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TITLE

Editor and Assembler for 57A Magnetic Tape System
(UCRL-50534)

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SOURCE LANGUAGE

MACRO-8

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EDITOR AND ASSEMBLER FOR 57A
MAGNETIC TAPE SYSTEM (UCRL-50534)

DECUS Program Library Write-up

DECUS No. 8-180

Abstract

Software is given with which PDP-8 assembly language programs can be edited and assembled from IBM-compatible magnetic tape. The Digital Equipment Corporation PDP-8 Symbolic Editor and Macro-8 Assembler are used, with modifications for magnetic tape I/O. These

modified programs require 8192 12-bit words of core memory, and have been written for the DEC 57A Magnetic Tape Control and a single tape transport. Simple modifications of the programs also permit use with different magnetic tape systems.

Introduction

The PDP-8 family of computers is enjoying widespread popularity in the small general-purpose computer field. However, the programming system of the basic machine is designed around paper tape as the input-output medium. Although economical, paper tape is well known for its low speed, handling inconvenience, and low reliability because of punch and reader failures.

Users of DECTapes or DEC discs have convenient means of editing and assembling programs, but no such capability exists for PDP-8 installations with the Digital Equipment Corp. (DEC) 57A Magnetic Tape

Control and IBM-compatible transports. The programming system described herein was created to fill that need by replacing paper tape with magnetic tape as the text storage medium. The result is considerable gain in speed, reliability, and convenience of developing new programs.

The programming system comprises three programs:

- (1) "Fast Editor" expands Symbolic Editor (DEC-08-ESAB, August 4, 1967) to read and write text on magnetic tape as well as paper tape. Text is stored in pages which may

be individually addressed with teletype commands. All the original editor operations are retained.

- (2) "Fast Macro-8" expands High-Speed Macro-8 (Digital-8-8-S, February 3, 1966) to read and assemble text from magnetic tape. Binary output is on the high-speed paper-tape punch. A switch option either prints the Symbol Table and

Pass 3 listing on the teletype or writes it on the same magnetic tape, following the text. The latter option allows rapid listing of programs if a large computer with a line printer is available.

- (3) "Shuffle" moves pages of text from one area of tape to another, and is used to write newly edited text over an older version.

Equipment Requirements

The programming system uses the following DEC equipment: (1) PDP-8 with 8192 12-bit words of memory, (2) ASR33 teletype, (3) PC01 high-speed paper-tape punch, and (4) 57A Magnetic Tape Control with a single transport. With a few changes, Fast Macro-8 will punch the binary program on the ASR33. (See Operating Instructions.)

The magnetic tape control used must be capable of data transfers in Memory Field 1. Although the 57A Magnetic Tape Control does not have this capability, it

may be easily modified for memory field selection under program control, as described in 57A Modification for Extended Memory.

Our equipment uses an IBM 729-VI transport. Because there is no programmed delay between the end of the rewind operation and the next forward command, it may be necessary to modify the routines which rewind the tape in Fast Editor and Fast Macro-8 in order to use other transports.

All programs select Tape Unit 1 and write tape at 800 bpi with odd parity.

Program System Description

This program development system uses magnetic tape for temporary storage of an assembly language source program during editing and assembly. It greatly improves speed and reliability over paper tape, especially during debugging when a program may have to be re-edited and re-assembled many times.

Only one symbolic program at a time may be stored on a magnetic tape. When a new program is fully debugged, Fast Editor is used to punch it out on paper tape for permanent storage, thus freeing the magnetic tape. The binary output of Fast Macro-8 is also on paper tape, while the Symbol Table and Pass 3 listing may

either be printed on the teletype or written on magnetic tape for listing on a line printer. The program listings in Appendices A, B, and C were produced in this manner on Control Data 1000-line-per-minute printers at the LRL Computation Center. A Fortran program reads the tapes on a CDC-6600 and converts them to printer format.

TAPE FORMAT

The programming system uses a single tape transport. We have found it convenient to use "Program Assembly Tapes" containing a library of the programming routines plus working space for editor and assembler output. The first file of these tapes consists of a short library containing Fast Editor, Fast Macro-8, Shuffle, various useful debugging programs, and the BIN and RIM loaders, all of which can be called into memory from the teletype. The creation and use of such a library is described elsewhere.^{1,2}

The Program Assembly Tapes eliminate a lot of tedious tape changing by combining the programming system routines and the text storage area on the same tape. We use several of them so that more than one program at a time can be under development. The programming system could easily be modified to store text on a blank tape by removing the commands which space the tape over the library file.

Symbolic text is stored on the tape in a second file as an exact image of the ASCII paper-tape output of the Symbolic Editor. Thus, simple changes to the I/O routines of the editor and assembler are all that are needed to convert them from paper to magnetic tape I/O. Text is buffered on and off the tape in 450₁₀-word records,

each 12-bit word containing a right-adjusted 8-bit ASCII character.

Text on tape may be separated into pages, each of which may contain up to the core limit of the Fast Editor text buffer. Paging allows the programmer to edit and assemble programs too long to fit into the editor buffer. As on paper tape, pages are separated by Form Feed and trailer characters. The last record of a page on magnetic tape contains the last few text characters, a trailer character (all zeros), a Form Feed character (214₈), and enough trailer to fill the rest of the record. These Form Feeds define page boundaries, and Fast Editor uses them to locate a specified page on tape. An End of File (EOF) follows the last record of the text file.

Fast Macro-8 writes the Symbol Table and Pass 3 listing in a third file, if the magnetic tape output switch option is selected. This file is also subdivided into 450-word records. The Symbol Table is written first, followed by a Form Feed and enough trailer to fill the current record. The Pass 3 listing follows, and is similarly divided into pages corresponding to the pages in the text file. An EOF follows the last record of the Pass 3 listing.

FAST EDITOR

Fast Editor retains all the functions and switch options of the DEC Symbolic Editor,³ including high- and low-speed paper-tape I/O. Two new teletype commands have been added for magnetic tape I/O. They are: nW, to Write a page on tape, and nE, to Enter a page from tape, where n is a numerical argument specifying the page number.

The command W with no argument is used to write a new page at the end of the

The commands with an argument is used to insert a page from tape. I/O. They are: W, to write a page on magnetic tape; R, to read a page from tape; and E, to enter a page from tape. Where a is a numerical argument specifying the page number.

Past Editor retains all the functions and switch options of the DEC Symbolic Editor, including high- and low-speed paper-tape I/O. Two new tape commands have been added for magnetic tape I/O. They are: W, to write a page on magnetic tape; R, to read a page from tape; and E, to enter a page from tape.

PAST EDITOR

Last record of the Pass 3 listing. Pages in the text file. An EOF follows the divided into pages corresponding to the The Pass 3 listing follows, and is similarly and enough trailer to fill the current record, written first, followed by a Form Feed 450-word records. The Symbol Table is selected. This file is also subdivided into magnetic tape output switch option is and Pass 3 listing in a third file, if the Last Macro-8 writes the Symbol Table follows the last record of the text file. page on tape. An End of File (EOF) Past Editor uses them to locate a specific Form Feed define page boundaries, and trailer to fill the rest of the record. These a Form Feed character (214g), and enough characters, a trailer character (all zeros), magnetic tape contains the last few text characters. The last record of a page on are separated by Form Feed and trailer the editor buffer. As on paper tape, pages and assemble programs too long to fit into Pasting allows the programmer to edit core limit of the Past Editor text buffer. pages, each of which may contain up to the Text on tape may be separated into adjusted 8-bit ASCII character. each 18-bit word containing a right-

CDC-6600 and converts them to printer A Fortran program reads the tapes on a printers at the LRL Computation Center. on Control Data 1000-line-per-minute A, B, and C were produced in this manner printer. The program listings in Appendices on magnetic tape for listing on a line either be printed on the teletype or written

TABE FORMAT

The programming system uses a single tape transport. We have found it convenient to use "Program Assembly Tapes" containing a library of the programming routines plus working space for editor and assembler output. The first file of these tapes consists of a short library containing Past Editor, Test Macro-8, Shuttle, various useful debugging programs, and the BIN and RIM loaders, all of which can be called into memory from the teletype. The creation and use of such a library is described elsewhere.^{1,2}

The Program Assembly Tapes eliminate a lot of tedious tape changing by combining the programming system routines and the text storage area on the same tape. We use several of them so that more than one program at a time can be under development. The programming system could easily be modified to store text on a blank tape by removing the commands which space the tape over the library file. Symbolic text is stored on the tape in a second file as an exact image of the ASCII paper-tape output of the Symbolic Editor. Thus, simple changes to the I/O routines of the editor and assembler are all that are needed to convert them from paper to magnetic tape I/O. Text is buffered on and off the tape in 450-word records.

text file. First, the tape spaces to the end of the text file and backspaces over the EOF. The Fast Editor output routine then stores ASCII characters in a 450-word output buffer, writing a tape record whenever the buffer fills. The Form Feed and trailer characters are automatically stored in the output buffer after the final text character, before the last record is written on tape. An EOF follows the last record to mark the new end-of-the-text file.

If the command nW is given, the program searches through the text file, counting Form Feeds until reaching page n. All the text in core is then written over page n, followed by an EOF to terminate the file.

When the operator gives the command nE, the program similarly searches the text file for page n and enters it into the memory, appending it to whatever text is already in core. Tape records are read into the same 450-word buffer (locations 560-1461, Field 1) which refills every time the editor input routine empties it. This continues until either the Form Feed at the end of the page is read, or the core buffer becomes full.

If the command E is given with no argument, the next page in the text file enters.

During an Enter or Write operation, if the end of the text file is reached before the designated page has been found, the program jumps to the editor ERROR routine, which prints a question mark and returns to the command mode. No text transfers to or from tape in this case.

The beginning of the editor text buffer has been moved from location 1467 to 1715 to accommodate the magnetic tape routines. The end of the text buffer has been ex-

tended from location 6700 to 7571. The net increase to the buffer capacity is about 500₁₀ characters. In addition, a modification has been made so that the editor rings the bell and enters the command mode on the first character that overflows the buffer, rather than ringing the bell for every overflow character.

Finally, the keyboard command CTRL/C causes Fast Editor to exit to the Magnetic Tape Library Bootstrap^{1,2} at location 7600.

FAST MACRO-8

With Fast Editor, the programmer builds up his symbolic program on magnetic tape, writing as many pages as necessary. Fast Macro-8 then assembles the entire program off tape. All switch options of Macro-8⁴ are retained, so the program may be started in any pass with the proper switch setting. Fast Macro-8 cycles through all successive pass and halts after Pass 3.

At the start of each pass, the tape is rewound and spaced over the library file, and the first record of the text file is read into a 450-word input buffer (locations 560 to 1461, Memory Field 1). The Fast Macro-8 input routine takes characters from this buffer, refilling it with the next tape record whenever it empties. Form Feeds, trailer, and PAUSE statements are ignored. Assembly continues until a dollar sign (\$) is found, when the computer rewinds the tape and automatically enters the next pass, halting only after all three passes are complete.

All characters intended for teletype output are sent to an output routine in Field 1. Diagnostic messages always go to the teletype. Bit 8 of the Switch

1887
The first of the year
was a very dry one
and the crops were
very poor. The
weather was very
warm and the
crops were very
poor. The
weather was very
warm and the
crops were very
poor.

The second of the year
was a very wet one
and the crops were
very good. The
weather was very
cool and the
crops were very
good. The
weather was very
cool and the
crops were very
good.

The third of the year
was a very dry one
and the crops were
very poor. The
weather was very
warm and the
crops were very
poor. The
weather was very
warm and the
crops were very
poor.

The fourth of the year
was a very wet one
and the crops were
very good. The
weather was very
cool and the
crops were very
good. The
weather was very
cool and the
crops were very
good.

The fifth of the year
was a very dry one
and the crops were
very poor. The
weather was very
warm and the
crops were very
poor. The
weather was very
warm and the
crops were very
poor.

The sixth of the year
was a very wet one
and the crops were
very good. The
weather was very
cool and the
crops were very
good. The
weather was very
cool and the
crops were very
good.

The seventh of the year
was a very dry one
and the crops were
very poor. The
weather was very
warm and the
crops were very
poor. The
weather was very
warm and the
crops were very
poor.

The eighth of the year
was a very wet one
and the crops were
very good. The
weather was very
cool and the
crops were very
good. The
weather was very
cool and the
crops were very
good.

Register (SR) determines the output mode for the Symbol Table and Pass 3 listing. If SR8 is 0, characters go to the teletype for normal listing; but if SR8 is 1, characters are instead stored in an output buffer, one right-adjusted 8-bit ASCII character per word. The buffer holds 3150_{10} characters and occupies locations 1462 to 7577 of Field 1. When the buffer fills, the tape spaces to the end of the text file, and the buffer is written as seven 450-word records. The tape then spaces back to its previous position and assembly continues. Subsequent output is written at the end of the last record. After the Symbol Table, and between pages of the text input, a Form Feed and enough trailer to fill the current record are stored in the output buffer. Therefore, the input and output files are paged similarly. After the final Pass 3 listing character, a Form Feed is stored, followed by enough trailer to fill the entire buffer. The buffer is written on tape, followed by an EOF, and the computer halts.

If the CONTINUE switch is pressed at this time, the Symbol Table and Pass 3 repeat, again using SR8 to determine the output mode. This makes it possible to get a complete listing on magnetic tape, plus a Symbol Table on the teletype for immediate debugging.

Control characters also go to the Field 1 output routine, and are used to rewind the tape and to set the proper pointers and flags for the next pass. They do not appear in the output.

SHUFFLE

When re-editing a multipage program, it is not possible to rewrite over a page on

tape, as part of the following page is likely to be destroyed. Hence, pages of re-edited text must be added to the end of the text file. Then the program called Shuffle moves them up to the beginning of the text file for reassembly. When starting Shuffle, the programmer sets an octal number N into the Switch Register to specify the number of pages to be moved. Shuffle searches through the text file for Form Feed characters and tabulates the number of records in each page. Shuffle then adds up the last N entries in the table to determine the number of records to be moved. The tape backspaces this amount, and the first eight of these records are read into a buffer in locations 560-7577 of Field 0 (Field 1 is not used.) The tape backspaces again, and these records are written at the beginning of the text file (possibly writing over part of the tape just read). To find the next block of eight records to be read, it is necessary to space to the end of the file, then count back from there. These next records are written in the proper place by counting eight records forward from the beginning of the text file. This method keeps Shuffle from getting lost in the partially destroyed text in the middle of the file.

Shuffle moves the remainder of the text in this fashion, eight records at a time. Reading and writing tape are done in the continuous mode. When the last block (which may contain fewer than eight records) has been written, a new EOF terminates the text file. Shuffle then exits to the Magnetic Tape Library Bootstrap at location 7600. This routine rewinds the tape and enters the Command Mode of the library system.^{1,2} If no tape reading or writing errors have occurred, the teletype prints "OK." There

When re-writing a multipage program it is not possible to rewrite over a page on the output. They do not appear flags for the next pass. Tape and to set the proper pointers and output routine, and are used to rewind the Control characters also go to the Field 1 immediate debugging.

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written on tape, followed by an EOF, and to fill the entire buffer. The buffer is found is stored, followed by enough trailer the final Pass 3 listing character, a Form output files are paged similarly. After output buffer. Therefore, the input and to fill the current record are stored in the text input, a Form Feed and enough trailer Symbol Table, and between pages of the at the end of the last record. After the continues. Subsequent output is written back to its previous position and assembly 450-word records. The tape then space life, and the buffer is written as seven fills, the tape spaces to the end of the text 1483 to 1537 of Field 1. When the buffer 8150 characters and occupies locations character per word. The buffer holds buffer, one right-adjusted 8-bit ASCII bytes are inlined stored in an output for normal listing; but if SR8 is 1, character for the Symbol Table and Pass 3 listing. Register (SR) determines the output mode

lately destroyed text in the middle of the keeps Shuffle from getting lost in the par- beginning of the text file. This method by counting eight records forward from the next records are written in the proper place the file, then count back from there. These read, it is necessary to space to the end of find the next block of eight records to be writing over part of the tape just read). To the beginning of the text file (possibly again and these records are written at a buffer in locations 880-1537 of Field 1 (Field 1 is not used). The tape then adds first eight of these records are read into The tape backspaces this amount, and the mine the number of records to be moved. up the last N entries in the table to deter- of records in each page. Shuffle then adds Feed characters and tabulates the number ascribed through the text file for Form number of pages to be moved. Shuffle into the Switch Register to specify the the programmer sets an octal number N life for reassembly. When starting Shuffle, moves them up to the beginning of the text text file. Then the program called Shuffle edited text must be added to the end of the to be destroyed. Hence, pages of text tape, as part of the following page is likely

SHUFFLE

It is not possible to rewrite over a page on the output. They do not appear flags for the next pass. Tape and to set the proper pointers and output routine, and are used to rewind the Control characters also go to the Field 1 immediate debugging.

is no printout if any Parity, Missed Character, or Data Request Late errors have occurred.

The newly edited program is now in position for assembly by Fast Macro-8.

57A Modification for Extended Memory

A simple modification described here adds the capability of Extended Memory transfers to the DEC 57A Magnetic Tape Control. The modification requires an additional I/O bus cable to the PDP-8, but uses spare modules existing in the 57A and requires no additional IOT's.

A 2-bit Extend Address (EA) register is formed from the unused flip-flops in the Current Address (CA) register (Fig. 1). When the CA is set with the MCA command (6745), the EA is cleared and loaded with the contents of the two low-order bits of the PDP-8 Data Field (DF) register. An I/O cable carries the buffered AE outputs to the Break Field Decoder in the PDP-8

Type 183 Memory Extension Control. The same cable carries the DF output levels.

Any memory field may be selected for tape transfers simply by loading the DF with that field number before giving the MCA instruction. The DF may then be changed since the EA holds the field number throughout the tape transfer. The two bits of EA provide for expansion up to 16,384 words of memory.

The carry connection on the CA board should be broken between CA0 and EA1. If this is not done, then when the CA is initialized to 7777 the carry will cause the transfer to start in location 0 of the field following the DF setting.

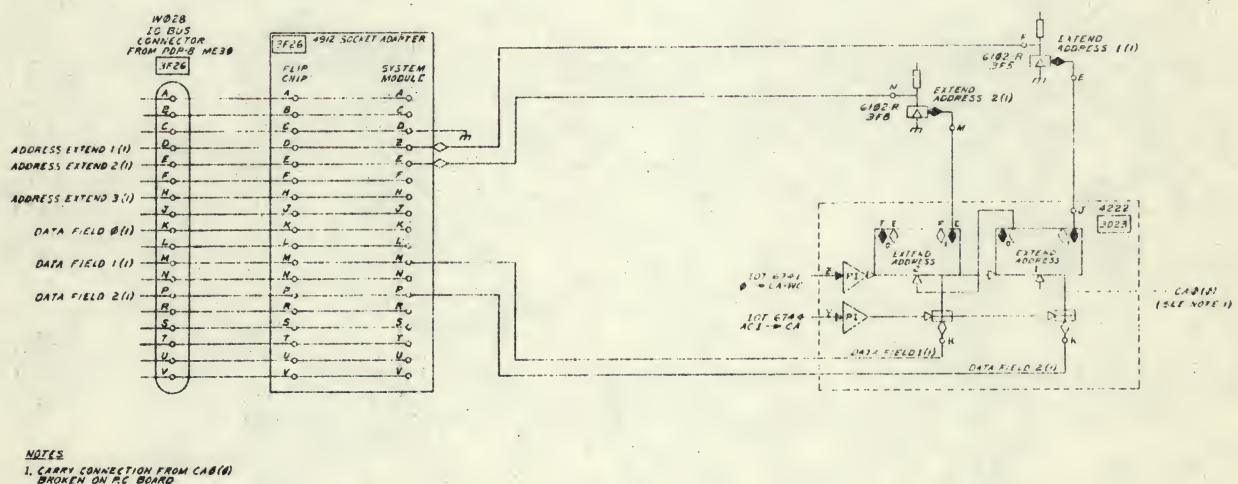


Fig. 1. Modification to 57A Magnetic Tape Control for PDP-8 Extended-Memory.

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57A Modification for Extended Memory

A simple modification described here adds the capability of Extended Memory transfers to the EBC 57A Magnetic Tape Control. The modification requires an additional I/O bus cable to the PDP-8, but uses spare modules existing in the 57A and requires no additional IOT's.

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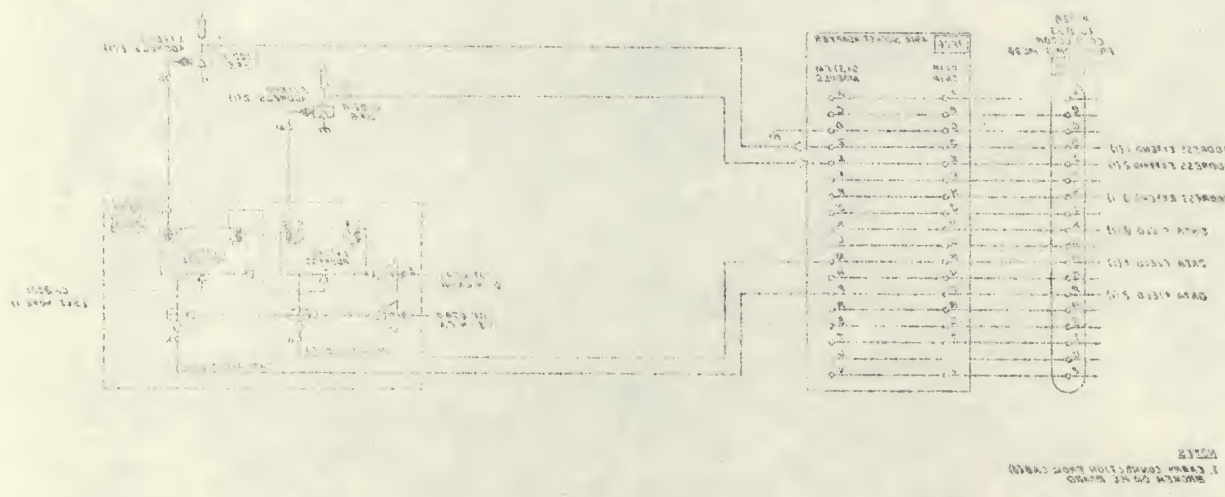


Fig. 1. Modification to 57A Magnetic Tape Control for PDP-8 Extended Memory.

Operating Instructions for Using Programs

FAST EDITOR

•The following commands have been added for magnetic tape I/O (↓ denotes the CARRIAGE RETURN key):

nE↓ Enter page n from magnetic tape and append to the text in the core buffer. The bell rings on completion or on buffer overflow. If SR (Switch Register) 0 is up, spaces will be compressed into tabs, as with paper-tape readin. If there are less than n pages on the tape, a "?" will be printed.

E↓ Enter the next page from the tape and append to the text in the buffer. If there are no more pages on the tape, a "?" will be printed. Otherwise this command is the same as nE↓.

CAUTION

After any nW or W operation, an EOF is written, and all following text on the tape will be inaccessible.

nW↓ Write all the text in core over page n on the magnetic tape, then terminate the text file with an EOF. If SR1 is up, tabs will be output as a TAB/RUBOUT combination. If SR1 is down, tabs will be output as spaces, the same as with paper tape output. If there are only n-1 pages

on tape, the text will be written after page n-1. If there are fewer than n-1 pages, nothing will be written, and a "?" will be printed.

W↓ Write all the text in core as a new page at the end of the text file; then terminate the file with a new EOF. Otherwise this command is the same as nW↓.

CTRL/C Jump to the Magnetic Tape Library Bootstrap at location 7600. This exit may be changed to any desired Field 0 address by changing the contents of location 373.

•The combination command has been changed for magnetic tape input as follows:

N↓ This executes the sequence P↓F↓K↓E↓. The computer punches the text in core (halting first if SR10 is down so that the ASR33 punch may be turned on), punches Form Feed, kills the buffer, and enters the next page from magnetic tape.

nN↓ This executes the above sequence n times. This is useful for punching or listing a multipage program that is on magnetic tape. The computer will halt only once, before the first cycle, if SR10 is down. For example, to punch the first n pages of a program, the command

1E↓ is given, followed by nN↓. On completion, the computer enters the command mode with page n+1 in the core buffer. If there are only n pages on tape, a "?" is printed, and the buffer is clear.

•If the computer halts during any Enter or Write operation, a tape status error has occurred. The Accumulator displays the tape status as follows:

Bit 0 Data Request Late

Bit 1 Parity Error

Bit 10 Missed Character

The operator should press CONTINUE to resume the operation.

•The punch initialization routine has been changed so that the computer will halt on punch commands (P, T, F, and N) only if SR10 is down. The operator should turn the ASR33 punch on and hit CONTINUE. If SR10 is up, the computer will punch on the high-speed punch without halting.

•The following duplicate commands have been eliminated to make room for the magnetic tape commands:

(1) ALTMOD no longer lists the next line. However, > (right angle bracket) and LINE FEED may still be used for this purpose.

(2) : (colon) no longer duplicates = (equals).

•All other operations and commands are unchanged.

FAST MACRO-8

•To assemble a program, perform the following steps:

a. Set SWITCH REGISTER to 0200.

b. Depress LOAD ADDRESS.

c. Set SWITCH REGISTER options as follows:

SR0, 1, 2, and 3 down - Enter Pass 1.

SR0 up - Restore symbol table to only the permanent symbols and enter Pass 1.

SR1 up - Enter Pass 2.

SR2 up - Enter Pass 1 without erasing any previously defined symbols.

SR3 up - Enter Pass 3.

SR8 up - Write Symbol Table and Pass 3 listing on magnetic tape.

SR8 down - Print Symbol Table and Pass 3 listing on the teletype.

SR10 up - The double precision integer and the floating point processors are deleted and may be used for user-defined symbols. This increases the size of the symbol table by 64_{10} symbols.

SR11 up - The macro, double-precision integer, and the floating point processors are deleted and may be used for storage of user-defined symbols. This increases the size of the symbol table by 125_{10} symbols.

d. Depress the START key. Fast Macro-8 enters the designated pass and completes all successive passes, halting after Pass 3. If CONTINUE is pressed at this point, the Symbol Table and Pass 3 printout will be

repeated. Set SR8 to select teletype or magnetic tape output.

•The Link Generated Diagnostic is suppressed. All other diagnostics are printed on the teletype, regardless of the setting of SR8.

•PAUSE statements are ignored. Each pass terminates when \$ is reached. Therefore, the magnetic tape must contain the entire symbolic text to be assembled.

•To use the ASR33 punch for binary tape output, change the following locations:

<u>Location</u>	<u>New contents</u>
601	6041
603	6046
2140	6046
3025	6041
3027	6046

SHUFFLE

•To move the last N text pages to the beginning of the text file, perform the following steps:

- a. Set SWITCH REGISTER to 0200.
- b. Depress LOAD ADDRESS.
- c. Set the SWITCH REGISTER to the number N (in octal) of pages of text to be moved. This number must be greater than one but less than the total number of pages on the tape.
- d. Press the START key. Shuffle moves the last N pages in the text file to the beginning of the file, then exits to the Mag Tape Bootstrap. If no tape-status errors occurred, "OK" is printed out. The system is in the Command Mode of the library^{1,2} at this point.
- e. If N does not meet the conditions of step c, the computer halts after counting the pages in the text file. Set a new number in the Switch Register and press CONTINUE. If this number is illegal, the computer halts again for another new number. Shuffling begins only when a legal number has been accepted.

References

1. Donald C. Uber, A Program Library System for the PDP-8 Computer Using IBM-Compatible Magnetic Tape, Lawrence Radiation Laboratory, Livermore, Rept. UCRL-50396 (1968).
2. Donald C. Uber, PDP-8/57A Magnetic Tape Program Library System, DECUS No. 8-129, Digital Equipment Corp. Users Society, Maynard, Mass. (1968).
3. PDP-8 Symbolic Editor Programming Manual DEC-08-ESAB-D, Digital Equipment Corporation, Maynard, Mass. (1967).
4. PDP-8 Macro-8 Programming Manual DEC-08-CMAO-D, Digital Equipment Corporation, Maynard, Mass. (1965).

- a. Set SWITCH REGISTER to 0300.
- b. Depress LOAD ADDRESS.

c. Set the SWITCH REGISTER to the number N (in octal) of pages of text to be moved. This number must be greater than one but less than the total number of pages on the tape.

- d. Press the START key. Shuffle moves the last N pages in the text file to the beginning of the file, then exits to the Mag Tape Bootstrap. If no tape-status errors occurred, "OK" is printed out. The system is in the Command Mode of the Library^{1,2} at this point.
- e. If N does not meet the conditions of step c, the computer halts after counting the pages in the text file. Set a new number in the Switch Register and press CONTINUE. If this number is illegal, the computer halts again for another new number. Shuffling begins only when a legal number has been accepted.

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The Link Generated Diagnostic is suppressed. All other diagnostics are printed on the teletype, regardless of the setting of SR8.

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Location	New contents
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3025	6041
3027	6046

SHUFFLE

• To move the last N text pages to the beginning of the text file, perform the following steps:

References

1. Donald C. Uber, A Program Library System for the PDP-8 Computer Using IBM-Compatible Magnetic Tape, Lawrence Radiation Laboratory, Livermore, Rept. UCRL-50388 (1968).
2. Donald C. Uber, PDP-8/57A Magnetic Tape Program Library System, DECUS No. 8-130, Digital Equipment Corp. Users Society, Maynard, Mass. (1968).
3. PDP-8 Symbolic Editor Programming Manual DEC-AR-D, Digital Equipment Corporation, Maynard, Mass. (1967).
4. PDP-8 Macro-8 Programming Manual DEC-AR-D, Digital Equipment Corporation, Maynard, Mass. (1967).