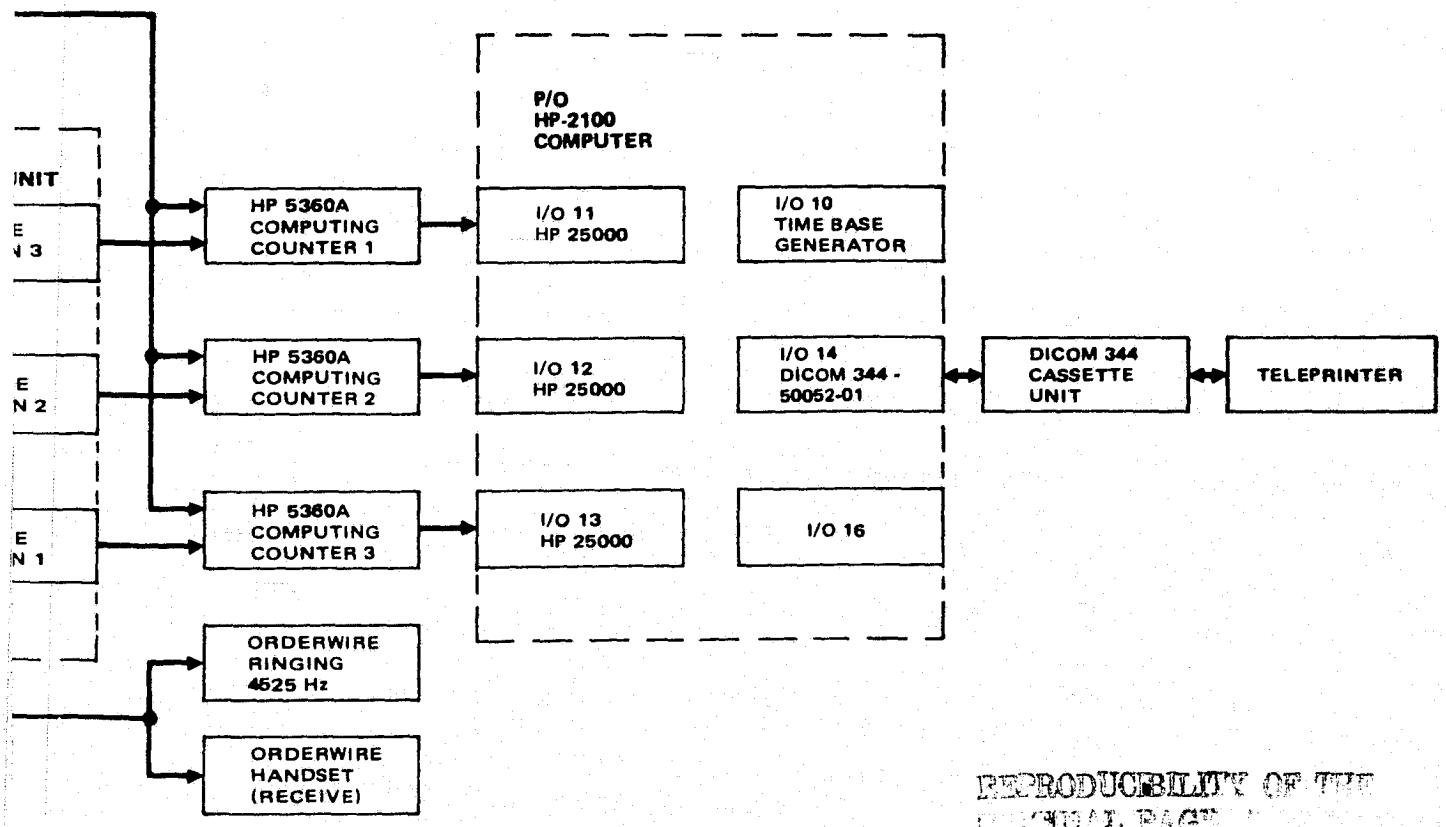


FIGURE 4-1. CDA OVERALL FUNCTION/

FOLDOUT FRAME 2





AL DIAGRAM

4.2.4 Orderwire Operations

Orderwire equipment is provided at the CDA to ensure coordinated operation between the CDA and each TARS. Switch functions are provided to enable the selection of either ranging operations or orderwire operations on the switch unit.

4.2.5 Computer Operations

The computer provides the capability of automatic ranging operations as well as range assessment from received data. When used in conjunction with the teleprinter unit, the computer can be programmed to store, as well as print out, processed data as required.

The computing counter is also required to limit the processing of selected tones. The range unit generates and sums all range tones within the mode selected on transmit tone select switch S1. However, only the tone selected on reference tone select switch S2 is processed. When selected, the reference tone is applied to the desired computing counter through an associated patch panel. The computing counter uses the reference tone to count the number of cycles transmitted to the SMS. When the count reaches a preselected number, a disabling signal is generated to stop the range determination process. Note that the computing counter is limited to four count selections: 10, 100, 1000, and 10000. In general, the count time allotted for each tone is based on practical considerations. For this reason, the count allocation for each tone, including computer time, is as follows:

200 kHz	3000 counts (3 sets of 1000)	~2.5 seconds
27.77 kHz	1000 counts	~1.0 second
3.968 kHz	1000 counts	~1.0 second
283.4 Hz	100 counts	~0.35 second
35.46 Hz	100 counts	~3.0 seconds

In processing the 200 kHz tone, the counts are taken in three sets of 1000, each set is processed, and the results of the analysis of each set averaged.

Each of the counts of each of the tones is compared in phase relationship with the reference tones generated in the range unit. The phase difference between the received tone and the reference tone is equated into time. The time functions for each of the counts are averaged by the computer and the average time for the count set is finally equated to distance. When successive count sets are computed, range rates can be determined.

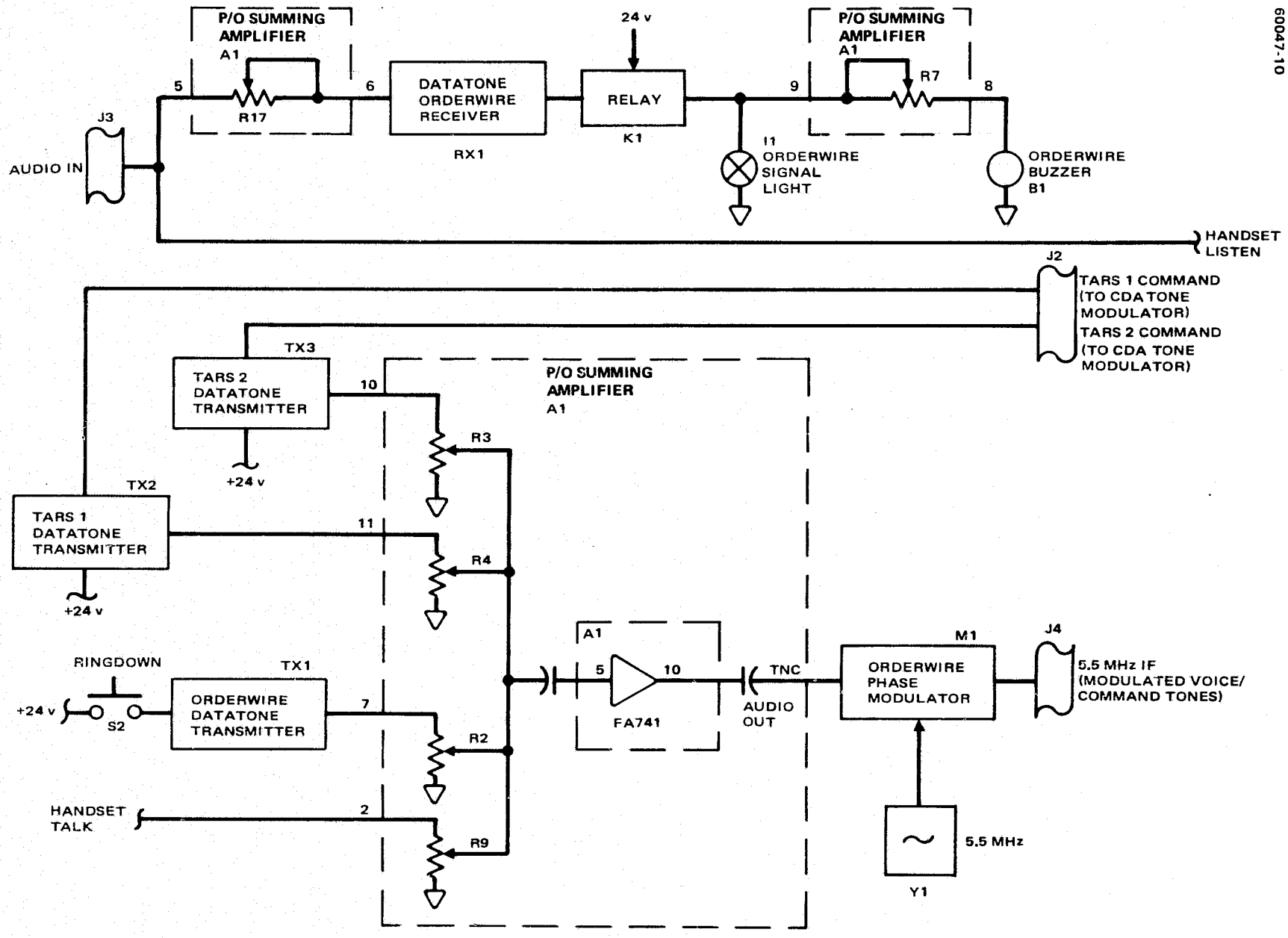


FIGURE 4-2. ORDERWIRE UNIT FUNCTIONAL BLOCK DIAGRAM

4.3 UNIT OPERATION

The theory of operation of the units of the CDA that have been fabricated or modified by Hughes is presented in the following paragraphs in the following order:

1)	Orderwire Unit (P/N 3029309)	Paragraph 4.3.1
2)	Switch Unit (P/N 3029322)	Paragraph 4.3.2
3)	Range Unit (P/N 3029304)	Paragraph 4.3.3
4)	Tone Modulator Unit (P/N 3029324)	Paragraph 4.3.4

For the theory of operation of commercial units, refer to the appropriate document as listed in Table 1-9.

4.3.1 Orderwire Unit Theory of Operation

The orderwire unit, Hughes P/N 3029309, contains the elements required to conduct orderwire operations and the signal generators required to enable and disable the TARS transmitting equipment. (See Figure 4-2.) Audio frequency signals from the FM demodulator in the Scientific Atlanta Model 410A receiver are applied to connector J3 of the orderwire unit. The orderwire ranging tone of 4525 Hz is detected in the Datatone orderwire receiver RX1 to actuate relay K1. When relay K1 operates, 24 vdc is applied to the orderwire signal light I1 and through register R7 to the orderwire buzzer B1. Voice communication is direct from J3 to the handset earpiece.

Four audio frequency signals are generated in the orderwire unit for transmission through the SMS to the TARS: voice, orderwire ringing, and the command tones for each of the TARS. When ringdown switch S2 is pressed, the Datatone transmitter TX1 generates a 4525 Hz ringing tone which is applied through resistor R2 and summing amplifier A1 to the orderwire phase modulator M1 for conversion to a 5.5 MHz IF by 5.5 MHz oscillator Y1. The voice and command tone transmitters are similarly processed; however, the TARS 1 Datatone transmitter TX2 which has an output of 2940 Hz and the TARS 2 Datatone transmitter TX3 which has an output of 3180 Hz can be applied to the orderwire modulator by momentarily pressing a push switch on the tone modulator unit. TARS 3 and 4 have the following command tones, 3625 and 3925 Hz, respectively.

4.3.2 Switch Unit Theory of Operation

The switch unit, Hughes P/N 3029322, is the interface between the computer and the various relays that perform the following functions: 1) selection and assignment of IF frequencies to each receiver in the CDA, 2) configuring the CDA for ranging, test, or orderwire operation, and 3) configuring computer range data for telephone line transmission. The

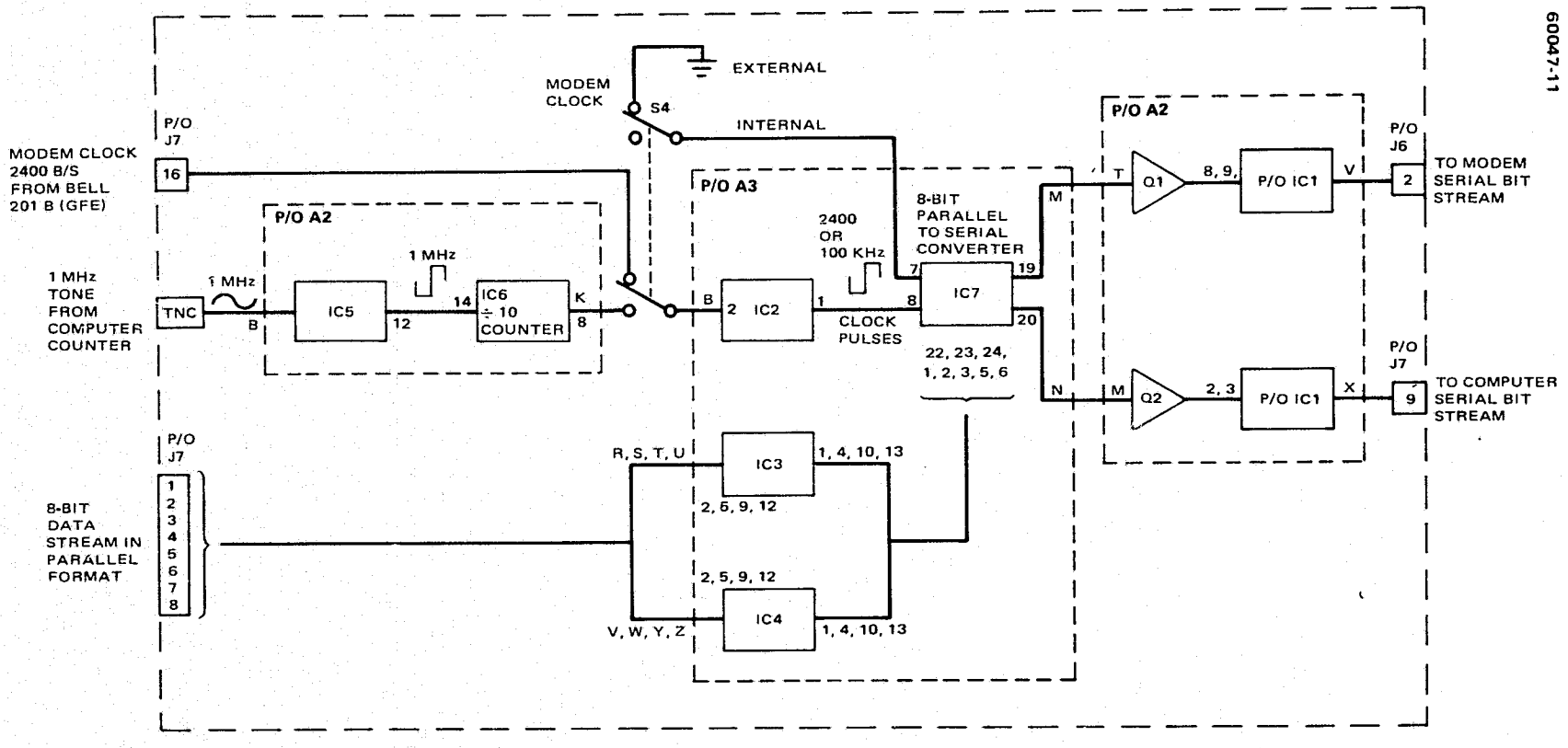


FIGURE 4-3. SWITCH UNIT MODEM INTERFACE SECTION FUNCTIONAL BLOCK DIAGRAM

detailed operation of each of the above functions is provided below in the following order:

1)	Modem Interface Section	Paragraph 4.3.2.1
2)	Receiver Antenna/Test Loop/Computer Select Switch 2 Operation	Paragraph 4.3.2.2
3)	Range Tone/Orderwire/Computer Select Switch S3 Operation	Paragraph 4.3.2.3
4)	TARS Command Tone Interface Function	Paragraph 4.3.2.4
5)	Receiver Frequency Assignment Function	Paragraph 4.3.2.5
6)	Computer Selected Count Period Function	Paragraph 4.3.2.6

4.3.2.1 Modem Interface Section

The function of the modem interface section of the switch unit is to configure the data stream generated in the computer into a bit rate compatible with telephone transmission lines. (See Figure 4-3.) The 8 bit data stream from the computer is applied from connector J7 through buffers IC3 and IC4 and loaded onto a register in 8 bit parallel to serial converter IC7. The serial bit rate output of the converter is determined by clock pulses from either of two sources: a modem clock from the Bell 201B system (GFE) or a CDA-generated clock pulse. The selection of either of these sources is controlled by switch S4 located on the interior of the switch unit.

When switch S4 is set to EXT, clock pulses are applied to IC7 through IC2 at a 2400 bps rate. When switch S4 is set to INT, clock pulses are generated by a 1 MHz tone from computer counter 3, which is converted from sinusoidal to square wave pattern by IC5 and divided by 10 in IC6 to form clock pulses at a 100 kHz rate. A ÷ 64 circuit in IC7 is enabled to convert the 100 kHz input to form the 1625 Hz clock pulse rate used for the parallel to serial conversion.

After the parallel to serial conversion, two signals are provided as outputs from IC7; one output is made available to GFE modems, while the remaining signal is provided to the computer for signal processing status functions. Transistors Q1 and Q2 provide signal amplification, while IC1 provides signal buffering.

4.3.2.2 Receiver Antenna/Test Loop/Computer Select Switch S2 Operation

The function of switch S2 is to configure the CDA for test or ranging operations. (See Figure 4-4.) When switch S2 is set to RCV ANT, 24 vdc is applied to position 2 of RF switch S3 in the tone modulator unit to connect the input to the CDA receivers to the NASA Station downconverter for normal operations; when the test loop is selected on switch S2, the 24 vdc power is applied through a relay in the switch unit to RF switch S3 to position 1 to connect the output of the tone modulator unit directly to each CDA receiver for closed loop testing. When CMPTR is selected on switch S2, normal and test operations are determined by computer programming.

4.3.2.3 Range Tone/Orderwire/Computer Select Switch S3 Operation

The function of switch S3 is to configure the CDA for ranging operations or for orderwire operations. (See Figure 4-5.) When the range tone is selected on switch S3, 24 vdc is applied to position 2 of RF switch S2 in the tone modulator unit to connect the output of the range unit to the NASA Station upconverter during normal ranging operations; when the orderwire is selected, the position 1 relay of RF switch S2 is operated to connect the orderwire output to the NASA Station upconverter. When the computer is selected on switch S3, ranging operations are determined by computer operations.

4.3.2.4 TARS Command Tone Interface Function

The TARS 1 and 2 command tones are interfaced in the switch unit when the computer is selected on switch S4 in the tone modulator unit. (See Figure 4-6.) When the CDA computer provides a ground signal to J0 -16, a ground return signal is applied from the switch unit through command tone switch S4 in the tone modulator to the TARS 1 and 2 command tone generator functions in the orderwire unit. Note that in the computer mode of operation, the TARS are commanded simultaneously.

4.3.2.5 Receiver Frequency Assignment Function

The switch unit contains circuitry to enable assignment of the detection of a specific IF frequency to each CDA receiver. The IF frequency assignment can be manually selected or remotely controlled from the CDA computer by setting a switch on the RF tuner section of the receiver in accordance with the placard mounted on the CDA rack above the receivers. (See Scientific Atlanta Instruction Manual for Model 410/70 MHz basic receiver unit.) When the RF tuner switch is set to REMOTE, the computer applies a signal to the relay functions in the switch unit which, in turn, supplies a ground connection to the appropriate relay in the RF tuner for correct frequency assignment. (See Figure 4-7.) Note that the difference in frequency assignments for each receiver is to enable the correct IF frequency detection for each of the modes of operation of the TRRR System including tests. (See Table 4-1.)

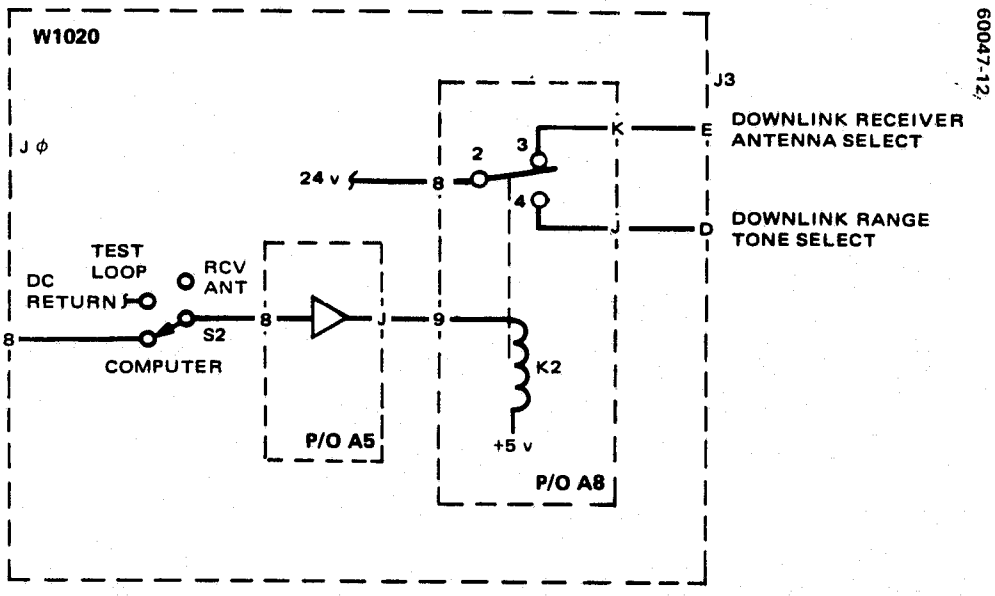


FIGURE 4-4. RECEIVER ANTENNA/TEST LOOP/COMPUTER TEST SWITCH FUNCTIONAL DIAGRAM

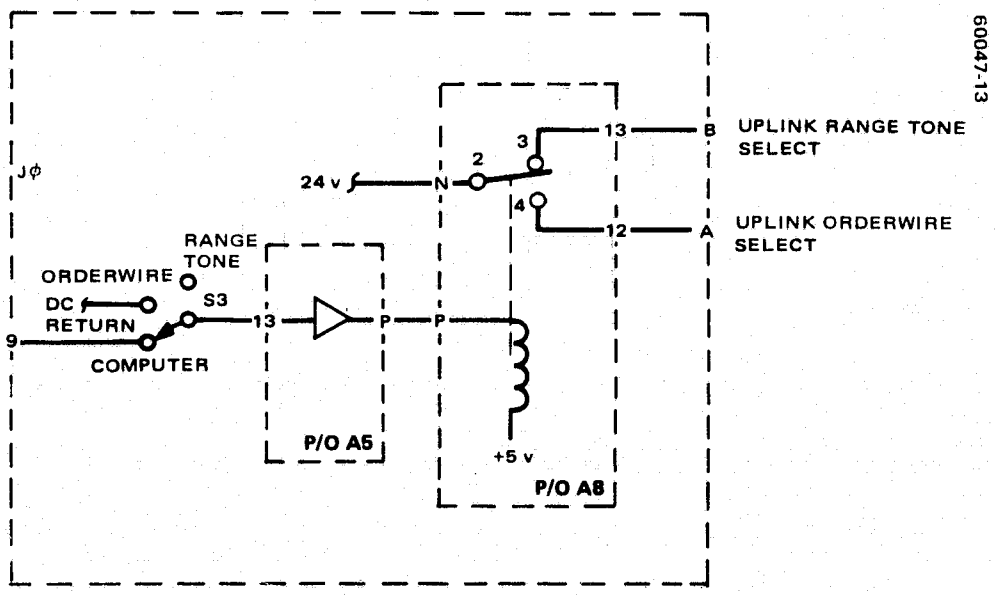


FIGURE 4-5. RANGE TONE/ORDERWIRE/COMPUTER SELECT SWITCH FUNCTIONAL DIAGRAM

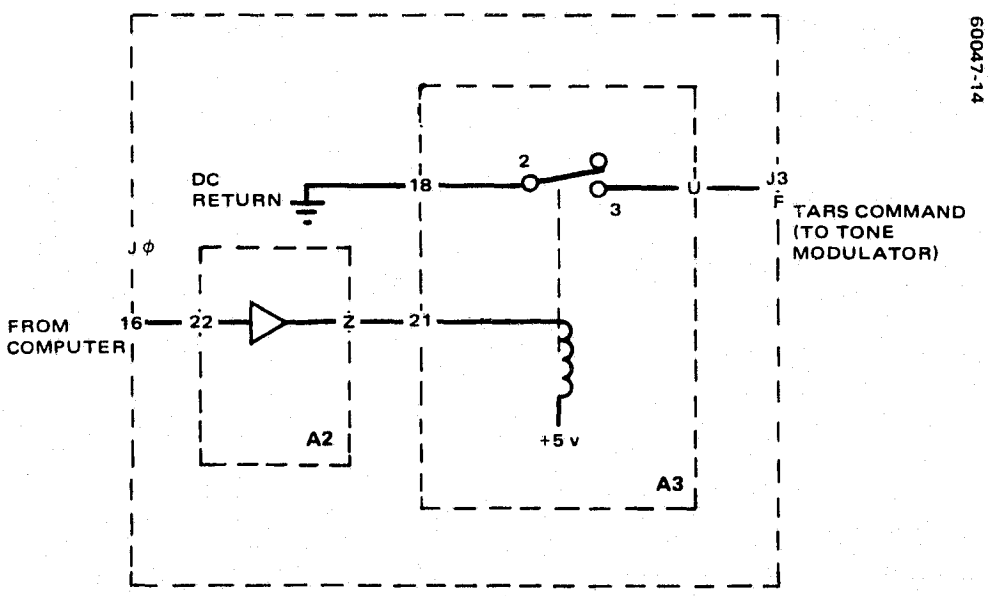


FIGURE 4-6. TARS COMMAND TONE INTERFACE

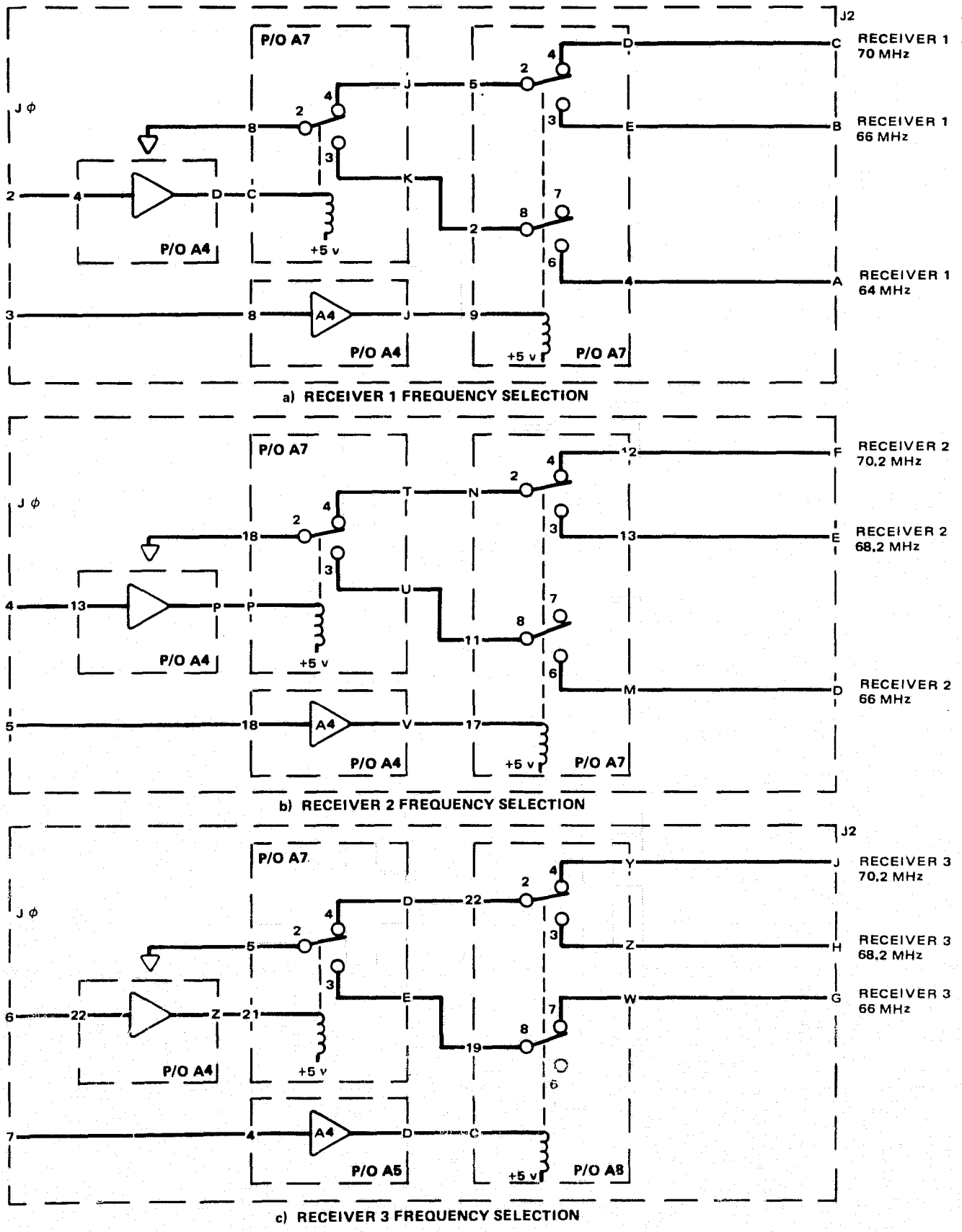


FIGURE 4-7. RECEIVER ASSIGNMENT FUNCTION

TABLE 4-1. CDA RECEIVER FREQUENCY ASSIGNMENTS

Receiver	Tuner Switch Position	Function	Frequency, MHz
1	1	CDA	64.0
	2	Loop	66.0
	3	-	70.0
	REMOTE*	CDA	64.0
2	1	Loop	66.0
	2	TARS 1	68.2
	3	TARS 2	70.2
	REMOTE*	TARS 1	68.2
3	1	Loop	66.0
	2	TARS 1	68.2
	3	TARS 2	70.2
	REMOTE*	TARS 2	70.2

*Computer controlled.

4.3.2.6 Computer-Selected Count Period Function

The CDA computer counters HP 5360A contain a modified time interval counter HP 5379A which provides the means for selecting any of five count time periods from either the counter TI (time interval) average switch or from the CDA computer. Five time interval counts are available from the computer counter: 1, 10, 100, 1000, and 10000. In order to select the time interval count from the computer, the multipin connector must be connected between the computing counter patch panel to the HP 5379A time interval module.

Each time interval is determined by a control circuit that has five control line inputs. When a specific time interval count is desired, a ground is applied to all other control lines; the control line for the desired time interval count remains ungrounded.

The multipin connector applies the ground connections from the switch unit and computing counter to the time interval module when the computer applies the appropriate relay actuating signals to the computer-selected count period function in the switch unit. (See Figure 4-8.)

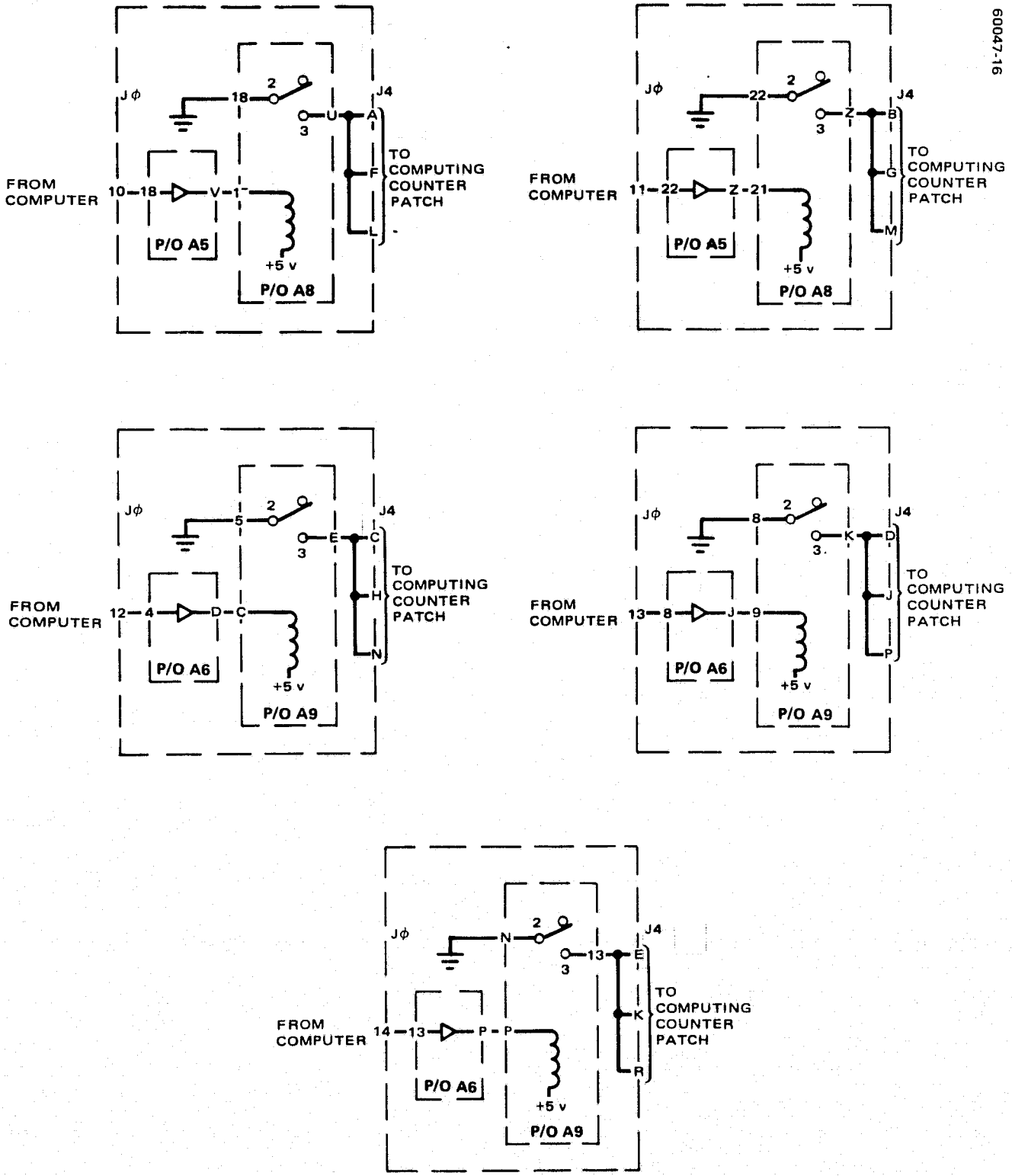


FIGURE 4-8. COMPUTER-SELECTED COUNT PERIOD FUNCTIONAL DIAGRAM

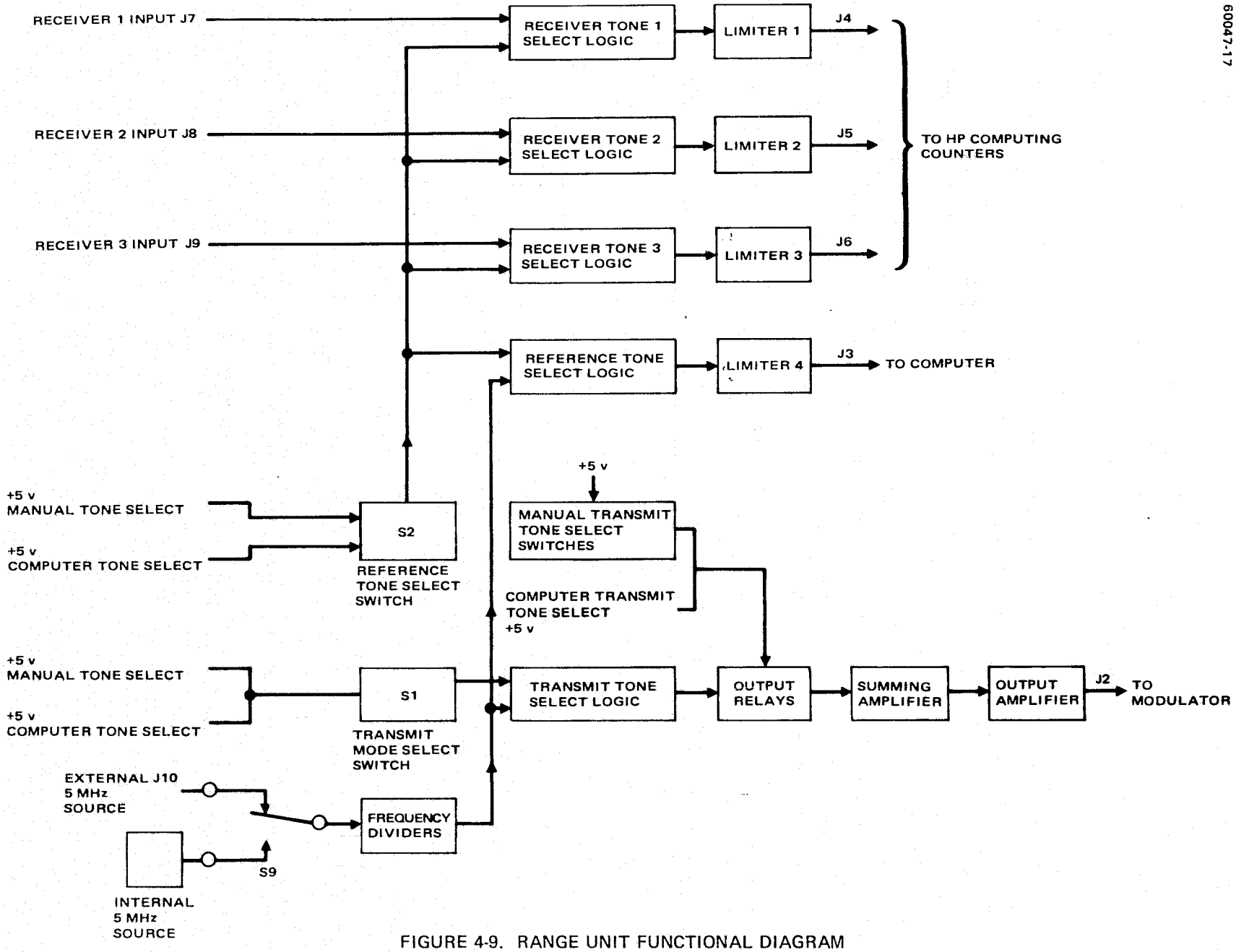


FIGURE 4-9. RANGE UNIT FUNCTIONAL DIAGRAM

4.3.3 Range Unit Theory of Operation

The range unit, Hughes P/N 3029322, has the capability of performing two basic functions in the CDA: the generation and distribution of range tones, and the detection of range tones from each of the CDA receivers. All range unit operations can be performed either semiautomatically from front panel controls, or automatically during computer operations. (See Figure 4-9.) All internal operations in either mode are identical with the exception of front panel switch selections.

The range tone generation and distribution are accomplished in the following manner. Five basic range tones are generated and distributed in any of three combination modes, A, B, or C in either a manual or automatic mode from mode select switch S1. (See Figure 4-10.) Each range tone selection is applied through appropriate output relays to a summing amplifier for ultimate application to the NASA Station transmitting section. The inputs and outputs of each of these modes are isolated through relays that are controlled by signals applied through transmit mode select switch S1. The basic difference between each of the frequency sections is the output level, controlled by individual potentiometers, which is selected to ensure that the output to the tone modulator produces the correct modulation index.

Range tone generation is accomplished from a 5 MHz source from either an internal oscillator or an external standard. The 5 MHz signal is applied to frequency dividers that provide the tone frequencies to the range unit transmit tone and reference tone select functions.

Three receive tone sections are provided that detect the individual range tone frequencies from each of the CDA receivers. In general, the sections are identical, each having five subsections, each subsection required for the detection of each of the ranging tones. Although each section is connected to a specific receiver, each receiver can be assigned to a specific function.

The detailed theory of operation of each of the above functions is supplied in the following paragraphs.

4.3.3.1 Range Tone Frequency Generation (Figure 4-11)

The tones used for ranging operations are generated in the range unit by dividing a 5 MHz signal developed either internally or from an external source. Counter 1 divides the signal by five to develop a 1 MHz tone. This tone is applied to counter 3 directly and to counter 2 through relay K1. When mode B is selected, relay K1 actuates to apply the 1 MHz signal to counter 2 which divides the signal by five to develop the 200 kHz tone used during mode B ranging. The 200 kHz tone is then filtered and applied to the 200 kHz transmit tone select logic function and distributed as a reference tone to the computer.

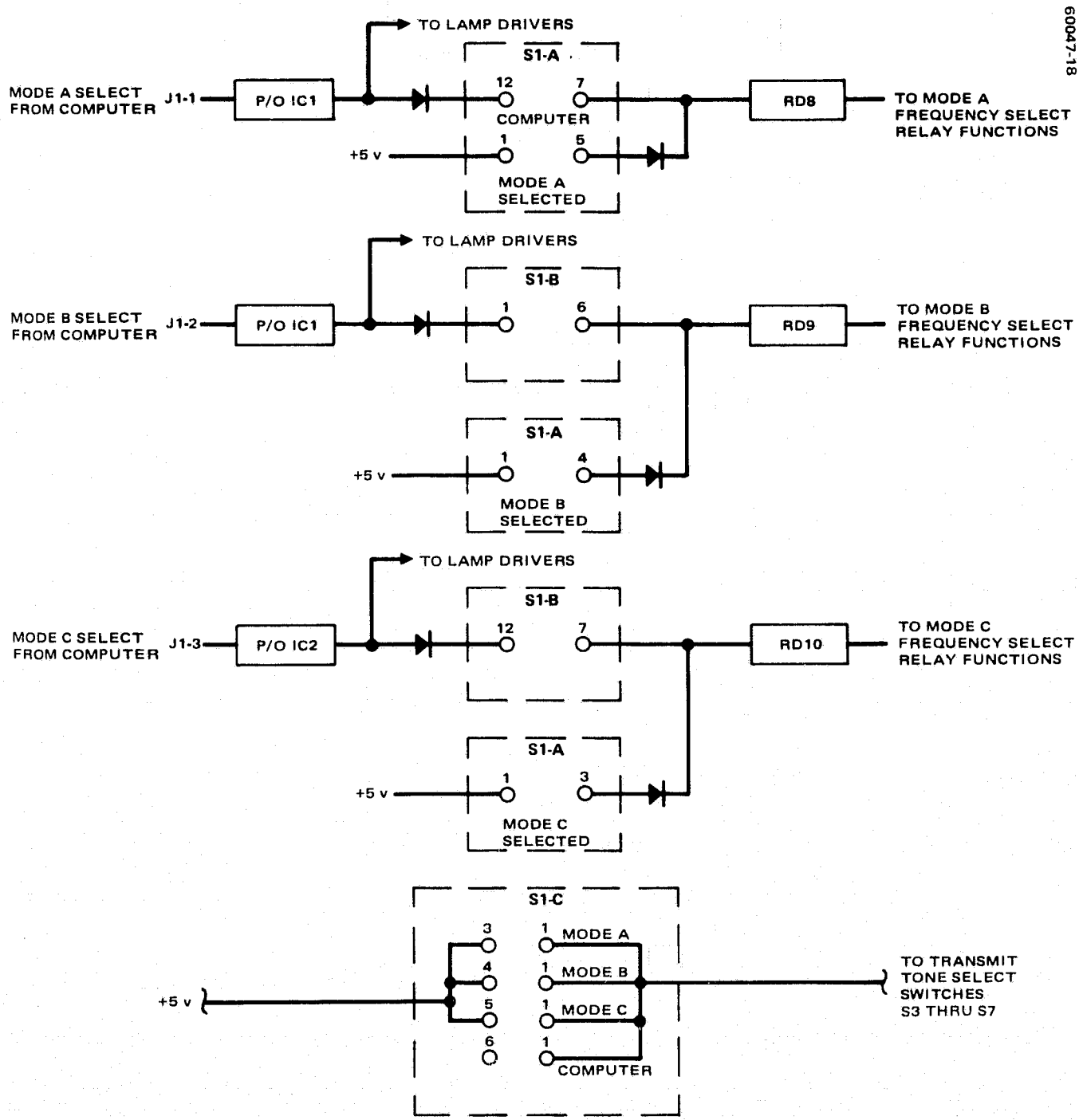


FIGURE 4-10. MODE SELECT SWITCH LOGIC

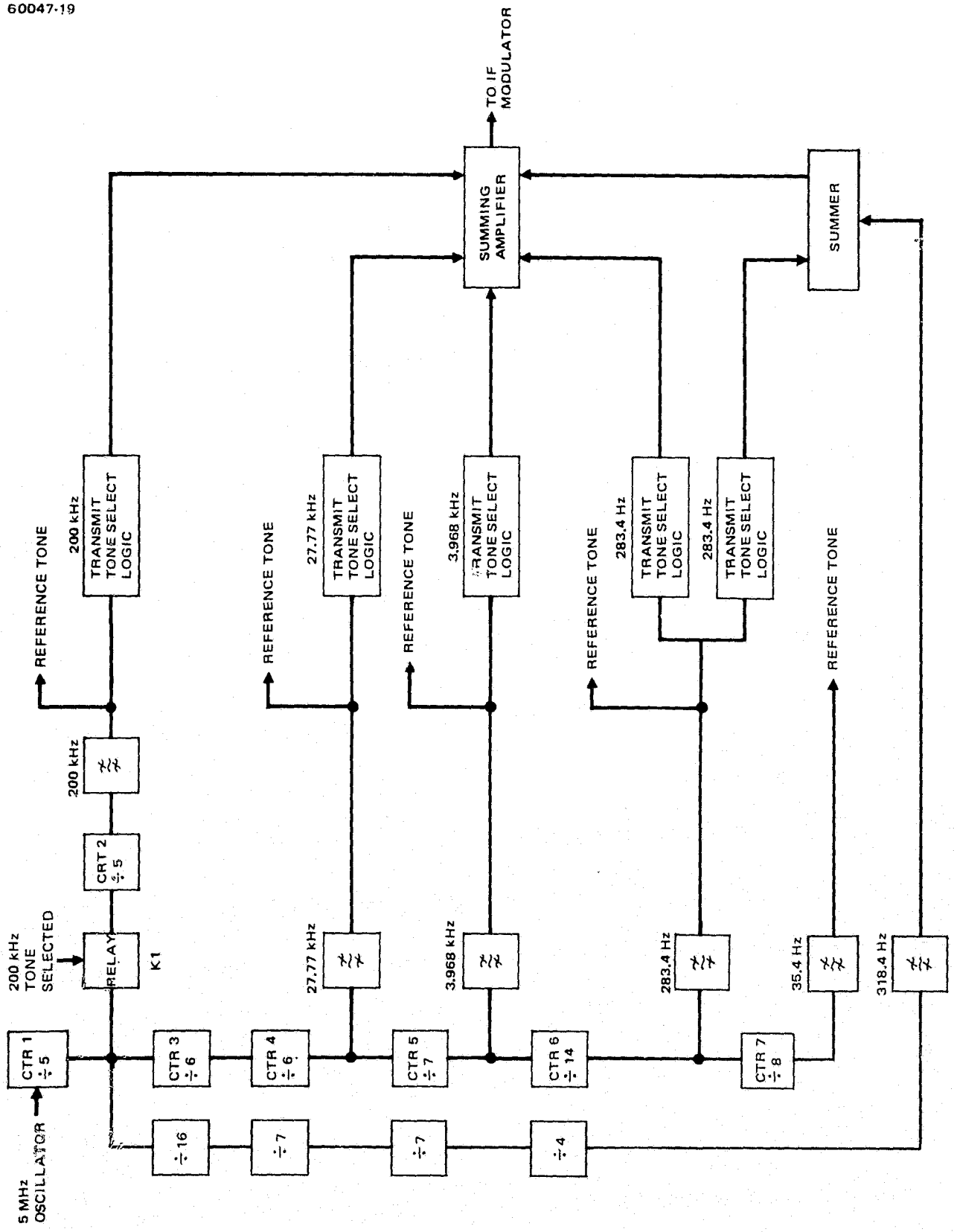


FIGURE 4-11. RANGE TONE FREQUENCY GENERATION

The 1 MHz signal applied to counter 3 is divided by six with the resultant signal also divided by six in counter 4. The 27.77 kHz signal thus obtained is applied to counter 5 for additional processing and to a 27.77 kHz filter for further distribution in the 27.77 kHz transmit tone logic section and as a reference tone to the computer.

The 27.77 kHz signal applied to counter 6 is divided by 14 to develop a 283.4 Hz signal which is applied to counter 7 for additional processing and to a 283.4 Hz filter for distribution to the computer as a reference tone, to the 283.4 Hz transmit tone select logic function and as an additional element in the processing of the 35.4 Hz range tone.

Counter 7 divides the 283.4 signal by eight to develop the 35.4 Hz signal required for the lowest range tone. This signal is distributed to the computer as a reference tone and to the 35.4 Hz transmit tone select logic function. Although the 35.4 Hz signal is developed as a ranging reference function, the actual frequency transmitted for ranging is 318.8 Hz. This is required as the 35.4 Hz signal would be tracked out by the phase lock loop in the CDA receivers. Accordingly, the transmission range tone transmitted through the NASA transmitter section is 318.8 Hz.

The 318.8 and 283.4 Hz tones are transmitted simultaneously and there best note is detected upon reception. The mod index of each tone is adjusted to be about 0.7.

4.3.3.2 Transmit Mode Switch Logic

Mode select switch S1 provides the capability of selecting four modes of range unit operation: mode A, B, or C, or computer-controlled operations. (See Figure 4-12.) During manual operations, +5 volts are applied through switch S1 to relay driver RD8, RD9, or RD10 when mode A, B, or C, respectively, is selected. When a voltage is applied to the input of the relay driver, the resultant output becomes zero; the absence of an input voltage causes a high voltage state at the output of the driver. In this manner, as the frequency select relays in the range unit are provided a high voltage state to one terminal of its coil, the application of 5 vdc to the input of the ac associated relay driver produces a low voltage state to the remaining terminal of the relay coil. The imbalance of voltage states at the terminals of the relay coil causes the relay to actuate and remain actuated until the voltage to the relay driver is removed. When that occurs, the output of the driver becomes high and the voltage states at both terminals of the relay coil become high, causing the coil to deenergize.

Computer operation is initiated in a similar manner; however, each mode is initiated from the computer through separate pins on connector J1. The computer 5 vdc power is applied through NAND gates in IC1 and IC2 to switch S1 with diodes CR4 through CR6 inserted in the circuit to ensure isolation between the computer-controlled functions and the manually controlled functions. The NAND gates inserted in the circuit are used to configure the power from the computer with the relay driver power functions.

In the computer mode, the lamp functions of transmit tone select switches S3 through S7 are lighted directly with the computer-switched power. In the manual mode, when mode A, B, or C is selected, the lamp functions of switches S3 through S7 are controlled by physically pressing the switch ON or pressing the switch OFF. Thus, during computer operation, the illumination of the switch lights indicate the range tone frequency enabled; during manual operation, the switch must be pressed on or off in conjunction with the mode functions enabled by switch S1 and in conjunction with the range tone frequencies to be transmitted.

4.3.3.3 Range Tone Transmit Frequency Distribution

In general, the sections in the transmit logic for each of the frequencies are identical, the major elements being an input filter, an input relay, an amplifier, an output level adjustment, an output relay, and final output signal controls and indicator circuits. These functions are described in the following paragraphs.

When mode A is selected in either the manual or computer mode, 5 vdc is applied through switch S2 to relay driver RD8 to apply relay actuating signals to the input and output relays which control the transmission of the mode A frequencies through the initial stages of the transmit section of the range unit. (See Figures 4-10 and 4-12.) To enable the transmission of the range tone signal to the signal summing amplifier in the manual mode, the associated switch S4 through S7 must be pressed ON. Pressing the associated switch ON enables the associated relay driver to actuate the proper relays to apply the frequency tone to signal summing amplifiers Q6 through Q9 and light the associated switch lamp. In the computer mode, all segments of the transmit section are enabled directly from computer-generated signals and no front panel operations are required.

For example, when mode A is selected in either the computer or manual mode, 5 vdc is applied through switch S1 to enable relay driver RD8. The low state of relay driver RD8 operates relays K5 and K11 in the 27.77 kHz section, relays K3 and K9 in the 3.968 kHz section, relays K16 and K20 in the 283.4 Hz section, and relays K17, K18, and K21 in the 35.4 Hz section. To this point, the operation is identical for both the manual and computer modes; however, output relays and indicator lamp circuits must be enabled in order to apply any output signals to the summing amplifier.

Note that the application of the 200 kHz to summing amplifier Q4 is controlled by K63, 27.77 kHz is controlled by K64, 3.968 kHz is controlled by K65, 283.4 Hz by K66, and 35.4 Hz (318.8 Hz) is controlled by relay K67. These relays are in turn controlled either by a signal from the associated transmit tone select switch when manual mode is selected, or from a signal from the computer from J1-1 (mode A), J1-2 (mode B), or J1-3 (mode C). When mode A is selected at the computer, the 5 vdc signal at J1-1 is applied to RD22 through RD25 to energize the relays associated

with each of the frequency tones in mode A. In addition, the 5 vdc signal is also applied to RD14 through 19 to actuate the applicable relay which in turn applies 28 vdc to the common terminal of the associated lamp for the frequency tone. Note that in the manual mode, the output relay can be enabled or disabled by pressing the associated transmit tone switch.

The above technique is used to control the output of tone frequencies to the summing amplifier in the range unit. The output of the summing amplifier is then applied to the modulator, multiplied to 66 MHz, and made available to the NASA Station amplifier at connector J2 in the range unit.

4.3.3.4 Receive Tone Detection and Distribution

Three receivers are provided with the CDA for the detection of the IF frequencies associated with the transmitting functions of each of the TARS and the CDA as well as test functions. As each of these functions is capable of transmitting five ranging tones, three sets of five receive frequency detection and distribution sections are provided in the range unit with each of the subsections capable of detecting a specific tone. (See Figure 4-12.) Note that the output of each section is applied to a limiter prior to applying the received tone to the computer for processing. Note also that only one frequency subsection can be actuated at one time. (See paragraph 4.3.3.5.)

In general, the frequency subsections are identical with the major elements being an input relay, an amplifier, an input filter, a second amplifier, an output level adjustment, and an output relay. These functions are described in the following paragraphs.

When a specific tone is selected on receive tone select switch S2, a 5 vdc signal is applied to the input and output relays for that subsection associated with receivers 1 through 3. Note that all received tones are amplified in the first amplifier prior to specific frequency detection in the associated bandpass filter. The detected tone is then amplified and attenuated prior to application through the associated output relay.

The output of the receiver 1 section is applied through an amplifier and potentiometer R179 to limiter 1 prior to application to the computing counter for analysis. The remaining frequency tone subsections are similarly processed prior to application to the CDA computer. Note that the detection of the 35.4 Hz tone follows combining the 318.8 Hz received tone and the 283.4 Hz received tone in all the amplifier circuits prior to filtering in the bandpass filter in the received tone subsection.

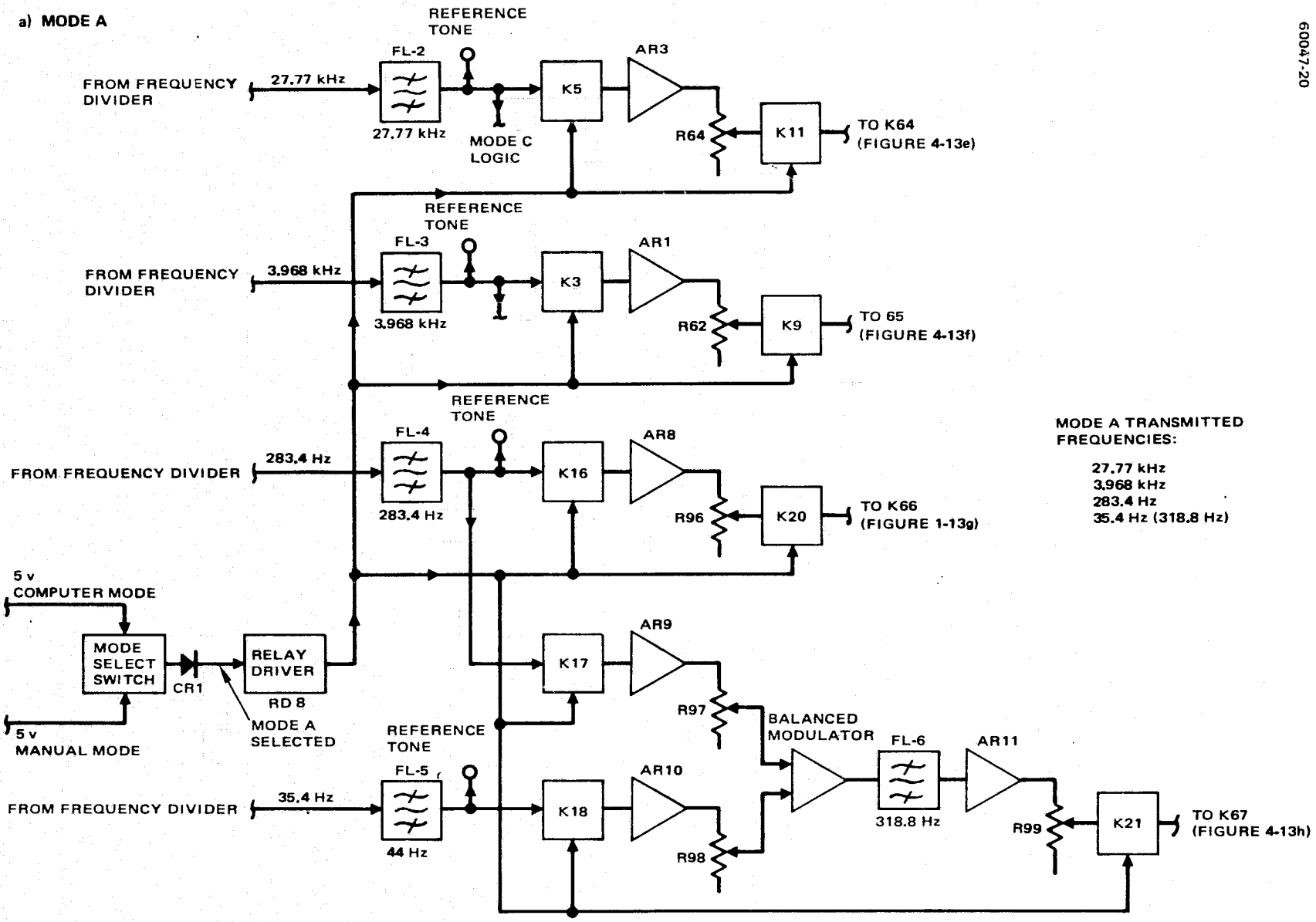
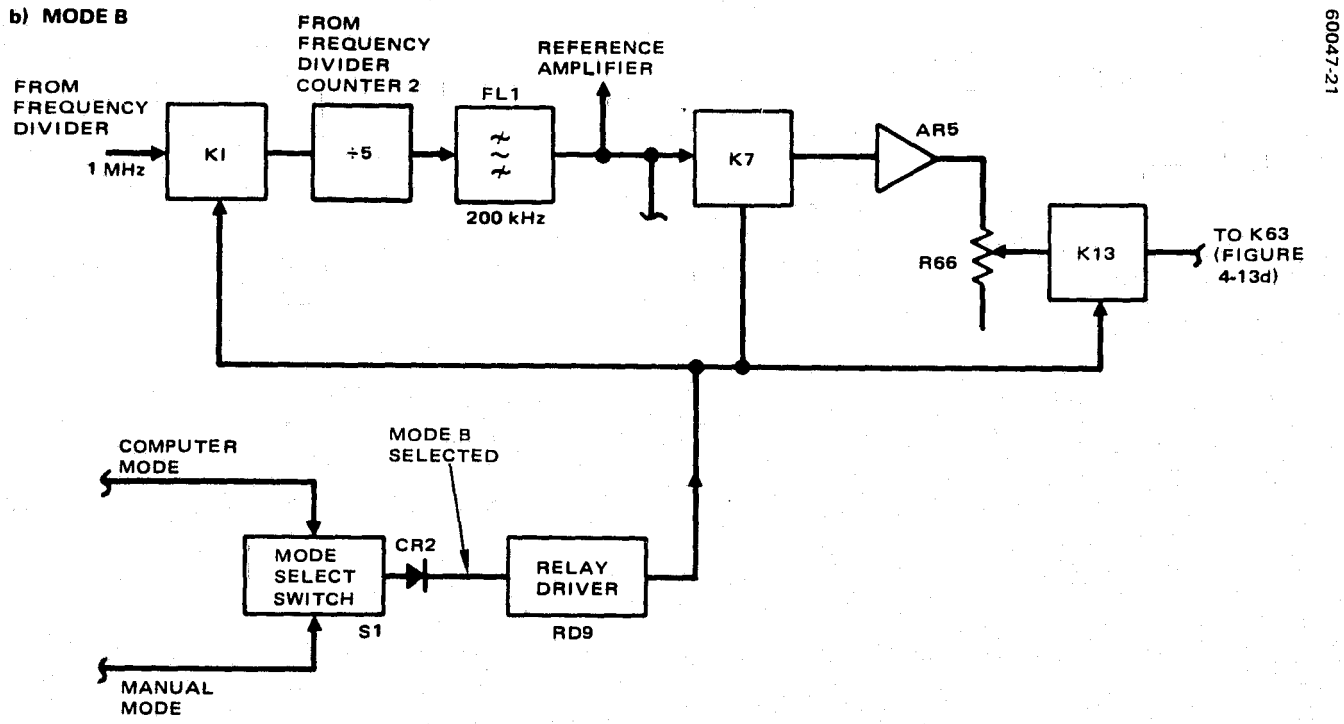


FIGURE 4-12. TRANSMIT SECTION FUNCTIONAL DIAGRAM



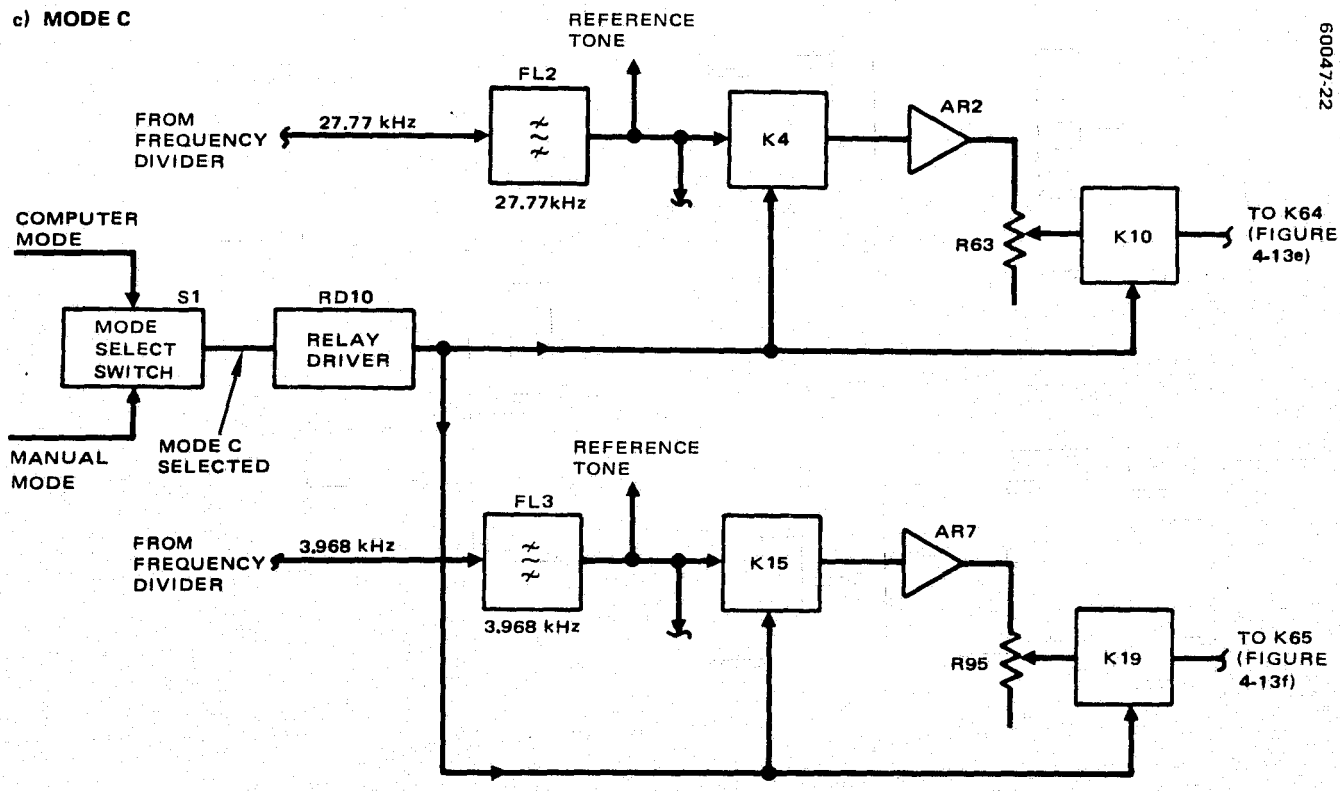


FIGURE 4-12 (CONTINUED). TRANSMIT SECTION FUNCTIONAL DIAGRAM

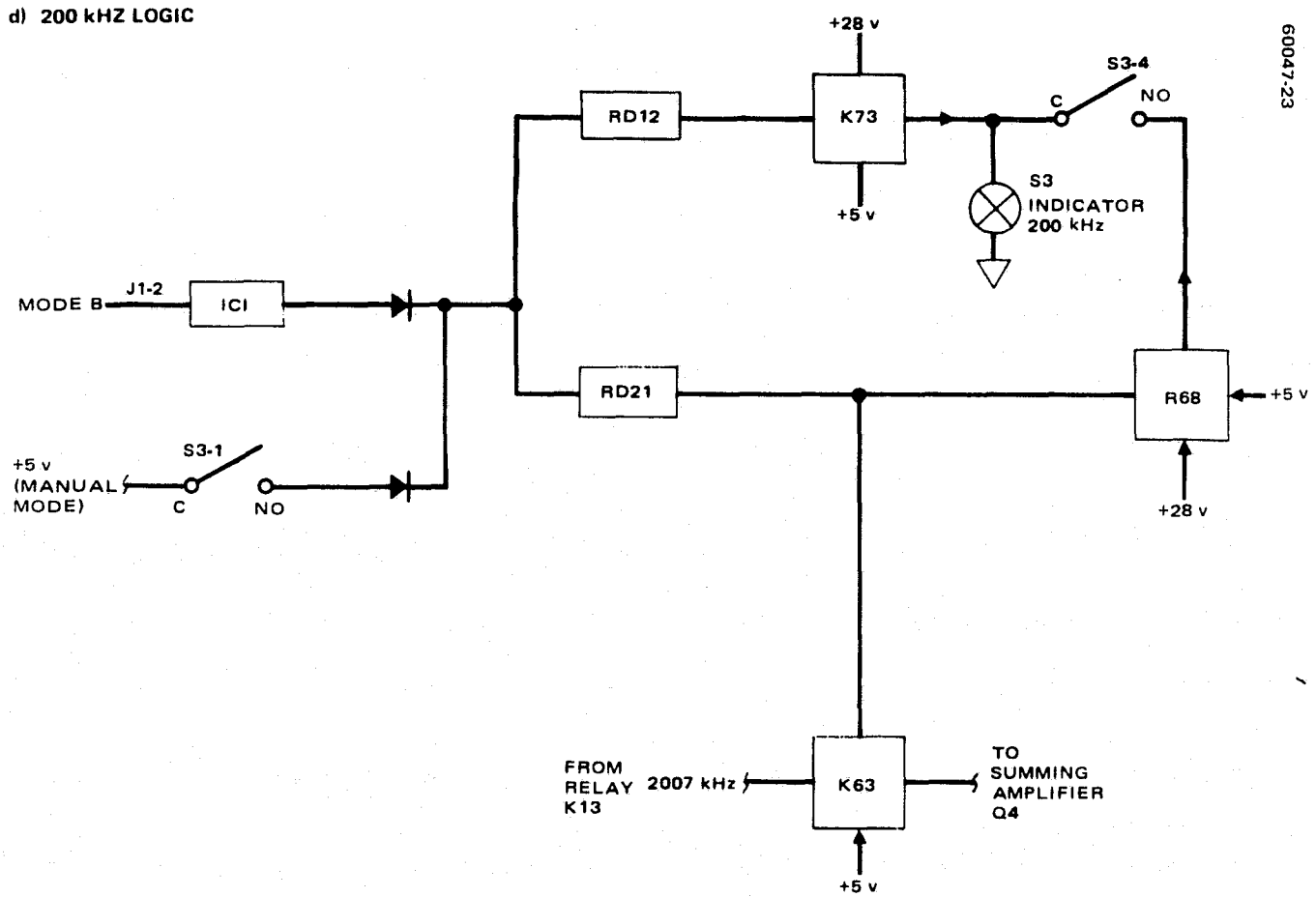


FIGURE 4-12 (CONTINUED). TRANSMIT SECTION FUNCTIONAL DIAGRAM

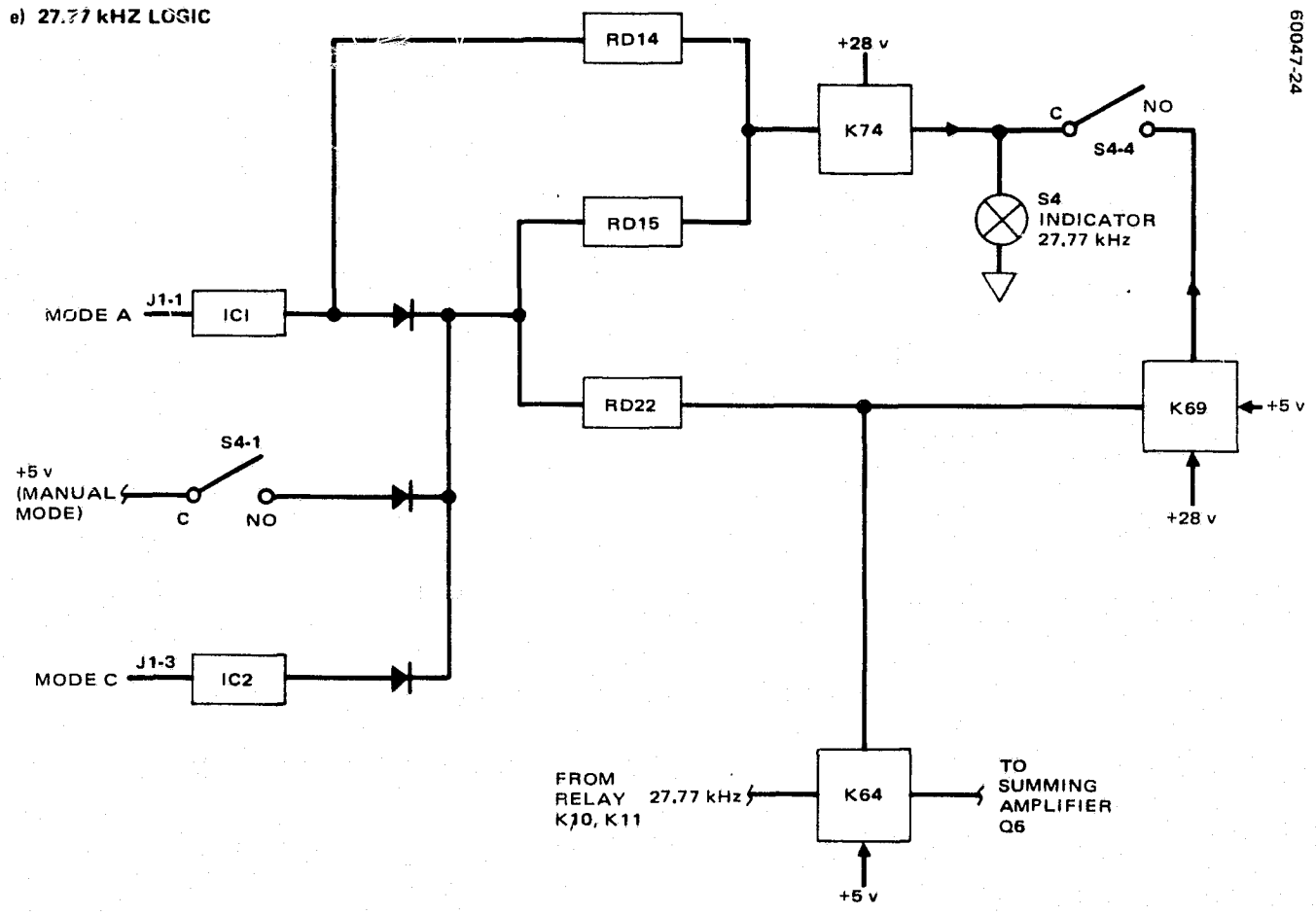


FIGURE 4-12 (CONTINUED). TRANSMIT SECTION FUNCTIONAL DIAGRAM

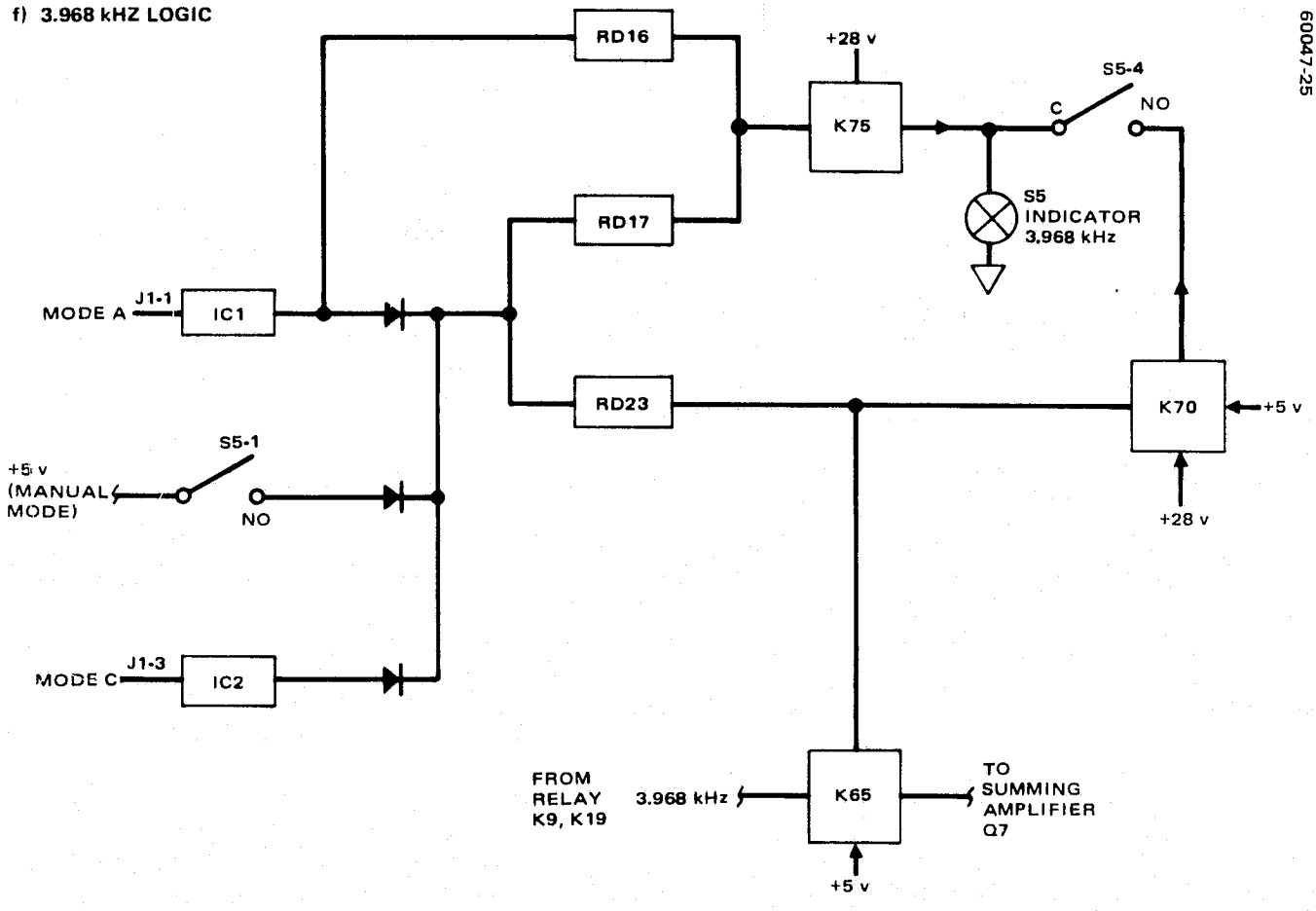
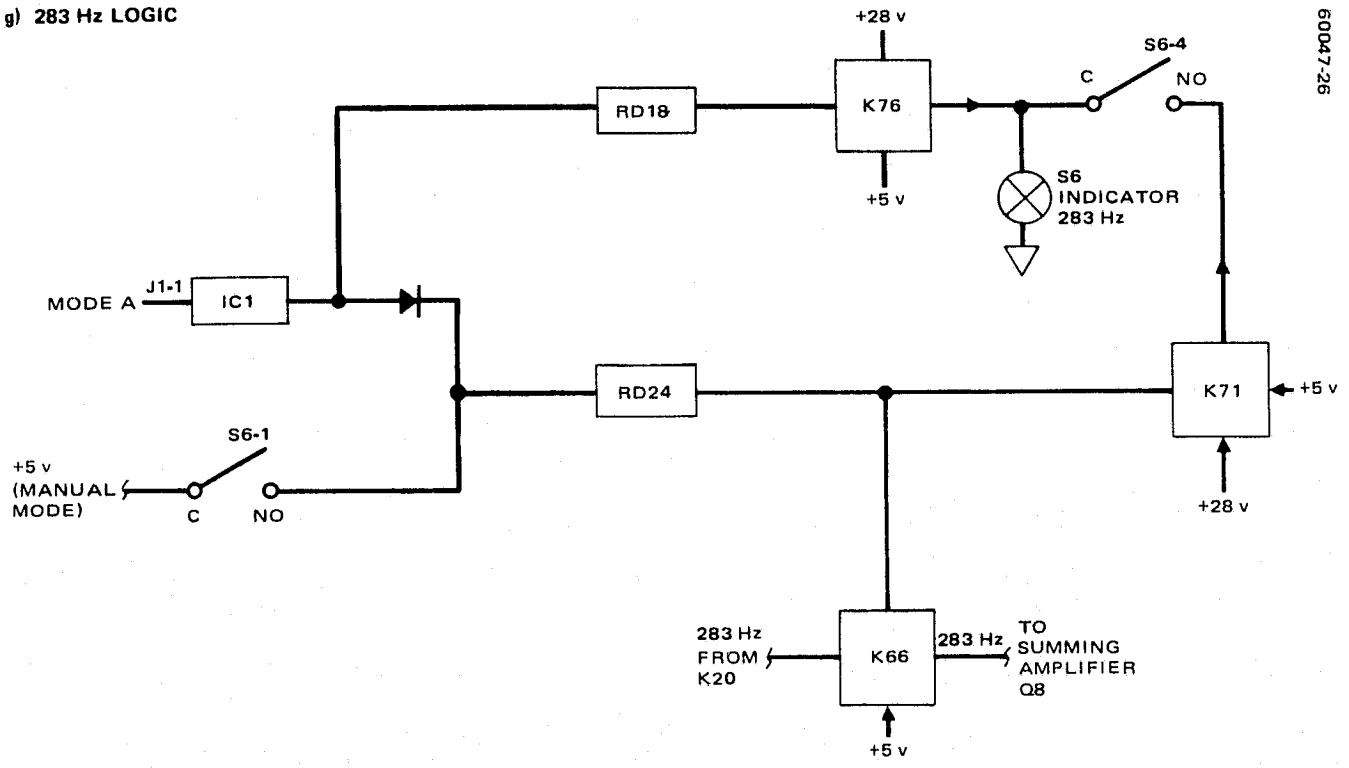


FIGURE 4-12 (CONTINUED). TRANSMIT SECTION FUNCTIONAL DIAGRAM



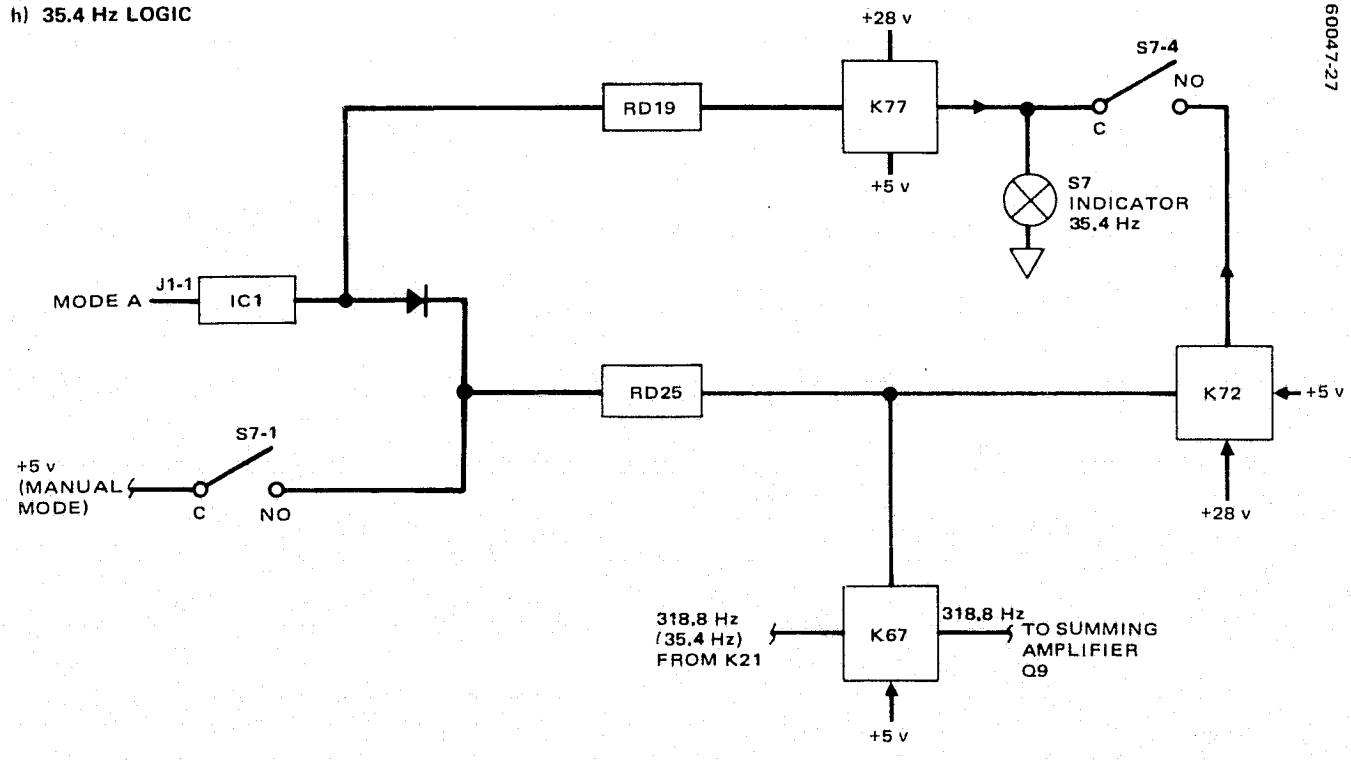


FIGURE 4-12 (CONTINUED). TRANSMIT SECTION FUNCTIONAL DIAGRAM

4.3.3.5 Reference Tone Selection and Distribution

The reference tone selection circuit has three basic functions in the range unit: to provide a means for the selection of one reference tone from any of the five range tones available, to provide relay driving signals to the reference tone select logic and receive tone detection and distribution logic, and to set the level of the reference tone prior to distribution limiter 4 and the computing counter.

When reference tone select switch S2 is set to any of the frequencies, +5 volts are applied to the associated relay driver to actuate relays in the reference tone logic function and the receiver tone select logic (Figure 4-13). For example, when switch S2 is set to 35.4 Hz, +5 volts are applied to relay driver RD7 which, in turn, actuates relays K22 and K27 in the reference tone select logic (Figure 4-14) and relays K32 and K37, relays K42 and K47, and relays K52 and K57 in the 35.4 Hz received tone logic (Figure 4-13e). Relays K22 and K27 control the application of the 35.4 Hz tone from the 35.4 Hz filter to reference tone limiter 4. The output of the reference tone limiter is applied to the computing counter in the CDA through the computing counter patch panel. The relays actuated in the received tone logic are used to apply the selected tone from each CDA receiver to an associated limiter prior to application to the computing counter through the computing counter patch panel.

Each of the remaining tones is processed in a similar manner in the manual mode. When switch S2 is set to CMPTR, the relay driving signals are developed from computer inputs from connector J1.

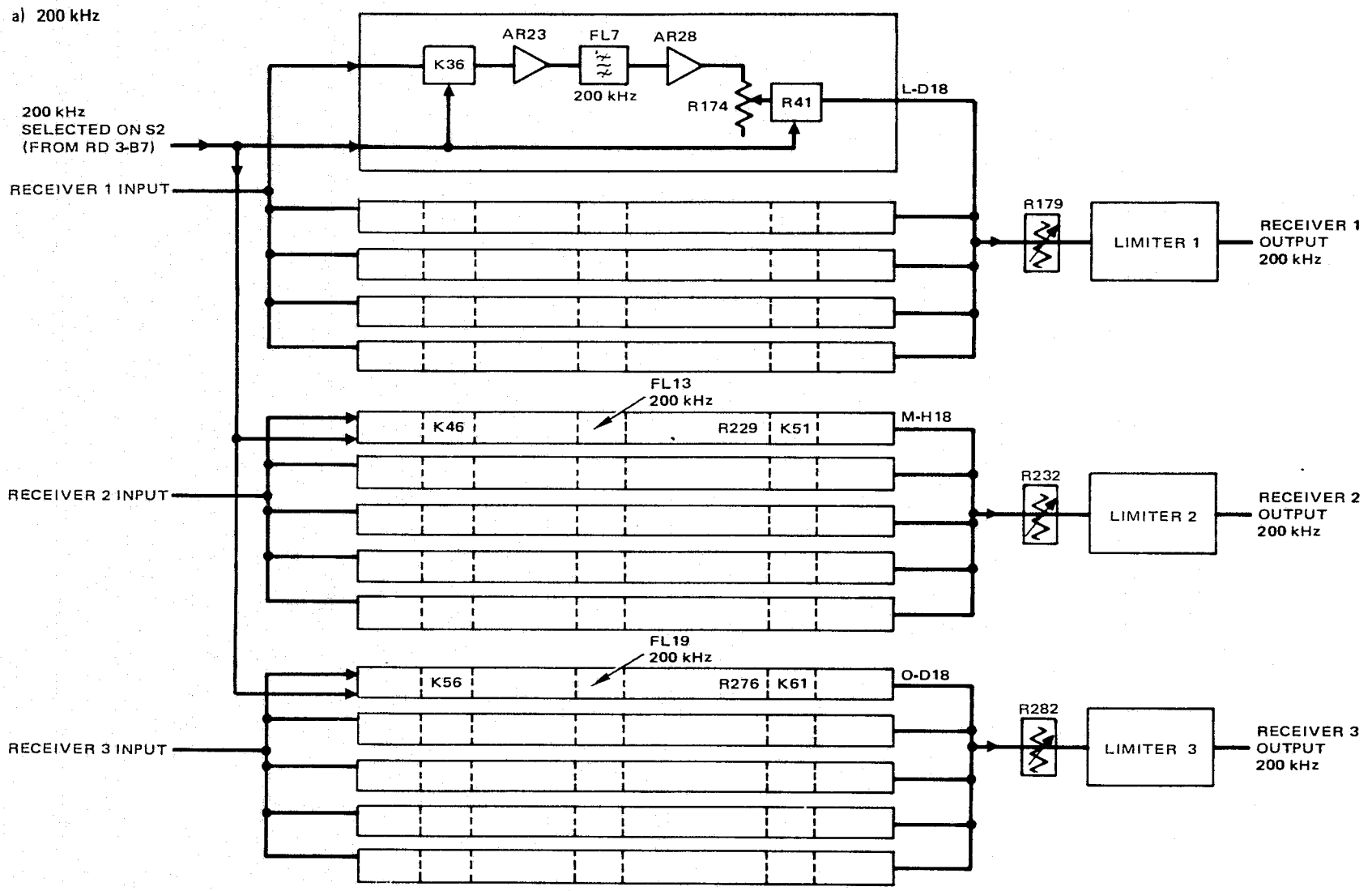


FIGURE 4-13. RECEIVED TONE DETECTION

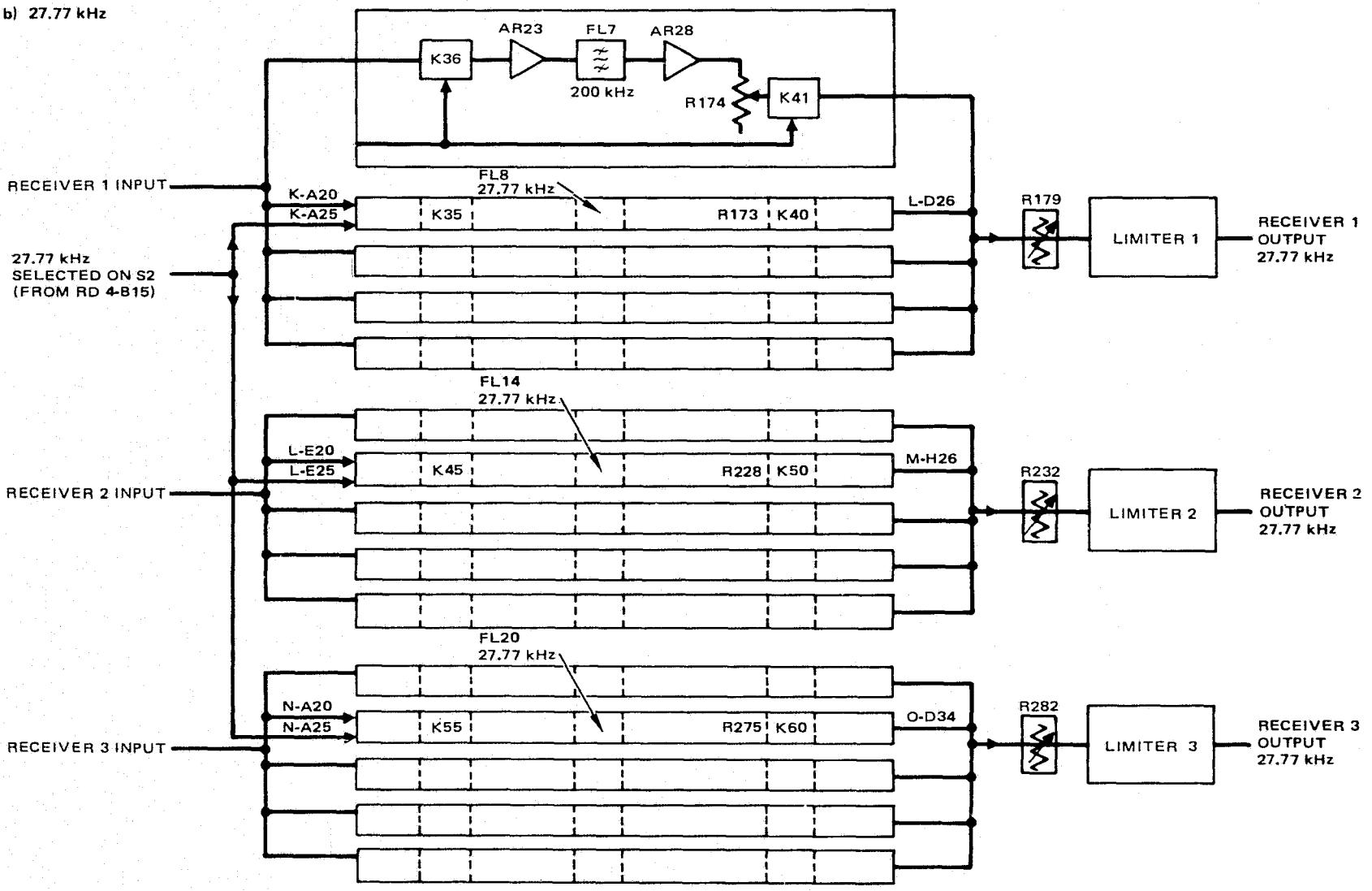


FIGURE 4-13 (CONTINUED). RECEIVED TONE DETECTION

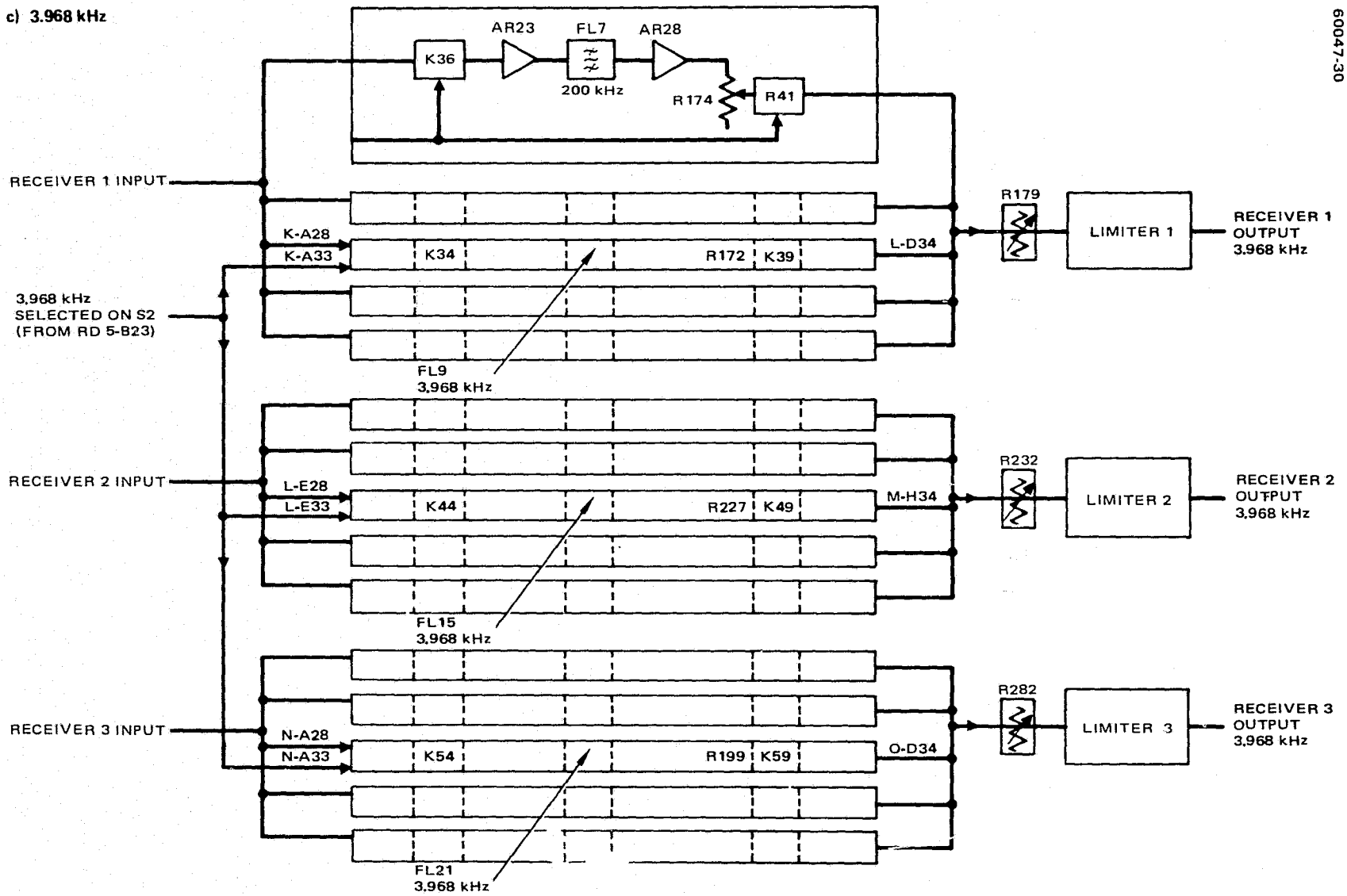


FIGURE 4-13 (CONTINUED). RECEIVED TONE DETECTION

d) 283.4 Hz

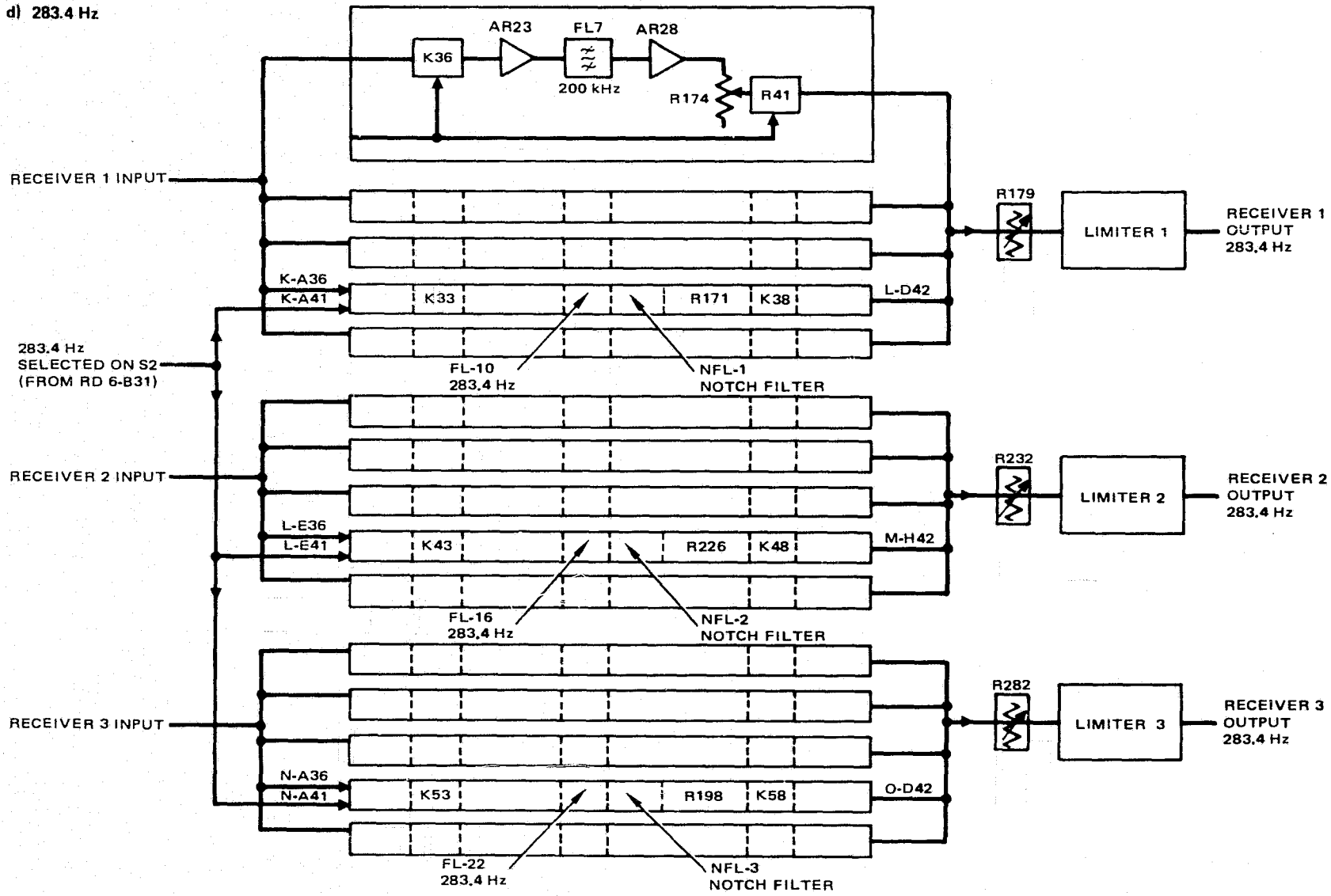
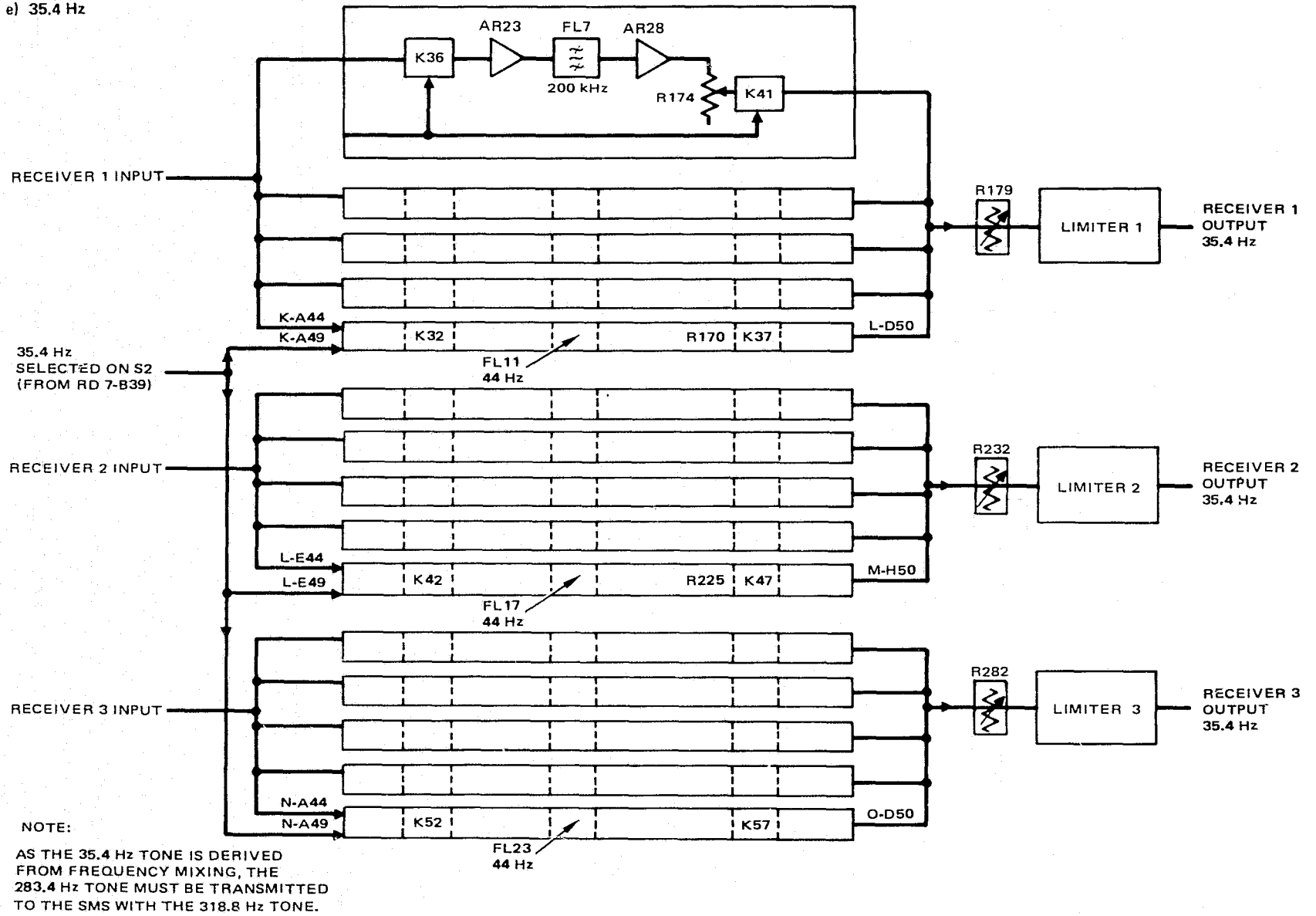


FIGURE 4-13 (CONTINUED). RECEIVED TONE DETECTION

e) 35.4 Hz



NOTE:

AS THE 35.4 Hz TONE IS DERIVED FROM FREQUENCY MIXING, THE 283.4 Hz TONE MUST BE TRANSMITTED TO THE SMS WITH THE 318.8 Hz TONE.

FIGURE 4-13 (CONTINUED). RECEIVED TONE DETECTION

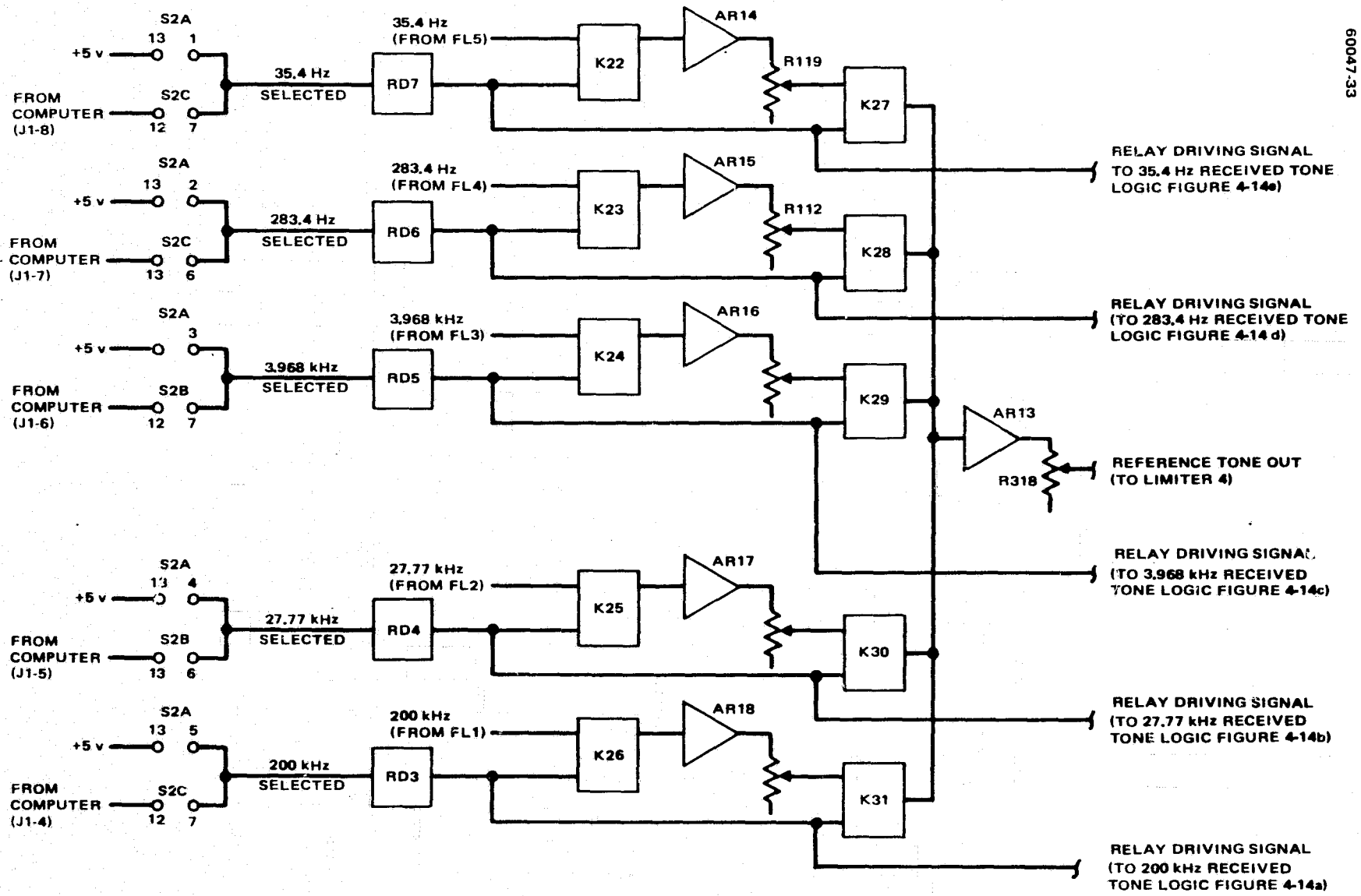


FIGURE 4-14. REFERENCE TONE SELECTION

60047-33

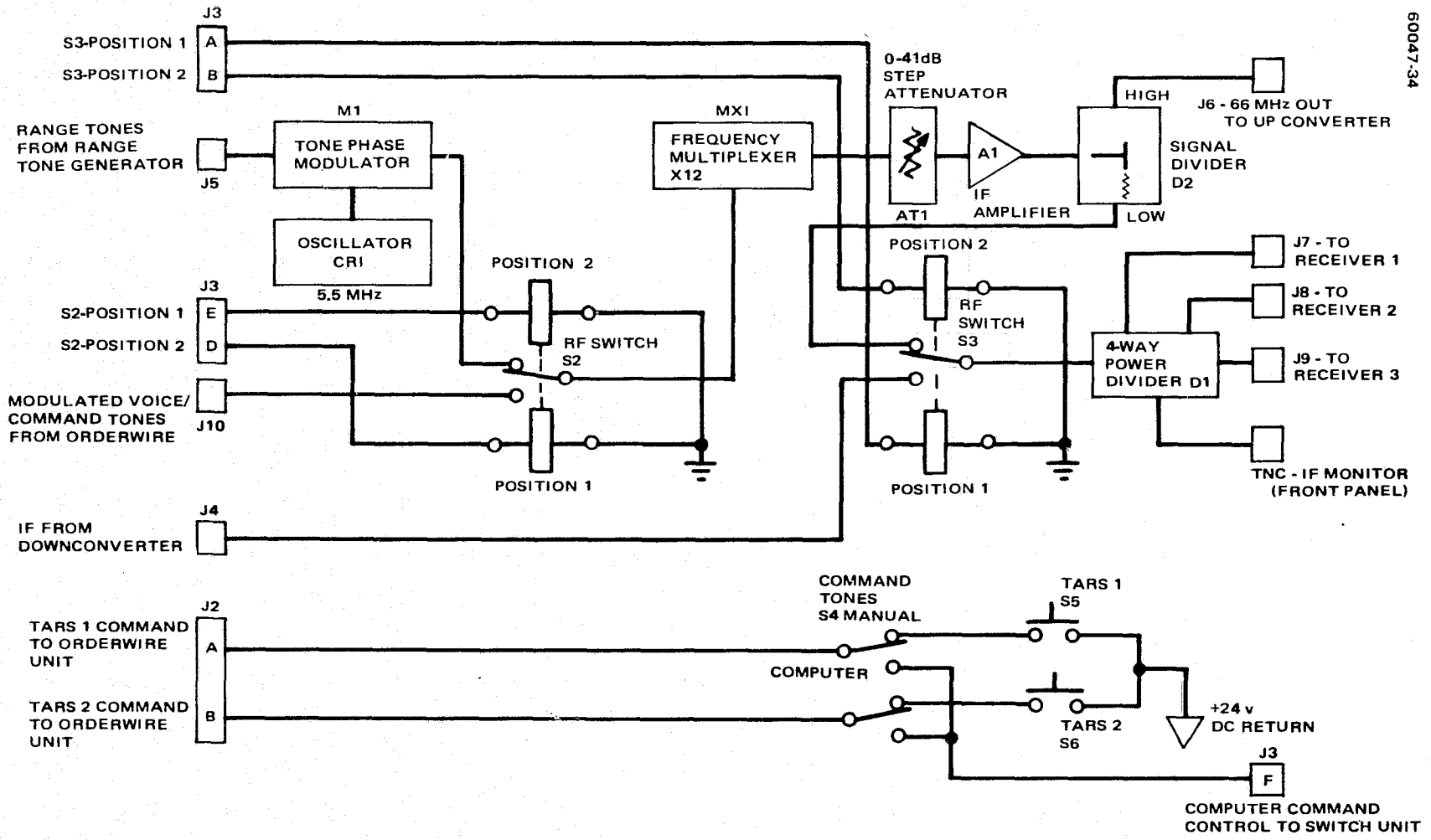


FIGURE 4-15. TONE MODULATOR FUNCTIONAL DIAGRAM

4.3.4 Tone Modulator Unit Theory of Operation

The tone modulator unit, Hughes P/N 3029324, contains the elements required to modulate the range tones developed in the range unit onto a 66 MHz IF frequency of the proper signal level for application to the NASA Station transmitter section. In addition, the tone modulator unit contains the signal switching function to configure the CDA for orderwire operation or for a test loop function. (See Figure 4-15.)

The range tones are applied to the tone modulator unit through connector J5 to tone phase modulator M1 which phase modulates the 5.5 MHz output of oscillator CR1. The modulated 5.5 MHz signal is then applied through RF switch S2 to the X12 frequency multiplier where the 66 MHz IF signal is developed. After the signal is provided with the desired characteristics in step attenuator AT1 and IF amplifier A1, it is applied to signal divider D2 which has asymmetrical outputs. The high level output is applied to connector J6 for ultimate connection to the NASA Station transmitter section; the low signal level output is connected through RF switch S3 to four-way power divider D1. The outputs of the power divider are applied to connectors for further application to each receiver in the CDA and to an IF monitor connector on the front panel of the tone modulator unit for test purposes.

The position of RF switch S2, which is controlled by functions in the switch unit, determines range tone or orderwire operation for the CDA. Note that the signal applied through connector J10 from the orderwire unit is at 5.5 MHz, with prior modulation of the audio frequency signals being accomplished in the orderwire unit.

In addition to the above, the tone modulator unit contains the switching functions required to generate command tones for controlling the transmitting functions in each of the TARS. The command tone generators are physically located and provided prime operating power in the orderwire unit; however, the dc return for the prime power is applied to the generators through TARS 1 and 2 switches S5 and S6 located on the front panel of the tone modulator. Note that the function of these switches is connected in series with command tones switch S4. With S4 in MANUAL, each of the TARS can be controlled as independent functions; with S4 in CMPTR, the CDA computer controls the simultaneous TARS 1 and 2 command tones.

5. TRRR SOFTWARE SYSTEM

5.1 TRRR SOFTWARE SYSTEM LOADING

The following procedure is required for the TRRR software system loading.

1) To use ranging system at the CDA, the "TRRR SYSTEM" tape must be loaded first.

2) To load, place tape in the Dicom numbered 1.

   a) Ensure the computer is in the halt mode (press HALT)

   b) Press "P"

   c) Press "CLEAR DISPLAY"

   d) Press address 27700 in octal into the display register (i.e., switches numbered 13, 11, 10, 9, 8, 7, and 6 should be on)

   e) Press "S"

   f) Press "EXTERNAL PRESET"

   g) Press "INTERNAL PRESET"

   h) Press "LOADER ENABLE" (light should lit and remain illuminated)

   i) Press "RUN"

3) The computer will come to a halt after about 2 minutes with 102077 in octal in the "DISPLAY REGISTER" (i.e., switches numbered 15, 10, 5, 4, 3, 2, 1, and 0 will be illuminated; "LOADER ENABLE" should be off). If this does not occur, return to step 2a.

4) Once this tape is loaded, it should not be necessary to load again unless the computer has been used for another purpose.

5.2 DATA WORD ALLOCATION

The computer output will be as specified in Table 5-1.

5.3 TRRR PROGRAM AND COMPUTER PRINTOUTS

The TRRR memory core allocation is as specified in Table 5-2 and in the computer printouts.

TABLE 5-1. DATA WORD ALLOCATIONS

Word No.	Description		Units
0	Synchronization pattern	1111	Binary
1	Synchronization pattern	0001	Binary
2	Synchronization pattern	1110	Binary
3	Synchronization pattern	0011	Binary
4	Synchronization pattern	1100	Binary
5	Synchronization pattern	0111	Binary
6	Synchronization pattern	1000	Binary
7	Synchronization pattern	1111	Binary
8	Hundreds of days		BCD
9	Tens of days		BCD
10	Units of days		BCD
11	Tens of hours		BCD
12	Units of hours		BCD
13	Tens of minutes		BCD
14	Units of minutes		BCD
15	Tens of seconds		BCD
16	Units of seconds		BCD
17	Spacecraft number		Binary
18	Experiment mode		Binary
	Spacecraft receiver filter temperature		
19	Hundreds of degrees F		BCD
20	Tens of degrees F		BCD
21	Units of degrees F		BCD
	CDA time delay at 200 kHz		BCD
22	10^{-1} sec		BCD
23	10^{-2} sec		BCD
24	10^{-3} sec		BCD
25	10^{-4} sec		BCD
26	10^{-5} sec		BCD
27	10^{-6} sec		BCD

Table 5-1 (continued)

Word #	Descriptions	Units
28	10^{-7} sec	BCD
29	10^{-8} sec	BCD
30	10^{-9} sec	BCD
31	10^{-10} sec	BCD
	CDA time delay at 27.77 kHz	
32	10^{-1} sec	BCD
33	10^{-2} sec	BCD
34	10^{-3} sec	BCD
35	10^{-4} sec	BCD
36	10^{-5} sec	BCD
37	10^{-6} sec	BCD
38	10^{-7} sec	BCD
39	10^{-8} sec	BCD
40	10^{-9} sec	BCD
41	10^{-10} sec	BCD
	CDA time delay at 3.968 kHz	
42	10^{-1} sec	BCD
43	10^{-2} sec	BCD
44	10^{-3} sec	BCD
45	10^{-4} sec	BCD
46	10^{-5} sec	BCD
47	10^{-6} sec	BCD
48	10^{-7} sec	BCD
49	10^{-8} sec	BCD
50	10^{-9} sec	BCD
51	10^{-10} sec	BCD

Table 5-1 (continued)

Word #	Descriptions	Units
	CDA time delay at 283.4 Hz	
52	10^{-1} sec	BCD
53	10^{-2} sec	BCD
54	10^{-3} sec	BCD
55	10^{-4} sec	BCD
56	10^{-5} sec	BCD
57	10^{-6} sec	BCD
58	10^{7} sec	BCD
59	10^{-8} sec	BCD
60	10^{-9} sec	BCD
61	10^{-10} sec	BCD
	CDA time delay at 35.4 Hz	
62	10^{-1} sec	BCD
63	10^{-2} sec	BCD
64	10^{-3} sec	BCD
65	10^{-4} sec	BCD
66	10^{-5} sec	BCD
67	10^{-6} sec	BCD
68	10^{-7} sec	BCD
69	10^{-8} sec	BCD
70	10^{-9} sec	BCD
71	10^{-10} sec	BCD
	TARS I time delay at 200 kHz	
72	10^{-1} sec	BCD
73	10^{-2} sec	BCD
74	10^{-3} sec	BCD
75	10^{-4} sec	BCD
76	10^{-5} sec	BCD
77	10^{-6} sec	BCD
78	10^{-7} sec	BCD

Table 5-1 (continued)

Word #	Descriptions	Units
79	10^{-8} sec	BCD
80	10^{-9} sec	BCD
81	10^{-10} sec	BCD
	TARS I time delay at 27.777 kHz	
82	10^{-1} sec	BCD
83	10^{-2} sec	BCD
84	10^{-3} sec	BCD
85	10^{-4} sec	BCD
86	10^{-5} sec	BCD
87	10^{-6} sec	BCD
88	10^{-7} sec	BCD
89	10^{-8} sec	BCD
90	10^{-9} sec	BCD
91	10^{-10} sec	BCD
	TARS I time delay at 3.968 kHz	
92	10^{-1} sec	BCD
93	10^{-2} sec	BCD
94	10^{-3} sec	BCD
95	10^{-4} sec	BCD
96	10^{-5} sec	BCD
97	10^{-6} sec	BCD
98	10^{-7} sec	BCD
99	10^{-8} sec	BCD
100	10^{-9} sec	BCD
101	10^{-10} sec	BCD
	TARS I time delay at 283.4 Hz	
102	10^{-1} sec	BCD
103	10^{-2} sec	BCD
104	10^{-3} sec	BCD

Table 5-1 (continued)

Word #	Description	Units
105	10^{-4} sec	BCD
106	10^{-5} sec	BCD
107	10^{-6} sec	BCD
108	10^{-7} sec	BCD
109	10^{-8} sec	BCD
110	10^{-9} sec	BCD
111	10^{-10} sec	BCD
	TARS I time delay at 35.4 Hz	
112	10^{-1} sec	BCD
113	10^{-2} sec	BCD
114	10^{-3} sec	BCD
115	10^{-4} sec	BCD
116	10^{-5} sec,	BCD
117	10^{-6} sec	BCD
118	10^{-7} sec	BCD
119	10^{-8} sec	BCD
120	10^{-9} sec	BCD
121	10^{-10} sec	BCD
122	10^{-1} sec	BCD
123	10^{-2} sec	BCD
124	10^{-3} sec	BCD
125	10^{-4} sec	BCD
126	10^{-5} sec	BCD
127	10^{-6} sec	BCD
128	10^{-7} sec	BCD
129	10^{-8} sec	BCD
130	10^{-9} sec	BCD
131	10^{-10} sec	BCD

Table 5-1 (continued)

Word #	Description	Units
	TARS II time delay at 27.777 kHz	
132	10^{-1} sec	BCD
133	10^{-2} sec	BCD
134	10^{-3} sec	BCD
135	10^{-4} sec	BCD
136	10^{-5} sec	BCD
137	10^{-6} sec	BCD
138	10^{-7} sec	BCD
139	10^{-8} sec	BCD
140	10^{-9} sec	BCD
141	10^{-10} sec	BCD
	TARS II time delay at 3.968 kHz	
142	10^{-1} sec	BCD
143	10^{-2} sec	BCD
144	10^{-3} sec	BCD
145	10^{-4} sec	BCD
146	10^{-5} sec	BCD
147	10^{-6} sec	BCD
148	10^{-7} sec	BCD
149	10^{-8} sec	BCD
150	10^{-9} sec	BCD
151	10^{-10} sec	BCD
	TARS II time delay at 283.4 Hz	
152	10^{-1} sec	BCD
153	10^{-2} sec	BCD
154	10^{-3} sec	BCD
155	10^{-4} sec	BCD
156	10^{-5} sec	BCD
157	10^{-6} sec	BCD
158	10^{-7} sec	BCD

Table 5-1 (continued)

Word #	Description	Units
159	10^{-8} sec	BCD
160	10^{-9} sec	BCD
161	10^{-10} sec	BCD
	TARS II time delay at 35.4 Hz	
162	10^{-1} sec	BCD
163	10^{-2} sec	BCD
164	10^{-3} sec	BCD
165	10^{-4} sec	BCD
166	10^{-5} sec	BCD
167	10^{-6} sec	BCD
168	10^{-7} sec	BCD
169	10^{-8} sec	BCD
170	10^{-9} sec	BCD
171	10^{-10} sec	BCD
172	Error message	Binary
173-207	Spares	
208-217	RCDA	BCD
218-227	RTARS I	BCD
228-237	RTARS II	BCD
238-244	$\dot{R}$CDA	BCD
245-251	$\dot{R}$TARS	BCD
252-258	$\dot{R}$TARS II	BCD
259-266	TIME TAG	BCD
267-276	RCDA	BCD
277-286	RTARS I	BCD
287-296	RTARS II	BCD
297-303	$\dot{R}$CDA	BCD
304-310	$\dot{R}$TARS I	BCD
311-317	$\dot{R}$TARS II	BCD
318-325	TIME TAG	BCD

Table 5-1 (continued)

Word #	Description	Units
326-335	RCDA	BCD
336-345	RTARS I	BCD
346-355	RTARS II	BCD
356-362	$\dot{R}$CDA	BCD
363-369	$\dot{R}$TARS I	BCD
370-376	$\dot{R}$TARS II	BCD
377-384	TIME TAG	BCD
385-394	RCDA	BCD
395-404	RTARS I	BCD
405-414	RTARS II	BCD
415-421	$\dot{R}$CDA	BCD
422-428	$\dot{R}$TARS I	BCD
429-435	$\dot{R}$TARS II	BCD
436-443	TIME TAG	BCD
444-453	RCDA	BCD
454-463	RTARS I	BCD
464-473	RTARS II	BCD
474-480	$\dot{R}$CDA	BCD
481-487	$\dot{R}$TARS I	BCD
488-494	$\dot{R}$TARS II	BCD
495-502	TIME TAG	BCD
503-512	RCDA	BCD
513-522	RTARS I	BCD
523-532	RTARS II	BCD
533-539	$\dot{R}$CDA	BCD
540-546	$\dot{R}$TARSI	BCD
547-553	$\dot{R}$TARS II	BCD
554-561	TIME TAG	BCD

Table 5-1 (continued)

Word #	Description	Units
562-571	RCDA	BCD
572-581	RTARS I	BCD
582-591	RTARS II	BCD
592-598	$\dot{R}$CDA	BCD
599-605	$\dot{R}$TARS I	BCD
606-612	$\dot{R}$TARS II	BCD
613-620	TIME TAG	BCD
621-630	RCDA	BCD
631-640	RTARS I	BCD
641-650	RTARS II	BCD
651-657	$\dot{R}$CDA	BCD
658-664	$\dot{R}$TARS I	BCD
665-671	$\dot{R}$TARS II	BCD
672-679	TIME TAG	BCD
680-689	RCDA	BCD
690-699	RTARS I	BCD
700-709	RTARS II	BCD
710-716	$\dot{R}$CDA	BCD
717-723	$\dot{R}$TARS I	BCD
724-730	$\dot{R}$TARS II	BCD
731-738	TIME TAG	BCD

TABLE 5-2. TRRR CORE MAP

System links	0 - 217
Buffer area	420 - 13427
Loader program	13430 - 13515
Equipment table	13516 - 13540
Input/output control	13541 - 13670
Miscellaneous subroutines	13671 - 14003
Modem	14004 - 15366
N5 computation	15367 - 16054
TRRR executive	16055 - 20245
Math routines	20246 - 22003
Time base generator	22004 - 22033
Binary to BCD	22034 - 22155
Read time of day	22156 - 22352
Teletype driver	22353 - 22663
Counter driver	22664 - 24006
Binary to decimal	24007 - 24135
Decimal to ASCII	24135 - 24407
Range rate/adjust	24410 - 26002
Modem send	26003 - 26052
Fixed delay	26053 - 26220
Teletype handler	26221 - 27677

COMPUTER PRINTOUTS

	Page
TRRR PCS Loader	5-15
TRRR Input/Output Control	5-19
Misc Subroutines	5-23
Modem Output	5-27
Decode Subroutine	5-31
N5A: Ambiguity Removal Routine	5-39
Storage and Constants	5-47
TRRR Operating System	5-49
Calibration-Loop and Period	5-53
Ambiguity Removal	5-55
Ranging Operation	5-57
Point Verification	5-61
Final Ambiguity Removal	5-65
Range Rate and Final Output	5-71
Subroutines	5-75
Constants and Working Storage	5-81
Add and Subtract - Full Precision	5-85
Multiply & Divide - Full Precision	5-93
Decimal to Binary	5-103
Time Base Generator Driver	5-107
Binary to BCD	5-109
BCD to Binary	5-111
Read Time of Day	5-113
TTY Driver	5-117
Counter Driver	5-123
Binary to Decimal	5-137
Decimal to ASCII	5-141
Range Rate Routine	5-147
Adjust Range Routine	5-155
Modem Send Routine	5-159
Fixed Delay Computation	5-161
TTY Handler	5-165

TRRR PCS LOADER

```
0001                        ASMB,R,B,L
0003  00000                       NAM LOADR
0004                              ENT .LDR.,HALT.,MEM.,LST
0005                              ENT AREA,TIME,POINT,CDA,TARS1,TARS2
0006                              EXT START
0007                              SUP
0008*
0009  00000 000000               NOP
0010  00001 000057R              DEF .MEM.
0011  00002 027000               OCT 27000
0012  00003 042515               ASC 2,EM.M
0013                              EXT .SQT.
0014  00005 000000               NOP
0015  00006 000002X              DEF .SQT.
0016  00007 027000               OCT 27000
0017  00010 050524               ASC 2,QT.S
0018                              EXT .IOC.
0019  00012 000000               NOP
0020  00013 000003X              DEF .IOC.
0021  00014 027000               OCT 27000
0022  00015 047503               ASC 2,OC.I
0023  00017 000003  LST          DEC 3
0024*
0025  00020 062060R .LDR.        LDA FWABP
0026  00021 042064R              ADA =B200
0027  00022 072053R              STA CDA
0028  00023 003004               CMA,INA
0029  00024 042063R              ADA LWAM
0030  00025 006400               CLB
0031  00026 100400               OCT 100400     DIVIDE BY 3
0032  00027 000047R              DEF .3
0033  00030 072051R              STA AREA
0034  00031 042065R              ADA =B4
0035  00032 042053R              ADA CDA
0036  00033 072054R              STA TARS1
0037  00034 042051R              ADA AREA
0038  00035 042065R              ADA =B4
0039  00036 072055R              STA TARS2
0040  00037 062051R              LDA AREA
0041  00040 001121               ARS,ARS
0042  00041 072052R              STA POINT
0043  00042 006400               CLB
0044  00043 100400               OCT 100400
0045  00044 000050R              DEF .30
0046  00045 072056R              STA TIME
0047  00046 026001X              JMP START
0048*
0049                              UNS
0050  00047 000003  .3           DEC 3
0051  00050 000036  .30          DEC 30
0052  00051 000000  AREA         NOP
0053  00052 000000  POINT        NOP
0054  00053 000000  CDA          NOP
0055  00054 000000  TARS1        NOP
0056  00055 000000  TARS2        NOP
0057  00056 000000  TIME         NOP
0058  00057 000060R MEMRY        DEF *+1
```

```
 PAGE 0003 #01  * TRRR PCS LOADER * 6MAR75


0059   00057           HALT   EQU MEMRY
0060   00057           .MEM.  EQU MEMRY
0061   00060 000000    FWABP  BSS 3
0062   00063 000000    LWAM   NOP
       00064 000200
       00065 000004
0063                           END
**  NO ERRORS! AMD ASMB,25117-40251B
```

TRRR INPUT/OUTPUT CONTROL

```
0001                    ASMB,R,B,L
0003  00000                   NAM IOC
0004                          ENT .IOC.,DMAC1,DMAC2,XSQT,XEQT
0005*
0006  00000 000000  .IOC. NOP
0007  00001 102100         STF 0          TURN ON INTERRUPTS
0008  00002 162000R        LDA .IOC.,I
0009  00003 001700         ALF
0010  00004 012123R        AND B17        REQUEST CODE
0011  00005 072110R        STA R.C.
0012*
0013  00006 162000R        LDA .IOC.,I    GET REQUEST
0014  00007 012124R        AND B77        MASK UNIT NUMBER
0015  00010 070001         STA 1
0016  00011 002003         SZA,RSS        SYSTEM CLEAR ?
0017  00012 026065R        JMP CLRIT      YES: CLEAR ALL DEVICES
0018  00013 042127R        ADA DM7        SUBTRACT 7 FROM ORDINAL. IF
0019  00014 002021         SSA,RSS          RESULT IS POSITIVE, THEN
0020  00015 026022R        JMP IOC1           ORDINAL IS TO EQT,OTHERWISE
0021  00016 046111R        ADB XSQT             IT IS SQT. IF SQT, THEN
0022  00017 046125R        ADB DM1              COMPUTE TO EQT.
0023  00020 160001         LDA 1,I
0024  00021 042127R        ADA DM7
0025*
0026  00022 001020  IOC1   ALS,ALS        MPY BY 4 (4 WD EQT)
0027  00023 002004         INA
0028  00024 042112R        ADA XEQT       STARTING ADDRESS OF EQT
0029  00025 070001         STA 1
0030  00026 072113R        STA EQTT       WORD 1 OF EQT
0031  00027 006004         INB            ADDRESS OF WORD 2 OF EQT
0032  00030 062110R        LDA R.C.
0033  00031 052122R        CPA B4
0034  00032 026061R        JMP IOC3       STATUS REQUEST
0035*
0036  00033 160001         LDA 1,I        WORD 2 OF EQT
0037  00034 046120R        ADB B2
0038  00035 164001         LDB 1,I        WORD 4 OF EQT
0039  00036 076114R        STB DRIV       DRIVER ADDRESS
0040  00037 066110R        LDB R.C.
0041  00040 006003         SZB,RSS        CLEAR REQUEST ?
0042  00041 026055R        JMP IOC4       YES: DON'T CK FOR BUSY
0043  00042 070001         STA 1
0044  00043 002020         SSA            DRIVER BUSY ?
0045  00044 026106R        JMP SST2+1     YES: REJECT REQUEST
0046*
0047  00045 066000R        LDB .IOC.      REQUEST CODE ADDRESS
0048  00046 062113R        LDA EQTT       EQT ADDRESS
0049  00047 116114R        JSB DRIV,I     GO TO DRIVER
0050  00050 002002         SZA            DID DRIVER REJECT ?
0051  00051 026106R        JMP SST2+1     YES: RETURN TO P+12
0052*
0053  00052 066000R        LDB .IOC.
0054  00053 046122R        ADB B4         FORM P+5 EXIT
0055  00054 124001         JMP 1,I        RETURN TO CALLER
0056*
0057  00055 066000R IOC4   LDB .IOC.      CLEAR REQUEST ADDRESS
0058  00056 062113R        LDA EQTT       EQT ADDRESS
```

```
0059  00057 116114R        JSB DRIV,I     GO TO DRIVER
0060  00060 026105R        JMP SST2       RETURN TO P+2
0061*
0062  00061 160001  IOC3   LDA 1,I        STATUS WORD
0063  00062 006004         INB
0064  00063 164001         LDB 1,I        XMISSION LOG
0065  00064 026106R        JMP SST2+1     RETURN TO P+2
0066*
0067  00065 162112R CLRIT  LDA XEQT,I     NUMBER OF EQT ENTRIES
0068  00066 003004         CMA,INA        MAKE NEGATIVE AND SAVE AS
0069  00067 072117R         STA SIOC       AN INDEX COUNTER
0070  00070 062112R         LDA XEQT
0071  00071 002004         INA            ADDRESS OF WORD 1 OF EQT
0072*
0073  00072 072115R CLR1   STA DMAC1
0074  00073 042121R         ADA B3       DRIVER ADDRESS
0075  00074 164000         LDB 0,I
0076  00075 076114R         STB DRIV
0077  00076 062115R         LDA DMAC1      EQT ENTRY ADDRESS
0078  00077 066000R         LDB .IOC.      REQUEST CODE ADDRESS
0079  00100 116114R         JSB DRIV,I     OPERATE DRIVER
0080*
0081  00101 062115R         LDA DMAC1
0082  00102 042122R         ADA B4       ADDRESS OF NEXT ENTRY
0083  00103 036117R         ISZ SIOC       ALL DONE ?
0084  00104 026072R         JMP CLR1       NO: DO NEXT ONE
0085  00105 006400  SST2     CLB            YES: RETURN TO P+2
0086  00106 036000R         ISZ .IOC.
0087  00107 126000R         JMP .IOC.,I
0088*
0089  00110 000000  R.C.     NOP
0090  00111 000000  XSQT     NOP
0091  00112 000000  XEQT     NOP
0092  00113 000000  EQTT     NOP
0093  00114 000000  DRIV     NOP
0094  00115 000000  DMAC1    NOP
0095  00116 000000  DMAC2    NOP
0096  00117 000000  SIOC     NOP
0097  00120 000002  B2       OCT 2
0098  00121 000003  B3       OCT 3
0099  00122 000004  B4       OCT 4
0100  00123 000017  B17      OCT 17
0101  00124 000077  B77      OCT 77
0102  00125 177777  DM1      DEC -1
0103  00126 177776  DM2      DEC -2
0104  00127 177771  DM7      DEC -7
0105                         END
** NO ERRORS: AMD ASMB,25117-402518
```

MISC SUBROUTINES

```
0001                        ASMB,R,B,L
0003  00000                       NAM MISC
0004                              ENT ABORT,LOCK1,LINK2,LINK3
0005                              ENT RUDOT,PRINT,CLEAR
0006                              EXT LINKS,.IOC.,START
0007                              EXT OKFLL,ETIME,RTTYB
0008*
0009  00000 000000  LINK2 NOP
0010  00001 060000R       LDB LINK2
0011  00002 076005R       STB LINK3
0012  00003 062106R       LDA =B-2
0013  00004 026007R       JMP LINK3+2
0014*
0015  00005 000000  LINK3 NOP
0016  00006 062107R       LDA =B-3
0017  00007 042001X       ADA LINKS
0018  00010 002021        SSA,RSS
0019  00011 036005R       ISZ LINK3
0020  00012 126005R       JMP LINK3,I
0021*
0022  00013 016002X ABORT JSB .IOC.
0023  00014 000000        NOP
0024  00015 003400        CCA
0025  00016 102615        OTA RUD
0026  00017 002400        CLA
0027  00020 072004X       STA OKFLL
0028  00021 026003X       JMP START
0029*
0030  00022 000000  RUDOT NOP
0031  00023 003000        CMA
0032  00024 012110R       AND =B377
0033  00025 102615        OTA RUD
0034  00026 062111R       LDA =D30000
0035  00027 016005X       JSB ETIME
0036  00030 126022R       JMP RUDOT,I
0037*
0038  00031 000000  LOCK1 NOP
0039  00032 062112R       LDA =D4
0040  00033 016043R       JSB PRINT
0041  00034 000102R       DEF MSG
0042  00035 036004X       ISZ OKFLL
0043  00036 003400        CCA
0044  00037 016006X       JSB RTTYB
0045  00040 002400        CLA
0046  00041 072004X       STA OKFLL
0047  00042 126031R       JMP LOCK1,I
0048*
0049  00043 000000  PRINT NOP
0050  00044 072062R       STA CNTP
0051  00045 162043R       LDA PRINT,I
0052  00046 036043R       ISZ PRINT
0053  00047 072061R       STA LOCP
0054  00050 016002X       JSB .IOC.
0055  00051 040001        OCT 40001
0056  00052 002021        SSA,RSS
0057  00053 026056R       JMP *+3
0058  00054 016002X       JSB .IOC.
```

```
0059  00055 000001          OCT 1
0060  00056 016002X         JSB .IOC.
0061  00057 020001          OCT 20001
0062  00060 026056R         JMP *-2
0063  00061 000000  LOCP    NOP
0064  00062 000000  CNTP    NOP
0065  00063 016002X         JSB .IOC.
0066  00064 040001          OCT 40001
0067  00065 002020          SSA
0068  00066 026063R         JMP *-3
0069  00067 126043R         JMP PRINT,I
0070*
0071  00070 000000  CLEAR   NOP
0072  00071 002021          SSA,RSS
0073  00072 003004          CMA,INA
0074  00073 072062R         STA CNTP
0075  00074 002400          CLA
0076  00075 170001          STA 1,I
0077  00076 006004          INB
0078  00077 036062R         ISZ CNTP
0079  00100 026075R         JMP *-3
0080  00101 126070R         JMP CLEAR,I
0081*
0082  00015           RUD   EQU 15B
0083  00102 046117  MSG     ASC 4,LOCK-UP?
      00103 041513
      00104 026525
      00105 050077
      00106 177776
      00107 177775
      00110 000377
      00111 072460
      00112 000004
0084                        END
**  NO ERRORS! AMD ASMB,25117-402518
```

MODEM OUTPUT

```
0001                    ASMB,R,B,L
0003  00000                     NAM MODEM
0004                            ENT MODEM,MODT,DECOD,MSX,MTX
0005                            EXT DONE,CDA,TARS1,TARS2,MODSX,A77B
0006                            EXT .35FD,MOVE,LINKS,BIBCD,BTD
0007                            EXT DMUL,DADD,SHAME,SEND,N5C,N5T1,N5T2
0008                            ENT B570,MODE
0009*
0010  00000 000000  MODEM NOP
0011  00001 062001X         LDA DONE
0012  00002 003004          CMA,INA         SAVE NUMBER OF POINTS
0013  00003 072645R         STA COUNT
0014  00004 062002X         LDA CDA
0015  00005 072116R         STA MODZ        ADDRESS OF CDA DATA
0016  00006 162000R         LDA MODEM,I
0017  00007 036000R         ISZ MODEM
0018  00010 072646R         STA R.CDA       RANGE RATE OF CDA
0019  00011 062003X         LDA TARS1
0020  00012 072647R         STA TAR1        TARS 1 DATA
0021  00013 072117R         STA MODZ+1
0022  00014 162000R         LDA MODEM,I
0023  00015 036000R         ISZ MODEM
0024  00016 072650R         STA R.TA1       RANGE RATE OF TARS 1
0025  00017 062004X         LDA TARS2
0026  00020 072651R         STA TAR2        TARS 2 DATA
0027  00021 072120R         STA MODZ+2
0028  00022 162000R         LDA MODEM,I
0029  00023 036000R         ISZ MODEM
0030  00024 072652R         STA R.TA2       RANGE RATE OF TARS 2
0031  00025 036006X         ISZ A77B
0032  00026 002001          RSS
0033  00027 126000R         JMP MODEM,I
0034*
0035  00030 002400  UP      CLA
0036  00031 016516R         JSB MSX         CLEAR OUT MODEM BUFR
0037  00032 067030R         LDB INDEX       1ST WORD OF PACKING BUFFER
0038  00033 076713R         STB XXX
0039  00034 047337R         ADB =D197
0040  00035 062005X         LDA MODSX       YEAR IN LAST WORD OF BUFFER
0041  00036 170001          STA 1,I
0042  00037 063340R         LDA =D-2
0043  00040 072714R         STA XXX1
0044  00041 000040          CLE
0045  00042 063341R         LDA =D-14
0046  00043 066715R         LDB MODT      PACK FIRST 21 CHARS,
0047  00044 016265R         JSB PACK        AND SEND OVER MODEM
0048*
0049  00045 063342R         LDA =D-3
0050  00046 072653R         STA CNT1
0051  00047 062007X         LDA .35FD       FIXED DELAY ADDRESS
0052  00050 072654R         STA FIXD
0053  00051 063343R         LDA =B5
0054  00052 072655R         STA CNT
0055*
0056  00053 062734R STORE   LDA B570        TEMP STORAGE FOR BCD DIGITS
0057  00054 072673R         STA MODD
0058  00055 003400          CCA
```

```
0059  00056 042655R        ADA CNT
0060  00057 072655R        STA CNT
0061  00060 002020         SSA             5 SETS OF READINGS SENT OUT ?
0062  00061 026100R        JMP OVER        YES: PICK UP NEXT SET
0063  00062 001020         ALS,ALS         NO: MULTIPLY CNT BY 4
0064  00063 042654R        ADA FIXD        ADD FIXED DELAY ADDRESS
0065  00064 066407R        LDB ANSY
0066  00065 016010X        JSB MOVE        MOVE DECIMAL NUMBER INTOTHIS PRO
0067  00066 063342R        LDA =D-3
0068  00067 016453R        JSB SHIFT       SHIFT DIGITS INTO POSITION
0069  00070 067344R        LDB =D-10        UNPACK 10 BCD DIGITS
0070  00071 016307R        JSB UNPK
0071  00072 000657R        DEF ANS+1
0072  00073 000040         CLE
0073  00074 063344R        LDA =D-10        OUTPUT DIGITS OVER MODEM
0074  00075 066734R        LDB B570
0075  00076 016265R        JSB PACK
0076  00077 026053R        JMP STORE       GET NEXT FIXED DELAY
0077*
0078  00100 062654R OVER   LDA FIXD        SET ADDRESS FOR NEXT SET
0079  00101 043345R        ADA =D20          OF 5 FIXED DELAYS
0080  00102 072654R        STA FIXD
0081  00103 036653R        ISZ CNT1        3 SETS OF 5 FINISHED ?
0082  00104 026051R        JMP STORE-2      NO: GET NEXT SET
0083*
0084  00105 067346R        LDB =D-18        PACK ZEROS FOR SPARES
0085  00106 002400         CLA
0086  00107 072670R        STA TEMP2
0087  00110 016501R        JSB PLACE
0088  00111 006006         INB,SZB
0089  00112 026106R        JMP *-4
0090*
0091  00113 063344R        LDA =D-10        SET FOR 10 SETS OF READINGS
0092  00114 072671R        STA START
0093  00115 016161R        JSB DECOD       DECODE DATA
0094  00116 000000  MODZ   BSS 3
0095  00121 062671R        LDA START
0096  00122 000040         CLE             CHECK TO SEE IF WORKING ON
0097  00123 000010         SLA              ODD OR EVEN WORD
0098  00124 002200         CME             ODD
0099  00125 063347R        LDA =D-59
0100  00126 066734R        LDB B570
0101  00127 016265R        JSB PACK        PACK AND SEND BCD DIGITS
0102  00130 062116R        LDA MODZ        BUMP ADDRESSES BY 4
0103  00131 043350R        ADA =B4
0104  00132 072116R        STA MODZ
0105  00133 062117R        LDA MODZ+1
0106  00134 043350R        ADA =B4
0107  00135 072117R        STA MODZ+1
0108  00136 062120R        LDA MODZ+2
0109  00137 043350R        ADA =B4
0110  00140 072120R        STA MODZ+2
0111*
0112  00141 036645R        ISZ COUNT       ALL POINTS FINISHED
0113  00142 002001         RSS             NO:
0114  00143 026151R        JMP FINI        YES: GET OUT
0115  00144 036671R        ISZ START       10 SETS OF POINTS FINISHED ?
```

```
0116  00145 026115R        JMP MODZ-1     NO: KEEP GOING
0117  00146 002400         CLA
0118  00147 016545R        JSB MTX        SEND OUT OVER MODEM
0119  00150 026030R        JMP UP         SEND OUT NEXT 800 WORDS
0120*
0121  00151 062671R FINI    LDA START      SEND OUT ZEROS TO COMPLETE
0122  00152 000010          SLA             800 WORDS
0123  00153 026156R         JMP EVEN
0124  00154 062670R         LDA TEMP2
0125  00155 016501R         JSB PLACE
0126  00156 002400  EVEN     CLA
0127  00157 016545R         JSB MTX         SEND OVER MODEM
0128  00160 126000R         JMP MODEM,I    RETURN TO CALLER
```

DECODE SUBROUTINE

```
0131  00161 000000  DECOD NOP
0132  00162 162161R       LDA DECOD,I
0133  00163 036161R       ISZ DECOD
0134  00164 072212R       STA RCDA
0135  00165 162161R       LDA DECOD,I
0136  00166 036161R       ISZ DECOD
0137  00167 072215R       STA TART1
0138  00170 162161R       LDA DECOD,I
0139  00171 036161R       ISZ DECOD
0140  00172 072220R       STA TART2
0141*
0142  00173 006400        CLB
0143  00174 062002X       LDA CDA        SUBTRACT START OF CDA TABLE
0144  00175 003004        CMA,INA         FROM WHERE CALLER IS
0145  00176 042212R       ADA RCDA
0146  00177 001121        ARS,ARS        DIVIDE BY 4
0147  00200 043351R       ADA =D-30       SUBTRACT 30 UNTIL NUMBER GOES
0148  00201 002020        SSA             NEGATIVE,THIS TELLS WHICH
0149  00202 026205R       JMP *+3          R, TO PICK UP
0150  00203 006004        INB
0151  00204 026200R       JMP *-4
0152  00205 076672R       STB MARK
0153*
0154  00206 062734R       LDA B570
0155  00207 072673R       STA MODO       TEMP STORAGE FOR BCD DIGITS
0156  00210 062020X       LDA N5C
0157  00211 016335R       JSB TDIGS      CONVERT RCDA TO 10 DIGITS
0158  00212 000000  RCDA  NOP
0159  00213 062021X       LDA N5T1
0160  00214 016335R       JSB TDIGS      CONVERT TART 1 TO 10 DIGITS
0161  00215 000000  TART1 NOP
0162  00216 062022X       LDA N5T2
0163  00217 016335R       JSB TDIGS      CONVERT TART 2 TO 10 DIGITS
0164  00220 000000  TART2 NOP
0165*
0166  00221 062646R       LDA R,CDA      CONVERT R,CDA TO 7 DIGITS
0167  00222 016425R       JSB SEDIG
0168  00223 062650R       LDA R,TA1      CONVERT R,TART 1 TO 7 DIGITS
0169  00224 016425R       JSB SEDIG
0170  00225 062652R       LDA R,TA2      CONVERT R,TART 2 TO 7 DIGITS
0171  00226 016425R       JSB SEDIG
0172*
0173  00227 002400        CLA
0174  00230 072656R       STA ANS
0175  00231 072657R       STA ANS+1
0176  00232 062212R       LDA RCDA       ADD THE 3 TIME TAGS
0177  00233 016437R       JSB ADDIT
0178  00234 062215R       LDA TART1
0179  00235 016437R       JSB ADDIT
0180  00236 062220R       LDA TART2
0181  00237 016437R       JSB ADDIT
0182  00240 062011X       LDA LINKS       NUMBER OF LINKS
0183  00241 100200        OCT 100200      MPY BY 10,000
0184  00242 000675R       DEF D10K
0185  00243 072676R       STA DIVSR
0186  00244 104200        OCT 104200     DLD THE SUM OF TIME TAGS
0187  00245 000656R       DEF ANS
```

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0188  00246 100400          OCT 100400     DIVIDE BY 30000
0189  00247 000676R         DEF DIVSR
0190  00250 076656R         STB ANS        SAVE REMAINDER
0191  00251 016012X         JSB BIBCD      CONVERT SECONDS TO BCD
0192  00252 072657R         STA ANS+1
0193  00253 062656R         LDA ANS        CONVERT MS TO BCD
0194  00254 006400          CLB
0195  00255 100400          OCT 100400     DIVIDE BY 3
0196  00256 000011X         DEF LINKS       ADDRESS OF NUMBER OF LINKS
0197  00257 016012X         JSB BIBCD
0198  00260 072660R         STA ANS+2
0199  00261 067352R         LDB =D-8        UNPACK THE 8 DIGITS
0200  00262 016307R         JSB UNPK
0201  00263 000657R         DEF ANS+1
0202  00264 126161R         JMP DECOD,I    EXIT
0203*
0204  00265 000000  PACK    NOP
0205  00266 072677R         STA CNT2       NUMBER OF DIGITS TO PACK
0206  00267 002040          SEZ
0207  00270 026300R         JMP ODD        ODD PACK
0208  00271 160001  SENT    LDA 1,I        PICK UP BCD DIGIT
0209  00272 001700          ALF            POSITION
0210  00273 072670R         STA TEMP2      SAVE CHAR.
0211  00274 006004          INB            BUMP ADDRESS
0212  00275 036677R         ISZ CNT2       ALL CHARS. PICKED UP ?
0213  00276 002001          RSS            NO: GET NEXT ONE
0214  00277 126265R         JMP PACK,I     YES: EXIT
0215  00300 062670R ODD     LDA TEMP2      COMBINE 2 BCD DIGITS
0216  00301 130001          IOR 1,I
0217  00302 006004          INB            BUMP ADDRESS
0218  00303 016501R         JSB PLACE       PACK FOR MODEM
0219  00304 036677R         ISZ CNT2       ALL DONE ?
0220  00305 026271R         JMP SENT       NO: PICK UP NEXT CHAR.
0221  00306 126265R         JMP PACK,I     YES: EXIT
0222*
0223  00307 000000  UNPK    NOP
0224  00310 076677R         STB CNT2       NUMBER OF DIGITS TO UNPACK
0225  00311 162307R         LDA UNPK,I
0226  00312 036307R         ISZ UNPK
0227  00313 072700R         STA FIND
0228*
0229  00314 063353R AG1     LDA =D-4        COUNTER FOR 4 BCD DIG. PER WORD
0230  00315 072701R         STA CNT3
0231  00316 162700R         LDA FIND,I
0232  00317 036700R         ISZ FIND
0233  00320 072702R         STA TEMP1      SAVE DIGITS
0234*
0235  00321 062702R AG2     LDA TEMP1
0236  00322 001700          ALF            ROTATE HIGH DIGIT TO LOW ORDER
0237  00323 072702R         STA TEMP1
0238  00324 013354R         AND =B17        MASK DIGIT
0239  00325 172673R         STA MODO,I     PUT IT AWAY IN TEMP AREA
0240  00326 036673R         ISZ MODO
0241  00327 036677R         ISZ CNT2       ALL DIGITS UNPACKED ?
0242  00330 002001          RSS            NO:
0243  00331 126307R         JMP UNPK,I     YES: EXIT
0244  00332 036701R         ISZ CNT3       4 DIGITS UNPAXED ?
```

```
0245  00333 026321R        JMP AG2         NO: GET NEXT ONE
0246  00334 026314R        JMP AG1         PICK UP NEXT WORD
0247*
0248  00335 000000  TDIGS  NOP
0249  00336 016472R        JSB SAVES
0250  00337 166335R        LDB TDIGS,I     IF IT IS A BAD POINT
0251  00340 036335R        ISZ TDIGS       PUT 0'S IN BUFFER
0252  00341 002400         CLA
0253  00342 072342R        STA .....       SET SIGN TO PLUS
0254  00343 104200         OCT 104200      DLD 1,I
0255  00344 100001         DEF 1,I
0256  00345 002021         SSA,RSS         NEGATIVE NO. ?
0257  00346 026354R        JMP ....        NO: POSITIVE
0258  00347 003100         CMA,CLE         YES: 2'S COMPLIMENT
0259  00350 007004         CMB,INB
0260  00351 002040         SEZ
0261  00352 002004         INA
0262  00353 036642R        ISZ .....       SET SIGN TO NEGATIVE
0263  00354 104400  .... OCT 104400       DST
0264  00355 000643R ..OFF  DEF .OFF
0265  00356 002003         SZA,RSS
0266  00357 006002         SZB
0267  00360 026367R        JMP NZERO
0268*
0269  00361 067344R        LDB =D-10
0270  00362 172673R        STA MODO,I
0271  00363 036673R        ISZ MODO
0272  00364 006006         INB,SZB
0273  00365 026362R        JMP *-3
0274  00366 126335R        JMP TDIGS,I
0275*
0276  00367 016013X NZERO  JSB BTD         'CONVERT MS DIGITS OF NUMBER
0277  00370 000643R        DEF .OFF          TO DECIMAL
0278  00371 000664R        DEF DEC
0279  00372 016014X        JSB DMUL        MULTIPLY BY 131,072
0280  00373 000664R        DEF DEC
0281  00374 000703R        DEF T131
0282  00375 000664R        DEF DEC
0283  00376 062355R        LDA ..OFF
0284  00377 002004         INA             CONVERT LS DIGITS TO DECIMAL
0285  00400 072402R        STA **2
0286  00401 016013X        JSB BTD
0287  00402 000000         NOP
0288  00403 000707R        DEF DEC1
0289  00404 016015X        JSB DADD        ADD THE 2 TOGETHER
0290  00405 000664R        DEF DEC
0291  00406 000707R        DEF DEC1
0292  00407 000656R ANSY   DEF ANS
0293  00410 062642R        LDA .....       SIGN OF NO.
0294  00411 002002         SZA
0295  00412 036656R        ISZ ANS         ADJUST SIGN
0296  00413 016015X        JSB DADD        ADD N5T5
0297  00414 000656R        DEF ANS
0298  00415 000000  ADDR   NOP
0299  00416 000656R        DEF ANS
0300  00417 063340R        LDA =D-2         IF THE ANSWER IS IN NANO SEC,
0301  00420 016453R        JSB SHIFT        ADJUST THE DIGITS.IF NOT  ?????
```

```
0302  00421 067344R        LDB =D-10       UNPACK 10 DIGITS
0303  00422 016307R        JSB UNPK
0304  00423 000657R        DEF ANS+1
0305  00424 126335R        JMP TDIGS,I     EXIT
0306*
0307  00425 000000  SEDIG  NOP
0308  00426 016472R        JSB SAVES
0309  00427 066407R        LDB ANSY        MOVE NUMBER INTO PROGRAM
0310  00430 016010X        JSB MOVE
0311  00431 063355R        LDA =D-5
0312  00432 016453R        JSB SHIFT
0313  00433 067356R        LDB =D-7        UNPACK 7 DIGITS
0314  00434 016307R        JSB UNPK
0315  00435 000657R        DEF ANS+1
0316  00436 126425R        JMP SEDIG,I     EXIT
0317*
0318  00437 000000  ADDIT  NOP
0319  00440 043357R        ADA =B2         ADDRESS OF TIME TAG
0320  00441 104200         OCT 104200      DLD 0,I
0321  00442 100000         DEF 0,I
0322  00443 000040         CLE
0323  00444 042656R        ADA ANS         ADD PREVIOUS ANSWER
0324  00445 002040         SEZ
0325  00446 006004         INB
0326  00447 046657R        ADB ANS+1
0327  00450 104400         OCT 104400      DST ANS
0328  00451 000656R        DEF ANS
0329  00452 126437R        JMP ADDIT,I
0330*
0331  00453 000000  SHIFT  NOP
0332  00454 072664R        STA DEC
0333  00455 062656R        LDA ANS         FETCH EXPONENT
0334  00456 001727         ALF,ALF
0335  00457 013360R        AND =B177
0336  00460 042664R        ADA DEC         SCALING NUMBER
0337  00461 003004         CMA,INA
0338  00462 072664R        STA DEC         SHIFT COUNTER
0339  00463 002021         SSA,RSS         IF IT IS A PLUS NO. ,TOO BAD !!!
0340  00464 126453R        JMP SHIFT,I
0341  00465 062407R        LDA ANSY        SHIFT DIGITS RITE
0342  00466 016016X        JSB SHAME
0343  00467 036664R        ISZ DEC
0344  00470 026465R        JMP *-3
0345  00471 126453R        JMP SHIFT,I
0346*
0347  00472 000000  SAVES  NOP
0348  00473 072415R        STA ADDR
0349  00474 062672R        LDA MARK
0350  00475 001020         ALS,ALS
0351  00476 042415R        ADA ADDR
0352  00477 072415R        STA ADDR
0353  00500 126472R        JMP SAVES,I
0354*
0355  00501 000000  PLACE  NOP
0356  00502 036714R        ISZ XXX1
0357  00503 026512R        JMP WHY
0358  00504 132713R        IOR XXX,I
```

```
0359  00505 172713R         STA XXX,I
0360  00506 036713R         ISZ XXX
0361  00507 063340R         LDA =D-2
0362  00510 072714R         STA XXX1
0363  00511 126501R         JMP PLACE,I
0364  00512 001727   WHY     ALF,ALF
0365  00513 132713R         IOR XXX,I
0366  00514 172713R         STA XXX,I
0367  00515 126501R         JMP PLACE,I
0368*
0369  00516 000000   MSX     NOP             MODEM SET
0370  00517 072636R         STA VALUE
0371  00520 063030R         LDA INDEX
0372  00521 072637R         STA POINT
0373  00522 063361R         LDA =D-198
0374  00523 072640R         STA COUNR
0375  00524 063353R MS10    LDA =D-4
0376  00525 072641R         STA CNTR
0377*
0378  00526 002400          CLA
0379  00527 172637R         STA POINT,I
0380  00530 062636R MS20    LDA VALUE
0381  00531 013354R         AND =B17
0382  00532 070001          STA 1
0383  00533 162637R         LDA POINT,I
0384  00534 001700          ALF
0385  00535 030001          IOR 1
0386  00536 172637R         STA POINT,I
0387  00537 036641R         ISZ CNTR
0388  00540 026530R         JMP MS20
0389*
0390  00541 036637R         ISZ POINT
0391  00542 036640R         ISZ COUNR
0392  00543 026524R         JMP MS10
0393  00544 126516R         JMP MSX,I
0394*
0395  00545 000000   MTX     NOP             MODEM SEND
0396  00546 002003          SZA,RSS
0397  00547 002004          INA
0398  00550 003004          CMA,INA
0399  00551 072640R         STA COUNR
0400  00552 067362R         LDB =D-400      SEND PREAMBLE
0401  00553 002400          CLA
0402  00554 016017X         JSB SEND
0403  00555 006006          INB,SZB
0404  00556 026553R         JMP *-3
0405  00557 062632R MT10    LDA TAB         SEND SYNC
0406  00560 001727          ALF,ALF
0407  00561 016017X         JSB SEND
0408  00562 062632R         LDA TAB
0409  00563 016017X         JSB SEND
0410  00564 062633R         LDA TAB+1
0411  00565 001727          ALF,ALF
0412  00566 016017X         JSB SEND
0413  00567 062633R         LDA TAB+1
0414  00570 016017X         JSB SEND
0415*
```

```
0416  00571 063361R        LDA =D-198
0417  00572 072641R        STA CNTR
0418  00573 063030R        LDA INDEX
0419  00574 072637R        STA POINT
0420  00575 162637R MT20    LDA POINT,I
0421  00576 001727          ALF,ALF
0422  00577 016610R         JSB REW          REVERSE BITS
0423  00600 162637R         LDA POINT,I
0424  00601 016610R         JSB REW
0425  00602 036637R         ISZ POINT
0426  00603 036641R         ISZ CNTR
0427  00604 026575R         JMP MT20
0428  00605 036640R         ISZ COUNR
0429  00606 026557R         JMP MT10
0430  00607 126545R         JMP MTX,I
0431*
0432  00610 000000  REW     NOP
0433  00611 016621R         JSB SHFT
0434  00612 076635R         STB SAVER
0435  00613 016621R         JSB SHFT
0436  00614 005700          BLF
0437  00615 060001          LDA 1
0438  00616 032635R         IOR SAVER
0439  00617 016017X         JSB SEND
0440  00620 126610R         JMP REW,I
0441*
0442  00621 000000  SHFT    NOP
0443  00622 067353R         LDB =D-4
0444  00623 076634R         STB CNTR1
0445  00624 006400          CLB
0446  00625 001500          ERA
0447  00626 005600          ELB
0448  00627 036634R         ISZ CNTR1
0449  00630 026625R         JMP *-3
0450  00631 126621R         JMP SHFT,I
0451*
0452  00632 004214  TAB     OCT 4214         8,10,10,14
0453  00633 147357          OCT 147357       14,10,10,17
0454  00634 000000  CNTR1   NOP
0455  00635 000000  SAVER   NOP
0456  00636 000000  VALUE   NOP
0457  00637 000000  POINT   NOP
0458  00640 000000  COUNR   NOP
0459  00641 000000  CNTR    NOP
0460  00642 000000  .....   NOP
0461  00643 000000  .OFF    BSS 2
0462  00645 000000  COUNT   NOP
0463  00646 000000  R.CDA   NOP
0464  00647 000000  TAR1    NOP
0465  00650 000000  R.TA1   NOP
0466  00651 000000  TAR2    NOP
0467  00652 000000  R.TA2   NOP
0468  00653 000000  CNT1    NOP
0469  00654 000000  FIXD    NOP
0470  00655 000000  CNT     NOP
0471  00656 000000  ANS     BSS 6
0472  00664 000000  DEC     BSS 4
```

```
0473   00670 000000   TEMP2 NOP
0474   00671 000000   START NOP
0475   00672 000000   MARK  NOP
0476   00673 000000   MODO  NOP
0477   00674 072460   D30K  DEC 30000
0478   00675 023420   D10K  DEC 10000
0479   00676 000000   DIVSR NOP
0480   00677 000000   CNT2  NOP
0481   00700 000000   FIND  NOP
0482   00701 000000   CNT3  NOP
0483   00702 000000   TEMP1 NOP
0484   00703 000000   T131  OCT 0,0,23,10162
       00704 000000
       00705 000023
       00706 010162
0485   00707 000000   DEC1  BSS 4
0486   00713 000000   XXX   NOP
0487   00714 000000   XXX1  NOP
0488   00715 000716R MODT   DEF *+1
0489   00716 000000         BSS 10
0490   00730 000000   MODE  NOP
0491   00731 000000         BSS 3
0492   00734 000735R B570   DEF *+1
0493   00735 000000         BSS 59
0494   01030 001031R INDEX  DEF *+1
0495   01031 000000         BSS 198
       01337 000305
       01340 177776
       01341 177762
       01342 177775
       01343 000005
       01344 177766
       01345 000024
       01346 177756
       01347 177705
       01350 000004
       01351 177742
       01352 177770
       01353 177774
       01354 000017
       01355 177773
       01356 177771
       01357 000002
       01360 000177
       01361 177472
       01362 177160
0496                        END
**  NO ERRORS: AMD ASMB,25117-402518
```

N5A: AMBIGUITY REMOVAL ROUTINE

```
0001                    ASMB,R,B,L
0003  00000                    NAM N5A
0004                           ENT N5A
0005                           EXT DSUB,DADD,DDIV,DMUL,DTBI
0006                           EXT BTD,N.VAL,MODE,IN0C,IN0T1,IN0T2
0007*
0008***  6MAR75
0009*
0010*    N5A:  AMBIGUITY REMOVAL ROUTINE
0011*     CALL: LDB LINK
0012*           JSB N5A
0013*           DEF RDNGS    ADDR OF LOW TONE RDNG
0014*           DEF FD,A        FIXED DELAYS
0015*           DEF N5ADR       ADDR FOR
0016*           DEF DN5           RESULTS
0017*
0018*****************************************************
0019*
0020                           SUP
0021*
0022  00000 000000  N5A    NOP
0023  00001 076406R        STB LINK
0024  00002 166000R        LDB N5A,I     ADDR OF 35HZ RDNG
0025  00003 076061R        STB R35H
0026  00004 076074R        STB RD35
0027  00005 046410R        ADB .4        ADDR OF 283HZ RDNG
0028  00006 076103R        STB R283A
0029  00007 076107R        STB R283B
0030  00010 046410R        ADB .4        ADDR OF 4K RDNG
0031  00011 076116R        STB .4KAD
0032  00012 076122R        STB R4KA
0033  00013 046410R        ADB .4          ADDR OF 27.7K HZ RDNG
0034  00014 076131R        STB R27K
0035  00015 076135R        STB R27KA
0036  00016 036000R        ISZ N5A
0037  00017 166000R        LDB N5A,I     ADDR OF FIXED DELAYS
0038  00020 076062R        STB FD35
0039  00021 046410R        ADB .4
0040  00022 076104R        STB FD283
0041  00023 046410R        ADB .4
0042  00024 076117R        STB FD4K
0043  00025 046410R        ADB .4
0044  00026 076132R        STB FD27K
0045  00027 036000R        ISZ N5A
0046  00030 166000R        LDB N5A,I      ADDR FOR N5(EST)
0047  00031 076165R        STB N5ADR
0048  00032 076170R        STB N5AD1
0049  00033 076156R        STB N5AD4
0050  00034 036000R        ISZ N5A
0051  00035 166000R        LDB N5A,I     ADDR FOR DN(EST)
0052  00036 076200R        STB DN5AD
0053  00037 036000R        ISZ N5A
0054*
0055  00040 062406R        LDA LINK       GET RANGE ESTIMATE
0056  00041 066013X        LDB IN0T2
0057  00042 002003         SZA,RSS
0058  00043 066011X        LDB IN0C
```

```
0059  00044 000010          SLA
0060  00045 066012X         LDB  IN0T1
0061  00046 076050R         STB  *+2
0062  00047 016004X         JSB  DMUL        GET 2 WAY RANGE
0063  00050 000000          NOP
0064  00051 000421R         DEF  D2
0065  00052 000366R         DEF  N.EST
0066*
0067  00053 062010X         LDA  MODE
0068  00054 052407R         CPA  .2
0069  00055 026354R         JMP  BMODE
0070  00056 052410R         CPA  .4          MODE C ?
0071  00057 026357R         JMP  CMODE         YES.
0072*
0073**  PROCESS 35.4 HZ READING
0074*
0075  00060 016266R         JSB  PEROD       CK FOR PERIOD CHANGE
0076  00061 000000  R35H    NOP
0077  00062 000000  FD35    NOP
0078  00063 000441R         DEF  T1
0079*
0080  00064 016337R         JSB  METER       COMPUTE N1+DN1
0081  00065 000441R         DEF  T1
0082  00066 016323R         JSB  .INT        CONV TO INT & DEC PARTS
0083*
0084  00067 016004X         JSB  DMUL
0085  00070 000372R         DEF  DNEST
0086  00071 000441R         DEF  T1
0087  00072 000376R         DEF  DTEST     EST OF 35 HZ READING
0088*
0089  00073 016202R         JSB  WAVE        WAVELENGTH TEST
0090  00074 000000  RD35    NOP
0091*
0092  00075 016323R BMO     JSB  .INT
0093*
0094  00076 016004X         JSB  DMUL
0095  00077 000372R         DEF  DNEST
0096  00100 000445R         DEF  T2
0097  00101 000376R         DEF  DTEST
0098*
0099*
0100**  PROCESS 283 HZ READING
0101*
0102  00102 016266R         JSB  PEROD
0103  00103 000000  R283A   NOP
0104  00104 000000  FD283   NOP
0105  00105 000445R         DEF  T2
0106*
0107  00106 016202R         JSB  WAVE
0108  00107 000000  R283B   NOP
0109*
0110  00110 016323R CMO     JSB  .INT        CONV TO INT & DEC PARTS
0111*
0112  00111 016004X         JSB  DMUL
0113  00112 000372R         DEF  DNEST     CONVERT DN3 TO # OF SECONDS
0114  00113 000451R         DEF  T3
0115  00114 000376R         DEF  DTEST
```

```
0116*
0117***  PROCESS 3.968 KHZ READING
0118*
0119   00115 016266R         JSB PEROD
0120   00116 000000  .4KAD   NOP
0121   00117 000000  FD4K    NOP
0122   00120 000451R         DEF T3
0123*
0124   00121 016202R         JSB WAVE
0125   00122 000000  R4KA    NOP
0126*
0127   00123 016323R         JSB .INT        CONV TO INT & DEC PART
0128*
0129   00124 016004X         JSB DMUL
0130   00125 000372R         DEF DNEST
0131   00126 000455R         DEF T4
0132   00127 000376R         DEF DTEST
0133*
0134**  PROCESS 27.7 KHZ READING
0135*
0136   00130 016266R         JSB PEROD
0137   00131 000000  R27K    NOP
0138   00132 000000  FD27K   NOP
0139   00133 000455R         DEF T4
0140*
0141   00134 016202R         JSB WAVE
0142   00135 000000  R27KA   NOP
0143*
0144   00136 016001X         JSB DSUB
0145   00137 000362R         DEF NDN,E
0146   00140 000411R         DEF D60K
0147   00141 000402R         DEF DELTA
0148*
0149   00142 062402R         LDA DELTA
0150   00143 000010          SLA
0151   00144 026160R         JMP MINUS
0152*
0153   00145 016005X         JSB DTBI
0154   00146 000402R         DEF DELTA
0155   00147 000465R         DEF NI
0156   00150 016006X         JSB BTD
0157   00151 000465R         DEF NI
0158   00152 000402R         DEF DELTA
0159*
0160   00153 016002X         JSB DADD
0161   00154 000402R         DEF DELTA
0162   00155 000411R         DEF D60K
0163   00156 000000  N5AD4   NOP
0164   00157 026166R         JMP N5ADR+1
0165*
0166   00160 016005X MINUS   JSB DTBI
0167   00161 000362R         DEF NDN,E
0168   00162 000465R         DEF NI
0169*
0170   00163 016006X         JSB BTD
0171   00164 000465R         DEF NI
0172   00165 000000  N5ADR   NOP
```

```
0173*
0174  00166 016001X        JSB DSUB
0175  00167 000362R        DEF NDN.E
0176  00170 000000  N5AD1  NOP
0177  00171 000372R        DEF DNEST
0178*
0179  00172 016004X        JSB DMUL
0180  00173 000372R        DEF DNEST
0181  00174 000461R        DEF T5
0182  00175 000376R        DEF DTEST     * DN5A(ESTIMATE)
0183*
0184  00176 016005X        JSB DTBI
0185  00177 000376R        DEF DTEST
0186  00200 000000  DN5AD  NOP           INTEGER # OF NANSECONDS
0187*
0188  00201 126000R        JMP N5A,I     RETURN.
0189*
0190*
0191*  WAVELENGTH TEST SUBROUTINE  ****
0192  00202 000000  WAVE   NOP
0193  00203 162202R        LDA WAVE,I
0194  00204 036202R        ISZ WAVE
0195  00205 072214R        STA R1
0196  00206 072257R        STA R2
0197*
0198  00207 016003X        JSB DDIV       DIVIDE PERIOD BY 2
0199  00210 000000  TN03   NOP
0200  00211 000421R        DEF D2
0201  00212 000431R        DEF HAF
0202*
0203  00213 016001X        JSB DSUB      DELTA = DN.M - DNEST
0204  00214 000000  R1     NOP
0205  00215 000376R        DEF DTEST
0206  00216 000402R        DEF DELTA
0207*
0208  00217 062402R        LDA DELTA
0209  00220 000010         SLA           DELTA POSITIVE ?
0210  00221 026236R        JMP NEG       NO.
0211  00222 016001X        JSB DSUB        YES. >0.5 ?
0212  00223 000402R        DEF DELTA
0213  00224 000431R        DEF HAF
0214  00225 000402R        DEF DELTA
0215*
0216  00226 062402R        LDA DELTA     STILL POSITIVE ?
0217  00227 000010         SLA
0218  00230 026251R        JMP DOWN      NO. N.EST IS OK
0219  00231 016001X        JSB DSUB      YES.
0220  00232 000366R        DEF N.EST       N.EST = N.EST - 1
0221  00233 000415R        DEF D1
0222  00234 000366R        DEF N.EST
0223  00235 026251R        JMP DOWN      RETURN.
0224*
0225  00236 016002X  NEG    JSB DADD       ADD .5 TO DELTA TO
0226  00237 000402R        DEF DELTA       TEST IF < -0.5
0227  00240 000431R        DEF HAF
0228  00241 000402R        DEF DELTA
0229  00242 062402R        LDA DELTA     STILL NEGATIVE ?
```

```
0230  00243 002011          SLA,RSS       YES, ADD ONE TO N
0231  00244 026251R         JMP DOWN      NO, N IS OK
0232*
0233  00245 016002X        JSB DADD
0234  00246 000366R         DEF N,EST
0235  00247 000415R         DEF D1
0236  00250 000366R         DEF N,EST
0237  00251 016004X DOWN    JSB DMUL      SOLVE FOR N
0238  00252 000366R         DEF N,EST
0239  00253 000000  TNO1    NOP
0240  00254 000362R         DEF NDN,E
0241*
0242  00255 016002X         JSB DADD
0243  00256 000362R         DEF NDN,E
0244  00257 000000  R2      NOP
0245  00260 000362R         DEF NDN,E
0246*
0247  00261 016003X         JSB DDIV
0248  00262 000362R         DEF NDN,E
0249  00263 000000  TNO2    NOP
0250  00264 000362R         DEF NDN,E     N*DN
0251  00265 126202R         JMP WAVE,I
0252**
0253  00266 000000  PEROD   NOP
0254  00267 162266R         LDA PEROD,I   READING
0255  00270 036266R         ISZ PEROD
0256  00271 072310R         STA FROM
0257  00272 072317R         STA FROM1
0258  00273 072312R         STA TO
0259  00274 072321R         STA TO1
0260  00275 162266R         LDA PEROD,I   FIXED DELAY
0261  00276 036266R         ISZ PEROD
0262  00277 072311R         STA DELAY
0263  00300 162266R         LDA PEROD,I   T VALUE
0264  00301 036266R         ISZ PEROD
0265  00302 072320R         STA TNO
0266  00303 072253R         STA TNO1
0267  00304 072210R         STA TNO3
0268  00305 042410R         ADA .4        NEXT T VALUE
0269  00306 072263R         STA TNO2
0270*
0271  00307 016001X         JSB DSUB      SUBTRACT FIXED DELAY
0272  00310 000000  FROM    NOP
0273  00311 000000  DELAY   NOP
0274  00312 000000  TO      NOP
0275*
0276  00313 162312R         LDA TO,I
0277  00314 002011          SLA,RSS       NEGATIVE ?
0278  00315 126266R         JMP PEROD,I   NO: EXIT
0279  00316 016002X         JSB DADD      YES: ADD 1 PERIOD
0280  00317 000000  FROM1   NOP
0281  00320 000000  TNO     NOP
0282  00321 000000  TO1     NOP
0283  00322 126266R         JMP PEROD,I   EXIT
0284*
0285***  SUBROUTINE TO CALC INTEGER & DEC PART OF NDN
0286*
```

```
0287  00323 000000  .INT  NOP
0288  00324 016005X       JSB DTBI
0289  00325 000362R       DEF NDN,E
0290  00326 000465R       DEF NI
0291*
0292  00327 016006X       JSB BTD
0293  00330 000465R       DEF NI
0294  00331 000366R       DEF N,EST
0295*
0296  00332 016001X       JSB DSUB
0297  00333 000362R       DEF NDN,E
0298  00334 000366R       DEF N,EST
0299  00335 000372R       DEF DNEST
0300  00336 126323R       JMP .INT,I
0301*
0302***   COMPUTE N+DN
0303*
0304  00337 000000  METER NOP
0305  00340 162337R       LDA METER,I
0306  00341 036337R       ISZ METER
0307  00342 072344R       STA TONE
0308  00343 016004X       JSB DMUL      MPY PERIOD BY SPEED OF LITE
0309  00344 000000  TONE  NOP
0310  00345 000435R       DEF LIGHT
0311  00346 000425R       DEF LAM
0312  00347 016003X       JSB DDIV      ESTIMATE/LAMDA
0313  00350 000366R       DEF N,EST
0314  00351 000425R       DEF LAM
0315  00352 000362R       DEF NDN,E
0316  00353 126337R       JMP METER,I
0317*
0318***   MODE B CALCULATION
0319*
0320  00354 016337R BMODE JSB METER     N2+DN2
0321  00355 000445R       DEF T2
0322  00356 026075R       JMP BMO
0323*
0324***   MODE C CALCULATION
0325*
0326  00357 016337R CMODE JSB METER     N3+DN3
0327  00360 000451R       DEF T3
0328  00361 026110R       JMP CMO
```

STORAGE AND CONSTANTS

```
0330*
0331   00362 000000   NDN.E BSS 4
0332   00366 000000   N.EST BSS 4
0333   00372 000000   DNEST BSS 4
0334   00376 000000   DTEST BSS 4
0335   00402 000000   DELTA BSS 4
0336   00406 000000   LINK  NOP
0337   00407 000002   .2    DEC 2
0338   00410 000004   .4    DEC 4
0339   00411 000000   D60K  OCT 0,0,6,0
0340   00415 105400   D1    OCT 105400,10000,0,0
0341   00421 105400   D2    OCT 105400,20000,0,0
0342   00425 000000   LAM   BSS 4
0343   00431 000000   HAF   BSS 4
0344   00435 106000   LIGHT OCT 106000,24627,111105,61000     .2997924562
0345   00441 102000   T1    OCT 102000,24042,40000,0   28224000
0346   00445 102400   T2    OCT 102400,32450,0,0        3528000
0347   00451 103000   T3    OCT 103000,22440,0,0         252000
0348   00455 103400   T4    OCT 103400,33000,0,0          36000
0349   00461 104000   T5    OCT 104000,50000,0,0
0350   00465 000000   NI    NOP
0351                        END
**  NO ERRORS: AMD ASMB,25117-402518
```

TRRR OPERATING SYSTEM

```
0001                    ASMB,R,B,L
0003  00000                   NAM TRRR
0004                          ENT START,.35FD,N.VAL,TTYST,A77B,OKFLL
0005                          ENT LABLE,LINKS
0006                          EXT .IOC.,AREA,TIME,POINT,CDA,TARS1,TARS2
0007                          EXT TMARK,PRINT,RTOD,ETIME,CLEAR,DONE,BTD
0008                          EXT N5A,MODEM,DDTA,TIMEX,TIMEY,CULL1
0009                          EXT CULL2,RTTYB,FIX.D,RDOT,ADJUT
0010                          EXT BIBCD,DADD,DSUB,DTBI
0011                          EXT TTYDA,MSG1,MODT,MODE
0012                          EXT IN0C,IN0T1,IN0T2,MOVE
0013                          EXT TTO,ABORT,LOCK1,LINK2,LINK3,RUDOT
0014                          EXT BB200,BB27,BB39,BB283
0015                          EXT SPAN,TSPAN
0016                          EXT RRADR,N5T5A
0017*
0018***    APR 15,1975
0019*
0020  00000 016012X START JSB RTOD        READ TIME OF DAY
0021  00001 016001X       JSB .IOC.       CLEAR ALL DEVICES
0022  00002 000000        NOP
0023  00003 062037X       LDA MSG1
0024  00004 072007R       STA *+3
0025  00005 062147R       LDA =D14
0026  00006 016011X      JSB PRINT      PRINT TIME OF DAY
0027  00007 000000        NOP
0028*
0029  00010 003400  STRTA CCA             STATUS CHECK CODE FOR TTY
0030  00011 016026X       JSB RTTYB       INPUT LOOP TO UPDATE DATA BASE
0031  00012 020011R       JMP *-2



0033*      RUN MODE      *



0035  00013 062002X TTYST LDA AREA        CLEAR ALL DATA
0036  00014 042150R       ADA =B4
0037  00015 070001        STA 1
0038  00016 001000        ALS
0039  00017 040001        ADA 1
0040  00020 066005X       LDB CDA
0041  00021 046151R       ADB =B-4
0042  00022 016014X       JSB CLEAR
0043  00023 062152R       LDA =D48        CLEAR FINAL AMBIGUITIES
0044  00024 067627R       LDB X35
0045  00025 016014X       JSB CLEAR
0046  00026 062153R       LDA =D60        CLEAR FIXED DELAYS
0047  00027 067566R       LDB .35FD
0048  00030 016014X       JSB CLEAR
0049  00031 062154R       LDA =D72        CLEAR AMBIGUITY TABLE
0050  00032 067605R       LDB N.VAL
```

```
00033 016014X        JSB CLEAR
00034 066062X        LDB RRADR        CLEAR RANGE & RANGE RATE TABLES
00035 062155R        LDA =D180
00036 016014X        JSB CLEAR
00037 066063X        LDB N5T5A
00040 062155R        LDA =D180
00041 016014X        JSB CLEAR
00042 062024X        LDA CULL1        IF CULL IS NOT SET,SET IT
00043 002003         SZA,RSS           TO 200
00044 062156R        LDA =D-200
00045 072024X        STA CULL1
00046 062025X        LDA CULL2
00047 002003         SZA,RSS
00050 062157R        LDA =D-4600
00051 072025X        STA CULL2
00052 062060X        LDA SPAN
00053 072751R        STA SPCN
00054 062061X        LDA TSPAN
00055 072754R        STA TEMPR
*
00056 062042X        LDA IN0C          MOVE ESTIMATES TO N0 BUFFERS
00057 067605R        LDB N.VAL
00060 016045X        JSB MOVE
00061 062043X        LDA IN0T1
00062 067606R        LDB N0T1
00063 016045X        JSB MOVE
00064 062044X        LDA IN0T2
00065 067607R        LDB N0T2
00066 016045X        JSB MOVE
*
00067 062046X        LDA TTO          TARS TURN ON
00070 102617         OTA RX
00071 016013X        JSB ETIME
00072 063364R        LDA LOOPO
00073 017101R        JSB TURN
*
00074 062054X        LDA B6200        200 KHZ
00075 016053X        JSB RUDOT
*
00076 016050X GOT1   JSB LOCK1         PRINT LOCKUP & WAIT FOR RESPONS
00077 016001X        JSB .IOC.        CLEAR TTY
00100 000001         OCT 1
00101 016001X        JSB .IOC.        READ 200 FIXED DELAY
00102 020003         OCT 20003
00103 026101R        JMP *-2
00104 001602R        DEF .20FD
00105 000001         DEC 1
00106 017304R        JSB STAT1
00107 063747R        LDA .20FC
00110 073563R        STA TITC
00111 016016X        JSB BTD
00112 001747R        DEF .20FC
00113 001747R        DEF .20FC
00114 063773R        LDA .20F1
00115 073564R        STA TITT1
00116 016016X        JSB BTD
00117 001773R        DEF .20F1
```

```
0108  0W120 001773R        DEF .20F1
0109  0W121 062017R        LDA .20F2
0110  W0122 073565R        STA TITT2
0111  00123 016016X        JSB BTD
0112  W0124 002017R        DEF .20F2
0113  W0125 002017R        DEF .20F2
0114*
0115  W0126 002400  GOM1   CLA             INITIALIZE POINTERS
0116  W0127 073405R        STA PRIOR        AND MARKS
0117  00130 073404R        STA CNTR
0118  W0131 062005X        LDA CDA          DEF CDA
0119  W0132 072311R        STA CKC
0120  00133 073643R        STA RPTS
0121  W0134 062006X        LDA TARS1        DEF TAR1
0122  00135 072323R        STA CK1
0123  W0136 073644R        STA RPTS+1
0124  W0137 062007X        LDA TARS2        DEF TAR2
0125  00140 072336R        STA CK2
0126  00141 073645R        STA RPTS+2
0127  00142 062004X        LDA POINT
0128  00143 073374R        STA ACNT         MAKE ACTUAL COUNT MAX POSSIBLE
0129  W0144 072234R        STA NUCNT
0130*
0131  W0145 062055X        LDA BB27         27.7
0132  W0146 016053X        JSB RUDOT        ENCODE RANGE UNIT DRIVER
0133*
```

CALIBRATION-LOOP AND PERIOD

```
0136   00147 017326R        JSB CTR         27 FIXED DELAY
0137   00150 001577R        DEF .27FD
0138*
0139   00151 062056X        LDA BB39
0140   00152 016053X        JSB RUDOT
0141   00153 017326R        JSB CTR         3.9 FIXED DELAY
0142   00154 001574R        DEF .39FD
0143*
0144   00155 017110R        JSB FNL         SEND 283 & 35 TONES IF
0145   00156 001571R        DEF .28FD        PROPER MODE
0146   00157 001566R        DEF .35FD
0147*
0148   00160 002400         CLA             PRINT FIXED DELAY VALUES
0149   00161 017144R        JSB CALPT
0150   00162 063365R        LDA LOOPI
0151   00163 017101R        JSB TURN
0152*
```

AMBIGUITY REMOVAL

```
0155  00104 015027X        JSB FIX.D      COMPUTE FIXED DELAYS
0156  00105 001727R        DEF .35CF
0157  00106 016050X GOT2   JSB LOCK1
0158*
0159  00107 062041X        LDA MODE
0160  00110 052150R        CPA =B4
0161  00111 026210R        JMP NN35C
0162  00112 052160R        CPA =B2
0163  00113 026201R        JMP NN35B
0164  00114 063366R        LDA LOOPX
0165  00115 032161R        IOR =B2000
0166  00116 102617         OTA RX
0167  00117 017326R        JSB CTR
0168  00200 001610R        DEF N1
0169  00201 062057X NN35B  LDA BB283
0170  00202 016053X        JSB RUDOT
0171  00203 063366R        LDA LOOPX
0172  00204 032162R        IOR =B4000
0173  00205 102617         OTA RX
0174  00206 017326R        JSB CTR
0175  00207 001613R        DEF N2
0176  00210 062056X NN35C  LDA BB39
0177  00211 016053X        JSB RUDOT
0178  00212 017326R        JSB CTR
0179  00213 001616R        DEF N3
0180  00214 062055X        LDA BB27       27.7
0181  00215 016053X        JSB RUDOT
0182  00216 017326R        JSB CTR        N4 AMBIGUITY
0183  00217 001621R        DEF N4
0184*
0185  00220 062054X        LDA BB200
0186  00221 016053X        JSB RUDOT
0187*
0188  00222 063365R        LDA LOOPI
0189  00223 017101R        JSB TURN
```

RANGING OPERATION

```
0192  00224 016012X        JSB RTOD
0193  00225 002400         CLA
0194  00226 072022X       STA TIMEX      CLEAR DIFFERENTIAL TIME MARKS
0195  00227 072023X        STA TIMEY
0196*
0197  00230 016001X        JSB .IOC.      START RANGING
0198  00231 020003         OCT 20003
0199  00232 026230R        JMP *-2
0200  00233 001643R        DEF RPTS
0201  00234 000000  NUCNT NOP
0202*
0203  00235 002404         CLA,INA         PRINT AMBIGUITY VALUES
0204  00236 017144R        JSB CALPT
0205*
0206  00237 006400         CLB
0207  00240 016017X        JSB N5A        COMPUTE N5
0208  00241 002027R        DEF N1C         N1-N4 POINTERS
0209  00242 001727R        DEF .35FC       FIXED DELAY POINTERS
0210  00243 002047R        DEF N5C         N(5) CDA RESULT
0211  00244 000142R        DEF TCE         T(5) ESTIMATE
0212*
0213  00245 063420R        LDA TCE        ADJUST FOR FIXED DELAYS
0214  00246 043563R        ADA TITC
0215  00247 017246R        JSB FND
0216  00250 073420R        STA TCE
0217*
0218  00251 016051X        JSB LINK2      CK FOR NO. OF COUNTERS WORKING
0219  00252 026301R        JMP NLNK
0220  00253 006404         CLB,INB
0221  00254 016017X        JSB N5A
0222  00255 002057R        DEF N1T1
0223  00256 001753R        DEF .35F1      SAME PARAMETERS AS ABOVE
0224  00257 002077R        DEF N5T1
0225  00260 001421R        DEF TT1E
0226*
0227  00261 063421R        LDA TT1E
0228  00262 043564R        ADA TITT1
0229  00263 017246R        JSB FND
0230  00264 073421R        STA TT1E
0231*
0232  00265 016052X        JSB LINK3
0233  00266 026301R        JMP NLNK
0234  00267 066160R        LDB =02
0235  00270 016017X        JSB N5A
0236  00271 002107R        DEF N1T2
0237  00272 001777R        DEF .35F2      SAME PARAMETERS
0238  00273 002127R        DEF N5T2
0239  00274 001422R        DEF TT2E
0240*
0241  00275 063422R        LDA TT2E
0242  00276 043565R        ADA TITT2
0243  00277 017246R        JSB FND
0244  00300 073422R        STA TT2E
0245  00301 002400  NLNK   CLA      SET FOR WAVELENGTH CHECK
0246  00302 072416R        STA PI1
0247  00303 072417R        STA PI2
0248  00304 072420R        STA PI3
```

0249 00305 01602BX JSB RTTYB

POINT VERIFICATION

```
0252  000306 062416R CHECK LDA PI1
0253  000307 016403R       JSB FAX
0254*
0255  000310 017254R       JSB STAT       NO: SEE IF POINT READY
0256  000311 000000  CKC    NOP
0257  000312 026310R       JMP *-2        NO:
0258  000313 017010R       JSB MATH       YES: VERIFY DATA POINT
0259  000314 000311R       DEF CKC
0260  000315 001420R       DEF TCE
0261  000316 066415R       LDB PIA      CHECK FOR BAD POINT
0262  000317 016364R       JSB BAPT
0263*
0264  000320 016051X       JSB LINK2
0265  000321 026346R       JMP CK3
0266  000322 017254R       JSB STAT       CHECK TO SEE IF POINT IS READY
0267  000323 000000  CK1    NOP
0268  000324 026322R       JMP *-2
0269  000325 017010R       JSB MATH
0270  000326 000323R       DEF CK1
0271  000327 001421R       DEF TT1E
0272  000330 066415R       LDB PIA
0273  000331 000004         INB
0274  000332 016364R       JSB BAPT
0275*
0276  000333 016052X       JSB LINK3
0277  000334 026346R       JMP CK3
0278  000335 017254R       JSB STAT
0279  000336 000000  CK2    NOP
0280  000337 026335R       JMP *-2
0281  000340 017010R       JSB MATH
0282  000341 000336R       DEF CK2
0283  000342 001422R       DEF TT2E
0284  000343 066415R       LDB PIA
0285  000344 046160R       ADB =D2
0286  000345 016364R       JSB BAPT
0287*
0288  000346 037404R CK3    ISZ CNTR       UPDATE NUMBER COMPLETED
0289  000347 063404R       LDA CNTR
0290  000350 053374R       CPA ACNT       CHECK FOR COMPLETION
0291  000351 026423R       JMP LAST1      ALL POINTS VERIFIED
0292*
0293  000352 062311R       LDA CKC        NOT FINISHED YET
0294  000353 042150R       ADA =B4         UPDATE ALL POINTERS
0295  000354 072311R       STA CKC
0296  000355 062323R       LDA CK1
0297  000356 042150R       ADA =B4
0298  000357 072323R       STA CK1
0299  000360 062336R       LDA CK2
0300  000361 042150R       ADA =B4
0301  000362 072336R       STA CK2
0302  000363 026306R       JMP CHECK      RESUME CHECKING OPERATION
0303*
0304  000364 000000  BAPT   NOP
0305  000365 052163R       CPA =D-1        BAD POINT?
0306  000366 026375R       JMP BPT        YES
0307  000367 062164R       LDA =D-5        NO: RESTORE COUNTER
0308  000370 170001         STA 1,I
```

```
0309   00371 000004   HI      INB
0310   00372 160001           LDA 1,I
0311   00373 016403R          JSB FAX
0312   00374 126364R          JMP BAPT,I
0313*
0314   00375 160001   BPT     LDA 1,I
0315   00376 002004           INA
0316   00377 002021           SSA,RSS
0317   00400 002400           CLA
0318   00401 170001           STA 1,I
0319   00402 026371R          JMP HI
0320*
0321   00403 000000   FAX     NOP
0322   00404 066025X          LDB CULL2
0323   00405 002003           SZA,RSS
0324   00406 006400           CLB
0325   00407 076421R          STB MIXB
0326*
0327   00410 066024X          LDB CULL1
0328   00411 002003           SZA,RSS
0329   00412 006165R          LDB =D-2500
0330   00413 076422R          STB MIXC
0331   00414 126403R          JMP FAX,I
0332*
0333   00415 000416R  PIA     DEF *+1
0334   00416 000000   PI1     NOP
0335   00417 000000   PI2     NOP
0336   00420 000000   PI3     NOP
0337   00421 000000   MIXB    NOP
0338   00422 000000   MIXC    NOP
```

FINAL AMBIGUITY REMOVAL

```
0341*
0342   00423 037405R LAST1 ISZ PRIOR      FINAL CALIBRATION DONE IF:
0343   00424 016426R       JSB LAST        PRIOR = -1, OTHERWISE DO IT
0344   00425 026465R       JMP ARND       THEN GO ON
0345*
0346   00426 000000  LAST  NOP
0347   00427 062015X       LDA DONE       ACTUAL COUNT ON BASE PAGE
0348   00430 073374R       STA ACNT       STORE IN COMPARATOR
0349*
0350   00431 062055X       LDA BB27
0351   00432 016053X       JSB RUDOT
0352   00433 063365R       LDA LOOPI
0353   00434 017101R       JSB TURN
0354   00435 016001X       JSB .IOC.      CLEAR CNTRS
0355   00436 000003  B3    OCT 3
0356*
0357   00437 017326R       JSB CTR        FINAL AMBIGUITY 27
0358   00440 001640R       DEF X27
0359*
0360   00441 062056X       LDA BB39
0361   00442 016053X       JSB RUDOT
0362*
0363   00443 017326R       JSB CTR        FINAL 3,9
0364   00444 001635R       DEF X39
0365   00445 017110R       JSB FNL        SEND 283 & 35 TONES
0366   00446 001632R       DEF X28
0367   00447 001627R       DEF X35
0368*
0369   00450 002400        CLA
0370   00451 016053X       JSB RUDOT      TURN OFF RANGE UNIT DRIVER
0371*
0372   00452 063364R       LDA LOOPO
0373   00453 032046X       IOR TTO        TARS TURN OFF
0374   00454 102617        OTA RX
0375   00455 016013X       JSB ETIME
0376   00456 063364R       LDA LOOPO
0377   00457 102617        OTA RX
0378   00460 062160R       LDA =B2
0379   00461 017144R       JSB CALPT      PRINT VALUES
0380   00462 063374R       LDA ACNT
0381   00463 072015X       STA DONE
0382   00464 126426R       JMP LAST,I
0383*
0384   00465 006400  ARND  CLB
0385   00466 016017X       JSB N5A        COMPUTE FINAL N(5)
0386   00467 001647R       DEF X35C        AMBIGUITY VALUES
0387   00470 001727R       DEF .35FC       FIXED DELAYS
0388   00471 002133R DN5XC DEF N5XC        RESULT CDA
0389   00472 001423R       DEF TEXC        DELTA T ESTIMATE
0390*
0391   00473 016051X       JSB LINK2
0392   00474 026513R       JMP NLNK1
0393   00475 006004        CLB,INB
0394   00476 016017X       JSB N5A
0395   00477 001567R       DEF X35T1
0396   00500 001753R       DEF .35F1
0397   00501 002137R DN5X1 DEF N5XT1
```

```
0398   000502 001425R         DEF TEXT1
0399*
0400   000503 016752X         JSB LINK3
0401   000504 026513R         JMP NLNK1
0402   000505 066160R         LDB =D2
0403   000506 016017X         JSB N5A
0404   000507 001707R         DEF X35T2
0405   000510 001777R         DEF .35F2
0406   000511 002143R DN5X2   DEF N5XT2
0407   000512 001424R         DEF TEXT2
0408*
0409   000513 003400  NLNK1   CCA
0410   000514 043374R         ADA ACNT
0411   000515 001020          ALS,ALS
0412   000516 072311R         STA CKC
0413   000517 062166R         LDA =5-2
0414   000520 073375R         STA TRY
0415   000521 063560R         LDA M1
0416   000522 072701R         STA MSG
0417   000523 066005X         LDB CDA
0418   000524 063423R         LDA TEXC        NEW T(ESTIMATE)
0419   000525 073415R         STA DELTA
0420   000526 062471R         LDA DN5XC       NEW N5(ESTIMATE)
0421   000527 072646R         STA DN5X
0422   000530 063563R         LDA TITC
0423   000531 003004          CMA,INA
0424   000532 043420R         ADA TCE
0425   000533 002020          SSA
0426   000534 042167R         ADA =D5000
0427   000535 073416R         STA DELTX
0428   000536 063406R         LDA DN5C        ORIGINAL N5
0429   000537 072642R GO0     STA DN5
0430   000540 046311R       ADB CKC
0431   000541 077426R         STB CK
0432   000542 026505R         JMP COMP
0433*
0434   000543 016051X GO1     JSB LINK2
0435   000544 026703R         JMP GOOD
0436   000545 063561R         LDA M2
0437   000546 072701R         STA MSG
0438   000547 066006X         LDB TARS1
0439   000550 063425R         LDA TEXT1
0440   000551 073415R         STA DELTA
0441   000552 062501R         LDA DN5X1
0442   000553 072646R         STA DN5X
0443   000554 063564R         LDA TITT1
0444   000555 003004          CMA,INA
0445   000556 043421R         ADA TTIE
0446   000557 002020          SSA
0447   000560 042167R         ADA =D5000
0448   000561 073416R         STA DELTX
0449   000562 063407R         LDA DN5T1
0450   000563 026537R         JMP GO0
0451*
0452   000564 016052X GO2     JSB LINK3
0453   000565 026703R         JMP GOOD
0454   000566 063562R         LDA M3
```

```
0455  000567 072701R        STA MSG
0456  000570 066007X        LDB TARS2
0457  000571 063424R        LDA TEXT2
0458  000572 073415R        STA DELTA
0459  000573 062511R        LDA DN5X2
0460  000574 072646R        STA DN5X
0461  000575 063565R        LDA TITT2
0462  000576 003004         CMA,INA
0463  000577 043422R        ADA TT2E
0464  000600 002020         SSA
0465  000601 042167R        ADA =D5000
0466  000602 073416R        STA DELTX
0467  000603 063410R        LDA DN5T2
0468  000604 020537R        JMP G00
0469*
0470  000605 062150R COMP    LDA =B4
0471  000606 066643R        LDB TTMP
0472  000607 016014X        JSB CLEAR
0473  000610 163426R        LDA CK,I
0474  000611 002007         INA,SZA,RSS    LAST POINT OF RANGING WAS BAD
0475  000612 025671R        JMP GOT6        SKIP CHECK
0476*
0477  000613 007400         CCB
0478  000614 063415R        LDA DELTA
0479  000615 003004         CMA,INA
0480  000616 043416R        ADA DELTX
0481  000617 003004         CMA,INA
0482  000620 002021         SSA,RSS
0483  000621 026524R        JMP *+3
0484  000622 006004         CLB,INB
0485  000623 003004         CMA,INA
0486*
0487  000624 042165R        ADA =D-2500
0488  000625 002020         SSA
0489  000626 006400         CLB            DO NOT ADJUST FINAL N5
0490  000627 063426R        LDA CK         ADJUST N5 FOR PHASE SHIFT
0491  000630 002004         INA
0492  000631 144000         ADB 0,I
0493  000632 074000         STB 0          NET CHANGE TO N5
0494  000633 002021         SSA,RSS
0495  000634 026637R        JMP *+3        PLUS CHANGE
0496  000635 037367R        ISZ TEMP
0497  000636 003004         CMA,INA
0498  000637 016032X        JSB BIBCD      MAKE A DEC # FOR CHANGE
0499  000640 073372R        STA TEMP+3
0500*
0501  000641 016033X        JSB DADD       ORIGINAL N5 PLUS ADJUSTMENT
0502  000642 000000  DN5     NOP
0503  000643 001367R TTMP    DEF TEMP
0504  000644 001376R         DEF RELT
0505*
0506  000645 016034X         JSB DSUB       NEW N5 MINUS OLD N5
0507  000646 000000  DN5X    NOP
0508  000647 001376R         DEF RELT
0509  000650 001376R ANS     DEF RELT
0510*
0511  000651 016035X         JSB DTBI
```

```
0512  000652 003737R        DEF RELT
0513  000653 001376R        DEF RELT
0514  000654 063376R        LDA RELT
0515  000655 002020         SSA
0516  000656 003004         CMA,INA
0517  000657 012166R        AND =B177776
0518  000660 002002         SZA
0519  000661 026671R        JMP GOT6
0520*
0521  000662 037375R NETRY   ISZ TRY
0522  000663 002001         RSS
0523  000664 026564R         JMP GO2
0524  000665 003400          CCA
0525  000666 053375R         CPA TRY
0526  000667 026543R         JMP GO1
0527*
0528*    ALL N5 VALUES HAVE BEEN CHECKED
0529*
0530  000670 027003R         JMP GOOD
0531  000671 062154R GOT6    LDA =D4          PRINT WARNING
0532  000672 016011X         JSB PRINT
0533  000673 001543R         DEF WARN
0534  000674 062170R         LDA =D9
0535  000675 016011X         JSB PRINT        PRINT END RANGE CHECK
0536  000676 001547R         DEF MSG5X
0537  000677 062150R         LDA =B4
0538  000700 016011X         JSB PRINT
0539  000701 000000  MSG     NOP
0540  000702 026662R         JMP NETRY
```

RANGE RATE AND FINAL OUTPUT

```
0543  00703 062062X GOOD  LDA RRADR
0544  00704 072730R       STA R.C
0545  00705 072777R       STA XR.C
0546  00706 042153R       ADA =D60
0547  00707 072735R       STA R.T1
0548  00710 073000R       STA XR.T1
0549  00711 042153R       ADA =D60
0550  00712 072742R       STA R.T2
0551  00713 073001R       STA XR.T2
0552  00714 006400        CLB
0553  00715 016030X       JSB RDOT      COMPUTE RANGE RATE CDA
0554*
0555  00716 016051X       JSB LINK2
0556  00717 026726R       JMP R.C-2
0557  00720 006404        CLB,INB
0558  00721 016030X       JSB RDOT      COMPUTE RANGE RATE TARS 1
0559*
0560  00722 016052X       JSB LINK3
0561  00723 026726R       JMP R.C-2
0562  00724 066160R       LDB =D2
0563  00725 016030X       JSB RDOT
0564*
0565  00726 006400        CLB
0566  00727 016031X       JSB ADJUT     ADJUST RANGES BASED ON RANGE RAT
0567  00730 000000  R.C    NOP
0568*
0569  00731 016051X       JSB LINK2
0570  00732 026743R       JMP R.T2+1
0571  00733 006404        CLB,INB
0572  00734 016031X       JSB ADJUT     ADJUST TARS 1
0573  00735 000000  R.T1   NOP
0574*
0575  00736 016052X       JSB LINK3
0576  00737 026743R       JMP R.T2+1
0577  00740 066160R       LDB =D2
0578  00741 016031X       JSB ADJUT     ADJUST TARS2
0579  00742 000000  R.T2   NOP
0580*
0581  00743 062040X       LDA MODT
0582  00744 042170R       ADA =D9
0583  00745 072752R       STA NUMB
0584  00746 042160R       ADA =D2
0585  00747 073427R       STA MTEMP
0586  00750 016035X       JSB DTBI
0587  00751 000000  SPCN   NOP
0588  00752 000000  NUMB   NOP
0589*
0590  00753 016035X       JSB DTBI
0591  00754 000000  TEMPR  NOP           CONVERT TEMPERATURE
0592  00755 001434R       DEF BT
0593  00756 063434R       LDA BT
0594  00757 006400        CLB            FOR MODEM
0595  00760 100400        OCT 100400     DIVIDE
0596  00761 001646R       DEF D10         BY TEN
0597  00762 077436R       STB BT+2
0598  00763 006400        CLB
0599  00764 100400        OCT 100400     DIVIDE
```

```
0600  000765 001646R        DEF D10          BY TEN
0601  000766 173427R        STA MTEMP,I
0602  000767 037427R        ISZ MTEMP
0603  000770 177427R        STB MTEMP,I
0604  000771 037427R        ISZ MTEMP
0605  000772 063436R        LDA BT+2
0606  000773 173427R        STA MTEMP,I
0607*
0608  000774 000400          CCB
0609  000775 077432R        STB A77B
0610*
0611  000776 016020X LABLE  JSB MODEM
0612  000777 000000  XR.C    NOP
0613  010000 000000  XR.T1   NOP
0614  010001 000000  XR.T2   NOP
0615*
0616  010002 002171R GOT7    LDA =D8
0617  010003 016311X         JSB PRINT       PRINT "OPERATION COMPLETE"
0618  010004 001464R         DEF MSG3
0619*
0620  010005 003400          CCA
0621  010006 102515          OTA RUD
0622  010007 026010R         JMP STRTA
0623*
```

SUBROUTINES

```
0626*************************************
0627* MATH:  VERIFIES DATA POINTS    *
0628*         AND UPDATES N(5)       *
0629*         OFFSET AS NEEDED       *
0630*************************************
0631  01010 002000  MATH  NOP
0632  01011 167010R       LDB MATH,I
0633  01012 164001        LDB 1,I        ADDRESS OF DATA
0634  01013 077367R       STB TEMP
0635  01014 037010R       ISZ MATH
0636  01015 160001        LDA 1,I        T READING
0637  01016 006004        INB            POSITION TO N COUNTER
0638  01017 077411R       STB LOC        POSITION OF N(5) OFFSET
0639  01020 046151R       ADB =B-4
0640  01021 164001        LDB 1,I        GET LAST N(5)
0641  01022 177411R       STB LOC,I      N(5,I)=N(5,I-1) INITIAL PPINT FO
0642*
0643  01023 157010R       LDB MATH,I     T(ESTIMATE) ADDRESS
0644  01024 037010R       ISZ MATH
0645  01025 077412R       STB DEL        ADDRESS OF ESTIMATE
0646  01026 167412R       LDB DEL,I
0647  01027 006007        INB,SZB,RSS
0648  01030 027057R       JMP DONEY+1
0649*
0650  01031 007400        CCB
0651  01032 073403R       STA T,I
0652  01033 003004        CMA,INA
0653  01034 143412R       ADA DEL,I      COMPUTE T(I)-T(I-1)
0654  01035 003004        CMA,INA
0655  01036 002020        SSA
0656  01037 006004       CLB,INB
0657  01040 077413R       STB NV         POSSIBLE CHANGE TO N(5)
0658*
0659  01041 002020       SSA
0660  01042 003004        CMA,INA        ABS(T(I))
0661  01043 042422R       ADA MIXC        CHECK FOR PHASE SHIFT
0662  01044 002020        SSA
0663  01045 027056R       JMP DONEY
0664  01046 002003        SZA,RSS
0665  01047 027056R       JMP DONEY
0666  01050 042421R       ADA MIXB
0667  01051 002020        SSA
0668  01052 027061R       JMP BADD
0669  01053 167411R       LDB LOC,I      CHANGE N(5)
0670  01054 047413R       ADB NV
0671  01055 177411R       STB LOC,I
0672  01056 063403R DONEY  LDA T,I
0673  01057 173412R       STA DEL,I
0674  01060 127010R       JMP MATH,I     UPDATED ESTIMATE STORED FOR NEXT
0675  01061 003400  BADD  CCA             IF THE PPINT IS BAD,
0676  01062 067367R       LDB TEMP        RETAIN LAST EST
0677  01063 170001        STA 1,I        CHANGE T(I) TO -1 TO INDICATE
0678  01064 056005X       CPB CDA
0679  01065 027057R       JMP DONEY+1
0680  01066 056006X       CPB TARS1
0681  01067 027057R       JMP DONEY+1
0682  01070 056007X       CPB TARS2
```

```
0683  01071 027057R        JMP DONEY+1
0684  01072 046151R        ADB =B-4
0685  01073 160001         LDA 1,I
0686  01074 002020         SSA
0687  01075 127010R        JMP MATH,I
0688  01076 003400         CCA
0689  01077 170001         STA 1,I
0690  01100 127010R        JMP MATH,I



0692  01101 000000  TURN   NOP
0693  01102 073366R        STA LOOPX
0694  01103 032162R        IOR =B4000
0695  01104 102617         OTA RX
0696  01105 063646R        LDA D10
0697  01106 016013X        JSB ETIME
0698  01107 127101R        JMP TURN,I
0699*
0700  01110 000000  FNL    NOP
0701  01111 163110R        LDA FNL,I      WHERE TO PUT CNTR READING
0702  01112 037110R        ISZ FNL
0703  01113 073130R        STA .28R       283 READING
0704  01114 163110R        LDA FNL,I
0705  01115 037110R        ISZ FNL
0706  01116 073142R        STA .35R       35 READING
0707  01117 062041X        LDA MODE
0708  01120 052150R        CPA =B4
0709  01121 127110R        JMP FNL,I      RETURN IF MODE C
0710  01122 062057X        LDA BB283      283
0711  01123 016053X        JSB RUDOT
0712  01124 063366R        LDA LOOPX
0713  01125 032162R        IOR =B4000
0714  01126 102617         OTA RX
0715  01127 017326R        JSB CTR
0716  01130 000000  .28R    NOP
0717*
0718  01131 062041X        LDA MODE
0719  01132 052160R        CPA =B2
0720  01133 127110R        JMP FNL,I      RETURN IF MODE B
0721  01134 062172R        LDA =B41       35 TO CNTRS
0722  01135 016053X        JSB RUDOT
0723  01136 063366R        LDA LOOPX
0724  01137 032161R        IOR =B2000
0725  01140 102617         OTA RX
0726  01141 017326R        JSB CTR
0727  01142 000000  .35R    NOP
0728  01143 127110R        JMP FNL,I      EXIT



0730  01144 000000  CALPT  NOP
0731  01145 073430R        STA SAVA
```

```
0732  01146 067542R        LDB MS5.
0733  01147 002003         SZA,RSS
0734  01150 067540R        LDB MS4
0735  01151 000010         SLA
0736  01152 067541R        LDB MS5
0737  01153 077156R        STB PRR
0738  01154 062170R        LDA =D9
0739  01155 016011X        JSB PRINT      PRINT "CALIBRATION VALUES"
0740  01156 000000  PRR    NOP
0741  01157 062173R        LDA =B-3       NUMBER OF LINKS
0742  01160 073414R        STA REF
0743  01161 067430R        LDB SAVA
0744  01162 063627R        LDA X35
0745  01163 006003         SZB,RSS
0746  01164 063566R        LDA .35FD
0747  01165 004010         SLB
0748  01166 063610R        LDA N1
0749  01167 073206R        STA VAL
0750  01170 063242R CAL1   LDA TAB
0751  01171 043414R        ADA REF
0752  01172 002004         INA            POINT TO HEADING
0753  01173 160000         LDA 0,I
0754  01174 073177R        STA HEDV
0755*
0756  01175 062150R        LDA =D4
0757  01176 016011X        JSB PRINT      PRINT APPLICABLE HEADING
0758  01177 000000  HEDV   NOP
0759*
0760  01200 067430R        LDB SAVA
0761  01201 062151R        LDA =B-4
0762  01202 006003         SZB,RSS
0763  01203 062164R        LDA =B-5
0764  01204 073373R        STA CNT
0765*
0766  01205 016021X        JSB DDTA       DECIMAL TO ASCII CONVERSION
0767  01206 000000  VAL    NOP
0768  01207 001474R        DEF STORE
0769  01210 062170R        LDA =D9
0770  01211 016011X        JSB PRINT      PRINT APPLICABLE FIXED DELAY
0771  01212 001474R        DEF STORE
0772*
0773  01213 063206R        LDA VAL
0774  01214 042150R        ADA =D4        POINT TO NEXT VALUE
0775  01215 073206R        STA VAL
0776  01216 037373R        ISZ CNT
0777  01217 027205R        JMP VAL-1
0778*
0779  01220 037414R        ISZ REF
0780  01221 002001         RSS
0781  01222 027236R        JMP CERRK
0782  01223 063414R        LDA REF
0783  01224 042436R        ADA B3
0784  01225 053431R        CPA LINKS
0785  01226 027236R        JMP CERRK
0786  01227 067430R        LDB SAVA
0787  01230 006011         SLB,RSS
0788  01231 027170R        JMP CAL1
```

```
0789   01232 063206R        LDA VAL
0790   01233 042171R        ADA =D8
0791   01234 073206R        STA VAL
0792   01235 027170R        JMP CAL1
0793*
0794   01236 063417R CERRK  LDA ERRFZ      CK FOR COUNTER ERROR
0795   01237 002002         SZA
0796   01240 027322R        JMP TIMOT      COUNTER ERROR
0797   01241 127144R        JMP CALPT,I
0798   01242 001245R TAB    DEF *+3        HEADING TABLE
0799   01243 001450R        DEF HEDC
0800   01244 001454R        DEF HEDT1
0801   01245 001460R        DEF HEDT2



0803   01246 000000  FND    NOP
0804   01247 042174R        ADA =D-10000
0805   01250 002021         SSA,RSS
0806   01251 027247R        JMP *-2
0807   01252 042175R        ADA =D10000
0808   01253 127246R        JMP FND,I



0810   01254 000000  STAT   NOP
0811   01255 163254R        LDA STAT,I     ADDRESS OF BUFFER
0812   01256 037254R        ISZ STAT
0813   01257 002004         INA
0814   01260 160000         LDA 0,I        STATUS WORD
0815   01261 002021         SSA,RSS        READY?
0816   01262 027276R        JMP CKO        NO RETURN TO REJECT POINT
0817   01263 037254R        ISZ STAT       YES!  BUMP RETURN ADDRESS
0818   01264 062015X        LDA DONE
0819   01265 002020         SSA
0820   01266 127254R        JMP STAT,I     ALL READINGS NOT COMPLETED
0821   01267 063405R        LDA PRIOR
0822   01270 002002         SZA
0823   01271 127254R        JMP STAT,I
0824   01272 016426R        JSB LAST       ALL READINGS FINISHED
0825   01273 003400         CCA
0826   01274 073405R        STA PRIOR
0827   01275 127254R        JMP STAT,I
0828*
0829   01276 062036X CKO    LDA TTYDA
0830   01277 053402R        CPA STARA
0831   01300 026047X        JMP ABORT
0832   01301 053437R        CPA XXX
0833   01302 026047X        JMP ABORT
0834   01303 127254R        JMP STAT,I
```

```
0836  01304 000000  STAT1 NOP
0837  01305 066166R       LDB =B-2
0838  01306 002400       CLA
0839  01307 072710X       STA TMARK      SET TIME OUT START
0840  01310 062015X STIFF LDA DONE
0841  01311 002021       SSA,RSS        READING FINISHED?
0842  01312 127304R       JMP STAT1,I    YES: RETURN
0843  01313 003400       CLA            NO: CHECK TIMEOUT
0844  01314 052010X       CPA TMARK
0845  01315 002001       RSS
0846  01316 027310R       JMP STIFF
0847  01317 006007       INB,SZB,RSS
0848  01320 002001       RSS            TIMEOUT
0849  01321 027306R       JMP STIFF-2
0850*
0851  01322 062176R TIMOT LDA =D7
0852  01323 016011X       JSB PRINT
0853  01324 001441R       DEF CERR
0854  01325 026047X       JMP ABORT
0855*
0856  01326 000000  CTR   NOP
0857  01327 002400       CLA
0858  01330 073417R       STA ERRFZ
0859  01331 163326R       LDA CTR,I
0860  01332 037326R       ISZ CTR
0861  01333 073337R       STA CALL
0862  01334 016001X       JSB .IOC.
0863  01335 020003       OCT 20003
0864  01336 027334R       JMP *-2
0865  01337 000000  CALL  NOP
0866  01340 000000       NOP
0867  01341 017304R       JSB STAT1
0868  01342 063431R       LDA LINKS      CK FOR 0 READING
0869  01343 003004       CMA,INA
0870  01344 073101R       STA TURN
0871  01345 062173R WINT  LDA =D-3
0872  01346 073246R       STA FND
0873  01347 167337R       LDB CALL,I
0874  01350 006004       INB
0875  01351 160001       LDA 1,I
0876  01352 002002       SZA
0877  01353 027360R       JMP NCK
0878  01354 037246R       ISZ FND
0879  01355 027350R       JMP *-5
0880  01356 037417R       ISZ ERRFZ      COUNTER ERROR FLAG
0881  01357 127326R       JMP CTR,I
0882  01360 037337R NCK   ISZ CALL
0883  01361 037101R       ISZ TURN
0884  01362 027345R       JMP WINT
0885  01363 127326R       JMP CTR,I
```

CONSTANTS AND WORKING STORAGE

```
0868  000015          RUD    EQU 15B
0869                         SUP
086A  01364 000126    LOOPO  OCT 126
0891  01365 000071    LOOPI  OCT 71
0892  01366 000000    LOOPX  NOP
0893  01367 000000    TEMP   BSS 4
0894  01373 000000    CNT    NOP
0895  01374 000000    ACNT   NOP
0896  01375 000000    TRY    NOP
0897  01376 000000    RELT   BSS 4
0898  01402 025101    STARA  ASC 1,*A
0899  01403 000000    T.I    NOP
090A  01404 000000    CNTR   NOP
090B  01405 000000    PRIOR  NOP
090C  01406 002047R   DN5C   DEF N5C
090D  01407 002077R   DN5T1  DEF N5T1
090E  01410 002127R   DN5T2  DEF N5T2
090F  01411 000000    LOC    NOP
0910  01412 000000    DEL    NOP
0911  01413 000000    NV     NOP
0912  01414 000000    REF    NOP
0913  01415 000000    DELTA  NOP
0914  01416 000000    DELTX  NOP
0915  01417 000000    ERRFZ  NOP
0916  01420 000000    TCE    NOP
0917  01421 000000    TT1E   NOP
0918  01422 000000    TT2E   NOP
0919  01423 000000    TEXC   NOP
091A  01424 000000    TEXT2  NOP
091B  01425 000000    TEXT1  NOP
091C  01426 000000    CK     NOP
091D  01427 000000    MTEMP  NOP
091E  01430 000000    SAVA   NOP
091F  01431 000003    LINKS  OCT 3
0920  01432 000000    A77B   NOP
0921  01433 000000    OKFLL  NOP
0922  01434 000000    BT     BSS 3
0923  01437 025052    XXX    ASC 1,**
0924  01440 020137           OCT 20137
0925  01441 041517    CERR   ASC 7,COUNTER ERROR
0926  01450 020040    HEDC   ASC 4,  CDA
0927  01454 020124    HEDT1  ASC 4, TARS 1
0928  01460 020124    HEDT2  ASC 4, TARS 2
0929  01464 051101    MSG3   ASC 8,RANGING COMPLETE
092A  01474 020040    STORE  ASC 9,
092B  01505 043111    MSG4   ASC 9,FIXED DELAY VALUES
092C  01516 043111    MSG5.  ASC 9,FINAL AMBIGUITY
092D  01527 040515    MSG5   ASC 9,AMBIGUITY VALUES
092E  01540 001505R   MS4    DEF MSG4
092F  01541 001527R   MS5    DEF MSG5
0930  01542 001516R   MS5.   DEF MSG5.
0931  01543 053501    WARN   ASC 4,WARNING:
0932  01547 051116    MSG5X  ASC 8,RNG INCONSISTANT
0933  01557 020137           OCT 20137
0934  01560 001450R   M1     DEF HEDC
0935  01561 001454R   M2     DEF HEDT1
0936  01562 001460R   M3     DEF HEDT2
```

```
0945  01563 000000  TITC   NOP
0946  01564 000000  TITT1  NOP
0947  01565 000000  TITT2  NOP
0948  01566 001727R .35FD  DEF  .35CF
0949  01567 001753R        DEF  .35CF+20
0950  01570 001777R        DEF  .35CF+40
0951  01571 001733R .28FD  DEF  .35CF+4
0952  01572 001757R        DEF  .35CF+24
0953  01573 002003R        DEF  .35CF+44
0954  01574 001737R .39FD  DEF  .35CF+8
0955  01575 001763R        DEF  .35CF+28
0956  01576 002007R        DEF  .35CF+48
0957  01577 001743R .27FD  DEF  .35CF+12
0958  01600 001767R        DEF  .35CF+32
0959  01601 002013R        DEF  .35CF+52
0960  01602 001747R .20FD  DEF  .35CF+16
0961  01603 001773R        DEF  .35CF+36
0962  01604 002017R        DEF  .35CF+56
0963  01605 002023R N.VAL  DEF  N0CD
0964  01606 002053R N0T1   DEF  N0CD+24
0965  01607 002103R N0T2   DEF  N0CD+48
0966  01610 002027R N1     DEF  N0CD+4
0967  01611 002057R        DEF  N0CD+28
0968  01612 002107R        DEF  N0CD+52
0969  01613 002033R N2     DEF  N0CD+8
0970  01614 002063R        DEF  N0CD+32
0971  01615 002113R        DEF  N0CD+56
0972  01616 002037R N3     DEF  N0CD+12
0973  01617 002067R        DEF  N0CD+36
0974  01620 002117R        DEF  N0CD+60
0975  01621 002043R N4     DEF  N0CD+16
0976  01622 002073R        DEF  N0CD+40
0977  01623 002123R        DEF  N0CD+64
0978  01624 002047R N5     DEF  N0CD+20
0979  01625 002077R        DEF  N0CD+44
0980  01626 002127R        DEF  N0CD+68
0981  01527 001647R X35    DEF  AMBIG
0982  01630 001667R        DEF  AMBIG+16
0983  01631 001707R        DEF  AMBIG+32
0984  01632 001653R X28    DEF  AMBIG+4
0985  01633 001673R        DEF  AMBIG+20
0986  01634 001713R        DEF  AMBIG+36
0987  01635 001657R X39    DEF  AMBIG+8
0988  01636 001677R        DEF  AMBIG+24
0989  01637 001717R        DEF  AMBIG+40
0990  01640 001663R X27    DEF  AMBIG+12
0991  01641 001703R        DEF  AMBIG+28
0992  01642 001723R        DEF  AMBIG+44
0993  01643 000000  RPTS   BSS  3
0994  01646 000012  D10    DEC  10
0995  01647 000000  AMBIG  BSS  48
0996  01727 000000  .35CF  BSS  60
0997  02023 000000  N0CD   BSS  72
0998  02027        N1C    EQU  N0CD+4
0999  02057        N1T1   EQU  N0CD+28
1000  02107        N1T2   EQU  N0CD+52
1001  01727        .35FC  EQU  .35CF
```

```
1002  01753           .35F1 EQU .35CF+20
1003  01777           .35F2 EQU .35CF+40
1004  02047           N5C   EQU N0CD+20
1005  02077           N5T1  EQU N0CD+44
1006  02127           N5T2  EQU N0CD+68
1007  01647           X35C  EQU AMBIG
1008  01667           X35T1 EQU AMBIG+16
1009  01707           X35T2 EQU AMBIG+32
1010  01747           .20FC EQU .35CF+16
1011  01773           .20F1 EQU .35CF+36
1012  02017           .20F2 EQU .35CF+56
1013  02133 000000    N5XC  BSS 4
1014  02137 000000    N5XT1 BSS 4
1015  02143 000000    N5XT2 BSS 4
1016  00017           RX    EQU 17B
1017                        UNS
      02147 000016
      02150 000004
      02151 177774
      02152 000060
      02153 000074
      02154 000110
      02155 000264
      02156 17747A
      02157 167010
      02160 000002
      02161 002000
      02162 004000
      02163 177777
      02164 177773
      02165 173074
      02166 177776
      02167 011610
      02170 000011
      02171 000010
      02172 000041
      02173 177775
      02174 154360
      02175 023420
      02176 000007
1018                        END
** NO ERRORS: AMD ASMB,25117-4A251B
```

ADD AND SUBTRACT - FULL PRECISION

```
0001                        ASMB,R,B,L
0003  00000                       NAM MATH
0004                              ENT DADD,DSUB,DTBI
0005                              ENT DMUL,DDIV,MOVE,SHAME
0006                              EXT CLEAR
0007*
0008  00000 000000  DADD    NOP
0009  00001 016353R          JSB UNPAK
0010  00002 026012R          JMP ADMUP
0011*
0012  00003 000000  DSUB    NOP
0013  00004 016353R          JSB UNPAK
0014  00005 062500R          LDA Y
0015  00006 001500           ERA
0016  00007 002200           CME
0017  00010 001600           ELA
0018  00011 072500R          STA Y
0019*
0020  00012 066523R ADMUP    LDB EXPY
0021  00013 007004           CMB,INB
0022  00014 046522R          ADB EXPX
0023  00015 006021           SSB,RSS
0024  00016 026035R          JMP ADDEM
0025*
0026  00017 062476R          LDA AX
0027  00020 066474R          LDB TEMP1
0028  00021 016415R          JSB MOVE
0029  00022 062475R          LDA AY
0030  00023 066476R          LDB AX
0031  00024 016415R          JSB MOVE
0032  00025 062474R          LDA TEMP1
0033  00026 066475R          LDB AY
0034  00027 016415R          JSB MOVE
0035  00030 062522R          LDA EXPX
0036  00031 066523R          LDB EXPY
0037  00032 072523R          STA EXPY
0038  00033 076522R          STB EXPX
0039  00034 026012R          JMP ADMUP
0040*
0041  00035 047522R ADDEM    ADB M13
0042  00036 062522R          LDA EXPX
0043  00037 002021           SSA,RSS
0044  00040 026166R          JMP CKPL
0045  00041 062476R NICE     LDA AX
0046  00042 006021           SSB,RSS
0047  00043 026160R          JMP FLOP1
0048  00044 007000           CMB
0049  00045 047522R          ADB M13
0050  00046 076531R          STB SHFCN
0051  00047 016466R          JSB GETU
0052*
0053  00050 036531R LOOP     ISZ SHFCN
0054  00051 002001           RSS
0055  00052 026056R          JMP CALC
0056  00053 062475R          LDA AY
0057  00054 016440R          JSB SHAME
0058  00055 026050R          JMP LOOP
```

```
0059*
0060  00056 062537R CALC  LDA SIGND
0061  00057 000010        SLA
0062  00060 026211R       JMP DIFF
0063  00061 062504R       LDA Y+4
0064  00062 072526R       STA TEMP+2
0065  00063 062505R       LDA Y+5
0066  00064 072527R       STA TEMP+3
0067*
0068  00065 002400        CLA
0069  00066 072533R       STA BIN1
0070  00067 063535R       LDA M12
0071  00070 072524R       STA TEMP
0072*
0073  00071 062511R COVT  LDA X+3
0074  00072 012546R       AND B17
0075  00073 072532R       STA BIN
0076  00074 062503R       LDA Y+3
0077  00075 012546R       AND B17
0078  00076 042532R       ADA BIN
0079  00077 042533R       ADA BIN1
0080  00100 043534R       ADA M10
0081  00101 002020        SSA
0082  00102 026163R       JMP LESST
0083  00103 006404        CLB,INB
0084  00104 076533R COVT1 STB BIN1
0085  00105 012546R       AND B17
0086  00106 072532R       STA BIN
0087  00107 062477R       LDA AZ
0088  00110 016440R       JSB SHAME
0089  00111 062532R       LDA BIN
0090  00112 001323        RAR,RAR
0091  00113 001323        RAR,RAR
0092  00114 032515R       IOR Z+1
0093  00115 072515R       STA Z+1
0094*
0095  00116 062476R       LDA AX
0096  00117 016440R       JSB SHAME
0097  00120 062475R       LDA AY
0098  00121 016440R       JSB SHAME
0099  00122 036524R       ISZ TEMP
0100  00123 026071R       JMP COVT
0101*
0102  00124 062526R       LDA TEMP+2
0103  00125 072520R       STA Z+4
0104  00126 062527R       LDA TEMP+3
0105  00127 072521R       STA Z+5
0106  00130 062533R       LDA BIN1
0107  00131 002003        SZA,RSS
0108  00132 026144R       JMP NEAR
0109*
0110  00133 062477R       LDA AZ
0111  00134 016440R       JSB SHAME
0112  00135 062533R       LDA BIN1
0113  00136 001323        RAR,RAR
0114  00137 001323        RAR,RAR
0115  00140 032515R       IOR Z+1
```

```
0115  00141 072515R        STA Z+1
0117  00142 036522R        ISZ EXPX
0118  00143 000000         NOP
0119*
0120  00144 062506R NEAR   LDA X
0121  00145 006400         CLB
0122  00146 000010         SLA
0123  00147 006004         INB
0124  00150 076514R        STB Z
0125*
0126  00151 057535R        LDB M12
0127  00152 062477R        LDA AZ
0128  00153 017270R        JSB LEFT
0129*
0130  00154 017256R ALMOT  JSB REVER
0131  00155 032514R        IOR Z
0132  00156 072514R        STA Z
0133*
0134  00157 062477R        LDA AZ
0135  00160 066536R FLOP1  LDB ADRZ
0136  00161 016415R        JSB MOVE
0137  00162 126555R        JMP RETN,I
0138*
0139  00163 006400  LESST  CLB
0140  00164 043527R        ADA .10
0141  00165 026104R        JMP COVT1
0142*
0143  00166 003004  CKPL    CMA,INA
0144  00167 042523R        ADA EXPY
0145  00170 002021         SSA,RSS
0146  00171 026041R        JMP NICE
0147  00172 062507R        LDA X+1
0148  00173 001700         ALF
0149  00174 012546R        AND B17
0150  00175 002002         SZA
0151  00176 026041R        JMP NICE
0152  00177 007400         CCB
0153  00200 062476R        LDA AX
0154  00201 017270R        JSB LEFT
0155  00202 017256R        JSB REVER
0156  00203 070001         STA 1
0157  00204 062506R        LDA X
0158  00205 012547R        AND B377
0159  00206 030001         IOR 1
0160  00207 072506R        STA X
0161  00210 026012R        JMP ADMUP
0162*
0163  00211 063531R DIFF    LDA M3
0164  00212 072542R        STA CNT
0165  00213 062476R        LDA AX
0166  00214 072540R        STA UNITX
0167  00215 062475R        LDA AY
0168  00216 072541R        STA UNITY
0169  00217 036540R SSA     ISZ UNITX
0170  00220 036541R        ISZ UNITY
0171  00221 162540R        LDA UNITX,I
0172  00222 166541R        LDB UNITY,I
```

```
0173   00223 002020          SSA
0174   00224 026334R         JMP XY
0175   00225 006020          SSB
0176   00226 026245R         JMP YBIG
0177   00227 007004  COMPL    CMB,INB
0178   00230 040001          ADA 1
0179   00231 002020          SSA
0180   00232 026245R         JMP YBIG
0181   00233 002002          SZA
0182   00234 026343R         JMP XBIG
0183   00235 036542R         ISZ CNT
0184   00236 026217R         JMP SSA
0185*
0186   00237 062504R         LDA Y+4
0187   00240 066505R         LDB Y+5
0188   00241 002003          SZA,RSS
0189   00242 006002          SZB
0190   00243 026245R         JMP YBIG
0191   00244 026154R         JMP ALMOT
0192*
0193   00245 062475R YBIG    LDA AY
0194   00246 066476R         LDB AX
0195*
0196   00247 072552R V..     STA BIG
0197   00250 076553R         STB SMALL
0198   00251 002400          CLA
0199   00252 072554R         STA CB
0200   00253 063525R         LDA .5
0201   00254 072544R         STA TEMPA
0202   00255 062552R V...    LDA BIG
0203   00256 042544R         ADA TEMPA
0204   00257 160000          LDA 0,I
0205   00260 072532R         STA BIN
0206   00261 062553R         LDA SMALL
0207   00262 042544R         ADA TEMPA
0208   00263 160000          LDA 0,I
0209   00264 072533R         STA BIN1
0210   00265 063532R         LDA M4
0211   00266 072545R         STA TEMPB
0212*
0213   00267 062532R V....   LDA BIN
0214   00270 012546R         AND B17
0215   00271 042554R         ADA CB
0216   00272 006400          CLB
0217   00273 076554R         STB CB
0218   00274 002020          SSA
0219   00275 016346R         JSB NEG
0220   00276 070001          STA 1
0221   00277 062533R         LDA BIN1
0222   00300 012546R         AND B17
0223   00301 003004          CMA,INA
0224   00302 040001          ADA 1
0225   00303 002020          SSA
0226   00304 016346R         JSB NEG
0227*
0228   00305 066477R         LDB AZ
0229   00306 046544R         ADB TEMPA
```

```
0230   00307 130001          IOR 1,I
0231   00310 001323          RAR,RAR
0232   00311 001323          RAR,RAR
0233   00312 170001          STA 1,I
0234   00313 062532R         LDA BIN
0235   00314 001323          RAR,RAR
0236   00315 001323          RAR,RAR
0237   00316 072532R         STA BIN
0238   00317 062533R         LDA BIN1
0239   00320 001323          RAR,RAR
0240   00321 001323          RAR,RAR
0241   00322 072533R         STA BIN1
0242   00323 036545R         ISZ TEMPB
0243   00324 026267R         JMP V....
0244   00325 003400          CCA
0245   00326 042544R         ADA TEMPA
0246   00327 072544R         STA TEMPA
0247   00330 002002          SZA
0248   00331 026255R         JMP V...
0249*
0250   00332 162552R         LDA BIG,I
0251   00333 026145R         JMP NEAR+1
0252*
0253   00334 006021  XY      SSB,RSS
0254   00335 026343R         JMP XBIG
0255   00336 001640          ELA,CLE
0256   00337 001500          ERA
0257   00340 005640          ELB,CLE
0258   00341 005500          ERB
0259   00342 026227R         JMP COMPL
0260*
0261   00343 062476R XBIG    LDA AX
0262   00344 066475R         LDB AY
0263   00345 026247R         JMP V..
0264*
0265*
0266   00346 000000  NEG     NOP
0267   00347 007400          CCB
0268   00350 076554R         STB CB
0269   00351 043527R         ADA .10
0270   00352 126346R         JMP NEG,I
0271*
0272   00353 000000  UNPAK   NOP
0273   00354 062353R         LDA UNPAK
0274   00355 043530R         ADA M2
0275   00356 160000          LDA 0,I
0276   00357 072555R         STA RETN
0277   00360 160000          LDA 0,I
0278   00361 072534R         STA ADRX
0279   00362 036555R         ISZ RETN
0280   00363 162555R         LDA RETN,I
0281   00364 072535R         STA ADRY
0282   00365 036555R         ISZ RETN
0283   00366 162555R         LDA RETN,I
0284   00367 072536R         STA ADRZ
0285   00370 036555R         ISZ RETN
0286*
```

```
0287  00371 162534R        LDA ADRX,I
0288  00372 016430R        JSB EXP
0289  00373 072522R        STA EXPX
0290  00374 162535R        LDA ADRY,I
0291  00375 016430R        JSB EXP
0292  00376 072523R        STA EXPY
0293*
0294  00377 062534R        LDA ADRX
0295  00400 066476R        LDB AX
0296  00401 016415R        JSB MOVE
0297*
0298  00402 062535R        LDA ADRY
0299  00403 066475R        LDB AY
0300  00404 016415R        JSB MOVE
0301*
0302  00405 066477R        LDB AZ
0303  00406 062551R        LDA .8
0304  00407 016001X        JSB CLEAR
0305  00410 072512R        STA X+4
0306  00411 072513R        STA X+5
0307  00412 072504R        STA Y+4
0308  00413 072505R        STA Y+5
0309  00414 126353R        JMP UNPAK,I
0310*
0311  00415 000000  MOVE    NOP
0312  00416 072556R        STA FROM
0313  00417 063532R        LDA M4
0314  00420 072542R        STA CNT
0315  00421 162556R UP      LDA FROM,I
0316  00422 170001          STA 1,I
0317  00423 036556R         ISZ FROM
0318  00424 006004          INB
0319  00425 036542R         ISZ CNT
0320  00426 026421R         JMP UP
0321  00427 126415R         JMP MOVE,I
0322*
0323  00430 000000  EXP     NOP
0324  00431 000006          CLE,ELA
0325  00432 001300          RAR
0326  00433 001727          ALF,ALF
0327  00434 012547R         AND B377
0328  00435 002040          SEZ
0329  00436 003004          CMA,INA
0330  00437 126430R         JMP EXP,I
0331*
0332  00440 000000  SHAME   NOP
0333  00441 002004          INA
0334  00442 072544R         STA TEMPA
0335  00443 063533R         LDA M5
0336  00444 072543R         STA CNT1
0337  00445 002400          CLA
0338  00446 072545R         STA TEMPB
0339*
0340  00447 006400  LOOP1   CLB
0341  00450 063532R         LDA M4
0342  00451 072542R         STA CNT
0343  00452 162544R         LDA TEMPA,I
```

```
0344   00453 000065          CLE,ERA
0345   00454 005500          ERB
0346   00455 038542R         ISZ CNT
0347   00456 026453R         JMP *-3
0348   00457 032545R         IOR TEMPB
0349   00460 172544R         STA TEMPA,I
0350   00461 076545R         STB TEMPB
0351   00462 036544R         ISZ TEMPA
0352   00463 036543R         ISZ CNT1
0353   00464 026447R         JMP LOOP1
0354   00465 126440R         JMP SHAME,I
0355*
0356   00466 000000  GETU    NOP
0357   00467 062506R         LDA X
0358   00470 022500R         XOR Y
0359   00471 012547R         AND B377
0360   00472 072537R         STA SIGND
0361   00473 126466R         JMP GETU,I
0362*
0363*
0364   00474 000524R TEMP1   DEF TEMP
0365   00475 000500R AY      DEF Y
0366   00476 000506R AX      DEF X
0367   00477 000514R AZ      DEF Z
0368   00500 000000  Y       BSS 6
0369   00506 000000  X       BSS 6
0370   00514 000000  Z       BSS 6
0371   00522 000000  EXPX    NOP
0372   00523 000000  EXPY    NOP
0373   00524 000000  TEMP    BSS 5
0374   00531 000000  SHFCN   NOP
0375   00532 000000  BIN     NOP
0376   00533 000000  BIN1    NOP
0377   00534 000000  ADRX    NOP
0378   00535 000000  ADRY    NOP
0379   00536 000000  ADRZ    NOP
0380   00537 000000  SIGND   NOP
0381   00540 000000  UNITX   NOP
0382   00541 000000  UNITY   NOP
0383   00542 000000  CNT     NOP
0384   00543 000000  CNT1    NOP
0385   00544 000000  TEMPA   NOP
0386   00545 000000  TEMPB   NOP
0387   00546 000017  B17     OCT 17
0388   00547 000377  B377    OCT 377
0389   00550 000004  B4      OCT 4
0390   00551 000006  .6      OCT 6
0391   00552 000000  BIG     NOP
0392   00553 000000  SMALL   NOP
0393   00554 000000  CB      NOP
0394   00555 000000  RETN    NOP
0395   00556 000000  FROM    NOP
0396   00557 000000  TEMPZ   NOP
```

MULTIPLY & DIVIDE - FULL PRECISION

```
0399*
0400   00560 000000  DMUL   NOP
0401   00561 016353R        JSB UNPAK
0402   00562 006400         CLB
0403   00563 076545R        STB TEMPB
0404   00564 017076R        JSB INIT
0405   00565 062522R        LDA EXPX
0406   00566 042523R        ADA EXPY
0407   00567 073334R        STA SHIFT
0408   00570 017222R        JSB FINDP
0409   00571 063373R        LDA PRECZ
0410   00572 072557R        STA TEMPZ
0411   00573 016714R        JSB SLINK
0412   00574 066476R BLAST  LDB AX
0413   00575 017161R        JSB RITE
0414   00576 026602R        JMP NOX
0415   00577 037334R        ISZ SHIFT
0416   00600 000000         NOP
0417   00601 026574R        JMP BLAST
0418*
0419   00602 066475R NOX    LDB AY
0420   00603 017161R        JSB RITE
0421   00604 026610R        JMP NOY
0422   00605 037334R        ISZ SHIFT
0423   00606 000000         NOP
0424   00607 026602R        JMP NOX
0425*
0426   00610 017222R NOY    JSB FINDP
0427   00611 062557R        LDA TEMPZ
0428   00612 073373R        STA PRECZ
0429   00613 007004         CMB,INB
0430   00614 046532R        ADB BIN
0431   00615 006020         SSB
0432   00616 026706R        JMP YPREC
0433   00617 062475R        LDA AY
0434   00620 067027R        LDB PLIER
0435   00621 016415R        JSB MOVE
0436   00622 062476R        LDA AX
0437   00623 066533R        LDB BIN1
0438*
0439   00624 007004  RIGHT  CMB,INB
0440   00625 077335R        STB DIGIT
0441   00626 017207R        JSB TURN
0442*
0443   00627 062550R NEWSU  LDA B4
0444   00630 066644R        LDB SUM1
0445   00631 016001X        JSB CLEAR
0446   00632 067027R        LDB PLIER
0447   00633 047524R        ADB .3
0448   00634 160001         LDA 1,I
0449   00635 012546R        AND B17
0450   00636 003000         CMA
0451   00637 073372R        STA ADDIT
0452*
0453   00640 037372R KEEP   ISZ ADDIT
0454   00641 002001         RSS
0455   00642 026650R        JMP FING
```

```
0456  00643 016000R        JSB DADD
0457  00644 001352R SUM1   DEF SUM
0458  00645 001344R CAND   DEF MUCAN
0459  00646 001352R        DEF SUM
0460  00647 026640R        JMP KEEP
0461*
0462  00650 063352R FING   LDA SUM
0463  00651 016430R        JSB EXP
0464  00652 043370R        ADA TIMES
0465  00653 072522R        STA EXPX
0466  00654 017256R        JSB REVER
0467  00655 073352R        STA SUM
0468  00656 037370R        ISZ TIMES
0469  00657 016000R        JSB DADD
0470  00660 001352R        DEF SUM
0471  00661 001361R ANS2   DEF ANS1
0472  00662 001361R        DEF ANS1
0473  00663 017174R        JSB SWIT
0474*
0475  00664 063027R        LDA PLIER
0476  00665 016440R        JSB SHAME
0477  00666 037335R        ISZ DIGIT
0478  00667 026627R        JMP NEWSU
0479*
0480  00670 063361R        LDA ANS1
0481  00671 016430R        JSB EXP
0482  00672 043334R        ADA SHIFT
0483  00673 072522R        STA EXPX
0484  00674 067535R ZERO1  LDB M12
0485  00675 062661R        LDA ANS2
0486  00676 017270R        JSB LEFT
0487  00677 017256R GLOBS  JSB REVER
0488  00700 033367R        IOR ANS
0489  00701 073361R        STA ANS1
0490  00702 062661R        LDA ANS2
0491  00703 067360R        LDB ADDRZ
0492  00704 016415R        JSB MOVE
0493  00705 127401R        JMP RETN1,I
0494*
0495  00706 062476R YPREC  LDA AX
0496  00707 067027R        LDB PLIER
0497  00710 016415R        JSB MOVE
0498  00711 066532R        LDB BIN
0499  00712 062475R        LDA AY
0500  00713 026624R        JMP RIGHT
0501*
0502  00714 000000  SLINK  NOP
0503  00715 062533R        LDA BIN1
0504  00716 007004         CMB,INB
0505  00717 046532R        ADB BIN
0506  00720 006020         SSB
0507  00721 062532R        LDA BIN
0508  00722 072724R        STA CLUNK
0509  00723 126714R        JMP SLINK,I
0510*
0511  00674         HOORY  EQU ZERO1
0512  00724 000000  CLUNK  NOP
```

```
0513*
0514  00725 000000  DDIV  NOP
0515  00726 016353R       JSB UNPAK
0516  00727 007400        CCB
0517  00730 076545R       STB TEMPB
0518  00731 017076R       JSB INIT
0519  00732 062523R       LDA EXPY
0520  00733 002021        SSA,RSS
0521  00734 002400        CLA
0522  00735 003004        CMA,INA
0523  00736 042522R       ADA EXPX
0524  00737 073334R       STA SHIFT
0525  00740 017222R       JSB FINDP
0526*
0527  00741 016714R       JSB SLINK
0528  00742 063334R       LDA SHIFT
0529  00743 072522R       STA EXPX
0530  00744 067535R       LDB M12
0531  00745 062476R       LDA AX
0532  00746 017270R       JSB LEFT
0533  00747 066475R GOGO  LDB AY
0534  00750 017161R       JSB RITE
0535  00751 026756R       JMP NMORE
0536  00752 003400        CCA
0537  00753 042522R       ADA EXPX
0538  00754 072522R       STA EXPX
0539  00755 026747R       JMP GOGO
0540*
0541  00756 062522R NMORE LDA EXPX
0542  00757 073334R       STA SHIFT
0543  00760 062475R       LDA AY
0544  00761 067027R       LDB PLIER
0545  00762 016415R       JSB MOVE
0546  00763 062476R       LDA AX
0547  00764 017207R       JSB TURN
0548  00765 173027R       STA PLIER,I
0549  00766 062551R       LDA .6
0550  00767 066644R       LDB SUM1
0551  00770 016001X       JSB CLEAR
0552  00771 073351R       STA MUCAN+5
0553  00772 073350R       STA MUCAN+4
0554*
0555  00773 062644R       LDA SUM1
0556  00774 002004        INA
0557  00775 073374R       STA TEMPQ
0558  00776 063533R       LDA M5
0559  00777 073375R       STA TEMPD
0560  01000 062645R       LDA CAND
0561  01001 002004        INA
0562  01002 073376R       STA TEMPE
0563  01003 063532R       LDA M4
0564  01004 073400R       STA TEMPC
0565*
0566  01005 163376R LOTS  LDA TEMPE,I
0567  01006 001700        ALF
0568  01007 173376R       STA TEMPE,I
0569  01010 012546R       AND B17
```

```
0570  01011 073405R        STA CLEAZ+3
0571  01012 063361R        LDA ANS1
0572  01013 016430R        JSB EXP
0573  01014 002004         INA
0574  01015 072522R        STA EXPX
0575  01016 017256R        JSB REVER
0576  01017 073361R        STA ANS1
0577  01020 016000R        JSB DADD
0578  01021 001402R        DEF CLEAZ
0579  01022 001361R        DEF ANS1
0580  01023 001361R        DEF ANS1
0581*
0582  01024 017174R        JSB SWIT
0583  01025 016003R MORE   JSB DSUB
0584  01026 001361R        DEF ANS1
0585  01027 001336R PLIER  DEF MPLY
0586  01030 000514R        DEF Z
0587  01031 062514R        LDA Z
0588  01032 000010         SLA
0589  01033 027041R        JMP OVERT
0590  01034 037370R        ISZ TIMES
0591  01035 062477R        LDA AZ
0592  01036 066661R        LDB ANS2
0593  01037 016415R        JSB MOVE
0594  01040 027025R        JMP MORE
0595*
0596  01041 063370R OVERT  LDA TIMES
0597  01042 067400R        LDB TEMPC
0598  01043 006004         INB
0599  01044 006003         SZB,RSS
0600  01045 027051R        JMP IOR1
0601  01046 001700         ALF
0602  01047 034001         ISZ 1
0603  01050 027046R        JMP *-2
0604  01051 133374R IOR1   IOR TEMPQ,I
0605  01052 173374R        STA TEMPQ,I
0606  01053 002400         CLA
0607  01054 073370R        STA TIMES
0608  01055 037400R        ISZ TEMPC
0609  01056 027005R        JMP LOTS
0610  01057 037375R        ISZ TEMPD
0611  01060 002001         RSS
0612  01061 027065R        JMP DONE1
0613  01062 037376R        ISZ TEMPE
0614  01063 037374R        ISZ TEMPQ
0615  01064 027003R        JMP LOTS-2
0616*
0617  01065 063334R DONE1  LDA SHIFT
0618  01066 072522R        STA EXPX
0619  01067 067535R        LDB M12
0620  01070 062644R        LDA SUM1
0621  01071 017270R        JSB LEFT
0622  01072 062644R        LDA SUM1
0623  01073 066661R        LDB ANS2
0624  01074 016415R        JSB MOVE
0625  01075 026674R        JMP HOORY
0626*
```

```
0627  01076 000000  INIT  NOP
0628  01077 016466R       JSB GETU
0629  01100 006400       CLB
0630  01101 062537R       LDA SIGND
0631  01102 000010       SLA
0632  01103 006004       INB
0633  01104 077367R       STB ANS
0634  01105 062555R       LDA RETN
0635  01106 073401R       STA RETN1
0636  01107 127076R       JMP INIT,I
0637*
0638  01110 000000  PRECN NOP
0639  01111 002004       INA
0640  01112 164000       LDB 0,I
0641  01113 076415R       STB MOVE
0642  01114 002004       INA
0643  01115 164000       LDB 0,I
0644  01116 076545R       STB TEMPB
0645  01117 002004       INA
0646  01120 164000       LDB 0,I
0647  01121 076353R       STB UNPAK
0648  01122 062415R       LDA MOVE
0649  01123 007400       CCB
0650  01124 076000R       STB DADD
0651  01125 077161R       STB RITE
0652  01126 006400  PREC3 CLB
0653  01127 076003R       STB DSUB
0654  01130 067532R       LDB M4
0655  01131 076544R       STB TEMPA
0656  01132 002003  PREC1 SZA,RSS
0657  01133 027142R       JMP PREC4
0658  01134 000065       CLE,ERA
0659  01135 001121       ARS,ARS
0660  01136 001100       ARS
0661  01137 036003R       ISZ DSUB
0662  01140 036544R       ISZ TEMPA
0663  01141 027132R       JMP PREC1
0664  01142 066003R PREC4 LDB DSUB
0665  01143 036000R       ISZ DADD
0666  01144 027152R       JMP PREC5
0667  01145 062545R       LDA TEMPB
0668  01146 006003       SZB,RSS
0669  01147 027126R       JMP PREC3
0670  01150 047526R       ADB .8
0671  01151 127110R       JMP PRECN,I
0672  01152 062353R PREC5 LDA UNPAK
0673  01153 037161R       ISZ RITE
0674  01154 127110R       JMP PRECN,I
0675  01155 006003       SZB,RSS
0676  01156 027126R       JMP PREC3
0677  01157 046550R       ADB B4
0678  01160 127110R       JMP PRECN,I
0679*
0680  01161 000000  RITE  NOP
0681  01162 074000       STB 0
0682  01163 043524R       ADA ,3
0683  01164 160000       LDA 0,I
```

```
0684  01165 012546R        AND B17
0685  01166 002002         SZA
0686  01167 127161R        JMP RITE,I
0687  01170 037161R        ISZ RITE
0688  01171 074000         STB 0
0689  01172 016440R        JSB SHAME
0690  01173 127161R        JMP RITE,I
0691*
0692  01174 000000  SWIT    NOP
0693  01175 063361R         LDA ANS1
0694  01176 002021          SSA,RSS
0695  01177 127174R         JMP SWIT,I
0696  01200 016430R         JSB EXP
0697  01201 073361R         STA ANS1
0698  01202 062661R         LDA ANS2
0699  01203 016440R         JSB SHAME
0700  01204 037361R         ISZ ANS1
0701  01205 027202R         JMP *-3
0702  01206 127174R         JMP SWIT,I
0703*
0704  01207 000000  TURN    NOP
0705  01210 066645R         LDB CAND
0706  01211 016415R         JSB MOVE
0707  01212 062536R         LDA ADRZ
0708  01213 073360R         STA ADDRZ
0709  01214 062551R         LDA .6
0710  01215 066661R         LDB ANS2
0711  01216 016001X         JSB CLEAR
0712  01217 073370R         STA TIMES
0713  01220 172645R         STA CAND,I
0714  01221 127207R         JMP TURN,I
0715*
0716  01222 000000  FINDP   NOP
0717  01223 066523R         LDB EXPY
0718  01224 062522R         LDA EXPX
0719  01225 003004          CMA,INA
0720  01226 042523R         ADA EXPY
0721  01227 002020          SSA
0722  01230 066522R         LDB EXPX
0723  01231 077373R         STB PRECZ
0724*
0725  01232 062476R         LDA AX
0726  01233 017110R         JSB PRECN
0727  01234 076532R         STB BIN
0728  01235 006003          SZB,RSS
0729  01236 027245R         JMP ZERO
0730  01237 062475R         LDA AY
0731  01240 017110R         JSB PRECN
0732  01241 076533R         STB BIN1
0733  01242 006003          SZB,RSS
0734  01243 027245R         JMP ZERO
0735  01244 127222R         JMP FINDP,I
0736*
0737  01245 063373R ZERO    LDA PRECZ
0738  01246 072522R         STA EXPX
0739  01247 062536R         LDA ADRZ
0740  01250 073360R         STA ADDRZ     * CORR.
```

```
0741  01251 002400         CLA
0742  01252 073362R        STA ANS1+1
0743  01253 073363R        STA ANS1+2
0744  01254 073364R        STA ANS1+3
0745  01255 026674R        JMP ZERO1
0746*
0747  01256 000000  REVER   NOP
0748  01257 062522R        LDA EXPX
0749  01260 006700         CLB,CCE
0750  01261 002020         SSA
0751  01262 005500         ERB
0752  01263 002020         SSA
0753  01264 003004         CMA,INA
0754  01265 001727         ALF,ALF
0755  01266 030001         IOR 1
0756  01267 127256R        JMP REVER,I
0757*
0758  01270 000000  LEFT    NOP
0759  01271 076542R        STB CNT
0760  01272 072557R        STA TEMPZ
0761  01273 062557R SHFL    LDA TEMPZ
0762  01274 002004         INA
0763  01275 072544R        STA TEMPA
0764  01276 063531R        LDA M3
0765  01277 072543R        STA CNT1
0766  01300 162544R        LDA TEMPA,I
0767  01301 001700         ALF
0768  01302 012546R        AND B17
0769  01303 002002         SZA
0770  01304 127270R        JMP LEFT,I
0771  01305 162544R        LDA TEMPA,I
0772  01306 001700         ALF
0773  01307 172544R        STA TEMPA,I
0774*
0775  01310 066544R USI     LDB TEMPA
0776  01311 006004         INB
0777  01312 160001         LDA 1,I
0778  01313 001700         ALF
0779  01314 012546R        AND B17
0780  01315 132544R        IOR TEMPA,I
0781  01316 172544R        STA TEMPA,I
0782  01317 160001         LDA 1,I
0783  01320 013523R        AND B7777
0784  01321 001700         ALF
0785  01322 170001         STA 1,I
0786  01323 076544R        STB TEMPA
0787  01324 036543R        ISZ CNT1
0788  01325 027310R        JMP USI
0789  01326 003400         CCA
0790  01327 042522R        ADA EXPX
0791  01330 072522R        STA EXPX
0792  01331 036542R        ISZ CNT
0793  01332 027273R        JMP SHFL
0794  01333 127270R        JMP LEFT,I
0795*
0796  01334 000000  SHIFT   NOP
0797  01335 000000  DIGIT   NOP
```

```
0798  01336 000000  MPLY   BSS 6
0799  01344 000000  MUCAN  BSS 6
0800  01352 000000  SUM    BSS 6
0801  01360 000000  ADDRZ  NOP
0802  01361 000000  ANS1   BSS 6
0803  01367 000000  ANS    NOP
0804  01370 000000  TIMES  NOP
0805  01371 000002  B2     OCT 2
0806  01372 000000  ADDIT  NOP
0807  01373 000000  PRECZ  NOP
0808  01374 000000  TEMPQ  NOP
0809  01375 000000  TEMPD  NOP
0810  01376 000000  TEMPE  NOP
0811  01377 000000  TEMPF  NOP
0812  01400 000000  TEMPC  NOP
0813  01401 000000  RETN1  NOP
0814  01402 000000  CLEAZ  OCT 0,0,0
      01403 000000
      01404 000000
0815  01405 000000         NOP
```

DECIMAL TO BINARY

```
0818  01406 000000  DTBI   NOP
0819  01407 006400         CLB
0820  01410 077507R        STB BNUM
0821  01411 077515R        STB YZ+4
0822  01412 077516R        STB YZ+5
0823  01413 103101         CLO
0824  01414 163406R        LDA DTBI,I
0825  01415 073517R        STA XADDR
0826  01416 037406R        ISZ DTBI
0827  01417 163406R        LDA DTBI,I
0828  01420 073520R        STA ZADDR
0829  01421 037406R        ISZ DTBI
0830  01422 062522R        LDA EXPX
0831  01423 073521R        STA XFLAG
0832*
0833  01424 063517R        LDA XADDR
0834  01425 067510R        LDB YADDR
0835  01426 016415R        JSB MOVE
0836  01427 063511R        LDA YZ
0837  01430 016430R        JSB EXP
0838  01431 002003         SZA,RSS
0839  01432 027441R        JMP DOWNT
0840  01433 002020         SSA
0841  01434 027475R        JMP GORIT
0842  01435 003004         CMA,INA
0843  01436 070001         STA 1
0844  01437 063510R        LDA YADDR
0845  01440 017270R        JSB LEFT
0846*
0847  01441 063512R DOWNT  LDA YZ+1
0848  01442 002002         SZA
0849  01443 027467R        JMP BADDO
0850  01444 063513R        LDA YZ+2
0851  01445 006404         CLB,INB
0852  01446 001700  DT25   ALF
0853  01447 072524R        STA TEMP
0854  01450 012546R        AND B17
0855  01451 043507R        ADA BNUM
0856  01452 072525R        STA TEMP+1
0857  01453 057526R        CPB .8
0858  01454 027471R        JMP DONEW
0859  01455 017503R        JSB OFLO
0860  01456 017503R        JSB OFLO
0861  01457 042525R        ADA TEMP+1
0862  01460 017503R        JSB OFLO
0863  01461 073507R        STA BNUM
0864  01462 062524R        LDA TEMP
0865  01463 056550R        CPB B4
0866  01464 063514R        LDA YZ+3
0867  01465 006004         INB
0868  01466 027446R        JMP DT25
0869*
0870  01467 003400  BADDO  CCA
0871  01470 102101         STO
0872  01471 173520R DONEW  STA ZADDR,I
0873  01472 063521R        LDA XFLAG
0874  01473 072522R        STA EXPX
```

```
0875  01474 127406R        JMP DTBI,I
0876*
0877  01475 072415R GORIT  STA MOVE
0878  01476 063510R        LDA YADDR
0879  01477 016440R        JSB $NAME
0880  01500 036415R        ISZ MOVE
0881  01501 027476R        JMP GORIT+1
0882  01502 027441R        JMP DOWNT
0883*
0884  01503 000000  OFLO    NOP
0885  01504 001210          RAL,SLA
0886  01505 027467R         JMP BADDO
0887  01506 127503R         JMP OFLO,I
0888*
0889  01507 000000  BNUM    NOP
0890  01510 001511R YADDR   DEF *+1
0891  01511 000000  YZ      BSS 6
0892  01517 000000  XADDR   NOP
0893  01520 000000  ZADDR   NOP
0894  01521 000000  XFLAG   NOP
0895*
0896  01522 177763  M13     DEC -13
0897  01523 007777  87777   OCT 7777
0898  01524 000003  .3      OCT 3
0899  01525 000005  .5      OCT 5
0900  01526 000010  .8      DEC 8
0901  01527 000012  .10     DEC 10
0902  01530 177776  M2      DEC -2
0903  01531 177775  M3      DEC -3
0904  01532 177774  M4      DEC -4
0905  01533 177773  M5      DEC -5
0906  01534 177766  M10     DEC -10
0907  01535 177764  M12     DEC -12
0908                        END
** NO ERRORS: AMD ASMB,25117-402518
```

TIME BASE GENERATOR DRIVER

```
0001                    ASMB,R,B,L
0003  00000                     NAM D.43
0004                            ENT D.43,ETIME,I.43
0005                            ENT TIMEX,TIMEY,MAXT,MAXT1,TMARK
0006*
0007  00000 000000  D.43   NOP             INITIATOR ENTRY
0008  00001 002400         CLA
0009  00002 102610         OTA TBG         OUTPUT TO CHANNEL
0010  00003 103710         STC TBG,C       ENCODE CHANNEL
0011  00004 126000R        JMP D.43,I      RETURN TO CALLER
0012*
0013  00005 000000  I.43   NOP             CONTINUATOR ENTRY
0014  00006 036023R        ISZ TMARK       ADD 1 TO INTERRUPT COUNTER
0015  00007 000000         NOP             IN CASE OF OVERFLOW
0016  00010 036024R        ISZ TIMEX       ADD 1 TO TIME COUNTER
0017  00011 002001         RSS             IF NO OVERFLOW, RETURN
0018  00012 036025R        ISZ TIMEY       IF OVERFLOW ADD 1 TO 2ND WORD
0019  00013 103710         STC TBG,C       ENCODE CHANNEL
0020  00014 126005R        JMP I.43,I      RETURN TO INTERRUPTED SEQUENCE
0021*
0022*  TIME DELAY ROUTINE
0023*
0024  00015 000000  ETIME  NOP
0025  00016 006400         CLB             SET INTERRUPT MARK TO 0
0026  00017 076023R        STB TMARK
0027  00020 052023R        CPA TMARK       WHEN 'A' EQUALS TMARK,RETURN
0028  00021 126015R        JMP ETIME,I      OTHERWISE KEEP LOOPING
0029  00022 026020R        JMP *-2
0030*
0031  00010           TBG    EQU 10B
0032  00023 000000    TMARK  NOP
0033  00024 000000    TIMEX  NOP
0034  00025 000000    TIMEY  NOP
0035  00026 000000    MAXT   NOP
0036  00027 000000    MAXT1  NOP
0037                    END
**  NO ERRORS: AMD ASMB,25117-402518
```

BINARY TO BCD

```
0001                          ASMB,R,B,L
0003  00000                   NAM BIBCD
0004                          ENT BIBCD,BCDBI
0005  00000 000000  BIBCD NOP
0006  00001 072103R          STA TEMP
0007  00002 072110R          STA NUMB
0008  00003 002003          SZA,RSS
0009  00004 126000R          JMP BIBCD,I
0010  00005 006400          CLB
0011  00006 076111R          STB CNTR3
0012  00007 066116R          LDB DM10
0013  00010 076112R          STB CNTR4
0014*
0015  00011 066110R LOOP1 LDB NUMB
0016  00012 046116R          ADB DM10
0017  00013 076110R          STB NUMB
0018  00014 036111R          ISZ CNTR3
0019  00015 006020          SSB
0020  00016 026046R          JMP FIN
0021*
0022  00017 062103R          LDA TEMP
0023  00020 042117R          ADA B6
0024  00021 072103R          STA TEMP
0025  00022 036112R          ISZ CNTR4
0026  00023 026011R          JMP LOOP1
0027*
0028  00024 062116R          LDA DM10
0029  00025 072112R          STA CNTR4
0030  00026 002004          INA
0031  00027 072113R          STA CNTR5
0032  00030 062111R          LDA CNTR3
0033  00031 006400          CLB
0034*
0035  00032 046104R ADD   ADB B144
0036  00033 050001          CPA 1
0037  00034 026043R          JMP OUT
0038  00035 036113R          ISZ CNTR5
0039  00036 026032R          JMP ADD
0040*
0041  00037 062103R          LDA TEMP
0042  00040 042115R          ADA B140
0043  00041 072103R OUT1  STA TEMP
0044  00042 026011R          JMP LOOP1
0045*
0046  00043 062103R OUT   LDA TEMP
0047  00044 042114R          ADA B3140
0048  00045 026041R          JMP OUT1
0049*
0050  00046 062103R FIN   LDA TEMP
0051  00047 126000R          JMP BIBCD,I
0052*
```

BCD TO BINARY

```
0055   00050 000000  BCDBI NOP
0056   00051 002003        SZA,RSS
0057   00052 126050R       JMP BCDBI,I
0058   00053 072103R       STA TEMP
0059   00054 012120R       AND B17
0060   00055 072107R       STA ANS
0061   00056 062105R       LDA B1750
0062   00057 016066R       JSB SHIFT
0063*
0064   00060 062104R       LDA B144
0065   00061 016066R       JSB SHIFT
0066*
0067   00062 062121R       LDA B12
0068   00063 016066R       JSB SHIFT
0069*
0070   00064 062107R       LDA ANS
0071   00065 126050R       JMP BCDBI,I
0072*
0073   00066 000000  SHIFT NOP
0074   00067 072106R       STA N
0075   00070 062103R       LDA TEMP
0076   00071 001700        ALF
0077   00072 072103R       STA TEMP
0078   00073 012120R       AND B17
0079   00074 002003        SZA,RSS
0080   00075 126066R       JMP SHIFT,I
0081   00076 100200        OCT 100200     MPY
0082   00077 000106R       DEF N
0083   00100 042107R       ADA ANS
0084   00101 072107R       STA ANS
0085   00102 126066R       JMP SHIFT,I
0086*
0087   00103 000000  TEMP  NOP
0088   00104 000144  B144  OCT 144
0089   00105 001750  B1750 OCT 1750
0090   00106 000000  N     NOP
0091   00107 000000  ANS   NOP
0092   00110 000000  NUMB  NOP
0093   00111 000000  CNTR3 NOP
0094   00112 000000  CNTR4 NOP
0095   00113 000000  CNTR5 NOP
0096   00114 003140  B3140 OCT 3140
0097   00115 000140  B140  OCT 140
0098   00116 177766  DM10  DEC -10
0099   00117 000006  B6    OCT 6
0100   00120 000017  B17   OCT 17
0101   00121 000012  B12   OCT 12
0102                       END
**  NO ERRORS: AMD ASMB,25117-402518
```

READ TIME OF DAY

```
0001                    ASMB,R,B,L
0003  00000                     NAM RTOD
0004                            ENT RTOD,MSG1,YR
0005                            EXT PRINT,MODT
0006*
0007  00000 000000  RTOD  NOP
0008  00001 062002X        LDA MODT        MODEM TABLE
0009  00002 072134R        STA TAB
0010  00003 062136R        LDA MSG         MESSAGE BUFFER
0011  00004 072135R        STA BUFF
0012  00005 002400         CLA
0013  00006 072137R        STA ERROR       ERROR FLAG
0014  00007 103716         STC TCG,C
0015  00010 066166R        LDB =D-10
0016  00011 102316  TOD2   SFS TCG         SEE IF ON
0017  00012 002001         RSS             NOT YET
0018  00013 026022R        JMP TOD3        OK GET TIME
0019  00014 034000         ISZ 0
0020  00015 026011R        JMP TOD2
0021  00016 034001         ISZ 1
0022  00017 026011R        JMP TOD2
0023  00020 036137R        ISZ ERROR       SET ERROR FLAG AND FILL
0024  00021 026027R        JMP TOD4         BUFFER WITH 0
0025*
0026  00022 102516  TOD3   LIA TCG         DDDDDDDDDDHHHHHH
0027  00023 007400         CCB
0028  00024 050001         CPA 1
0029  00025 026014R        JMP TOD2+3      BAD DATA
0030*
0031  00026 106516         LIB TCG         MMMMMMMMSSSSSSSS
0032  00027 072140R TOD4   STA NASA1
0033  00030 060001         LDA 1
0034  00031 012167R        AND =B77577
0035  00032 072141R        STA NASA2
0036*
0037  00033 062140R        LDA NASA1
0038  00034 001222         RAL,RAL
0039  00035 070001         STA 1
0040  00036 005700         BLF
0041  00037 012170R        AND =B3
0042  00040 016103R        JSB PUT         PUT 1ST 2 DIGITS OF DAYS AWAY
0043  00041 005323         RBR,RBR
0044  00042 005323         RBR,RBR
0045  00043 060001         LDA 1
0046  00044 016121R        JSB PUT1        PUT 3RD DIGIT OF DAY AWAY
0047*
0048  00045 062140R        LDA NASA1
0049  00046 070001         STA 1
0050  00047 001727         ALF,ALF
0051  00050 001700         ALF
0052  00051 012170R        AND =B3
0053  00052 016103R        JSB PUT         PUT HOURS AWAY
0054*
0055  00053 062141R        LDA NASA2
0056  00054 070001         STA 1
0057  00055 001700         ALF
0058  00056 012171R        AND =B17
```

```
0059  00057 172134R        STA TAB,I      1ST DIGIT OF MIN
0060  00060 036134R        ISZ TAB
0061  00061 042172R        ADA =B35060    ADD SEMICOLON
0062  00062 172135R        STA BUFF,I
0063  00063 036135R        ISZ BUFF
0064*
0065  00064 062141R        LDA NASA2
0066  00065 016121R        JSB PUT1       2ND DIGIT OF MIN
0067*
0068  00066 062141R        LDA NASA2
0069  00067 001727         ALF,ALF
0070  00070 001700         ALF
0071  00071 012171R        AND =B17
0072  00072 016103R        JSB PUT        PUT SECONDS AWAY
0073*
0074  00073 107716         CLC TCG,C
0075  00074 062137R        LDA ERROR
0076  00075 002003         SZA,RSS
0077  00076 126000R        JMP RTOD,I     NO ERROR
0078*
0079  00077 062173R        LDA =D5        PRINT ERROR
0080  00100 016001X        JSB PRINT
0081  00101 000142R        DEF MSG9
0082  00102 126000R        JMP RTOD,I
0083*
0084  00103 000000  PUT    NOP
0085  00104 172134R        STA TAB,I
0086  00105 036134R        ISZ TAB
0087  00106 001727         ALF,ALF
0088  00107 072133R        STA TEMP
0089  00110 060001         LDA 1
0090  00111 012171R        AND =B17
0091  00112 172134R        STA TAB,I
0092  00113 036134R        ISZ TAB
0093  00114 032133R        IOR TEMP
0094  00115 032174R        IOR =B30000
0095  00116 172135R        STA BUFF,I
0096  00117 036135R        ISZ BUFF
0097  00120 126103R        JMP PUT,I
0098*
0099  00121 000000  PUT1   NOP
0100  00122 001727         ALF,ALF
0101  00123 012171R        AND =B17
0102  00124 172134R        STA TAB,I
0103  00125 036134R        ISZ TAB
0104  00126 042172R        ADA =B35060    ADD SEMICOLON
0105  00127 001727         ALF,ALF
0106  00130 172135R        STA BUFF,I
0107  00131 036135R        ISZ BUFF
0108  00132 126121R        JMP PUT1,I
0109*
0110                       SUP
0111  00133 000000  TEMP   NOP
0112  00134 000000  TAB    NOP
0113  00135 000000  BUFF   NOP
0114  00136 000153R MSG    DEF TIMEB
0115  00137 000000  ERROR  NOP
```

```
0116   00016           TCG    EQU 16B
0117   00140 000000    NASA1  NOP
0118   00141 000000    NASA2  NOP
0119   00142 052103    MSG9   ASC 5,TCG ERROR
0120   00147 000150R   MSG1   DEF **1
0121   00150 052111           ASC 3,TIME:
0122   00153 020040    TIMEB  ASC 6,
0123   00161 020040           ASC 4,      19
0124   00165 033465    YR     ASC 1,75
0125                          UNS
       00166 177766
       00167 077577
       00170 000003
       00171 000017
       00172 035060
       00173 000005
       00174 030060
0126                          END
**  NO ERRORS: AMD ASMB,25117-402518
```

TTY DRIVER

```
0001                    ASMB,R,B,L
0003  00000                    NAM TTY
0004                           ENT D.00,I.00
0005*****************************************************************
0006* ENTRY TO INITIATOR SECTION:                                   *
0007*   JSB .IOC.                                                   *
0008*   DCT  (0=CLEAR;1=READ;2=WRITE                                *
0009*   JMP REJECT                                                  *
0010*   DEF BUFFER                                                  *
0011*   DEC X   X=NUMBER OF WORDS                                   *
0012* RETURN FROM STATUS:                                           *
0013*   A=0 FOR CLEAR, OR =1 FOR BUSY                               *
0014*   B= NUMBER OF CHARACTERS TRANSMITTED                         *
0015*****************************************************************



0017  00000 000000  D.00   NOP
0018  00001 002004         INA
0019  00002 072262R        STA EQUIP      STATUS WORD
0020  00003 002004         INA
0021  00004 072302R        STA XMIT       TRANSMISSION LOG
0022  00005 160001         LDA 1,I
0023  00006 001700         ALF
0024  00007 012260R        AND B7
0025  00010 002003         SZA,RSS
0026  00011 026056R        JMP CLEAR      CLEAR REQUEST
0027  00012 046257R        ADB B2
0028  00013 076261R        STB TEMP
0029  00014 066272R        LDB BUSY
0030  00015 006002         SZB            OPERATION IN PROGRESS ?
0031  00016 126000R        JMP D.00,I      YES: GO TO REJECT ADDRESS
0032  00017 166261R        LDB TEMP,I     BUFFER ADDRESS
0033  00020 036261R        ISZ TEMP
0034  00021 076276R        STB BADD       BUFFER ADDRESS
0035  00022 076277R        STB BADD1
0036  00023 166261R        LDB TEMP,I
0037  00024 005000         BLS            MULTIPLY WORD COUNT BY 2
0038  00025 076300R        STB SIZE       SAVE CHARACTER COUNT
0039  00026 076301R        STB SIZE1
0040  00027 006400         CLB
0041  00030 176302R        STB XMIT,I     NUMBER OF CHARS. XMITTED
0042  00031 076270R        STB LFLAG    LINE FEED FLAG
0043  00032 076271R        STB DELFL    LINE DELETE FLAG
0044  00033 076273R        STB CHAR     LAST CHARACTER OUTPUTED
0045  00034 066263R        LDB SIGN
0046  00035 176262R        STB EQUIP,I
0047  00036 072272R        STA BUSY       SET BUSY FLAG
0048  00037 000010         SLA
0049  00040 026050R        JMP READ       READ REQUEST
0050*
0051  00041 062307R        LDA B1200      SET UP WRITE MODE
0052  00042 102614         OTA CH
0053  00043 062000R        LDA D.00       RETURN ADDRESS
0054  00044 072061R        STA I.00
```

```
0055  00045 002400          CLA
0056  00046 072304R         STA SAVA
0057  00047 026105R         JMP OUTPT     SEND 1ST CHARACTER
0058*
0059  00050 016241R READ    JSB SPACE     FILL BUFFER WITH SPACES
0060  00051 062303R         LDA B1400     SET FOR READ MODE
0061  00052 102614          OTA CH
0062  00053 002400          CLA
0063  00054 103714          STC CH,C      ENCODE CHANNEL
0064  00055 126000R         JMP D.00,I     RETURN TO CALLER
0065*
0066  00056 062000R CLEAR   LDA D.00      RETURN ADDRESS
0067  00057 072061R         STA I.00
0068  00060 026203R         JMP CR        SEND CR LF
0069*
0070  00061 000000  I.00     NOP           CONTINUATOR ENTRY
0071  00062 107714          CLC CH,C      INHIBIT INTERRUPTS ON CHANNEL
0072  00063 072304R         STA SAVA      SAVE WORKING REGISTERS
0073  00064 076305R         STB SAVB
0074  00065 002400          CLA
0075  00066 001500          ERA
0076  00067 102201          SOC
0077  00070 002004          INA
0078  00071 072306R         STA SAVE
0079*
0080  00072 036270R         ISZ LFLAG
0081  00073 002001          RSS
0082  00074 026215R         JMP LF        OUTPUT LF
0083  00075 062272R         LDA BUSY
0084  00076 002003          SZA,RSS       OPERATION IN PROGRESS ?
0085  00077 026124R         JMP RET       NO: FALSE INTERRUPT
0086  00100 000010          SLA
0087  00101 026141R         JMP READS     READ IN PROGRESS
0088*
0089  00102 062273R         LDA CHAR
0090  00103 052265R         CPA B12
0091  00104 026217R         JMP DONE
0092  00105 166302R OUTPT   LDB XMIT,I    NO: FETCH CHARACTER COUNT
0093  00106 056300R         CPB SIZE      DONE OUTPUTTING ?
0094  00107 026203R         JMP CR        YES: OUTPUT CR LF
0095  00110 006004          INB           ADD 1 TO CHAR. COUNT
0096  00111 176302R         STB XMIT,I
0097  00112 162276R         LDA BADD,I    FETCH WORD
0098  00113 004010          SLB           WORKING ON HIGH ORDER
0099  00114 001727          ALF,ALF       YES: PUT IN LOW ORDER
0100  00115 012264R         AND B177      MASK CHAR.
0101  00116 052274R         CPA ARRO
0102  00117 026237R         JMP ARROW     BACK ARROW
0103  00120 006011          SLB,RSS       IF EVEN BUMP BUFFER ADDRESS
0104  00121 036276R         ISZ BADD
0105*
0106  00122 102614  SEND    OTA CH        OUTPUT
0107  00123 072273R         STA CHAR
0108  00124 062306R RET     LDA SAVE      RESTORE WORKING REGISTERS
0109  00125 103101          CLO
0110  00126 000036          SLA,ELA
0111  00127 102101          STF 1
```

```
0112  00130 062272R          LDA BUSY
0113  00131 002003           SZA,RSS
0114  00132 003400           CCA
0115  00133 072241R          STA SPACE
0116  00134 062304R          LDA SAVA
0117  00135 066305R          LDB SAVB
0118  00136 036241R          ISZ SPACE
0119  00137 103714           STC CH,C        ENCODE CHANNEL
0120  00140 126061R          JMP I.00,I      RETURN TO INTERRUPTED SEQUENCE
0121*
0122  00141 102514  READS    LIA CH          READ IN CHAR.
0123  00142 012264R          AND B177        MASK OFF EXTRANEOUS BITS
0124  00143 052264R          CPA B177
0125  00144 026235R          JMP DEL         DELETE LINE
0126  00145 052275R          CPA CARRT       CARROT IS ALSO DELETE
0127  00146 026235R          JMP DEL
0128  00147 052265R          CPA B12
0129  00150 026123R          JMP SEND+1      IGNORE LINE FEED
0130  00151 052310R          CPA B15
0131  00152 026203R          JMP CR          CARRIAGE RETURN
0132  00153 002003           SZA,RSS
0133  00154 026123R          JMP SEND+1      NO CHAR
0134*
0135  00155 166302R          LDB XMIT,I      ADD 1 TO NUMBER OF CHARS.
0136  00156 006004           INB
0137  00157 176302R          STB XMIT,I
0138  00160 006011           SLB,RSS
0139  00161 026171R          JMP EVEN        2ND HALF OF WORD
0140  00162 001727           ALF,ALF         ROTATE TO TOP HALF
0141  00163 070001           STA 1
0142  00164 162276R          LDA BADD,I
0143  00165 012264R          AND B177        MASK LOW ORDER
0144  00166 030001           IOR 1           MERGE 2 CHARS.
0145  00167 172276R          STA BADD,I      PUT THEM AWAY
0146  00170 026123R          JMP SEND+1      WAIT,I FOR NEXT CHAR
0147*
0148  00171 070001  EVEN     STA 1
0149  00172 162276R          LDA BADD,I
0150  00173 012267R          AND B774        MASK HIGH ORDER CHAR.
0151  00174 030001           IOR 1           MERGE 2 CHARS.
0152  00175 172276R          STA BADD,I      PUT IT,I  AWAY
0153  00176 036276R          ISZ BADD        BUMP BUFFER ADDRESS
0154  00177 162302R          LDA XMIT,I
0155  00200 052300R          CPA SIZE        ALL DONE ?
0156  00201 002001           RSS             YES; OUTPUT CR LF
0157  00202 026123R          JMP SEND+1      NO; WAIT FOR NEXT CHAR.
0158*
0159  00203 002400  CR       CLA
0160  00204 072271R          STA DELFL       LINE DELETE
0161  00205 003400           CCA
0162  00206 072270R          STA LFLAG
0163  00207 062307R          LDA B1200       SET FOR WRITE MODE
0164  00210 102614           OTA CH
0165  00211 062257R          LDA B2
0166  00212 072272R          STA BUSY
0167  00213 062310R          LDA B15          CARRIAGE RETURN
0168  00214 026122R          JMP SEND
```

```
0169*
0170   00215 062265R LF     LDA B12        LINE FEED
0171   00216 026122R        JMP SEND
0172*
0173   00217 002400  DONE   CLA            WAIT 300 MS
0174   00220 034000         ISZ 0
0175   00221 026220R        JMP *-1
0176   00222 062271R        LDA DELFL
0177   00223 002002         SZA
0178   00224 026230R        JMP DEL2       LINE DELETE
0179   00225 072272R FIN    STA BUSY       CLEAR BUSY FLAG
0180   00226 172262R        STA EQUIP,I
0181   00227 026123R        JMP SEND+1     GET OUT
0182*
0183   00230 016241R DEL2   JSB SPACE      FILL BUFFER WITH SPACES
0184   00231 002404         CLA,INA        SET UP FOR READ MODE
0185   00232 072272R        STA BUSY
0186   00233 062303R        LDA B1400
0187   00234 026122R        JMP SEND
0188*
0189   00235 002404  DEL    CLA,INA
0190   00236 026204R        JMP CR+1
0191*
0192   00237 002400  ARROW  CLA            CLEAR BUSY FLAG
0193   00240 026225R        JMP FIN
0194*
0195   00241 000000  SPACE  NOP
0196   00242 066301R        LDB SIZE1
0197   00243 076300R        STB SIZE
0198   00244 005100         BRS            DIVIDE CHAR. COUNT BY 2
0199   00245 007004         CMB,INB
0200   00246 176302R        STB XMIT,I
0201   00247 062266R        LDA B40        FILL USER BUFFER WIT,IH SPACES
0202   00250 066277R        LDB BADD1
0203   00251 076276R        STB BADD
0204   00252 170001         STA 1,I
0205   00253 006004         INB
0206   00254 136302R        ISZ XMIT,I
0207   00255 026252R        JMP *-3
0208   00256 126241R        JMP SPACE,I
0209*
0210*
0211* CONSTANTS AND WORKING STORAGE ***
0212*
0213   00257 000002  B2     OCT 2
0214   00260 000007  B7     OCT 7
0215   00261 000000  TEMP   NOP
0216   00262 000000  EQUIP  NOP
0217   00263 100000  SIGN   OCT 100000
0218   00264 000177  B177   OCT 177
0219   00265 000012  B12    OCT 12
0220   00266 020040  B40    OCT 20040
0221   00267 177400  B774   OCT 177400
0222   00270 000000  LFLAG  NOP
0223   00271 000000  DELFL  NOP
0224   00272 000000  BUSY   NOP
0225   00273 000000  CHAR   NOP
```

```
0226   00274 000137   ARRO   OCT 137
0227   00275 000136   CARRT  OCT 136
0228   00276 000000   BADD   NOP
0229   00277 000000   BADD1  NOP
0230   00300 000000   SIZE   NOP
0231   00301 000000   SIZE1  NOP
0232   00302 000000   XMIT   NOP
0233   00303 140000   B1400  OCT 140000       READ COMMAND
0234   00304 000000   SAVA   NOP
0235   00305 000000   SAVB   NOP
0236   00306 000000   SAVE   NOP
0237   00307 120000   B1200  OCT 120000       WRITE COMMAND
0238   00310 000015   B15    OCT 15         CARRIAGE RETURN
0239   00014          CH     EQU 14B
0240                         END
** NO ERRORS: AMD ASMB,25117-40251B
```

COUNTER DRIVER

```
0001                    ASMB,R,B,L
0003  00000                     NAM D.44
0004                            ENT D.44,DONE,I.441,I.442,I.443
0005                            EXT ABORT,BCDBI,TIMEX,LINKS
0006                            EXT MAXT,MAXT1
0007*****************************************************************
0008* ENTRY TO INITIATOR:                                           *
0009*     JSB .IOC.                                                 *
0010*     OCT 10003                                                 *
0011*     JMP REJ                                                   *
0012*     DEF BUFFER ADDRESSES FOR 3 COUNTERS                       *
0013*     DEC X                                                     *
0014*                                                               *
0015* WHERE X = 0 FOR 1 READING IN 4 WORD BCD FORMAT                *
0016*         = NUMBER OF READINGS IN INTEGER FORMAT                *
0017* RETURN FROM CONTINUATOR SECTION =                             *
0018*   BCD FORMAT CONTAINS A 4 WORD BCD NUMBER                     *
0019*   INTEGER FORMAT CONTAINS THE AVERAGE OF 3 READINGS           *
0020*     + A STATUS WORD + 2 WORDS OF TIME TAG                     *
0021*****************************************************************

0023  00000 000000  D.44  NOP             INITIATOR ENTRY
0024  00001 160001        LDA 1,I
0025  00002 013113R       AND =B70000
0026  00003 002003        SZA,RSS
0027  00004 026037R       JMP CLEAR       CLEAR DRIVER
0028  00005 063030R       LDA UNIT
0029  00006 002002        SZA             OPERATION IN PROGRESS ?
0030  00007 026001X       JMP ABORT        YES: BOMB
0031  00010 063114R       LDA =B643       PLUG IN CODE
0032  00011 073030R       STA UNIT
0033  00012 047115R       ADB =B2
0034  00013 077027R       STB TEMP        BUFFER ADDRESSES
0035  00014 006004        INB
0036  00015 160001        LDA 1,I         NUMBER OF READINGS
0037  00016 073037R       STA MARK
0038  00017 003004        CMA,INA
0039  00020 002003        SZA,RSS         IF 0,MAKE =1
0040  00021 003400        CCA
0041  00022 073111R       STA DONE        SAVE AS INDEX
0042*
0043  00023 167027R       LDB TEMP,I
0044  00024 160001        LDA 1,I
0045  00025 073034R       STA ADDR1
0046  00026 006004        INB
0047  00027 160001        LDA 1,I
0048  00030 073035R       STA ADDR2
0049  00031 006004        INB
0050  00032 160001        LDA 1,I
0051  00033 073036R       STA ADDR3
0052*
0053  00034 016777R       JSB CALL        START THE COUNTERS
0054  00035 002400        CLA
```

```
0055  00036 126000R        JMP D,44,I    RETURN TO CALLER
0056*
0057  00037 107711  CLEAR  CLC CH1,C
0058  00040 107712         CLC CH2,C
0059  00041 107713         CLC CH3,C
0060  00042 002400         CLA           CLEAR OPERATION FLAG
0061  00043 073030R        STA UNIT       AND TURN OFF COUNTERS
0062  00044 073040R        STA MAJ1
0063  00045 073041R        STA MAJ2
0064  00046 073042R        STA MAJ3
0065  00047 126000R        JMP D,44,I    RETURN TO CALLER
0066*
```

```
0068* CONTINUATOR SECTION OF 1ST COUNTER
0069*
0070  00050 000000  I,441  NOP
0071  00051 107711         CLC CH1,C
0072  00052 073046R        STA SAVA1     SAVE WORKING REGISTERS
0073  00053 077047R        STB SAVB1
0074  00054 002400         CLA
0075  00055 001500         ERA
0076  00056 102201         SOC
0077  00057 002004         INA
0078  00060 073050R        STA SAVE1
0079  00061 063030R        LDA UNIT
0080  00062 002003         SZA,RSS       FALSE INTERRUPT ?
0081  00063 026111R        JMP FAL1      YES: RETURN
0082*
0083  00064 037043R        ISZ MINR1     DONE OUTPUTTING ?
0084  00065 002001         RSS           NO:
0085  00066 026114R        JMP READ1     YES: TAKE A READING
0086  00067 063074R  GO1   LDA STC1
0087  00070 072106R        STA BUS1
0088  00071 063033R        LDA ENDT
0089  00072 043043R        ADA MINR1
0090  00073 160000         LDA 0,I       FETCH OUTPUT WORD
0091  00074 103100         CLF 0
0092  00075 106711         CLC CH1       CLEAR CHANNEL
0093  00076 102111         STF CH1       POINT TO WORD 4
0094  00077 102611         OTA CH1       SEND THE WORD
0095  00100 063050R  RET1   LDA SAVE1     RESTORE THE REGISTERS
0096  00101 103101         CLO
0097  00102 000036         SLA,ELA
0098  00103 102101         STF 1
0099  00104 063046R        LDA SAVA1
0100  00105 067047R        LDB SAVB1
0101  00106 000000  BUS1   NOP
0102  00107 102100         STF 0
0103  00110 126050R        JMP I,441,I   RETURN TO INTERRUPTED SEQUENCE
0104*
0105  00111 002400  FAL1   CLA
0106  00112 072106R        STA BUS1
0107  00113 026100R        JMP RET1
```

```
0108*
0109   00114 104200  READ1 OCT 104200     DLD TIME MARK
0110   00115 000003X       DEF TIMEX
0111   00116 104400        OCT 104400     TEMPORARY SAVE
0112   00117 001062R       DEF TEMP1
0113   00120 063037R       LDA MARK
0114   00121 002003        SZA,RSS
0115   00122 026220R       JMP BCD1       BCD FORMAT
0116   00123 102511        LIA CH1        FETCH 1ST 2 INPUT WORDS
0117   00124 106511        LIB CH1
0118   00125 016672R       JSB FLIP       FLIP DIGITS
0119*
0120   00126 073105R       STA IN1
0121   00127 063040R       LDA MAJ1
0122   00130 002004        INA
0123   00131 002003        SZA,RSS
0124   00132 026160R       JMP DONE1
0125   00133 002021        SSA,RSS
0126   00134 026001X       JMP ABORT
0127   00135 073040R       STA MAJ1
0128   00136 063105R       LDA IN1
0129   00137 143034R       ADA ADDR1,I    ADD 2 READINGS
0130   00140 173034R       STA ADDR1,I    SAVE TOTAL
0131   00141 063034R       LDA ADDR1
0132   00142 043115R       ADA =B2
0133   00143 073070R       STA FAR1       TIME TAG ADDRESS
0134   00144 104200        OCT 104200     ADD THE 2 TIME TAGS
0135   00145 100000        DEF 0,I        DLD 0,I
0136   00146 000040        CLE
0137   00147 043062R       ADA TEMP1
0138   00150 002040        SEZ
0139   00151 006004        INB
0140   00152 047063R       ADB TEMP1+1
0141   00153 104400        OCT 104400     DST FAR1,I
0142   00154 101070R       DEF FAR1,I
0143   00155 063116R SEN1  LDA =B-3        INIATIATE NEXT READING
0144   00156 073043R       STA MINR1
0145   00157 026067R       JMP GO1
0146*
0147   00160 063105R DONE1 LDA IN1
0148   00161 143034R       ADA ADDR1,I    ADD 3RD READING
0149   00162 006400        CLB
0150   00163 100400        OCT 100400     DIVIDE BY 3
0151   00164 001110R       DEF B3
0152   00165 173034R       STA ADDR1,I    PUT IT AWAY
0153   00166 037034R       ISZ ADDR1
0154   00167 063073R       LDA SIGN       PUT STATUS AWAY
0155   00170 173034R       STA ADDR1,I
0156   00171 037034R       ISZ ADDR1
0157   00172 104200        OCT 104200     DLD TIME TAG
0158   00173 101034R       DEF ADDR1,I    DIVIDE BY 2 AND SAVE
0159   00174 000040        CLE
0160   00175 005500        ERB
0161   00176 001500        ERA
0162   00177 104400        OCT 104400     DST ADDR1,I
0163   00200 101034R       DEF ADDR1,I
0164   00201 037034R       ISZ ADDR1
```

```
0165   00202 037034R         ISZ ADDR1
0166*
0167   00203 002400  FIN1    CLA
0168   00204 073040R         STA MAJ1
0169   00205 063041R         LDA MAJ2
0170   00206 067042R         LDB MAJ3
0171   00207 002003          SZA,RSS
0172   00210 006002          SZB                ARE OTHER 2 COUNTERS FINISHED ?
0173   00211 026111R         JMP FAL1           NO: RETURN
0174   00212 104200          OCT 104200         OLD TIME MARK
0175   00213 001062R         DEF TEMP1
0176   00214 016716R         JSB TIMCK          CHECK TO SEE IF DONE
0177   00215 000111R         DEF FAL1
0178   00216 001046R         DEF SAVA1
0179   00217 000050R         DEF I,441
0180*
0181   00220 102511  BCD1    LIA CH1            BCD FORMAT
0182   00221 073105R         STA IN1
0183   00222 067117R         LDB =B-4
0184   00223 077102R         STB CNT1
0185   00224 006400          CLB
0186   00225 001600          ELA                SIGN OF MANTISSA
0187   00226 002200          CME
0188   00227 005600          ELB
0189   00230 001200          RAL
0190   00231 002021          SSA,RSS            SIGN OF XPONENT
0191   00232 047073R         ADB SIGN
0192   00233 063105R         LDA IN1
0193   00234 001727          ALF,ALF
0194   00235 073105R         STA IN1
0195   00236 013120R         AND =B37            MASK EXPONENT
0196   00237 043115R         ADA =B2             ADJUST TO NANO SEC
0197   00240 001727          ALF,ALF
0198   00241 040001          ADA 1              MERGE EXPONENT AND SIGNS
0199   00242 067105R         LDB IN1
0200*
0201   00243 173034R PUT1    STA ADDR1,I        PUT WORD AWAY
0202   00244 037034R         ISZ ADDR1
0203   00245 037102R         ISZ CNT1           ALL 4 WORDS DONE ?
0204   00246 002001          RSS                NO:
0205   00247 026203R         JMP FIN1           YES: PUT TIME AWAY
0206   00250 060001          LDA 1              MERGE BCD DIGITS
0207   00251 001727          ALF,ALF
0208   00252 013121R         AND =B377
0209   00253 106511          LIB CH1
0210   00254 100110          OCT 100110         RRL 8
0211   00255 026243R         JMP PUT1
```

```
0213*  CONTINUATOR SECTION OF 2ND COUNTER
0214*
0215* THIS IS IDENTICAL TO COUNTER NUMBER 1
0216*
0217  00256 000000  I.442 NOP
0218  00257 107712        CLC CH2,C
0219  00260 073051R       STA SAVA2
0220  00261 077052R       STB SAVB2
0221  00262 002400        CLA
0222  00263 001500        ERA
0223  00264 102201        SOC
0224  00265 002004        INA
0225  00266 073053R       STA SAVE2
0226  00267 063030R       LDA UNIT
0227  00270 002003        SZA,RSS
0228  00271 026317R       JMP FAL2
0229*
0230  00272 037044R       ISZ MINR2
0231  00273 002001        RSS
0232  00274 026322R       JMP READ2
0233  00275 063075R GO2   LDA STC2
0234  00276 072314R       STA BUS2
0235  00277 063033R       LDA ENDT
0236  00300 043044R       ADA MINR2
0237  00301 160000        LDA 0,I
0238  00302 103100        CLF 0
0239  00303 106712        CLC CH2
0240  00304 102112        STF CH2
0241  00305 102612        OTA CH2
0242  00306 063053R RET2  LDA SAVE2
0243  00307 103101        CLO
0244  00310 000036        SLA,ELA
0245  00311 102101        STF 1
0246  00312 063051R       LDA SAVA2
0247  00313 067052R       LDB SAVB2
0248  00314 000000  BUS2  NOP
0249  00315 102100        STF 0
0250  00316 126256R       JMP I.442,I
0251*
0252  00317 002400  FAL2  CLA
0253  00320 072314R       STA BUS2
0254  00321 026306R       JMP RET2
0255*
0256  00322 104200  READ2 OCT 104200
0257  00323 000003X       DEF TIMEX
0258  00324 104400        OCT 104400
0259  00325 001064R       DEF TEMP2
0260  00326 063037R       LDA MARK
0261  00327 002003        SZA,RSS
0262  00330 026426R       JMP BCD2
0263  00331 102512        LIA CH2
0264  00332 106512        LIB CH2
0265  00333 016672R       JSB FLIP
0266*
0267  00334 073106R       STA IN2
0268  00335 063041R       LDA MAJ2
0269  00336 002004        INA
```

```
0270  00337 002003          SZA,RSS
0271  00340 026366R         JMP DONE2
0272  00341 002021          SSA,RSS
0273  00342 026001X         JMP ABORT
0274  00343 073041R         STA MAJ2
0275  00344 063106R         LDA IN2
0276  00345 143035R         ADA ADDR2,I
0277  00346 173035R         STA ADDR2,I
0278  00347 063035R         LDA ADDR2
0279  00350 043115R         ADA =B2
0280  00351 073071R         STA FAR2
0281  00352 104200          OCT 104200
0282  00353 100000          DEF 0,I
0283  00354 000040          CLE
0284  00355 043064R         ADA TEMP2
0285  00356 002040          SEZ
0286  00357 006004          INB
0287  00360 047065R         ADB TEMP2+1
0288  00361 104400          OCT 104400
0289  00362 101071R         DEF FAR2,I
0290  00363 063116R SEN2    LDA =B-3
0291  00364 073044R         STA MINR2
0292  00365 026275R         JMP GO2
0293*
0294  00366 063106R DONE2   LDA IN2
0295  00367 143035R         ADA ADDR2,I
0296  00370 006400          CLB
0297  00371 100400          OCT 100400
0298  00372 001110R         DEF B3
0299  00373 173035R         STA ADDR2,I
0300  00374 037035R         ISZ ADDR2
0301  00375 063073R         LDA SIGN
0302  00376 173035R         STA ADDR2,I
0303  00377 037035R         ISZ ADDR2
0304  00400 104200          OCT 104200
0305  00401 101035R         DEF ADDR2,I
0306  00402 000040          CLE
0307  00403 005500          ERB
0308  00404 001500          ERA
0309  00405 104400          OCT 104400
0310  00406 101035R         DEF ADDR2,I
0311  00407 037035R        ISZ ADDR2
0312  00410 037035R         ISZ ADDR2
0313*
0314  00411 002400  FIN2    CLA
0315  00412 073041R         STA MAJ2
0316  00413 063040R         LDA MAJ1
0317  00414 067042R         LDB MAJ3
0318  00415 002003          SZA,RSS
0319  00416 006002          SZB
0320  00417 026317R         JMP FAL2
0321  00420 104200          OCT 104200
0322  00421 001064R         DEF TEMP2
0323  00422 016716R         JSB TIMCK
0324  00423 000317R         DEF FAL2
0325  00424 001051R         DEF SAVA2
0326  00425 000256R         DEF I.442
```

```
0327*
0328  00426 102512  BCD2  LIA CH2
0329  00427 073106R       STA IN2
0330  00430 067117R       LDB =B-4
0331  00431 077103R       STB CNT2
0332  00432 006400        CLB
0333  00433 001600        ELA
0334  00434 002200        CME
0335  00435 005600        ELB
0336  00436 001200        RAL
0337  00437 002021        SSA,RSS
0338  00440 047073R       ADB SIGN
0339  00441 063106R       LDA IN2
0340  00442 001727        ALF,ALF
0341  00443 073106R       STA IN2
0342  00444 013120R       AND =B37
0343  00445 043115R       ADA =B2
0344  00446 001727        ALF,ALF
0345  00447 040001        ADA 1
0346  00450 067106R       LDB IN2
0347*
0348  00451 173035R PUT2  STA ADDR2,I
0349  00452 037035R       ISZ ADDR2
0350  00453 037103R       ISZ CNT2
0351  00454 002001        RSS
0352  00455 026411R       JMP FIN2
0353  00456 060001        LDA 1
0354  00457 001727        ALF,ALF
0355  00460 013121R       AND =B377
0356  00461 106512        LIB CH2
0357  00462 100110        OCT 100110
0358  00463 026451R       JMP PUT2
```

```
0360*  CONTINUATOR SECTION OF 3RD COUNTER
0361*
0362* THIS IS IDENTICAL TO COUNTER NUMBER 1
0363*
0364  00464 000000  I,443 NOP
0365  00465 107713        CLC CH3,C
0366  00466 073054R       STA SAVA3
0367  00467 077055R       STB SAVB3
0368  00470 002400        CLA
0369  00471 001500        ERA
0370  00472 102201        SOC
0371  00473 002004        INA
0372  00474 073056R       STA SAVE3
0373  00475 063030R       LDA UNIT
0374  00476 002003        SZA,RSS
0375  00477 026525R       JMP FAL3
0376*
0377  00500 037045R       ISZ MINR3
0378  00501 002001        RSS
0379  00502 026530R      JMP READ3
0380  00503 063076R GO3   LDA STC3
0381  00504 072522R       STA BUS3
0382  00505 063033R       LDA ENDT
0383  00506 043045R       ADA MINR3
0384  00507 160000        LDA 0,I
0385  00510 103100        CLF 0
0386  00511 106713        CLC CH3
0387  00512 102113        STF CH3
0388  00513 102613        OTA CH3
0389  00514 063056R RET3  LDA SAVE3
0390  00515 103101        CLO
0391  00516 000036        SLA,ELA
0392  00517 102101        STF 1
0393  00520 063054R       LDA SAVA3
0394  00521 067055R       LDB SAVB3
0395  00522 000000  BUS3  NOP
0396  00523 102100        STF 0
0397  00524 126464R       JMP I,443,I
0398*
0399  00525 002400  FAL3  CLA
0400  00526 072522R       STA BUS3
0401  00527 026514R       JMP RET3
0402*
0403  00530 104200  READ3 OCT 104200
0404  00531 000003X       DEF TIMEX
0405  00532 104400        OCT 104400
0406  00533 001066R       DEF TEMP3
0407  00534 063037R       LDA MARK
0408  00535 002003        SZA,RSS
0409  00536 026634R       JMP BCD3
0410  00537 102513        LIA CH3
0411  00540 106513        LIB CH3
0412  00541 016672R       JSB FLIP
0413*
0414  00542 073107R       STA IN3
0415  00543 063042R       LDA MAJ3
0416  00544 002004        INA
```

```
0417   00545 002003          SZA,RSS
0418   00546 026574R         JMP DONE3
0419   00547 002021          SSA,RSS
0420   00550 026001X         JMP ABORT
0421   00551 073042R         STA MAJ3
0422   00552 063107R         LDA IN3
0423   00553 143036R         ADA ADDR3,I
0424   00554 173036R         STA ADDR3,I
0425   00555 063036R         LDA ADDR3
0426   00556 043115R         ADA =B2
0427   00557 073072R         STA FAR3
0428   00560 104200          OCT 104200
0429   00561 100000          DEF 0,I
0430   00562 000040          CLE
0431   00563 043066R         ADA TEMP3
0432   00564 002040          SEZ
0433   00565 006004          INB
0434   00566 047067R         ADB TEMP3+1
0435   00567 104400          OCT 104400
0436   00570 101072R         DEF FAR3,I
0437   00571 063116R SEN3    LDA =B-3
0438   00572 073045R         STA MINR3
0439   00573 026503R         JMP GO3
0440*
0441   00574 063107R DONE3   LDA IN3
0442   00575 143036R         ADA ADDR3,I
0443   00576 006400          CLB
0444   00577 100400          OCT 100400
0445   00600 001110R         DEF B3
0446   00601 173036R         STA ADDR3,I
0447   00602 037036R         ISZ ADDR3
0448   00603 063073R         LDA SIGN
0449   00604 173036R         STA ADDR3,I
0450   00605 037036R         ISZ ADDR3
0451   00606 104200          OCT 104200
0452   00607 101036R         DEF ADDR3,I
0453   00610 000040          CLE
0454   00611 005500          ERB
0455   00612 001500          ERA
0456   00613 104400          OCT 104400
0457   00614 101036R         DEF ADDR3,I
0458   00615 037036R         ISZ ADDR3
0459   00616 037036R         ISZ ADDR3
0460*
0461   00617 002400 FIN3     CLA
0462   00620 073042R         STA MAJ3
0463   00621 063040R         LDA MAJ1
0464   00622 067041R         LDB MAJ2
0465   00623 002003          SZA,RSS
0466   00624 006002          SZB
0467   00625 026525R         JMP FAL3
0468   00626 104200          OCT 104200
0469   00627 001066R         DEF TEMP3
0470   00630 016716R         JSB TIMCK
0471   00631 000525R         DEF FAL3
0472   00632 001054R         DEF SAVA3
0473   00633 000464R         DEF I.443
```

```
0474*
0475  00634 102513  BCD3  LIA CH3
0476  00635 073107R       STA IN3
0477  00636 067117R       LDB =B-4
0478  00637 077104R       STB CNT3
0479  00640 006400        CLB
0480  00641 001600        ELA
0481  00642 002200        CME
0482  00643 005600       ELB
0483  00644 001200        RAL
0484  00645 002021        SSA,RSS
0485  00646 047073R       ADB SIGN
0486  00647 063107R       LDA IN3
0487  00650 001727        ALF,ALF
0488  00651 073107R       STA IN3
0489  00652 013120R       AND =B37
0490  00653 043115R       ADA =B2
0491  00654 001727        ALF,ALF
0492  00655 040001        ADA 1
0493  00656 067107R       LDB IN3
0494*
0495  00657 173036R PUT3  STA ADDR3,I
0496  00660 037036R       ISZ ADDR3
0497  00661 037104R       ISZ CNT3
0498  00662 002001        RSS
0499  00663 026617R       JMP FIN3
0500  00664 060001        LDA 1
0501  00665 001727        ALF,ALF
0502  00666 013121R       AND =B377
0503  00667 106513        LIB CH3
0504  00670 100110        OCT 100110
0505  00671 026657R       JMP PUT3
```

```
0507* SUBROUTINES ***
0508  00672 000000  FLIP  NOP
0509  00673 103100       CLF 0
0510  00674 073027R      STA TEMP      SAVE 1ST WORD OF READ
0511  00675 001727       ALF,ALF
0512  00676 013120R      AND =B37       MASK EXPONENT
0513  00677 043122R      ADA =D-8       SUBTRACT 8
0514  00700 073112R      STA TCNT      SAVE AS SHIFT COUNTER
0515  00701 002021       SSA,RSS
0516  00702 026713R      JMP NOSHT
0517  00703 063027R      LDA TEMP
0518  00704 013121R      AND =B377
0519  00705 100104       OCT 100104    RRL 4
0520  00706 037112R      ISZ TCNT      DONE SHIFTING ?
0521  00707 026705R      JMP *-2       NO: SHIFT ANOTHER DIGIT
0522  00710 016002X      JSB BCDBI     CONVERT TO BINARY
0523  00711 102100  OVER  STF 0
0524  00712 126672R      JMP FLIP,I
0525*
0526  00713 063027R NOSHT LDA TEMP
0527  00714 013121R      AND =B377
0528  00715 026710R      JMP OVER-1
0529*
0530  00716 000000  TIMCK NOP
0531  00717 037111R      ISZ DONE
0532  00720 026730R      JMP NOT       IF READINGS NOT DONE,CK TIME
0533  00721 002400  CLR   CLA           CLEAR BUSY FLAG
0534  00722 073030R      STA UNIT
0535  00723 063037R      LDA MARK      PUT TOTAL READINGS AWAY
0536  00724 043111R      ADA DONE
0537  00725 073111R      STA DONE
0538  00726 162716R      LDA TIMCK,I
0539  00727 124000       JMP 0,I       RETURN TO CONTINUATOR
0540*
0541  00730 104400  NOT   OCT 104400    DST TIME MARK
0542  00731 001077R      DEF TIMEO
0543  00732 066716R      LDB TIMCK     SAVE RETURN ADDRESS
0544  00733 006004       INB
0545  00734 160001       LDA 1,I       WORKING REGISTER ADDRESS
0546  00735 006004       INB
0547  00736 164001       LDB 1,I       INTERRUPT ADDRESS
0548  00737 164001       LDB 1,I
0549  00740 077101R      STB BACK
0550  00741 164000       LDB 0,I       SAVE WORKING REGISTERS
0551  00742 077057R      STB SAVA
0552  00743 002004       INA
0553  00744 164000       LDB 0,I
0554  00745 077060R      STB SAVB
0555  00746 002004       INA
0556  00747 164000       LDB 0,I
0557  00750 077061R      STB SAVE
0558  00751 104200       OCT 104200    DLD TIME  MARK
0559  00752 001077R      DEF TIMEO
0560  00753 003000       CMA
0561  00754 007100       CMB,CLE       MAKE NEGATIVE
0562  00755 002004       INA
0563  00756 002040       SEZ
```

```
0564  00757 006004          INB
0565  00760 000040          CLE
0566  00761 042005X          ADA MAXT        ADD MAX TIME
0567  00762 002040          SEZ
0568  00763 006004          INB
0569  00764 046006X          ADB MAXT1
0570  00765 006020          SSB
0571  00766 026721R          JMP CLR         TIME UP,CLEAR DRIVER
0572  00767 016777R          JSB CALL        SETUP DRIVERS FOR NEW READ
0573  00770 063061R          LDA SAVE        RESTORE REGISTERS
0574  00771 103101          CLO
0575  00772 000036          SLA,ELA
0576  00773 102101          STF 1
0577  00774 063057R          LDA SAVA
0578  00775 067060R          LDB SAVB
0579  00776 127101R          JMP BACK,I
0580*
0581  00777 000000  CALL    NOP
0582  01000 063116R          LDA =B-3        SET FOR 3 READINGS
0583  01001 066004X          LDB LINKS
0584  01002 007004          CMB,INB
0585  01003 073040R          STA MAJ1
0586  01004 006007          INB,SZB,RSS       START DRIVERS OF COUNTERS
0587  01005 027012R          JMP CALL1          TO BE USED IN THIS RANGE
0588  01006 073041R          STA MAJ2
0589  01007 006007          INB,SZB,RSS
0590  01010 027012R          JMP CALL1
0591  01011 073042R          STA MAJ3
0592  01012 063117R CALL1   LDA =B-4
0593  01013 073043R          STA MINR1
0594  01014 073044R          STA MINR2
0595  01015 073045R          STA MINR3
0596  01016 066004X          LDB LINKS
0597  01017 007004          CMB,INB
0598  01020 016050R          JSB I,441
0599  01021 006007          INB,SZB,RSS
0600  01022 126777R          JMP CALL,I
0601  01023 016256R          JSB I,442
0602  01024 006006          INB,SZB
0603  01025 016464R          JSB I,443
0604  01026 126777R          JMP CALL,I
0605*
0606* CONSTANTS AND WORKING STORAGE
0607*
0608  01027 000000  TEMP    NOP
0609  01030 000000  UNIT    OCT 0,10,31     WORDS TO BE SENT TO COUNTER
      01031 000010
      01032 000031
0610  01033 001033R ENDT    DEF *           END OF 3 WORD TABLE
0611  01034 000000  ADDR1   NOP
0612  01035 000000  ADDR2   NOP
0613  01036 000000  ADDR3   NOP
0614  01037 000000  MARK    NOP             BCD OR INTEGER MARK
0615  01040 000000  MAJ1    NOP
0616  01041 000000  MAJ2    NOP
0617  01042 000000  MAJ3    NOP
0618  01043 000000  MINR1   NOP
```

```
0619  01044 000000  MINR2 NOP
0620  01045 000000  MINR3 NOP
0621  01046 000000  SAVA1 NOP
0622  01047 000000  SAVB1 NOP
0623  01050 000000  SAVE1 NOP
0624  01051 000000  SAVA2 NOP
0625  01052 000000  SAVB2 NOP
0626  01053 000000  SAVE2 NOP
0627  01054 000000  SAVA3 NOP
0628  01055 000000  SAVB3 NOP
0629  01056 000000  SAVE3 NOP
0630  01057 000000  SAVA  NOP
0631  01060 000000  SAVB  NOP
0632  01061 000000  SAVE  NOP
0633  01062 000000  TEMP1 BSS 2
0634  01064 000000  TEMP2 BSS 2
0635  01066 000000  TEMP3 BSS 2
0636  01070 000000  FAR1  NOP
0637  01071 000000  FAR2  NOP
0638  01072 000000  FAR3  NOP
0639  01073 100000  SIGN  OCT 100000
0640  01074 103711  STC1  STC CH1,C
0641  01075 103712  STC2  STC CH2,C
0642  01076 103713  STC3  STC CH3,C
0643  01077 000000  TIMEO BSS 2
0644  01101 000000  BACK  NOP
0645  01102 000000  CNT1  NOP
0646  01103 000000  CNT2  NOP
0647  01104 000000  CNT3  NOP
0648  01105 000000  IN1   NOP
0649  01106 000000  IN2   NOP
0650  01107 000000  IN3   NOP
0651  01110 000003  B3    OCT 3
0652  01111 000000  DONE  NOP
0653  01112 000000  TCNT  NOP
0654  00011         CH1   EQU 11B
0655  00012         CH2   EQU 12B
0656  00013         CH3   EQU 13B
      01113 070000
      01114 000643
      01115 000002
      01116 177775
      01117 177774
      01120 000037
      01121 000377
      01122 177770
0657                      END
** NO ERRORS: AMD ASMB,25117-402518
```

BINARY TO DECIMAL

```
0001                          ASMB,R,B,L
0003  00000                         NAM BTD
0004                                ENT BTD
0005                                EXT CLEAR
0006*
0007  00000 000000  BTD       NOP
0008  00001 162000R           LDA BTD,I
0009  00002 036000R           ISZ BTD
0010  00003 160000            LDA 0,I
0011  00004 072107R           STA TEMP
0012  00005 072110R           STA NUM
0013  00006 166000R           LDB BTD,I
0014  00007 076111R           STB BUF
0015  00010 036000R           ISZ BTD
0016  00011 062116R           LDA D4
0017  00012 016001X           JSB CLEAR
0018  00013 036111R           ISZ BUF
0019  00014 036111R           ISZ BUF
0020  00015 072112R           STA CNTR3
0021  00016 072115R           STA MARK
0022*
0023  00017 062117R           LDA DM10
0024  00020 072113R           STA CNTR4
0025  00021 062107R           LDA TEMP
0026  00022 002003            SZA,RSS
0027  00023 126000R           JMP BTD,I
0028  00024 002020            SSA
0029  00025 036115R           ISZ MARK
0030*
0031  00026 066110R LOOP1     LDB NUM
0032  00027 046117R           ADB DM10
0033  00030 076110R           STB NUM
0034  00031 036112R           ISZ CNTR3
0035  00032 006020            SSB
0036  00033 026072R           JMP DONE
0037*
0038  00034 002400            CLA
0039  00035 072115R           STA MARK
0040  00036 062120R AD1       LDA B6
0041  00037 016100R           JSB ADDIT
0042  00040 036113R           ISZ CNTR4
0043  00041 026026R           JMP LOOP1
0044*
0045  00042 062117R           LDA DM10
0046  00043 072113R           STA CNTR4
0047  00044 002004            INA
0048  00045 072114R           STA CNTR5
0049  00046 062112R           LDA CNTR3
0050  00047 006400            CLB
0051  00050 046121R ADD       ADB D100
0052  00051 050001            CPA 1
0053  00052 026062R           JMP OUT
0054  00053 036114R           ISZ CNTR5
0055  00054 026050R           JMP ADD
0056  00055 052122R           CPA D1000
0057  00056 026065R           JMP OUT2
0058*
```

```
0059  00057 062123R        LDA B140
0060  00060 016100R        JSB ADDIT
0061  00061 026026R        JMP LOOP1
0062*
0063  00062 062124R OUT     LDA B3140
0064  00063 016100R        JSB ADDIT
0065  00064 026026R        JMP LOOP1
0066*
0067  00065 062125R OUT2    LDA B6314
0068  00066 016100R        JSB ADDIT
0069  00067 006400         CLB
0070  00070 076112R        STB CNTR3
0071  00071 026026R        JMP LOOP1
0072*
0073  00072 066115R DONE    LDB MARK
0074  00073 006002         SZB
0075  00074 026036R        JMP AD1
0076  00075 036111R        ISZ BUF
0077  00076 172111R        STA BUF,I
0078  00077 126000R        JMP BTD,I
0079*
0080  00100 000000  ADDIT   NOP
0081  00101 000040         CLE
0082  00102 042107R        ADA TEMP
0083  00103 002040         SEZ
0084  00104 136111R        ISZ BUF,I
0085  00105 072107R        STA TEMP
0086  00106 126100R        JMP ADDIT,I
0087*
0088  00107 000000  TEMP    NOP
0089  00110 000000  NUM     NOP
0090  00111 000000  BUF     NOP
0091  00112 000000  CNTR3   NOP
0092  00113 000000  CNTR4   NOP
0093  00114 000000  CNTR5   NOP
0094  00115 000000  MARK    NOP
0095  00116 000004  D4      DEC 4
0096  00117 177766  DM10    DEC -10
0097  00120 000006  B6      OCT 6
0098  00121 000144  D100    DEC 100
0099  00122 001750  D1000   DEC 1000
0100  00123 000140  B140    OCT 140
0101  00124 003140  B3140   OCT 3140
0102  00125 063140  B6314   OCT 63140
0103                        END
**  NO ERRORS! AMD ASMB,25117-402518
```

DECIMAL TO ASCII

```
0001                    ASMB,R,B,L
0003  00000                     NAM DDTA
0004                            ENT DDTA
0005*
0006  00000 000000  DDTA  NOP
0007  00001 162000R        LDA DDTA,I      ADDRESS OF NUMBER
0008  00002 036000R        ISZ DDTA
0009  00003 072220R        STA TEMP
0010  00004 162000R        LDA DDTA,I      ADDRESS OF BUFFER
0011  00005 036000R        ISZ DDTA
0012  00006 072222R        STA ADDR
0013  00007 002400         CLA             INITIALIZE EXPONENT
0014  00010 072223R        STA EXP
0015*
0016  00011 162220R        LDA TEMP,I      FETCH 1ST WORD OF DEC NO.
0017  00012 036220R        ISZ TEMP
0018  00013 066250R        LDB POSTV
0019  00014 000010         SLA
0020  00015 066251R        LDB MINUS     PUT SIGN OF NO. IN BUFFER
0021  00016 176222R        STB ADDR,I
0022*
0023  00017 000066         CLE,ELA         PUT SIGN OF EXP IN E
0024  00020 001327         RAR,ALF         POSITION EXP
0025  00021 001700         ALF
0026  00022 012236R        AND B377      MASK
0027  00023 002003         SZA,RSS         0 EXP ?
0028  00024 026027R        JMP SUB         YES:
0029  00025 002041         SEZ,RSS         PLUS EXP ?
0030  00026 026105R        JMP PLUS        YES:
0031*
0032  00027 042235R SUB     ADA M12       SUBTRACT 12
0033  00030 002003         SZA,RSS         EXP = 12 ?
0034  00031 026034R        JMP DOWN        YES:
0035  00032 002021         SSA,RSS         EXP LARGER THAN 12 ?
0036  00033 026121R        JMP SHIFT       YES:
0037*
0038  00034 042231R DOWN    ADA M1        INDEX FOR DEC. POINT
0039  00035 072224R        STA IC
0040  00036 003400         CCA
0041  00037 072225R        STA BLC         INDEX FOR LS OR MS STORAGE
0042*
0043  00040 016144R        JSB STUFF       PUT 1ST 4 DIGITS IN BUFFER
0044  00041 016144R        JSB STUFF       2ND 4 DIGITS
0045  00042 016144R        JSB STUFF       3RD 4 DIGITS
0046  00043 036224R        ISZ IC          HAS DEC. PT. BEEN PLACED ?
0047  00044 026052R        JMP OUT         YES:
0048  00045 162222R        LDA ADDR,I      NO: PUT IN BUFFER
0049  00046 012240R        AND B1774
0050  00047 042245R        ADA B56
0051  00050 172222R        STA ADDR,I
0052  00051 036222R        ISZ ADDR
0053*
0054  00052 062223R OUT     LDA EXP
0055  00053 002003         SZA,RSS         0 EXP. ?
0056  00054 026100R        JMP NOEXP       YES:
0057  00055 000066         CLE,ELA         SIGN OF EXP IN E
0058  00056 001300         RAR
```

```
0059  00057 066247R        LDB EPLUS
0060  00060 002040         SEZ
0061  00061 066246R        LDB ENEG
0062  00062 176222R        STB ADDR,I      PUT IN BUFFER
0063  00063 036222R        ISZ ADDR
0064*
0065  00064 070001         STA 1           CONVERT EXP TO BCD
0066  00065 046235R        ADB M12
0067  00066 006020         SSB
0068  00067 026072R        JMP *+3
0069  00070 042230R        ADA .6
0070  00071 026065R        JMP *-4
0071*
0072  00072 001727         ALF,ALF         CONVERT TO ASCII
0073  00073 066232R        LDB M2
0074  00074 076226R        STB CTR
0075  00075 076225R        STB BLC
0076  00076 016153R        JSB PUT
0077  00077 126000R        JMP DDTA,I      RETURN
0078*
0079  00100 062252R NOEXP  LDA BLANK     PUT BLANKS IN BUFFER
0080  00101 172222R        STA ADDR,I
0081  00102 036222R        ISZ ADDR
0082  00103 172222R        STA ADDR,I
0083  00104 126000R        JMP DDTA,I
0084*
0085  00105 042233R PLUS   ADA M3        SUBTRACT 3 FROM EXP
0086  00106 036223R        ISZ EXP         ADD 1 TO MARK
0087  00107 002002         SZA             IF 0 OR -,MULTIPLE OF 3 FOUND
0088  00110 002020         SSA
0089  00111 002001         RSS
0090  00112 026105R        JMP PLUS        IF NOT DO IT AGAIN
0091*
0092  00113 003004         CMA,INA         MAKE REMAINDER +
0093  00114 066223R        LDB EXP         MULTIPLY MARK BY 3
0094  00115 005000         BLS
0095  00116 046223R        ADB EXP
0096  00117 076223R        STB EXP         SAVE AS EXP.
0097  00120 026027R        JMP SUB         WORK ON DIGITS
0098*
0099  00121 042241R SHIFT  ADA .12        RESTORE EXP.
0100  00122 042233R        ADA M3          FIND MULTIPLE OF 3
0101  00123 036223R        ISZ EXP
0102  00124 072221R        STA TEMP1       SAVE REMAINDER
0103  00125 002003         SZA,RSS         ANY REMAINDER ?
0104  00126 026134R        JMP OVER        NO!
0105  00127 002021         SSA,RSS         REMAINDER STILL +
0106  00130 026122R        JMP SHIFT+1     YES! SUBTRACT AGAIN
0107*
0108  00131 042227R        ADA .3          NO! ADD 3 TO REMAINDER
0109  00132 072221R        STA TEMP1       AS DEC PT.
0110  00133 003400         CCA             SUBTRACT 1 FROM MULTIPLE
0111  00134 042223R OVER   ADA EXP
0112  00135 070001         STA 1           MULTIPLY BY 3
0113  00136 001000         ALS
0114  00137 040001         ADA 1
0115  00140 032244R        IOR B100K       ADD - SIGN
```

```
0116   00141 072223R          STA EXP          SAVE AS EXP.
0117   00142 062221R          LDA TEMP1        FETCH REMAINDER AND
0118   00143 026027R          JMP SUB           WORK ON DIGITS
0119*
0120   00144 000000   STUFF   NOP
0121   00145 062234R          LDA M4
0122   00146 072226R          STA CTR
0123   00147 162220R          LDA TEMP,I       FETCH DIGITS
0124   00150 036220R          ISZ TEMP
0125   00151 016153R          JSB PUT          PUT THEM AWAY
0126   00152 126144R          JMP STUFF,I
0127*
0128   00153 000000   PUT     NOP
0129   00154 072221R          STA TEMP1
0130   00155 066221R LOOP     LDB TEMP1        FETCH BCD DIGITS
0131   00156 036224R          ISZ IC           PLACE DEC. PT ?
0132   00157 026165R          JMP MASK1        NO:
0133   00160 003400           CCA              YES: CORRECT DIGIT COUNTER
0134   00161 042226R          ADA CTR
0135   00162 072226R          STA CTR
0136   00163 062243R          LDA B27K
0137   00164 026174R          JMP CONT
0138*
0139   00165 062237R MASK1    LDA B170K      BCD MASK
0140   00166 010001           AND 1            ISOLATE MS DIGIT
0141   00167 005700           BLF              SHIFT BCD FOR NEXT STEP
0142   00170 076221R          STB TEMP1
0143   00171 001323           RAR,RAR          POSITION TO MS ASCII CHARACTER
0144   00172 001323           RAR,RAR
0145   00173 042242R          ADA B30K       ADD ASCII CONSTANT
0146*
0147   00174 036225R CONT     ISZ BLC          CHAR TO MS BUFFER ?
0148   00175 026212R          JMP MSPT         YES:
0149   00176 001727           ALF,ALF          NO: PUT IN LS PART
0150   00177 070001           STA 1
0151   00200 162222R          LDA ADDR,I
0152   00201 012240R          AND B1774
0153   00202 040001           ADA 1
0154   00203 172222R          STA ADDR,I
0155   00204 036222R          ISZ ADDR
0156   00205 062232R          LDA M2         RESTORE COUNTER
0157   00206 072225R          STA BLC
0158*
0159   00207 036226R CHK      ISZ CTR          FINISHED ?
0160   00210 026155R          JMP LOOP         NO:
0161   00211 126153R          JMP PUT,I        YES:
0162*
0163   00212 070001   MSPT    STA 1
0164   00213 162222R          LDA ADDR,I
0165   00214 012236R          AND B377
0166   00215 040001           ADA 1
0167   00216 172222R          STA ADDR,I
0168   00217 026207R          JMP CHK
0169*
0170   00220 000000   TEMP    NOP
0171   00221 000000   TEMP1   NOP
0172   00222 000000   ADDR    NOP
```

```
0173   00223 000000  EXP    NOP
0174   00224 000000  IC     NOP
0175   00225 000000  BLC    NOP
0176   00226 000000  CTR    NOP
0177   00227 000003  .3     OCT 3
0178   00230 000006  .6     OCT 6
0179   00231 177777  M1     DEC -1
0180   00232 177776  M2     DEC -2
0181   00233 177775  M3     DEC -3
0182   00234 177774  M4     DEC -4
0183   00235 177764  M12    DEC -12
0184   00236 000377  B377   OCT 377
0185   00237 170000  B170K  OCT 170000
0186   00240 177400  B1774  OCT 177400
0187   00241 000014  .12    DEC 12
0188   00242 030000  B30K   OCT 30000
0189   00243 027000  B27K   OCT 27000
0190   00244 100000  B100K  OCT 100000
0191   00245 000056  B56    OCT 56
0192   00246 042455  ENEG   ASC 1,E-
0193   00247 042453  EPLUS  ASC 1,E+
0194   00250 025440  POSTV  ASC 1,+
0195   00251 026440  MINUS  ASC 1,-
0196   00252 020040  BLANK  ASC 1,
0197                        END
** NO ERRORS: AMD ASMB,25117-402518
```

RANGE RATE ROUTINE

```
0001                    ASMB,R,B,L
0003  000000                NAM RDOT
0004                      ENT RDOT,N5C,N5T1,N5T2,ADJUT
0005                      ENT RRADR,N5T5A
0006                      EXT CDA,TARS1,TARS2,DONE,DMUL,DADD
0007                      EXT .35FD,DTBI,BTD,DADD,N.VAL,DDIV
0008********************************************** ***
0009*
0010***   APR 15,1975
0011*
0012*    RANGE RATE ROUTINE
0013*     CALL: LDB LINK  0,1, OR 2
0014*           JSB RDOT
0015*
0016*   THIS ROUTINE TAKES THE T(I)(IN NANOSECS) AND N-CHANGE
0017*     FROM THE BUFFER, SUBTRACTS THE FIXED DELAYS,
0018*     CONVERTS THEM TO 2 WDS BINARY # OF NANOSECONDS
0019*       FROM THE INITIAL POINT,DIVIDES BY TWO FOR 1-WAY
0020*     RANGE,AND STORES IT BACK IN THE BUFFER. IF WORD
0021*     #1=-1(FOR A BAD POINT), THE TWO WDS IN THE BUFFER
0022*      ARE ZEROED.  THE RANGE RATE IS CALC FOR EVERY
0023*      30 POINTS ; THE RESULTS ARE STORED IN A BUFFER
0024*      WHOSE ADDR IS RETURNED IN (A). (NANOSEC/SEC)
0025*
0026*************************************************************
0027*
0028                      SUP
0029  000000 000000  RDOT NOP
0030  000001 062003X       LDA TARS2
0031  000002 006003        SZB,RSS
0032  000003 062001X       LDA CDA
0033  000004 003010        SLB
0034  000005 062002X       LDA TARS1
0035  000006 072577R       STA RADR       ADDRESS OF POINTS
0036  000007 062004X       LDA DONE       NUMBER OF POINTS
0037  000010 072576R       STA CNT
0038  000011 077355R       STB LINK
0039  000012 060001        LDA B
0040  000013 100200        OCT 100200     MPY;
0041  000014 001361R       DEF .60
0042  000015 042407R       ADA RRADR
0043  000016 072316R       STA RESAD      ADDR FOR RESULT
0044*
0045  000017 063355R       LDA LINK       SET FIXED DELAY
0046  000020 100200        OCT 100200     MPY; GET ADDR FOR CORRECT
0047  000021 000705R       DEF .20
0048  000022 042007X       ADA .35FD
0049  000023 042704R       ADA .16
0050  000024 072030R       STA FDADR
0051*
0052  000025 003400        CCA
0053  000026 073376R       STA FIRST
0054*
0055  000027 016010X       JSB DTBI       CONVERT TO BINARY
0056  000030 000000  FDADR NOP
0057  000031 000362R       DEF MFD
0058*
```

```
0059  000032 002362R        LDA MFD       MAKE NEGATIVE.
0060  000033 003004         CMA,INA
0061  000034 072362R        STA MFD
0062*
0063  000035 002400         CLA           CLEAR SUMS
0064  000036 072377R        STA RTSUM
0065  000037 072400R        STA RTSUM+1
0066  000040 072403R        STA TTSUM
0067  000041 072404R        STA TTSUM+1
0068*
0069  000042 062676R        LDA CNT       COMPUTE COUNTERS:
0070  000043 006400         CLB
0071  000044 100400         OCT 100400     DIV: CALC # OF ROOTS TO CALC.
0072  000045 000714R        DEF .30
0073  000046 006002         SZB
0074  000047 002004         INA           CNT2=INT(CNT/30)+1*(B)
0075  000050 003004         CMA,INA
0076  000051 072675R        STA CNT2
0077*
0078  000052 062676R COUNT  LDA CNT       30 PTS. AVAILABLE ?
0079  000053 042701R        ADA M30
0080  000054 002020         SSA
0081  000055 026061R        JMP NO          NO.
0082  000056 066701R        LDB M30
0083  000057 076674R        STB CNT1
0084  000060 026066R        JMP RRLUP+1
0085  000061 042714R NO     ADA .30
0086  000062 003004         CMA,INA         N < 30: SET COUNT
0087  000063 072674R        STA CNT1
0088  000064 026066R        JMP RRLUP+1
0089*
0090  000065 036677R RRLUP  ISZ RADR
0091  000066 162677R        LDA RADR,I      LOAD DELTA T (NS)
0092  000067 002006         INA,SZA         GOOD POINT ??
0093  000070 026106R        JMP GOOD2         YES.
0094  000071 066677R        LDB RADR
0095  000072 170001         STA B,I
0096  000073 006004         INB
0097  000074 170001         STA B,I
0098  000075 046702R        ADB .2
0099  000076 076677R        STB RADR
0100  000077 003400         CCA
0101  000100 073370R        STA FIRST
0102  000101 036674R        ISZ CNT1
0103  000102 026065R        JMP RRLUP       LOOP AGAIN
0104  000103 046700R        ADB M1          MINUS 1
0105  000104 076677R        STB RADR        FOR LAST POINT
0106  000105 026241R        JMP ON1
0107*
0108  000106 042700R GOOD2  ADA M1          RESTORE (A)
0109  000107 042362R        ADA MFD         SUBTRACT FIXED DELAY (*NS)
0110  000110 066677R        LDB RADR
0111  000111 076363R        STB TEMPA
0112  000112 036677R        ISZ RADR
0113  000113 166677R        LDB RADR,I
0114  000114 002021         SSA,RSS
0115  000115 026121R        JMP *+4
```

```
0116  001116 027126R        ADA IT5
0117  001117 047001R        ADB M1          SUBTRACT 1 WAVELENGHTH
0118  001120 026114R        JMP *-4
0119  001121 002103          SZA,RSS
0120  001122 027002R        LDA .2
0121  001123 072367R        STA TEMP
0122  001124 000001  OK3     LDA B
0123  001125 100200          OCT 100200      MPY; N5 * T5
0124  001126 000712R         DEF IT5
0125  001127 000040          CLE
0126  001130 042367R         ADA TEMP        ADD DELTA T(5)
0127  001131 002040          SEZ
0128  001132 006004          INB
0129  001133 000004          CLE             DIVIDE BY 2
0130  001134 006020          SSB
0131  001135 026152R         JMP MINUS
0132  001136 000500          ERB
0133  001137 001500          ERA
0134  001140 104400  REST    OCT 104400      DST;
0135  001141 001371R         DEF RTEMP
0136  001142 176363R         STB TEMPA,I     STORE BACK IN BUFFER.
0137  001143 036363R         ISZ TEMPA
0138  001144 172363R         STA TEMPA,I
0139*
0140  001145 037370R         ISZ FIRST       FIRST TIME ?
0141  001146 026160R         JMP CONT-1
0142  001147 003400          CCA               YES.
0143  001150 037370R       STA FIRST       RESET FLG FOR 1ST TIME TAG.
0144  001151 026175R         JMP FURST
0145*
0146  001152 016340R MINUS   JSB COMP        COMPLIMENT NUMBER
0147  001153 000040          CLE
0148  001154 000500          ERB             DIVIDE BY 2
0149  001155 001500          ERA
0150  001156 016340R         JSB COMP
0151  001157 026140R         JMP REST
0152*
0153  001160 000040          CLE
0154  001161 042375R CONT    ADA RTL         DELTA = RT(I) - RT(I-1)
0155  001162 002040          SEZ
0156  001163 036376R         ISZ RTL+1
0157  001164 000000          NOP
0158  001165 046376R         ADB RTL+1
0159  001166 000040          CLE             SUM DELTAS
0160  001167 042377R       ADA RTSUM
0161  001170 002040          SEZ
0162  001171 006004          INB
0163  001172 046400R         ADB RTSUM+1
0164  001173 072377R         STA RTSUM
0165  001174 076400R         STB RTSUM+1     SAVE
0166*
0167  001175 102200  FURST   OCT 102200      DLD; CURRENT RANGE TIME.
0168  001176 001371R         DEF RTEMP
0169  001177 016340R         JSB COMP        CHANGE SIGN
0170  002000 104400          OCT 104400      DST; AT RT(LAST)
0171  002001 000375R         DEF RTL
0172*
```

```
0173  000202 036677R          ISZ RADR       LOAD TIME TAG
0174  000203 104200          OCT 104200     DLD; (A) = LSB'S
0175  000204 100577R          DEF RADR,I           (B) = MSB'S
0176  000205 104400          OCT 104400     DST; SAVE FOR MOVE
0177  000206 000363R          DEF TEMPA
0178  000207 037370R          ISZ FIRST      FIRST TIME THRU ?
0179  000210 000201          RSS            NO.
0180  000211 026227R          JMP FRST2      YES. MOVE TIME TAG.
0181  000212 000040          CLE            CALC DELTA TIME.
0182  000213 042373R          ADA TTL          LSB'S
0183  000214 002040          SEZ
0184  000215 036374R          ISZ TTL+1
0185  000216 000000          NOP
0186  000217 046374R          ADB TTL+1
0187*
0188  000220 000040          CLE
0189  000221 042403R          ADA TTSUM      SUM: LSB'S
0190  000222 002040          SEZ
0191  000223 006004          INB
0192  000224 046404R          ADB TTSUM+1          MSB'S
0193  000225 104400          OCT 104400     DST;
0194  000226 000403R          DEF TTSUM
0195*
0196  000227 104200  FRST2    OCT 104200     DLD; LOAD CURRENT TIME TAG
0197  000230 000363R          DEF TEMPA
0198  000231 016340R          JSB COMP       MAKE NEGATIVE
0199  000232 104400          OCT 104400     DST; SAVE AT TTLAST
0200  000233 000373R          DEF TTL
0201*
0202  000234 036674R .NEXT    ISZ CNT1       DONE WITH 30 PTS. ?
0203  000235 026237R          JMP RRL          NO.
0204  000236 026241R          JMP ON1        DONE;
0205  000237 036677R RRL      ISZ RADR
0206  000240 026265R          JMP RRLUP
0207  000241 104200  ON1      OCT 104200     DLD; YES, CALC RDOT.
0208  000242 000377R          DEF RTSUM
0209  000243 006020          SSB
0210  000244 016340R          JSB COMP
0211  000245 100400  ITSOK    OCT 100400     DIV:
0212  000246 000715R          DEF .1K
0213*
0214  000247 104400          OCT 104400     DST; CONV TO POSITIVE NO.
0215  000250 000363R          DEF TEMPA        AND SAVE SIGN.
0216  000251 016011X POS      JSB BTD
0217  000252 000363R          DEF TEMPA
0218  000253 000367R          DEF TEMP       DEC # US
0219*
0220  000254 062367R          LDA TEMP
0221  000255 017032R          JSB GOFUP
0222  000256 000003  .3       DEC 3
0223  000257 072367R          STA TEMP       TEMP = RTSUM(NANOSECONDS)
0224  000260 016011X          JSB BTD
0225  000261 000364R          DEF TEMPA+1
0226  000262 000363R          DEF TEMPA
0227*
0228  000263 016006X          JSB DADD       COMBINE
0229  000264 000367R          DEF TEMP
```

```
*
     00265 000363R        DEF TEMPA
     00266 000377R        DEF RTSUM    DECIMAL NO. OF NS IN RTSUM
*
     00267 104200         OCT 104200   DLD, CONV TTSUM TO DEC
     00270 000403R        DEF TTSUM
     00271 100400         OCT 100400   DIV. (A)=#SEC.  (B)=#.1MS
     00272 000707R        DEF .10K
     00273 104400         OCT 104400   DST
     00274 000363R        DEF TEMPA
     00275 016011X        JSB BTD
     00276 000363R        DEF TEMPA
     00277 000367R        DEF TEMP     DEC # OF SECONDS
*
     00300 016011X        JSB BTD
     00301 000364R        DEF TEMPA+1
     00302 000363R        DEF TEMPA    DEC # OF .1MS'S
*
     00303 062363R        LDA TEMPA    CONVERT TO SECONDS
     00304 017032R        JSB GOFUP
     00305 177774         DEC -4
     00306 072363R        STA TEMPA
*
     00307 016006X        JSB DADD     COMBINE
     00310 000367R        DEF TEMP
     00311 000363R        DEF TEMPA
     00312 000403R        DEF TTSUM
*
     00313 016013X        JSB DDIV
     00314 000377R        DEF RTSUM    SUM RT'S/SUM TT'S
     00315 000403R        DEF TTSUM
     00316 000410R RESAD  DEF RRATA    * RANGE RATE(NS/SEC)
*
     00317 036675R        ISZ CNT2       DONE WITH  ALL RANGE RATE ?
     00320 002001         RSS            NO.
     00321 126000R        JMP ROOT,I     YES.
     00322 062316R        LDA RESAD
     00323 042703R        ADA .4
     00324 072316R        STA RESAD
     00325 002400         CLA
     00326 072377R        STA RTSUM
     00327 072400R        STA RTSUM+1
     00330 072403R        STA TTSUM
     00331 072404R        STA TTSUM+1
     00332 036677R        ISZ RADR
     00333 036677R        ISZ RADR
     00334 062676R        LDA CNT
     00335 042701R        ADA M30
     00336 072676R        STA CNT
     00337 026052R        JMP COUNT
*
     00340 000000  COMP   NOP
     00341 007100         CMB,CLE
     00342 003004         CMA,INA
     00343 002040         SEZ
     00344 006004         INB
     00345 126340R        JMP COMP,I
**
```

```
0287***  CONSTANTS AND STORAGE *****
0288   000346 105400   D1     OCT 105400,10000,0,0
0289   000352 105400   D2     OCT 105400,20000,0,0
0290   000356 104000   T5   OCT 104000,50000,0,0
0291   000362 000000   MPD    OCT 0
0292   000363 000000   TEMPA  BSS 4
0293   000367 000000   TEMP   BSS 4
0294   000373 000000   TTL    BSS 2
0295   000375 000000   RTL    BSS 2
0296   000377 000000   RTSUM  BSS 4
0297   000403 000000   TTSUM  BSS 4
0298   000407 000410R  RRADR  DEF RRATA
0299*
0300   000410 000000   RRATA  BSS 60
0301   000504 000000   RRATB  BSS 60
0302   000600 000000   RRATC  BSS 60
0303   000674 000000   CNT1   NOP
0304   000675 000000   CNT2   NOP
0305   000676 000000   CNT    NOP
0306   000677 000000   RADR   NOP
0307   000000          A      EQU 0
0308   000001          B      EQU 1
0309   000700 177777   M1     DEC -1
0310   000701 177742   M30    DEC -30
0311   000702 000002   .2     DEC 2
0312   000703 000004   .4     DEC 4
0313   000704 000020   .16    DEC 16
0314   000705 000024   .20    DEC 20
0315   000706 000177   B177   OCT 177
0316   000707 023420   .10K   DEC 10000
0317   000710 000030   D30    OCT 30
0318   000711 000200   .SIN.  OCT 200
0319   000712 011610   IT5    DEC 5000
0320   000713 166170   N5000  DEC -5000
0321   000714 000036   .30    DEC 30
0322   000715 001750   .1K    DEC 1000
```

ADJUST RANGE ROUTINE

```
0324*
0325*****************************************************
0326*
0327*     ADJUST ROUTINE:
0328*        LDB LINK     0,1, OR 2
0329*        JSB ADJUT
0330*        DEF RDOT     ADDR OF 10 RDOT'S
0331*
0332*     THIS ROUTINE MULTIPLIES THE NOMINAL
0333*       RANGE N5*T5 BY THE RANGE RATE
0334*       CORRECTION FACTOR:(1+RDOT)/2
0335*****************************************************
0336*
0337  000716 000000  ADJUT NOP
0338  000717 052004X       LDA DONE
0339  000720 077355R       STB LINK
0340  000721 006040        CLB
0341  000722 100400        DCT 100400    DIV; CALC COUNT
0342  000723 000714R       DEF .30
0343  000724 006002        SZB
0344  000725 002004        INA
0345  000726 003004        CMA,INA
0346  000727 073360R       STA .CNT
0347  000730 162716R       LDA ADJUT,I
0348  000731 036716R       ISZ ADJUT
0349  000732 073362R       STA RDOTA     ADDR OF 1ST RANGE RATE
0350  000733 073357R       STA RDOTB
0351  000734 063355R       LDA LINK
0352  000735 100200        DCT 100200    MPY
0353  000736 000703R       DEF .4
0354  000737 043356R       ADA C5ADR     ADDR OF N5T5(#NS NOMINAL)
0355  000740 073011R       STA N5TAD
0356  000741 072761R       STA .OFF
0357  000742 063355R       LDA  LINK
0358  000743 100200        DCT 100200    MPY
0359  000744 001361R       DEF .60
0360  000745 043050R       ADA N5T5A
0361  000746 073013R       STA ANS
0362  000747 073367R       STA ANS1
0363*
0364  000750 063355R       LDA LINK
0365  000751 100200        DCT 100200    MPY BY 30
0366  000752 000716R       DEF 030
0367  000753 042012X       ADA N.VAL     N5
0368  000754 042705R       ADA .20
0369  000755 072757R       STA .RIP
0370*
0371  000756 016005X       JSB DMUL
0372  000757 000000  .RIP   NOP
0373  000760 000356R       DEF T5
0374  000761 000000  .OFF   NOP
0375*
0376  000762 067362R UNFUP  LDB RDOTA     LOAD RANGE RATE, CONV
0377  000763 160001         LDA 0,I         TO # SECONDS AND
0378  000764 017032R        JSB GUFUP
0379  000765 177767         DEC -9
0380  000766 073363R        STA .RD
```

```
0381  00767 006004          INB
0382  00770 100001          LDA B,I
0383  00771 073364R         STA .RD+1
0384  00772 006004          INB
0385  00773 100001          LDA B,I
0386  00774 073365R         STA .RD+2
0387  00775 006004          INB
0388  00776 100001          LDA B,I
0389  00777 073366R         STA .RD+3
0390*
0391  01000 016006X ALUP    JSB DADD
0392  01001 001363R         DEF .RD
0393  01002 000346R         DEF D1
0394  01003 000367R         DEF TEMP
0395*
0396  01004 016013X         JSB DDIV
0397  01005 000367R         DEF TEMP
0398  01006 000352R         DEF D2
0399  01007 000367R         DEF TEMP
0400*
0401  01010 016005X         JSB DMUL
0402  01011 000000  N5TAD    NOP                 N5T5*(1+RDOT)/2
0403  01012 000367R         DEF TEMP
0404  01013 000000  ANS      NOP
0405*
0406  01014 037360R         ISZ .CNT            DONE ?
0407  01015 027023R         JMP AGAIN             NO.
0408  01016 063367R         LDA ANS1            ADDR OF 1ST
0409  01017 067351R         LDB .725              ADJUSTED C5
0410  01020 047355R         ADB LINK
0411  01021 170001          STA B,I
0412  01022 126716R         JMP ADJUT,I           RETURN.
0413*
0414  01023 063362R AGAIN    LDA RDOTA           GET NEXT
0415  01024 042703R         ADA .4                RANGE RATE
0416  01025 073362R         STA RDOTA
0417  01026 063013R         LDA ANS
0418  01027 042703R         ADA .4
0419  01030 073013R         STA ANS
0420  01031 026762R         JMP UNFUP
0421*
0422  01032 000000  GOFUP    NOP
0423  01033 001623          ELA,RAR
0424  01034 001727          ALF,ALF
0425  01035 012706R         AND B177
0426  01036 002040          SEZ
0427  01037 003004          CMA,INA
0428  01040 143032R         ADA GOFUP,I
0429  01041 002021          SSA,RSS
0430  01042 027045R         JMP RETX.
0431  01043 003004          CMA,INA
0432  01044 032711R         IOR .SIN.
0433  01045 001727  RETX.    ALF,ALF
0434  01046 037032R         ISZ GOFUP
0435  01047 127032R         JMP GOFUP,I
0436*
0437**          STORAGE AND CONSTANTS      *********
```

```
0438  01050 001051R N5T5A DEF C5CRA
0439  01051 000000  C5CRA BSS 60
0440  01145 000000  C5CRB BSS 60
0441  01241 000000  C5CRC BSS 60
0442  01335 000000  NTADR BSS 12
0443  01351 001352R .725  DEF N5C
0444  01352 000000  N5C    NOP
0445  01353 000000  N5T1   NOP
0446  01354 000000  N5T2   NOP
0447  01355 000000  LINK   NOP
0448  01356 001335R C5ADR  DEF NTADR
0449  01357 000000  RDOTB  NOP
0450  01360 000000  .CNT   NOP
0451  01361 000074  .60    DEC 60
0452  01362 000000  RDOTA  NOP
0453  01363 000000  .RD    BSS 4
0454  01367 000000  ANS1   NOP
0455  01370 000000  FIRST  NOP
0456  01371 000000  RTEMP  BSS 2
0457                       END
** NO ERRORS: AMD ASMB,25117-40251B
```

MODEM SEND ROUTINE

```
0001                        ASMB,R,B,L
0003  00000                       NAM SEND
0004                              ENT SEND
0005                              EXT PRINT,RTTYB
0006*
0007  00000 000000  SEND    NOP
0008  00001 001727          ALF,ALF          PUT IN HIGH ORDER
0009  00002 076034R         STB SAVE         SAVE B
0010  00003 012045R         AND =B177400      12XX
0011  00004 001700          ALF              2XX1
0012  00005 072035R         STA SAVE1
0013  00006 003000          CMA
0014  00007 012046R         AND =B17
0015  00010 001727          ALF,ALF
0016  00011 032035R         IOR SAVE1        21XX
0017  00012 006400          CLB
0018  00013 012045R         AND =B177400
0019  00014 102615          OTA CH
0020  00015 103715          STC CH,C
0021  00016 102315  SFS     SFS CH
0022  00017 026023R         JMP TIME         CHECK FOR TIMEOUT
0023  00020 107715          CLC CH,C
0024  00021 066034R         LDB SAVE         RESTORE B
0025  00022 126000R         JMP SEND,I       EXIT
0026*
0027  00023 034001  TIME    ISZ 1
0028  00024 026016R         JMP SFS          NOT YET
0029  00025 107715          CLC CH,C         TIMED OUT, CLEAR CHANNEL
0030  00026 062047R         LDA =D7          PRINT TIMEOUT
0031  00027 016001X         JSB PRINT
0032  00030 000036R         DEF ERROR
0033  00031 003400          CCA              WAIT FOR INSTRUCTIONS
0034  00032 016002X         JSB RTTYB
0035  00033 026031R         JMP *-2
0036*
0037  00034 000000  SAVE    NOP
0038  00035 000000  SAVE1   NOP
0039  00015         CH      EQU 15B
0040  00036 046517  ERROR   ASC 7,MODEM TIMEOUT
      00037 042105
      00040 046440
      00041 052111
      00042 046505
      00043 047525
      00044 052040
      00045 177400
      00046 000017
      00047 000007
0041                        END
** NO ERRORS! AMD ASMB,25117-402518
```

FIXED DELAY COMPUTATION

```
0001                    ASMB,R,B,L
0003  00000                     NAM FIXD
0004                            ENT FIX,D
0005                            EXT MODE,MOVE,DADD,FIXT1
0006*
0007  00000 000000  FIX,D NOP
0008  00001 162000R       LDA FIX,D,I   FIXED DELAY TABLE
0009  00002 036000R       ISZ FIX,D
0010  00003 072130R       STA CDA
0011  00004 042137R       ADA =D20
0012  00005 072050R       STA TARS1
0013  00006 042137R       ADA =D20
0014  00007 072060R       STA TARS2
0015*
0016  00010 062004X       LDA FIXT1     SATELITE DELAY TABLE
0017  00011 072051R       STA .1DT1
0018  00012 042137R       ADA =D20
0019  00013 072061R       STA .1DT2
0020  00014 042137R       ADA =D20
0021  00015 072117R       STA .1DSP
0022  00016 042137R       ADA =D20
0023  00017 072125R       STA .1DTR
0024*
0025  00020 062001X       LDA MODE
0026  00021 052140R       CPA =B2
0027  00022 026030R       JMP MODEB
0028  00023 002011        SLA,RSS
0029  00024 026034R       JMP MODEC
0030*
0031  00025 062141R MODEA LDA =D-5
0032  00026 072131R       STA CNT
0033  00027 026040R       JMP GO
0034  00030 062142R MODEB LDA =D-4
0035  00031 072131R       STA CNT
0036  00032 016066R AGAIN JSB GO1
0037  00033 026040R       JMP GO
0038  00034 062143R MODEC LDA =D-3
0039  00035 072131R       STA CNT
0040  00036 016066R       JSB GO1
0041  00037 026032R       JMP AGAIN
0042*
0043  00040 062130R GO    LDA CDA
0044  00041 007400        CCB
0045  00042 016110R       JSB ADD        DELAY+,1DTR+,1DSP
0046*
0047  00043 062050R       LDA TARS1
0048  00044 072052R       STA ADD3
0049  00045 066144R       LDB =D-2
0050  00046 016110R       JSB ADD       DELAY+,1DSP+,1DSP+,1DTR
0051  00047 016003X       JSB DADD      +,1DT1
0052  00050 000000  TARS1 NOP
0053  00051 000000  .1DT1 NOP
0054  00052 000000  ADD3  NOP
0055*
0056  00053 062060R       LDA TARS2
0057  00054 072062R       STA ADD4
0058  00055 066144R       LDB =D-2
```

```
0059  00056 016110R        JSB ADD         SAME AS TARS1
0060  00057 016003X        JSB DADD        *.1DT2
0061  00060 000000  TARS2  NOP
0062  00061 000000  .1DT2  NOP
0063  00062 000000  ADD4   NOP
0064*
0065  00063 036131R        ISZ CNT
0066  00064 026032R        JMP AGAIN       DO NEXT DELAY
0067  00065 126000R        JMP FIX.D,I     EXIT
0068*
0069  00066 000000  GO1    NOP
0070  00067 062130R        LDA CDA
0071  00070 042145R        ADA =D4
0072  00071 072130R        STA CDA
0073  00072 042137R        ADA =D20
0074  00073 072050R        STA TARS1
0075  00074 042137R        ADA =D20
0076  00075 072060R        STA TARS2
0077  00076 062051R        LDA .1DT1
0078  00077 042145R        ADA =D4
0079  00100 072051R        STA .1DT1
0080  00101 042137R        ADA =D20
0081  00102 072061R        STA .1DT2
0082  00103 042137R        ADA =D20
0083  00104 072117R        STA .1DSP
0084  00105 042137R        ADA =D20
0085  00106 072125R        STA .1DTR
0086  00107 126066R        JMP GO1,I
0087*
0088  00110 000000  ADD    NOP
0089  00111 072126R        STA ADD1
0090  00112 076136R        STB SAVEB
0091  00113 066116R        LDB SAVEX
0092  00114 016002X        JSB MOVE
0093  00115 016003X        JSB DADD
0094  00116 000132R SAVEX  DEF SAVE
0095  00117 000000  .1DSP  NOP
0096  00120 000132R        DEF SAVE
0097  00121 036136R        ISZ SAVEB
0098  00122 026115R        JMP SAVEX-1     IF TARS ADD .1DSP AGAIN
0099  00123 016003X        JSB DADD
0100  00124 000132R        DEF SAVE
0101  00125 000000  .1DTR  NOP
0102  00126 000000  ADD1   NOP
0103  00127 126110R        JMP ADD,I
0104*
0105  00130 000000  CDA    NOP
0106  00131 000000  CNT    NOP
0107  00132 000000  SAVE   BSS 4
0108  00136 000000  SAVEB  NOP
      00137 000024
      00140 000002
      00141 177773
      00142 177774
      00143 177775
      00144 177776
      00145 000004
```

```
0109                              END
** NO ERRORS: AMD ASMB,25117-402518
```

TTY HANDLER

```
0001                    ASMB,R,B,L
0003  00000                     NAM HAND
0004                            ENT TTO,CULL1,CULL2,RTTYB,FIXT1,TTYDA
0005                            ENT MODSX,IN0C,IN0T1,IN0T2
0006                            EXT A77B,MODT,MSX,MTX,MSG1
0007                            EXT CDA,TARS1,TARS2,DECOD,DDTA,BCDBI
0008                            EXT OKFLL,ETIME,TTYST,.IOC.,ABORT,LABLE
0009                            EXT LINKS,MAXT,MAXT1,TIME,MODE,YR
0010                            EXT PRINT,CLEAR,DONE
0011                            ENT BB200,BB27,BB39,BB283
0012                            ENT SPAN,TSPAN
0013                            EXT B570
0014                            SUP
0015***    MAR 12,1975
0016*
0017* RTTY  TELETYPE HANDLER
0018*
0019  00000 000000  RTTYB  NOP
0020  00001 073327R        STA TTYM
0021  00002 063420R        LDA =D2
0022  00003 016030X        JSB PRINT
0023  00004 001277R        DEF XXX
0024  00005 016017X        JSB .IOC.
0025  00006 010001         OCT 10001
0026  00007 026005R        JMP *-2          READ TTY
0027  00010 001301R        DEF TTYDA
0028  00011 000013         DEC 11
0029*
0030  00012 063327R        LDA TTYM
0031  00013 002006         INA,SZA
0032  00014 126000R        JMP RTTYB,I      STATUS NOT REQUIRED
0033*
0034  00015 016017X        JSB .IOC.        STATUS CHECK
0035  00016 040001         OCT 40001
0036  00017 002020         SSA
0037  00020 026015R        JMP *-3
0038*
0039  00021 066054R        LDB TTYTB
0040  00022 063322R        LDA TTYB
0041  00023 073317R        STA ZBUF
0042  00024 002400         CLA
0043  00025 073330R        STA CNTT
0044  00026 160001  UP     LDA 1,I
0045  00027 002003         SZA,RSS
0046  00030 026036R        JMP OUT
0047  00031 053301R        CPA TTYDA
0048  00032 026045R        JMP OK           LEGAL CALL
0049  00033 006004         INB
0050  00034 006004         INB
0051  00035 026026R        JMP UP           CHECK NEXT ENTRY
0052  00036 062014X OUT    LDA OKFLL
0053  00037 002002         SZA
0054  00040 026115R        JMP MIKE         WAITING FOR OK
0055  00041 063421R ERROR  LDA =D3
0056  00042 016030X        JSB PRINT
0057  00043 001324R        DEF MSG
0058  00044 126000R        JMP RTTYB,I
```

```
0059*
0060  00045 052103R OK     CPA OKS
0061  00046 026115R        JMP MIKE        OK TYPED
0062  00047 062014X        LDA OKFLL
0063  00050 002002         SZA
0064  00051 026020X        JMP ABORT       EXPECTING OK,BUT DIDNT COME
0065  00052 006004         INB             POSITION TO POINTER
0066  00053 124001         JMP 1,I
0067*
0068  00054 000055R TTYTB  DEF *+1
0069  00055 041454         ASC 1,C,
0070  00056 026122R        JMP CULL        SET CULLING NUMBER
0071  00057 044454         ASC 1,I,
0072  00060 026255R        JMP MOSET      MODEM SET
0073  00061 052054         ASC 1,T,
0074  00062 026262R        JMP MTEST      MODEM TEST
0075  00063 054454         ASC 1,Y,
0076  00064 026136R        JMP YEAR
0077  00065 051462         ASC 1,S2
0078  00066 026145R        JMP SYS.A
0079  00067 051461         ASC 1,S1
0080  00070 026147R        JMP SYS.B
0081  00071 051054         ASC 1,R,
0082  00072 026171R        JMP .RUN
0083  00073 051454         ASC 1,S,
0084  00074 026621R        JMP .SET
0085  00075 042054         ASC 1,D,
0086  00076 027001R        JMP .DMP
0087  00077 025101         ASC 1,*A
0088  00100 026020X        JMP ABORT
0089  00101 025052         ASC 1,**
0090  00102 026020X        JMP ABORT
0091  00103 047513  OKS    ASC 1,OK
0092  00104 026115R        JMP MIKE        OPERATOR RESPONSE
0093  00105 042454         ASC 1,E,
0094  00106 026267R        JMP .ERPT
0095  00107 025115         ASC 1,*M
0096  00110 026112R        JMP MOD.
0097  00111 000000         NOP
0098*
0099  00112 006400  MOD.   CLB
0100  00113 076001X        STB A77B
0101  00114 026021X        JMP LABLE
0102*
0103  00115 002400  MIKE   CLA
0104  00116 072014X        STA OKFLL
0105  00117 063422R        LDA =D30000
0106  00120 016015X        JSB ETIME
0107  00121 126000R        JMP RTTYB,I
0108*
0109  00122 063423R CULL   LDA =B-3
0110  00123 006404         CLB,INB
0111  00124 017055R        JSB NGETB
0112  00125 003004         CMA,INA
0113  00126 002003         SZA,RSS
0114  00127 026041R        JMP ERROR
0115  00130 073315R        STA CULL1
```

```
0116  00131 003004          CMA,INA
0117  00132 001000          ALS
0118  00133 043424R         ADA =D-5000
0119  00134 073316R         STA CULL2
0120  00135 126000R         JMP RTTYB,I
0121*
0122  00136 063302R YEAR    LDA TTYDA+1
0123  00137 072027X         STA YR
0124  00140 063425R         LDA =B-2        CONV YR TO BCD FOR MODEM
0125  00141 006400          CLB
0126  00142 017055R         JSB NGETB
0127  00143 073251R         STA MODSX
0128  00144 126000R         JMP RTTYB,I
0129*
0130  00145 063252R SYS.A    LDA TTOSA
0131  00146 002001          RSS
0132  00147 063253R SYS.B    LDA TTOSB
0133  00150 073254R         STA TTO           SET OF TARS TO USE
0134  00151 063301R         LDA TTYDA
0135  00152 073350R         STA SNO
0136  00153 013426R         AND =B17
0137  00154 073274R         STA SPCN+3
0138  00155 037330R         ISZ CNTT
0139  00156 003400          CCA
0140  00157 006404          CLB,INB
0141  00160 017055R         JSB NGETB         NUMBER TO USE
0142  00161 002003          SZA,RSS
0143  00162 026041R         JMP ERROR
0144  00163 070001          STA 1
0145  00164 047427R         ADB =B-4
0146  00165 006021          SSB,RSS
0147  00166 026041R         JMP ERROR
0148  00167 072022X         STA LINKS
0149  00170 126000R         JMP RTTYB,I
0150*
0151  00171 006404  .RUN     CLB,INB
0152  00172 063425R         LDA =D-2
0153  00173 017055R         JSB NGETB       GET NUMBER IN BINARY
0154  00174 073260R         STA COUNT
0155  00175 100200          OCT 100200      MPY
0156  00176 001255R         DEF D60          60 TO GET SECONDS
0157  00177 100200          OCT 100200      MPY BY
0158  00200 001256R         DEF D10K         10,000 (# OF .1 MSEC)
0159  00201 072023X         STA MAXT        MAXIMUN TIME
0160  00202 076024X         STB MAXT1
0161  00203 063260R         LDA COUNT        MAX IS 15 MIN
0162  00204 043430R         ADA =D-16
0163  00205 002021          SSA,RSS
0164  00206 026041R         JMP ERROR
0165  00207 063260R         LDA COUNT
0166  00210 066025X         LDB TIME
0167  00211 007000          CMB
0168  00212 040001          ADA 1
0169  00213 002021          SSA,RSS
0170  00214 026041R         JMP ERROR       TOO MANY MINUTES
0171  00215 063431R         LDA =D30
0172  00216 100200          OCT 100200      MPY BY
```

```
0173  00217 001260R        DEF COUNT       30 FOR ACTUAL # OF POINTS
0174  00220 073260R        STA COUNT
0175  00221 063303R        LDA TTYDA+2
0176  00222 001727         ALF,ALF
0177  00223 013432R        AND =B177
0178  00224 053433R        CPA =B54         ;COMMA
0179  00225 002001         RSS             MODE IS RIGHT HALF
0180  00226 026231R        JMP *+3         MODE IS LEFT HALF
0181  00227 063303R        LDA TTYDA+2
0182  00230 013432R        AND =B177        REDUCE MODE
0183  00231 043434R        ADA =B-100        TO INTEGER
0184  00232 002020         SSA
0185  00233 026041R        JMP ERROR
0186  00234 053421R        CPA =B3           EQUIVALENT
0187  00235 002004         INA             A=1
0188  00236 072026X        STA MODE        B=2
0189  00237 043435R        ADA =B-5         C=4
0190  00240 002021         SSA,RSS
0191  00241 026041R        JMP ERROR       MODE ILLEGAL
0192  00242 062026X        LDA MODE
0193  00243 001722         ALF,RAL
0194  00244 043420R        ADA =B2
0195  00245 073250R        STA BB283
0196  00246 043420R        ADA =B2
0197  00247 073247R        STA BB39
0198  00250 043436R        ADA =B4
0199  00251 073246R        STA BB27
0200  00252 043437R        ADA =D8
0201  00253 073245R        STA BB200
0202  00254 026016X        JMP TTYST          BEGIN OPERATION
0203*
0204  00255 006404  MOSET   CLB,INB
0205  00256 063425R        LDA =B-2
0206  00257 017055R        JSB NGETB
0207  00260 016003X        JSB MSX
0208  00261 126000R        JMP RTTYB,I
0209*
0210  00262 006404  MTEST   CLB,INB
0211  00263 063425R        LDA =B-2
0212  00264 017055R        JSB NGETB
0213  00265 016004X        JSB MTX
0214  00266 126000R        JMP RTTYB,I
0215*
0216  00267 006404  .ERPT   CLB,INB
0217  00270 063425R        LDA =B-2
0218  00271 017055R        JSB NGETB
0219  00272 002003         SZA,RSS
0220  00273 002404         CLA,INA
0221  00274 073264R        STA SKIP
0222  00275 062005X        LDA MSG1
0223  00276 072301R        STA *+3
0224  00277 063440R        LDA =D14
0225  00300 016030X        JSB PRINT       PRINT START TIME
0226  00301 000005X        DEF MSG1
0227*
0228  00302 007400         CCB
0229  00303 062026X        LDA MODE
```

```
0230   00304 053257R          CPA D4
0231   00305 040001           ADA 1
0232   00306 043340R          ADA CASCI      CONVERT TO ASCII
0233   00307 073346R          STA MSG6+2
0234   00310 063441R          LDA =D5
0235   00311 016030X         JSB PRINT       PRINT "MODE"
0236   00312 001344R          DEF MSG6
0237*
0238   00313 066002X          LDB MODT        DECODE TEMPERATURE
0239   00314 047442R          ADB =D11
0240   00315 017045R          JSB CONV
0241   00316 073354R          STA MSG7+3
0242   00317 160001           LDA 1,I
0243   00320 001727           ALF,ALF
0244   00321 033341R          IOR CANUM
0245   00322 073355R          STA MSG7+4
0246*
0247   00323 063441R          LDA =D5
0248   00324 016030X          JSB PRINT       PRINT TEMPERATURE
0249   00325 001351R          DEF MSG7
0250   00326 062032X          LDA DONE
0251   00327 002020           SSA
0252   00330 002400           CLA
0253   00331 002003           SZA,RSS
0254   00332 126000R          JMP RTTYB,I
0255   00333 006400           CLB
0256   00334 100400           OCT 100400      DIV BY
0257   00335 001264R          DEF SKIP         SKIP
0258   00336 003000           CMA
0259   00337 006003           SZB,RSS
0260   00340 002004           INA
0261   00341 073261R          STA CNT         NUMBER OF LINES TO OUTPUT
0262   00342 063264R          LDA SKIP
0263   00343 100200           OCT 100200      MPY BY
0264   00344 001257R          DEF D4           FOUR
0265   00345 073264R          STA SKIP        SKIP LOCATIONS
0266   00346 063443R          LDA =D34
0267   00347 016030X          JSB PRINT       PRINT HEADING
0268   00350 001356R          DEF OUTHD
0269*
0270   00351 062006X          LDA CDA
0271   00352 072360R          STA REFC
0272   00353 062007X          LDA TARS1
0273   00354 072361R          STA REF1
0274   00355 062010X          LDA TARS2
0275   00356 072362R          STA REF2
0276*
0277   00357 016011X DOIT     JSB DECOD       DECODE DATA
0278   00360 000000  REFC     NOP
0279   00361 000000  REF1     NOP
0280   00362 000000  REF2     NOP
0281*
0282   00363 066033X          LDB B570
0283   00364 076442R          STB ADRS
0284   00365 077275R          STB LOC
0285   00366 063423R          LDA =B-3
0286   00367 073263R          STA CNTY
```

```
0287   00370 063435R        LDA =B-5
0288   00371 073262R        STA CNTX
0289*
0290   00372 017045R DONT   JSB CONV
0291   00373 173275R        STA LOC,I
0292   00374 037275R        ISZ LOC
0293   00375 037262R        ISZ CNTX
0294   00376 026372R        JMP DONT
0295   00377 063356R        LDA SPACE
0296   00400 173275R        STA LOC,I
0297   00401 037275R        ISZ LOC          SKIP ONE
0298   00402 037263R        ISZ CNTY
0299   00403 026370R        JMP DONT-2
0300*
0301   00404 063423R        LDA =B-3
0302   00405 073263R        STA CNTY
0303   00406 063427R        LDA =B-4
0304   00407 073262R        STA CNTX
0305*
0306   00410 160001  DO     LDA 1,I
0307   00411 001727         ALF,ALF
0308   00412 006004         INB
0309   00413 037262R        ISZ CNTX
0310   00414 002001         RSS
0311   00415 026424R        JMP DONOT
0312   00416 130001         IOR 1,I
0313   00417 006004         INB
0314   00420 033342R        IOR CAN
0315   00421 173275R        STA LOC,I
0316   00422 037275R        ISZ LOC
0317   00423 026410R        JMP DO
0318*
0319   00424 033343R DONOT  IOR CANT
0320   00425 173275R        STA LOC,I
0321   00426 037275R        ISZ LOC
0322   00427 037263R        ISZ CNTY
0323   00430 026406R        JMP DO-2
0324*
0325   00431 063427R        LDA =B-4
0326   00432 073262R        STA CNTX
0327   00433 017045R MAYBE  JSB CONV
0328   00434 173275R        STA LOC,I
0329   00435 037275R        ISZ LOC
0330   00436 037262R        ISZ CNTX
0331   00437 026433R       JMP MAYBE
0332*
0333   00440 063443R        LDA =D34
0334   00441 016030X        JSB PRINT        PRINT RESULTS OF RANGE
0335   00442 000000  ADRS   NOP              OUTPUT DATA BUFFER SHARED WITH M
0336*
0337   00443 037261R        ISZ CNT
0338   00444 002001         RSS
0339   00445 126000R        JMP RTTYB,I
0340*
0341*
0342   00446 052360R        LDA REFC
0343   00447 043264R        ADA SKIP
```

```
0344  00450 072360R          STA REFC
0345  00451 062361R          LDA REF1
0346  00452 043264R          ADA SKIP
0347  00453 072361R          STA REF1
0348  00454 062362R          LDA REF2
0349  00455 043264R          ADA SKIP
0350  00456 072362R          STA REF2
0351  00457 026357R          JMP DOIT
0352*
0353*
0354  00460 000000  SRCH      NOP
0355  00461 067444R          LDB =D-26
0356  00462 077261R          STB CNT
0357  00463 066502R          LDB CTAB        TABLE ADDRESS
0358  00464 063302R S1        LDA TTYDA+1     INPUT VALUE
0359  00465 150001            CPA 1,I
0360  00466 002001            RSS
0361  00467 026475R          JMP DN          TRY NEXT ONE
0362*
0363  00470 063303R          LDA TTYDA+2
0364  00471 006004            INB
0365  00472 150001            CPA 1,I
0366  00473 126460R          JMP SRCH,I      FOUND VARIABLE
0367  00474 002001            RSS
0368  00475 006004  DN        INB
0369  00476 047420R          ADB =B2
0370  00477 037261R          ISZ CNT
0371  00500 026464R          JMP S1
0372  00501 026041R          JMP ERROR
0373*
0374*
0375  00502 000503R CTAB      DEF *+1
0376  00503 052105            ASC 2,TEMP      SPACECRAFT TEMPERATURE
0377  00505 001265R TSPAN     DEF TEMPR
0378  00506 051105            ASC 2,RECD      RANGE ESTIMATE CDA
0379  00510 001231R IN0C      DEF N0CD
0380  00511 051105            ASC 2,RET1      RANGE ESTIMATE TARS 1
0381  00513 001235R IN0T1     DEF N0T1
0382  00514 051105            ASC 2,RET2      RANGE ESTIMATE TARS 2
0383  00516 001241R IN0T2     DEF N0T2
0384  00517 051520            ASC 2,SPCN      SPACECRAFT NUMBER
0385  00521 001271R SPAN      DEF SPCN
0386  00522 030504            ASC 2,1DT1      FIXED DELAY VALUES
0387  00524 001111R FIXT1     DEF .1DT1
0388  00525 031104            ASC 2,2DT1
0389  00527 001115R           DEF .2DT1
0390  00530 031504            ASC 2,3DT1
0391  00532 001121R           DEF .3DT1
0392  00533 032104            ASC 2,4DT1
0393  00535 001125R           DEF .4DT1
0394  00536 032504            ASC 2,5DT1
0395  00540 001131R           DEF .5DT1
0396  00541 030504            ASC 2,1DT2
0397  00543 001135R           DEF .1DT2
0398  00544 031104            ASC 2,2DT2
0399  00546 001141R           DEF .2DT2
0400  00547 031504            ASC 2,3DT2
```

```
0401   00551 001145R          DEF .3DT2
0402   00552 032104           ASC 2,4DT2
0403   00554 001151R          DEF .4DT2
0404   00555 032504           ASC 2,5DT2
0405   00557 001155R          DEF .5DT2
0406   00560 030504           ASC 2,1DSP
0407   00562 001161R          DEF .1DSP
0408   00563 031104           ASC 2,2DSP
0409   00565 001165R          DEF .2DSP
0410   00566 031504           ASC 2,3DSP
0411   00570 001171R          DEF .3DSP
0412   00571 032104           ASC 2,4DSP
0413   00573 001175R          DEF .4DSP
0414   00574 032504           ASC 2,5DSP
0415   00576 001201R          DEF .5DSP
0416   00577 030504           ASC 2,1DTR
0417   00601 001205R          DEF  .1DTR
0418   00602 031104           ASC 2,2DTR
0419   00604 001211R          DEF  .2DTR
0420   00605 031504           ASC 2,3DTR
0421   00607 001215R          DEF .3DTR
0422   00610 032104           ASC 2,4DTR
0423   00612 001221R          DEF  .4DTR
0424   00613 032504           ASC 2,5DTR
0425   00615 001225R          DEF  .5DTR
0426   00616 040514           ASC 2,ALLX
0427   00620 000000           NOP
0428*
0429   00621 016460R .SET     JSB SRCH       CHECK FOR LEGAL VARIABLE
0430   00622 006004           INB            POINT TO ADDRESS OF VARIABLE
0431   00623 160001           LDA 1,I
0432   00624 002003           SZA,RSS
0433   00625 026762R          JMP SALL.
0434   00626 073275R          STA LOC
0435   00627 052521R          CPA SPAN        CANNOT CHG SPACECRAFT NO.
0436   00630 026041R          JMP ERROR
0437*
0438* DATA:  S,VVVV,(VALUE),
0439*
0440   00631 002400           CLA            INITIALIZE
0441   00632 073336R          STA SIGN
0442   00633 073337R          STA SYNC
0443   00634 067040R          LDB V1X        DEF TTYDA
0444   00635 077333R          STB V1
0445   00636 063423R          LDA =B-3
0446   00637 016031X          JSB CLEAR
0447   00640 063445R          LDA =D-12
0448   00641 073335R          STA EXP
0449   00642 043425R          ADA =D-2
0450   00643 073261R          STA CNT
0451   00644 062761R          LDA .ISZ.
0452   00645 072723R          STA OPTON
0453   00646 063427R          LDA =D-4
0454   00647 073334R          STA SHIFT      SHIFT COUNTER
0455*
0456   00650 067314R          LDB TTYBF      DEF TTYDA+3
0457   00651 077276R          STB REF
```

```
0458  00652 160001         LDA 1,I
0459  00653 013432R        AND =B177
0460  00654 053446R        CPA =B55        (-) MINUS
0461  00655 026661R        JMP S1X
0462  00656 053447R        CPA =B53        (+) PLUS
0463  00657 026665R        JMP S3         IGNORE
0464  00660 026701R        JMP PUTIT
0465*
0466  00661 037336R S1X     ISZ SIGN
0467  00662 026665R        JMP S3
0468  00663 002400  S2      CLA
0469  00664 072723R        STA OPTON      STOP UPDATING EXPONENT
0470*
0471  00665 037337R S3      ISZ SYNC
0472  00666 063337R        LDA SYNC
0473  00667 000010         SLA
0474  00670 026674R        JMP S4         1 LEFT HALF
0475  00671 063331R        LDA SAVE       0 RIGHT HALF
0476  00672 013432R        AND =B177
0477  00673 026701R        JMP PUTIT
0478  00674 037276R S4      ISZ REF
0479  00675 163276R        LDA REF,I
0480  00676 073331R        STA SAVE
0481  00677 001727         ALF,ALF
0482  00700 013432R        AND =B177
0483  00701 053450R PUTIT   CPA =B56        (.) DECIMAL POINT
0484  00702 026663R        JMP S2
0485  00703 053451R        CPA =B40        ( ) SPACE  TERMINATOR
0486  00704 026736R        JMP EXIT
0487  00705 053433R        CPA =B54        (,) COMMA TERMINATOR
0488  00706 026736R        JMP EXIT
0489  00707 043452R        ADA =B-60       CONVER TO BCD.
0490  00710 070001         STA 1
0491  00711 047453R        ADB =D-10
0492  00712 006021         SSB,RSS
0493  00713 026041R        JMP ERROR      ILLEGAL POINT
0494*
0495  00714 067334R        LDB SHIFT
0496  00715 006007         INB,SZB,RSS
0497  00716 026721R        JMP *+3
0498  00717 001700         ALF
0499  00720 026715R        JMP *-3
0500  00721 133333R        IOR V1,I
0501  00722 173333R        STA V1,I
0502*
0503  00723 037335R OPTON   ISZ EXP        INCREMENT EXPONENT COUNT
0504  00724 000000         NOP
0505  00725 037261R        ISZ CNT        INCREMENT DIGIT COUNT
0506  00726 002001         RSS
0507  00727 026041R        JMP ERROR      TOO MANY POINTS
0508  00730 037334R        ISZ SHIFT
0509  00731 026665R        JMP S3
0510  00732 037333R        ISZ V1         UP DATE BCD POINTER
0511  00733 063427R        LDA =D-4
0512  00734 073334R        STA SHIFT
0513  00735 026665R        JMP S3
0514*
```

```
0515  00736 063335R EXIT  LDA EXP
0516  00737 002021        SSA,RSS
0517  00740 026743R        JMP E1          PLUS EXPONENT
0518  00741 003004        CMA,INA
0519  00742 033454R        IOR =B200        NEGATIVE EXTRAPOLATION
0520  00743 001727  E1     ALF,ALF
0521  00744 043336R        ADA SIGN
0522  00745 173275R        STA LOC,I
0523*
0524  00746 063423R        LDA =B-3
0525  00747 073334R        STA SHIFT
0526  00750 037275R        ISZ LOC         UPDATE STUFF POINTER
0527  00751 067040R        LDB V1X
0528  00752 160001  SAVIT  LDA 1,I
0529  00753 173275R        STA LOC,I
0530  00754 006004        INB
0531  00755 037275R        ISZ LOC
0532  00756 037334R        ISZ SHIFT
0533  00757 026752R        JMP SAVIT
0534  00760 126000R        JMP RTTYB,I
0535*
0536  00761 037335R .ISZ.  ISZ EXP
0537*
0538  00762 063.35R SALL.  LDA =D-25
0539  00763 073261R        STA CNT         SET ALL INITIAL VALUES TO 0.0
0540  00764 066502R        LDB CTAB
0541  00765 047420R SAL1.  ADB =D2
0542  00766 077037R        STB WILD
0543  00767 164001        LDB 1,I
0544  00770 056521R        CPB SPAN         CANNOT RESET SPACECRAFT NO.
0545  00771 026774R        JMP *+3
0546  00772 063427R        LDA =D-4
0547  00773 016031X        JSB CLEAR
0548  00774 067037R        LDB WILD
0549  00775 006004        INB
0550  00776 037261R        ISZ CNT
0551  00777 026765R        JMP SAL1.
0552  01000 126000R        JMP RTTYB,I
0553*
0554*
0555  01001 016460R .DMP   JSB SRCH
0556  01002 006004        INB
0557  01003 160001        LDA 1,I
0558  01004 073037R        STA WILD
0559  01005 002002        SZA
0560  01006 027036R        JMP WILD-1
0561  01007 066502R        LDB CTAB
0562  01010 063455R        LDA =D-25
0563  01011 073261R        STA CNT
0564  01012 077015R        STB MILD
0565  01013 063420R        LDA =D2
0566  01014 016030X        JSB PRINT
0567  01015 000000  MILD   NOP
0568  01016 067015R        LDB MILD
0569  01017 047420R        ADB =D2
0570  01020 160001        LDA 1,I
0571  01021 073023R        STA *+2
```

```
0572  01022 016012X        JSB DDTA
0573  01023 000000         NOP
0574  01024 001301R        DEF TTYDA
0575  01025 063456R        LDA =D9
0576  01026 016030X        JSB PRINT
0577  01027 001301R        DEF TTYDA
0578  01030 067015R        LDB MILD
0579  01031 047421R        ADB =D3
0580  01032 077015R        STB MILD
0581  01033 037261R        ISZ CNT
0582  01034 027013R        JMP MILD-2
0583  01035 126000R        JMP RTTYB,I
0584*
0585  01036 016012X        JSB DDTA
0586  01037 000000  WILD    NOP
0587  01040 001301R V1X     DEF TTYDA
0588*
0589  01041 063456R        LDA =D9
0590  01042 016030X        JSB PRINT      PRINT VARIABLE VALUE
0591  01043 001301R        DEF TTYDA
0592  01044 126000R        JMP RTTYB,I




0594  01045 000000  CONV    NOP
0595  01046 160001         LDA 1,I
0596  01047 001727         ALF,ALF
0597  01050 006004         INB
0598  01051 130001         IOR 1,I
0599  01052 006004         INB
0600  01053 033342R        IOR CAN
0601  01054 127045R        JMP CONV,I




0603  01055 000000  NGETB  NOP
0604  01056 073321R        STA CHAR
0605  01057 077320R        STB Z
0606  01060 002400         CLA
0607  01061 073323R        STA BCD
0608  01062 163317R AG     LDA ZBUF,I
0609  01063 067330R        LDB CNTT
0610  01064 006011         SLB,RSS
0611  01065 001727         ALF,ALF
0612  01066 013432R        AND =B177
0613  01067 043452R        ADA =B-60
0614  01070 002020         SSA
0615  01071 027104R        JMP FINI
0616  01072 067323R        LDB BCD
0617  01073 005700         BLF
0618  01074 030001         IOR 1
0619  01075 073323R        STA BCD
0620  01076 067330R        LDB CNTT
```

```
0621   01077 037330R         ISZ CNTT
0622   01100 004010          SLB
0623   01101 037317R         ISZ ZBUF
0624   01102 037321R         ISZ CHAR
0625   01103 027062R         JMP AG
0626   01104 063323R FINI    LDA BCD
0627   01105 067320R         LDB Z
0628   01106 006002          SZB
0629   01107 016013X         JSB BCDBI
0630   01110 127055R         JMP NGETB,I
```

```
0632  01111 000000  .1DT1  BSS 4          FIXED DELAY TABLES
0633  01115 000000  .2DT1  BSS 4
0634  01121 000000  .3DT1  BSS 4
0635  01125 000000  .4DT1  BSS 4
0636  01131 000000  .5DT1  BSS 4
0637  01135 000000  .1DT2  BSS 4
0638  01141 000000  .2DT2  BSS 4
0639  01145 000000  .3DT2  BSS 4
0640  01151 000000  .4DT2  BSS 4
0641  01155 000000  .5DT2  BSS 4
0642  01161 000000  .1DSP  BSS 4
0643  01165 000000  .2DSP  BSS 4
0644  01171 000000  .3DSP  BSS 4
0645  01175 000000  .4DSP  BSS 4
0646  01201 000000  .5DSP  BSS 4
0647  01205 000000  .1DTR  BSS 4
0648  01211 000000  .2DTR  BSS 4
0649  01215 000000  .3DTR  BSS 4
0650  01221 000000  .4DTR  BSS 4
0651  01225 000000  .5DTR  BSS 4
0652  01231 000000  N0CD   BSS 4
0653  01235 000000  N0T1   BSS 4
0654  01241 000000  N0T2   BSS 4
0655*
0656  01245 000000  BB200  NOP
0657  01246 000000  BB27   NOP
0658  01247 000000  BB39   NOP
0659  01250 000000  BB283  NOP
0660  01251 000000  MODSX  NOP
0661  01252 040200  TTOSA  OCT 40200
0662  01253 020200  TTOSB  OCT 20200
0663  01254 020200  TTO    OCT 20200
0664  01255 000074  D60    DEC 60
0665  01256 023420  D10K   DEC 10000
0666  01257 000004  D4     DEC 4
0667  01260 000000  COUNT  NOP
0668  01261 000000  CNT    NOP
0669  01262 000000  CNTX   NOP
0670  01263 000000  CNTY   NOP
0671  01264 000000  SKIP   NOP
0672  01265 000000  TEMPR  BSS 4
0673  01271 000000  SPCN   OCT 0,0,0,0
0674  01275 000000  LOC    NOP
0675  01276 000000  REF    NOP
0676  01277 025052  XXX    ASC 1,**
0677  01300 020137         OCT 20137
0678  01301 020040  TTYDA  ASC 11,
0679  01314 001304R TTYBF  DEF TTYDA+3
0680  01315 000000  CULL1  NOP
0681  01316 000000  CULL2  NOP
0682  01317 000000  ZBUF   NOP
0683  01320 000000  Z      NOP
0684  01321 000000  CHAR   NOP
0685  01322 001302R TTYB   DEF TTYDA+1
0686  01323 000000  BCD    NOP
0687  01324 042522  MSG    ASC 3,ERROR
0688  01327 000000  TTYM   NOP
```

```
0689   01330 000000  CNTT   NOP
0690   01331 000000  SAVE   BSS 2
0691   01333 000000  V1     NOP
0692   01334 000000  SHIFT  NOP
0693   01335 000000  EXP    NOP
0694   01336 000000  SIGN   NOP
0695   01337 000000  SYNC   NOP
0696   01340 020100  CASCI  OCT 20100
0697   01341 030106  CANUM  OCT 30106
0698   01342 030060  CAN    OCT 30060
0699   01343 030040  CANT   OCT 30040
0700   01344 046517  MSG6   ASC 3,MODE
0701   01347 020040         ASC 1,
0702   01350 020040  SNO    ASC 1,
0703   01351 052105  MSG7   ASC 5,TEMP
0704   01356 020040  OUTHD  ASC 18,   RCDA        RTARS1     RTARS2
0705   01400 051056         ASC 12,R.CDA   R.TARS1 R.TARS2
0706   01414 052111         ASC 4,TIME TAG
0707   01356        SPACE  EQU OUTHD
0708                       UNS
       01420 000002
       01421 000003
       01422 072460
       01423 177775
       01424 166170
       01425 177776
       01426 000017
       01427 177774
       01430 177760
       01431 000036
       01432 000177
       01433 000054
       01434 177700
       01435 177773
       01436 000004
       01437 000010
       01440 000016
       01441 000005
       01442 000013
       01443 000042
       01444 177746
       01445 177764
       01446 000055
       01447 000053
       01450 000056
       01451 000040
       01452 177720
       01453 177766
       01454 000200
       01455 177747
       01456 000011
0709                         END
** NO ERRORS: AMD ASMB,25117-402518
```

APPENDIX A. TRRR OPERATIONAL MODES

A.1 INTRODUCTION

The measurement of range with discrete tones is based on a priori knowledge of the two-way range to at least ±1/2 wavelength of the tone being used for the measurement. This is necessary since the measurement technique does not measure propagation time but phase delay which is always ambiguous to some multiple of 2π. Therefore, it is necessary to remove this ambiguity by at first estimating the two-way range to ±1/2 wavelength for the lowest tone, and then by design, each tone measurement will yield a range accurate to a small fraction of the wavelength of the next higher tone.

After the first initial measurement of the range using all the tones, succeeding measurements are made using only the highest tone. Each preceding range measurement is used as an estimate of the next range measurement. A maximum of 15 minutes of ranging data can be taken and processed by the computer program.

Finally, after the last range measurement, the lower tones are cycled through once again to obtain an unambiguous final range. If the unambiguous measurement does not agree with the final range measurement (obtained by using the previous measurement to eliminate ambiguity), all intervening range measurements should be scrutinized for a possible wavelength error.

In order to determine the position of the satellite as a function of time, each range measurement must be accurately time-tagged. A time tag is assigned to each range measurement at the time of measurement; however, the range information has been retarded by the speed of light which necessitates a correction in either the time tag or the range. This program corrects the range by adding or subtracting a term proportional to the measured two-way range rate.

The description of the logic for the range program is divided into the following parts:

1) Constants necessary to calculate range

2) System loop calibration

3) Ambiguity removal by the lower tones

4) Range determination using prior measurements to eliminate ambiguity

5) Time tag

6) Range rate and range correction

7) Range endpoint check

A.2 NUMERICAL CONSTANTS IN RANGE PROGRAM

Table A-1 indicates the tone frequencies and their respective periods. The tones are obtained by dividing a 5 MHz oscillator by integral numbers; hence, their respective periods are rational numbers as opposed to the frequency. Table A-1 lists the range frequencies and their periods since the range measurement is calculated in terms of time.

A.3 SYSTEM LOOP CALIBRATION

At the beginning of each range measurement, the ranging equipment is calibrated by looping the transmit IF to the receiver. This calibration is handled by a software routine which switches all receivers to a 66 MHz center frequency. Each tone is counted sequentially and those delays are used to update the program utilized to calculate the satellite range.

TABLE A-1

Tone	Period
200.00 kHz	5.0×10^{-6} sec
27.777 kHz	3.6×10^{-5} sec
3.9682 kHz	2.52×10^{-4} sec
283.44 Hz	3.528×10^{-3} sec
35.43 Hz	2.8224×15^{-2} sec

Speed of light in vacuum $2.997924562 \times 10^{8}$ m/s $\pm 10 \times 10^{8}$ m/s. (NBS - 1972)

A.4 AMBIGUITY REMOVAL BY LOWER TONES

In order to utilize the tone system of ranging, the one-way range must be known to an accuracy of better than ±1/2 of a wavelength of the lowest frequency tone utilized for the measurements. There are three modes used for ranging, and they are listed in Table A-2. Additionally, the modulation index for each tone, the modulation loss factor for conversion of C/N to S/N, the number of total axis crossings counted in the measurement, and the phase error given in seconds, for a nominal receive C/N_O=50.76 is presented in this table.

Mode A will normally be used for ranging. This requires the one-way range from the satellite to TARS I, II, and the CDA is known to an accuracy of 2.12×10^6 meters or 6 percent of synchronous altitude.

For utilization of Modes B and C, the one-way range must be known to an accuracy of 2.5×10^{-1} and 1.89×10^{-2} percent of synchronous altitude, respectively. If Mode A is selected, the lower tones are simultaneously transmitted and the returned signal is counted for the indicated number of axis crossings of each tone. These measurements are used to remove the ambiguity associated with the 200 kHz measurement. After measurements with Mode A are complete, the 200 kHz tone is modulated on the carrier and transmitted continuously for the desired ranging interval. The switching

TABLE A-2

	Mod Index	Mod Loss, dB	Total Counts
Mode A			
35.46 Hz	1.5	-7	100
283.4 Hz	1.5	-2.2	100
3.968 kHz	1.5	-2.2	1000
27.77 kHz	1.5	-2.2	1000
200.0 kHz	1.5	-2.2	3000
Mode B			
283.4 Hz	1.5	-2.2	100
3.968 kHz	1.5	-2.2	1000
27.77 kHz	1.5	-2.2	1000
200.0 kHz	1.5	-2.2	3000
Mode C			
3.968 kHz	1.5	-2.2	1000
27.77 kHz	1.5	-2.2	1000
200.0 kHz	1.5	-2.2	3000

interval between tones should not exceed 13.6 seconds in order to avoid range rate errors during those periods when the satellite is moving with maximum range rate.

A.5 RANGE DETERMINATION USING PRIOR MEASUREMENTS TO ELIMINATE AMBIGUITY

After the range ambiguity is removed by the lower ranging tones, all further range measurements are obtained with the 200 kHz tone. These measurements are approximately 3 seconds apart and consist of an average of 3000 axis crossings of the 200 kHz tone. Each range measurement, after the first, is obtained by using the preceding measurement as an estimate to remove the ambiguity associated with the 200 kHz phase measurement. The software program has been designed so that if the measurement disagrees 250 ns, the measurement is rejected. The purpose of this rejection is to exclude those range measurements that take place when the phase measurement is going from 360 to 0 degrees. Averaging during this time will cause errors that could be progressively added to the remaining measurements. In order to avoid this, errors greater than 250 ns second are rejected. If less than 250 ns second, they will not influence succeeding measurements, which is the ultimate purpose of this rejection routine. The erroneous range measurements that do pass this test will be subsequently culled by a least square fit in the trilateration software routines stored at Suitland, Virginia.

A.6 TIME TAG

The time tag at which each range measurement is recorded by an internal oscillator within the HP 2100 A computer. The time tags are differential time measured from the station standard time which starts the time measurement at the beginning of the range measurement. Since the range measurements are the result of averaging three groups of 1000 axis crossings of the 200 kHz tone, the time tag is taken at the midpoint of the second group of measurements. This is determined by measuring the time at the beginning and end of this particular group of 1000 measurements, and taking the average. Computer cycle time (5×10^{-6} sec) is not accounted for in this measurement since the time tag accuracy is only necessary to ± 0.1 millisecond. The time tag is printed out with each range measurement.

A.7 RANGE RATE

The range rates on each of the three ranging links for the trilateration are computed by subtracting adjacent range measurements and dividing by the difference in time tags. Thirty range rate measurements are then averaged. The range rate is then utilized to correct the range as shown in the addendum to this appendix.

A.8 RANGE ENDPOINT CHECK

At the end of the range measurements, Mode A is again switched on to remove ambiguity. Hence, the last range measurement is computed by using the preceding range measurement for ambiguity removal and by using the lower tones. If these two measurements do not result in identical ranges, an error of one 200 kHz wavelength has probably occurred during the range measurements. A warning is printed out on the teletype to indicate this.

ADDENDUM TO APPENDIX A

INTRODUCTION

The objective of the TRRR program is to predict the position coordinates of the SMS satellite to within several hundred meters over a 24 hour period. The prediction is based on range and range rate measurements to the satellite which are obtained a few times a day. As a design goal of the project, the two-way range measurements are specified to be accurate to within 3 meters. In order to achieve this accuracy, the ranges or the time tags of the range measurements must be corrected for the retardation of the range information by the speed of light.

The correction must be in terms of the physical variables that are measured during the ranging period. Although there are several ways to derive this correction, the following method expresses it as a function of the measured range and range rate. The range was chosen to be corrected instead of the time tag of the range measurement because as a consequence the three range measurements will have a simultaneous time tag and the trilateration solution for the spacecraft position will be independent of curve fitting.

RANGE CORRECTION DUE TO SATELLITE MOTION

The round trip propagation time for the RF signal is defined to be

$$t_r = t_1 + t_2 + t_3 + t_4 \qquad (1)$$

where

t_1 = propagation time up to the satellite from the ground station

t_2 = propagation time from the satellite down to the turn-around station

t_3 = propagation time from the turn-around station to the satellite

t_4 = propagation time from the satellite to the ground station

t_r = total round-trip propagation time

Referring to Figure A-1, the round-trip time t_r may be given in terms of the ranges R_1 and R_2.

$$t_r = \frac{R_1}{C} + \frac{2R_2 + \dot{R}_2 * (t_1 + t_2)}{C} + \frac{\dot{R}_1 t_r + R_1}{C} \qquad (2)$$

R_1 and R_2 are the ranges between the earth station and satellite and the turn-around station and satellite, respectively, at the time of emanation of the RF signal from the earth station. $\dot{R}_1$ and $\dot{R}_2$ are the range rates, which are assumed constant during the measurement period of 1/2 second. The measured range from the earth station to the turn-around station via the satellite is obtained by multiplying the round-trip time t_r by the speed of light and dividing by two.

$$R_m = t_r \cdot C/2$$

$$= R_1 + R_2 + \dot{R}_2 (t_1 + t_2) + \frac{\dot{R}_1 t_r}{2} \qquad (3)$$

where R_m is the measured range to the turn-around station. The range to the turn-around station at the time of measurement (when the RF signal returns to the earth station) is given by

$$R_i = R_1 + R_2 + t_r (\dot{R}_1 + \dot{R}_2) \qquad (4)$$

R_i = instantaneous range to the turn-around station.

The difference between the instantaneous range and the measured range is given by

$$R_i - R_m = \dot{R}_2 * t_r - \dot{R}_2 * (t_1 + t_2) + \dot{R}_1 * \frac{t_r}{2} \qquad (5)$$

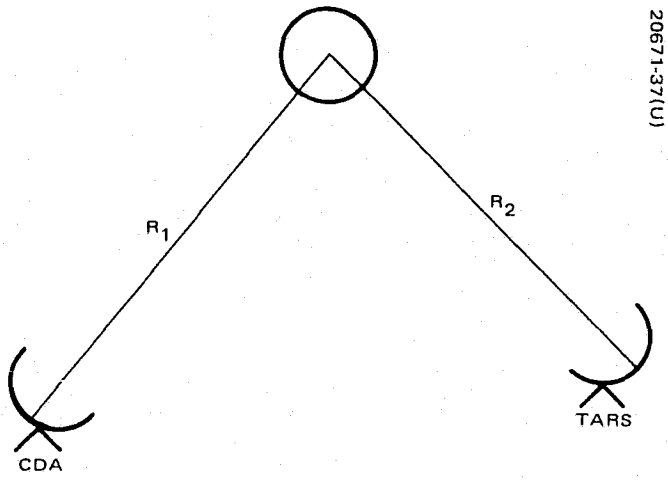


Figure A-1. Round Trip

Since

$$t_r = t_1 + t_2 + t_2 + t_1 + \frac{R_1 * t_r}{C}$$

then

$$t_1 + t_2 = \frac{t_r}{2} - \frac{\dot{R}_1 * t_r}{2C} \tag{6}$$

Thus

$$R_i - R_m = \frac{t_r}{2} (\dot{R}_2 + \dot{R}_1 + \dot{R}_2 * \dot{R}_1 / C) \tag{7}$$

The range rates for the SMS propagation links are 30 m/s at maximum, Therefore

$$\frac{\dot{R}_2 \dot{R}_1}{C} \cong \frac{9 \times 10^2}{3 \times 10^8} = 3 \times 10^{-6} \text{ m/sec}$$

This term causes a correction to the range of about 10^{-6} meter and can be discarded. Hence

$$R_i = R_m + (\dot{R}_1 + \dot{R}_2) * \frac{t_r}{2} \tag{8}$$

$$= R_m + \dot{R}_m \frac{t_r}{2} \tag{9}$$

$\dot{R}_m \cong$ total range rate on the RF link

Formula 9 indicates that the measured range can be corrected for the motion of the satellite by either adding to the measured range the quantity $R_m(t_r/2)$ or by correcting the time tag of the range measurement by subtracting $t_r/2$. For the TRRR program, the range is corrected instead of the time tag in order to obtain simultaneous range information from all three links.

The range for the TRRR program is given in terms of one-way propagation time. Hence the corrected propagation time is

$$t_r^i = (1 + \frac{\dot{R}_m}{C})\frac{t_r}{2} \tag{10}$$

The propagation time to the satellite should be measured to an accuracy of 10^{-8} second; hence any error associated with the corrective term in Equation 10 should be less than 10^{-9} second.

$$\delta t_r^i = \frac{\delta \dot{R}_m t_r}{C \quad 2} < 10^{-9} \text{ second}$$

$$\delta \dot{R}_m < \frac{10^{-9} \text{ sec } 0.2C}{0.5 \text{ second}}$$

$$< 4 \times 10^{-1} \text{ m/sec}$$

Hence the range rate should be measured with an accuracy of better than 4×10^{-1} m/sec in order to correct the propagation time without influencing the accuracy of the measurement. This accuracy is well within the capability of the range rate measurement.

In summary, the measured one-way propagation time should be corrected by the following:

CDA to SMS link	$t_r^1(1+\dot{R}_m^1)$ 1/2
CDA to Chile link	$t_r^2(1+\dot{R}_m^2)$ 1/2
CDA to Hawaii link	$t_r^3(1+\dot{R}_m^3)$ 1/2

The superscript on the above corrected range refers to times and range rates measured for that particular link.

APPENDIX B. TARS ANTENNA ALIGNMENT PROCEDURE

This procedure is used to align the TARS antenna. The field technician should first align their receive antenna (use same procedure described here) at the time the satellite crosses the equatorial plane. The transmit antenna should be initially set to approximately the same azimuth and elevation as the receive TARS antenna. The operator at the CDA will set up the Hewlett-Packard spectrum analyzer (using the 8553B RF section and 8552B IF section) with the instrument readings listed below. The analyzer will be connected to the receive IF at the CDA.

*Bandwidth 30 kHz

*Scanwidth 1 MHz/div

Video filter 10 Hz

Scan mode Internal

*Scan time/division sec

*Log reference scale 10 db

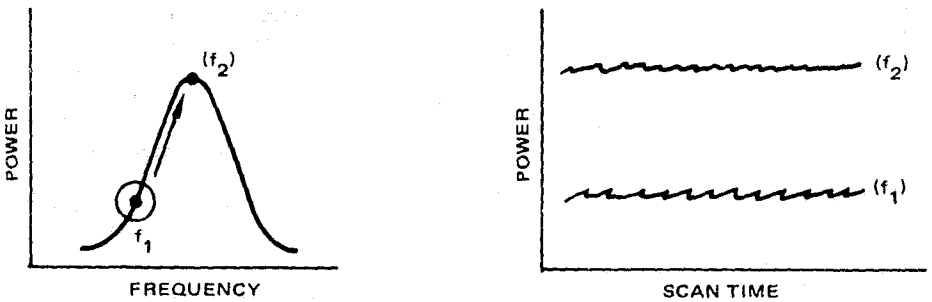
Scan trigger - Auto

Writing speed - Standard

Adjust persistence and intensity for a proper display.

Depending on which TARS is being aligned, turn the coarse tune frequency scale to 68.2 or 70.2 MHz. The transmit signal from the TARS should be visible on the analyzer (identify by commanding the TARS on and off). Reduce the scanwidth to 10 kHz per division, keeping the signal at the center frequency of the display. Reduce the bandwidth to 10 kHz.

Now, with the display at center frequency, turn the scanwidth dial to zero scan. Adjust the fine frequency tune so that the straight line display moves up on the vertical scale to maximum (see to Figure B-1). Turn the log reference level to linear and again adjust the fine tune for a maximum signal on the display. Adjust scan time to 50 ms/division. Readjust intensity if necessary. Finally, one is ready to adjust the TARS transmit



a) FREQUENCY SWEPT DISPLAY

b) MANUAL FREQUENCY SCAN

FIGURE B-1. MANUAL VERSUS SWEPT DISPLAY OF RETURN SIGNAL

antenna. Have the field technician adjust the azimuth for maximum signal on the display. Return to the azimuth adjustment and over the orderwire mark the points on the antenna screw where the technician (at the CDA) observes the signal to fall 2 scale divisions below the maximum signal. The antenna azimuth should be set at the midpoint of the screw markings. The same procedure should be followed for the antenna elevation.

Finally, the carrier-to-noise (C/N_O) density should be measured. With the 10 kHz bandwidth setting, the C/N_O may be approximately measured by using the fine frequency tune dial to measure the difference between the peak and alley of the signal. In order to proceed with this measurement, flip the log reference level from linear to 10 dB and readjust the attenuator setting to obtain a display. Add 40 dB to the measured difference to obtain the C/N_O. The result should be close to 60 db.

Measure C/N_O again, six hours from the equatorial crossing. For SMSA the ratio should drop by approximately 3 dB. If it drops significantly less or more, the antennas have not been properly centered.

SUMMARY

The Hughes Aircraft Company interface specifications are as follows:

Computer output to modem

Type of signal	Serial bit stream
Signal level	0 to 5 volts TTL
Bit rate	1800 laps
Frame length	800 words
Word length	4 bits
Synchrous pattern length	8 words

Starting with word number 8, every other word will be complimented before being sent across modem. For example, if data words 8, 9, 10, and 11 were 0001, 0010, 0011, 0100, they would be sent as 1110, 0010, 0011, 0100.

The data timing will be provided by the modem that must have a data request line to the Hughes interface to indicate the modem is ready for the next word. See Table 5-1 in Section 5, TRRR Software System, for word allocation list.