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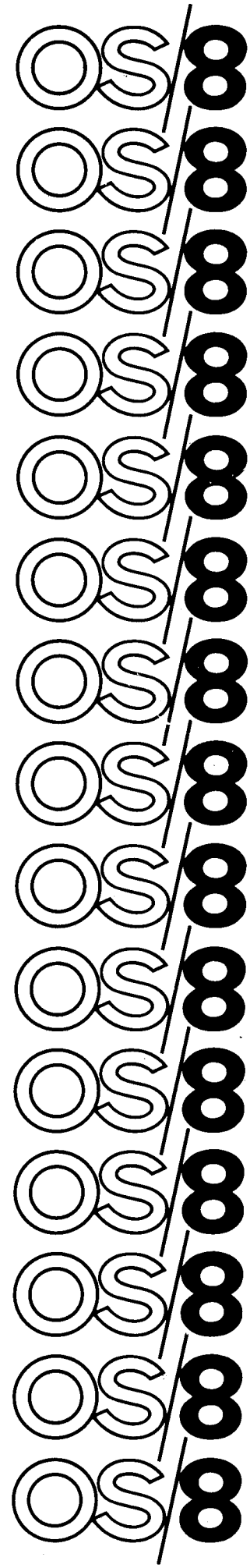

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OS/8 SYSTEM REFERENCE MANUAL

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The "HOW TO OBTAIN SOFTWARE INFORMATION" page, located at the back of this document, explains the various services available to DIGITAL software users.

The postage prepaid "READER'S COMMENTS" form on the last page of this document requests the user's critical evaluation. All comments received are acknowleged and will be considered when subsequent documents are prepared.

OS/8 SYSTEM

OS/8 system

INTRODUCTION

The OS/8 Operating System is a powerful programming system designed for the PDP-8/E computer. This system permits use of a wide range of peripherals and all available core up to 32K. OS/8 offers a versatile Keyboard Monitor which allows the user to control the flow of programs. In addition to the Keyboard Monitor, OS/8 offers extensive I/O facilties at the Monitor level—many commonly performed I/O functions such as file LOOKUPS, ENTERS, and CLOSES have been incorporated as part of the Monitor. These features make OS/8 a significant improvement in small computer operating systems.

Besides the Monitor facilities, OS/8 includes a library of powerful system programs which allow the user to do program development using FORTRAN or assembly language. A brief summary of the system programs follows:

1. Symbolic Editor (EDIT)
   EDIT is used to create or modify source files for use as input to language processing programs such as PAL8, SABR, or FORTRAN. EDIT contains powerful text manipulation commands for quick and easy editing.
2. PAL8 Assembler
   PAL8 is the assembler for the OS/8 system. PAL8 accepts source files in the PAL language and generates absolute binary files as output. PAL8 also generates listing files which can be used as input to CREF.
3. Peripheral Interchange Program (PIP)
   PIP allows the user to transfer files between devices which

are in the OS/8 system. Complete file and directory maintenance functions are available in PIP.

4. Cross Reference (CREF)
   CREF operates on the listings produced by PAL8 and SABR. It produces a sequence numbered listing and a table indicating where each user-defined tag and literal is referenced.
5. Absolute Binary Loader (ABSLDR)
   ABSLDR accepts the binary output files produced by PAL8 and loads them into core.
6. Octal Debugging Program (ODT)
   ODT is a new, powerful octal debugging tool. All of the features of older versions of ODT are implemented, but the OS/8 version is designed so that no user core is needed.
7. FORTRAN
   The OS/8 system contains an extensive and powerful FORTRAN package, consisting of the FORTRAN compiler, SABR assembler, Linking Loader, and library function routines. Some of the many features of FORTRAN are:
   a. FORTRAN is very easy to use. If desired, a FORTRAN source program can be compiled, loaded, and executed with a single Teletype command.
   b. Implied DO loops are permitted in FORTRAN.
   c. FORTRAN contains facilities to do program chaining; this technique can be used to increase the effective program size.
   d. Device independent I/O is available, as well as the standard devices (Teletype, high-speed reader/punch, card reader, and line printer).
8. Library Setup (LIBSET)
   OS/8 LIBSET allows the user to create his own FORTRAN run-time libraries. The standard library supplied with the system is LIB8. By using LIBSET, the user can write his own routines in SABR and create a library.
9. System Builder (BUILD)
   BUILD allows rapid and easy alteration of the device configuration in the system. New devices can be inserted by simple Keyboard commands. BUILD also makes interfacing user-coded device handlers a quick and easy job.

OS/8 provides true device-independence. For the first time on a PDP-8 computer, programs can be written without concern for specific I/O devices. In running a program the user can select the most effective I/O devices available. Further, if the system configuration is altered, programs need not be rewritten to take advantage of the new configuration.

The OS/8 system controls the copying of data from any medium to any other medium by means of subroutine calls to execute I/O routines. Logical names can be assigned to devices within the system to enable symbolic referencing of devices.

Variable length I/O buffers can be specified by the user program. Large buffers ensure efficient use of storage devices and a minimum of time spent in data transfer operations by minimizing disk and tape motion. OS/8 takes full advantage of the RK8 disk pack for the fast bulk storage, yet full system services are possible with a single DECtape.

Hardware Configurations

The OS/8 system can operate with a wide variety of devices as the *system device.*[1] The devices which can be used are:

TC01/TC08 DECtape
LINCtape (PDP-12)
TD8E DECtape
DF32/RF08 disk
RK8 disk

The TD8E can be used either with 12K of core memory, or with 8K of core memory and 256 words of Read-Only-Memory (ROM).

If DF32 is the system device, at least 64K (2 platters) must be available. In addition, if disk is the system device, high-speed reader/punch provides a very useful tool.

The minimum OS/8 configuration is a PDP-8 series computer with 8K of core, one DECtape used as the system device, and an

---

[1] The term *system device* refers to the device on which the OS/8 system resides and which it utilizes for system functions. Thus, DECtape Unit 0 is the system device for a DECtape-based system. A non-system device is any peripheral not specifically used for system functions, such as LPT:, PTR:, DTA2:, etc.

ASR-33 Teletype terminal. A multiple DECtape system performs appreciably faster than a single DECtape system. The multiple DECtape system reduces DECtape motion since it is possible to copy directly (without intermediate searching) from the system DECtape to another DECtape (or vice versa) when editing or assembling.

A typical medium-sized system might contain a PDP-8/E with at least 8K of core, TD8E DECtape and control, and an RK8 disk pack and control. A disk system offers the additional convenience of easy and fast access to files, and large amounts of storage.

Up to fifteen devices can be interfaced to a single OS/8 system. These optional devices include:

As many as 8 DECtape units (TC01/TU55, TC08/TU56 or TD8E/TU56).
High-speed paper tape reader/punch.
Up to four RK8 disks.
Up to four RS08 disks.
Up to four DF32 disks.
Card reader (optical mark or punched cards).
Line printer.
PDP-12 LINCtape.
Any other device for which it is possible to write a device handler in one or two pages of core.

System Software Components

The main software components of the OS/8 system are five:

Keyboard Monitor
Command Decoder
Library of system programs
Device handlers
User Service Routine (USR)

The Keyboard Monitor provides communication between the user and the OS/8 executive routines by accepting commands from the Teletype keyboard. The commands enable the user to create logical names for devices, run system and user programs, save program and call ODT.

The Command Decoder allows the user to communicate with a system library program by accepting a command string from the keyboard indicating input/output files. Following the keyboard command to run a system library program, the Command Decoder prints an asterisk (*) and then accepts the command line containing the files to be used as input, file name and destination of output, etc.

The library of system programs, as mentioned earlier, contains the Peripheral Interchange Program (PIP), Symbolic Editor, PAL8, an Absolute Binary Loader, a new, improved 8K FORTRAN, 8K SABR, the Linking Loader, CREF, LIBSET, and BUILD. Other system library programs will be added as they become available.

Device handlers are subroutines designed to transfer data to and from peripheral devices. OS/8 is able to interface with as many as 15 different peripherals at a time. During system generation, device handlers become an integral part of the system; both system and user programs have access to any available device. (The program BUILD allows quick and easy alteration of any available device.)

The User Service Routine (USR) controls the directory operations for the OS/8 system. A program can use the USR by means of standard subroutine calls such as those used to activate device handler subroutines. Some of the functions performed by the USR are loading device handlers, searching file directories, creating and closing output files, calling the Command Decoder, and chaining of programs. The details on the operation and use of the USR are contained in the *OS/8 Software Support Manual* (DEC-S8-OSSMA-A-D). For normal OS/8 usage, the USR function is unseen by the user and need be of no concern.

When OS/8 is operating, the Command Decoder, Keyboard Monitor, and USR are swapped into core from the system device as required, and when their operation has been completed, the previous contents of core are restored.

The core-resident portion of OS/8 is extremely small (256 words), allowing for a maximum use of core by user programs.

GETTING ON LINE WITH OS/8

OS/8 software is distributed to the user in a form appropriate for his particular hardware configuration. The two general system

categories are DECtape and Paper Tape. This section provides the information that the user of either type of system needs in order to start using OS/8.

DECtape Systems

This category includes TC01/TC08, TD8E, and LINCtape (PDP-12) hardware configurations. Since the software is delivered on a system DECtape (or LINCtape), it is not necessary to build an initial system, as it is if using paper tape.

Two DECtapes are distributed with each DECtape (LINCtape) OS/8 system. One is the system tape which contains the system programs and all OS/8 Monitor functions. The second DECtape contains a source of CONFIG (the standard OS/8 system configurator) and a group of binary format device handlers. CONFIG can be used to create a certain number of standard OS/8 configurations (for details on the use of CONFIG, refer to the *OS/8 Software Support Manual*, DEC-S8-OSSMA-A-D). The other files on the DECtape are device handlers in a format suitable for the BUILD program. Each file contains a handler for a specific device type. These files are to be used as input for the LOAD command in BUILD and are described in Table 9-32 in the BUILD section. In addition to these files, binary files of LIB8 and LIBSET have been included. LIB8.BN is a *relocatable binary file*, and should be processed with LIBSET to create a FORTRAN library. (For details concerning loading and using LIBSET, refer to the section describing OS/8 LIBSET.)

TC01/TC08 DECTAPE USERS

The following short procedure is used to start OS/8 on a TC01/TC08 system:

1. Mount the system DECtape (DEC-S8-OSYSA-A-UC) on unit 0 (this appears as 8 on some DECtape units), making certain to wind at least 10 feet of tape onto the empty reel. Put the tape unit switches to REMOTE and WRITE LOCK.
2. Toggle the following program into core from the programmer's console switches (refer to Appendix A for instructions concerning manual loading of programs):

```
                        *7613
7613    6774            DTLB
7614    1222            TAD K600
7615    6766            DTLA
7616    6771            DTSF
7617    5216            JMP .-1
7620    1223            TAD K220
7621    5215            JMP .-4
7622    0600    K600,   600
7623    0220    K220,   220
                        *7754
7754    7577            7577        /WORD COUNT
7755    7577            7577        /CURRENT ADDRESS
```

This bootstrap first rewinds unit 0 to the end zone then starts it moving forward, reading block 0 into location 7600 in field 0. In block 0 is a larger bootstrap which continues reading the tape, installing the resident code, and finally turning control over the the Keyboard Monitor.

3. Set the Teletype to LINE, and start the computer at location 7613 in field 0. Unit 0 will rock and the console Teletype will respond by typing a dot (.) at the left margin. At this point, OS/8 is active; DECtape unit 0 must be set to WRITE ENABLE.

NOTE

If the Teletype does not respond properly, check that the bootstrap was loaded correctly, that unit 0 is selected and set to REMOTE, and that the Teletype is set to LINE. If trouble persists contact the local DEC sales office.

TD8E DECTAPE USERS

TD8E DECtape hardware is supported in two configurations: TD8E DECtape and 12K core; TD8E DECtape and 8K core and 256 word Read-Only-Memory (ROM).

TD8E DECtape users must run a special initialization program before OS/8 can be used. This program need only be run once to create the proper configuration; thereafter, the standard TD8E bootstrap (discussed shortly), can be used to start OS/8.

TD8E Initialization Program

Follow this short procedure to run the TD8E initialization program:

1. Put the RIM loader into core in field 0 (refer to Chapter 5 of Introduction to Programming for instructions on loading programs manually and on paper tape).
2. Place the RIM format paper tape marked TDINIT (DEC-8-OTINA-A-PM) into the appropriate reader. Load this tape with the RIM loader into field 0.
3. Mount the system DECtape (DEC-S8-OSYSA-A-UC) on tape unit 0, setting the tape switches to WRITE ENABLE and REMOTE. Make certain to wind at least ten feet of tape onto the empty reel.
4. Set the Teletype to LINE and start the computer at one of following two addresses in field 0:
   a. location 20—If the configuration is 8K with 256 word ROM.
   b. location 21—If the configuration is 12K (and no ROM):

   Tape unit 0 will rock several times and the Teletype will respond by typing a dot (.). OS/8 is now active. If a system I/O error should occur, a message will be printed on the Teletype, and the computer will halt. In such a case, the above procedure should be repeated; if problems persist, consult the local DEC sales office.

After the initialization, the system DECtape contains an OS/8 system appropriate to the hardware configuration. One of the following standard OS/8 bootstrapping procedures is now used to start OS/8.

TD8E Bootstraps

8K ROM Bootstrap (PDP-8/E)

1. Mount the system DECtape on unit 0, set to WRITE LOCK, and REMOTE. Turn the Teletype to LINE.
2. Set the switch register to 7470.
3. Press EXTD ADDR LOAD, ADDR LOAD, CLEAR, and CONTinue. The tape bootstrap will be executed and the Teletype will respond by typing a dot(.). OS/8 is now active. At this point, WRITE ENABLE Unit 0.

12K TD8E Bootstrap

The bootstrap for the 12K TD8E is distributed on a RIM format paper tape. The following procedure is used to start up OS/8 on a 12K TD8E system:

1. Put the RIM loader into core (any field).
2. Using RIM, load the 12K TD8E BOOTSTRAP tape (DEC-S8-OTBSA-A-PM) into field 0.
3. Mount the system DECtape, WRITE LOCKed and REMOTE on unit 0.
4. Set the switch register to 0 and press EXTD ADDR LOAD; set the switch register to 7300 and press ADDR LOAD, CLEAR and CONTinue. The tape bootstrap will be executed and the Teletype will respond with a dot (.). OS/8 is now active. At this point, WRITE ENABLE unit 0.

The contents of the 12K TD8E Bootstrap are included here in the event that the user might wish to manually load the bootstrap.

```
                        *7300
7300    1312  K1000,    TAD GET         /PUT DRIVE IN REVERSE
7301    4312            JMS GET         /LOOK FOR END ZONE
7302    4312            JMS GET         /LOOK FOR 31 CODE
7303    6773  RD,       SDSQ            /NOW READ ALL WORDS
7304    5303            JMP .-1         /INTO CORE
7305    6777            SDRD            /READ 12 BIT WORD
7306    3726            DCA I WCT       /AND PUT IT IN CORE
7307    2326            ISZ WCT
7310    5303            JMP RD          /LOOP UNTIL FIELD 0
7311    5732            JMP I STRT      /IS LOADED, THEN START
7312    2000  GET,      2000
7313    1300            TAD K1000       /SET MOTION & DIRECTION
7314    6774            SDLC
7315    6771  BSRCH,    SDSS            /HERE WAIT FOR EITHER 22
                                        /OR 31 CODE
7316    5315            JMP .-1         /22 IS END ZONE, 31 IS
7317    6776            SDRC            /CODE BEFORE DATA WORD
7320    0331            AND K77         /IS THIS WHAT WE WANT?
7321    1327            TAD BM22        /THIS GETS INCREMENTED
7322    7640            SZA CLA         /IF YES, RETURN
7323    5315            JMP BSRCH       /NO, KEEP LOOKING
7324    2321            ISZ .-3         /LOOK FOR NEXT IN LIST
7325    5712            JMP I GET
7326    7354  WCT,      7354            /START LOADING CORE
                                        /AT 7354
7327    7756  BM22,     -22             /THE OTHER BOOTSTRAP
7330    7747            -31             /GETS LOADED AT 7400
7331    0077            77
7332    7400  STRT,     7400
```

Both the 8K-ROM and 12K TD8E bootstraps perform the same function: reading record 0 of the sytsem tape into core, and then starting it at location 7400 in field 0. The code that is read into 7400 is a larger bootstrap which installs all core resident tables and then turns control over to the Keyboard Monitor. The 12K system must move down to tape block 154 to accomplish the full bootstrap, which explains the extra tape motion.

When the TD8E system (either 8K-ROM or 12K) is initialized, only DECtapes 0 and 1 (DTA0, DTA1) are available on the system. The others (DTA2-DTA7) are not in the system. To make other drives available, OS/8 BUILD must be used. Reference the BUILD section of this manual for details concerning re-configuring a system.

LINCTAPE (PDP-12 USERS)

The following is the bootstrap procedure for PDP-12 systems:

1. Mount the system LINCtape (DEC-12-OSYSA-A-UO) on unit 0, WRITE LOCKed and in the REMOTE position. Set the Teletype to LINE.
2. Set the left switches to 0700.
   Set the right switches to 0000.
   Set the MODE key to LINC.
3. Press I/O PRESET.
4. Press DO.

The LINCtape bootstrap will be executed causing unit 0 to move. When it stops, press the START 20 key. Unit 0 will again move, and the Teletype will respond by typing a dot (.) at the left margin. OS/8 is now active, and tape unit 0 should be set to WRITE ENABLE.

Building OS/8 From Paper Tapes

An OS/8 system can be initially constructed on a device from the paper tapes supplied with each OS/8 kit. This is only necessary when DECtape is not available as a system device (although initial systems can also be constructed on DECtapes).

Building an OS/8 system from paper tapes may be done in two distinct ways: using the CONFIG tapes supplied with OS/8, and using the system library program BUILD.

CREATING OS/8 WITH CONFIG

The CONFIG tapes are standard configurations supported by

OS/8 which contain device handlers for the system. They allow the user to build a disk based system using the following devices[2]:

DF32 disk (2 platters)
RF08 disk (1 platter)
RK8 disk

The CONFIG tapes should be used when high-speed paper tape input is not available. Since the paper tape reader/punch (devices PTR, PTP) on systems created with CONFIG utilize the ASR-33 as the reader/punch, the CONFIG method of building OS/8 should be used only by those systems not having the high-speed unit. (If high-speed I/O is available, the initial system can be constructed using OS/8 BUILD. See the section entitled Creating OS/8 with BUILD.)

Follow this procedure to create an OS/8 system using the low-speed reader:

1. Load the RIM and Binary Loaders. For convenience, assume that the Binary Loader is in field 0. (This is not required, it may go into any available memory field.)
2. Load the OS/8 binary tape (DEC-S8-OOS8A-A-PB) into field 0 using the Binary Loader. (See Appendix A for details of using the Binary Loader.) The tape should read in and stop on binary leader/trailer. If no checksum error has occurred (i.e., AC=0), proceed with step 3; if the AC is non-zero after step 2, try reloading the tape.
3. Several configuration tapes (CONFIG), corresponding to the different possible system devices supported by OS/8, are supplied with the OS/8 kit. These are:

CONFIG Tape #	System Device
DEC-S8-ODRKA-A-PB	RK8 disk
DEC-S8-ODRFA-A-PB	RF08 disk (1 platter)
DEC-S8-ODDFA-A-PB	DF32 disk (2 platters)

(The source of CONFIG is distributed on three separate paper tapes labeled DEC-S8-OCFGA-A-PA1, -PA2, -PA3 respectively.)

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[2] If DECtape or LINCtape is the system device no initial system generation is required.

After the OS/8 binary tape has been loaded in properly, place the appropriate CONFIG binary tape in the low-speed reader and press CONTinue; this loads the tape into field 0. If the AC = 0 proceed to step 4. If the AC is non-zero, repeat step 3.

NOTE

The system device to be used *must* be WRITE ENABLEd at this point. Start the computer at location 0200 in field 0. This causes parts of the Monitor to be written to the system device. The computer should halt with 7777 in the AC. (If the AC does not contain 7777, go back to step 2; if the AC is 7777, proceed to step 4.)

4. Place the Command Decoder binary tape (DEC-S8-OCMDA-A-PB) in the low-speed reader, and load it using the Binary Loader (which is still in core in memory field 0). If the AC = 0 at the completion of loading, proceed to step 5. If the AC is non-zero, repeat step 4.
5. Start the computer at 0200 in memory field 0. This causes the Command Decoder and ODT to be written to the system device. The Keyboard Monitor is then activated—the Teletype prints a dot (.), and OS/8 is active.

OS/8 is up and running; the default device is the same as the system device. ABSLDR (which resides on the system device) should now be used to load the various system programs. Refer to the section entitled Loading OS/8 System Programs for details.

Disk Bootstrap

Once an OS/8 system has been built on a disk (RF08/DF32 or RK8), it may occasionally be necessary to start (bootstrap) the system into operation when nothing is in core. For example, whenever an RK8 disk cartridge is placed into its slot and is to be used, the system should be bootstrapped. Also, if a program error is encountered such that the contents of page 7600 in either field 0 or field 1 are in doubt, the system should be restarted.

The bootstrap for the RF08 and DF32 disks is:

Location	Contents
07750	7600
07751	6603
07752	6622
07753	5352
07754	5752

After depositing the bootstrap, the computer should be started at location 7750 in field 0. The Keyboard Monitor should respond with a dot (.). If it does not, repeat the procedure. If an error persists, consult the local DEC sales office.

The RK8 bootstrap is as follows:

Location	Contents
00030	6733
00031	5031

The computer should be started at location 30 in field 0.

NOTE

If a PDP-12 is being used, execute an I/O PRESET in 8 mode before starting at location 30.

Restart Address

If the system ever ceases apparent response to the user, the computer can be restarted at either locations 7600 or 7605 in field 0. Starting at 07600 causes the contents of locations 0-1777 to be saved on the system device. These locations are then available when the Keyboard Monitor resumes operations. Starting at 7605 does not save the core locations. Starting at 7605 saves time on a DECtape configuration.

CREATING OS/8 WITH BUILD

If a high-speed reader unit is available, the BUILD program can be used to create the initial OS/8 system from paper tapes. Follow this procedure to create OS/8 with BUILD:

1. Load the RIM and Binary Loaders into field 0.
2. Using the Binary Loader, load the BUILD binary tape (DEC-S8-OBLDA-A-PB) into core.

NOTE

Since BUILD is made up of three binary segments it will be necessary to depress CONTinue twice to completely load BUILD.

3. After the entire BUILD binary tape has been loaded with no checksum errors, (i.e. AC = 0), start the computer at location 0200 in field 0. BUILD prints:

```
HI SPEED?
```

   If a high-speed reader is contained in the system, respond YES (followed by a carriage return[3]); if only a low-speed reader is available, respond NO.
4. Make certain the system device is WRITE ENABLEd (and in REMOTE if using DECtape or LINCtape).
5. BUILD asks the user to specify which type of device will be used as the system device as follows:

```
SYS=
```

   Enter the system device to be used in the following form:

   DEV=n

   where DEV represents one of the legal replies taken from the following list. =n is optional and need only be used to indicate the number of physical disk platters which are present if the system device is RF08 or DF32. The possible replies and the maximum value of n which can be used for each one are indicated below.

Table 1 System Devices

Device		Maximum n
TC08	(TC08 DECtape)	1
TD8E	(12K TD8E)	1
LINC	(LINCtape)	1
DF32	(DF32 disk)	4
RF08	(RF08 disk)	4
RK8	(RK8 disk)	1
ROM	(TD8E with Read-Only-Memory)	1

[3] Unless otherwise indicated, all commands should be followed by a carriage return.

n must be a digit in the range 1 to 4. If no value for n is specified, a value of 1 is assumed. If a response other than a digit is entered, the message:

```
BAD #
```

is generated, and the system request is repeated. If n is specified as a digit but is too large for the device specified, the system request is repeated. For example:[4]

```
SYS=TC08=4
SYS=
```

is illegal since 4 is too large for the TC08 specification.

```
SYS=RK8=C
BAD #
SYS=
```

is illegal because C is not a digit.

```
SYS=TC08$
```

and

```
SYS=DF32=3
```

(where $ = ALT MODE) are both legal replies; n is assumed to be 1 in the first case.

6. BUILD writes data on the system device, and then types:

```
LOAD OS8↑
```

At this point load the OS/8 System binary tape (DEC-S8-OOS8A-A-PB) in the proper reader and strike any keyboard character. BUILD will load and write out the various parts of OS/8. If a SYS ERR message occurs at any time

[4] In cases in which there may be some discrepancy as to whether a character was typed by the user or by a system program, that typed by the system will be underlined.

during the load, check that the system device is WRITE ENABLEd, and go back to step 2.

7. After BUILD writes OS/8, it types:

```
LOAD CD↑
```

Place the Command Decoder binary tape (DEC-S8-OCMDA-A-PB) in the reader and strike any keyboard character. BUILD will load and write out the Command Decoder; when it has finished it will indicate this by printing on the Teletype:

```
$
```

Again, if a SYS ERR message occurs, WRITE ENABLE the system device and repeat step 2.

NOTE

There are a few points of information the user should keep in mind when using BUILD to create a system from paper tape.

a. CTRL/C (↑C) should *never* be typed during the building process. If a ↑C is typed while BUILD is loading either the OS/8 System or Command Decoder tapes to the system device, the ↑C is ignored and the user is requested to reload the tape. Thus ↑C can only serve to slow the creation process.

b. After the OS/8 System and Command Decoder tapes have been written to the system device, BUILD is ready to accept commands for adding the desired non-system devices. ↑C should *never* be used while executing these commands. The system device at this point contains no peripheral devices and no bootstrapping facilities, and typing a CTRL/C will serve no purpose. (If the user does type a ↑C, it is necessary

to type START to continue system configuration.)

c. If, by accident, the OS/8 System and Command Decoder binary tapes are loaded in reverse order, the system will be improperly generated and the building procedure must be repeated.
d. After the system has been generated using BUILD, the directory of the system device will contain the ABSLDR program. Any directory previously contained on the device will be destroyed when the system is generated from paper tape.

The OS/8 Monitor now resides on the system device. If the system had been created using the CONFIG tapes, device handlers would already have been inserted into the system. Since BUILD was used in the creation process, the only device which is available is SYS—the system device, and BUILD must now be used to insert the desired devices. The following commands are used to create the initial system. (After following this procedure, the user may wish to refer to the section at the end of this manual devoted to BUILD for detailed information concerning its use.)

In response to the $ typed by BUILD (indicated here by an underline), type the following (each command line should be followed by typing the ALT MODE key, which echoes as $):

```
$IN PT8E,PTP$
$IN PT8E,PTR$
$IN AS33$
$IN LP08$
```

These commands activate the following devices:

Permanent Device Name	Device
PTP:	High-speed punch
PTR:	High-speed reader
TTY:	Keyboard
LPT:	LP08 line printer

Next, DECtapes (if required) may be inserted in the system.

Execute *one* of the following groups of BUILD commands, depending on the type of DECtape available. The permanent names for DECtapes are DTA0-DTA7, the names for LINCtapes are LTA0-LTA7:

TC01/TC08

```
$IN TC08,DTA0$
$IN TC08,DTA1$
$IN TC08,DTA2$
$IN TC08,DTA3$
$IN TC08,DTA4$
$IN TC08,DTA5$
$IN TC08,DTA6$
$IN TC08,DTA7$
```

TD8E

```
$IN TD8A,DTA0$
$IN TD8A,DTA1$
```

LINCtape

```
$IN LINC,LTA0$
$IN LINC,LTA1$
$IN LINC,LTA2$
$IN LINC,LTA3$
$IN LINC,LTA4$
$IN LINC,LTA5$
$IN LINC,LTA6$
$IN LINC,LTA7$
```

After DECtapes have been entered, type:

```
$BOOT$
```

which initiates the final system creation process. BUILD responds with:

```
DSK=
```

The user may now specify what device is to be the default device DSK. If a carriage return or SYS is the reply, device DSK will be equivalent to SYS, the system device. Any other reply must be the

permanent name of a device which appeared in one of the IN commands. For example:

```
DSK=DTA1
```

will cause DTA1 to be used as the default device. If the device specified is not a file structured device, the request is repeated, as in the following example:

```
DSK=LPT
DSK=
```

If the device specified is not active, BUILD prints:

```
dev NOT FOUND
DSK=
```

After DSK has been specified, BUILD types out the message:

```
SYSTEM BUILT
```

and the OS/8 Keyboard Monitor is activated.

BUILD is still in core, and at this time it would be to the user's advantage to SAVE the copy of BUILD just used. This is done by the following procedure:

```
.SAVE SYS BUILD 0-7577,10000-17577=0;200
.
```

This copy of BUILD reflects the current status of the system. It can be loaded and rerun with the command:

```
.R BUILD
```

See the section concerning BUILD for details of using BUILD effectively.

Loading OS/8 System Programs

After an OS/8 system has been created from paper tapes using either the procedure involving CONFIG or BUILD, the system programs should be loaded using ABSLDR, which is resident on the system device.

NOTE

Users with DECtape (LINCtape) as the system device already have core images of the system programs on their tape. Thus, this section may be disregarded.

Use the following procedure to load the various system programs. *When an up-arrow (↑) is printed by the Command Decoder, typing any character on the keyboard in response will cause the tape to be read into core.*

PIP (DEC-S8-OPIPA-A-PB)

Place the PIP binary tape into the appropriate paper tape reader, and type the following responses to the . and * printed by the Keyboard Monitor and Command Decoder, respectively:

```
.R ABSLDR                    (RETURN key)
*PTR:=13000(89)$             ($=ALT MODE key)
```

When loading is complete, the Keyboard Monitor responds with a dot (.). Type:

```
.SAVE SYS PIP                (RETURN key)
```

PIP has been saved on the system device.

EDITOR (DEC-S8-OEDTA-A-PB)

Place the Editor binary tape in the reader, and load as follows:

```
.R ABSLDR                    (RETURN key)
*PTR:/9$                     ($=ALT MODE key)
```

The Editor is read and the Keyboard Monitor responds with a dot (.). Type:

```
.SAVE SYS EDIT               (RETURN key)
```

The Editor is now written on the system device.

PAL8 (DEC-S8-OPALA-A-PB)

Place the PAL8 Assembler binary tape in the reader, and load as follows:

```
.R ABSLDR                    (RETURN key)
*PTR:/9$                     ($=ALT MODE key)
```

The tape is read and the Keyboard Monitor responds by printing a dot (.). Type:

```
.SAVE SYS PAL8               (RETURN key)
```

PAL8 is now written onto the system device.

FORTRAN (DEC-S8-LFORA-A-PB)

Place the FORTRAN Compiler binary tape in the reader, and load as follows:

```
.R ABSLDR                    (RETURN key)
*PTR:/S$                     ($=ALT MODE key)
```

When loading is complete, the Monitor responds with a dot (.). Type:

```
.SAVE SYS FORT               (RETURN key)
```

FORT has been saved on the system device.

SABR (DEC-S8-OSABA-A-PB)

Place the SABR Assembler binary tape into the reader, and load as follows:

```
.R ABSLDR                    (RETURN key)
*PTR:/S$                     ($=ALT MODE key)
```

When loading is complete, the Keyboard Monitor responds with a dot (.). Type:

```
.SAVE SYS SABR               (RETURN key)
```

SABR has been saved on the system device.

Linking Loader (DEC-S8-OLLDA-A-PB)

Place the Linking Loader binary tape in the reader. Load as follows:

```
.R ABSLDR                    (RETURN key)
*PTR:/9$                     ($=ALT MODE key)
```

When loading is complete, the Monitor responds with a dot (.). Type:

```
.SAVE SYS LOADER             (RETURN key)
```

The Linking Loader has been saved on the system device.

LIB8 (DEC-S8-OLIBA-A-PB)

Place the Library Setup (LIBSET) (DEC-S8-OLSTA-A-PB) binary tape in the reader. Load as follows:

```
.R ABSLDR                    (RETURN key)
*PTR:/G=12600                (RETURN key)
```

When this tape is loaded, the system responds by printing an asterisk (*). Now place the LIB8 relocatable binary tape in the reader and type:

```
*/S$                         ($=ALT MODE key)
```

The tape is read, and a LIB8.RL file is created on the system device.

CREF (DEC-S8-OCRFA-A-PB)

Place the CREF binary tape in the reader. Load as follows:

```
.R ABSLDR                    (RETURN key)
*PTR:/9$                     ($=ALT MODE key)
```

After loading, Monitor responds with a dot (.). Type:

```
.SAVE SYS CREF               (RETURN key)
```

CREF is now written onto the system device.
This completes the building of the OS/8 system.

KEYBOARD MONITOR

The Keyboard Monitor provides communication between the user and the OS/8 executive routines by accepting commands from the Teletype Keyboard. The Keyboard Monitor allows the user to create logical names for devices, run system and user programs, save programs and to call ODT.

System Conventions

The OS/8 system has various conventions which are quickly mastered by even the novice programmer. Naming procedures for devices and file extensions have been designed as simple mnemonics. OS/8 makes use of the terms: "word", "page", "record", and "block" as units of storage. In directory listings and elsewhere file lengths are referenced in terms of blocks (or records). The terms are defined as follows:

$$1 \text{ block} = 1 \text{ record} = 2 \text{ pages} = 256_{10} \text{ words}$$

Each word is composed of 12 bits. The internal structure of the PDP-8 words and pages is described in detail in Chapter 2 of Introduction to Programming.

PERMANENT DEVICE NAMES

Each device in the OS/8 system is referenced by means of a standard permanent device name. These names are used in all I/O designations and are listed in Table 2.

These names are the device names assigned when the OS/8 system is configured. They may be changed by reconfiguring the system; however, caution should be observed when doing so. Certain system programs operate on the premise that a specific device name will be present in the system; for instance, PIP makes use of the device name TTY: as the default device when doing directory listings, CREF assumes LPT: as the default output device, and the Command Decoder uses device DSK: as the general default output device. Therefore, it is suggested that the following device names remain present on the system:

SYS:
DSK:
TTY:
LPT:

Table 2 Permanent Device Names

Permanent Name	I/O Device
SYS	System device (disk if the system has a large disk —RK8 or RF08; otherwise DTA0).
DTAn	DECtape n, where n is an integer in the range 0 to 7, inclusive.
LTAn	When using BUILD, LINCtapes may be called LTA rather than DTA. n is an integer in the range 0 to 7 inclusive.
DSK	The default storage device for all files. The assignment of DSK is specified at system generation time. Usually DSK is the disk on a single disk system or DTA0 on a DECtape system.
TTY	Teletype keyboard and printer.
PTP	Paper tape punch.
PTR	Paper tape reader (before accepting input, the system prints an up-arrow (↑), to which the user replies by typing any key).
CDR	Card Reader
LPT	Line printer (performs a form feed before it begins printing output from a new program).

FILE NAMES AND EXTENSIONS

Files are referenced symbolically by a name of up to six alphanumeric characters followed, optionally, by a period and an extension of two alphanumeric characters. The extension to a file name is generally used as an aid for remembering the format of a file.

In most cases the user will want to conform to the standard file name extensions established for OS/8. If an extension is not specified for an output file, some system programs append assumed extensions. Where an extension for an input file is not specified by the user, the system does a search for that file name with the default extension. Failing to find such a file, a search is then done for the original file without an extension. For example, if PROG were specified as an input file to PAL8, the Command Decoder would first look for the file PROG.PA (since .PA is the

standard extension for PAL8 input files). If PROG.PA were not found, the Command Decoder would try to find the file PROG (with no extension). As not all system programs utilize default extensions, reference the following table and the individual system programs for details:

Table 3 Assumed Extensions

Extension	Meaning
.SV	Core image file or SAVE file; appended to a file name by the R, RUN, SAVE, and GET Keyboard Monitor commands.
.FT	8K FORTRAN source file.
.SB	8K SABR source file.
.PA	PAL8 source file.
.BN	Absolute binary file (default extension for a Binary Loader input file. Also used as the default extension for PAL8 binary output file).
.RL	Relocatable binary file (default extension for a Linking Loader input file. Also used as the default extension for an 8K SABR output file).
.MP	File containing a loading map (used by the Linking Loader).
.LS	PAL8 or 8K SABR assembly listing output file.
.TM	Temporary file generated by FORTRAN or SABR for system use.

For example, if the user types:

```
.RUN DSK PROG
```

the file PROG.SV (on device DSK) is run, if found. If the user types:

```
.RUN DSK PROG.A
```

then PROG.A (on device DSK) is run, if found.

Using the Keyboard Monitor

Each command to the Keyboard Monitor is typed at the Teletype keyboard. If corrections are necessary, they must be made before entering the command line to the system. A command line is entered to the system by typing either the RETURN key, which causes a carriage return/line feed operation but no printed character, or an ALTMODE (ESCAPE on some Teletype Keyboards), which prints a $, but causes no carriage return/line feed. Correcting mistakes is accomplished by typing the RUBOUT key, which deletes the last character typed and causes a backslash (\) character to be printed followed by the character which was deleted. Successive RUBOUTS each cause one more character to be printed and deleted. The first non-RUBOUT character typed (after the last RUBOUT in a sequence) causes a closing backslash (\) to be printed, thus enclosing the deleted characters with backslashes. For example:

User types: .RUN DSK (RUBOUT) (RUBOUT) (RUBOUT) DTA1:FILE

Teleprinter
Shows: .RUN DSK\KSD\DTA1:FILE
Keyboard
Monitor sees: .RUN DTA1:FILE

If at any time an input line becomes so corrected that it is no longer intelligible to the user, he can verify the contents of the line by typing the LINE FEED key. This causes the entire input line to be echoed as the Keyboard Monitor would see it at that point. The line is not considered to be entered to the system, and the user can proceed to edit, delete, or enter the line at his discretion.
For example:

User types: .RUN DTA3\3\2:PRG \G\OG (LINE FEED key typed)
System echoes: RUN DTA2:PROG

A command line may be deleted completely before it is entered by typing a CTRL/U (produced by pressing the CTRL key and U key simultaneously). This echoes as a ↑U, and returns control to the Keyboard Monitor without accepting the current input

line. Typing a CTRL/U will *not* cause a dot (.) to be printed at the left margin; however, the Keyboard Monitor is ready to accept commands.

Control can be returned to the Keyboard Monitor while under any of the system library programs by typing a CTRL/C (produced by pressing the CTRL and C keys simultaneously). This echoes as a ↑C and the Keyboard Monitor signals that it is ready to accept input by printing a dot (.) at the left margin of the teleprinter paper.

KEYBOARD MONITOR COMMANDS

The user has a choice of nine commands which he may type in response to the dot (.) printed by the Keyboard Monitor. These are: ASSIGN, DEASSIGN, GET, SAVE, ODT, RUN, R, START, and DATE. Commands may be abbreviated by typing only the first two characters. Execution occurs after typing the RETURN or ALT MODE key.

Any errors the user may make while utilizing these commands result in an error message being typed by the Keyboard Monitor. After occurrence of an error, control returns to the Keyboard Monitor and the command must be retyped. The error messages and their explanations are listed in Table 4, following the descriptions of the commands.

ASSIGN Command

The ASSIGN command is of the form:

```
.ASSIGN dev udev
or
.AS dev udev
```

This command causes a new, user-defined device name (udev) to be considered equivalent to the permanent device name (dev). Only one user name can be associated with a single device at a time. For example:

```
.AS DTA1 IN
```

causes all future references to IN to refer to DECtape unit 1, (references can still be made to the device DTA1 also).

If a user-defined device name is not indicated, any existing

user-defined name is removed and only the permanent device name is valid. For example:

```
.AS DTA1 IN
.AS DTA1
```

The above sequence changes the name of DECtape 1 to IN and then back to simply DTA1 again.

The user-defined name is composed of up to four alphanumeric characters, the first of which must be alphabetic; the user-defined name takes procedence over the permanent name. Device-independent programs are easily possible since a change in the user name of a device by means of the ASSIGN command can change the operation of a routine without changing the code.

Although user-defined names may be four characters long, the name may not be unique in the OS/8 system. (This is due to the fact that the device name is internally coded in only one word.) A three or four character name may be tested for uniqueness by typing an ASSIGN command as follows:

.AS name

If a 'name NOT AVAILABLE' message results, the name is unique within the current system, is not in the system tables, and therefore may be used.

All user-defined device names of one or two characters in length are unique.

DEASSIGN Command

The DEASSIGN command is of the form:

.DEASSIGN

or

.DE

and causes all permanent device names to be restored, discarding all previous user-defined device names. For example:

```
.AS DTA1 IN
.DE
```

causes DECtape 1 to be assigned the name IN. The DEASSIGN command removes the name IN from the system tables; DTA1 can no longer be referenced as IN.

GET Command

The GET command is of the form:

.GET dev file.ex

or

.GE dev file.ex

The GET command loads *core image* files (.SV format, not ASCII or binary) into core from a device. This device (dev) is specified along with the file name (file) and an optional file name extension (.ex). The file is loaded into core with its core control block; the core control block is then moved to a special area on the system device, where it is maintained on the system device and contains information about the file such as its starting address and areas of core occupied by the file. Also contained is a Job Status Word, which is saved (with the SAVE command) and loaded in location 7746 of field 0 with the file to indicate what parts of core the file uses and how, as follows:

Job Status Word

Bit Condition	Meaning
Bit 0 = 1	File does not load into locations 0-1777 in field 0, (0000-1777).
Bit 1 = 1	File does not load into locations 0-1777 in field 1, (10000-11777).
Bit 2 = 1	Program must be reloaded before it can be restarted because it modifies itself during execution.
Bits 3 – 9	Unused, and reserved for future expansion.
Bit 10 = 1	Locations 0-1777 in field 0 need not be saved when calling the Command Decoder overlays.
Bit 11 = 1	Locations 0-1777 in field 1 need not be saved when calling the USR.

A core control block is created for each core-image file when the file is created by the Linking Loader, ABSLDR, or the SAVE command.

If a file name extension is not specified to the GET command, the extension .SV (for core-image file) is added automatically to the file name. For example:

```
.GE DTA3 OH
```

attempts to fetch the file OH.SV from device DTA3.

The GET command is typically used before a debugging session with ODT. GET is used to load the object program into core, then ODT is called, and the program can be altered and/or debugged (see the section on ODT for more details).

SAVE Command

The SAVE command is of the form:

```
.SAVE dev file.ex a-b,c,...;s=n
```

or

```
.SA dev file.ex a-b,c,...;s=n
```

where:

a-b,c,... are the addresses of the areas and locations in core to be saved. (In this case, locations a through b, location c, and any other specified locations.) a, b, and c are five digit locations. (The first digit represents the field.) When a single location is indicated (c) the entire page on which c is located is saved.

;s is the starting address of the file.

=n n is a four digit octal number representing the contents of the Job Status Word (see the GET command).

The program currently in core is saved on the device (dev) specified, with the file name indicated (file.ex). If an extension is not specified, the extension .SV is automatically added by the system. If the remaining arguments are not given, the required information is taken from the current core control block (refer to the GET command).

There are some restrictions on the SAVE arguments which should be noted:

1. Each set of limits (a-b) must be in the same field and not cross field boundaries. For example:

```
.SAVE SYS FOO 0200-20200
```

   is illegal since the limits transcend a field boundary.
2. No two sets of limits can overlap; (i.e. a-b, c-d must not overlap). In fact, once a location on a specific page is included in the limits, any other location on that core page, whether overlapping or not, will produce an error message. For example:

   `.SAVE SYS FOO 0-177,200-377` is legal, but

   `.SAVE SYS FOO 0-200,201-377` is illegal.

3. In SAVEs involving memory fields other than field 0, the field must be specified before each of the two core limits. If the field is unspecified, field 0 is assumed. Thus:

   `.SAVE SYS FOO 20200-0377` is illegal, while

   `.SAVE SYS FOO 20200-20377` is legal.

4. SAVE files can include 7600 in any field. However, *extreme* care must be taken when manipulating these areas, particularly in fields 0 and 1, as the system resident code could be destroyed by GETting area 07600-07777. It is suggested that SAVEs involving 7600 be limited to fields above field 2.

If an error message is printed in response to a SAVE command, the program currently in core has not yet been saved.

Examples of SAVE commands are:

```
.SAVE DSK CPROG 55,10500-10577;10502
```

This statement saves the program in core on the disk as a file named CPROG.SV. The areas of core saved are locations 0 to 177 in field 0 and locations 400 to 577 of field 1 (when a single core location or part of a page is indicated, the entire page on which the locations occur is saved). The starting address of the program is 502 in field 1. The core control block is updated to contain this information and the old Job Status Word is taken intact from the original core control block.

```
.SAVE DSK CPROG
```

The above statement causes the program in core to be saved on device DSK under the name CPROG.SV where the areas of core to be saved are taken from the core control block currently available.

ODT Command

The ODT command is of the form:

.ODT

or

.OD

This command causes the system ODT to be loaded into core and started. ODT is a system overlay, and as such takes up none of the user's program area unless the breakpoint feature is used, in which case ODT uses locations 4, 5, and 6 of every field in which a breakpoint had been placed. When using ODT to debug programs, the user-defined device names cannot be used; each I/O device must be called by its permanent device name.

ODT is described in greater detail later in this manual.

RUN Command

The RUN command is of the form:

.RUN dev file.ex

or

.RU dev file.ex

The RUN command, like the SAVE command, handles *only* core-image files. The file indicated (file.ex) on the device specified (dev) is loaded into core and its core control block is moved to the system scratch area. The program is started at its starting

address. The RUN command is equivalent to a GET and a START command.

If an extension to the file name is not specified, the extension .SV is automatically added to the file name. For example:

```
.RU DTA1 PROG
```

causes the file PROG.SV on DECtape 1 to be loaded and started.

R Command

The R Command is of the form:

.R file.ex

and is similar to

.RUN SYS file.ex

This command handles only core image files from the system device. The file is loaded and started. If the file name extension is not specified, the extension .SV is automatically added.

The R command differs from the RUN command in that a core control block is *not* written to the system device. In order to save a program which does not have its core control block in the usual location on the system device, all the optional arguments of the SAVE command must be explicitly stated. System programs are most often called using the R command, since they need not be resaved.

To call a program which is to be later up-dated and saved, use of the RUN or GET commands is suggested.

START Command

The START command is of the form:

.START nnnnn

or

.ST nnnnn

The program currently in core is started at location nnnnn. If the argument nnnnn is omitted, the program is started at the starting address specified in the core control block.
For example:

```
.ST 10555
```

starts the program in core at location 555 in field 1.

```
.ST
```

starts the program at the starting address given in the core control block.

The START command clears certain areas of core—the device handler in core table and the Command Decoder output area.

DATE Command

The DATE command is of the form:

.DATE mm/dd/yy

or

.DA mm/dd/yy

The DATE command sets up the date in the system for purposes of dating directory entries and listings, printing on program output, etc. For example:

```
.DA 3/13/70
```

indicates that the date is March 13, 1970.

Keyboard Monitor Error Messages

Table 4 lists the generalized and command Keyboard Monitor errors. All errors return control to the Keyboard Monitor and the command must be retyped. xxxx indicates the core location where the error was detected.

Table 4 Keyboard Monitor Error Messages

Message	Meaning
BAD ARGS	The arguments to the SAVE command are not consistent and violate restrictions listed in 1, 2, 3 under SAVE command.
BAD CORE IMAGE	The file requested was not a core-image file (it could have been an ASCII or binary file).
BAD DATE	The date has not been entered correctly (using slashes), or incorrect arguments were used.

Table 4 (Cont.) Keyboard Monitor Error Messages

Message	Meaning
ILLEGAL ARG.	The SAVE command was not expressed correctly; illegal syntax used.
MONITOR ERROR 2 AT xxxx	Attempt made to output to a WRITE-LOCKed device, usually DECtape; or an error has occurred reading/writing a directory.
MONITOR ERROR 5 AT xxxx	An error occurred while doing I/O to the system device. This error is normally the result of not WRITE-ENABLE the system device.
MONITOR ERROR 6 AT xxxx	This message results if a directory overflow has occurred (no room for tentative file entry in directory).
name NOT AVAILABLE	The device with the name given is not listed in any system table, or it is not available for use at the moment (check the device in question), or the user tried to obtain input from an output-only device (such as the high-speed paper tape punch).
name NOT FOUND	The file with the name given was not found on the device indicated, or the user tried to input from an output-only device.
NO!!	The user attempted to start (with .ST) a program which cannot be started. The user must not restart any user program or system library program which modified itself while in core (bit 2 of the Job Status Word is set; see the GET command for details.)
SAVE ERROR	An I/O error has occurred while saving the program. The program remains intact in core.
SYSTEM ERR	An error occurred while doing I/O to the system device. The system should be restarted at 7600 or 7605. Do *not* press CONTinue, as this is sure to cause further errors.

Table 4 (Cont.) Keyboard Monitor Error Messages

Message	Meaning
TOO FEW ARGS	An important argument has been omitted from a command. For example, .RUN DSK would generate this message, as the program to be run has not been entered in the command.
USER ERROR 0 AT xxxx	An input error was detected while loading the program. xxxx refers to the Monitor location where the error was generated.
abcd?	Where abcd is not a legal command; for example, if the user typed: .HELLO the system would echo: HELLO?

COMMAND DECODER

Once a system program has been called via the Keyboard Monitor, that system program may make use of the Command Decoder by permitting the user to enter a list of I/O files and devices. The Command Decoder prints an asterisk (*) at the left margin to indicate it is ready to accept a command string.

The Command Decoder uses the same keyboard characters as the Keyboard Monitor for the purpose of correcting typing mistakes. The RUBOUT key deletes one character per rubout. The CTRL/U (↑U) combination deletes an entire line. CTRL/C returns the user to the Keyboard Monitor, and the LINE FEED key causes the entire line to be printed on the teleprinter paper as it appears in the Teletype input buffer.

The description of files, file names, extensions, devices, and device names is contained in the section concerning the Keyboard

Monitor; this description pertains to the Command Decoder as well.

Command Decoder Input String

The expected string for I/O specification takes the form:

DEV:OUTPUT FILES<DEV:INPUT FILES

(While the left angle bracket (<) is the accepted divider character between output and input files, the back arrow (←) may also be used.) There may be 0-3 output files and 0-9 input files, depending on the requirements of the individual system program. The particular I/O string used with each system library program is described in its respective section.
For example:

```
*DTA1:XY1,LPT:<DSK:PROG
```

The PAL8 assembler would use the first output file (DTA1:XY1) for the binary output of the assembly and the second output device (LPT:) for the listing. DSK:PROG or PROG.PA is the input source file.

Multiple file specifications are separated by commas. If no output files are indicated, the left angle bracket can be omitted. For example:

```
*DSK:PROG
```

would cause the file PROG on device DSK to be accepted as an input file.

The forms in which I/O files may be specified in a command string are illustrated below:

File Specifications

Form	Example	Meaning
DEVICE:FILE NAME	`*DTA3:FILE1`	The I/O file is to be found under the specified name (FILE1) on the device indicated (DTA3:)

File Specifications

Form	Example	Meaning
DEVICE:	*LPT:	When a device is indicated without an associated file name, the device is usually a non-directory device. (If a directory device is used, the device can be read, but not written; for example, referencing DTA0 causes the entire DECtape Unit 0 to be used as the input file. DSK: is always the default output device.)
FILENAME	*NAME<DTA2:PROG	A file name used without an associated device indicates that the file will be found on an assumed device. For all output files and the first input file, the device is assumed to be DSK:. The example indicates DSK:NAME as an output file. For input files after the first, the device is assumed to be the device of the previous entry. For example:

```
*DSK:PROG1<DTA1:FILE1,FILE2,FILE3
```

causes the three input files to be taken from DTA1.

NULL FILE

```
*,LPT:<DTA1:QUEST,DTA2:STAR
```

The absence of an explicit file specification has different meanings in context, and is indicated by a comma which is not preceded by a file designation. For output files, a null file indicates that there is no

Form	Example	Meaning
		output file for this position. If the example given were an input line to PAL8, the first output file (binary) would not be generated, but the listing would be output to the line printer. For input files, a null file indicates that the device of the most recent entry is to be used as a non-directory device:

```
*DSK:A<PTR:,,
```

This input string allows three paper tapes to be read from the high-speed reader.

EXAMPLES OF COMMAND STRINGS

Some examples of command strings specifying I/O are shown below with appropriate explanations.

Example 1:

```
*DSK:BINARY,LPT:<SOURCE
```

The file named SOURCE is the input file on device DSK: The two output files are BINARY on DSK, and a second file on the line printer (LPT). The PAL8 assembler uses this format; however, the assembler also adds the extension .BN onto the file labeled BINARY. Thus, the output file on device DSK: will be named BINARY.BN.

Example 2:

```
*INPUT1,INPUT2,INPUT3,PTR:,
```

This is a string of input files with no output file. Notice that the left angle bracket is not necessary if there are only input files specified. This type of input might be given to one of the loaders (which do not require output files). Three files are taken from device DSK and then two are taken from the paper tape reader (PTR:,).
Example 3:

```
*DTA2:A,B<XYZ:C,D
```

The input files C and D are taken from device XYZ (which could be any device with the user-defined named XYZ). The output files are a file named A on DTA2 and a file named B on DSK.
Example 4:

```
*,LPT:<SRC
```

The input file is named SRC and is on DSK. The two output files specified are one null file (no output file in that position) and a file to be sent to the line printer (LPT).
Example 5:

```
*PTR:,,DTA1:X
```

As in Example 2, this is another input only file string. The first input file comes from the paper tape reader, as does the second (PTR:,,). The third input file is named X and is on DTA1.
Example 6:

```
*A<TTY:,
```

Both input files in this example come from the Teletype (generally the low-speed reader). The single output file is named A and is stored on DSK.

INPUT/OUTPUT SPECIFICATION OPTIONS

In addition to output and input files which are indicated on the file specification line to the Command Decoder, there are various options which can also be indicated on this line. These options are interpreted by the individual system programs and are covered

in detail in the sections describing the various programs. Options are either numbers or alphanumeric option characters.

Numbers used as options are generally contained in the command line with the equal sign (=) or square brackets ([ ]) construction. The alphanumeric option characters are set off from the I/O specifications by the slash (/) character for single character options, and parentheses for a string of single characters. The usage of the slash, parentheses, equal sign, and square brackets is explained below. These explanations will serve as references and format specifications once the user has learned from reading about each individual program which options he will be needing.

The format for input to the Command Decoder looks generally like the following:

DEV:OUPUT FILES<DEV:INPUT FILES/OPTIONS

The Slash Construction

A single alphanumeric option character is preceded by a slash and can occur anywhere in the input line, even in the middle of a name, although the usual position is after the input files. For example:

```
*TTY:/L<DSK:AB
```

is equivalent to:

```
*TTY:<DSK:AB/L
```

The option specified is L, which PIP interprets as a command to list the DSK directory beginning at file AB.

The Parentheses Construction

Any number of option characters can be grouped together inside parentheses. This construction is also valid anywhere in the input line. For example:

```
*OUT:X<IN:Y(AQZ)
```

is equivalent to:

```
*OUT:X<IN:Y/A/Q/Z
```

The Equal Sign Construction

An octal number up to seven digits long and preceded by an equal sign (=) may optionally be used as an indicator. This construction is often used to set a starting address, but may be assigned other functions as well. It may only occur once in a line and must be followed by a separator character (comma, left angle bracket, back arrow, ALT MODE key or RETURN key) or by other options and a separator character. The following example uses the equal sign construction and indicates three separate options:

```
*FILE1=1002(AQX),FILE2
```

Interpretation of options and = sign numbers varies depending upon the program which called the Command Decoder. See the individual system programs for details.

The Square Bracket Construction

The square bracket construction can only occur immediately after an output file name and consists of an open bracket, a *decimal* number between 1 and 255, and a close bracket. The square bracket construction is generally only used by the more sophisticated user to optimize file storage.

The open bracket ([) is produced by holding down the SHIFT key while typing a K (i.e., SHIFT/K); the close bracket (]) is produced by typing a SHIFT/M. This construction is used to provide an upper limit on the number of blocks (256 words per block) to be contained in the output file in order to allow the system to optimize file storage. For example:

```
*BINARY[19],LISTING[200]<SOURCE/8
```

The output files are a file named BINARY on device DSK: having a maximum length of 19 blocks, and a file name LISTIN (only six characters are significant) on the device DSK with a maximum length of 200 blocks. The input file is SOURCE on device DSK; the option specified is 8, which is interpreted by the program being run.

Notes On Device Handlers

The device handlers supplied with the OS/8 system have certain operating characteristics which the user should understand. Most of these are extremely simple and require no action on the part of the user. Some device handlers perform additional operations for the user when I/O is being performed on a given device.

The device handler for the high-speed paper tape reader, before reading a tape, prints an up arrow (↑) and waits for the user to type any single character at the keyboard.[5] This gives the user time to check the reader to be sure the tape is loaded correctly, and it facilitates reading multiple tapes. Characters are read from the paper tape and packed into an input buffer. The end of the paper tape or a full input buffer causes the buffer to be made available to the user program. Typing CTRL/C while the tape is moving causes a return to the Keyboard Monitor.

The handler for the high-speed paper tape punch unpacks characters from the output buffer and punches them on paper tape. Typing CTRL/C causes a return to the Keyboard Monitor. The punch must be manually turned on before an attempt is made to output to that device.

In addition to the handler for the high-speed reader/punch (type PC8-E), a similar handler is available for the ASR-33 Teletype low-speed reader/punch. This handler allows users not having high-speed I/O to read and punch binary format tapes. (The standard TTY handler cannot be used for binary format tapes, as the binary format can appear as control characters to the handler.) The operation of this handler is exactly the same as that for the PC8-E reader/punch, and can be made a part of the system by altering the device configuration. For more information, refer back to Getting On Line With OS/8, or to the section concerning Using BUILD, which describes how to insert new devices into the system.

The line printer performs a form feed operation before beginning an output task. The characters are unpacked from the output buffer and printed. A form feed is also produced following the completion of an output task. Typing CTRL/C while the line printer is in operation causes a return to the Keyboard Monitor.

---

[5] When using PAL8, the user is required to load the source tape three times for the three passes of the assembler; each pass generates an up arrow.

A CTRL/Z found in the output buffer causes printing to terminate and a form feed to be produced.

The line printer handler for the LP08 (LE8) printer is capable of using either the 80 or 132 column printers. The program BUILD can be used to make the appropriate change. (Refer to the ALTER command in the section concerning BUILD for this procedure.)

The Teletype handler performs I/O transfers between the Teletype keyboard and an input buffer, or between an output buffer and the teleprinter. A CTRL/O typed while output is being printed terminates printing of the current output buffer. A CTRL/C typed at any time during input or output causes a return to the Keyboard Monitor. Typing CTRL/Z as input terminates input and gives an end-of-file indication to the calling program. The teleprinter echoes all typed input and performs a line feed operation after any typed carriage return. The Teletype handler should *not* be used to read binary tapes from the low-speed reader.

The device handler for the card reader reads cards in alphanumeric format from either a punched card reader or an optical mark card reader. Card format can have up to 80 characters per card; trailing blanks are deleted from each card. Blank cards cause a carriage return/line feed to be entered into the data stream. Typing CTRL/C while cards are being read terminates reading and returns control to the Keyboard Monitor. Typing CTRL/Z terminates further reading and acts as if an end-of-file card was read. (An end-of-file card contains a ← character in Column 1 (0-8-5 punch) with the remaining columns blank. Either CTRL/Z or the end-of-file card is necessary to terminate reading.) It is not possible to RUN or GET a program from the card reader as these commands assume a directory device. Any DECtape other than the system device (if it is a DECtape system) can be interrupted with a CTRL/C, returning control to the Keyboard Monitor. DECtape Unit 0 on a DECtape system must *never* be WRITE LOCKed while operating OS/8.

The DSK and SYS device handlers work automatically without any user intervention. Consult the *OS/8 Software Support Manual* (DEC-S8-OSSMA-A-D) for additional information on devices and device handlers.

Command Decoder Error Messages

The following is a complete list of the error messages which the Command Decoder generates if a command string is improperly input.

Table 5 Command Decoder Error Messages

Message	Meaning
ILLEGAL SYNTAX	The command line was formatted incorrectly.
name DOES NOT EXIST	The device with the name specified could not be found in the system tables.
name NOT FOUND	The file with the name specified does not exist on the device indicated.
TOO MANY FILES	More than three output files or nine input files were specified.

SYMBOLIC EDITOR

The Symbolic Editor is used to create and modify ASCII source files so that these files may be used as input to other system programs (such as FORTRAN, SABR, and PAL8).

The Editor considers a file to be divided into logical units called *pages*. A page of text is generally 50-60 lines long, and corresponds approximately to a physical page of a program listing. (Note that this is *not* the same as a core memory page.) The Editor reads one page of text at a time from the input file into its internal buffer where the page becomes available for editing. The Editor contains commands for creating, modifying, or deleting characters, lines, or complete logical pages of text.

Calling and Using the Editor

To call the Editor from the system device, type:

```
R EDIT
```

in response to the dot (.) printed by the Keyboard Monitor. The system prints an asterisk (*) at the left margin, and in answer to the asterisk, the user types the device designation and the output

file name, a left angle bracket, and the input device and file designation(s). For example:

```
*DSK:ABC<PTR:,DSK:AA1
```

causes input from the paper tape reader and from a file named AA1 on DSK. The output file is named ABC and is stored on DSK.

Once I/O file designations are entered, the Symbolic Editor is ready to accept commands from the keyboard and signifies its readiness by printing a number sign (#) at the left margin. This symbol occurs whenever the Editor is waiting for a command.

Any device which operates in ASCII mode and has a device handler in the system is available for use by the Editor. For example, the high and low-speed reader/punch, DECtape, disk, card reader and line printer are each legal devices. The Editor only operates properly on ASCII files, however. No error message is given if non-ASCII files are input to the Editor, but the results of operations are garbled.

As many as nine and as few as zero input files are permitted. If the number of input files is zero, (that is, a new file is to be created using the Teletype keyboard) the Editor allows input from the keyboard via the Append command.[6] The Editor uses a keyboard input routine which is independent of the OS/8 Teletype handler, thus it is not necessary to specify TTY: as an input device if text is to be created. (It is, in fact, recommended that TTY: *not* be used as an input device, as input buffering may cause a loss of characters on input.) Commands which attempt to read from any other device (when no file name is specified) are disabled, and a question mark (?) appears when a Read command is attempted.

The Editor allows only one output file. If no output file is specified, the only output operations which may be performed are L (list buffer on TTY:) or V (list buffer on LP08 line printer).

Chaining to the Editor is not permitted, and will produce a fatal error message (?5↑C). Attempts to restart after this error will produce NO!! from the Keyboard Monitor.

---

[6] See Example Using the Editor for an illustration of using the Editor to create a program.

EDITOR OPTIONS

The following two options are the valid I/O specification options for the Editor. (The format for I/O specification options has been previously described in the section detailing the Command Decoder. After reading these options, the reader is advised to turn to that section to review the various formats.)

Table 6 Editor Options

Option	Meaning
/B	Convert two or more spaces to a TAB when reading from input device.
/D	Delete the old copy of the output file (if one exists) before opening the new output file on the device. If /D is not used, the old copy of the output file is not deleted until all data has been transferred to the new file by an E or Q command.

For example, the I/O specification line:

```
*DTA2:FILE<DTA1:ARG/D
```

deletes FILE on DTA2 (if such a file exists) before creating a new FILE on DTA2.

Special Key Commands to the Editor

The Editor can be considered as operating in two different modes. During *command mode,* the Editor prints a # at the left margin of the teleprinter paper indicating that it is waiting for a command from the keyboard. *Text mode* is the condition of the Editor when it is processing various editing and I/O commands (such as Insert and Append).

The following commands allow the user to transfer between modes. (These commands are produced by pressing the CTRL key and the appropriate character key simultaneously.)

Table 7 Editor Key Commands

Command	Mode in Which Used	Meaning
CTRL/C	Text and command mode	Returns control to the Keyboard Monitor. The text buffer is retained and the Editor remains accessible to the user with the START command. In text mode, text between the last carriage return and the ↑C is lost. The START command can be used to restart the Editor as follows: ↑C .START * START recalls the Command Decoder to accept new I/O file designations. When the START command is given, and the previous output file is not closed, that output file and the contents of the output buffer are deleted.
CTRL/O	Text Mode	Stops the listing of text. Returns control to Command Mode.
CTRL/FORM	Text Mode	Returns the Editor to Command Mode.
CTRL/U	Text Mode	Typing CTRL/U while entering text from the keyboard causes text in the current line to be ignored. A carriage return/line feed is generated and the line may be retyped. (The command is equivalent to typing rubouts back to the beginning of the line.)

Other special Editor characters used to represent numbers or perform erasures are listed in Table 8:

Table 8 Special Characters

Character	Example	Meaning
.	.+1C .-7L .L	The dot (.) character is used as the current line counter character. The dot can be used alone, with + or − an integer, or any place where a number can be used.
/	/-7L /-5L	The slash character is similar in use to the dot and represents the highest numbered line in the text buffer.
RUBOUT Key		Typing the RUBOUT key in text mode deletes one character from the text buffer and causes a backslash to be printed. The erasure is done right to left up to the last CR/LF. Typing the RUBOUT key in command mode causes the entire command line to be deleted.

Editor Text Buffer

In text mode, the Editor performs I/O operations on text stored within the text buffer. Text is input to the Editor buffer until a form feed is encountered on input. A line of text is terminated by a carriage return. If no carriage return is present, the text entered on that current line is ignored. The buffer has room for approximately 5600 (decimal) characters. When text has been input to the extent that there are only 256 decimal locations available in the buffer, the TTY rings a warning bell. From this point on, whenever a carriage return is detected during text input, control returns to the Editor command mode and the TTY bell is rung. This line-at-a-time input may continue until the absolute end of buffer is encountered. At this point, no more text will be accommodated in the buffer; a '?' is printed and control returns to command mode.

TEXT COLLECTION

The OS/8 version of the Editor contains an automatic *text collector* which reclaims buffer space following the use of a D (delete), S (Search), or C (Change) command. Formerly, deleted text was

not physically removed from the buffer; now this text is removed by the text collector, and the necessary pointers updated. If a full buffer condition is reached, the user may output lines of text (using the Punch command, for example), and then delete these lines from the buffer—text collection is automatic and always occurs on the three commands mentioned above.

NOTE

If extremely large amounts of text are deleted, the text collection process could take several seconds. For small amounts of text, no appreciable time is lost.

Search Mode

There are two types of searches available in the Editor. The first is the standard character search, and the second is the character string search which allows the user to search for a combination of characters. Each is explained in turn.

SINGLE CHARACTER SEARCH

The single character search is of the form:

#S
or #nS
or #m,nS

where m and n represent line numbers ($m \leq n$), and S initiates the search command.[7] This search command searches the entire text buffer or the line(s) indicated for the search character. The search character is typed by the user after he types the RETURN key which enters the command, and does not echo on the teleprinter. The Editor prints the contents of the entire buffer or the indicated line(s) until the search character is found. When the search character is found, printing stops and the user may type one of the following:

---

[7] A command summary is included in Table 10 at the end of this section.

Option	Result
text	Enter text at that point at which the search character was found and printing stopped.
CTRL/G (TTY bell rings)	Change the search character to the next character typed; search continues. If the character is not contained in the line, the remainder of the line will be typed and control will be returned to command mode.
CTRL/FORM	Continue searching for the next occurrence of the character.
RETURN key	End line here, deleting all subsequent text on that line.
LINE FEED key	Make two lines out of the current line by inserting a carriage return at this point.
RUBOUT key	Delete characters from this line. Each rubout echoes a backslash (\) for each character deleted. When all characters have been deleted, echoing of '\' stops.

CHARACTER STRING SEARCH

The character string search can identify a given line in the buffer by the contents of that line or any unique combination of characters. This search returns the line number as a parameter that can be used to further edit the text. There are two types of string search available: intra-buffer search and inter-buffer search.

Intra-Buffer Character String Search

The intra-buffer search scans all text in the current buffer for a specified character string. If the string is not found, a ? is printed and control returns to command mode. If the string is found, the number of the line which contains the string is put into the current line counter and control waits for the user to issue a command.

Thus, searching for a character string in this manner furnishes a line number which can then be used in conjunction with other Editor commands. This provides a useful framework for editing, as it eliminates the need to count lines or search for line numbers by listing lines.

An intra-buffer search is signalled by typing the ALT MODE key (which echoes as $) in response to the Editor's #. The user then types the string to be found (up to 20 characters long—any additional characters typed are echoed but not included in the search). The search string cannot be broken across line boundaries. Typing a single quote (') terminates the character string and causes the search to be performed beginning at line 1 of the text buffer. Use of the double quote (") causes the search to begin at the current line +1. (Use of ' and " as command elements prohibits their use in the search string.)

For example, assume the text buffer contains the following text:

```
ABC DEF GJO
1A2B3C4D5E6
.STRINGABCD
.
.
```

The user wants to list the line that contains ABC; this could be done by typing:

```
#$ABC'L
```

The search begins with line 1 and continues until the string is found. The current line counter is set equal to the line in which the string ABC occurred, and the L command causes the line to be printed as follows:

```
ABC DEF GJO
```

Control returns to command mode, awaiting further commands. If the user wanted to find the next reference to ABC, he could type:

```
#"L
```

In this case, " is a command which causes the last string searched for to be used again, with the search beginning at the current line +1. It is no necessary to enter the search string again. The command may be used several times in succession. For example, if the user wanted to find the fourth occurrence of a string containing the characters FEWMET he could type:

```
#$FEWMET'"""L
```

This command will list the line which contains the fourth occurrence of that string. The L (List) command (or any other command code) can be given following either ' or ". The L command causes the line to be listed when and if it is found.

In order to clear the text string buffer, the user can type:

```
#$'
```

The system will respond with a question mark and the text string buffer is cleared.

The properties of the commands ' and " allow for easy and useful editing, as the following example illustrates. In order to change the CIF 20 to CIF 10, the user can give the following commands:

```
#$DUM,'$CIF 20"C
CIF 10      /NEW FIELD          (CTRL/FORM)
```

The above set of instructions first causes the Editor to start at line 1 and search for the line beginning with DUM,. A search is then made for CIF 20, starting from the line after the line containing DUM,. When this string is found, the line number of the line containing the string CIF 20 becomes the current line number. The C (Change) command is given, and the user then changes the line to the correct instruction.

Since this search feature produces a line number as a result, any operations which can be done by explicitly specifying a line number can be done by specifying a string instead. For example:

```
#$STRING'+4L
```

will list the fourth line after the first occurrence of the text STRING in the text buffer.

```
#$LABEL1,',$LABEL2,"L
```

will list all lines between the two labels, inclusive.

```
#$PFLUG'S
```

will do a character search on the line which contains PFLUG. (The user types the search character after typing the RETURN key that enters the line.)

In cases where both strings and explicit numbers are used, strings should be used first. For example, the following commands:

```
#1+$BAD!'L
```

will not list the next line after the string BAD! occurs. The correct syntax is:

```
#$BAD!'+1L
```

Inter-Buffer Character String Search

The inter-buffer search scans the current text buffer for a character string. If the string is not found, the current buffer is written to the output file, the buffer is cleared, and the next buffer is read from the input device. The search then resumes at line 1 of the new buffer. This process continues until either the string is found or no more input is left. If input is exhausted, control returns to command mode with all the text having been written to the output file. If the string is found, control returns to command mode with the current line equal to the number of the line containing the first occurrence of the string. For example, a command to find the character string GONZO may appear as follows:

```
#J
$GONZO'
#.=0024
```

The J command initiates an inter-buffer search; the $ is printed automatically by the Editor, and the user types in the character

string he wishes to search for. The search proceeds, and when the string is found, control returns to command mode. The user types the .= construction to discover the number of the line in the current buffer on which the string is contained. To find further occurrences of the string GONZO, the user can use the F command. The F command uses the last character string entered to search the buffer starting from the current line count + 1.

```
#F

#.=0106
```

The above example causes a search for the string GONZO starting at the current line + 1. If no output file is specified to the J or F commands, the Editor reads the next input buffer without attempting to produce any output. This provides an easy way of paging through text for a particular string.

After the J or F commands have processed the entire input file, it is necessary to execute either an E or Q command to close the output file. If this is not done, the file will be deleted by the Monitor.

The following two commands may be used to abort the string search command, once given:

Command	Explanation

CTRL/U	A CTRL/U will return control to the Editor command mode if executed while entering text in a string search command; the string search command is ignored, as in the following example:
	
	`#J`
	`$WORD↑U`
	`#`
	
	The inter-buffer search for the characters WORD was aborted by the user typing ↑U before terminating the string with ' or ".

RUBOUT	Executing the RUBOUT key while entering text for a string search causes the text so far entered to be ignored and allows a new string to be inserted. Editor answers the command by typing $, as in the following example:

```
#$CHAR
$
```

An example of the use of the character string search is contained in the OS/8 Demonstration Run, at the end of this chapter.

Editor Error Messages

Errors made by the user while running the Editor may be of two types. Minor errors (such as an Editor command string error, an attempt to execute a read or write command without assigning a device, or a search for a non-existent string) will cause a question mark to be typed at the left margin of the Teletype paper. The command may be retyped. Major errors cause control to return to the Keyboard Monitor and may be due to one of the causes listed in Table 9. These errors cause a message to be typed in the form:

?n↑C

where n is an error code and ↑C indicates that control has passed to the Keyboard Monitor.

Table 9 Editor Error Codes

Error Code	Meaning
0	Editor failed in reading a device. Error occurred in device handler; most likely a hardware malfunction.
1	Editor failed in writing onto a device; generally a hardware malfunction.
2	File close error occurred. For some reason the output file could not be closed; the file does not exist on that device.
3	File open error occurred. This error occurs if the output device is a read-only device or if no output file name is specified on a file-oriented output device.
4	Device handler error occurred. The Editor could not load the device handler for the specified device. This error should never occur.
5	An attempt was made to CHAIN to the Editor. This is not permitted; the Editor must be loaded by a RUN or R command.

During the editing of a file, the output device specified in the command string may become full before the editing process is complete. If this is the case and a write is attempted on that device, an error occurs. The output file is closed, the message:

```
FULL
*
```

is printed; control returns to the Command Decoder for a new set of I/O specifications. The user must indicate a new output file which will contain the text that would not fit on the output device, and any further editing the user wishes to do. Since the contents of the text buffer are retained through this procedure, no text will be lost if this error occurs.

NOTE

If no output file is specified when control returns to the Command Decoder, the Editor returns to the Command Decoder again; this continues until an output device is specified. However, specifying an improper output device (such as PTR:) will cause a fatal error and the output buffer will be destroyed.

Assuming the output device is valid, the Editor will continue the operation which filled the old file, putting all output into the new output file. After editing is completed, the output files should be combined with PIP. The entire process may appear as follows:

```
.R EDIT
*OUT<IN
#Y
#J
$STRING'
FULL
*DTA3:OUT2<
#.L
          TAD STRING
#.D
#E
FULL
*DTA4:OUT3<
```

Device DSK: is full; DTA3: is specified as the new output device, and editing continues.

Device DTA3: has become full; DTA4: is now specified as the output device, and editing continues.

At this point the output "file" is the series of files—DSK:OUT, DTA3:OUT2, and DTA4:OUT3. When output is split like this, the split may have occurred in the middle of a line. Therefore, the output files should never be edited separately as the split lines will then be lost. In a case such as this, the files should be combined with PIP as follows:

```
.R PIP
*DTA2:OUT<DSK:OUT,DTA3:OUT2,DTA4:OUT3
```

The new file, OUT, may then be edited.

Example Using the Editor

The following example illustrates both the use of the Editor to create a new file, and a few of the commands available for editing. Sections of the print out are coded by letter—corresponding explanations follow the example.

A The user calls EDIT; the output file will be called FILE and will be stored on the default device. There is no input file since one will be created from the Teletype keyboard. The Append command is used to insert text into the empty buffer.

B Text is inserted.

C The user makes a mistake and uses the RUBOUT key to correct it.

D More text is added.

E The user notices a typing mistake he has made several lines back in the text. He types a CTRL/FORM to finish the Append command, searches for the illegal character, corrects it, and then lists the line.

F The P command writes the current buffer into the output file placing a form feed after the last line. The K command deletes all text in the current buffer, in preparation for a new page of text.

G The user inserts new text using the Append command. When he is finished, he types a CTRL/FORM to end the command, and

H closes out the file. Control returns to the Keyboard Monitor.

```
A   .R EDIT
    *FILE<
    #A

B   /PTP, PTR HANDLER FOR THOSE
    /WITHOUT HIGH SPEED I/O

            IFZERO NOHSPT+LIST <XLIST>
            IFNZRO NOHSPT  <

C   PTP,    Ø
            CLA CLL CMX\L    /SET LINK
            JMS PSETUP

D   PTPLP,  KSF
            JMP PTPCNT       /KEYBOARD FLAG OFF
            KRT
            AND PTP177
            TAD PTPM3

E   #.-2S
            KRT\S

    #.L
            KRS

F   #P
    #K

G   #A
            SZA CLA
            JMP PTPCNT
            .
            .
            .

H   #E
    .
```

Summary of Editor Commands

The commands discussed in Table 10 can each be given whenever the Editor prints a # at the left margin, and are of the general form:

#X
#n X

or

#m,nX

where m and n represent the line number designation, ($m \leq n$) and X represents the command letter. The command is entered to the Editor with the RETURN key. Numbers used in Editor commands are decimal numbers.

Table 10 Symbolic Editor Commands

Command	Format	Meaning
A	#A	Append the following text being typed at the keyboard until a form feed (ASCII 214 or CTRL/FORM) is found. The form feed returns control to command mode. Text input following the A command is appended to whatever is present in the text buffer.
B	#B	List the number of available core locations in the text buffer. The Editor returns the number of locations on the next line. To estimate the number of characters that can be accommodated in this area, multiply the number of free locations by 1.7.
C	#nC	Change the text of line n to the line(s) typed after the command is entered (typing a form feed terminates the command).
	#m, nC	Delete lines m through n and replace with the text line(s) typed after the command is entered. (Typing CTRL/FORM indicates the end of the inserted lines.) The C command utilizes the text collector in altering text.
D	#nD	Delete line n from the buffer.
	#m, nD	Delete lines m through n from the buffer. The space used by the line to be deleted is reclaimed as part of the DELETE function. (Refer to Text Collection in the section entitled Editor Text Buffer.)

Table 10 (Cont.) Symbolic Editor Commands

Command	Format	Meaning
E	#E	Output the current buffer and transfer all input to the output file, closing the output file.
F	#F	Follows a string search. Look for next occurrence of the string currently being searched for. (See section under Search Mode concerning Inter-Buffer Character String Search.)
G	#G	Get and list the next line which has a label associated with it. A label in this context is any line of text which does not begin with one of the following: space (ASCII 240) / (ASCII 257) TAB (ASCII 211) RETURN (ASCII 215) At the termination of a G command, control goes to command mode with the current line counter equal to the line just listed.
	#nG	Get and list the first line which begins with a label, starting the search at line n.
I	#I	Insert whatever text is typed before line 1 of the text buffer. The form feed (CTRL/FORM) terminates the entering process and sends control to the command mode where Editor prints a #.
	#nI	Insert whatever text is typed (until a form feed is typed) before line n of the text buffer.
J	#J	Inter-buffer search command for character strings (see section under Search Mode concerning Inter-Buffer Character String Search).
K	#K	Kill the buffer. Reset the text buffer pointers so that there is no text in the buffer.

Table 10 (Cont.) Symbolic Editor Commands

Command	Format	Meaning
		NOTE The Editor ignores the commands nK or m,nK. This is to prevent the buffer from accidentally being destroyed if the user means to type a List command (m,nL).
L	#L	List entire contents of the text buffer on the teleprinter.
	#nL	List line n of the text buffer on the teleprinter.
	#m, nL	List lines m through n of the text buffer on the teleprinter. Control then returns to command mode.
M	#m, n$xM	Move lines m through n directly before line x in the text buffer. The $ character represents typing the dollar sign key (SHIFT/4). The old occurrence of the moved text is removed; no buffer space is lost.
N	#N	Write the current buffer to the indicated output file and read the next logical page.
	#nN	Write the current buffer to the output file, zero the buffer, and read the next logical page. This is done n times until the nth logical page is in the text buffer. Control then returns to command mode.
		The N command cannot be used with an empty text buffer. ? is printed if this is attempted.
P	#P	Write the entire text buffer to the output buffer.
	#nP	Write line n of the text buffer to the output buffer.
	#m, nP	Writes lines m through n, inclusive, to the output buffer. When this buffer is

Table 10 (Cont.) Symbolic Editor Commands

Command	Format	Meaning
		full, the text is output to the indicated output file. The P command automatically outputs a FORM character (214) after the last line of output.
Q	#Q	Immediate end-of-file. Q causes the text buffer to be output. All text written into the output buffer is then written into the output file and the file closed, with control returning to the Keyboard Monitor.
R	#R	Read from the specified input device and append the new text to the current contents of the buffer. If no input file was indicated or if no input remains, a ? is printed and control returns to command mode.
S	#S	Character search command (see the section entitled Search Mode).
T	#T	Punch trailer tape. Causes 32 frames of blank tape to be written into the output buffer (only to non-directory devices).
V	#V	If an LP08 line printer is available, the V command causes the entire text buffer to be listed on the line printer.
	#nV	List line n of buffer on the line printer.
	#m, nV	List lines m through n inclusive on the line printer.
Y	#nY	Skip to a logical page in the input file, without writing any output. For example: #5Y reads through four logical pages of input, deleting them without producing output. The fifth page is read into the text buffer and control automatically returns to command mode.

Table 10 (Cont.) Symbolic Editor Commands

Command	Format	Meaning
$	#$TEXT" #$TEXT' #"	Perform a character string search for the string TEXT. (See the section under Search Mode concerning Intra-Buffer Character String Search). Following a string search, #" causes a search for the next occurrence of the string.
.= or .: /= or /:		By typing these characters the user can obtain the current line number (.=) and the last line number in the text buffer (/=). The number is printed by the Editor immediately after the user types the equal sign. (The colon character is equivalent to the equal sign.)
>	$>	Equivalent to .+1L; list the next line in the text buffer on the teleprinter.
<	$<	Equivalent to .−1L; list the next line in the text buffer on the teleprinter.
LINE FEED Key		Equivalent to .+1L; list the next line in the text buffer on the teleprinter.

PERIPHERAL INTERCHANGE PROGRAM (PIP)

PIP is the OS/8 system program which is used to transfer files between devices, merge and delete files, and list, zero, and compress directories.

Calling and Using PIP

To call PIP from the system device the user types:

```
R PIP
```

in response to the dot printed by the Keyboard Monitor. The Command Decoder then prints an asterisk at the left margin of the teleprinter paper and waits to receive a line of I/O files and options. PIP accepts up to nine input files and performs output to a single output file; options generally are placed at the end of the command string.

Since PIP performs file transfers for all file types (ASCII, Image or SAVE format, or Binary), there are no assumed extensions assigned by PIP to file names for either input or output files. All extensions, where present, must be explicitly specified.

Following completion of a PIP operation, the Command Decoder again prints an asterisk at the left margin and waits for another PIP I/O specification line. The user can return to the Keyboard Monitor by typing CTRL/C.

PIP OPTIONS

The various options allowed on a PIP I/O specification line are detailed in the following table. Either /A, /B, or /I is generally indicated for each transfer; if none of these are specified, the system proceeds as though /A had been typed.

Table 11 PIP Options

Option	Meaning
/A	Transfer files in ASCII mode. The file is modified as it is copied: embedded blank tape and rubouts are deleted and leader/trailer code is reduced to a standard length. PIP may also do some editing of the input file under control of the /C and /T options (see below).
/B	Transfer files in Binary mode (used for absolute and relocatable binary files). Leader/trailer code is reduced to a standard length, but the checksum is not recalculated. **NOTE** If several absolute binary files are combined into one, the /S option must be indicated to the Absolute Loader in order for the files to load properly. (The Linking Loader will not load combined files.)
/C	Eliminate trailing blanks. Valid in ASCII mode only.
/D	Delete the old copy of the output file before doing any data transfer. If /D is not used, the old copy is not deleted until all input has been processed. For example: `*DTA1:OFILE<DTA2:NFILE/D` will first delete file OFILE on DTA1, and then transfer the data from NFILE to a new OFILE. /D is useful when insufficient room exists on the output device for both the old file and the new file.

Table 11 (Cont.) PIP Options

Option	Meaning
	/D may be used to delete up to three files at a time by specifying the files to be deleted as output files and not specifying any input files. For example: *OLDABC,DTA3:FILES/D< This command string deletes OLDABC from DSK, and FILES from DTA3.
/E	List directories in extended form (the lengths of the empty files are also listed).
/F	List directories in short form (file names only).
/G	Ignore any errors which occur during a file transfer and continue copying.
/I	Transfer files in image mode. Used to transfer core image (SAVE format) files, and any other files which do not fall into either ASCII or Binary categories.
/L	List the directories of the input devices onto the output file starting at the file specified. Notice that in this case the input file itself is not transferred, only the directory. The directory listing is in extended form, but empty files are excluded.
=n	Save n extra words per file entry in the directory to contain descriptive information about the file. For use with the /Z and /S options only. Typing =1 allows the date of the file creation to be automatically stored in the directory. (=1 is assumed after /Z or /S options unless otherwise specified. Specifying =0 will still reserve one extra word per entry.)
/S	Move all files from the input device to the output device, eliminating any embedded empty files. All device names should be explicitly stated, as no default devices are assumed. The directory of the output device will contain only those files that appeared on the input device. Whenever a /S is initiated, PIP asks: ARE YOU SURE? The user responds with a "Y" if he wishes the compression; typing any other character aborts the command.

Table 11 (Cont.) PIP Options

Option	Meaning

In addition to compressing directories, /S provides a means of copying one device to another. DECtapes, for example, can be copied by compressing one DECtape onto another tape.

/T Perform the following conversions of special characters:

Character	Is Converted To:
TAB	enough spaces to reach the next TAB stop (every eighth position)
Vertical TAB	5 LINE FEEDs
FORM FEED	9 LINE FEEDs

/T option is valid in ASCII mode only.

/Y Copy the OS/8 System Area (records 0, 7-67) between the output and first input file. Both devices must be file structured devices. If no file name is specified after a device name, the System Area of that device is assumed. If the /Z option is used with /Y, a zeroed system directory is placed on the output device before the system transfer takes place. A system directory indicates that file storage starts at record 70 rather than record 7.

/Z Zero directory of output device before file transfer. Before using a DECtape for the first time, the /Z option should always be used to create an empty file directory. No input files are specified. For example:

```
*DTA2:/Z<=1
```

One extra word per entry is used if no "=" is specified. Thus, the DATE word is always left available in a new directory.

If an attempt is made to zero the directory of the system device, the message:

```
ZERO SYS?
```

is printed. A response of 'Y' will zero the directory; any other response will abort the command and return control to the Command Decoder.

No data transfer occurs if no input files are specified. Thus, as mentioned previously, /Z can be used to zero a directory, and /D can be used to delete a permanent file without creating a file. For the three directory listing options (/E, /F, /L), if no output device is specified, the device TTY; is assumed. If no input device is specified, device DSK: is assumed.

EXAMPLES OF PIP SPECIFICATION COMMANDS

The following are legal command strings to PIP. When PIP has completed an operation, control returns to the Command Decoder for additional input.

Example 1 (ASCII Transfer):

```
.R PIP
*SYS:BLACK<PTR:
```

This command string transfers a tape from the paper tape reader to a file on the system device under the name BLACK. PIP assumes that the input tape is in ASCII format. (Control returns to the Command Decoder, therefore, the .R PIP command need only be given once.)

Example 2 (ASCII File Merge):

```
*DTA3:MERGE<DTA1:FILE1,FILE2
```

This command string instructs PIP to merge the ASCII files FILE1 and FILE2 on DTA1 into one ASCII file, MERGE, on DTA3.

Example 3 (Binary Transfer):

```
*BIN.BN<PTR:/B
```

The above command reads a binary paper tape from the paper tape reader and creates a binary file BIN.BN on the device DSK.

Example 4 (Image Transfer):

```
*SYS:GAG.SV<PAL8.SV/I
```

PIP transfers the core image file PAL8.SV from the device DSK to GAG.SV on the system device.

NOTE

A problem occurs when files longer than 255 blocks are transferred in Image Mode from a directory device. If this is attemped, the transfer will not end with the real end-of-file, but will continue until the output limit is reached; an error message will occur. For example, trying to transfer FORT.PA or SABR.PA from the directory device using Image Mode will cause this error. ASCII mode must be used for all transfers of this type.

Example 5 (Directory Listing):

```
*TTY:</E
```

This command string produces an extended listing of the device DSK on the Teletype. An extended listing contains all files with their associated lengths, and all empty spaces in the directory. For example, an extended listing might appear as follows. (The current date is printed before the file listing provided the DATE command has been given; see the section concerning the Keyboard Monitor for a description of the DATE command.):

```
 2/17/72
EDIT  .SV   12 1/10/72
TEST2        4 1/10/72
ABCD  .DA    1 2/17/72
<EMPTY>      7
TEST2 .RL    4 1/10/72
<EMPTY>    702
 709 FREE BLOCKS
```

The file lengths and number of free blocks are designated as decimal values. The date of file creation is printed if at least one additional information word is present in the directory (refer to the section Additional Information Words in File Directories).

Example 6 (Directory Listing):

```
*/F
```

This command produces a directory listing of file names only. Thus, the preceding directory would appear on the teleprinter as follows:

```
 2/17/72
EDIT  .SV
TEST2
ABCD  .DA
TEST2 .RL
 709 FREE BLOCKS
```

Example 7 (Directory Listing):

```
*LPT:<DTA2:FETCH/L
```

A command such as the above produces a listing of the DTA2 directory on the line printer; however, the files that occur before FETCH are not listed. The /L option gives the regular listing which includes the file name and extension length, and date (if a date is contained in the directory). Empty files are not indicated in the listing.

Example 8 (System Area Transfer):

```
*DTA1:HEAD</Y
```

Records 0 and 7-67 are transferred from SYS: to a file named HEAD on DTA1.

Example 9 (System Area Transfer):

```
*SYS:<DTA1:HEAD/Y
```

The contents of the file HEAD on DTA1 are transferred to the System Area (records 0 and 7-67) of the system device. The input file is checked for validity before the transfer occurs.

Example 10 (System Transfer with Directory Zero):

```
*DTA1:<DTA0:(YZ)
```

This first creates a zero system directory on DTA1, and then transfers the system area from DTA0 to to the System Area on DTA1. A system directory indicates that file storage begins at record 70 rather than record 7.

Example 11 (System Area Transfer):

```
*DTA1:TRAN<DTA2:TRAN/Y
```

This command string instructs PIP to transfer TRAN from DTA2 to DTA1. Since the /Y option is used, TRAN must be a copy of the OS/8 System Area. However, since transfers of this type involve files on both the I/O devices, and not the System Area, the transfer is treated as an image transfer and either the /Y or /I options can be used.

Additional Information Words in File Directories

If a device has any additional information words specified in its directory, OS/8 automatically enters the last date specified in a DATE command into the first of the additional information words when a file is created on that device. Dates put into these additional words appear in directory listings. Words after the first are not currently used by the OS/8 system.

The system always uses one additional information word. Whenever a /Z or /S is given, one word is allocated for the DATE. Additional words can be specified by a /Z=n or /S=n construction. The number of additional words can be changed by compressing a device onto itself.

NOTE

The system is initially created with one additional word in the file directory.

PIP Error Messages

The following messages are printed by PIP in response to user errors or improper command strings:

Table 12 PIP Error Messages

Message	Meaning
ARE YOU SURE?	Occurs when using the /S option. A response of 'Y' will compress the files.
BAD DIRECTORY ON DEVICE # n	Error message occurs when: 1. PIP is trying to read the directory, but it is not a OS/8 directory. 2. The output device does not have a system directory, i.e., file storage begins at record 7 (occurs during a /Y transfer). n is the number of the file in the input file list.

Table 12 (Cont.) PIP Error Messages

Message	Meaning
BAD SYSTEM HEAD	If the /Y option is used and the area being transferred does not contain OS/8, this error message results.
CAN'T OPEN OUTPUT FILE	Message has occurred due to one of the following: 1. Output file is on a read-only device. 2. No name has been specified for the output file. 3. A /Y transfer has been attempted to a non-directory device. 4. Output file has zero free blocks.
DEVICE # n NOT A DIRECTORY DEVICE	Message occurs when: 1. Trying to list the directory of a non-directory device. 2. The input designated in a /Y transfer is not on a directory device. n gives the number of the device in the input list.
DIRECTORY ERROR	An error has occurred while reading or writing the directory during a /S option. The option is aborted; output is likely to be garbled.
ERROR DELETING FILE	An attempt was made to delete a file that does not exist. Check that the device name was explicitly given for all files.
ILLEGAL BINARY INPUT, FILE # n	Self explanatory; n is the number of the file in the input file list.
INPUT ERROR, FILE # n	An input error occurred while reading file number n in the input file list.
IO ERROR IN (file name) —CONTINUING	An error has occurred during a /S transfer. The name of the file being transferred is indicated.
LINE TOO LONG IN FILE # n	In ASCII mode a line has been found greater than 140 characters. Make certain the file is an ASCII file. n is the number of this file in the input list.

Table 12 (Cont.) PIP Error Messages

Message	Meaning
NO ROOM FOR OUTPUT FILE	Self-explanatory; either room on device or room in directory is lacking.
NO ROOM IN (file name) —CONTINUING	Occurs during use of the /S option. The output device cannot contain all of the files on the input device. The message is printed for each file which will not fit into the output device. The file name is indicated.
OUTPUT ERROR	Output error—possibly a WRITE LOCKed device, parity error, or attempt to output to a read-only device.
PREMATURE END OF FILE, FILE # n	Message occurs in Binary Mode (/B) only. A physical end-of-file has been found before the final leader/trailer.
SORRY—NO INTERRUPTIONS	Error message occurs if: 1. ↑C (CTRL/C) is typed while compressing a file onto itself; the transfer continues. 2. A /Y transfer is done with system device as the output device, or if the transfer has both input and output on the same device.
ZERO SYSTEM?	If any attempt is made to zero the system device directory, this message occurs. Responding with 'Y' causes the directory to be zeroed. Any other character aborts the operation.

ABSOLUTE BINARY LOADER

The Absolute Binary Loader is used to load the binary output created by the PAL8 assembler. Input files are loaded according to the options discussed in this section, and a core control block is constructed (see the section concerning the GET command). The standard input devices are the paper tape reader, DECtape, LINCtape, the default storage device (DSK:), and SYS:, which represents the system device. Any other device which can contain absolute binary files can be used as an input device if a device

handler exists. The Teletype (TTY:) should not be used, as the binary code may appear as control characters to the TTY handler.

Calling and Using ABSLDR

ABSLDR normally accepts absolute binary files (relocatable files must be loaded with the Linking Loader); however, save (.SV) format files can be loaded with ABSLDR providing the /I option is used. If no extension to the input file name is typed, ABSLDR assumes the .BN extension. Up to nine input files are allowed, but if more than one program is present in a file, only the first program is loaded. (This features allows ABSLDR to ignore any 'noise characters' which might be caused by reading over the end of a paper tape.)

The user calls the Absolute Binary Loader from the system device by typing:

```
R ABSLDR
```

in response to the dot printed by the Keyboard Monitor. The system responds by printing an asterisk at the left margin. The user then types an input line to ABSLDR, indicating input files and any options desired. ABSLDR does not recognize any output files, since the purpose of the loader is to load and optionally start binary output files. The format of the input line is:

*DEV:INPUT.EX/(Options)

By typing the RETURN key at the end of an input specification line, the loader is signalled that more input is to be given on the next line. If the ALT MODE key is used as a line terminator, no more input is expected, the Command Decoder is not recalled, and control returns to the Keyboard Monitor. For example:

```
.R ABSLDR
*DTA1:FILE1,FILE2,FILE3,FILE4    (Carriage RETURN)
*PTR:$
                                 (ALT MODE)
```

The preceding lines cause FILE1, FILE2, FILE3, and FILE4 to be loaded at their absolute locations in core from DECtape 1. A file is then to be read from the paper tape reader. The $ character is printed by the ALT MODE key which indicates a return to the Keyboard Monitor.

NOTE

If the /G option (load and begin execution) is specified, control always passes to the program just loaded, regardless of which line terminator was typed.

When ABSLDR has completed loading and control has returned to the Keyboard Monitor, the program loaded may *not* be physically in core at that moment. ABSLDR utilizes system scratch blocks to store those locations which would overlay various parts of the Monitor. To examine core locations after using ABSLDR, use ODT (see the section concerning ODT for instructions detailing its use).

ABSLDR OPTIONS

The various options accepted by ABSLDR are described in Table 13.

Table 13 ABSLDR Options

Option	Meaning
/8	Used when locations 0-1777 of field 0 are not being used by the program. Eliminates extra DECtape motions to save these locations, hence saves time. See the OS/8 Software Support Manual for details of Job Status Word.
/9	Similar to the /8 option; used when locations 0-1777 of field 1 are not to be saved.
/I	Treat the input file(s) as a core-image-file to be overlaid with the input of succeeding lines. (If this option is not used in the first command line, it cannot be used unless ABSLDR is recalled from the Keyboard Monitor level.) The /I option can be used to make patches to an already saved program without reassembling the entire program.
/R	Reset internal core map of ABSLDR to appear as though nothing has been loaded into core.
/S	Load all binary programs in the specified input file(s) (instead of loading only the first program in each file, which is normally done). /S and /I operate on a line-at-a-time basis. Each successive command line must have the option respecified if it is required. For example: *PTR:,,/S *DTA1:A,B,C

Table 13 (Cont.) ABSLDR Options

Option	Meaning
	These command strings instruct ABSLDR to take three files from PTR (loading all binary programs in each file) and three files from DTA1 (loading only the first binary program in each file). /S is not implemented on the second line.
/G	Start program execution upon finishing the loading procedure. Normally, control returns either to the Monitor or Command Decoder (depending on the terminator key). If /G is specified, control is given to the program just loaded. The starting address is assumed to be 200 unless specified in the input string. Control stays with the user's program until it is released to the Monitor from within the program. No automatic return to Monitor or the Command Decoder occurs.
/n	Force loading of all files specified on this input line into field n (where n is an integer).
=n	Set the starting address of the program in core to n, where n is a 5 digit octal integer. ABSLDR inserts a starting address of 0200 in field 0 if no other address is indicated. Specifying 0 as a starting address is equivalent to not specifying a starting address, thus ABSLDR would insert a starting address of 0200.

EXAMPLES OF INPUT LINES
Example 1:

```
.R ABSLDR
*SYS:PROG.SV/I
*DTA1:PATCH$
.SAVE SYS:PROG
```

The above commands load the core-image file PROG.SV and then overlay part of that program file with a binary patch from DTA1. Control then returns to Monitor, at which time the user saves the patched program on the system device.

When using the /I option, the starting address and Job Status Word of the core image being loaded are ignored by the Loader. The user must specify the starting address and contents of the Job

Status Word (unless the starting address is 200 in field 0, in which case it need not be specified).
Example 2:

```
.R ABSLDR
*PIP.SV/I
*PTR:=13000(89)$
.SAVE SYS PIP
```

In this example, the user overlays PIP with a binary patch which will not change its starting parameters. This could also be accomplished using an explicit SAVE:

```
.R ABSLDR
*PIP.SV/I
*PTR:$
.SAVE SYS PIP;13000=6003
```

Example 3:

```
.R ABSLDR
*PTR:(89G)$
```

One binary tape is loaded from the paper tape reader. Areas 00000-01777 and 10000-11777 of core are not used by the program. The starting address of the program is considered to be 00200; control is transferred to the user program.

Notes On Using ABSLDR Correctly

ABSLDR is a complex program which, when used incorrectly, can give unrecoverable errors. Points to remember when using ABSLDR are:

1. If an erroneous starting address is specified, control *will* be passed to that address, however random it may be. Thus, specifying a starting address in non-existent memory, for example, will very likely produce erroneous results, and should not be attempted.
2. Trying to load a program into non-existent memory should not be attempted.
3. Programs which load into 07600 or 17600 are ignored by ABSLDR. No error is generated, but these locations are

never loaded. (It is a good idea not to use 7600 in any field.)

4. Old versions of ABSLDR should not be used with a new monitor.

ABSLDR Error Messages

Table 14 lists the error messages output by ABSLDR. In each case, control returns to the Command Decoder; the entire procedure may be attemped again by resetting the loader (with the /R option) and using different inputs.

Table 14 ABSLDR Error Messages

Message	Meaning
BAD CHECKSUM, FILE # n	File number n of the input file list has a checksum error.
BAD INPUT, FILE # n	Attempt was made to load a non-binary file as file number n of the input file list, or a non-core image with /I option.
IO ERROR FILE # n	An I/O error has occurred in input file number n.
NO INPUT	No input file was found on the designated device.
NO /I!	Use of /I is prohibited at this point.

OCTAL DEBUGGING TECHNIQUE (ODT)

ODT allows the programmer to run his binary program on the computer, control its execution, and make alterations to the program by typing instructions at the keyboard; this section presents a summary of the ODT commands and their application in the OS/8 system.

Calling and Using ODT

As explained in the section concerning the Keyboard Monitor, ODT is called into use by typing:

```
ODT
```

in response to the dot printed by the Keyboard Monitor. Before ODT is called, the user should have a running version of his program in core. None of the user's core is disturbed by the running of ODT, because the sections of the program which ODT may occupy when in core are preserved on the system device and swapped back into core as necessary. ODT uses the Job Status Word of the particular program to determine whether or not swapping occurs. If the program does not use locations 0-1777 in field 0, less swapping occurs during use of the breakpoint feature.

If the user is typing any amount of a program directly into core (in octal), the core control block of the program may not reflect the true extent of the program. If octal additions are made below location 2000 in field 0, ODT may give erroneous results. The user can correct this condition by correcting the Job Status Word, which is location 7746 of field 0, and which can be examined and changed using ODT. Location 7745 of field 0 is the 12-bit starting address of the program in core and location 7744 contains the field designation in the form 62n3, where n is the field designation of the starting address.

When using the breakpoint feature of ODT, the user should keep certain operating characteristics in mind:

1. If a breakpoint is inserted at a location which contains an auto-indexed instruction, the auto-indexed register is bumped immediately after the breakpoint is hit. Thus, when control returns to the user in ODT, the register will have been increased by one. The breakpoint instruction is executed properly, but the index register, if examined, may appear one greater than it should.
2. ODT keeps track of the TTY flag and restores the TTY flag when it continues from a breakpoint.
3. The breakpoint feature uses locations 4, 5, and 6 in the memory field in which the breakpoint is set.
4. The breakpoint feature of ODT uses the table of user-defined device names as scratch storage, destroying any device names the user may have created. After a session with ODT in which breakpoints are used, the user should give a DEASSIGN command to clear out the user-device name table.

5. Breakpoints must not be set in the Monitor, in the device handlers, or between a CIF and the following JMP instruction.

The user is advised not to use user-defined device names in programs being developed with ODT breakpoints.

If any operations are attemped in non-existent memory, ODT ignores the command and types "?". Thus, assuming the machine in use has 8K (fields 0 and 1) and the user attempts to examine locations in field 2 and above, ODT responds with ?.

ODT should not be used to debug programs which use interrupts.

Typing CRTL/C returns control to the Keyboard Monitor; the program can be saved on any device.

Summary of ODT Commands

The following table presents a brief summary of the ODT commands. All addresses can be input as 5 digits, and are printed as 5 digits.

Table 15 ODT Command Summary

Command	Meaning
nnnnn/	Open location designated by the octal number nnnnn, where the first digit represents the memory field. ODT prints the contents of the location, a space, and waits for the user to enter a new value for that location or close the location.
/	Reopen latest opened location.
nnnn;	Deposit nnnn in the currently opened location, close that location and open the next sequential location for modification. A series of octal values can be deposited in sequential locations through use of the ; character. Multiple ;'s skip a memory location for each ; typed and prepare to insert subsequent values beyond the one(s) skipped.
RETURN key	Close the previously opened location.
LINE FEED key	Close location; open the next sequential location for modification, and print the contents of that location.

Table 15 (Cont.) ODT Command Summary

Command	Meaning
n+	Open the current location plus n for modification and print the contents of that location.
n—	Open the current location minus n for modification and print its contents.
↑ or ^ (up-arrow or circumflex)	Close location, take contents of that location as a memory reference and open the location referenced, printing its contents.
	NOTE No distinction is made between instruction op-codes when using ↑. Thus, *all* op-codes (0-7) are treated as memory reference instructions. Also, great care should be exercised when using ↑ with indirectly referenced auto-index registers. If ↑ is used in this case, the contents of the auto-index register is incremented by one. The user must check to see that the register contains the proper value before proceeding.
← or _ (back-arrow or underline)	Close location, take contents of that location as a 12-bit address and open that address for modification, printing its contents.
nnnnnG	Transfer control of program to location nnnnn, where the first digit represents the memory field.
nnnnnB	Establish a breakpoint at location nnnnn, where the first digit represents the memory field. Only one breakpoint is allowed at any given time.
B	Remove the breakpoint.
A	Open for modification the location in which the contents of the accumulator were stored when the breakpoint was encountered.
L	Open for modification the location in which the contents of the link were stored when the breakpoint was encountered.
C	Proceed from a breakpoint.
nnnnC	Continue from a breakpoint and iterate past the breakpoint nnnn times before interrupting the user's program at the breakpoint location.

Table 15 (Cont.) ODT Command Summary

Command	Meaning
M	Open the search mask, initially set to 7777, which can be changed by typing a new value.
LINE FEED	Open the lower search limit. Type in the location (4 octal digits) where the search will begin.
LINE FEED	Open the upper search limit. Type in the location (4 octal digits) where the search will terminate.
nnnnW	Search the portion of core as defined by the upper and lower limits for the octal value nnnn. Search can only be done on a single memory field at a time. See the F command.
D	Open for modification the word containing the data field which was in effect at the last breakpoint. Contents of D always appear as multiples of 10_8—i.e., 10 means field 1, 20 field 2, etc.
CTRL/O	Stop any printing currently in progress.
F	Open for modification the word containing the field used by ODT in the W (search) command, in the ← and ↑ (indirect addressing) commands, or in the last breakpoint (depending upon which was used most recently. The contents of F are always expressed as multiples of 10_8 (as in the D command).
RUBOUT key	Cancels previous number typed, up to the last non-numeric character typed.

PAL8 ASSEMBLER

PAL8 is an 8K, two pass assembler designed to run under the OS/8 Operating System. Pass 1 reads the input file and sets up the symbol table. Pass 2 reads the input file and uses the symbol table created in Pass 1 to generate the binary (object) file. The binary file is an absolute binary tape and may be loaded into core with the Absolute Loader or Binary Loader. As an optional third pass, a side-by-side octal and symbolic listing and the symbol

table are output. (Using the options available, the three passes may be automatically executed. However, if the source file is to be read from the paper tape reader, the user must reload the tape for each pass.) The listing file may be used as input to the Cross Reference Program (CREF), and the symbol table may be requested to be in a form suitable for input to DDT.

PAL8 can handle I/O from any OS/8 device which handles ASCII text, and has pseudo-ops and options not available in the other PDP-8 assemblers. It is loaded and saved by way of the OS/8 Monitor and Absolute Loader. It will accept input generated by the Editor and will generate output acceptable to the Absolute Loader and CREF.

Features available in the PAL8 assembler are documented in Chapter 2 of 8K FORTRAN SABR ASSEMBLER; the user is referred to that handbook for information concerning PAL8 assembly language programming.

Calling and Using PAL8

PAL8 is called from the system device by typing:

```
R PAL8
```

in response to the dot printed by the Keyboard Monitor. The system replies by activating the Command Decoder, which in turn prints an asterisk (*) at the left margin of the teleprinter paper. At this point a command string is entered which indicates the binary and listing output devices and file names, the input devices and file names, and any options selected by the user. 1 to 9 input files may be specified. The format of the command string is:

*DEV:BINARY,DEV:LISTING<DEV:INPUT/OPTIONS

If the extension to the file name is omitted, the following assumed extensions are assigned:

.PA for input file
.BN for binary output file
.LS for listing output file

A null output file indicates no output of that type is to be generated. For example, to assemble, load and run a PAL8 program

named PROGRM which is stored on DECtape unit 1, the user would type;

```
.R PAL8
*BIN<DTA1:PROGRM/G
```

After the assembly, the program will be loaded and run with the starting address assumed to be location 0200 in field 0, and the binary stored on the system device as BIN.BN.

The assembler prints on the teleprinter any error messages encountered in the program. Typing CTRL/O (↑O) at the keyboard during an assembly will suppress the printing of error messages on the teleprinter; however, messages are still printed in the output file and occur immediately before the line that is in error.

PAL8 OPTIONS

Table 16 lists the options available in PAL8 which can be indicated in the command string typed to the Command Decoder.

Table 16 PAL8 Options

Option	Meaning
/D	Generate a DDT-compatible symbol table (applicable only if a listing file is specified).
/G	Call the Absolute Loader, load the binary file, and begin execution at the indicated starting address. If none is indicated, start at 00200.
/H	Generate non-paginated output. Header, page numbers and page format are suppressed (applicable only if a listing file is specified).
/K	Used in assembling very large programs; causes system containing 12K or more of core to use field(s) 2 and up as symbol table storage.
/L	Call the Absolute Loader at the end of the assembly and load the binary file (applicable only if a binary file is specified).
/N	Generate the symbol table, but not the listing (applicable only if a listing file is specified. The /H option is assumed.)
/S	Omit the symbol table normally generated with the listing (applicable only if a listing file is specified.)
/T	Output a carriage return/line feed in place of the form feed character(s) in the program (applicable only if a listing file is specified).

When the /L or /G option is specified, the user can also include any option to the Absolute Loader in the I/O specification line for PAL8, such as the = starting address option. If no address is specified, execution begins at 00200. If no binary output file is specified with /L or /G a temporary file, PAL8BN.TM, is created and loaded.

EXAMPLES OF SPECIFICATION STRINGS

Example 1:

```
.R PAL8
*PTP:,LPT:<SOURCE
```

The above lines cause the PAL8 assembler to be loaded from the system device and the program SOURCE.PA (or SOURCE) to be assembled. The binary output of the assembly is put onto the paper tape punch, and the listing and symbol table on the line printer.

Example 2:

```
.R PAL8
*,LISTIN<PROG/S
```

The above I/O specification line causes PAL8 to assemble PROG.PA (or PROG), putting the listing only into the file LISTIN.LS on the default device (see the section on default devices under Command Decoder). No binary output and no symbol table are generated.

Example 3:

```
.R PAL8
*BIN<INPUT.XY/G=600
```

The above I/O specification line assembles INPUT.XY, putting the binary output into a file named BIN.BN, and then calls the Absolute Loader, which loads BIN.BN and starts it at 00600. (=600 is an option to the Absolute Loader specifying the starting address.)

Example 4:

```
.R PAL8
*DTA1:PROG
```

The preceding lines will assemble the file PROG from device DTA1, checking for errors, which are listed on the teleprinter. There are no output files.

RESTARTING AND TERMINATING PAL8

PAL8 may only be restarted if the Command Decoder has not been dismissed. For example:

```
.R PAL8
*↑C
.ASSIGN DTA7 DSK
.ST
*
```

If a restart is attempted after the Command Decoder has been dismissed, NO! ! is typed and control returns to the Keyboard Monitor. The user must call PAL8 for each assembly.

PAL8 will terminate assembly and return control to the Monitor under the following conditions:

1. Normal exit—The $ at the end of the source program was executed on Pass 2 (or Pass 3 if a listing is being generated).
2. Fatal error—One of the following error conditions was found and flagged (see PAL8 Error Codes):

   BE DE DF PH SE

3. ↑C—If typed by the user, this command returns control to the Monitor at 07600 immediately.

Optional Patches to PAL8

There are three patches to PAL8 which may be made before it is saved initially. These patches will do the following:

1. Omit re-origin to 200 after a field setting.
2. Interpret ! to mean a 6-bit left shift prior to the inclusive OR
3. Omit adding a word of zeros after a text string which was an even number of characters.

These patches may be inserted by the following procedure:

```
.R ABSLDR
*PTR:/9$
.ST 5600
```

The system will return with:

```
1 NO 200 ORIGIN
2 ! IS SHIFT
4 NO 0 FILL
```

The user then types a single digit (0 through 7) signifying his choice of patches. For example, 7 would mean all three patches, 0 no patches. 4 would mean no 0 fill, while 6 is no 0 fill *and* ! is shift. In the following example:

```
TAG,     TEXT/123*/
```

This string is normally stored as:

```
6162
6352
0000
```

However, if the no 0 fill patch has been made to the system, that same string would be stored as simply:

```
6162
6352
```

The special patch routine is not restartable and must be used before the assembler is saved.

Assembly Listing Format (General)

An example of a program assembled with PAL8 and listed with CREF can be found in the section of this manual concerning CREF. That example illustrates link generation and field settings.

PAL8 Pseudo-Operators

The following Table is a summary of the PAL8 pseudo-ops:

Table 17 PAL8 Pseudo-Ops

Mnemonic Code	Operation
$	Indicates the end of a program; terminates each pass of the assembly.
DECIMAL	Decimal conversion; (numeric conversion interprets all numbers input as being decimal numbers.)
DEVICE	Used to generate I/O routine parameters.
DTORG	Used as a signal to a special typesetting loader. DTORG should not be used in programs which are not typesetting programs, as the OS/8 ABSLDR will not load such files properly.
EJECT	Causes the listing to jump to the top of the next page. If followed by a string of characters, the first 40_8 characters of that string will be used for the new header line.
ENPUNCH	Causes the assembler to resume binary output after NOPUNCH.
EXPUNGE	Removes all symbols except pseudo-ops from the symbol table.
FIELD	Instructs the assembler to output a field setting on Pass 2 which will be interpreted by the Absolute Loader as the field into which the following data is to be loaded.
FILENAME	Used to generate I/O routine parameters.
FIXMRI	Used to create memory reference instructions.
FIXTAB	When encountered, causes all symbols in the symbol table to become permanent symbols.
I	Symbolic representation for indirect addressing.
IFDEF	Allows the code enclosed in angle brackets to be assembled or ignored contingent upon the definition of the symbol after IFDEF.
IFNDEF	Similar to IFDEF. Inclusion or exclusion of code depending upon the definition of the symbol after IFNDEF.
IFZERO	If the evaluated (arithmetic or logical) expression is equal to zero, assemble the code within the angle brackets; if the expression is non-zero, ignore the code.

Table 17 (Cont.) PAL8 Pseudo-Ops

Mnemonic Code	Operation
IFNZRO	Similar to IFZERO. Inclusion or exclusion of code depending upon the value of the expression within the angle brackets.
NOPUNCH	Causes the assembler to cease binary output but continue assembling code.
OCTAL	Octal conversion. Numeric conversion is originally set to octal and can be changed back to octal after a DECIMAL pseudo-op has been used.
PAGE n	Resets the location counter to the first address of page n, where n is an integer, a previously defined symbol, or a symbolic expression. If n is not specified, the location counter is reset to the next logical page of core.
PAUSE	Indicates that the end-of-tape or end-of-file has been found. It is also effectively an end-of-line.
TEXT	A string of text characters may be entered as data and stored in six-bit ASCII by using the pseudo-op TEXT.
XLIST	Those portions of the source program enclosed by XLIST pseudo-ops will not appear in the listing file, but the code will be assembled.
Z	Optional method of denoting a page zero reference.
ZBLOCK n	Causes the assembler to reserve n words of memory containing zeros, starting at the word indicated by the current location counter.

PAL-8 Error Conditions

PAL8 will detect and flag error conditions and generate error messages on the teleprinter. The format of the error message is:

CODE ADDRESS

where CODE is a two-letter code which specifies the type of error, and ADDRESS is either the absolute octal address where the error occurred or the address of the error relative to the last symbolic tag (if there was one) on the current page. For example, the following code:

```
BEG,    TAD LBL
        %TAD LBL
```

would produce the error message:

```
IC  BEG+0001
```

since % is an illegal character. The programmer should examine each error indication to determine whether correction is required. Those labeled Fatal Error are followed immediately by an exit to 07600 (effective ↑C).

On the Pass 3 listing, error messages are output as a two character message on the line just prior to the line in which the error occurred. The following table lists the PAL8 error codes.

Table 18 PAL8 Error Codes

Error Code	Explanation
BE	Two PAL8 internal tables have overlapped. Fatal error—control is returned to the Monitor.
DE	Device error. An error was detected when trying to read or write a device. Fatal error—control returns to the Monitor.
DF	Device full. Fatal error—assembly is terminated and control is returned to the Monitor.
IC	Illegal character. The character is ignored and the assembly continued.
ID	Illegal redefinition of a symbol. An attempt was made to give a previously defined symbol a new value by means other than the equal sign. The symbol is not redefined.
IE	Illegal equals—an equal sign was used in the wrong context. Considered a warning and may not indicate an error but rather an undefined symbol at that point.

Table 18 (Cont.) PAL8 Error Codes

Error Code	Explanation
II	Illegal indirect—an off-page reference was made.
IP	Illegal pseudo-op—a pseudo-op was used in the wrong context or with incorrect syntax.
IZ	Illegal page zero reference—the pseudo-op Z was found in an instruction which did not refer to page zero. The Z is ignored.
LD	This message is given if the /L or /G options have been specified and the Absolute Loader cannot be found on the system device.
PE	Current non-zero page exceeded—an attempt was made to: 1. Override a literal with an instruction, or 2. Override an instruction with a literal, or 3. Use more literals than the assembler allows on that page. This can be corrected by decreasing either the number of literals on the page or the number of instructions on the page.
PH	Phase error—either no $ appeared at the end of the program, or < and > in conditional pseudo-ops did not match. Fatal error—control returns to the Monitor.
RD	Redefinition—a permanent symbol has been defined with =. The new and old definitions do not match. The redefinition is allowed.
SE	Symbol table exceeded—too many symbols have been defined for the amount of core available. Fatal error —control returns to the Monitor.
UO	Undefined origin—an undefined symbol has occurred in an origin statement.
US	Undefined symbols—a symbol has been processed during Pass 2 that was not defined before the end of Pass 1.
ZE	Page 0 exceeded—same as PE except with reference to page 0.

CROSS-REFERENCE PROGRAM (CREF)

CREF aids the programmer in writing, debugging and maintaining assembly language programs by providing the ability to pinpoint all references to a particular symbol. CREF operates on output from either the PAL8 or SABR assemblers.

Calling and Using CREF

To call CREF from the system device, type

```
R CREF
```

in response to the dot printed by the Keyboard Monitor. The Command Decoder is then loaded and replies by printing an asterisk at the left margin. The user enters one output file specification and one input file specification.

NOTE

The input to CREF must be the listing pass output from either the PAL8 or SABR assembler. If this is not the case, CREF will not operate properly.

If no output file is specified, CREF assumes the output is to be sent to the line printer. If no input file extension is specified, the extension .LS is assumed. If no input specification is given, control returns to the Command Decoder until an input file is specified.

CREF OPTIONS

The following options are available to the user. The option is placed at the end of the command string.

Table 19 CREF Options

Option Code	Meaning
/P	Disable pass one listing output. The output is re-enabled when $ (or END if SABR code) is encountered. Thus the $ (END) and symbol table are printed if /P is used.
/R	Interpret input as SABR code. Signal to CREF to accept special SABR characters. Also, if /R is used, /X is forced on.
/X	Do not process literals. For programs with too many symbols and literals for CREF, this option may create enough space for CREF to operate.

EXAMPLES OF CREF USAGE

Examples of calling and using CREF are given below.

Example 1:

```
.R CREF
*PTEMP
```

The Command Decoder prints *, CREF assigns LPT: as the output device. The input file is PTEMP, assumed to be on device DSK, with the extension .LS. If the file PTEMP is not found, a search for DSK:PTEMP.LS is attempted.

Example 2:

```
.R CREF
*SBRLS/R
```

The line to the Command Decoder causes output to be sent to the line printer. The input is expected to be a SABR listing file named SBRLS.LS or SBRLS from device DSK:.

Example 3:

```
.R CREF
*DTA1:LIST<DTA3:PALIST/X
```

This command string causes output to be sent to DECtape unit 1, to a file named LIST. Input is expected to be a PAL8 listing file called PALIST.LS or PALIST. No literals appear in the CREF output table.

CREF Pseudo-Ops

CREF recognizes the pseudo-ops of the assembler whose output it is processing. Certain pseudo-ops cause CREF to perform actions similar to those taken by the assembler, and these are described below:

PAL8 Pseudo-Op	Action Taken by CREF
EXPUNGE	CREF purges its current symbol table of all permanent and user-defined symbols. If any literals were in the table they are not deleted.

PAL8 Pseudo-Op	Action Taken by CREF
FIXTAB	Causes all symbols (except literals) to be marked as permanent symbols. After a FIXTAB, no references to previously defined symbols will be reported by CREF.
TEXT	Ignores characters between delimiters.
$	End-of-input signal.

SABR Pseudo-Op	Action Taken by CREF
END	End-of-input signal.
OPDEF	Creates a new permanent symbol, a non-skip type instruction.
SKPDF	Creates a new permanent symbol, a skip type instruction.

NOTE

Symbols entered by OPDEF and SKPDF are processed by CREF. All references to these defined symbols are listed. However, no reference is flagged as a definition (i.e., no reference is followed by a # in the CREF listing).

TEXT	Ignores characters between delimiters.

Interpreting CREF OUTPUT

The output from CREF consists of two parts. On the first pass through the input file, CREF generates a sequence numbered listing of the file. The sequence numbers are decimal. /P disables this part of the output.

Following the listing, the cross reference table appears. This contains every user-defined symbol and literal sorted alphabetically. Each literal is indicated by an underline (or back-arrow on most DEC Teletypes) and L followed by the address at which the literal occurs. For each symbol and literal, there appears a list of numbers specifying the lines in which each is referenced.

If CREF finds too many references to fit in core at one time, multiple passes are required to process all symbols. The minimum number of passes is two. The maximum depends on the size of the

input file, and the amount of core available. CREF calculates the number of core fields available and uses all available space for reference tables. If enough core is not available, three or more passes are required. For example, the current OS/8 SABR assembler (5518 source lines, 849 symbols) requires a total of four passes through CREF on an 8K machine.

The following example illustrates a program which has been assembled with PAL8 and listed with CREF. Form feeds on the Teletype are converted to a series of carriage return/line feed combinations and a dotted tear line. Notice that in the CREF table the line where the symbol is defined is followed by a #. Symbols defined by OPDEF or SKPDF in SABR and all literals do *not* have a # following them.

```
/EXAMPLE PROGRAM                    PAL8-V7              PAGE 1

   1                    /EXAMPLE PROGRAM
   2                    /ILLUSTRATES DETAILS OF LISTING FORMAT
   3                    /USING PAL8 AND CREF
   4
   5            0200    *200
   6    00200   1777'   START,  TAD B
   7    00201   1376            TAD (3          /CURRENT PAGE LITERAL
   8    00202   3777'           DCA LINK        /LINK GENERATED
   9    00203   5775'           JMP P2          /LINK GENERATED
  10
  11    00375   0400
  12    00376   0003
  13    00377   0406
  14            0400    *400
  15    00400   1206    P2,     TAD LINK
  16    00401   1377            TAD (3
  17    00402   1177            TAD [2
  18    00403   3206            DCA B
  19    00404   6213            CDF CIF 10
  20    00405   5776'           JMP FLD1
  21    00406   0000    LINK,   0
  22            0406            B=LINK
  23
  24    00576   0200
  25    00577   0003
  26    00177   0002
  27            0001    FIELD 1
  28    10200   1177    FLD1,   TAD [2
  29    10201   6223            CDF CIF 20
  30    10202   5200            JMP FLD2
  31
  32    10177   0002
  33            0002    FIELD 2
  34    20200   1177    FLD2,   TAD [3
  35    20201   6203            CDF CIF 0
  36    20202   5200            JMP START
  37                    $
  38    20177   0003
```

```
/EXAMPLE PROGRAM                PAL8-V7          PAGE 1-1

B       0406
FLD1    0200
FLD2    0200
LINK    0406
P2      0400
START   0200
  39



------



B             6     18     22#
FLD1         20     28#
FLD2         30     34#
LINK          8     15     21#    22
P2            9     15#
START         6#    36
.L0177       17     28     34
.L0376        7
.L0577       16

.
```

Restrictions

CREF has the following restrictions:

1. Input format—CREF can only detect errors of a simple form (described below). If the input is neither a PAL8 or SABR listing file, the results of CREF are unpredictable in the cross-reference table.
2. CREF can handle a maximum of 896 (decimal) symbols. (In 8K, PAL8 is limited to 897 symbols while SABR is limimited to fewer than 800 symbols.) If more than 896 symbols are found, an error message is generated.
3. If any symbol in the input file has more than 2044 (decimal) references, an error message is generated.
4. If more than 8192 (decimal) source lines are input, sequence numbers return to 4096, not 0.
5. If the /D option is used in PAL8 (to generate a DDT compatible symbol table) and the output listing is put through CREF, no symbol table listing will appear.
6. Use of semi-colons—This is a restriction which, when not observed, could cause errors in the CREF table. It is recommended that the user follow these suggestions when preparing source files in order to insure a proper CREF listing.

Semi-colons should not be used on lines with pseudo-ops. In particular, a combination such as the following must not be used:

```
*3000
TEST  %ERROR% ; TAD [42
```

In this case, CREF does not process the page zero literal properly. A literal is generated which is derived from the expanded TEXT message. No error message is generated, but the literal table entry is meaningless.
As a general rule, semicolons should not be used as line terminators inside of conditional assembly brackets (<>). For example:

```
EXOR=0
IFNZRO EXOR<CLA;TAD B; HLT /ERROR>
/THIS IS THE NEXT LINE PAST IFNZRO
```

The conditional code is not assembled; however, CREF does not realize this and does try to process the bracketed instructions. As a result of these semicolons, extra symbols may be processed and some valid references missed. If the code had been assembled, however, CREF *would* operate properly.
There are two ways around this:

a. Write straight line code:

```
EXOR=0
IFNZRO EXOR <
CLA
TAD B
HLT ERROR
>
```

b. Use XLIST around conditional code, in the above example:

```
IFZERO EXOR <XLIST>
IFNZRO EXOR <CLA;TAD B; HLT/ERROR>
IFZERO EXOR <XLIST>
```

XLIST turns off the listing if the code does not assemble and turns it back on after the conditional code.

7. Formats—There are several output formats that can be used in generating a PAL8 listing file:

   /T Form feeds converted to carriage return/line feeds.

   /H No headings or form feeds generated.

   /D DDT compatible symbol table is generated.

   For best results with CREF, *none* of these switches should be used. This generates a heading and form feeds in the output. CREF automatically converts form feeds to carriage return/line feeds if output is to the Teletype.

8. PAL8 generated links do not cause a reference to a link to be noted by CREF. Only literals specifically generated with (and [are processed by CREF.

CREF Error Messages

CREF errors are non-recoverable errors, and control returns to the Keyboard Monitor through 07605 (no core saved). CREF is not restartable and typing START results in:

```
NO!!
```

being printed in reply. Table 20 lists the error messages printed by CREF.

Table 20 CREF Error Messages

Error Message	Meaning
SYM OVERFLOW	More than 896 (decimal) symbols and literals were encountered.
ENTER FAILED	Entering an output file was unsuccessful—possibly output was specified to a read-only device.
OUT DEV FULL	The output device is full (directory devices only).
CLOSE FAILED	CLOSE on output file failed.
INPUT ERROR	A read from input device failed.

Table 20 (Cont.) CREF Error Messages

Error Message	Meaning
DEV LPT BAD	The default output device, LPT, cannot be used as it is not available on this system.
2045 REFS	More than 2044 (decimal) references to one symbol were made.
HANDLER FAIL	This is a fatal error on output, and can occur if either the system device or the selected output device is WRITE-LOCKed.

FORTRAN

OS/8 FORTRAN is an improved version of the paper tape 8K FORTRAN. OS/8 FORTRAN contains such added features as Hollerith constants, implied DO loops, chaining, mixing of SABR and FORTRAN statements, and device-independent I/O. The features of both OS/8 FORTRAN and the paper tape version are discussed in detail in Chapter 1 of 8K FORTRAN SABR ASSEMBLER (DEC-08-LFTNA-A-D); it is suggested that those users who are unfamiliar with DEC's 8K FORTRAN first read that chapter.

Calling and Using the OS/8 FORTRAN Compiler

The user calls the FORTRAN compiler by typing:

```
R FORT
```

in reply to the dot generated by the Keyboard Monitor. When the Command Decoder prints an asterisk at the left margin, the user types the appropriate device designations, I/O files, and any of the acceptable specification options allowed for 8K FORTRAN. A carriage return is used to terminate a command string and begin compilation.

The line to the Command Decoder consists of 0 to 3 output files, 1 to 9 input files, and any of the available options. The format of the command line is:

*BINARY,LISTING,MAP<INPUT/OPTION(S)

The first output file holds the binary output in relocatable binary format. If no extension is specified, the extension .RL is assumed.

If a binary output file is not indicated in the command line, then no binary output will be generated. (An exception to this occurs when either the /L or /G options are used; this is explained in the section describing the individual options). The second output file contains the listing; if no extension is specified, the extension .LS is assumed. If no listing file is specified, a listing will not be generated. The third output file is the Linking Loader output, and, unless otherwise specified, this file assumes the extension .MP. (This output is produced by use of the /M, /U and /P options, which are discussed in the section of this manual concerning the Linking Loader.) 1 to 9 input files are available with OS/8 FORTRAN, although ordinarily only 1 is used. The default extension for input files is .FT.

FORTRAN OPTIONS

The following table provides a list of the options which are available under OS/8 FORTRAN. In addition to these, the /N and /S options to the SABR Assembler may be specified to the FORTRAN compiler, and options to the Linking Loader other than /L may be used. (The user is referred to the respective sections for details.)

Table 21 FORTRAN Options

Option	Meaning
/G	Load and execute the file. The Linking Loader is called, the binary output file is loaded and executed. (If a binary file is not specified, a temporary file named FORTRL.TM is created and stored on the file device. This file is loaded into core and then deleted from the file device.) If a starting address is not specified (using the options described under the Linking Loader) control is sent to the program entry point MAIN (the FORTRAN compiler gives this name automatically to the main program.
/K	Keep the file FORTRAN.TM as a permanent file. The FORTRAN compiler produces an output file named FORTRN.TM on the system device. This file is the FORTRAN source program converted into SABR assembly language, and serves as input to the 8K SABR assembler, which is automatically called by

Table 21 (Cont.) FORTRAN Options

Option	Meaning
	the compiler. The file FORTRAN.TM is then deleted unless the /K option has been specified. The /K option saves the file as a permanent file, allowing future editing and assembling.
/L	Load, but do not start execution. Call the Linking Loader at the end of the assembly and load the specified binary file. (If a binary output file is not specified, then the temporary file FORTRL.TM is loaded into core and deleted from the file device.) When using the /L option, the user has the choice of terminating the command string with either an ALT MODE or a carriage return. If ALT MODE is typed, the Loader returns to the Keyboard Monitor with a core image in core, while the RETURN key instructs the Loader to ask for more input.

EXAMPLE PROGRAM

The following example illustrates the ease with which a FORTRAN program can be executed under OS/8. The program TEST has been created with the Symbolic Editor and saved on device SYS:

```
C       FORTRAN DEMO 'TEST'
C       COMPUTE AND PRINT POWERS OF TWO

        DIMENSION A(16)
        WRITE (1,15)
15      FORMAT (/'POWERS OF TWO..EXAMPLE PROGRAM'/)
        DO 20 N=1,16
20      A(N)=2.**N
        WRITE (1,25) (N,A(N),N=1,16)
25      FORMAT ('2** 'I2'='F10.2)
        CALL EXIT
        END
```

By issuing the following commands, TEST is loaded and executed; execution is automatic with the /G option:

```
.R FORT
*TEST/G

POWERS OF TWO..EXAMPLE PROGRAM

2**  1=       2.00
2**  2=       4.00
2**  3=       8.00
2**  4=      16.00
2**  5=      32.00
2**  6=      64.00
2**  7=     128.00
2**  8=     256.00
2**  9=     512.00
2** 10=    1024.00
2** 11=    2048.00
2** 12=    4096.00
2** 13=    8192.00
2** 14=   16384.00
2** 15=   32768.00
2** 16=   65536.00

.
```

FORTRAN assembles one main program or subroutine per call. A job with multiple subprograms is run by compiling each routine separately and combining them with the Linking Loader.

Typing a CTRL/C (↑C) at run time during a non-compute bound job will return control to the Keyboard Monitor. Typing .ST at this point will restart the user's FORTRAN program. If ↑C is typed when compiling a program, FORTRAN will have to be recalled.

EXAMPLES OF FORTRAN I/O SPECIFICATION COMMANDS

Example 1:

```
.R FORT
*DTA1:TEST/G
```

The input file TEST.FT (or TEST) on DTA1 is compiled, the output stored in FORTRN.TM on the system device, and SABR is called. SABR uses FORTRN.TM as input and outputs the assembled file into FORTRL.TM, deleting the old FORTRN.TM. The /G option specifies that the Linking Loader then loads

FORTRL.TM and the Library Subroutines, deletes FORTRL.TM upon loading, and sends control to the entry point MAIN.
Example 2:

```
.R FORT
*MATRIX<MATRIX.AB/G/U
```

The input file MATRIX.AB on DSK is compiled and the output stored in SYS:FORTRN.TM. SABR is called and assembles SYS:FORTRN.TM, putting the relocatable binary output into DSK:MATRIX.RL, deleting the file FORTRN.MT. The /G option specifies that the Linking Loader then loads MATRIX.RL and the Library Subroutines, and then prints on the teleprinter (via /U) a list of undefined external symbols and a count of the unused pages in each memory field.
Example 3:

```
.R FORT
*,,LPT:<INPUT/L/M
*
```

The FORTRAN Compiler compiles and SABR assembles the file DSK:INPUT.FT (or INPUT), outputting the binary file as SYS:FORTRL.TM. The Linking Loader is automatically called (/L) to load SYS:FORTRL.TM into core and delete that file from SYS. The Linking Loader puts a full loading map on the LPT device (/M). The Loader then asks for another command string. If the line had been terminated with the ALT MODE key instead of the RETURN key, control would be returned to the Keyboard Monitor after loading.
Example 4:

```
.R FORT
*SUB1<SUB1
.R FORT
*SUB2<SUB2
.R FORT
*MAIN/L
*SUB1,SUB2/G
```

The subroutines and the MAIN program are each compiled separately, and the MAIN program is loaded but not executed (as the /L option indicates). The Linking Loader is called at the end of

the assembly and waits for more input. The /G option is used to load the FORTRAN Library Subroutines and initiate execution of the MAIN program.
Example 5:

```
.R FORT
*DTA5:SOURCE/L
```

The file SOURCE on DTA5 is compiled, assembled, and loaded but not executed.
Example 6:

```
.R FORT
*DTA1:PROG,PTP:,PTP:<DTA1:PROG(NMG)
```

For those users with DECtape systems, keeping the source program on a non-system DECtape and putting the binary on a non-system DECtape gives the best possible results in terms of minimizing tape motion. The above file, PROG, is loaded and executed. The binary is stored on DTA1 under the name PROG.RL, and the symbol table, the map of the loaded program and the count of the free pages in each field are punched onto paper tape.

In DECtape systems, excessive DECtape motion can also be eliminated by storing LIB8.RL on a non-system tape. The user would then specify to the Loader:

```
*DTA2:LIB8.RL/L
```

Using FORTRAN or SABR with the Interrupt On

SABR code can be run with the interrupt on, providing the user supplies his own interrupt handling code. That code which is executed when the interrupt is off must not call any of the SABR subroutines and must be independent of all SABR or library subroutines and linkage subroutines. With the interrupt on, the user should not call exit routines or do any generalized (device-independent) I/O, unless those routines are modified to make allowances for interrupts.

Using PAL8 with SABR or FORTRAN

It is possible to call PAL8 subroutines from a SABR or FORTRAN program. The user should build a core image of the running FORTRAN or SABR program and return to the Keyboard Monitor by typing $ (ALT MODE key) on the last Linking Loader Command. He should then save the core image. The core image file (.SV) can be used as input to the Absolute Loader (ABSLDR) with the /I option, followed by the binary of the PAL8 routine. For example:

```
.R ABSLDR
*DTA7:CHAIN2.SV/I
*PALSUB.BN/G$
```

The above calls the Absolute Loader, loads the core image CHAIN2.SV and then merges the PALSUB.BN program with it. Execution starts at location 200 and, when completed, the system returns to the Keyboard Monitor for further instructions.

FORTRAN Data Files

When doing FORTRAN output onto DECtape or disk into a file which is to be read only as a data file by another FORTRAN program, a significant time saving can be obtained by using A6 format to output floating-point variables and A2 format to output integer values. The same format specifications must be used when the data is read. The data file is not an ASCII file and should not be edited with EDIT. The file should only be moved by PIP in image mode (/I option).

The following caution should be observed concerning programs which may have been written and compiled with a previous version of OS/8 FORTRAN:

CAUTION

A FORTRAN compiler and its corresponding Library constitute an interlocking set of programs. No user should attempt to compile a program under OS/8 and load it with the paper tape FORTRAN, or vice versa. Similarly, programs developed with the current FORTRAN compiler should not be run under an old FORTRAN system.

FORTRAN Function Library

The following functions are available under OS/8 FORTRAN:

Table 22 FORTRAN Function Library

Function	Definition	Type of Argument(s)
ABS(x)	the absolute value of x	real
IABS(x)	the absolute value of x	integer
FLOAT(x)	convert x from integer to real format	integer
IFIX(x)	convert x from real to integer format	real
IREM(0)	remainder of last integer divide is returned	integer
IREM(x/y)	remainder of x/y is returned	integer
EXP(x)	exponential of x, e^x	real
ALOG(x)	natural logarithm of x, $\log_e x$	real
SIN (x)	sine of x, where x is given in radians	real
COS (x)	cosine of x, where x is given in radians	real
TAN(x)	tangent of x, where x is given in radians	real
ATAN(x)	arc tangent of x, where x is given in radians	real
SQRT(x)	square root of x is returned	real
IRDSW(0)	read the console switch register, returning a decimal equivalent of the octal integer in the switch register. The switch register can be set before executing the FORTRAN program or, using the PAUSE statement, during execution.	integer

Device Codes

The I/O Device designations used in READ and WRITE statements are as follows:

Device Code	Input Designation	Output Designation
1	Teletype keyboard or low-speed reader	Teleprinter
2	High-speed reader	High-speed punch
3	Card reader (CR8/I)	Line printer (LP08)
4[8]	Assignable device	Assignable device

Control characters for the line printer are:

Character in Column 1	Resultant Spacing
space	single space
0	double space
1	Form Feed
all others	single space

FORTRAN Library Subroutines

A table containing OS/8 FORTRAN Library Subroutines and their entry points is contained in Chapter 1 of 8K FORTRAN SABR ASSEMBLER (DEC-08-LFTNA-A-D)

FORTRAN Statement Summary

A summary of the statements available under OS/8 FORTRAN follows. Complete explanations concerning these statements are contained in Chapter 1 of 8K FORTRAN SABR ASSEMBLER (DEC-08-LFTNA-A-D)

Table 23 FORTRAN Language Summary

Statement	Definition
Arithmetic Statements	
v=e	v is a variable (scalar or array); e is an expression.
Control Statements	
GOTO n	Transfer control to the statement numbered n.

[8] If using device code 4, the /I and /O options to the Linking Loader must be given. If the assignable device is a two-page handler, the /H option must be given also.

Table 23 (Cont.) FORTRAN Language Summary

Statement	Definition
GOTO (n_1,n_2,...,n_i)j	Where n_1-n_i are statement numbers and j is a scalar integer variable. This statement transfers control to the j^{th} member of the series of n_i.
IF(expression)n_1,n_2,n_3	This statement transfers control to the statement numbered n_1,n_2, or n_3 if the value of the numeric expression is less than, equal to, or greater than zero, respectively. The expression can be simple or complex.
DO n i=m_1,m_2,m_3	Repeat execution through statement n, beginning with i=m_1, incrementing by m_3, while i is less than or equal to m_2. If m_3 is omitted, it is assumed to be 1. m's and i's cannot be subscripted. m's can be either integer numbers or integer variables; i is an integer variable.
CONTINUE	Dummy statement, used primarily as a target for transfers, particularly the last statement in the range of a DO loop. A DO loop need not end with a CONTINUE statement.
PAUSE PAUSE n	Temporarily suspend execution. The octal equivalent of the decimal number n is displayed in the accumulator. Program execution can be resumed by following the statement with a call to the OPEN subroutine.
STOP	Terminate execution.
END	Terminate compilation; must be the last statement in a program.
Input/Output Statements	
FORMAT (s_1,s_2,...,s_n)	Where S_1-S_n are data field specifications, this statement is used with either a READ or WRITE statement.

Table 23 (Cont.) FORTRAN Language Summary

Statement	Definition
READ (u,f) list	Where u is a device designation (integer constant or integer variable), f is a FORMAT statement number, and list is a list of variables.
WRITE (u,f) list	Where u is a device designation (integer constant or integer variable), f is a format statement number, and list is a list of variables.
Specification Statements	
COMMON v_1, v_2,...,v_n	Specified variables or arrays are stored in an area available to other programs.
DIMENSION a_1,a_2,...,a_n	Used to declare variable names to be array names and specify the number and bounds of each one and two dimensional array.
EQUIVALENCE (v_1,v_2,...), (v_i,v_{i+1},...)	The inclusion of two or more variable or array names in a parenthetical list indicates that the quantities in the list are to share the same memory location and hence have the same value. Subscripts of array variables must be integer constants. Names must not appear in both EQUIVALENCE and COMMON statements.
Subprogram Statements	
FUNCTION v(a_1,a_2,...,a_n)	Declares the program which follows to be a function subprogram. v is the name of the function being defined. v must appear as a scalar variable and be assigned a value during execution of the subprogram.

Table 23 (Cont.) FORTRAN Language Summary

Statement	Definition
SUBROUTINE v(a_1,a_2,...,a_n)	Declares the program which follows to be a subroutine subprogram. The arguments in the list(s) are dummy arguments representing the arguments of the subprogram. Dummy arguments must agree in number, order, and type with the arguments used by the calling program.

CALL v
CALL v (a_1,a_2,...,a_n)
	Statement used to transfer control to a subroutine subprogram. v is the subroutine name in the SUBROUTINE statement. The arguments can be of any type, but must agree in number, order, type and array size with the arguments in the SUBROUTINE statement. One or more of the arguments can be used to return results to the calling program. For example:
	`CALL EXIT`
	`CALL TEXT (VALUE,123,275)`
	`CALL TECK ('MAS',3)`

RETURN	Returns control from a subprogram to the calling program. Each subprogram must contain at least one RETURN statement. RETURN cannot be used in the main program.

FORTRAN Error Messages

COMPILER ERROR MESSAGES

The following OS/8 FORTRAN Compiler error messages are self-explanatory.

ARITHMETIC EXPRESSION TOO COMPLEX
EXCESSIVE SUBSCRIPTS
ILLEGAL ARITHMETIC EXPRESSION
ILLEGAL CONSTANT
ILLEGAL CONTINUATION
ILLEGAL EQUIVALENCING
ILLEGAL OR EXCESSIVE DO NESTING
ILLEGAL STATEMENT
ILLEGAL STATEMENT NUMBER
ILLEGAL VARIABLE
MIXED MODE EXPRESSION
SYMBOL TABLE EXCEEDED
SYNTAX ERROR (usually indicates illegal punctuation)
SUBR. OR FUNCT. STMT. NOT FIRST

In addition, OS/8 FORTRAN contains the following error messages:

Message	Explanation
COMPILER MALFUNCTION	The meaning of this message has been extended to cover various unlikely Monitor errors.
IO	A device handler has signalled an I/O error.
NO END STATEMENT	The input to the Compiler has been exhausted.
NO ROOM FOR OUTPUT	The file FORTRN.TM cannot fit on the system device.
SABR.SV NOT FOUND	The SABR assembler is not present on the system device.

LIBRARY ERROR MESSAGES

During execution, the various library programs check for certain errors and print error messages in the form:

XXXX ERROR AT LOC NNNNN

where XXXX is the error code and NNNNN is the location of the error.

Table 24 FORTRAN Library Error Messages

Error Code	Meaning
The following errors are fatal and cause a return to the Keyboard Monitor.	
ALOG	Attempt to compute log of negative number.
IOER	One of the following has occurred: 1. Device-independent input or output attempted without /I or /O options, or user attempted to specify a device requiring a two-page handler for device-independent I/O without using the /H option. 2. Bad arguments to IOPEN or OOPEN, or 3. Transmission error while doing I/O.
CHER	File specified as argument to CHAIN not found on system device.
FMT1	Invalid Format statement.
The following input errors are fatal unless input is coming from the Teletype, in which case the entire READ statement is tried again.	
FMT2	Illegal character in I format.
FMT3	Illegal character in F or E format.
The following errors do not termniate execution of the user's program.	
DIVZ	Division by zero—very large number is returned.
EXP	Argument to EXP too large—very large number is returned.
OVFL	Floating point overflow—very large number is returned.
FLPW	Negative number raised to floating point power—absolute value taken.
SQRT	Attempt to take square root of negative number —absolute value used.
FIX	Attempt to fix a number >2047; 2047 is returned.

In addition, the error message:

USER ERROR 1 AT XXXX

means that the user tried to reference an entry point of a program which was not loaded, or possibly that he failed to define a subscripted variable in a DIMENSION statement. XXXX has no meaning.

To pinpoint the location of a library program execution error:

1. Determine, from the storage map, the next lowest numbered location (external symbol) which is the entry point of the program or subprogram containing the error.
2. Subtract, in octal, the entry point location of the program or subprogram containing the error from the location of the error indicated in the error message.
3. From the assembly symbol table, determine the relative address of the external symbol found in step 1 and add that relative address to the result of step 2.
4. The sum of step 3 is the relative address of the error, which can then be compared with the relative addresses of the numbered statements in the program.

Undefined statement numbers are not detected until the assembly phase, at which time a U error message is given. (Refer to the list of SABR error messages.)

RTPS FORTRAN[9]

RTPS FORTRAN is a real-time programming system which implements an extended version of ANSI standard FORTRAN IV. This FORTRAN is industry compatible and includes such features as direct access I/O (in which the user can directly reference the n^{th} record of a file, allowing faster processing of bulk data), n-dimensional arrays ($n \leq 7$), generalized array subscripting, mixed mode arithmetic, initial values in specification statements, floating DO loops, and use of all format codes.

The minimum hardware requirements for the RTPS FORTRAN system are a PDP-8 series (or PDP-12) computer equipped with

[9] The user should note that RTPS FORTRAN is an option and is not standard on the OS/8 system.

a 24-bit Floating Point Processor[10] and configured for OS/8 operation (including a minimum of 8,192 words of core, and a mass storage device—either disk, DECtape, or LINCtape). Supported peripheral devices include such standard OS/8 devices as disks, DECtape, LINCtape, line printer, Teletype, and paper tape reader/punch, and non-standard devices such as A/D converters, multiplexers, real time clocks, control relays, digital I/O, and graphic displays. The standard 8K configuration will handle approximately 250 lines of FORTRAN source program, with each additional 4K allowing approximately 200 additional lines of core resident program.

One of the most important features of the RTPS FORTRAN system is its ability to handle multiple level overlays. The Linking Loader provides an overlay level mechanism which automatically loads overlays on call. As many as eight independent overlay levels may be defined, containing up to sixteen overlays within each level. Each overlay, in turn, can contain a number of subprograms. This feature provides the capability of running much larger programs to solve much more complex problems.

In addition, the error traceback feature of the RTPS FORTRAN Compiler detects, flags, and explains many syntax errors. Complete error traceback is provided when an error is detected during execution of the program.

Fully parallel processing is available. While the Floating Point Processor is processing data, the PDP-8/E may be acquiring data, displaying it, or reading and writing files, thus greatly increasing system through-put.

The typical speed of operation is as follows:

Compile Speed:	1000 lines per minute
Execution Speed:	2000 statements per second
Analog Sampling Rates:	100 points per second

Further information concerning the RTPS FORTRAN system may be obtained from the PDP-8 Marketing Department or from the *RTPS FORTRAN User's Manual* (DEC-08-LRTPA-A-D), available from the DEC Program Library.

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[10] If double precision floating point is required, the double precision option must be available on the processor.

SABR ASSEMBLER

The OS/8 SABR assembler is a modified version of the 8K SABR assembler which is designed to run under the OS/8 Operating System. (The 8K SABR assembler is described in Chapter 2 of 8K FORTRAN SABR ASSEMBLER; for more complete details and examples of usage, the reader is referred to that chapter.)

The OS/8 SABR assembler can be used as the automatic second pass of the FORTRAN compiler, called separately to do assemblies of FORTRAN compiled files, or used as an independent assembler with its own assembly language. In addition, SABR statements may be used in an OS/8 FORTRAN program, expanding the capabilities of the FORTRAN language.

Calling and Using OS/8 SABR

Unless otherwise specified, the SABR assembler is called automatically by the system to assemble the output of a FORTRAN compilation. At other times the user can call SABR by typing:

```
R SABR
```

in response to the dot printed by the Keyboard Monitor. When the Command Decoder prints an asterisk at the left margin, the user types the appropriate device assignations, I/O files, and any of the acceptable options.

The line to the Command Decoder consists of 0 to 3 output device and file designations, 1 to 9 input device and file designations, and the desired option(s). The form is:

*BINARY,LISTING,MAP<INPUT FILE(S)/OPTION(S)

where BINARY represents the binary output, LISTING the listing output, and MAP the Linking Loader loading map input. Unless alternate extensions are indicated, SABR assumes the following extensions:

File Type	Extension
input file	.SB
binary output	.RL
listing output	.LS

If no binary output file is indicated, no binary output will be generated. However, if the /L or /G options are specified, a binary

file will be generated under the assigned name SYS:FORTRL.TM.

OS/8 SABR OPTIONS

The options which can be included in a command string to OS/8 SABR are listed in Table 25.

Table 25 SABR Options

Option	Meaning
/F	Indicates that the input file is an 8K FORTRAN output file.
/G	Calls the Linking Loader, loads the program into core and begins execution. If a binary output file is not specified, then FORTRL.TM is loaded into core and deleted from the file device. If a starting address is not specified (using the options to the Linking Loader), control is sent to the program entry point MAIN (the FORTRAN compiler gives this name automatically to the main program).
/L	Calls the Linking Loader at the end of the assembly and loads the specified binary file. If a binary output file is not specified, then the temporary file FORTRL.TM is loaded into core and deleted from the file device. The Loader then either returns to the Keyboard Monitor with a core image or asks for more input, depending on whether an ALT MODE or RETURN key has terminated the input line.
/N	Outputs the symbol table but not the rest of the listing (applicable only if a listing file is specified).
/S	Omits the symbol table from the listing (applicable only if a listing file is specified).

When the /L or /G options are specified, any options to the Linking Loader (described in the section concerning the Linking Loader) can be included in the command string for SABR. This does not include the /L (Library) option of the Linking Loader, since it would conflict with the SABR /L option.

NOTE

The FORTRAN compiler automatically generates an entry point named MAIN whose address is the beginning of the program. When writing a main program in SABR, the user should specify the entry point MAIN with the entry pseudo-op in order to symbolically specify the starting address to the Linking Loader. (Otherwise the starting address must be specified to the Loader as a five digit address.)

EXAMPLES OF OS/8 SABR I/O SPECIFICATION COMMANDS

Example 1:

```
.R SABR
*FORTRN.TM/F/G
```

DSK:FORTRN.TM is assembled as a FORTRAN output file and the relocatable binary is loaded and started at the entry point MAIN.

Example 2:

```
.R SABR
*SYS:TEERL,TTY:<TEE/S
```

The input file TEE.SB (or TEE) on DSK: is assembled. The relocatable binary goes to the output file TEERL.RL on SYS:, the listing without a symbol table goes to the Teletype.

Examples of SABR listings are included in Chapter 2 of 8K FORTRAN SABR ASSEMBLER (DEC-08-LFTNA-A-D)

Pseudo-Operators

The table below contains a list and brief descriptions of the pseudo-operators used with SABR.

Table 26 SABR Pseudo-Operators

Mnemonic Code	Operation
ABSYM	Direct absolute symbol definition, used to indicate an absolute core address. For example: `ABSYM TEM 177 /PAGE ZERO ADDRESS`

ARG	Argument for subroutine call, indicating a value to be transmitted, one value per ARG statement. Used only with CALL. For example:
	
	`N1, ARG (50`
	`N2, ARG LOCATN`

BLOCK	Reserve storage block; reserves n words of core by placing zeros in them. For example:
	
	`BLOCK 200 /RESERVE 300`
	`BLOCK 100 /(OCTAL) LOCATIONS`

CALL	Call external subroutine. For example: `CALL 2, SUBR` where 2 is the number of arguments to be passed and SUBR is the subroutine name.
COMMN	Common storage definition, used to name locations in field 1 as externals to be referenced by any program. For example: `A, COMMN 20 /20 WORDS IN COMMON`
CPAGE	Check if page will hold data, followed by the number of words of code which must be kept together in a unit on a page. That number of words following the CPAGE will be assembled as a unit on the next available core page.
DECIM	Decimal conversion, numeric conversion interprets all numbers input as being decimal numbers.

Table 26 (Cont.) SABR Pseudo-Operators

Mnemonic Code	Operation

DUMMY	Dummy argument definition, used in passing arguments to and from subroutines. DUMMY variables are defined in the subprograms which reference them. For example:
	
	`ENTRY A1`
	`DUMMY X`
	`DUMMY Y`

EAP	Enter automatic paging mode, restore automatic paging (See LAP).
END	End of program or subprogram.

ENTRY	Define program entry point, used at beginning of subprograms to give name of entry point for the Linking Loader. For example:
	
	`ENTRY SUBROU`
	`SUBROU, BLOCK 2`

FORTR	Assemble FORTRAN tape.
I	Symbolic representation for indirect addressing. For example: `DCA I ADD`
IF	Conditional assembly, of form: `IF NAME, 7` If the symbol NAME has been previously defined, the statement has no effect. If NAME is not defined, the next 7 symbolic instructions are not assembled.
LAP	Leave automatic paging. Assembler is initially set for automatic jumps to the next core page when the current page is full (or upon REORG or PAGE statements). This feature can be suppressed with LAP.

Table 26 (Cont.) SABR Pseudo-Operators

Mnemonic Code	Operation
OCTAL	Octal conversion, numeric conversion is originally set to octal and can be changed back to octal after a DECIM pseudo-op has been used.
OPDEF	Define non-skip operator. For example: `OPDEF DTRA 6761`
PAGE	Terminate current page, begin assembly of succeeding instructions on next core page.
PAUSE	Pause for next tape, designed to allow large source tapes to be broken into several smaller segments. Assembly is continued by pressing the CONT switch.
REORG	Terminate page and reset origin; origin settings are always to the first address of a page. For example: `REORG 1000`
RETRN	Return from external subroutine, the name of the subroutine being left must be specified. Before the RETRN statement is used, the pointer in the second word of the subprogram entry must be incremented to the point following all arguments in the calling program (after the CALL statement).
SKPDF	Define skip-type operator. For example: `SKPDF DTSF 6771`

TEXT	Text string similar to BLOCK, except that the argument is a text string. Characters are stored in six-bit stripped ASCII with a printing character used to delimit the string. For example:
	
	`TAG,  TEXT /123*/`
	
	the string would be stored as:
	
	`6162`
	`6352`

Table 26 (Cont.) SABR Pseudo-Operators

Mnemonic Code	Operation
	Odd characters are filled with zeros on the right. *The floating-point accumulator (in field 1).*
ACH	High-order word.
ACM	Middle word.
ACL	Low-order word.

SABR Errors

In case of error, SABR prints the following codes in the address field of the instruction line:

Table 27 SABR Error Codes

Error Code	Meaning
A	Too many or too few ARG statements follow a call statement.
C	An illegal character appears on the line.
D	A device handler has returned a fatal condition.
L	/L or /G option was indicated, but the LOADER.SV file does not exist on the system device.
M	A symbol is multiply defined. Listing of programs with multiple definitions have unmarked errors.
I	An illegal syntax has been used, (as one of the following): 1. a pseudo-op with improper arguments, 2. a quote mark with no argument, 3. a non-terminated text string, 4. an improper address, 5. an illegal combination of micro-instructions.
E	There is no END statement.

Table 27 (Cont.) SABR Error Codes

Error Code	Meaning
S	Either the symbol table has overflowed, common storage has been exhausted, more than 64 different user-defined symbols occurred in a core page, or more than 64 external symbols have been declared. Could also indicate a system error such as overflowed output file.
U	No symbol table is being produced, but there is at least one undefined symbol in the program.
UNDF	Undefined symbol, printed in the symbol table listing.

LINKING LOADER

The Linking Loader is the system program used to load and link a user's program and subprograms in any field(s) of memory. It can be called automatically to load or load and start a FORTRAN or SABR program, or independently to load or load and start a relocatable binary file stored on a device. It is capable of loading programs over itself, and has options which allow the user to obtain storage map listings of core availability.

The Linking Loader has the capability of searching program libraries for subroutines which are referenced by the program in core and to load those subroutines needed. (A library is a collection of relocatable subroutines—FORTRAN or SABR output—with a directory at the beginning to facilitate searching.) Any library can be searched by using the /L option to the Loader, but the system library, LIB8.RL, is searched automatically just before the Loader completes the building of a core image of the user's program. If LIB8.RL is not on the system device, there is no automatic library search. (The system program LIBSET is available to allow the user to build his own subroutine library.)

The Linking Loader is capable of loading any number of user and library programs into any field of memory. Several programs are usually loaded into each field. Because of the space reserved for the Linkage Routines, the available space in field 0 is three pages smaller than in all other fields.

Any common storage reserved by the programs being loaded is allocated in field 1 from location 200 upwards. The space reserved for common storage is subtracted from the available loading area in field 1. The program reserving the largest amount of common storage must be loaded first.

The Run-Time Linkage Routines necessary to execute SABR programs are automatically loaded into the required areas of every field by the Linking Loader as part of its initialization. The user needs to know nothing more about these routines than the particular areas of core they occupy. (See the Core Availability and Storage Map options.

Calling and Using the Linking Loader

The user can automatically call the Linking Loader following assembly of either a SABR program or a SABR-assembled FORTRAN program by use of the /L or /G options. For details on automatic calling of the Linking Loader, see the FORTRAN section of this manual.

When the user wishes to call the Linking Loader specifically to load or load and start a relocatable binary file, he issues the command:

```
R LOADER
```

in response to the dot printed by the Keyboard Monitor. The Command Decoder replies by printing an asterisk at the left margin; the user then indicates input and output files and any desired options. 0 to 1 output files and 1 to 9 input files are possible. Only one binary program per file is permitted. The assumed extension for input files is .RL. The output file, if indicated, is used to hold a map of the loaded program.

The user has the ability to either specify all options and operations to be performed on one line or to have various operations performed individually. Where all options are being specified at one time the line to the Command Decoder contains the complete instructions for the Linking Loader. If operations are to be done individually, the user can type a command, enter it with the RETURN key, and that command will be executed, with another command expected when the first is completed. To indicate the

last command, the user types an ALT MODE character, or ends the last command with a /G option to start the program.

LINKING LOADER OPTIONS

The options to the Linking Loader are as shown in Table 28.

Table 28 Linking Loader Options

Option	Meaning
/I	A program doing device-independent input is to be loaded. (This feature costs the user 3 pages of core.)
/O	A program doing device-independent output is to be loaded. (This feature costs the user 3 pages of core.)
	If both /I and /O are indicated, 6 pages of core are used to handle device-independent I/O.
	/I and /O, if used, must be given before or on the first input line specifying files to be loaded. For example:
	`*INPUT,FILES/O$`
	is acceptable, but
	`*INPUT` `*/O FILES`
	is not legal and will generate an error message.
/H	A program doing device-independent I/O requires two-page device handlers at run-time. (This feature costs the user one additional page if he is doing just input or output, and two additional pages if he is doing input and output.
	If /I, /O, and /H are indicated, 8 pages of core are used to handle device-independent I/O. /H, if used, must be indicated on or before the first line containing /I or /O, and is meaningless without /I or /O also being specified.
/G	Start the program after processing the rest of the command string. Execution starts at the symbol MAIN unless otherwise indicated.
=n	Specifies the starting address of the program if other than the entry point MAIN; n is an octal number up to 5 digits long.

Table 28 (Cont.) Linking Loader Options

Option	Meaning
/M	Output a map of the loaded programs onto the output file specified, followed by a count of the free pages in each field. If no output is specified, the map is put onto the teleprinter. The assumed extension for map output file is .MP. The map is printed after the rest of the command line is processed.
/U	Similar to /M, but only outputs undefined symbols.
/P	Similar to /M, but only outputs counts of free pages in each field.
/n	Search through the available fields starting at field n for space large enough to hold each input file; n is an integer in the range 0 to 7, inclusive. Only one binary program can be in each input file. If n is not specified, the Loader starts looking at field 0.
/R	Restart loading process (forget all previously loaded programs). This command is equivalent to restarting the Linking Loader, but is much faster for DECtape systems since no tape motion is involved.
/L	Load the first input file as a library file (Loader expects a Library Directory as the first block of the file). All other input files on the line are ignored.

The Core Availability option (/P) causes the number of free pages of memory in every field of memory to be printed in a list on the teleprinter. For example, if the user has a 16K configuration, a list like the following might be printed:

```
0002    (number of free pages in field 0)
0010    (number of free pages in field 1)
0030    (number of free pages in field 2)
0036    (number of free pages in field 3)
```

The number of pages initially available in field 0 is 0033 and in all other fields is 0036.

The Storage Map option (/M), when selected, causes a list of all program entry points to be printed along with the actual address at which they have been loaded. Entry points of programs which have been called but which have not been loaded are also

listed along with U flag for "undefined". Such flagged programs must be loaded before execution of the user's programs are possible. The core availability list is automatically appended to the storage map. A sample is shown below for an 8K machine:

```
MAIN     10200
READ     01050
WRITE    01066
IOH      03031
ERROR    00000 U
GENIO    00000 U
FDV      04722
CLEAR    05247
IFAD     05131
FMP      04632
ISTO     05074
STO      04447
FLOT     05210
FAD      04010
DIV      00000 U
IREM     00000 U
FSB      04000
FLOAT    05046
FIX      04513
IFIX     04561
CHS      05231
0011
0033
```

EXAMPLES OF I/O COMMAND STRINGS

The following are examples of possible input command strings:

```
*PROG,DTA2:SUB1,SUB2/G
```

This string loads DSK:PROG.RL, DTA2:SUB1.RL, DTA2:SUB2. RL, loads any necessary library routines requested, and starts the program at the entry point MAIN. The same process could have been done as follows:

Load DSK:PROG.RL ;

Get a list of undefined symbols on the teleprinter;

```
*PROG

*/U
.       (Symbols go here)
.
.
.
*DTA2:SUBR1,SUBR2
```

Load DTA2:SUBR1.RL,SUB2.RL ;

```
*LPT:/M<$
```

Put loading map on the line printer, load the binary of any library routines requested by the program, and exit ($ is printed by the ALT MODE key);

```
.SAVE DTA2 FORTPG
```

Save the core image on DTA2 as FORTPG.SV;

Start the core image at its starting address (entry point MAIN in this case).

```
.START
```

Linking Loader Error Messages

The Linking Loader outputs error messages in the form

ERROR nnnn

where nnnn represents a 4-digit error code. Table 29 lists the meanings of these error codes.

Table 29 Linking Loader Error Messages

Error Code	Meaning
0000	/I or /0 specified too late.
0001	Symbol table overflow; more than 64 subprogram names.
0002	Program will not fit into core.
0003	Program with largest common storage area was not loaded first.
0004	Checksum error in input tape.
0005	Illegal relocation code.
0006	An output error has occurred.
0007	An input error has occurred (either a physical device error, or an attempt was made to read from a write-only device such as LPT:).
0010	No starting address has been specified and there is no entry point named MAIN.
0011	An error occurred while the Loader attempted to load a device handler.
0012	I/O error on system device.

LIBRARY SETUP (LIBSET)

LIBSET, the FORTRAN Library Setup program, creates a library of subroutines from the relocatable binary output of SABR. These library files can be quickly and effectively scanned by the Linking Loader, thus saving a great deal of the time involved in loading frequently used subroutines. (Refer to the section concerning the Linking Loader for information pertaining to relocatable library files, automatic loading of the LIB8.RL file, and the /L option.)

Calling and Using LIBSET

To call LIBSET from the system device, the user types

```
R LIBSET
```

in response to the dot printed by the Keyboard Monitor. The Command Decoder then prints an asterisk at the left margin of the teleprinter paper and waits to receive a line of input. The general form of input required to build a library file is:

```
*DEV:OUTPUT FILE <DEV:INPUT FILE(S)
*(additional input files) $
```

No more than nine input files are allowed on any one line, but several input lines can be entered. The last input line must end with the user typing the ALT MODE key (which echoes as $). Only the first line can contain an output file. If no output file is specified, a file named LIB8.RL is created on the system device. The assumed extension for both input and output files is .RL.

NOTE

Files output from LIBSET are in a special relocatable library format and must *not* be copied with the /B option in PIP. Instead, they should be copied by PIP in image (/I) mode.

LIBSET OPTIONS

Only one option is allowed in the use of LIBSET, and this is described below:

Option	Meaning
/S	The /S option means that all input files on a line are to be regarded as containing more than one relocatable binary file. (This is analogous to the /S option in ABSLDR.

NOTE

If /S is used on a line that contains no input files, input from PTR: is assumed.

EXAMPLES OF LIBSET USAGE

Example 1:

```
*DTA2:SUBS<DTA1:SUB1,SUB2,SUB3,PTR:
↑*SYS:FUNC1,FUNC2.V5$
```

This example creates a relocatable library file on DTA2 named SUBS.RL. This library will contain six FORTRAN (or SABR) subroutines built by combining the relocatable binary file SUB1.RL, SUB2.RL, and SUB3.RL from DTA1 together with one relocatable binary paper tape (note the ↑ printed by OS/8 before loading from PTR:) and the files FUNC1.RL and FUNC2.V5 from the system device.
Example 2:

```
*ASIN,ACOS
*/S$↑
```

Since no output file was specified, this example creates a relocatable library file LIB8.RL on the system device. This produces a new FORTRAN library including the subroutines contained in the files ASIN and ACOS on device DSK, and several subroutines combined on a single paper tape loaded from the high-speed reader.

Subroutine Names

It is important to distinguish between the OS/8 file name of a relocatable binary program and its assigned Entry Point name. The file name has meaning only to the Command Decoder; the Entry Point name (or names) are the true subroutine names that are meaningful to the Loader.

Further details on the format of relocatable binary files and relocatable library files can be found in the *OS/8 Software Support Manual* (DEC-S8-OSSMA-A-D).

Sequence for Loading Subroutines

LIBSET can combine files in any sequence to form a relocatable library file. However, the subroutines in any single library are loaded by the Loader in the order in which they were originally specified to LIBSET. Therefore, it is important to make sure that subroutines are specified in order of size, with the largest subroutine being loaded first. If this is not done, cases can occur in which insufficient core is available in any single field to load a subroutine, whereas space would have been available if the subroutine had been loaded earlier.

LIBSET Error Messages

All errors are fatal. LIBSET recalls the Keyboard Monitor upon encountering any of the following error conditions, and must be recalled in order to enter another command string.

Table 30 LIBSET Error Messages

Error Message	Meaning
BAD FORMAT OR CHECKSUM— TRY AGAIN	Error in reading relocatable binary file.
ERROR WHILE WRITING OUTPUT FILE	Fatal output error occurred.
INPUT ERROR	Parity error on input.
LIBRARY DIRECTORY OVERFLOW	Too many subroutines were specified. Every subroutine name in the input file requires four words, and every relocatable binary file read requires two words. If the total number of words exceeds 250, the library must be split into two separate files.

BUILD

BUILD is the system generation program for OS/8 which allows the user to:

1. Create an OS/8 monitor system from paper tapes.
2. Maintain and update devices in an existing OS/8 system.

With BUILD, simple keyboard commands are used to manipulate the device handlers which make up the OS/8 peripheral configuration. BUILD allows the user to quickly and easily insert devices which are not standard on the system without the necessity of editing the CONFIG source tape.

Loading BUILD

BUILD is distributed both as a binary paper tape, and as a core image file (BUILD.SV) on the system DECtape (or LINCtape). To use the BUILD.SV file on the system DECtape, type the fol-

lowing command in response to the period printed by the OS/8 Keyboard Monitor:

```
R BUILD
```

BUILD responds by typing a $, signalling that it is ready to accept commands. The binary paper tape of BUILD can be loaded and saved on the system device with ABSDLR as follows:

```
.R ABSLDR
*PTR:/S$
.SAVE SYS BUILD
.
```

BUILD is now resident on the system device and can be accessed by the R command, as shown previously.

Using BUILD

In addition to allowing the user to build his OS/8 system from paper tape (as described in Getting On Line With OS/8), BUILD provides the user with a means of maintaining device handlers. The user may add devices to his system from the following list (these devices are supplied as a part of the BUILD program):

High-speed reader/punch
Low-speed reader/punch (simulates high-speed I/O on ASR-33)
TC01/TC08 DECtape
TD8E DECtape
LINCtape
LP08 line printer
ASR-33 Teletype

(The BUILD Auxiliary Device Handler Tape (DEC-S8-OBADA-A-PB) contains additional handlers which can be inserted via the LOAD command in BUILD. Use of this tape is presented shortly.)

The program BUILD uses a keyboard monitor similar to that contained in the OS/8 system. Text is input from the console TTY and interpreted by BUILD, and the following special characters are available for editing:

Character	Function
RUBOUT key	Delete the last typed character from the command.
CTRL/U	Ignore line; the line may be retyped.
LINE FEED key	Examine contents of the command line.
CARRIAGE RETURN key	Terminate command; begin command execution. Also generate carriage return/line feed combination.
ALT MODE key	Terminate command; begin command execution. No carriage return/line feed is generated.
CTRL/C	Terminate command; return immediately to 7600.

The standard characters permitted in a BUILD command line are:

A-Z 0-9 SPACE PERIOD = COMMA COLON

Typing any other characters causes the error message:

```
SYNTAX ERR
```

BUILD Commands

As mentioned previously, several device handlers are supplied with the BUILD program, and are loaded into core with BUILD. Commands are available to add or delete these handlers (or others not supplied with BUILD) from BUILD's device tables. To understand the operation of BUILD, a few terms should first be explained.

A device handler which BUILD is to include in the new OS/8 system is said to be *active*. A device can be included and thus made active by using either the INSERT or REPLACE commands.

A device is *inactive* if it has never been included with INSERT or REPLACE. Inactive devices, even though they may have been

loaded into core with BUILD, do not become part of the system when it is built.

Handlers in BUILD are identified by two names, the first of which is the *group name.* This is the name assigned to an entire group of handlers all of the same type. Thus, DECtape, which has eight separate handlers internally, has the group name TC08.

In addition to the group name; a device also has a *permanent device name.* This is the name by which OS/8 will identify the physical device. Thus, DECtape unit 3 has group name TC08 and permanent name DTA3. The PRINT command description contains examples of printout using group and permanent device names.

The commands available in BUILD are:

PRINT
UNLOAD
INSERT
DELETE
REPLACE
NAME
ALTER
SYSTEM
LOAD
BOOT

The general format of the command string is:

$COMMAND ARGS

where COMMAND represents a legal command from the list and ARGS represents a file name, device, group name, or other argument associated with the command. The commands can be typed in full, or abbreviated to the first two characters. For example:

```
$PRINT
$PR
```

are both correct. If the user attempts to issue an illegal command, BUILD replies with:

```
*?
$
```

Thus the illegal command FOO will appear as:

```
$FOO
FOO.?
$
```

Details concerning each command follow.

PRINT

Syntax: $PRINT or $PR

Function: PRINT gives the detailed status of the BUILD device tables. For example[11]:

```
$PRINT
SYSTEM
TC08    TD8E    LINC    RF08    DF32    RK8    ROM

NONSYS
PT8E:PTP*   PTR*
KS33:PTP    PTR
TC08:DTA0*   DTA1*   DTA2    DTA3    DTA4    DTA5    DTA6    DTA7
LINC:LTA0    LTA1    LTA2    LTA3    LTA4    LTA5    LTA6    LTA7
 TD8A:DTA0    DTA1
LP08:LPT*
AS33:TTY*

$
```

The available "system device" handlers are listed first, and then the non-system handlers. Each non-system handler has both a group name and an individual permanent device name. The group name appears to the left of the colon and the permanent device name(s) to the right. The permanent names are the names by which OS/8 will recognize the device. Any non-system handler which is active will be marked with an asterisk to the right of its permanent name (PTP, PTR, DTA0, etc. in the printout), and the devices will be included in the new OS/8 system. (That is, these handlers have been inserted by means of the INSERT or REPLACE commands. Other commands are available for removing, activating and deactivating handlers.)

The system portion of the printout can be disabled by striking

---

[11] KS33 simulates the high-speed reader/punch on the Teletype. PT8E represents the actual high-speed reader/punch.

↑N (CTRL/N) after the PRINT command has been initialized. This causes BUILD to immediately start printing out the NONSYS information. Printing can be disabled completely by striking CTRL/O (↑O). This stops all printout and returns control to BUILD, indicated by a:

```
$
```

LOAD

Syntax: $LOAD DEV:FILE(.BN)

Function: Device handlers which are not loaded into core with the BUILD program, but which the user wishes to make part of the OS/8 system (such as those contained on the Auxiliary Device Handler Tape, or device handlers the user may have written himself) may be added to those already in core with the LOAD command. To accomplish this, LOAD makes use of the input device handlers which exist in the current OS/8 system. (These are *not* the same as the handlers which BUILD has marked active. The input device handlers used in a LOAD command must already exist in the OS/8 system.)

The default extension for the filename specified is .BN. Thus, in the syntax example for LOAD, if FILE is not found on the specified device, a search is done for FILE.BN. The binary FILE must be in the special format indicated in the section entitled Device Handler Format.

Once the LOAD command has been successfully issued, the new device handlers are available for further manipulation. They will now appear in the PRINT output, being marked inactive.
Example:

```
$LOAD PTR:
↑
$
```

A binary file is to be loaded from the paper tape reader. The up arrow (↑) is a signal to the user to place the tape in the reader and strike a keyboard character. When the LOAD is complete, BUILD response with a $.

```
$LO SYS:DECTP
$
```

A file called DECTP (or DECTP.BN) on the current system device is loaded.

Incorrect usage of the LOAD command will result in error messages, and no LOAD will be performed. The possible errors generated with the LOAD command are: .

Error	Meaning
BAD ARG	No device name was detected.
BAD INPUT	An error has been detected in the binary file; it is not a proper input for the LOAD command.
(DEV.) NOT FOUND	The input device handler does not exist in the current OS/8 system.
(FILE) NOT FOUND	The file indicated does not exist on the specified device.
IO ERR	An error was encountered reading the input device.
OVERFLOW	Indicates that either: 1. an illegal origin has occurred (an origin outside of 200-577), or, 2. there is insufficient room to load a two-page handler. The overflow condition can be relieved by using the UNLOAD function.
.?	The input device is file structured but no filename was specified.

INSERT

Syntax: $INSERT DTYPE, PNAME

Function: After a LOAD command has made a handler or group of handlers available for insertion into the OS/8 system, the INSERT command is used to flag a particular device for inclusion. INSERT uses two arguments: DTYPE and PNAME. DTYPE is the group name of the handler; for example, the DTYPE for a TC08 DECtape is TC08. PNAME is the permanent name by which the device is currently known to BUILD. Thus, DECtape has group name TC08, and permanent names DTA0—

DTA7. An INSERT must be done once for each device inserted. An entire group may not be activated at one command. Example: To insert a DECtape (TC08) into the system, the following command is needed:

```
$IN TCØ8,DTA5
$
```

This command will flag DTA5 for insertion in the new system (this actually occurs when the BOOTSTRAP command is given). In cases where only one device is contained in the handler, the second name (permanent name) of the device need not be used. Thus, to insert the LP08 line printer handler into BUILD, either of the following commands could be used:

```
$INSERT LPØ8,LPT
```

```
$INSERT LPØ8
```

Either one of these commands will cause the LP08 printer to be activated.
The errors associated with INSERT are:

Error	Meaning
(NAME.) NOT FOUND	The name specified was not found in BUILD's internal tables.
NO SLOT	No records are available to hold this handler. OS/8 can only handle 8 device handler records. If a device requires a new slot and all 8 slots are in use, this error message is generated.
PERM NAME ?	BUILD needs a permanent name specification to insert this handler. Generated only in handlers with multiple entry points.

NOTE

BUILD automatically allocates device record storage, so that devices of the same group will use the same record as the others in that group.

If a NO SLOT error occurs, a slot can be created by deleting all active handlers in a particular group. For example, executing the DELETE command on the line printer will always free a slot, because the line printer has only a single entry point. On the other hand, deleting one DECtape will only free a slot if no other DECtapes are marked active. The PRINT command will indicate which handler should be deleted to most easily free a device slot.

DELETE

Syntax: $DELETE PNAME

Function: DELETE takes a device which is currently flagged as being active, and makes it inactive. (Devices which are active are marked with a * in the PRINT output.)

The argument for DELETE is the permanent name of the device. The current permanent name can be obtained from the PRINT output.

The major function of DELETE is to make device slots available to BUILD. See the NOTE under the INSERT command for more explanation.

Example: Assume PRINT command output is:

```
SYSTEM
TCØ8     TD8E     LINC     RFØ8     DF32     RK8     ROM

NONSYS
RK8:RKAØ*    RKA1     RKA2     RKA3

$
```

If the following is executed:

```
$DELETE RKAØ
$
```

RKA0 will no longer be a permanent device, and the slot used by the RK8 group of devices will be made available to BUILD.

If both RKA0 and RKA1 had been marked active, no slot would have been made free, since RKA1 is still flagged as being active.

REPLACE

Syntax: $REPLACE PNAME=PTYPE,NAME2

Function: REPLACE combines the functions of DELETE and INSERT to provide a means of deleting one device and activating another in a single step. The arguments for REPLACE are:

PNAME	The permanent name of the device to be deleted. (Same as the argument of the DELETE function.)
DTYPE, PNAME2	The group name and permanent name of the particular device to be inserted into the system. (See INSERT for more details.)

Example: Assume the system looks like:

```
SYSTEM
.......
NONSYS
PT8E:PTP*    PTR*
CR8E:CDR*
RK8: RKA0    RKA1     RKA2     RKA3
```

REPLACE may be used to delete the card reader (CDR), and insert the RK8 group handler for RKA2:

```
$REPLACE CDR=RK8,RKA2
```

The output of PRINT after this REPLACE is:

```
SYSTEM
........



NONSYS
PT8E:PTP*    PTR*
CR8E:CDR
RK8:RKA0    RKA1    RKA2*   RKA3
```

The same errors apply to REPLACE as those associated with INSERT and DELETE.

UNLOAD

Syntax: $UNLOAD DTYPE

Function: UNLOAD is used to physically delete a handler group (DTYPE) from the BUILD system. (This differs from DELETE, which does not physically eliminate a device.) UNLOAD is primarily used when the NO ROOM or OVERFLOW errors occur during a LOAD command; and should only be used when no handlers of that group are marked active. If devices of the group are active, an error is generated and the handler is not deleted. The following error may occur due to improper usage:

Error	Meaning
ACTIVE HANDLERS	The group of handlers has at least one member still active.

Examples: Assume the NONSYS output from PRINT is:

```
NONSYS
LP08:LPT*
RK8: RKA0    RKA1    RKA2    RKA3
```

the command $UNLOAD LP08 will produce:

```
ACTIVE HANDLERS
$
```

since LPT is still active. However, the command:

```
$UNLOAD RK8
$
```

is legal and will reclaim the space used by the RK8 group of handlers.

NAME

Syntax: $NAME PNAM=PNM2

Function: The NAME command allows the user to alter the device name which will be used by OS/8. The first argument, PNAM must be the *current* name of a device marked active in

BUILD. PNM2 is the name the user wishes to call this device. After the NAME command, PNM2 is the current permanent name; PNAM is unknown to BUILD.
The following error may occur:

Error	Meaning
PNAM. NOT FOUND	No currently active device by the name of PNAM was found. Check PRINT output to see what the correct name is.

Example: Assume the PRINT output for NONSYS is:

```
NONSYS
PT8E:PTP     PTR
LP08:LPT*
```

To change the line printer so that it is recognized by permanent name KROK, execute:

```
$NAME LPT=KROK
$
```

The output from PRINT would now be:

```
NONSYS
PT8E:PTP    PTR
LP08:KROK*
```

NOTE

Only four character device names may be used in the NAME command. If longer names are typed in, all characters beyond the first four are ignored.

ALTER

Syntax: $ALTER DTYPE,AAAA=BBBB

Function: The ALTER command allows the user to change locations in device handlers. DTYPE represents the group device name and AAAA is the *relative octal location* to be altered. If the handler is a one-page handler, AAAA must be in the range 0-0177. If a two-page handler, the range must be 0-0377. AAAA must be an octal number; BBBB is the new contents of the location specified by AAAA, and must also be an octal number.

If the handler has multiple entry points (i.e., TC08, LINCtape, etc.) this alteration affects *all* coresident handlers.

Errors associated with this command are:

Error	Meaning
BAD#	A non-octal number has been entered.
BAD ARG	AAAA is too large for this handler. The limits are:

1 page handler—0-0177
2 page handler—0-0377

Example: A useful change is that which makes an 80 column LP08 handler a 128 column handler. Assume that LP08 is available, and the following command is executed:

```
$ALTER LP08,161=7600
```

This changes relative location 161 in the LP08 handler to 7600 which will print 128 characters per line. The following command will change the line so that it contains 80 columns:

```
$ALTER LP08,161=7660
```

SYSTEM

Syntax: $SYSTEM SNAM=n

Function: The SYSTEM command specifies the device on which BUILD is to construct the new OS/8 system. The number n reflects the number of discrete units included in the system device (valid only for multiple disk RF08 and DF32 disks). The available system handlers and their associated values for n are listed in Table 1 (under Creating OS/8 With BUILD). The argument SNAM must be one of the legal device names in this table. If it is not, or if the value specified for n is too large, BUILD asks for a new system specification. If no value for n is typed, BUILD assumes a value of 1.

n = 1 for ROM p. 14

Action is not taken on the SYSTEM command until the BOOTSTRAP command is given, so the user may change his mind and respecify a device with SYS as often as he likes. The system device used is the last one issued prior to the BOOT command. Specifying a new system device is not always necessary. For example, if the user wishes only to insert new peripheral handlers, then this com-

mand is not needed. If it is not issued, the OS/8 system which is resident is not affected beyond altering the device tables.

If the device specified in the SYSTEM command is *not* the current system device, the user will have an opportunity to have a zero directory placed on his new system device. If the system device is the same as the current system device, no new directory will be written. (In either case, BUILD will ask which device is to be used as DSK. The BOOTSTRAP command provides greater explanation.)

Possible error messages are:

Error	Meaning
BAD # SYS=	n was not an otcal number. BUILD requires valid system name again.
BAD ARG SYS=	n was too large for the specified device.

Example: The following command:

```
$SYSTEM TC08=1
$
```

is legal and specifies DECtape unit 0 as the system device.

```
$SYSTEM LINC=4
BAD ARG
SYS=
```

is illegal, since 4 is too large for any device but RF08 or DF32 disks.

BOOTSTRAP

Syntax: $BOOT or $BO

Function: BOOTSTRAP is the command which finally implements all the changes that have been made using BUILD. BOOT rewrites all relevant Monitor tables and device handlers to reflect the updated system status. The devices which BUILD had marked active now become device handlers in the system.

The operation of BOOT is slightly different depending on whether or not the SYSTEM command was explicitly used. Consider the following three cases:

1. No explicit SYSTEM command was issued.
In this case, the current system device is retained. Also, the default device DSK is made equivalent to SYS. The relevant Monitor sections are updated and rewritten to the system device. BUILD types:

```
DSK=SYS

SYSTEM BUILT
```

to remind the user that DSK and SYS are the same device. Control passes to the Keyboard Monitor. At this point, the devices which were activated in BUILD are available for use. The old directory and ABSLDR are unchanged.
2. The SYSTEM command is explicitly used; the new system device specified is the same as the current device.
Assume BUILD was run under a DECtape system, and a SYSTEM command was issued specifying TC08 as the new system device. In this case, BUILD requests information about the default device DSK as follows:

```
DSK=
```

The reply to this should be one of the following:

a. Carriage Return—If a CR is issued, DSK is made equivalent to SYS.
b. SYS—Typing SYS in response produces the same results as a RETURN.
c. PNAME—(where PNAME represents a permanent device name). Typing the permanent name of a file structured device which is currently active will set the default device DSK equal to that device. For example:

```
DSK=DTA1
```

If the device is not active or if the device is not file structured, an error message will be generated, and the request repeated.

When the default device has been specified, BUILD rewrites the various parts of the Monitor and types:

SYSTEM BUILT

Control returns to the Keyboard Monitor, indicated by a period (.) being typed at the left margin. The old directory and ABSLDR are unchanged.

NOTE

Paper tape system generation is a special case but follows the procedure of this case. See the section entitled Building OS/8 From Paper Tapes for details.

3. The SYSTEM command is issued; the new system device is not the same as the current. For example, assume BUILD was run under a TC08 system, and the SYSTEM command indicated a device other than TC08. In this case, BUILD requests information concerning the default device, DSK, as in 2. When answered, BUILD copies the system from the current system device to the new system device. After the copy is complete, BUILD asks:

NEW DIRECTORY?

requesting whether a new (zero) directory is to be written o the new system device. If the reply is YES, a zero directory will be placed on the device. Any other reply will cause the old directory to be retained.

NOTE

Care should be exercised if the old directory is to be retained. The directory *must* be that of an OS/8 system device.

After DIRECT has been answered, BUILD updates the system, and types:

SYSTEM BUILT

Control then returns to the OS/8 Keyboard Monitor. When the BOOTSTRAP command has performed its functions and the

Keyboard Monitor is once again active, it is a good idea to save the copy of BUILD just used. In this way, an image of the current system status is preserved, and the saved copy of BUILD can be used again. When it is used again, the devices which were initially marked active are still marked active. To save BUILD, type:

```
.SAVE SYS BUILD 0-7577,10000-17577=0;200
```

in response to the dot printed by the Keyboard Monitor.

General Error Messages

Following is a list of general error messages which may occur when using BUILD. These are not associated with any particular command, but are usually indicative of a syntax or user error.

Table 31 BUILD General Error Messages

Message	Explanation
BAD #	A non-octal digit was found where an octal digit was required.
IO ERR	An error has occurred while reading from an input device during a LOAD command.
NAME. NOT FOUND	The device or file name designated in the command was not found.
SYNTAX ERR	An illegal character was found in a BUILD command line. The line must be retyped.
.? or ABCD.?	An illegal command has been issued. BUILD did not recognize that command.

Start and Restart Addresses

If a SYS ERR message occurs while operating BUILD, the system will execute a HLT (7402). Under no conditions should the CONTinue switch be pressed. The halt is an indication that an error has occurred while doing system I/O. If the halt occurs while building an initial system from paper tapes, the error is fatal. BUILD must be reloaded in order to successfully generate a sys-

tem. The most common fault here is a WRITE LOCKed system device. If the halt occurs and the system device was WRITE ENABLEd, a hardware malfunction is indicated. If the halt occurs after executing one of the BUILD commands, BUILD may be restarted at location 202 in field 0.

Auxiliary Device Handler Tape (DEC-S8-OBADA-A-PB)

In addition to the device handlers which are present on the BUILD binary tape and described in the section Using BUILD, auxiliary device handlers are supplied on a separate binary paper tape. This tape contains handlers which can be loaded into core using the BUILD command LOAD.

This auxiliary device tape is composed of 13 separate segments, with a short length of leader/trailer code between them. (All of these handlers are in the special format described in BUILD Device Handler Format, which is described immediately following this section.) Table 32 contains a list of the handlers that are included on the auxiliary tape. This is the order in which they appear on the tape. Thus, the TC08 handler is the first segment, TD8E handler for drives 0 and 1 is second segment, etc. It is suggested that either the segments be labeled or separated for easier use.

Table 32 Auxiliary Device Handlers

Handler	Group Name	Permanent Name(s)	Filename[12]
TC08 DECtape	TC08	DTA0 - DTA7	TC08.BN
TD8E Drives 0 and 1	TD8A	DTA0, DTA1	TD8EA.BN
LINCtape (PDP-12)	LINC	LTA0 - LTA7	LINC.BN
High-speed reader/punch	PT8E	PTR, PTP	PT8E.BN
High-speed I/O simulated on ASR-33	KS33	PTR, PTP	LSPT.BN
ASR-33 Teletype	AS33	TTY	ASR33.BN
LP08 Line Printer	LP08	LPT	LP08.BN
Analex 645 Line Printer	L645	LPT	L645.BN
Card reader	CR8E	CDR	CR8E.BN
RK8 disk	RK8	RKA0 - RKA3	RK8.BN
TD8E Drives 2 and 3	TD8B	DTA2, DTA3	TD8EB.BN
TD8E Drives 4 and 5	TD8C	DTA4, DTA5	TD8EC.BN
TD8E Drives 6 and 7	TD8D	DTA6, DTA7	TD8ED.BN

[12] On CONFIG DECtape—see Getting On Line With OS/8.

(Handlers for new devices supported by OS/8 will be distributed as binary files in the BUILD format as they become available.)

To utilize this auxiliary binary file, place the desired segment into the paper tape reader. Use the BUILD LOAD command to load that segment as follows:

```
$LOAD PTR:
↑
$
```

The ↑ allows time to place the tape in the reader. Strike any keyboard character to load the tape. When the $ reappears, the handler has been loaded into BUILD's table.

BUILD Device Handler Format

The BUILD command LOAD is used to load device handlers not provided by BUILD into core where they can be inserted into the OS/8 system. The format of the input to LOAD is a binary file containing the handler, as well as a header block which contains information pertaining to the devices included in that file. The user should code the handler in PAL8 machine language according to the following format.

The structure of the source for a BUILD device handler is:

```
*0
HEADER BLOCK
*200
BODY OF DEVICE
HANDLER
```

The origins at 0 and 200 are vital to BUILD. The *0 is an important part of the Header Block, and if it is omitted no load is done. *200 is also necessary for the load. If the handler contains an origin outside the range 200-577, an error message is generated and the load is aborted.

HEADER BLOCK

The header block contains the following information:

Word 1:-X — X is the number of separate handlers contained in this file. Thus, a handler for TC08 has the first word equal to -10_8.

Words 2-9: "Descriptor block" for the first handler in the group.

Words 10-17: "Description block" for second handler in the group.

. . .

"Descriptor block" for second handler in the group.

Thus, each handler in the group must have an 8 word block describing its characteristics. If more than 12 handlers are in a group an error is generated during the LOAD.

DESCRIPTOR BLOCK

Each 8 word descriptor block contains the following information:

Words 1, 2: Device type name. This name is the group name, or type of all the handlers in this group, and is usually designated by the DEVICE pseudo-op.

Example: `DEVICE RK8`

Words 3, 4: OS/8 device name. This is the name (permanent name) by which the particular device will be recognized in the OS/8 system to be configured. It can be altered by the NAME command.

Example: `DEVICE RKA0`

Word 5: Device Control Block. This word reflects the type of device, in accordance with Table 1.

Example: `4050`

Word 6: Entry point word. This word must contain the entry point offset in bits 5-11 (Entry

Point Offset is described in detail further in this chapter.) Bit 0 should be a 1 if the handler is a two-page handler.

Example: 0020

Words 7, 8: 0, 0; specified by a ZBLOCK 2.

As an example, consider the handler for the non-system RK8 handlers. This file contains four separate handlers; the source code would appear as follows:

```
        *0
        -4                      /4 DEVICES

DEVICE RK8; DEVICE RKA0; 4050; 0020; ZBLOCK 2
DEVICE RK8; DEVICE RKA1; 4050; 0021; ZBLOCK 2
DEVICE RK8; DEVICE RKA2; 4050; 0022; ZBLOCK 2
DEVICE RK8; DEVICE RKA3; 4050; 0023; ZBLOCK 2

        *200


              (HANDLER BODY)
```

The device type of the group is RK8 (Words 1, 2). The permanent device names are RKA0-RKA3. Since each device is RK8, the device control block (DCB) word for each is identical.

The entry point word indicates where the entry point for that particular device occurs relative to the top of the page. Thus, in the above example, RKA0 enters at the 20th location from the top of the page, RKA1 at the 21st, etc.

NOTE

It is vital that this information be accurate. If errors are made in this data, unpredictable results occur when the system is generated.

BREAKDOWN OF DCB WORD

The DCB word for a device provides specific information which is used in the OS/8 Monitor. Its structure is detailed in Table 33.

Table 33 DCB Word

Bit	Meaning
0	1 if file-structured device
1	1 if read-only device (PTR, for example)
2	1 if write-only device (LPT, for example)
3-8	Device Type 00 = Teletype 01 = High-speed reader 02 = High-speed punch 03 = Card reader 04 = Line printer 05 = RK8 Disk 06 = RF08 (1 platter) 07 = RF08 (2 platter) 10 = RF08 (3 platter) 11 = RF08 (4 platter) 12 = DF32 (1 platter) 13 = DF32 (2 platter) 14 = DF32 (3 platter) 15 = DF32 (4 platter) 16 = DECtape 17 = LINCtape 20 = Magtape 21 = TD8E DECtape 22-77 = Unused
9-11	Used only by OS/8 Monitor

Whenever a device is to be inserted into OS/8, this structure must be followed to obtain correct results.

ENTRY POINT OFFSET

Word 6 of each device descriptor block specifies the relative entry point of that particular handler. DEC-supplied devices have a fixed set of entry points, described below. Care should be used when coding new device handlers for insertion into the system. The entry point offset for the new handler should *not* be the same as that for any other file-structured device in the system. For example, currently, OS/8 uses relative entry points 7-23 for file-structured devices.

NOTE

No new handler should have entry points at 7 to 23 of the page. If this occurs the system may perform incorrectly.

Current file devices and entry point offsets are listed below:

Device	Entry Relative to Top of Page
TC08 DECtape	10-17
TD8E DECtape	10-17
LINCtape	10-17
System device	7
RK8 disk	20-23

Thus, the user-coded file devices should use entry points other than 7-23.

If a new file-structured user device is added to the system, it will be necessary to alter the device length table in PIP in order to be able to properly zero the device directory. To do this, ODT is used as follows:

```
.GET SYS PIP
.ODT
136NN/0000 XXXX
↑C
.SAVE SYS PIP
```

NN represents the two-digit device type indicated in the Device Control Block Table (Table 33). XXXX is the negative of the last block number on the device. Both NN and XXXX are octal numbers.

For example, if the new device is assigned a code of 22 (currently the first unused entry), and the last OS/8 block on the device was block 1000, PIP would be changed as follows:

```
.GET SYS PIP
.ODT
13622/0000 7000
↑C
.SAVE SYS PIP
```

OS/8 DEMONSTRATION RUN

The following pages present a demonstration of the use of the OS/8 system. The Teletype output is set off by letters (to its left) which correspond to the textual explanations on the facing page. This demonstration illustrates the procedures involved and use of many of the OS/8 system programs and commands.

A The user calls PIP into core. The first input line gives a command to zero the DECtape on Unit 1, specifying one additional information word in the directory.

B The user begins to type a command but decides to return control to the Keyboard Monitor first. He types a CTRL/C and uses the DATE command to set the system date to January 10, 1972.

C The ASSIGN command is used to give DTA1 the additional name IN. All subsequent references to IN refer to DTA1.

D PIP is again called to list the directory of DECtape Unit 1. The user gets the error message "IN NOT FOUND" because he neglected to insert a colon after IN in the command string. The command is retyped correctly.

E An extended directory listing of DTA1 is produced. Control remains in PIP. The user types CTRL/C to return to the Keyboard Monitor.

F The Keyboard Monitor GET and SAVE commands are used to copy EDIT from the system device to DTA1.

G The FORTRAN compiler is run to compile and execute the program TEST1 on the device DSK: . The /G, /I, and /O options cause automatic loading and execution of the program and the device independent I/O. An output relocatable binary file named TEST1 is saved by SABR on DECtape Unit 1. The program has an error in it. Control is returned to the Keyboard Monitor after execution and the error message printed on the Teletype.

H The program EDIT, located on DTA1, is used to correct the error in TEST1. The old program, TEST1, is input to the Editor, and the new (corrected) program, TEST2, is written by the Editor onto DTA1. The first page is yanked into core.

I The user has noticed a misspelled word in FORMAT line 35 and used the string search feature of the Editor to correct it. An END statement is appended to the program.

A
```
.R PIP
*DTA1:</Z=1
```
B
```
*/E↑C
.DATE 1/10/72
```
C
```
.ASSIGN DTA1 IN
.R PIP
```
D
```
*IN/E
IN NOT FOUND
*IN:/E
```
E
```
 1/10/72
<EMPTY>    730
 730 FREE BLOCKS

*↑C
```
F
```
.GET SYS EDIT

.SAVE IN EDIT 0-5000;200=2001
```
G
```
.R FORT
*IN:TEST1<TEST1/G/I/O
/       CALL EXIT
                  ↑
NO END STATEMENT

.RUN IN EDIT
```
H
```
*IN:TEST2<TEST1

#Y
```
I
```
#/:0055
#$35     'L
35       FORMAT ('THE AVERATE IS' F20.2/)

#.S
35       FORMAT ('THE AVERAT\GE IS' F20.2/)

#.L
35       FORMAT ('THE AVERAGE IS' F20.2/)

#/L
         CALL EXIT

#A
         END
```

```
#L
C       THIS PROGRAM PRESENTS A FEW OF THE FEATURES
C       OF OS/8 FORTRAN; SPECIFICALLY IT INCLUDES IM-
C       PLIED DO LOOPS, DIRECT INSERTION OF SABR CODE
C       AND EXPANDED I/O.

C       THIS SECTION READS DATA FROM THE TTY AND WRITES
C       IT ONTO THE DSK AS AN ARRAY.

        DIMENSION A(10)
L(5     CALL OOPEN ('DSK','ABCD')
        WRITE (1,10)
  10    FORMAT ('ENTER 10 NUMBERS IN F6.2 FORMAT.')
        WRITE (1,11)
  11    FORMAT ('FOLLOW EACH WITH A CARRIAGE RETURN:'//)
K       READ (1,15) (A(N), N=1,10)
        WRITE (4,15) (A(N), N=1,10)
  15    FORMAT (F6.2)
L       CALL OCLOSE

C       THIS SECTION ADDS THE NUMBERS STORED ON THE DSK
C       AND AVERAGES THEM, PRINTING BOTH RESULTS ON
C       THE TELETYPE.

        SUM=0.0
        DO 20 I=1,10
L(20    A(I)=0.0
        CALL IOPEN ('DSK','ABCD')
J       K(  READ (4,15) (A(N), N=1,10)
        DO 25 N=1,10
        SUM=SUM+A(N)
  25    CONTINUE
        WRITE (1,30) SUM
  30    FORMAT (/'THE SUM IS' F20.2)
        AVR=SUM/10.
        WRITE (1,35)AVR
  35    FORMAT ('THE AVERAGE IS' F20.2/)

C       THE SABR CODE FOLLOWING CHECKS FOR A CARRIAGE
C       RETURN CHARACTER TO INITIATE REPEATING THE
C       PROGRAM.  ANY OTHER CHARACTER TERMINATES THE
C       PROGRAM.

        WRITE (1,40)
  40    FORMAT ('TO REPEAT, TYPE A CARRIAGE RETURN.'//)
  SX,   KSF
  S     JMP X
  S     KRB
M S     TAD MYES
  S     SZA
  S     JMP \50
        GO TO 5
  SMYES, -215
  50    WRITE (1,60)
  60    FORMAT (/'PROGRAM DONE'//)
N(      CALL EXIT
        END

O( #E
```

J The user instructs the Editor to list the entire FORTRAN program.

K Note the use of implied DO loops in the READ and WRITE statements . . .

L and device independent I/O. A file named ABCD.DA is opened on the default device DSK and data is written into it. When all the data is entered, the file is closed. Later, this file is again opened, and the data is read and used by the program.

M An S in column 1 of a FORTRAN line indicates that the line contains SABR code.

N CALL EXIT is used to return control to the Keyboard Monitor after execution.

O After listing the program, the E command to the Editor closes the file and returns control to the Keyboard Monitor.

```
P  .AS DTA1 OUT
   .R FORT
   *OUT:TEST2<OUT:TEST2/G/I/O

   ENTER 10 NUMBERS IN F6.2 FORMAT.
   FOLLOW EACH WITH A CARRIAGE RETURN:


   16.23
   32.00
   171.45
   2.15
   22.10
   77.35
Q  2.91
   66.00
   .46
   27.50

   THE SUM IS                  418.15
   THE AVERAGE IS                41.81

   TO REPEAT, TYPE A CARRIAGE RETURN.


   PROGRAM DONE
```

```
   .DEAS
R  .AS DTA1 X
   .R PIP
   *X:/L

    1/10/72
S  EDIT  .SV   12 1/10/72
   TEST2        4 1/10/72
   TEST2 .RL    4 1/10/72
   710 FREE BLOCKS
```

P The ASSIGN command is used to change the assigned name of DTA1 from IN to OUT. The FORTRAN compiler is called again, and the program is loaded. An output relocatable binary file named TEST2 is saved by SABR on DECtape Unit 1.

Q The FORTRAN program is executed. Input is requested, and results are calculated and returned. Execution is not repeated.

R The DEASSIGN command is used to delete all user-assigned device names. The ASSIGN command is then used to give the name X to DTA1.

S PIP is run to obtain a directory listing of DECtape Unit 1. TEST2.RL is the relocatable binary output file from the FORTRAN compilation.

```
*TTY:<SYS:/L

 1/10/72
ABSLDR.SV    5  10/31/70
LIB8   .RL   30  10/30/70
PIP    .SV    9  11/2/70
EDIT   .SV    9  11/5/70
PAL8   .SV   14  11/5/70
FORT   .SV   25  11/1/70
SABR   .SV   23  11/5/70
LOADER.SV   11  11/2/70
CONVRT.SV    8  10/29/70
CONFIG.PA  119  11/6/70
SWAP   .SV    3  11/6/70
CONV10.SV   11  11/6/70
ESCAPE.SV    2  11/6/70
PS8    .BN   19  11/6/70
CD     .BN    9  11/6/70
TC01   .BN    6  11/6/70
RF08   .BN    5  11/6/70
DF32   .BN    5  11/6/70
RK8    .BN    6  11/6/70
DTC8   .SV    5  11/6/70
TOG8   .SV    7  11/6/70
BLURB        12  11/6/70
PIP10  .SV   17
CREF   .SV   13
PROG3         4
PROG4         4
TEST1         4
ABCD   .DA    1  1/10/72
 295 FREE BLOCKS
```

T

```
*PROG3,PROG4,TEST1</D
*TEST2<X:TEST2
*↑C

.
```

U

T Next, PIP is used to print the directory of the system device. ABCD.DA is the FORTRAN data file created in the preceding program.

U PIP is used to delete the unwanted files PROG3, PROG4, and TEST1 from the system device. Then the ASCII file TEST2 is copied from DECtape Unit 1 to the system device. CTRL/C returns control to the Keyboard Monitor before leaving the system.

ERROR MESSAGE SUMMARIES

The following summaries are provided for the user's convenience. Error messages are grouped in alphabetical order according to the system program by which they are generated. These are only summaries; the user is referred to the appropriate sections for details.

Keyboard Monitor

Message	Meaning
BAD ARGS	The arguments to the SAVE command are not consistent and violate restrictions.
BAD CORE IMAGE	The file requested was not a core image file.
BAD DATE	The date has not been entered correctly, or incorrect arguments were used.
ILLEGAL ARG.	The SAVE command was not expressed correctly; illegal syntax used.
MONITOR ERROR 2 AT xxxx	Attempt made to output to a WRITE-LOCKed device, usually DECtape; or an error has occurred reading/writing a directory.
MONITOR ERROR 5 AT xxxx	An error occurred while doing I/O to the system device. This error is normally the result of not WRITE-ENABLEing the system device.
MONITOR ERROR 6 AT xxxx	A directory overflow has occurred (no room for tentative file entry in directory).
name NOT AVAILABLE	The device with the name given is not listed in any system table, or it is not available for use at the moment, or the user tried to obtain input from an output-only device.
name NOT FOUND	The file with the name given was not found on the device indicated, or the user tried to input from an output-only device.
NO! !	The user attempted to start (with .ST) a program which cannot be started.

Keyboard Monitor (Cont.)

Message	Meaning
SAVE ERROR	An I/O error has occurred while saving the program. The program remains intact in core.
SYSTEM ERR	An error occurred while doing I/O to the system device. The system should be restarted at 7600 or 7605. Do *not* press CONTinue as this is sure to cause further errors.
TOO FEW ARGS	An important argument has been omitted from a command.
USER ERROR 0 AT xxxx	An input error was detected while loading the program. xxxx refers to the Monitor location where the error was generated.
abcd	Where abcd represents an illegal command.

Command Decoder

Message	Meaning
ILLEGAL SYNTAX	The command line was formatted incorrectly.
name DOES NOT EXIST	The device with the name specified could not be found in the system tables.
name NOT FOUND	The file with the name specified does not exist on the device indicated.
TOO MANY FILES	More than three output files or nine input files were specified.

Symbolic Editor

Error Code	Meaning
0	Editor failed in reading a device. Error occurred in device handler; most likely a hardware malfunction.
1	Editor failed in writing onto a device. Generally a hardware malfunction or WRITE-LOCKed device.
2	File close error occurred. The output file could not be closed; the file does not exist on that device.
3	File open error occurred. This error occurs if the output device is a read-only device or if no output file name is specified on a file-oriented output device.
4	Device handler error occurred. The Editor could not load the device handler for the specified device. This error should never occur.
5	An attempt was made to CHAIN to the Editor. (This is not permitted; the Editor must be loaded by a RUN or R command.)
FULL *	The specified output device has become full. The file is closed; the user must specify a new output file.

PIP

Message	Meaning
ARE YOU SURE?	Occurs when using the /S option. A response of 'Y' will compress the files.
BAD DIRECTORY ON DEVICE # n	Error message occurs when: 1. PIP is trying to read the directory, but it is not an OS/8 directory. 2. The output device does not have a system directory; i.e. file storage begins at record 7 (occurs during a /Y transfer) n is the number of the file in the input file list.
BAD SYSTEM HEAD	If the /Y option is used and the area being transferred does not contain OS/8, this message results.

Message	Meaning
CAN'T OPEN OUTPUT FILE	Message occurs due to one of the following: 1. Output file is on a read-only device 2. No name has been specified for the output file 3. A /Y transfer has been attempted to a non-directory device 4. Output file has zero free blocks
DEVICE # n NOT A DIRECTORY DEVICE	Message occurs when: 1. Trying to list the directory of a non-directory device 2. The input designated in a /Y transfer is not on a directory device n gives the number of the device in the input list.
DIRECTORY ERROR	An error has occurred while reading or writing the directory during a /S option.
ERROR DELETING FILE	An attempt was made to delete a file that does not exist.
ILLEGAL BINARY INPUT, FILE # n	Self explanatory; n is the number of the file in the input file list.
INPUT ERROR, FILE # n	An input error occurred while reading file number n in the input file list.
IO ERROR IN (file name) —CONTINUING	An error has occurred during a /S transfer.
LINE TOO LONG IN FILE # n	In ASCII mode, a line has been found greater than 140 characters.
NO ROOM FOR OUTPUT FILE	Either room on device or room in directory is lacking.
NO ROOM IN (file name) —CONTINUING	Occurs during use of the /S option. The output device cannot contain all of the files on the input device.
OUTPUT ERROR	Output error—possibly a WRITE-LOCKed device, parity error, or attempt to output to a read-only device.

PIP (Cont.)

Message	Meaning
PREMATURE END OF FILE, FILE # n	Message occurs in Binary Mode (/B) only. A physical end-of-file has been found before the final leader/trailer.
SORRY—NO INTERRUPTIONS	Error message occurs if: 1. ↑C (CTRL/C) is typed while compressing a file onto itself; the transfer continues 2. A /Y transfer is done with system device as the output, or if the transfer has both input and output on the same device.
ZERO SYSTEM?	If any attempt is made to zero the system device directory, this message occurs. Responding with 'Y' causes the directory to be zeroed; any other character aborts the operation.

ABSLDR

Message	Meaning
BAD CHECKSUM, FILE # n	File number n of the input file list has a checksum error.
BAD INPUT, FILE # n	Attempt was made to load a non-binary file as file number n of the input file list; or a non-core image with /I option.
I/O ERROR, FILE # n	An I/O error has occurred in input file number n.
NO INPUT	No input file was found on the designated device.
NO /I!	Use of /I is prohibited at this point.

Error Code	Explanation
BE	Two PAL8 internal tables have overlapped; fatal error.
DE	Device error; an error was detected when trying to read or write a device; fatal error.
DF	Device full; fatal error.
IC	Illegal character; the character is ignored and the assembly continued.
ID	Illegal redefinition of a symbol; the symbol is not redefined.
IE	Illegal equals; an equal sign was used in the wrong context.
II	Illegal indirect; an off-page reference was made.
IP	Illegal pseudo-op; a pseudo-op was used in the wrong context or with incorrect syntax.
IZ	Illegal page zero reference; the pseudo-op Z was found in an instruction which did not refer to page zero. The Z is ignored.
LD	This message is given if the /L or /G options have been specified and the Absolute Loader cannot be found on the system device.
PE	Current non-zero page exceeded; an attempt was made to: 1. Override a literal with an instruction, 2. Override an instruction with a literal, or 3. Use more literals than the assembler allows on that page.
PH	Phase error; either no $ appeared at the end of the program, or < and > in conditional pseudo-ops did not match; fatal error.
RD	Redefinition; a permanent symbol has been defined with =. The new and old definitions do not match; the redefinition is allowed.
SE	Symbol table exceeded; too many symbols have been defined for the amount of core available; fatal error.
UO	Undefined origin; an undefined symbol has occurred in an origin statement.

Error Code	Explanation
US	Undefined symbols; a symbol has been processed during pass 2 that was not defined before the end of pass 1.
ZE	Page 0 exceeded; same as PE except with reference to page 0.

CREF

Message	Meaning
CLOSE FAILED	CLOSE on output file failed.
DEV LPT BAD	The default output device, LPT, cannot be used as it is not available on this system.
ENTER FAILED	Entering an output file was unsuccessful—possibly output was specified to a read-only device.
HANDLER FAIL	This is a fatal error on output, and can occur if either the system device or the selected input device is WRITE-LOCKed.
INPUT ERROR	A read from input device failed.
OUT DEV FULL	The output device is full (directory devices only).
SYM OVERFLOW	More than 896 (decimal) symbols and literals were encountered.
2045 REFS	More than 2044 (decimal) references to one symbol were made.

FORTRAN

COMPILER ERROR MESSAGES

The following error messages are self-explanatory:

ARITHMETIC EXPRESSION TOO COMPLEX
EXCESSIVE SUBSCRIPTS
ILLEGAL ARITHMETIC EXPRESSION
ILLEGAL CONSTANT
ILLEGAL CONTINUATION
ILLEGAL EQUIVALENCING

ILLEGAL OR EXCESSIVE DO NESTING
ILLEGAL STATEMENT
ILLEGAL STATEMENT NUMBER
ILLEGAL VARIABLE
MIXED MODE EXPRESSION
SYMBOL TABLE EXCEEDED
SYNTAX ERROR (usually indicates illegal punctuation)
SUBR. OR FUNCT. STMT. NOT FIRST

Message	Meaning
COMPILER MALFUNCTION	The meaning of this message has been extended to cover various unlikely Monitor errors.
IO	A device handler has signalled an I/O error.
NO END STATEMENT	The input to the Compiler has been exhausted.
NO ROOM FOR OUTPUT	The file FORTRN.TM cannot fit on the system device.
SABR.SV NOT FOUND	The SABR assembler is not present on the system device.

LIBRARY ERROR MESSAGES

Error Code	Meaning

The following errors are fatal and cause a return to the Keyboard Monitor.

ALOG — Attempt to compute log of negative number.

CHER — File specified as argument to CHAIN not found on system device.

FMT1 — Invalid format statement.

IOER — One of the following has occurred:

1. Device independent input or output attempted without /I or /O options, or user attempted to specify a device requiring a two-page handler for device-independent I/O without using the /H option.
2. Bad arguments to IOPEN or OOPEN, or
3. Transmission error while doing I/O.

FORTRAN (Cont.)

Error Code	Meaning
The following input errors are fatal unless input is coming from the Teletype, in which case the entire READ statement is tried again.	
FMT2	Illegal character in I format.
FMT3	Illegal character if F or E format.
The following errors do not terminate execution of the user's program.	
DIVZ	Division by zero; very large number is returned.
EXP	Argument to EXP too large; very large number is returned.
FIX	Attempt to fix a number >2047; 2047 is returned.
FLPW	Negative number raised to floating point power; absolute value taken.
OVFL	Floating point overflow; very large number is returned.
SQRT	Attempt to take square root of negative number; absolute value used.
USER ERROR 1 AT xxxx	The user tried to reference an entry point of a program which was not loaded, or he failed to define a subscripted variable in a DIMENSION statement. xxxx has no meaning.

SABR

Error Code	Meaning
A	Too many or too few ARG statements follow a CALL statement.
C	An illegal character appears on the line.
D	A device handler has returned a fatal error condition.
E	There is no END statement.
I	An illegal syntax has been used (i.e. one of the following): 1. A pseudo-op with improper arguments 2. A quote mark with no argument 3. A non-terminated text-string 4. An improper address 5. An illegal combination of micro-instructions

SABR (Cont.)

Error Code	Meaning
L	/L or /G option was indicated, but the LOADER.SV file does not exist on the system device.
M	A symbol is multiply defined. Listings of programs with multiple definitions have unmarked errors.
S	Either the symbol table has overflowed, common storage has been exhausted, more than 64 different user-defined symbols occurred in a core page, or more than 64 external symbols have been declared. Could also indicate a system error such as overflowed output file.
U	No symbol table is being produced, but there is at least one undefined symbol in the program.
UNDF	Undefined symbol; printed in the symbol table listing.

Linking Loader

Error Code	Meaning
0000	/I or /O specified too late.
0001	Symbol table overflow; more than 64 subprogram names.
0002	Program will not fit into core.
0003	Program with largest common storage area was not loaded first.
0004	Checksum error in input tape.
0005	Illegal relocation code.
0006	An output error has occurred.
0007	An input error has occurred (either a physical device error, or an attempt was made to read from a write-only device such as LPT:).
0010	No starting address has been specified and there is no entry point named MAIN.
0011	An error occurred while the Loader attemped to load a device handler.
0012	I/O error on system device.

LIBSET

Message	Meaning
BAD FORMAT OR CHECKSUM—TRY AGAIN	Error in reading relocatable binary file.
ERROR WHILE WRITING OUTPUT FILE	Fatal output error occurred.
INPUT ERROR	Parity error on input.
LIBRARY DIRECTORY OVERFLOW	Too many subroutines were specified. Every subroutine name in the input file requires four words, and every relocatable binary file read requires two words. If the total number of words exceeds 250, the library must be split into two separate files.

BUILD

Individual commands in BUILD have separate error messages associated with them. Each command will be listed, followed by the possible error messages.

Message	Meaning
LOAD	
BAD ARG	No device name was detected.
BAD INPUT	An error has been detected in the binary file; it is not a proper input for the LOAD command.
(DEV.) NOT FOUND	The input device handler does not exist in the current OS/8 system.
(FILE.) NOT FOUND	The file indicated does not exist on the specified device.
IO ERR	An error was encountered reading the input device.

Message	Meaning
OVERFLOW	Indicates that either: 1. An illegal origin has occurred (an origin outside of 200-577) or 2. There is insufficient room to load a two-page handler. The overflow condition can be relieved by using the UNLOAD function.
.?	The input device is file structured but no filename was specified.
INSERT	
(NAME.) NOT FOUND	The name specified was not found in BUILD'S internal tables.
NO SLOT	No records are available to hold this handler. OS/8 can only handle 8 device handler records. If a device requires a new slot and all 8 slots are in use, this error message is generated.
PERM NAME?	BUILD needs a permanent name specification to insert this handler. Generated only with multiple entry points.
UNLOAD	
ACTIVE HANDLERS	The group of handlers has at least one member still active.
NAME	
PNAM. NOT FOUND	No currently active device by the name of PNAM was found. Check PRINT to see what the correct name was.
ALTER	
BAD #	A non-octal number has been entered.
BAD ARG	AAAA is too large for this handler. The limits are: 1 page handler 0-0177 2 page handler 0-0377

Message	Meaning
SYSTEM	
BAD # SYS=	n was not an octal number. BUILD requests valid system name again.
BAD ARG SYS=	n was too large for the specified device.
General Error Messages	
BAD #	A non-octal digit was found where an octal digit was required.
IO ERR	An error has occurred while reading from an input device during a LOAD command.
(NAME.) NOT FOUND	The device or file name designated in the command was not found.
SYNTAX ERR	An illegal character was found in a BUILD command line. The line must be retyped.
.? or ABCD?	An illegal command has been issued. BUILD did not recognize that command.

appendix a
loading procedures

Initializing the system

Before using the computer system, it is good practice to initialize all units. To initialize the system, ensure that all switches and controls are as specified below.

1. Main power cord is properly plugged in.
2. Teletype is turned OFF.
3. Low-speed punch is OFF.
4. Low-speed reader is set to FREE.
5. Computer POWER key is ON.
6. PANEL LOCK is unlocked.
7. Console switches are set to 0.
8. SING STEP is not set.
9. High-speed punch is OFF.
10. DECtape REMOTE lamps OFF.

The system is now initialized and ready for your use.

Loaders

READ-IN MODE (RIM) LOADER

When a computer in the PDP-8 series is first received, it is nothing more than a piece of hardware; its core memory is completely demagnetized. The computer "knows" absolutely nothing, not even how to receive input. However, the programmer can manually load data directly into core using the console switches.

The RIM Loader is the very first program loaded into the computer, and it is loaded by the programmer using the console

switches. The RIM Loader instructs the computer to receive and store, in core, data punched on paper tape in RIM coded format (RIM Loader is used to load the BIN Loader described below.)

There are two RIM loader programs: one is used when the input is to be from the low-speed paper tape reader, and the other is used when input is to be from the high-speed paper tape reader. The locations and corresponding instructions for both loaders are listed in Table A-1.

The procedure for loading (toggling) the RIM Loader into core is illustrated in Figure A-1.

Table A-1. RIM Loader Programs

Location	Instruction	
	Low-Speed Reader	High-Speed Reader
7756	6032	6014
7757	6031	6011
7760	5357	5357
7761	6036	6016
7762	7106	7106
7763	7006	7006
7764	7510	7510
7765	5357	5374
7766	7006	7006
7767	6031	6011
7770	5367	5367
7771	6034	6016
7772	7420	7420
7773	3776	3776
7774	3376	3376
7775	5356	5357
7776	0000	0000

After RIM has been loaded, it is good programming practice to verify that all instructions were stored properly. This can be done by performing the steps illustrated in Figure A-2, which also shows how to correct an incorrectly stored instruction.

When loaded, the RIM Loader occupies absolute locations 7756 through 7776.

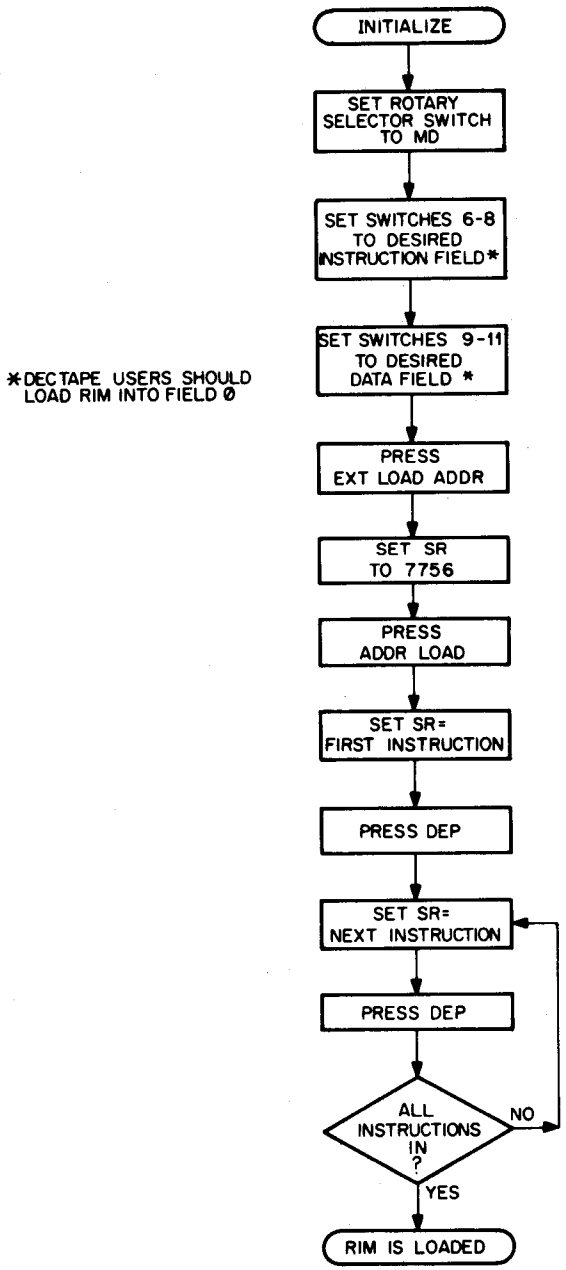

Figure A-1. Loading the RIM Loader

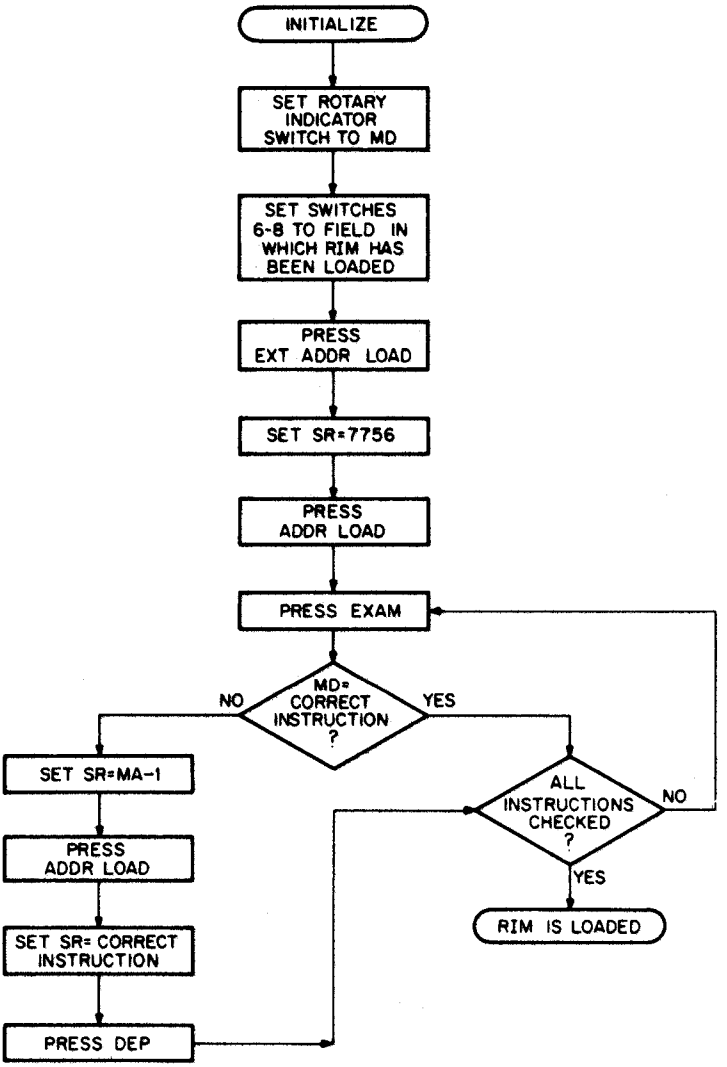

Figure A-2. Checking the RIM Loader

BINARY (BIN) LOADER—

The BIN Loader is a short utility program which, when in core, instructs the computer to read binary-coded data punched on paper tape and store it in core memory. BIN is used primarily to load the programs furnished in the software package (excluding the loaders and certain subroutines) and the programmer's binary tapes.

BIN is furnished to the programmer on punched paper tape in RIM-coded format. Therefore, RIM must be in core before BIN can be loaded. Figure A-3 illustrates the steps necessary to properly load BIN. And when loading, the input device (low- or high-speed reader) must be that which was selected when loading RIM.

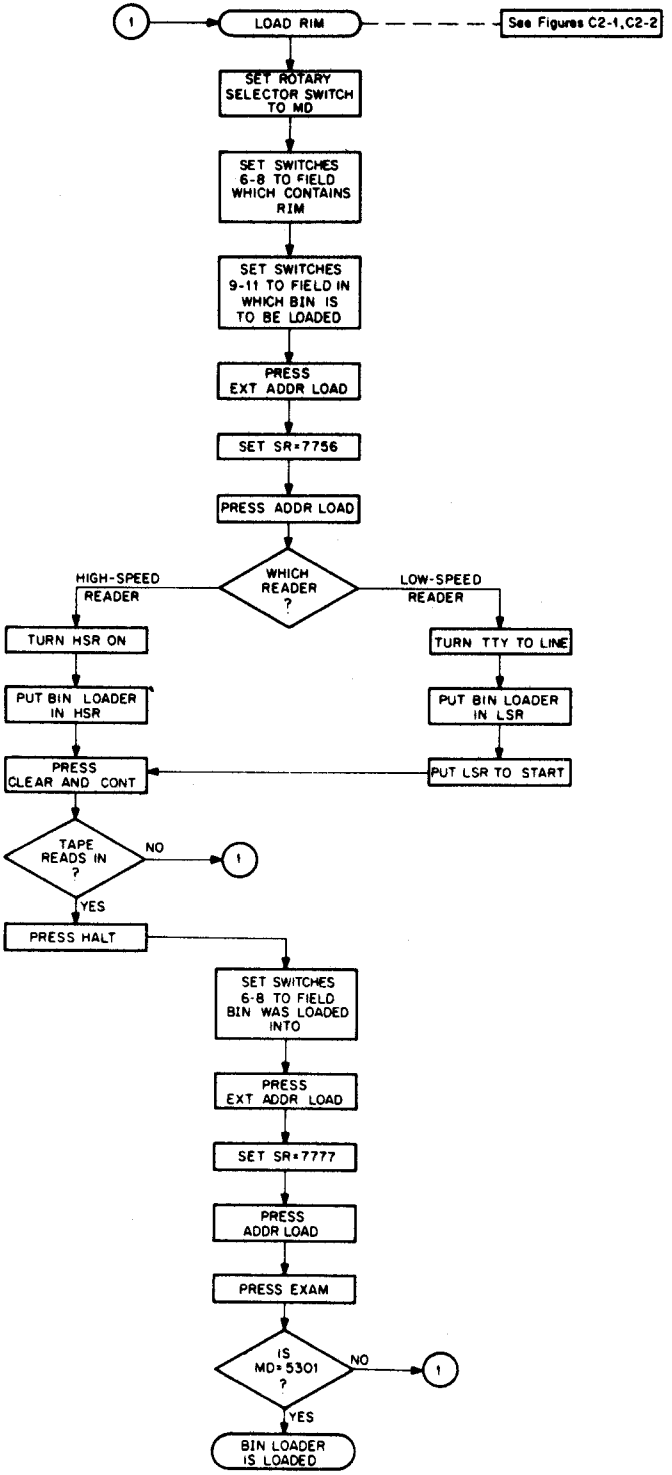

Figure A-3 Loading the BIN Loader

When stored in core, BIN resides on the last page of core, occupying absolute locations 7625 through 7752 and 7777.

BIN was purposely placed on the last page of core so that it would always be available for use—the programs in DEC's software package do not use the last page of core (excluding the Disk Monitor). The programmer must be aware that if he writes a program which uses the last page of core, BIN will be wiped out when that program runs on the computer. When this happens, the programmer must load RIM and then BIN before he can load another binary tape.

Binary tapes to be loaded should be started on the leader-trailer code (Code 200), otherwise zeros may be loaded into core, destroying previous instructions.

Figure A-4 lilustrates the procedure for loading binary tapes into core.

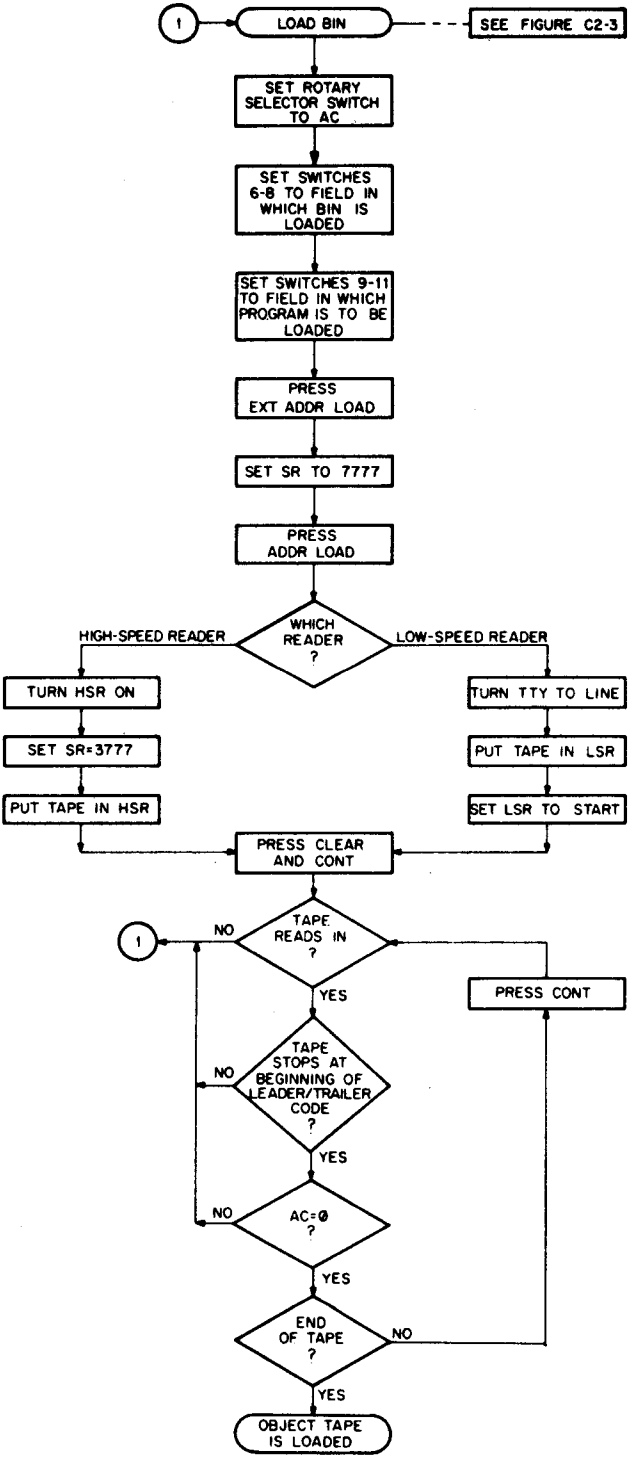

Figure A-4. Loading A Binary Tape Using BIN

appendix b
character codes

ASCII-1[1] Character Set

Character	8-Bit Octal	6-Bit Octal	Decimal Equivalent (A1 Format)	Character	8-Bit Octal	6-Bit Octal	Decimal Equivalent (A1 Format)
A	301	01	96	!	241	41	−1952
B	302	02	160	"	242	42	−1888
C	303	03	224	#	243	43	−1824
D	304	04	288	$	244	44	−1760
E	305	05	352	%	245	45	−1696
F	306	06	416	&	246	46	−1632
G	307	07	480	'	247	47	−1568
H	310	10	544	(	250	50	−1504
I	311	11	608	)	251	51	−1440
J	312	12	672	*	252	52	−1376
K	313	13	736	+	253	53	−1312
L	314	14	800	,	254	54	−1248
M	315	15	864	-	255	55	−1184
N	316	16	928	.	256	56	−1120
O	317	17	992	/	257	57	−1056
P	320	20	1056	:	272	72	−352
Q	321	21	1120	;	273	73	−288
R	322	22	1184	<	274	74	−224
S	323	23	1248	=	275	75	−160
T	324	24	1312	>	276	76	−96
U	325	25	1376	?	277	77	−32
V	326	26	1440	@	300		32
W	327	27	1504	[	333	33	1760
X	330	30	1568	\	334	34	1824
Y	331	31	1632	]	335	35	1888
Z	332	32	1696	↑(^)[2]	336	36	1952
0	260	60	−992	←(_)[2]	337	37	2016
1	261	61	−928	Leader/Trailer	200		
2	262	62	−864	LINE FEED	212		
3	263	63	−800	Carriage RETURN	215		
4	264	64	−736	SPACE	240	40	−2016
5	265	65	−672	RUBOUT	377		
6	266	66	−608	Blank	000		
7	267	67	−544	BELL	207		
8	270	70	−480	TAB	211		
9	271	71	−416	FORM	214		

[1] **An abbreviation for American Standard Code for Information Interchange.**

[2] The character in parentheses is printed on some Teletypes.

appendix c
permanent symbol table

The following are the elements of the PDP-8 instruction set found in the SABR permanent symbol table. These instructions are already defined within the computer. For additional information on these instructions and for a description of the symbols used when programming other, optional, I/O devices, see the *Small Computer Handbook,* available from the DEC Software Distribution Center.

INSTRUCTION CODES

Mnemonic	Code	Operation	Time (μsec.)[1]
Memory Reference Instructions			
AND	0000	Logical AND	2.6
TAD	1000	Two's complement add	2.6
ISZ	2000	Increment and skip if zero	2.6
INC	2000	Nonskip ISZ	2.6
DCA	3000	Deposit and clear AC	2.6
JMS	4000	Jump to subroutine	2.6
JMP	5000	Jump	1.2
			Sequence
Group 1 Operate Microinstructions (1 cycle[2])			
NOP	7000	No operation	—
IAC	7001	Increment AC	3
RAL	7004	Rotate AC and link left one	4
RTL	7006	Rotate AC and link left two	4
RAR	7010	Rotate AC and link right one	4
RTR	7012	Rotate AC and link right two	4
CML	7020	Complemented link	2
CMA	7040	Complement AC	2
CLL	7100	Clear link	1
CLA	7200	Clear AC	1

[1] Times are representative of the PDP-8/E.

[2] 1 cycle is equal to 1.2 microseconds.

Mnemonic	Code	Operation	Sequence
Group 2 Operate Microinstructions (1 cycle)			
HLT	7402	Halts the computer	3
OSR	7404	Inclusive OR SR with AC	3
SKP	7410	Skip unconditionally	1
SNL	7420	Skip on nonzero link	1
SZL	7430	Skip on zero link	1
SZA	7440	Skip on zero AC	1
SNA	7450	Skip on nonzero AC	1
SMA	7500	Skip on minus AC	1
SPA	7510	Skip on positive AC (zero is positive	1
Combined Operate Microinstructions			
CIA	7041	Complement and increment AC	2, 3
STL	7120	Sent link to 1	1, 2
STA	7240	Set AC to - 1	2
Internal IOT Microinstructions			
ION	6001	Turn interrupt processor on	
IOF	6002	Disable interrupt processor	
Keyboard/Reader (1 cycle)			
KSF	6031	Skip on keyboard/reader flag	
KRB	6036	Clear AC, read keyboard buffer (dynamic), clear keyboard flags	
Teleprinter/Punch (1 cycle)			
TSF	6041	Skip on teleprinter/punch flag	
TLS	6046	Load teleprinter/punch, print, and clear teleprinter/punch flag	
High Speed Reader—Type PR8/E (1 cycle)			
RSF	6011	Skip on reader flag	
RRB	6012	Read reader buffer and clear reader flag	
RFC	6014	Clear flag and buffer and fetch character	
High Speed Punch—Type PP8/E (1 cycle)			
PSF	6021	Skip on punch flag	
PLS	6026	Clear flag and buffer, load buffer and punch character	

PSEUDO-OPERATORS

The following is a list of the SABR assembler pseudo-operators.

ABSYM
ACH
ACM
ACL
ARG
BLOCK
CALL
COMMN
CPAGE
DECIM
DUMMY
EAP
END
ENTRY
FORTR
I
IF
LAP
OCTAL
OPDEF
PAGE
PAUSE
REORG
RETRN
SKPDF
TEXT

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OS/8 SYSTEM REFERENCE MANUAL
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