DECUS
PROGRAM LIBRARY

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TITLE   Magnetic Tape Program Library System

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SOURCE LANGUAGE

A PROGRAM LIBRARY SYSTEM
FOR THE PDP-8 COMPUTER USING
IBM-COMPATIBLE MAGNETIC TAPE

Abstract

This system enables the user to create a large library of programs for the PDP-8 computer which can be written on and called off IBM tape by name from the teletype. It also includes high-speed and low-speed BIN and RIM paper tape loaders, which are also called in from the teletype. The entire system uses only the last page of memory.

Programs may be subdivided into several records on tape, each with the same name. When a program is called, all records with that label are loaded into core. This makes it possible to modify, correct, or add to programs by adding records of the same name to the library.

A switch option permits programs to be relocated in core as they are loaded in. If a program is stored as several records, they may be individually relocated.

Introduction

The PDP-8 is enjoying widespread use in the small general-purpose computer field. However, the basic machine is limited to paper tape as a means of program storage, so that the user is constantly involved with the well-known problems of low speed, mechanical reader failure, and wear and tear on his frequently used tapes. Also, unless fan-fold is used, the paper tapes are difficult to handle and store.

Those users having DECtape have a convenient means of program storage and retrieval, but no such capability exists for PDP-8 installations with the 57A Magnetic Tape Control and IBM-compatible transports. The library system described in this report was developed to fill this need.

The library has several important features:

1. Since almost all operations are controlled from the keyboard, the system is convenient to use and is easily learned, even by those unfamiliar with the PDP-8.

2. Programs are called in by name from the teletype. This label may contain up to twelve characters. If a typing error is made, the RUBOUT key is used to delete the erroneous label.

3. Paper-tape capabilities are fully retained. BIN or RIM loaders are called off the library tape by typing the letters B or R.

4. All system operations use only the last page of memory. This is accomplished by swapping the various loaders in and out of core from the library tape.

5. Library programs may be of any length and may occupy any portion of memory except the last page.

6. When a program is called in, a switch option may be set if relocation is desired. The computer halts before loading the program in, allowing the operator to set the switch register to the new page at which he wishes to start loading the program.

7. After reading a program or loader off the library tape, the computer checks the parity error flag and halts on an error. The operator has the option of repeating the operation or ignoring the error and attempting to proceed.

8. After writing a program on the library tape, the computer reads it back and compares it word for word with the program in memory. If a discrepancy is found, the computer erases three inches of tape, and writes and checks the program again.

9. More than one program with the same name may be added to the library. When that name is called, all programs with that label are loaded in. This is useful if the program is subdivided into non-adjacent core areas. It also provides the capability of making future corrections and additions to library programs. It is possible to individually relocate the various sections of divided programs.

10. If the desired program is found and loaded in without error, the teletype prints "OK." There is no printout if no program exists with the given label.

11. Unless the relocation option is requested, tape motion is continuous during the search and load operation. This speeds up the search and reduces wear on the transport.

12. A tape with one hundred typical programs may be searched and a program loaded in about 30 sec, using a 112.5 in./sec transport. The library can hold 1365 programs, which requires a maximum of 1800 feet of tape at 800 cpi density.

13. Library material need not be executable programs. For example, the system may be used to fill memory (except the last page) with HLT, NOP, or zeros, or for data storage.

System Requirements

The library system operates with a basic PDP-8 with 4096-word memory, ASR-33 teletype, 57A Magnetic Tape Control, and a single tape transport. The system is in use on an IBM 729-VI transport. Modifications to the rewind portion of the Bootstrap program may be required if other transports are used; however this is not certain. The selected transport is Unit 1. The programs write tape at 800 cpi with odd parity.

Library Tape Organization

Beginning at the load point, the library tape is laid out as follows:

Record	Length (Octal PDP-8 words)	
Command Record	137	
BIN Record	137	
Fetch Record	137	Executive Records
Write Record	137	
RIM Record	137	
Label Record	14	
Location Record	14	First Program
Program Record	1-7600	

etc.

Record	Length	
Label Record	14	
Location Record	14	Last Program
Program Record	1-7600	
End of File		

The five Executive Records occupy the beginning of the tape and contain the actual routines for the library system operations. They are all the same length and are swapped in and out of the last page of core.

Programs are stored on the remainder of the tape with three records each. The first, or Label Record, contains the twelve-character name of the program. The second, or Location Record, specifies where in memory the program is to be loaded in. The third, or Program Record, is the program itself. An End of File follows the last program.

Memory Map

The library routines occupy the last page of core as follows:

7600 - 7623   Mag Tape Bootstrap   7763   :   FLAG

7624 - 7762   One of the five Executive

           Records   7764 - 7777 Teletype label buffer

Program Operation

BOOTSTRAP

The Bootstrap resides permanently in core. When started at location 7600, it rewinds the tape, reads the Command Record into locations 7624 - 7762, and transfers control to it. When the tape starts rewinding, the teletype bell is rung. This provides a 100-msec programmed delay which is necessary before the Unit Ready Flag can be sampled (at least if the IBM 729-VI transport is used) and alerts the operator that the Command Record is about to be read in.

COMMAND RECORD

The Command Record supervises the library system. It accepts operator commands and program labels from the teletype and passes control to the other four Executive Records. When entered from the Bootstrap, the Command Record first checks the contents of location 7763 (FLAG) and prints "OK" if FLAG is non-zero. (FLAG is cleared by the Bootstrap but is later set to indicate proper execution of the Fetch, Write, and BIN operations.) The system is now awaiting a teletype command and is said to be in the Command Mode. The command may be an F, W, B, or R, depending on whether the operator wants to Fetch or Write a program on the library tape, or use the BIN or RIM loaders. Any other letter is illegal and causes a question mark to be printed.

If commands B or R are given, the Command Record immediately loads the BIN or RIM Record in over itself. To read the BIN Record, the program simply jumps to the middle of the Bootstrap (location 7612), which reads the next record into locations 7624 - 7762 and begins executing it. The RIM Record is loaded the same way, except that the Command Record spaces forward over three records before jumping to 7612. The BIN and RIM Records are described in detail below.

When the command is F or W, the Command Record first accepts a label typed by the operator before transferring control to the Fetch or Write Record. For programming convenience, 215(8) is subtracted from label characters before they are stored in the buffer (locations 7764 - 7777). The label is terminated when the operator types either the twelfth character or the RETURN key. In the latter case, the program fills the remainder of the buffer with zeros. At this point, the program spaces the tape forward one or

two records (depending on the command) and jumps to location 7612 in the Bootstrap, which reads either the Fetch or Write Record in over the Command Record and begins executing it. The Fetch and Write Records are described in detail below.

BIN RECORD

The BIN Record operates identically to DIG-8-2-U revised 3/23/66. It will load programs into Extended Memory and provides a switch option for high-speed or low-speed readers. When it is entered via the Command Record, the BIN Record first halts to allow the operator to load his paper tape, set bit 0 of the Switch Register for high or low speed reader, and turn the reader on. When the CONTINUE key is pressed, the program reads in the BIN tape, halting at the end so the operator can turn the reader off. The AC (Accumulator) holds the checksum. When CONTINUE is pressed again, the AC is set if the checksum is zero, but cleared otherwise, and the program jumps out to the Bootstrap at 7600. The Bootstrap stores the AC in FLAG, rewinds the tape, and enters the Command Record. "OK" is now printed if FLAG is set (zero checksum), and the next command is awaited.

RIM RECORD

The RIM Record contains high-speed and low-speed RIM loaders, which the operator selects with bit 0 of the Switch Register. When entered via the Command Record, the RIM Record first halts to allow paper tape loading and switch setting.

The selected reader loads the RIM tape when CONTINUE is pressed. There is no exit from this program and the Bootstrap must be restarted at 7600 to reenter the Command Mode.

WRITE RECORD

After the operator has typed a W and the name of the program he wishes to add to the library, the Command Record replaces itself with the Write Record and begins executing it. This is the routine that writes on the tape the three records associated with that program. It begins with two halts which allow the operator to enter the IA (Initial Address) and FA (Final Address) of the program into the Switch Register. "IA/" and "FA/" are printed out to tell the operator which number to load next.

The tape is then spaced out to the EOF (End of File) and backspaced over the EOF, and the label buffer is written as the 12-word Label Record. The program then replaces the first character of the label buffer with IA-1 and writes the label buffer on tape again, this time as the 12-word Location Record. Next, the Program Record itself is written, the Word Count being computed from the IA and FA provided by the operator. After each of the three records is written, it is backspaced over and tested with a Read Compare operation. If an error is found, the faulty record is backspaced over, three inches of blank tape are written (write EOF and backspace), and the record is written and checked again. This repeats until a good record is written. Finally, new EOF is written and the program jumps out to the Bootstrap, which

rewinds the tape and loads in the Command Record. FLAG has been set by the temporary storage of -FA, which will always be non-zero (writing the last page of core on tape is forbidden), so the teletype prints "OK". The system is again in the Command Mode.

A maximum of 1365 programs can be written. This figure is dictated by the fact that when the tape is commanded to space to EOF (Space Forward Continuous with Word Count = 0), it will stop after 4096 records if EOF is not sensed first. When 1365 programs are on the tape and space to EOF is commanded, the tape will space forward 4096 records (1365 $\times$ 3 records per program plus one for the RIM Record) and halt just <u>before</u> the EOF. For this reason, the 1366th program will be written in the wrong place. However, in most applications this limit will never be approached. Even if it were, a 2400-ft reel of tape would not be exhausted, because the maximum program (locations 0000 - 7600) occupies only about 15 in. of tape, including the Label and Location Records.

FETCH RECORD

The Command Record calls and begins executing the Fetch Record when the operator has typed an F and the name of the program he wishes to load. This routine searches the tape and loads in all programs having that name. It also controls relocation of the program if the operator has requested it by setting bit 11 of the Switch Register before the tape search starts.

The Fetch Record begins in the Read Compare Continuous mode to search the tape for the label stored in the teletype buffer. Every record is searched, beginning with the Write and RIM Records and continuing into the Label, Location, and Program Records of the library. The Word Count is cleared before each record, so that the entire record is compared against the same number of core words, starting at the label buffer. This makes it extremely unlikely that a match will be found in any but the desired label record, and in fact no such problem has occurred in our library.

At the end of each record, the Read Compare Error and End of File status bits are tested to see if the label has been found or the end of the library reached. When the label is found, the first word (IA-1) of the following record (the Location Record) is read in and temporarily stored in FLAG. Bit 11 of the Switch Register is then tested to see if the operator has requested relocation, and if so, the teletype prints "PG/" and the tape and computer halt to allow him to set the relocation page in the Switch Register. At this point the Accumulator displays the unrelocated IA. Relocation is accomplished by moving this IA to the same location on another page; it will work only for single-page programs, or multi-page programs whose indirect linkages are all on page zero. When the CONTINUE key is pressed, the relocated IA is computed by combining bits 0-4 of the Switch Register with bits 5-11 of the AC, and the Program Record is loaded in, beginning at that address.

If relocation was not requested, the Program Record is immediately loaded in at the IA specified in the Location Record. Whether the program is relocated or not, the Word Count is cleared before

the program is read in, so words continue to enter core until the end of the record is reached. Tape parity is then checked. The computer clears FLAG and halts with the Link=1 on an error. Otherwise FLAG is set and the Read Compare Continuous mode is resumed to search for other records with the same label.

Each time the label is found, the program is read in and relocated as above, so that if a program has been subdivided into several records, they may be individually relocated. This would be useful, for example, in relocating the main body of a program while leaving linkages, constants, and subroutines on page zero.

The search continues until the EOF is found. The Bootstrap is then reentered to rewind the tape and read in the Command Record. "OK" will be printed if FLAG is set, indicating that the program has been found and that the last Program Record was loaded in with no parity error. The system is again in the Command Mode. The program may then be started from the console switches in the normal manner.

Deletions from the library are impossible. However, if the user desires to correct, modify, or add to a program,

he simply adds to the library, using the same name as the original program. When the program is fetched, the new version will load in over the old one.

GENERATE PROGRAM

The Generate Program is not part of the operating library system, but is used to create new library tapes by writing the five Executive Records on them. The Generate Program and the Executive Records are first placed in core by loading the Master Generator paper tape. The Executive Records then occupy the five core pages starting at 6400, 6600, 7000, 7200, and 7400, while the Generate Program itself occupies the page starting at 6200. When started at 6200, the Generate Program writes each Executive Record on the new tape, starting at the load point, and checks each one with a Read Compare. It halts on an error with the address +1 of the error word in the Accumulator. If CONTINUE is pressed, 3 in. of blank tape are written, and the record is written and checked again. When the last record has been successfully written, the computer writes an EOF and halts. The Bootstrap can then be toggled in and programs written on the new library tape.

Operating Instructions

GENERATING A NEW LIBRARY TAPE

1. Load the Master Generator binary paper tape.
2. Hang a blank magnetic tape on the transport, with the write lock ring in. Select Unit 1.

3. LOAD ADDRESS 6200, START. The five Executive Records are written on the tape, followed by an EOF. The computer halts with the AC and Link=0. The library is ready for use.
4. If the computer halts with the AC not zero, a Read Compare error has been

found. The AC displays the address +1 of the first word in error. Press the CONTINUE key to write 3 in. of blank tape and repeat the faulty record.

USING THE LIBRARY

1.0 Hang the library tape on the transport and select Unit 1. Unless programs are to be written, the write lock ring should be removed.

2.0 Toggle the Mag Tape Bootstrap into locations 7600 - 7623.

3.0 LOAD ADDRESS 7600, START. The bell rings and the system enters the Command Mode.

4.0 Type an F to Fetch a library program, a W to Write a new program on the library, a B to use the BIN loader, or an R to use the RIM loader. Any other command is illegal and causes the computer to print a question mark and reenter the Command Mode.

5.0 To Fetch a program (command F was typed):

　5.1 Type in the exact label of the program. If an error is made, type RUBOUT and start the label over.

　5.2 After the last character, type RETURN to start the tape search. (If the label has 12 characters, the last one automatically initiates the search.) When the end of the library is reached, the bell rings, the tape rewinds, and the Command Mode is reentered. "OK" is printed out if the desired program was loaded in. If no program with that name was found, there is no printout. Go to step 4.0 or start the loaded program

with the console switches in the normal manner.

　5.3 If relocation is desired, set SR (Switch Register) bit 11 to 1 before the tape search is started. Whenever the label is found, the computer prints "PG/" and halts with the unrelocated IA (Initial Address) in the AC. Set SR bits 0-4 to the relocated page address and hit the CONTINUE key. SR bits 0-4 and AC bits 5-11 form the relocated IA (SR bits 5-11 are ignored). The program is loaded in at that address and the search is resumed. Leave SR bit 11=1 to relocate subsequent records with the same label, otherwise set SR bit 11=0. Caution: Do not relocate programs into the last page of core.

6.0 To Write a program on the library (command W was typed):

　6.1 Type in any label up to twelve characters long. In case of a mistake, type RUBOUT and start a new label. After the last character, type RETURN. (If 12 characters are typed, the last automatically terminates the label.)

　6.2 The computer prints "IA/" and halts with the AC=0. Set the Switch Register to the Initial Address of the program and hit the CONTINUE key.

　6.3 The computer prints "FA/" and halts with the AC displaying the IA just loaded. Set the Switch Register to the Final Address of the program and hit the CON-TINUE key. Any area of core except the last page may be

written on tape. The computer prints "OK" and reenters the Command Mode when it finishes adding the new program to the library.

7.0 To use the BIN Loader (command B was typed):

    7.1 The computer halts with the Link and AC=0. Set SR bit 0 to 1 for the low speed reader or to 0 for the high speed reader.

    7.2 Place the paper tape in the reader and turn the reader on (if ASR 33).

    7.3 Hit the CONTINUE key. The BIN tape is loaded and the computer halts with the checksum in the AC. Turn the reader off (if ASR 33).

    7.4 Press the CONTINUE key to reenter the Command Mode. The computer prints "OK" if the checksum was zero, nothing otherwise. If CONTINUE is not hit at this time, the BIN Record remains in memory and may be manually started at location 7627 at any time.

8.0 To use the RIM Loader (command R was typed):

RIM tapes are loaded the same as BIN tapes as described in steps 7.1 - 7.3. There is no checksum halt, however, and the Bootstrap must be restarted at 7600 to reenter the Command Mode. If left in core, the RIM Loader may be manually started at 7627 at any time.

9.0 <u>Error Conditions and Recoveries</u>

    9.1 In general, if the computer halts in the library system with the Link=1, an error has been detected. The one exception is the checksum halt in the BIN Loader, where the link may =1. If the Link=0 at any halt, it is not an error halt.

    9.2 Whenever one of the five Executive Records is read into the last page of memory, the computer checks the tape parity error flag and halts on an error with the Link=1 and the AC=0. For the BIN and RIM Records, this halt is at location 7626. The computer always halts at this address so that the operator can load his paper tape, but the Link=1 only on a parity error. For the Command, Fetch, and Write Records, the error halt is at location 7627. In all cases, the error may be ignored by hitting the CONTINUE key, but it is safer to restart the Bootstrap at 7600 and try again.

    9.3 When fetching a program from the library, the computer will halt at location 7627 with the Link=1 and the AC=0 if a parity error is found in a Program Record. The operator may ignore the error by hitting CONTINUE, or may restart the Bootstrap at 7600 and repeat the operation. Although this halt is at the same address as the parity error halt for the Fetch Record, the Fetch Record halt occurs immediately after the label is typed in, while the Program Record halt occurs after the computer has searched the tape and found the label.

Program Listing

Listings for the Bootstrap, Generate Program, and the five Executive Records are given.

The Executive Records are listed at their core addresses on the Master Generator paper tape. These are the locations they occupy when the Generator Program writes them on a new library tape. However, in actual use the Executive Records alternately occupy the last page of core.

Each Executive Record was written and assembled as an independent one-page program. Therefore, many duplicate tags exist among the various programs.

```
            /PDP-8/57A MAG TAPE LIBRARY        7/21/67 BOOTSTRAP
            /SA=7600
            *7600
            FLAG=7763
7600  3363  BOOT, DCA FLAG      /STORE FLAG (CLEAR FLAG ON 1ST PASS)
7601  1220  TAD RWND
7602  6706  BELL, MTS
7603  6716  MTC                 /REWIND TAPE
7604  1202  TAD BELL
7605  6046  TLS                 /RING BELL
7606  6041  TSF
7607  5206  JMP .-1             /WAIT 100 msec.
7610  6711  MSUR
7611  5210  JMP .-1             /WAIT TILL REWIND FINISHED
7612  7623  NEXT, 7623          /ACTS AS CLA
7613  1212  TAD NEXT
7614  6745  MCA                 /LOAD IA-1 INTO CA AND CLEAR WC
7615  1221  TAD RD
7616  6706  MTS                 /SELECT UNIT 1, ODD PARITY, 800 BPI, LOW SLICE
7617  6716  MTC                 /READ RECORD INTO LOCATIONS 7624-7762
7620  1101  RWND, 1101          /DUMMY COMMAND
7621  7675  RD, 7675            /ACTS AS CLA
7622  6701  MSCR
7623  5222  JMP .-1             /WAIT UNTIL RECORD LOADS IN, THEN EXECUTE.
```

```
BELL    7602
BOOT    7600
FLAG    7763
NEXT    7612
RD      7621
RWND    7620
```

```
                    *6424
                    NEXT=6412
        6424  6734  MTRS              /ENTER FROM BOOTSTRAP
        6425  7006  RTL
        6426  7630  SZL CLA
        6427  7402  HLT               /PARITY ERROR.  LINK IS 1, AC IS Ø.
        6430  1363  START, TAD FLAG
        6431  7640  SZA CLA
        6432  5277  Ø, JMP TYPOK      /FLAG IS 1.  TYPE "OK".
        6433  4255  JMS CRLF
        6434  4255  JMS CRLF
        6435  4263  JMS READ          /COMMAND MODE.  GET COMMAND CHARACTER.
        6436  1311  TAD M302
        6437  7450  SNA               /B
        6440  5354  JMP B
        6441  1312  TAD M4
        6442  7450  SNA
        6443  5321  JMP FETCH         /F
        6444  1313  K, TAD M14
        6445  7450  SNA
        6446  5305  JMP RIM           /R
        6447  1314  TAD M5
        6450  7650  SNA CLA
        6451  5320  JMP WRITE         /W
        6452  1232  TAD Q
        6453  4271  JMS PRINT         /ILLEGAL CHARACTER.  PRINT "?".
        6454  5230  JMP START         /GET NEW COMMAND.
        6455  0000  CRLF, 0           /PRINTS CR, LF
        6456  1317  Ø, TAD CR
        6457  4271  JMS PRINT
        6460  1355  TAD LF
        6461  4271  JMS PRINT
        6462  5655  JMP I CRLF
        6463  0000  READ, 0           /GETS KEYBOARD CHARACTER
        6464  6031  KSF
        6465  5264  JMP .-1
        6466  6036  KRB
        6467  6046  TLS
        6470  5663  JMP I READ
        6471  0000  PRINT, 0          /PRINTS CHARACTER
        6472  6041  TSF
        6473  5272  JMP .-1
        6474  6046  TLS
        6475  7200  CLA
        6476  5671  JMP I PRINT
        6477  1256  TYPOK, TAD O      /PRINTS "OK"
        6500  4271  JMS PRINT
        6501  1244  TAD K
        6502  4271  JMS PRINT
        6503  3363  DCA FLAG          /CLEAR FLAG
        6504  5230  JMP START         /ENTER COMMAND MODE
        6505  1316  RIM, TAD M3
        6506  3356  DCA FWD
        6507  5342  JMP SPACE         /LOAD RECORD COUNTER WITH -3
        6510  1661  T1661, 1661
        6511  7476  M302, -302
        6512  7774  M4, -4
        6513  7764  M14, -14
        6514  7773  M5, -5
```

```
6515   7777   M1, -1
6516   7775   M3, -3
6517   0215   CR, 215
6520   1315   WRITE, TAD M1
6521   1315   FETCH, TAD M1        /LOAD RECORD COUNTER WITH -1 OR -2
6522   3356   DCA FWD
6523   4255   LABEL, JMS CRLF      /ROUTINE ENTERS LABEL FOR FETCH OR WRITE
6524   1362   TAD LBLIA
6525   3357   DCA ADR              /INITIALIZE LABEL ADDRESS
6526   4263   CHAR, JMS READ       /GET LABEL CHARACTER
6527   1360   TAD M377
6530   7450   SNA
6531   5323   JMP LABEL            /RUBOUT.  RE-INITIALIZE LABEL.
6532   1361   TAD P162
6533   7440   SZA
6534   5337   X, JMP STORE
6535   1334   TAD X                /CHAR WAS CR.  CHANGE "JMP CHAR" TO "JMP STORES"...
6536   3341   DCA STORE+2          /...TO FILL REST OF LABEL WITH ZEROS.
6537   3757   STORE, DCA I ADR     /STORE (CHAR-215), OR ZERO IF CR WAS HIT.
6540   2357   ISZ ADR
6541   5326   JMP CHAR             /GET NEXT CHAR, OR ANOTHER ZERO IF CR WAS HIT.
6542   6745   SPACE, MCA           /LABEL BUFFER FULL.  CLEAR CA AND WC.
6543   1356   TAD FWD
6544   6742   MRWC                 /LOAD WC WITH RECORD COUNTER
6545   7200   CLA
6546   1310   TAD T1661
6547   6706   MTS
6550   6716   MTC                  /SPACE FORWARD 1, 2, OR 3 RECORDS
6551   6701   MSCR
6552   5351   JMP .-1
6553   7200   CLA
6554   4255   B, JMS CRLF          /PRINT CR, LF
6555   5212   LF, JMP NEXT         /ENTER BOOTSTRAP TO READ RECORD IN OVER THIS ONE
6556   0000   FWD, 0
6557   0000   ADR, 0
6560   7401   M377, -377
6561   0162   P162, 162
6562   7764   LBLIA, 7764
6563   0000   FLAG, 0
```

```
ADR      6557
B        6554
CHAR     6526
CR       6517
CRLF     6455
FETCH    6521
FLAG     6563
FWD      6556
K        6444
LABEL    6523
LBLIA    6562
LF       6555
M1       6515
M14      6513
M3       6516
M302     6511
M377     6560
```

```
M4      6512
M5      6514
NEXT    6412
O       6456
PRINT   6471
P162    6561
Q       6432
READ    6463
RIM     6505
SPACE   6542
START   6430
STORE   6537
TYPOK   6477
T1661   6510
WRITE   6520
X       6534
```

```
                *6624
                BOOT=6600
6624    6734    MTRS            /ENTRY FROM COMMAND RECORD
6625    7006    RTL
6626    7602    CLA HLT         /L IS 1 IF PARITY ERROR.  SET SRØ FOR HI/LO READER
6627    5307    JMP BEGIN       /CONTINUE KEY STARTS BIN LOADER
6630    0000    BEGG, 0         /REMAINDER SAME AS DIG-8-2-U,  REV 3/23/66,...
6631    3365    DCA SWITCH      /... EXCEPT AS NOTED.
6632    4262    JMS READ
6633    1301    TAD M376
6634    7750    SPA SNA CLA
6635    5241    JMP .+4
6636    2365    ISZ SWITCH
6637    7040    CMA
6640    5231    JMP BEGG+1
6641    1365    TAD SWITCH
6642    7640    SZA CLA
6643    5232    JMP BEGG+2
6644    1367    TAD CHAR
6645    0362    AND MASK
6646    1347    TAD M200
6647    7510    SPA
6650    2230    ISZ BEGG
6651    7750    SPA SNA CLA
6652    5630    JMP I BEGG
6653    1367    TAD CHAR
6654    0260    AND FMASK
6655    1261    TAD CHANGE
6656    3366    DCA MEMTEM
6657    5232    JMP BEGG+2
6660    0070    FMASK, 70
6661    6201    CHANGE, CDF
6662    0000    READ, 0
6663    0000    0
6664    6031    LOR, KSF
6665    5264    JMP .-1
6666    6036    KRB
6667    3367    DCA CHAR
6670    1367    TAD CHAR
6671    5662    JMP I READ
6672    6011    HIR, RSF
6673    5272    JMP .-1
6674    6016    RRB RFC
6675    5267    JMP LOR+3
6676    4351    BEND, JMS ASSEMB
6677    7041    CIA
6700    1370    TAD CHKSUM
6701    7402    M376, HLT       /AC HOLDS CHECKSUM.  L MAY BE 1.  HIT CONT. KEY...
6702    7640    SZA CLA         /... TO RETURN TO COMMAND MODE.
6703    3305    DCA .+2         /CHECKSUM NOT Ø.  CHANGE "STA" TO "AND Ø"
6704    6032    KCC             /CLEAR KEYBOARD FLAG
6705    7240    STA             /SET FLAG IF CHECKSUM IS Ø.  OTHERWISE CLEAR FLAG.
6706    5200    JMP BOOT        /BOOTSTRAP STORES FLAG AND ENTERS COMMAND MODE.
6707    6032    BEGIN, KCC
6710    6014    RFC
6711    6224    RIF
6712    1261    TAD CHANGE
6713    3366    DCA MEMTEM
6714    7604    CLA OSR
6715    7700    SMA CLA
```

```
6716   1361   TAD HIRI
6717   1360   TAD LORI
6720   3263   DCA READ+1
6721   4230   JMS BEGG
6722   5321   JMP .-1
6723   3370   GO, DCA CHKSUM
6724   1366   TAD MEMTEM
6725   3344   DCA MEMFLD
6726   1367   TAD CHAR
6727   3363   DCA WORD1
6730   4262   JMS READ
6731   3364   DCA WORD2
6732   4230   JMS BEGG
6733   5276   JMP BEND
6734   4351   JMS ASSEMB
6735   7420   SNL
6736   5344   JMP MEMFLD
6737   3371   DCA ORIGIN
6740   1363   CHEX, TAD WORD1
6741   1364   TAD WORD2
6742   1370   TAD CHKSUM
6743   5323   JMP GO
6744   0000   MEMFLD, 0
6745   3771   DCA I ORIGIN
6746   2371   ISZ ORIGIN
6747   7600   M200, 7600
6750   5340   JMP CHEX
6751   0000   ASSEMB, 0
6752   1363   TAD WORD1
6753   7106   CLL RTL
6754   7006   RTL
6755   7006   RTL
6756   1364   TAD WORD2
6757   5751   JMP I ASSEMB
6760   5264   LORI, JMP LOR
6761   0006   HIRI, HIR-LOR
6762   0300   MASK, 300
6763   0000   WORD1, 0
6764   0000   WORD2, 0
6765   0000   SWITCH, 0
6766   0000   MEMTEM, 0
6767   0000   CHAR, 0
6770   0000   CHKSUM, 0
6771   0000   ORIGIN, 0
```

```
ASSEMB 6751
BEGG   6630
BEGIN  6707
BEND   6676
BOOT   6600
CHANGE 6661
CHAR   6767
CHEX   6740
CHKSUM 6770
FMASK  6660
GO     6723
HIR    6672
HIRI   6761
```

```
LOR     6664
LORI    6760
MASK    6762
MEMFLD  6744
MEMTEM  6766
M200    6747
M376    6701
ORIGIN  6771
READ    6662
SWITCH  6765
WORD1   6763
WORD2   6764
```

```
                  *7024
                  BOOT=7000
                  FLAG=7163
7024    6734    MTRS                    /ENTRY FROM COMMAND RECORD.  LABEL IS IN BUFFER.
7025    7006    RTL
7026    7630    SZL CLA
7027    7402    PARERR, HLT             /PARITY ERROR.  L IS 1, AC IS 0.
7030    1256    TAD BUFIA
7031    6745    MCA                     /INITIALIZE CA AND CLEAR WC
7032    1317    TAD I3461
7033    6706    MTS                     /SELECT UNIT 1, ODD PARITY, 800 BPI, LOW SLICE
7034    6716    MTC                     /CONTINUOUS READ COMPARE FOR LABEL
7035    4301    SEARCH, JMS WAIT        /WAIT FOR EOR, THEN GET TAPE STATUS
7036    7004    RAL
7037    7710    SPA CLA
7040    5313    JMP OUT                 /EOF
7041    7420    SNL
7042    5260    JMP FOUND               /LABEL FOUND
7043    1257    RESUME, TAD BUFIB
7044    6745    MCA                     /RE-INITIALIZE CA AND CLEAR WC
7045    7200    CLA
7046    6724    MRD                     /CHANGE TO CONTINUOUS READ COMPARE.  SET DATA RQ.
7047    5235    JMP SEARCH              /RESUME SEARCH
7050    0000    PRINT, 0                /PRINTS CHARACTER
7051    6041    ISF
7052    5251    JMP .-1
7053    6046    TLS
7054    7200    CLA
7055    5650    JMP I PRINT
7056    7763    BUFIA, 7763
7057    7764    BUFIB, 7764
7060    1277    FOUND, TAD LCNIA        /PROGRAM FOUND.  PREPARE TO READ IN LOCATION RECORD
7061    6745    MCA
7062    1300    TAD LCNWC
7063    6742    MRWC                    /1 WORD
7064    6724    MRC                     /CHANGE TO CONTINUOUS READ.  CLEAR DATA RQ.
7065    4301    JMS WAIT                /READ PROGRAM IA-1 INTO FLAG, THEN WAIT FOR EOR.
7066    7604    LAS
7067    7010    RAR
7070    7630    SZL CLA                 /CHECK SR11
7071    5323    JMP RELOC               /RELOCATION DESIRED
7072    1363    TAD FLAG                /RELOCATION NOT DESIRED
7073    6745    MCA                     /LOAD PROGRAM IA-1 INTO CA AND CLEAR WC
7074    7240    STA
7075    6724    MRC                     /CLEAR DATA RQ
7076    5351    JMP RDPGM               /READ PROGRAM IN
7077    7762    LCNIA, 7762
7100    0015    LCNWC, -7763
7101    0000    WAIT, 0
7102    7240    STA
7103    6722    MIWF                    /CLEAR AND ENABLE WCO
7104    6732    MIEF                    /   "       "       "    ERF
7105    6731    MSEF
7106    5305    JMP .-1                 /WAIT FOR EOR
7107    7600    P7600, 7600             /CLA
7110    6734    MTRS                    /GET TAPE STATUS
7111    7006    RTL
7112    5701    JMP I WAIT
7113    6702    OUT, MCD                /END OF LIBRARY.  STOP TAPE.
7114    6701    MSCR
7115    5314    JMP .-1
```

```
                                         /FETCH RECORD
7116    5201    JMP BOOT+1               /BOOTSTRAP REWINDS TAPE AND ENTERS COMMAND MODE
7117    3476    T3461, 3461-7763
7120    3561    T3561, 3561
7121    0177    P177, 177
7122    7777    M1, -1
7123    6702    RELOC, MCD               /RELOCATION DESIRED.  STOP TAPE.
7124    1346    TAD P
7125    4250    JMS PRINT
7126    1341    TAD G
7127    4250    JMS PRINT                /PRINT "PG/"
7130    1243    TAD RESUME
7131    4250    JMS PRINT
7132    1363    TAD FLAG                 /PROGRAM IA-1
7133    7001    IAC
7134    7100    CLL
7135    7402    HLT                      /AC HOLDS PROGRAM IA, L IS Ø.  SET SRØ-4 TO RELOC. PG.
7136    0321    AND P177                 /HIT CONT. KEY TO READ IN AND RELOCATE PROGRAM
7137    3363    DCA FLAG                 /STORE NON-PAGE BITS OF IA
7140    7604    LAS
7141    0307    G, AND P7600             /AC HOLDS RELOCATION PAGE
7142    1363    TAD FLAG                 /AC HOLDS RELOCATED IA
7143    1322    TAD M1
7144    6745    MCA                      /LOAD RELOCATED IA-1 INTO CA AND CLEAR WC
7145    7200    CLA
7146    1320    P, TAD T3561
7147    6706    MTS                      /SELECT UNIT 1, ODD PARITY, 8ØØ BPI, LOW SLICE
7150    6716    MTC                      /READ IN PROGRAM IN CONTINUOUS MODE
7151    4301    RDPGM, JMS WAIT          /WAIT FOR EOR, THEN GET TAPE STATUS
7152    7620    SNL CLA
7153    5357    JMP PAROK
7154    6702    MCD                      /PARITY ERROR.  STOP TAPE.
7155    3363    DCA FLAG                 /CLEAR FLAG
7156    5227    JMP PARERR
7157    7240    PAROK, STA               /PARITY OK
7160    3363    DCA FLAG                 /SET FLAG
7161    5243    JMP RESUME               /PREPARE TO RESUME SEARCH FOR LABEL


BOOT     7000
BUFIA    7056
BUFIB    7057
FLAG     7163
FOUND    7060
G        7141
LCNIA    7077
LCNWC    7100
M1       7122
OUT      7113
P        7146
PARERR   7027
PAROK    7157
PRINT    7050
P177     7121
P7600    7107
RDPGM    7151
RELOC    7123
RESUME   7043
SEARCH   7035
T3461    7117
T3561    7120
WAIT     7101
```

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```
              *7224
              BOOT=7200
              FLAG=7363
7224   6734   MTRS                /ENTRY FROM COMMAND RECORD.   LABEL IS IN BUFFER.
7225   7006   RTL
7226   7630   SZL CLA
7227   7402   HLT                 /PARITY ERROR.  L IS 1, AC IS ∅.
7230   1267   TAD P3
7231   4307   JMS TYPOUT          /PRINT "IA/"
7232   7402   HLT                 /SET SR TO IA, HIT CONT.
7233   7604   LAS
7234   3270   DCA IA              /STORE IA
7235   4307   JMS TYPOUT          /PRINT "FA/"
7236   7606   LAS HLT             /AC HOLDS IA.  L IS ∅.  SET SR TO FA, HIT CONT.
7237   7604   LAS
7240   7041   CIA
7241   3363   DCA FLAG            /STORE -FA.  THIS ALSO SETS FLAG.
7242   1305   TAD T1661
7243   4341   JMS TAPE            /SPACE TO EOF
7244   1306   TAD T1721
7245   4341   JMS TAPE            /BACKSPACE OVER EOF
7246   1271   TAD BUFIA
7247   3357   DCA TIA             /INITIALIZE TAPE IA FOR LABEL BUFFER
7250   7001   IAC
7251   3360   DCA TWC             /      "         "  WC       "        "
7252   4317   JMS WTCHK           /WRITE AND CHECK LABEL RECORD
7253   1270   TAD IA
7254   1272   TAD M1
7255   3364   DCA FLAG+1          /REPLACE 1ST LABEL CHAR WITH PROGRAM IA-1
7256   4317   JMS WTCHK           /WRITE AND CHECK LOCATION RECORD
7257   1364   TAD FLAG+1
7260   3357   DCA TIA             /PROGRAM IA-1
7261   1363   TAD FLAG
7262   3360   DCA TWC             /-FA
7263   4317   JMS WTCHK           /WRITE AND CHECK PROGRAM RECORD
7264   1303   TAD T1321
7265   4341   JMS TAPE            /WRITE EOF
7266   5201   JMP BOOT+1          /BOOTSTRAP REWINDS TAPE AND ENTERS COMMAND MODE
7267   0003   P3, 3
7270   0000   IA, 0
7271   7763   BUFIA, 7763
7272   7777   M1, -1
7273   0000   PRINT, 0            /PRINTS CHARACTER
7274   6041   TSF
7275   5274   JMP .-1
7276   6046   TLS
7277   7200   CLA
7300   5673   JMP I PRINT
7301   0257   SLASH, 257
7302   1221   T1221, 1221
7303   1321   T1321, 1321
7304   1421   T1421, 1421
7305   1661   T1661, 1661
7306   1721   T1721, 1721
7307   0000   TYPOUT, 0           /PRINTS "IA/" OR "FA/"
7310   1322   TAD F
7311   4273   JMS PRINT
7312   1314   TAD A
7313   4273   JMS PRINT
```

/WRITE RECORD

```
7314   1301    A, TAD SLASH
7315   4273    JMS PRINT
7316   5707    JMP I TYPOUT
7317   0000    WTCHK, 0
7320   1302    TAD T1221
7321   4341    JMS TAPE       /WRITE RECORD
7322   1306    F, TAD T1721
7323   4341    JMS TAPE       /BACKSPACE OVER RECORD
7324   1304    TAD T1421
7325   4341    JMS TAPE       /READ COMPARE RECORD
7326   6734    MTRS           /GET TAPE STATUS
7327   7006    RTL
7330   7700    SMA CLA
7331   5717    JMP I WTCHK    /NO ERROR
7332   1306    TAD T1721      /READ COMPARE ERROR
7333   4341    JMS TAPE       /BACKSPACE OVER BAD RECORD
7334   1303    TAD T1321      /WRITE...
7335   4341    JMS TAPE       /...3"
7336   1306    TAD T1721      /...BLANK
7337   4341    JMS TAPE       /...TAPE.
7340   5320    JMP WTCHK+1    /WRITE AND CHECK RECORD AGAIN
7341   0000    TAPE, 0        /BASIC TAPE SUBROUTINE
7342   3361    DCA TCM        /STORE TAPE COMMAND
7343   1357    TAD TIA
7344   6745    MCA            /LOAD CA
7345   1360    TAD TWC        /COMPUTE:  -WC = TIA ≠ TWC
7346   6742    MRWC           /LOAD WC
7347   7200    CLA
7350   1361    TAD TCM
7351   6706    MTS            /SELECT UNIT 1, ODD PARITY, 800 BPI, HIGH SLICE
7352   6716    MTC            /EXECUTE TAPE FUNCTION
7353   6701    MSCR
7354   5353    JMP .-1        /WAIT UNTIL THROUGH
7355   7200    CLA
7356   5741    JMP I TAPE
7357   0000    TIA, 0
7360   0000    TWC, 0
7361   0000    TCM, 0
```

```
                *7424
7424   6734    MTRS          /ENTRY FROM COMMAND RECORD
7425   7006    RTL
7426   7602    CLA HLT       /L IS 1 IF PARITY ERROR.  SET SRØ FOR HI/LO READER.
7427   7604    LAS           /CONT. STARTS RIM LOADER
7430   7700    SMA CLA
7431   5253    JMP HIR
7432   6032    LOR, KCC      /LOW SPEED RIM LOADER
7433   6031    KSF
7434   5233    JMP .-1
7435   6036    KRB
7436   7106    CLL RTL
7437   7006    RTL
7440   7510    SPA
7441   5233    JMP LOR+1
7442   7006    RTL
7443   6031    KSF
7444   5243    JMP .-1
7445   6034    KRS
7446   7420    SNL
7447   3652    DCA I TEMP
7450   3252    DCA TEMP
7451   5232    JMP LOR
7452   0000    TEMP,0
7453   6014    HIR, RFC      /HIGH SPEED RIM LOADER
7454   6011    RSF
7455   5254    JMP .-1
7456   6016    RRB RFC
7457   7106    CLL RTL
7460   7006    RTL
7461   7510    SPA
7462   5271    JMP REPEAT-1
7463   7006    RTL
7464   6011    RSF
7465   5264    JMP .-1
7466   6016    RRB RFC
7467   7420    SNL
7470   3652    DCA I TEMP
7471   3252    DCA TEMP
7472   5254    REPEAT, JMP HIR+1


HIR      7453
LOR      7432
REPEAT   7472
TEMP     7452
```

```
                          *6200              /SA=6200
6200   1377    TAD (6423
6201   4215    JMS WTCHK          /WRITE AND CHECK COMMAND RECORD
6202   1376    TAD (6623
6203   4215    JMS WTCHK          /    "     "      "    BIN            "
6204   1375    TAD (7023
6205   4215    JMS WTCHK          /    "     "      "    FETCH          "
6206   1374    TAD (7223
6207   4215    JMS WTCHK          /    "     "      "    WRITE          "
6210   1373    TAD (7423
6211   4215    JMS WTCHK          /    "     "      "    RIM            "
6212   1372    TAD (1321
6213   4243    JMS TAPE           /WRITE EOF
6214   7402    HLT                /ALL DONE.  AC IS 0.
6215   0000    WTCHK, 0
6216   3265    DCA TIA            /STORE IA-1
6217   1371    TAD (1221
6220   4243    JMS TAPE           /WRITE RECORD
6221   1370    TAD (1721
6222   4243    JMS TAPE           /BACKSPACE OVER RECORD
6223   1367    TAD (1421
6224   4243    JMS TAPE           /READ COMPARE RECORD
6225   6734    MTRS               /GET TAPE STATUS
6226   7006    RTL
6227   7700    SMA CLA
6230   5615    JMP I WTCHK        /NO ERROR
6231   6744    MRCA               /READ COMPARE ERROR.  GET CA.
6232   7402    HLT                /AC=ADDRESS+1 OF ERROR WORD
6233   7200    CLA                /HIT CONT. TO TRY AGAIN
6234   1370    TAD (1721
6235   4243    JMS TAPE           /BACK SPACE OVER BAD RECORD
6236   1372    TAD (1321          /WRITE,..
6237   4243    JMS TAPE           /...3"
6240   1370    TAD (1721          /...BLANK
6241   4243    JMS TAPE           /...TAPE.
6242   5217    JMP WTCHK+2        /WRITE AND CHECK RECORD AGAIN
6243   0000    TAPE, 0            /BASIC TAPE SUBROUTINE
6244   3264    DCA TCM            /STORE COMMAND
6245   1265    TAD TIA
6246   6745    MCA                /LOAD CA
6247   7200    CLA
6250   1366    TAD (-137
6251   6742    MRWC               /LOAD WC WITH -137(8)
6252   7200    CLA
6253   1264    TAD TCM
6254   6706    MTS                /SELECT UNIT 1, ODD PARITY, 800 BPI, LOW SLICE
6255   6711    MSUR
6256   5255    JMP .-1
6257   6716    MTC                /EXECUTE TAPE FUNCTION
6260   6701    MSCR
6261   5260    JMP .-1            /WAIT UNTIL THROUGH
6262   7200    CLA
6263   5643    JMP I TAPE
6264   0000    TCM, 0
6265   0000    TIA, 0
6366   7641    $
6367   1421
6370   1721
6371   1221
```

```
6372   1321
6373   7423
6374   7223
6375   7023
6376   6623
6377   6423
```

```
TAPE    6243
TCM     6264
TIA     6265
WTCHK   6215
```

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VE/lh