I/O MONITOR GUIDE
for
PAPER TAPE SYSTEMS

PDP-9 ADVANCED
Software System

Order No. DEC-9A-MIPA-D from Program Library, Maynard, Mass. Price $1.00
Direct comments concerning this manual to Software Quality Control, Maynard, Mass.

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INTRODUCTION

This guide for operating the paper tape version of the PDP-9 ADVANCED Software System is planned for convenient use at the computer. It contains general operating instructions, as well as concise summaries of operating procedures for individual system programs. For more detailed descriptions of the monitor and system programs, the reader is referred to the following PDP-9 ADVANCED Software System manuals.

Manual	Document Number
Utility Programs	DEC-9A-GUAB-D
MACRO-9	DEC-9A-AM9B-D
FORTRAN-IV	DEC-9A-AF4B-D
Monitors	DEC-9A-MAD0-D

1. LOADING PROGRAMS

In the paper tape system, each system program, accompanied by the necessary I/O device handlers and an appropriate version of the I/O Monitor, resides on a separate paper tape in absolute format. The eight system tapes supplied are:

FORTRAN IV

MACRO-9

PIP-9

Editor (EDIT-9)

Linking Loader (LINK-9)

DDT-9 (without patch file capabilities)

DDT-9 (with patch file capabilities)

7-To-9 Converter (CONV-9)

To load these programs, place the tape in the reader, set the loading address in the console address switches, press the tape feed button, depress I/O RESET, and then depress the READ IN switch.

The loading addresses are:

17720 for 8K systems

37720 for 16K systems

57720 for 24K systems

77720 for 32K systems

Either the Linking Loader or DDT-9 may be used to load user programs.

2. SYMBOLS (Used in This Manual)

↵	Represents carriage return.
␣	Represents space.
↑	Echoed on Teletype for CTRL (control key) functions.

1. LOADING INSTRUCTIONS

Place the FORTRAN IV Compiler tape in the paper tape reader, depress the tape-feed switch to clear the end-of-tape flag, set the address switches to 17720 (8K), and depress I/O RESET and READ IN.

When FORTRAN IV has been loaded, it types

```
FORTRAN 4
>
```

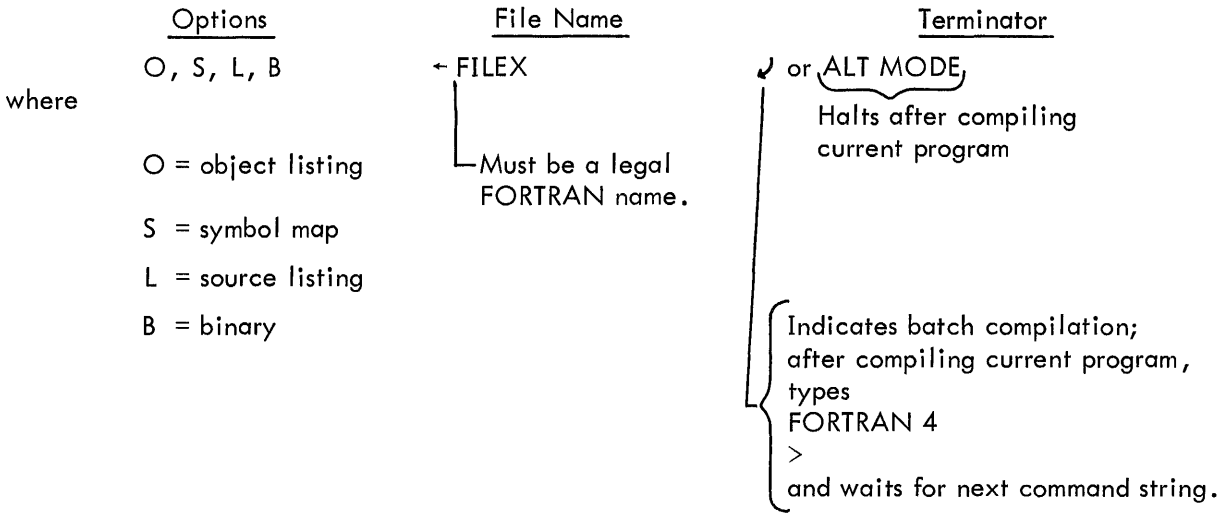
on the Teletype and waits for a command string from the user.

2. GENERAL COMMAND CHARACTERS

RUBOUT (echoes \)	Delete single character.
CTRL U (echoes @)	Delete entire line.
CTRL P (echoes ↑P)	a) If end of pass 1, begin pass 2. b) If compiler is running, restart at beginning of pass 1.

3. COMMAND STRING

The format expected by the FORTRAN IV command string processor is as follows:



The options may be used in any combination (or none at all). The options desired may appear in any order, separated by commas and terminated by ←. If none of the options are desired, ← is sufficient, with the sole output being compiler diagnostics on the Teletype. Rubouts may be used to delete unwanted characters, and CTRL U to delete entire lines, prior to typing the command string terminator.

4. RUNNING INSTRUCTIONS

After the compiler is loaded into core,

a. Place the source program tape in the paper tape reader, and momentarily depress the tape-feed switch.

b. Type the command string.

c. At the end of Pass 1 (when the END statement is encountered for the first time), FORTRAN IV types:

```
END PASS 1
↑P
```

d. Reload the source tape for Pass 2 and momentarily depress the tape-feed switch.

e. Initiate Pass 2 by typing CTRL P.

5. ERROR CONDITIONS AND RECOVERY

IOPS 4, device not ready. Check devices, correct condition, and type CTRL R.

IOPS 00-30, see Appendix 5 for system restart procedures.

See Appendix 7 for a list of compiler errors.

6. RESTART PROCEDURES

CTRL P, restart the compiler, if running.

See Appendix 5 for system restart procedures if FORTRAN IV has halted.

7. EXAMPLES

a. To compile a source tape with none of the options, type the command string:

```
← FILEX ↵
```

This is very useful for a first compilation when only error messages are desired.

b. If the output desired is a binary tape, type the command string:

```
B ← FILEX ↵
```

c. If the output desired is a complete listing, type the command string:

```
SLO ←FILEX ↵
```

LOADING INSTRUCTIONS

Place the MACRO-9 Assembler tape in the paper tape reader, depress the tape-feed switch to clear the end-of-tape flag, set address switches to 17720 (8K), and depress I/O RESET and READ IN. When MACRO-9 has been loaded, it types

```
MACRO
>
```

on the Teletype and waits for a command string from the user.

2. GENERAL COMMAND CHARACTERS

RUBOUT (echoes \)	Delete single character.
CTRL U (echoes @)	Delete complete line.
CTRL P (echoes ↑P)	a) If end of pass 1, begin pass 2. b) If assembler is running, restart at beginning of pass 1.

3. COMMAND STRING

The format expected by the MACRO-9 command string processor is as follows:

Options	File Name	Terminator
P, S, L, B	←FILEX	↵ or ALT MODE

ALT MODE: Halts after assembling current program.

↵: Return to MACRO-9 after assembling current program, types

```
MACRO
>
```

and waits for next assembly command string.

where

P = parameters to be entered on teletype

S = symbol table (on listing device)

L = listing

B = binary

Options may be used in any combination (or none at all). The options may appear in any order, separated by commas and terminated by ←. If no options are desired, ← is sufficient and the sole output will be assembly error messages on the Teletype. Rubouts may be used to delete unwanted characters, and CTRL U (↑U) to delete entire lines, prior to typing the command string terminator.

4. RUNNING INSTRUCTIONS

After the Assembler is in core,

a. Place the user program source tape in the paper tape reader, and momentarily depress the tape-feed switch.

b. Type the command string.

c. At the end of Pass 1 (when the .END statement is encountered for the first time) MACRO types

```
END OF PASS 1
↑P
```

d. Reload the source tape for Pass 2 and momentarily depress the tape-feed switch.

e. Initiate Pass 2 by typing CTRL P.

If this is a multi-tape assembly (where the first n source tapes are terminated with .EOT and the last is terminated with .END), MACRO-9 indicates the end of each tape by typing .EOT on the Teletype. This allows the user to load the next source tape (depress the tape-feed control) and then type CTRL P.

If the P option was used, the parameters are entered only at the beginning of Pass 1 and not again for Pass 2.

5. ERROR CONDITIONS AND RECOVERY PROCEDURES

IOPS 4, device not ready. Check devices, correct condition and type CTRL R.

IOPS 00-30, see Appendix 5 for procedures.

See Appendix 3 for a list of MACRO-9 error diagnostics.

6. RESTART PROCEDURES

CTRL P, restart MACRO-9, if running.

See Appendix 5 for system restart procedures if MACRO-9 has halted.

7. EXAMPLES

a. To assemble a source tape with none of the options, type the command string:

←FILEX ↵

This is very useful for the first assembly of a program, when only error messages are desired.

b. If the output desired is a binary tape and input includes parameters to be entered on the Teletype, type the command string:

P, B←FILEX ↵

The parameters should be entered during the first pass only. Parameters are typed following the command string, in the form of MACRO-9 direct assignment statements. After typing in parameters, the user types CTRL D, as shown in the example below.

```
BANK = 0
CTRL D
```

MACRO then types

```
EOT
↑P
```

the user should then type CTRL P when ready to proceed.

c. If the output desired is a complete listing but no binary tape, type the command string:

```
S, L←FILEX↵
```

PIP-9

1. LOADING INSTRUCTIONS

Place the PIP tape in the paper tape reader, depress the tape-feed switch to clear the end-of-tape flag, set the address switches to 17720 (8K), and depress I/O RESET and READ IN.

When PIP-9 has been loaded, it types:

```
PIP
>
```

on the Teletype and waits for a command string from the user.

2. GENERAL COMMAND CHARACTERS

RUBOUT (echoes \)	Delete single character.
CTRL U (echoes @)	Delete entire line.
CTRL P (echoes ↑P)	Restart PIP.

3. COMMAND STRING

The general format of a PIP command string is as follows:

F DD (S) ←SD

terminated by a carriage return or ALT MODE.

F is a function character, which may be:

T = transfer file

V = verify file

S = segment file

DD is the destination device.

PP = paper tape punch

TT = teletype

LP = line printer

(S) indicates the switch options.

Data Mode Switches:

A = IOPS ASCII

B = IOPS binary

I = Image Alphanumeric

Function switches:

G = correct bad parity lines

E = convert tabs to spaces

C = convert multiple spaces to tabs

T = delete trailing spaces

Q = delete sequence numbers

F = insert form feeds

Y = segment files (with n output tapes, use n-1 commas after PP)

W = combine files (with n input tapes, use n-1 commas after PR)

The back arrow (←) terminates information concerning the destination device. Data for the source device follows the back arrow.

SD is the source device.

PR = paper tape reader

TT = teletype

CD = card reader

Carriage return or ALT MODE is the command string terminator:

Carriage Return - return to PIP after completion of the current function.

ALT MODE - halt after completion of the current function.

Rubouts may be used to delete unwanted characters, and CTRL U to delete the entire line, prior to typing the command string terminator.

4. OPERATING INSTRUCTIONS

Legal function/switch combinations

Transfer (T):	all switches legal
ASCII mode (A):	all function switches legal
	E, C, and T are contradictory;
	Y and W are contradictory
	Q may be combined with E, C, or T.
Binary mode (B):	function switch W only
Image mode (I):	no function switches legal
Verify (V):	switches A and B only
Segment (S):	no switches legal

5. ERROR CONDITIONS AND RECOVERY PROCEDURES

IOPS 4 device not ready	Ready device and type CTRL R.
IOPS 00-30	See Appendix 5 for system restart procedures.

6. RESTART PROCEDURES

CTRL P, Restart PIP, if running

See Appendix 5 for system restart procedures if PIP has halted.

7. EXAMPLES

a. To reproduce an ASCII tape:

T␣PP␣(A)␣←␣PR ↵

Transfer to the paper tape punch from the paper tape reader in IOPS ASCII mode.

b. To list an ASCII tape:

T␣ TT␣(A)␣←␣PR ↵

c. To combine 3 binary subprogram tapes into one tape:

T␣ PP␣(BW) ␣←␣PR,, ↵

Since the W switch is on, the three binary tapes will be combined into one file, with the intermediate EOF's deleted. The final EOF is retained. This provides a very convenient method for creating a Library file.

d. To verify a binary tape:

V␣ PR␣(B) ↵

Checksum and parity verification are performed on the input binary tape. There will be no output. If a parity error occurs, the following message is typed:

INPUT PARITY ERROR

If a checksum error:

INPUT CHECKSUM FAILURE

e. To check parity:

T␣PP␣(AG)␣←␣PR ↵

Transfer files from paper tape to paper punch in ASCII mode with G switch to check for parity errors.

For actions to be taken if a parity error is encountered, refer to the explanation for G switch.

f. To reproduce a binary tape:

T␣ P␣ (B)␣←␣PR ↵

Transfer files from paper tape reader to paper tape punch in binary mode.

g. To reproduce in Image mode:

T␣PP␣(I)␣←␣PR ↵

Transfer files from paper tape reader to paper tape punch in image ASCII mode. This is the only way to reproduce a tape with channel 7 punches.

h. To segment a tape:

S␣TAGA, TAGB, TAGC ↵

Sets up the segmentation points.

T␣PP,,,(AY)←PR ↵

Transfers from paper tape reader to paper tape punch, providing EOT and blank tape just before each indicated tag.

↑P is output PIP at the end of each segment. When ready to continue, type CTRL P.

i. To transfer from cards to ASCII paper tape and delete trailing spaces and sequence numbers:

T␣PP␣(ATQ)␣←␣CD ↵

j. To insert a form feed every 56 lines or after every .EJECT:

T␣PP␣(AF)␣←␣CD ↵

EDITOR

1. LOADING INSTRUCTIONS

Place the Editor tape in the reader, depress the tape-feed switch to clear the end-of-tape flag, set the address switches to 17720 (8K), and depress I/O RESET and READ IN. When the Editor has been loaded, it types

```
EDITOR
>
```

on the Teletype and waits for a command string from the user. (It is initially in Edit Mode, and Block Mode is ON.) The user may either create a file or edit an existing file.

2. GENERAL COMMAND CHARACTERS

RUBOUT (echoes \)	Delete single character.
CTRL U (echoes @)	Delete entire line.
CTRL P (echoes ↑ P)	Restart the editor.

3. COMMAND STRING

Not applicable

4. OPERATING PROCEDURES

Editing Operation 1: Creating a file.

User Types In	Action	Effect
↵	INPUT	Mode is changed from Edit to Input.
Content of the program (each line is terminated by ↵)	Punches out previous line typed.	Line typed in is processed.
↵ (necessary before close)	EDIT >	Change from Input to Edit Mode.
CLOSE	punches blank tape EDITOR >	Finishes the current file.

Editing Operation 2: Modifying an existing file:

a. Place the source tape in the reader.

b. Depress tape-feed switch.

c. Type a READ command followed by any command desired. See summary of Edit commands listed below.

SUMMARY OF EDITING COMMANDS

Command	Abbreviation	Activity
File Housekeeping Requests		
CLOSE	n/a	Terminate editing on input file.
Locative Requests		
FIND string	F	Bring first line beginning with "string" to work area.
LOCATE string	L	Bring first line containing "string" to work area.
NEXT	N	Bring next consecutive line to work area.
BOTTOM	B	Bring last line to work area.
TOP*	T	Reset pointer to beginning of block.
PRINT	P	Print the current line on Teletype.
Manipulative Requests		
DELETE	D	Discard the current line.
RETYPE string	R	Replace current line with "string".
INSERT string	I	Add "string" as a complete line, after (below) the current line.
CHANGE/string1/string2/	C	Replace, in the current line, the first occurrence of "string1" with "string2".
OVERLAY	O	Replace multiple lines.
APPEND string	A	Add "string" of the rightmost end of the current line.
Mode Control		
VERIFY {ON / OFF}	V	Set verify mode to print (ON) or ignore printing (OFF) lines after processing CHANGE, LOCATE, FIND and BOTTOM requests.

*May be used only with BLOCK mode ON.

Command	Abbreviation	Activity
Mode Control (Cont)		
BLOCK {ON / OFF}	n/a	Set program to operate in block mode (ON) or in line-by-line mode (OFF).
BRIEF {ON / OFF}	n/a	Set brief mode to print truncated (ON) or full (OFF) lines.
OUTPUT {ON / OFF}	n/a	Set to ON when Editor is loaded into core. When set to OFF, user may examine any section in the input file without causing output.
Input/Output Requests		
READ*	n/a	Fill block buffer from input file.
WRITE*	n/a	Add block buffer to output file.
GET	G	Add lines from subsidiary input device after (below) current line.
Miscellaneous Requests		
SIZE	S	Set total lines to occupy block buffer.
INSERT	I	Change mode to input.

5. ERROR CONDITIONS AND RECOVERY PROCEDURES

a. END OF {FILE BUFFERS} REACHED BY:

NEXT n

Results if the command results in the pointer moving past the last line of the file or buffer.	a) If editing in line-by-line mode, use command CLOSE and reload the input tape. b) If in block mode, move the pointer to the top of the buffer (T ↲).

b. END OF {FILE BUFFER} REACHED BY:

PRINT n	For recovery, do exactly as above.

c. END OF MEDIUM REACHED BY:

GET n

If the end-of-medium condition is encountered on the subsidiary input device before n lines are read. The pointer remains at the last line read.	Place the original paper tape back in the reader where it left off and continue editing.

*May be used only with BLOCK mode ON.

d. NOT A REQUEST

P3 ↵ P␣3 ↵

Blank required between command and argument.

e. NOT A REQUEST

D␣. ↵ D ↵

␣. is not recognized by the Editor as a symbol with correct counter value.

f. READ ERROR:

Parity or checksum error in indicated line.

g. TRUNCATED:

Indicated line greater than 90 characters.

NOTE

The user has a choice, following either of the above errors, of either modifying the line that caused the error (via any manipulative request) or of allowing the line to remain as it is in the output file (via any locative request).

h. NOTHING IN FILE:

Caused by issuing a CLOSE command prior to a WRITE command with Block Mode ON; or OUTPUT is turned OFF when a WRITE or CLOSE command is issued. In either case, control returns to the Editor and the contents of the buffer are unchanged.

i. IOPS 4

Device not ready: ready device and type CTRL R (↑R).

j. IOPS 00-30 see Appendix 5 for system restart procedures.

6. RESTART PROCEDURES

CTRL P, restart Editor if running.

See Appendix 5 for system restart if the Editor has halted.

7. EXAMPLES

Purpose	Original	Desired Change		Correct Format Command (user types in)
To change one character in a word	JMP TAG1	JMS TAG1		C␣/P/S/
To eliminate one character in a word	JMS* LOOP	JMS LOOP	or	C␣/*// C␣/S*/S/
To add a string of characters at the end of a line	→| DAC␣CNTR	→| DAC␣CNTR/counter check		A␣/counter check
To print the current line				P ↵
To read the next line				N ↵
To change mode (from edit to input or vice versa)				↵

CLOSE should always be the last command issued to complete editing.

How to Use BLOCK MODE:

User types in:

BLOCK␣ON ↵	Set up Mode
SIZE␣N ↵	N = number of lines in block
READ ↵	N lines are brought in core
WRITE ↵	output all lines onto paper tape punch
BLOCK OFF ↵	back to line by line editing

1. LOADING INSTRUCTIONS

Place the Converter tape in the paper tape reader, depress the tape-feed switch to clear the end-of-tape flag, set the address switches to 17720 (8K), and depress I/O RESET and READ IN. When the Converter has been loaded, it types

```
7-TO-9 CONVERTER
>
```

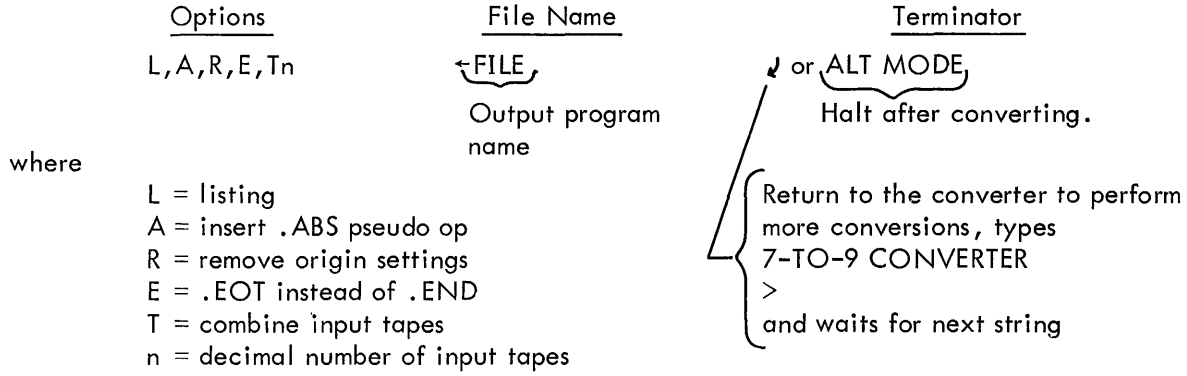
on the Teletype and waits for a command string from the user.

2. GENERAL COMMAND CHARACTERS

RUBOUT (echoes \)	Delete last character in command string - may be repeated n times to delete n characters.
CTRL U (echoes@)	Delete entire line.
CTRL P (echoes↑P)	a) Reinitialize converter. b) Resume operation after placing new tape in reader.

3. COMMAND STRING

The format expected by the Converter command string processor is as follows:



where

L = listing
A = insert .ABS pseudo op
R = remove origin settings
E = .EOT instead of .END
T = combine input tapes
n = decimal number of input tapes

Options may be used in any combination (or none at all). The options desired may appear in any order, separated by commas and terminated by ←. If no options are wanted, ← is sufficient. Rubouts may be used to delete unwanted characters, and CTRL U to delete entire lines prior to typing the command string terminator. If an error in the command string is detected, the converter types:

COMMAND STRING ERROR

>

and waits for a new command string.

4. OPERATING INSTRUCTIONS

The input tape to be converted must be ready in the reader (depress the tape-feed switch to clear the end-of-tape flag) before the command string terminator is typed. When the end of the input tape is reached, the converter punches several inches of blank tape; then do one of the following:

a. If a carriage return was used in the command string, the converter re-initializes, types

7-TO-9 CONVERTER

>

and waits for another command string.

b. If an ALT MODE was used in the command string, the computer halts. If the Tn option has been used to combine a number of tapes into one tape, the converter will type ↑P at the end of each tape except the last. Place the next tape in the reader, depress the tape feed switch to clear the end-of-flag and type CTRL P. Note that the Converter does not punch any blank tape at this time.

5. ERROR CONDITIONS

COMMAND STRING ERROR	Retype command string.
IOPS 4	Device not ready (possibly punch out of tape). Ready device and type CTRL R.
IOPS 00-30	See Appendix 5 system restart procedure.

6. RESTART PROCEDURE

CTRL P Reinitialize converter.

See Appendix 5 for system restart procedures if the converter has halted.

7. EXAMPLES

To convert a single paper tape to be assembled in the absolute mode with no listing, the command string would be

A←NAME↵

To combine three tapes into one ending with .EOT, to be assembled relocatably (but with locations settings) and to obtain a listing; the command string would be:

L, E, T3←NAME↵

1. LOADING PROCEDURE

Place the Linking Loader tape in the paper tape reader, depress the tape feed switch to clear the end-of-tape flag, set the address switches to 17720 (8K), and depress I/O RESET and READ IN. When the Loader has been loaded, it types

LOADER
>

on the Teletype and waits for a command string from the user.

2. GENERAL COMMAND CHARACTERS

RUBOUT (echoes \)	Delete last character typed. n rubouts may be used to delete n characters within a line.
CTRL U (echoes@)	Delete entire line.
CTRL P (echoes↑P)	a) Restart the Loader (when typing program names). b) Continue loading (when paper tape is ready).
CTRL S (echoes↑S)	Start user's program.

3. COMMAND STRING

The command string may have several different forms as follows: (The >'s are supplied by the loader.)

>NAME1, NAME2, NAME3 (ALT MODE)
or
>NAME1 ↵
>NAME2 ↵
>NAME3 (ALT MODE)
or
>,, (ALT MODE)

It is important to accurately specify the number of programs (n) to be loaded with n-1 commas or carriage returns before the ALT MODE.

4. OPERATING PROCEDURES

Place the main program in the reader, depress the tape feed switch to clear the end-of-tape flag, and then enter the command string.

When the main program has been loaded, the loader types ↑P. Place any subroutines to be loaded in the reader, depress the tape feed switch, and type CTRL P.

When all subroutines have been loaded, place the I/O library (tape 1 of 3) in the reader, depress the tape feed switch, and type CTRL P.

MACRO programs (that do not require programs from the FORTRAN library):

If the loader has not been satisfied at the end of the I/O library, place the short EOF tape (included with library tape) in the reader, push the feed button and type CTRL P.

FORTRAN programs (and MACRO programs that require programs from the FORTRAN library):

After the I/O library has been read, load the FORTRAN library (tapes 2 and 3) in the same manner (Tape 3 includes EOF).

If the loader is not satisfied by the library tapes, a subroutine has been omitted. The loader types out the names and addresses of all programs and library subroutines loaded. A .LOAD 3 error message and a zero address indicates a missing subroutine. (If this happens, it is necessary to reload the LOADER.) When loading has been successfully completed, the loader types ↑S. Ready all I/O devices required and type CTRL S to start execution.

5. ERROR MESSAGES

.LOAD 1	Memory overflow
.LOAD 2	Input data error
.LOAD 3	Unsatisfied global symbol (missing program)
.LOAD 4	Illegal .DAT slot request by user program
.IOPS 4	Device not ready. Ready device and type CTRL R.
.IOPS 00-30	Unrecoverable I/O error

6. RESTART PROCEDURE

To restart the Loader before the command string has been terminated by ALT MODE, type CTRL P. After the command string has been accepted by the Loader, there is no restart procedure; the Loader must be reloaded.

7. EXAMPLES

```
LOADER
>EX1 (ALT MODE)
 EX1 17365
↑S              Type control S to start program.
```

```
LOADER

>(ALT MODE)                    Program name not needed with paper tape
EX1        17365               input to loader.
↑S
```

```
LOADER

>EX2,SUB (ALT MODE)
EX2        17656
↑P↑P                           Place subroutine in reader and type control P.
SUB        17613
↑P↑P                           Place I/O library in reader and type control P.
↑P↑P                           Place FORTRAN library tape 2 in reader and type
.DA        17544               control P
↑P↑P                           Place FORTRAN library tape 3 in reader and type
BCDIO      14551               control P
STOP       14536
SPMSG      14442                              NOTE
FIOPS      13712
OTSER      13604               After placing tape in reader, push the tape feed button
REAL       12651               to clear the end-of-tape flag. First ↑P is signal to load
↑S                             next tape. Second ↑P is acknowledgment of user typing
                               control P.
```

```
LOADER

>, (ALT MODE)                  Program names not needed with paper tape input to loader.
EX2        17656
↑P↑P
SUB        17613
↑P↑P
↑P↑P
.DA        17544
↑P↑P
BCDIO      14551
STOP       14536
SPMSG      14442
FIOPS      13712
OTSER      13604
REAL       12651
↑S
```

```
LOADER

>EX2↵                          Carriage return may be used in place of comma.
>SUB (ALT MODE)
EX2        17656
↑P↑P
SUB        17613
↑P↑P
↑P↑P
.DA        17544
↑P↑P
```

```
BCDIO    14551
STOP     14536
SPMSG    14442
FIOPS    13712
OTSER    13604
REAL     12651
↑S

LOADER
> (ALT MODE)
EX2      17656
↑P↑P
↑P↑P
↑P↑P
BCDIO    14663
STOP     14650
SPMSG    14554
FIOPS    14024
OTSER    13716
REAL     12763
SUBROT   00000      The subroutine was omitted.
.LOAD 3             Unsatisfied global symbol.
```

1. LOADING PROCEDURES

Place the DDT tape (which includes the Linking Loader) in the paper tape reader, depress the tape feed switch to clear the end-of-tape flag, set address switches to 17720 (8K), and depress I/O RESET and READ IN. When DDT has been loaded, it types

LOADER
>

on the Teletype and waits for a user command string to load the program to be debugged.

2. GENERAL COMMAND CHARACTERS

RUBOUT (echoes \)	a) During load phase - delete last character typed. n rubouts may be used to delete n characters within a line.
(echoes@)	b) In DDT, delete all characters typed.
CTRL U (echoes@)	During load phase only, delete entire line.
CTRL P (echoes↑P)	a) Restart the Loader (when typing program names).
	b) Continue loading (when next paper tape is ready).
CTRL T (echoes↑T)	Restart DDT or bypass loading.

3. COMMAND STRING - LOADER PHASE

The command string may have several different forms as follows: (the >'s are supplied by Loader portion of DDT).

>NAME1, NAME2, NAME3 (ALT MODE)
or
>NAME1 ↵
>NAME2 ↵
>NAME3 (ALT MODE)
or
>,, (ALT MODE)

It is important to accurately specify the number of programs (n) to be loaded with n-1 commas or carriage returns before the ALT MODE.

4. OPERATING PROCEDURES

Place the main program in the reader, depress the tape feed switch to clear the end-of-tape flag, and type the command string.

When the main program has been loaded, the Loader types ↑P.

Place any subroutines to be loaded in the reader, depress the tape feed switch and type CTRL P.

When all subroutines have been loaded, place the I/O library (tape 1 of 3) in the reader, depress the tape feed switch, and type CTRL P.

MACRO programs (that do not require programs from the FORTRAN library):

If the loader has not been satisfied at the end of the I/O library, place the short EOF tape (included with library tape) in the reader, push the feed button, and type control P.

FORTRAN programs (and MACRO programs that require programs from the FORTRAN library):

After the I/O library has been read, load the FORTRAN library (tapes 2 and 3) in the same manner (tape 3 includes EOF).

If the loader is not satisfied by the library tapes, a subroutine has been omitted. The loader types out the names and addresses of all programs and library subroutines loaded. A .LOAD 3 error message and a zero address indicates a missing subroutine. (If this happens, it is necessary to reload DDT.)

When loading has been successfully completed, DDT types:

```
DDT
>
```

Debugging may now begin.

Following is a summary of DDT commands. For detailed information on the operation of each command, see the DDT manual.

SUMMARY OF COMMANDS

Linkage Characters

+'	Arithmetic plus
-	Arithmetic minus
(space)	Field separator

Breakpoints

k n"	Insert breakpoint at location k, assign number n (1-4)
n"	Remove breakpoint number n
"	Remove all existing breakpoints

Breakpoints (Cont)

!	Restart from breakpoint
n	Restart from breakpoint, wait n times before reentering breakpoint
↑T	Interrupt processing, go to DDT-9

Examinations and Modifications

k/	Open location k
↵	(Carriage return) Close the location
↓	(Line feed) Close the location, open next location
↑	(Up arrow) Close the location, open the preceding location.
↑Z	(CTRL Z) Close the location, open addressed location, continue original sequence
↑A	(CTRL A) Close the location, open addressed location, start new sequence
↑X	(CTRL X) Close the location, open the location addressed by 15-bit transfer vector, start new sequence
NUM$	Type contents as 6-digit octal numbers
TV$	Type contents as transfer vectors (15-bit addresses)
SYM$	Type contents as symbolic instructions (assumed if unspecified)
:	Retype in alternate mode (NUM$, SYM$)
=	Retype as transfer vector
REL$	Type addresses as relative to defined symbols (assumed if unspecified)
RLC$	Type addresses as relocatable numbers
ABS$	Type addresses as absolute numbers

Starts and Restarts

'	Starts user's program at normal starting point
k'	Starts user's program at location k
!	Restarts user's program from breakpoint
n'	Restarts user's program from breakpoint, waits n times before re-entering breakpoint
↑T	(CTRL T) Interrupt processing

Searching Operations

k␣EQ$	Search for words equal to k
k␣UN$	Search for words not equal to k
k␣ADR$	Search for instructions with effective address equal to k

Special DDT-9 Locations

AC$	Holds AC at a breakpoint
LNK$	Status of Link at a breakpoint
MSK$	Contains search mask
LO$	Lower limit of search
HI$	Upper limit of search
PA$	First unused location in patch area
AX$	Number of auto-index used by breakpoints
RF$	Current relocation factor
SA$	Normal starting address
Bn$	Address of breakpoint n

Symbol Definition

s)	Assign symbol s to the current location
k(s)	Assign symbol s to location k

Patch File Output

PFO$	Patch file output
k␣PFO$	Single location k patch file output
SN$$	Save new symbols
PFE$	Close patch file output

Patch File Input

PFI$	Read patch file

Coresident Subroutines

K HDR$	Use symbol table and relocation factor of subroutine k
HDR$	Use symbol table and relocation factor of main program

Miscellaneous Features

Q$	Contents of currently open location
.	Address of currently open or most recently opened location
&	Bypass mnemonic instruction lookup
k#	Execute the instruction k
↑U	(CTRL U) Cancel the line
↑T	(CTRL T) Interrupt processing

5. ERROR CONDITIONS

a. Loader errors

.LOAD 1	memory overflow
.LOAD 2	input data error
.LOAD 3	unsatisfied global symbol (missing program)
.LOAD 4	illegal .DAT slot request by user program

b. DDT running errors

OVERFLOW	too many new symbols defined - current entry ignored
ERROR	read error on patch file input - all patches loaded before error are good
?	general error indicator - current entry ignored undefined symbol address above core incorrect command illegal character

c. I/O errors

.IOPS 4 Device not ready - ready device and type CTRL R.

.IOPS 00-30 Unrecoverable during loading phase; returns to DDT during debug phase.

6. RESTART PROCEDURE

CTRL T (↑T) Restarts DDT; if halted, DDT must be reloaded.

CTRL P (↑P) When typing command string to the Loader, restarts the Loader.

7. EXAMPLES

```
LOADER
>EX1 (ALT MODE)
EX1         14455

DDT
>

LOADER
>EX2,SUB (ALT MODE)
EX2         14746
↑P↑P                    Place subroutine in reader and type control P.
SUB         14703
↑P↑P                    Place I/O library in reader and type control P.
↑P↑P                    Place FORTRAN library tape 2 in reader and type control P.
.DA         14634
↑P↑P                    Place FORTRAN library tape 3 in reader and type control P.
```

```
BCDIO     11641
STOP      11626
SPMSG     11532
FIOPS     11002
OTSER     10674
REAL      07741

DDT
>

LOADER

> (ALT MODE)
EX1       14455

DDT

>NUM$
>AC$/     000000
LNK$/     000000
MSK$/     777777
LO$/      014455    =   BEGIN      Low limit of program.
HI$/      015007    =   END+15     High limit of program.
PA$/      002420                   Low limit of available memory.
AX$/      000017
RF$/      014455                   Relocation factor.
SA$/      414455    =   BEGIN      Starting address.
B1$/      000000
B2$/      000000
B3$/      000000
B4$/      000000

>BEGIN/   000776

>SYM$
>./   CAL+776
BEGIN+1/  CAL+1
BEGIN+2/  CAL+14455    =   BEGIN
BEGIN+3/  CAL
BEGIN+4/  LAC END+1
READ-5/   JMS TYPE
READ-4/   LAC END+2
END+2/    LAW 17774
READ-3/   DAC COL

>
```

NOTE

After placing tape in reader, push the tape feed button to clear the end-of-tape flag. First ↑P is signal to load next tape. Second ↑P is acknowledgment of user typing control P.

Program name not needed with paper tape input to loader.

APPENDIX 1

DEVICE ASSIGNMENTS

Device Assignment Tables (.DAT)

In the I/O Monitor version, the .DAT slot assignments are permanent and cannot be changed.* The negative .DAT slots are those used by the system and the user need not be concerned with them. The positive .DAT slots, however, are user .DAT slots. When writing programs which are to be run within the system, the user should be careful to use the correct .DAT slot numbers.

.DAT SLOT	DEVICE	HANDLER	USE
1	TTY Printer	(TTA.)	Teleprinter Output
2	TTY Keyboard	(TTA.)	Keyboard Input
3	Paper Tape Reader	(PRA.)	Input
4	TTY Printer	(TTA.)	Listing
5	Paper Tape Punch	(PPA.)	Output
6	Paper Tape Reader	(PRA.)	Scratch
7	Paper Tape Punch	(PPA.)	Scratch
10	Paper Tape Reader	(PRA.)	Scratch

For example, if the user desires to output to the teleprinter from a FORTRAN IV program, the WRITE statement should read:

WRITE (1, 10), where 1 is .DAT slot 1 and 10 is the FORMAT statement number.

*Special software will be furnished by DEC for special systems using card reader, line printer, etc.

APPENDIX 2

PDP-9 ASCII CHARACTER SET

Listed below are the ASCII characters interpreted by the PDP-9 Monitor and system programs as meaningful data input or as control characters.

	00-37	40-77	100-137	140-177	
	ASCII CHAR.	ASCII CHAR.	ASCII CHAR.	ASCII CHAR.	
0	NUL	SP	\		0
1	SOH (↑A)		A		1
2		"	B		2
3	EXT (↑C)	#	C		3
4		$	D		4
5		%	E		5
6		&	F		6
7		'	G		7
10		(	H		10
11	HT	)	I		11
12	LF	*	J		12
13	VT	+	K		13
14	FF	,	L		14
15	CR	-	M		15
16		.	N		16
17		/	O		17
20	DLE (↑P)	0	P		20
21	(↑Q)	1	Q		21
22	DC2 (↑R)	2	R		22
23	DC3 (↑S)	3	S		23
24	DC4 (↑T)	4	T		24
25	NACK (↑U)	5	U		25
26		6	V		26
27		7	W		27
30	CNCL (↑X)	8	X		30
31		9	Y		31
32	SS (↑Z)	:	Z		32
33*	ESC	;			33
34		<			34
35		=		ESC	35
36	RS (↑)	>	^ or ↑	ESC	36
37		?		delete (RO)	37

*Codes 33, 176, 175 are interpreted as ESC (ALT MODE) and are converted on input to code 175 by IOPS handlers.

APPENDIX 3

MACRO-9 ERROR DIAGNOSTICS

Flag	Meaning
A	Error in direct Symbol Table assignment, assignment ignored.
B	Memory Bank error.
D	The statement contains a reference to a multiply defined symbol. It is assembled with the first value defined.
E	Erroneous results may have been produced. Will also occur on undefined .END value.
I	Line ignored. (Redundant Pseudo-op)
L	Literal phasing error.
M	An attempt is made to define a symbol which has already been defined. The symbol retains its original value.
N	Error in number usage.
P	Phase error. PASS1 value does not equal PASS2 value of a symbol. PASS1 value will be used.
Q	Questionable line.
R	Possible relocation error.
S	Symbol error. An illegal character was encountered and ignored.
U	An undefined symbol was encountered.
W	Line overflow during macro expansion.
X	Illegal usage of macro name.

APPENDIX 4

MACRO-9
PERMANENT SYMBOL TABLE

Memory Reference

CAL	000000
DAC	040000
JMS	100000
DZM	140000
LAC	200000
XOR	240000
ADD	300000
TAD	340000
XCT	400000
ISZ	440000
AND	500000
SAD	540000
JMP	600000

Operate

OPR	740000
NOP	740000
CMA	740001
CML	740002
OAS	740004
RAL	740010
RAR	740020
HLT	740040
XX	740040
SMA	740100
SZA	740200
SNL	740400
SML	740400
SKP	741000
SPA	741100
SNA	741200
SZL	741400
SPL	741400
RTL	742010
RTR	742020
CLL	744000
STL	744002
CCL	744002
RCL	744010
RCR	744020
CLA	750000
CLC	750001
LAS	750004
LAT	750004

Operate (Cont)

GLK	750010
LAW	760000

EAE Type KE09A

EAE	640000
OSC	640001
OMQ	640002
CMQ	640004
DIV	640323
NORM	640444
LRS	640500
LLS	640600
ALS	640700
LACS	641001
LACQ	641002
ABS	644000
DIVS	644323
CLQ	650000
FRDIV	650323
LMQ	652000
MUL	653122
IDIV	653323
FRDIVS	654323
MULS	657122
IDIVS	657323
NORMS	660444
LRSS	660500
LLSS	660600
ALSS	660700
GSM	664000

I/O States

IOT	700000
IORS	700314

Interrupt

IOF	700002
ION	700042
CAF	703302

Automatic Priority Interrupt Type KF09A

DBK	703304
DBR	703344
SPI	705501
ISA	705504

Memory Extension Control Type KE09B

SEM	707701
EEM	707702
LEM	707704

Memory Protect Type KX09A

MPSK	701701
MPLU	701702
MPLD	701704
MPEU	701742

APPENDIX 5
SYSTEM RESTART

SYSTEM RESTART can be used to attempt to restart a system program (excluding DDT and the Loader) which has halted during operation. It is most easily used if the symbolic program (SYSTEM RESTART), shown on the following page, has been punched onto tape and assembled by MACRO-9. If this has been done and a binary tape is available, proceed as follows:

1. Place binary tape in reader.
2. Depress the tape-feed switch to clear the end-of-tape flag.
3. Set address switches to 17720.
4. Press I/O RESET.
5. Press READ IN.

If a binary tape is not available, SYSTEM RESTART may be entered through the AC switches, using the deposit key. When this has been done, proceed as follows:

1. Set address switches to 17720.
2. Press I/O RESET.
3. Press START.

If the restart attempt is successful, the effect will be the same as a CTRL P restart. Further restarts are possible without reloading SYSTEM RESTART by the following procedure.

1. Set address switches to 17720.
2. Press I/O RESET.
3. Press START.

If the restart attempt fails, it will be necessary to reload the system program tape.

Since a halt usually indicates a rather serious problem, SYSTEM RESTART will often fail to restart the program.

Two instances in which it will work:

1. When the user has accidentally typed an ALT MODE instead of a carriage return as a command string terminator, and wishes to regain the program for another run.
2. After an IOPS 3 error if the offending device flag has been removed.

```
                                        .TITLE SYSTEM RESTART
                                        .FULL
17720                                   .LOC 17720
17720       707702          D           EEM
17721       237734                      LAC* E
17722       057731                      DAC A
17723       703302                      CAF
17724       700042                      ION
17725       237732                      LAC* B
17726       705504                      ISA
17727       177733                      DZM* C
17730       637731                      JMP* A
17731       000000          A           0
17732       000006          B           6
17733       001413          C           1413
17734       000632          E           632
            017720                      .END D
                                        NO ERROR LINES
```

APPENDIX 6

EXPLANATION OF IOPS ERROR CODES

ERROR CODE	ERROR	ERROR DATA
0	Illegal Function CAL	CAL address
1	CAL * illegal	CAL address
2	.DAT slot error	CAL address
3	Illegal interrupt	I/O status register
4	Device not ready (type CTRL R when ready)	
5	Illegal .SETUP CAL	CAL address
6	Illegal handler function	CAL address
7	Illegal data mode	CAL address
30	API software level error	API status register
31	Non-existent memory reference	Program counter
32	Memory protect violation	Program counter
33	Memory parity error	Program counter
34	Power fail with no skip setup	Program counter

APPENDIX 7

FORTRAN IV ERROR LIST

Error Code		Cause
X	Syntax error	Statement cannot be recognized as a properly constructed FORTRAN IV statement.
V	Variable/constant mode error	Illegal mode mixing. Missing constant, variable or exponent, or illegal matching of constants or variables in a DATA statement.
N	Statement number error	Phase error, number more than 5 digits, no statement number where one is required, statement shouldn't be labeled or doubly defined statement numbers.
S	Argument/subscript error	Missing argument or subscript, illegal use of subscripts, illegal construction of subscripted variable, more than 3 subscripts or stated number of subscripts does not agree with declared number.
F	FORMAT statement error	Illegal FORMAT specification or illegal construction of FORMAT statement.
I	Character/statement/term error	Illegal character, unrecognizable statement, illegal statement for program type, statement out of order or improper statement preceding END statement.
D	DO loop error	Illegal DO construction or illegal statement terminating DO LOOP.
T	Table overflow	Symbol/constant/arg (I)/OP(I) table limits exceeded.
L	Nesting error	Illegal nesting or DO nesting too deep.
M	Magnitude error	Program exceeds 8192 words, maximum number of dummy arguments or EQUIVALENCE classes exceeded, or constant/variable exceeds specified limits.
C	COMMON/EQUIVALENCE/ DIMENSION/DATA Statement error	Illegal construction of statement, illegal EQUIVALENCE relationships, illegal COMMON declaration or non-common storage declared in BLOCK DATA subprogram.
E	FUNCTION/SUBROUTINE/ EXTERNAL/CALL statement error	Illegal use of FUNCTION/SUBROUTINE name, out of order, or illegal variable for EXTERNAL declaration.
H	Hollerith error	Hollerith data illegal in this statement or illegal use of Hollerith constant.

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