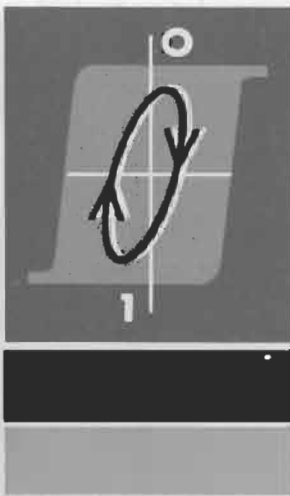
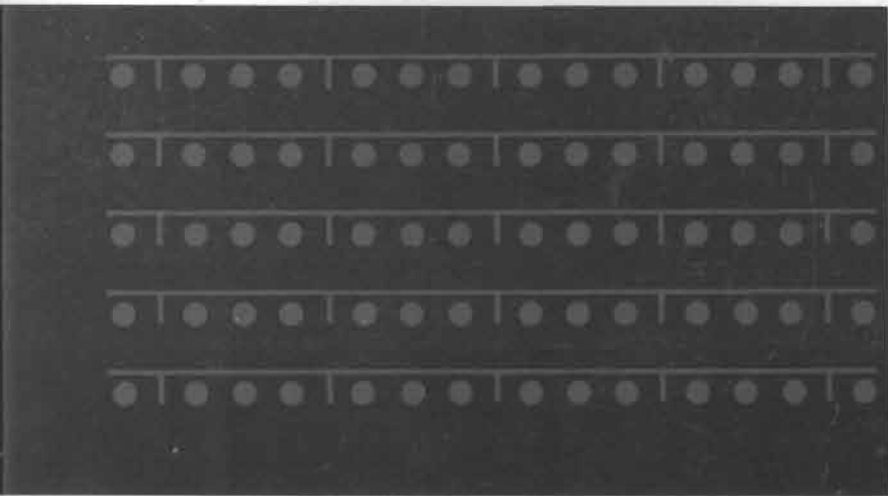


GTC



2116A/2115A COMPUTER

H E W L E T T • P A C K A R D



OPERATING MANUAL

SOFTWARE MANUAL CHANGES

OPERATING MANUAL



(HP Part Number 02116-9057)

dated January 1968

Some of the items below pertain not only to the OPERATING MANUAL but also to the Manual Change Sheet itself. The highest-numbered entry is the most current. Therefore, these changes should be recorded first. This ensures that earlier entries which have been modified are updated on this sheet. Earlier entries which no longer apply are deleted.

Change
Number

Description

- | | |
|---|--|
| 1 | Page 1-2. Under the title "LOADER LISTING". After the title "Input Device:" the complete statement should now be: "2752A Teleprinter with 12531A (serial) Teleprinter Input/Output Interface Kit)." |
| 2 | Page 1-2. At the bottom of the page. Replace the complete statements for "m" and "n" with the following:

m = 0 for 4K memory
= 1 for 8K memory
= 2 for 12K memory
= 3 for 16K memory

n = 7 for 4K memory
= 6 for 8K memory
= 5 for 12K memory
= 4 for 16K memory |
| 3 | Page 1-3. At the top of the page. After the title "Input Device:" the complete statement should now be "either a 2752A Teleprinter with 12531B (paralleled) Teleprinter Input/Output Interface Kit, or a 2737A Punched Tape Reader with 12532A High-Speed Punched Tape Input Interface Kit." |

Change
NumberDescription

- 4 Page 1-3. Under the table of instructions. Replace the complete statements for "m" and "n" with the following:
- m = 0 for 4K memory
 = 1 for 8K memory
 = 2 for 12K memory
 = 3 for 16K memory
- n = 7 for 4K memory
 = 6 for 8K memory
 = 5 for 12K memory
 = 4 for 16K memory
- 5 Page 5-1. At the end of the section for "Control Statement". Add this new note:
- "NOTICE"
- If a user wishes to obtain an Assembly listing of a FORTRAN compilation using Magnetic Tape FORTRAN and only one output device other than the Magnetic Tape Unit, he must compile separately using the control statement "FTN,A."
- For a source listing and binary output tape, the user should compile his program with the control statement "FTN,B,L."
- 6 Page 5-4. At the center of the page. Add this parenthetic note to the title "magnetic Tape System": "(2020A)".
- 7 Page 5-4. At the bottom of the page. Add step F as follows:
- F. If switch 0 is up (=1) during Mag. Tape FORTRAN Pass 2, leader and trailer will be suppressed on the binary output.
- 8 Page 8-1. In the first paragraph. In the first line after the sentence "The minimum configuration for Magnetic Tape System operation is:", add an asterisk (*) the number "2115A". Then, at the bottom of the page, add this note: "*If your Computer is Model 2115A and your BCS HP 2020 Driver D.21 is number HP 20013B, the 2020A Tape Unit can operate only at 200 BPI. To use 556 BPI, substitute the BCS HP 2020 Driver D.21 numbered HP 20013C."

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Change
NumberDescription

- 9 Page 12-1. At the top of this page. The title should be changed to read "SYSTEM INPUT/OUTPUT MAGNETIC TAPE DUMP". Then, in the first paragraph, the first six words "This System Input/Output (SIO) Dump" should be replaced by these words: "The SIO HP 2020 (or 3030, Mag. Tape) Dump". Next, in the second paragraph change the first three words "The SIO Dump" to read "This SIO Mag. Tape Dump". Finally, at the end of this same paragraph, change the words "SIO Dump" to "SIO Mag. Tape Dump".
- 10 Page 12-2. In step K. Insert the words "Mag. Tape" between the words "SIO" and "Dump". Then in step L, add this statement: "Set switch 15 down (0) if binary tape is to contain SIO Drivers and System Linkage only, or up (1) if software system is also to be included.
- 11 Page 13-5. In the Action column. In the line starting "d - 1 to 6 ---", change the letter "d" to "c".

 7-69

The following entry applies to owners of HP 2114A Computers.

- 12 Page 1-1. Under OPERATING PROCEDURES, substitute the following for instructions A through H:
- The 2737A Punched Tape Reader and the 2752A Teleprinter are typical input devices that can be used to read program data from the test tapes and transfer it into memory. If the Punched Tape Reader is used, three loading options can be selected. These options, and the entries required in bits 0 and 15 of the S-Register to select them, are specified in Table 5-4. Procedures for using each input device are presented in the following paragraphs.
- If using the Punched Tape Reader to load the tapes, proceed as follows:
- a. At the Punched Tape Reader, set POWER switch to ON.
 - b. Place RUN/LOAD lever in LOAD position.
 - c. Carefully position program tape to loaded in the tape reading mechanism and place the RUN/LOAD lever in the RUN position.
 - d. At the Computer front panel, press CLEAR REGISTER switch.

Change
NumberDescription

12 (Cont'd)

- e. Refer to Table 5-4 and enter the appropriate settings for bits 0 and 15 into the S-Register.
- f. Press and hold PRESET and LOAD switches, then release both switches. The Computer should go into the run mode (RUN indicator on) and the program tape should process through the tape reading mechanism of the Punched Tape Reader. When the Computer halts (RUN indicator off, HALT indicator program was correctly loaded into memory) halt instruction 102077 should be displayed.
- g. After loading, rewind the tape and return it to the appropriate storage box.

Table 5-4. Punched Tape Reader Loading Options

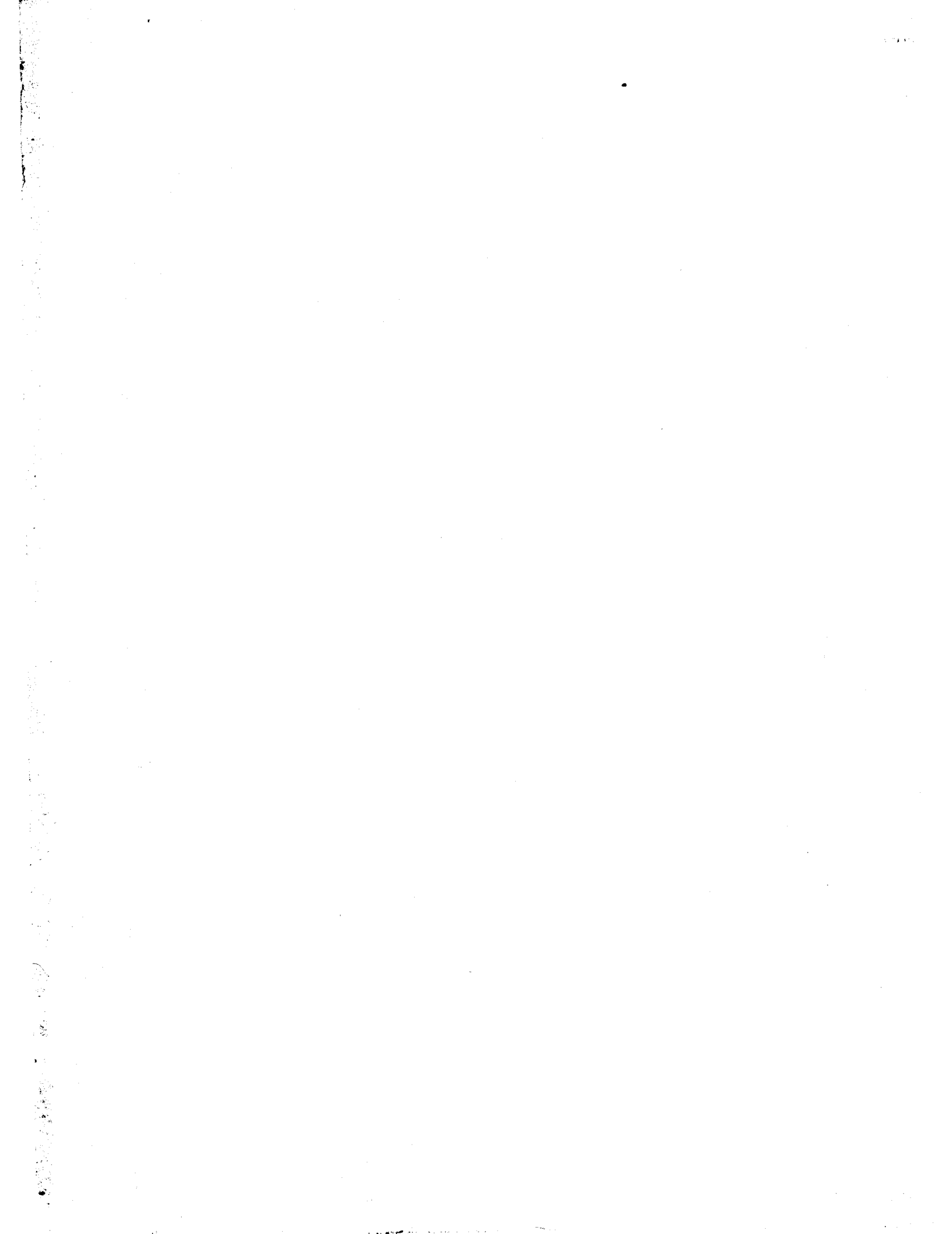
OPTION	SWITCH REGISTER SETTINGS	
	BIT 15	BIT 0
Load tape	0	0
Verify checksum without loading	0	0
Compare the contents of the tape with the contents of memory without loading	1	0/1

TELEPRINTER. If using the Teleprinter to load tape, proceed as follows:

- a. At the Teleprinter, set LINE/OFF/LOCAL switch to LINE position.
- b. Carefully position program tape to be loaded in the Teleprinter tape reader.
- c. Set START/STOP/FREE switch to START position.
- d. At the Computer front panel, press CLEAR REGISTER switch, then press and hold PRESET and LOAD switches. Release both switches. The Computer should go into the run mode (RUN indicator on) and the program tape should process through the tape reader of the Teleprinter. When the Computer halts (RUN indicator off, HALT indicator on), check the T-Register indicators. If the test program was correctly loaded into memory, halt instruction 102077 should be displayed.

Charge
NumberDescription

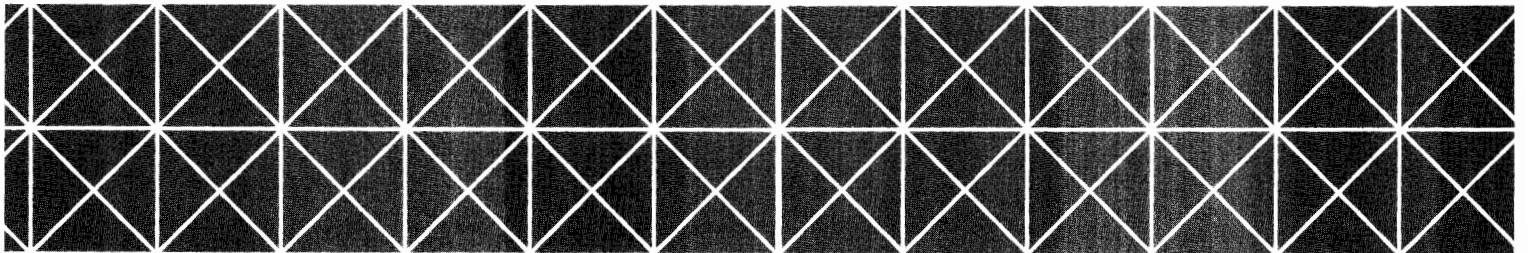
- 13 Page 8-1. At the bottom of the page. In the asterisk (*) note added by change #8 of this Manual Change Sheet, "2020A" should be changed to "2020".
- 14 Page 12-1. At the top of the page. In the first paragraph, change the parenthesis location added by change #9 of this Manual Change Sheet to enclose only the words "or 3030". Thus, the sentence should start, "The SIO HP 2020 (3030) Mag Tape Dump....."
- 15 In Change #10 of this Manual Change Sheet, the word "a" was erroneously included after the words, "(1) if software system is..."





STANDARD SOFTWARE SYSTEMS
operating manual

HEWLETT · PACKARD 2116A / 2115A COMPUTER



HEWLETT  PACKARD

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PREFACE

This publication is an operating manual for the user of HP2116A/2115A standard software systems. It includes the operating procedures for these systems and diagnostics that might occur during their execution.

The reader is assumed to be familiar with the HP Computers and with the Hewlett-Packard software systems. Completion of the Hewlett-Packard programming training courses or equivalent experience is a prerequisite to the use of this manual.

Other computer publications provided by Hewlett-Packard include:

Assembler Programmer's Reference Manual

FORTRAN Programmer's Reference Manual

ALGOL Programmer's Reference Manual

Symbolic Editor Programmer's Reference Manual

Basic Control System Programmer's Reference Manual

Specifications and Basic Operation Manual

TABLE OF CONTENTS

PREFACE	i
BASIC BINARY LOADER	1-1
MAGNETIC TAPE BINARY LOADER	2-1
BCS RELOCATING LOADER	3-1
BCS ABSOLUTE OUTPUT TAPE	4-1
FORTRAN	5-1
ALGOL	6-1
ASSEMBLER	7-1
MAGNETIC TAPE SYSTEM	8-1
SYMBOLIC EDITOR	9-1
CROSS REFERENCE TABLE GENERATOR	10-1
SYSTEM INPUT/OUTPUT DUMP	11-1
SYSTEM INPUT/OUTPUT DUMP (Magnetic Tape)	12-1
PREPARE CONTROL SYSTEM	13-1
PUNCH/VERIFY ROUTINE	14-1
DEBUGGING ROUTINE	15-1
APPENDIX A FORTRAN COMPILATION DIAGNOSTICS	A-1
APPENDIX B ALGOL COMPILATION DIAGNOSTICS	B-1
APPENDIX C ASSEMBLER DIAGNOSTICS	C-1
APPENDIX D FORTRAN/ALGOL INPUT/OUTPUT DIAGNOSTICS	D-1
APPENDIX E PROGRAM LIBRARY DIAGNOSTICS	E-1
APPENDIX F .IOC, OBJECT PROGRAM DIAGNOSTICS	F-1
APPENDIX G UNIT-REFERENCE NUMBER ASSIGNMENT	G-1
APPENDIX H 2752A TELEPRINTER OPERATING INSTRUCTIONS	H-1
APPENDIX I 2737A PUNCHED TAPE READER OPERATING INSTRUCTIONS	I-1
APPENDIX J 2753A TAPE PUNCH OPERATING INSTRUCTIONS	J-1
APPENDIX K HP CHARACTER SET	K-1
APPENDIX L CONSOLIDATED CODING SHEET	L-1

DESCRIPTION

The Basic Binary Loader loads absolute binary programs produced by the Assembler or the Basic Control System absolute output option. It is also used to load standard software systems that are in absolute form (e.g., FORTRAN, ALGOL, Assembler, Basic Control System, and Symbolic Editor). Familiarity with the Basic Binary Loader operating procedure is assumed in the operating procedures for all other software systems.

The Basic Binary Loader is stored in the highest 64 locations in memory. Separate versions of the Basic Binary Loader are available for the 2752A Teleprinter and the 2737A Punched Tape Reader and for 4K memory and 8K memory.

**LOADING
OPTIONS**

If the Punched Tape Reader version is being used, options are available to perform operations other than loading. The options and the required Switch Register settings are as follows:

<u>Option</u>	<u>Switch 15 Setting</u>	<u>Switch 0 Setting</u>
Load tape	0	0
Verify checksum without loading	0	1
Compare the contents of the tape with the contents of memory (without loading)	1	

**OPERATING
PROCEDURES**

- A. If Teleprinter is input unit, set to LINE.
- B. Place the absolute binary tape to be loaded in the device serving as the input unit.
- C. Set Switch Register to starting address of Basic Binary Loader (e.g., 007700 for 4K memory, 017700 for 8K memory).
- D. Press LOAD ADDRESS.
- E. If Punched Tape Reader is input unit, set Switches 15 and 0 according to loading option.
- F. Set LOADER switch to ENABLED.
- G. Press PRESET.
- H. Press RUN.

Halts

During the operation of the Basic Binary Loader, the following halts may occur:

<u>T-Register Contents</u>	<u>Explanation</u>	<u>Action</u>
102077	An end-of-tape condition has been detected (Note: ten consecutive feed frames are interpreted as end-of-tape).	a) If loading is complete, set LOADER switch to PROTECTED. b) If there is another tape to be loaded, place tape in input device and press RUN.
102011	Checksum error: The A-Register contains the checksum from the tape; the B-Register contains the computed checksum.	To restart, replace tape in input device and press RUN.
102055	Address error: An attempt has been made to destroy the loader or load outside the computer limits.	To restart, replace tape in input device and press RUN.
102000	The Punched Tape Reader compare option has been specified. The tape being read does not compare with memory. The A-Register contains the word from tape which did not agree.	To find the location of the corresponding word in memory, press SINGLE CYCLE twice. The contents of the T-Register minus one is the address of the desired word. To restart after displaying the contents of the address, set Switch Register to starting address of loader, press LOAD ADDRESS, replace tape in input device, and press RUN.

LOADER LISTING

Listed below are the absolute instructions for the Basic Binary Loader:

Input Device: 2752A Teleprinter

	0	1	2	3	4	5	6	7
0m7700:	107700	006401	067771	006006	027710	106700	102077	027700
0m7710:	017752	002003	027703	003004	073772	017752	017743	070001
0m7720:	073773	063773	000040	043774	002040	027741	017743	044000
0m7730:	173773	037773	037772	027721	017743	054000	027702	102011
0m7740:	027700	102055	027700	000000	017752	001727	073775	017752
0m7750:	033775	127743	000000	063771	073776	002400	1027cc	001300
0m7760:	1031cc	1023cc	027761	1024cc	037776	027757	001222	013777
0m7770:	127752	177765	000000	000000	1n0100	000000	000000	000377

cc = channel (higher) of Teleprinter

m = 1 for 8K memory

= 0 for 4K memory

n = 6 for 8K memory

= 7 for 4K memory

Input Device: 2737A Punched Tape Reader

	0	1	2	3	4	5	6	7
0m7700:	107700	063770	106501	004010	002400	006020	063771	073736
0m7710:	006401	067773	006006	027717	107700	102077	027700	017762
0m7720:	002003	027712	003104	073774	017762	017753	070001	073775
0m7730:	063775	043772	002040	027751	017753	044000	000000	002101
0m7740:	102000	037775	037774	027730	017753	054000	027711	102011
0m7750:	027700	102055	027700	000000	017762	001727	073776	017762
0m7760:	033776	127753	000000	1037cc	1023cc	027764	1025cc	127762
0m7770:	173775	153775	1n0100	177765	000000	000000	000000	000000

cc = channel number of Punched Tape Reader

m = 1 for 8K memory

= 0 for 4K memory

n = 6 for 8K memory

= 7 for 4K memory

To verify the Basic Binary Loader instructions in memory:

1. Set Switch Register to address of desired instruction.
2. Press LOAD ADDRESS.
3. Set LOADER switch to ENABLED.
4. Press DISPLAY MEMORY; the contents of the location specified is displayed in the T-Register. Each time the DISPLAY MEMORY button is pressed, the next consecutive memory location is displayed.
5. Set LOADER switch to PROTECTED when all desired locations have been displayed.

To enter an instruction for the Basic Binary Loader:

1. Set Switch Register to address of instruction to be entered.
2. Press LOAD ADDRESS.
3. Set Switch Register to value of instruction.
4. Press LOAD MEMORY.
5. Set LOADER switch to PROTECTED.

DESCRIPTION

The Magnetic Tape Binary Loader loads absolute binary programs from magnetic tape. The programs may be the standard software systems (e. g. FORTRAN, ALGOL, Assembler, and Symbolic Editor) or user programs in absolute form which have been previously stored on tape using the Prepare Tape System routine. †

The Magnetic Tape Binary Loader is stored in the highest 64 locations in memory. It may be entered in these locations using the Exchange Paper Tape for Magnetic Tape Loader program or through use of the Switch Register. † A configuration including 8K memory is required.

OPERATING PROCEDURES

- A. Set Switch Register to starting address of Magnetic Tape Loader, 017700.
- B. Press LOAD ADDRESS.
- C. Set identification number of absolute program in the switch register. (Make sure tape unit is in "AUTO" mode and the proper density has been selected.)
- D. Press PRESET.
- E. Set Loader switch to ENABLED.
- F. Press RUN.
- G. The computer halts at location 1 with 102077 in the T-Register; the program has been located and loaded.
- H. Set Loader switch to PROTECTED.
- I. Press RUN to initiate execution of the absolute program.



Halts

During execution of the Magnetic Tape Binary Loader, the following halt may occur:

<u>T-Register Contents</u>	<u>Explanation</u>	<u>Action</u>
102011	A locating or loading error.	If A-Register contains 000200, the program can not be located. Set in correct ID number and repeat procedure. If A-Register contains other than 000200, a tape read error (timing or parity) has occurred, restart at A.

† See Chapter 8, Magnetic Tape System.

LOADER LISTING

Listed below are the absolute instructions for the Magnetic Tape Binary Loader:

```
017700: 107700 102501 073776 063772 1036cc 1023cc 027705 017734
017710: 057776 002001 027705 017745 177777 037777 037775 027713
017720: 1023cc 027720 017762 017734 006003 027713 1023cc 027726
017730: 063772 1036cc 067774 024001 000000 063771 1036cc 017745
017740: 077775 017745 077777 017745 127734 000000 006400 017753
017750: 017753 017753 127745 000000 005722 017762 1023dc 027755
017760: 1074dc 127753 000000 1025cc 013773 002003 127762 102011
017770: 027700 000063 000201 000672 102077 xxxxxx xxxxxx xxxxxx
```

cc = command channel number for Magnetic Tape Unit.

dc = data channel number for Magnetic Tape Unit.

xxxxxx = variable - locations used by loader.

To verify the Magnetic Tape Binary Loader instructions in memory:

1. Set Switch Register to address of desired instruction.
2. Press LOAD ADDRESS.
3. Set LOADER switch to ENABLED.
4. Press DISPLAY MEMORY; the contents of the location specified is displayed in the T-Register. Each time the DISPLAY MEMORY button is pressed, the next consecutive memory location is displayed.

To enter an instruction for the Magnetic Tape Binary Loader:

1. Set Switch Register to address of instruction to be entered.
2. Press LOAD ADDRESS.
3. Set Switch Register to value of instruction.
4. Press LOAD MEMORY.
5. Set LOADER switch to PROTECTED.

DESCRIPTION

The Loader is the module of the Basic Control System that provides the capability of loading, linking, and initiating execution of relocatable object programs produced by the Assembler, FORTRAN, and ALGOL.

The Loader is stored in an absolute record format on an external medium with the Input/Output Control subroutine, .IOC., and the equipment driver subroutines. It is loaded by the Basic Binary Loader from the device serving as the Standard Input unit. † The Basic Control System may also be loaded from magnetic tape. ‡

The Relocating Loader loads object programs from the Standard Input unit and library routines from the device assigned as the Program Library unit. Comments to the user (e.g., Loader diagnostics) are written on the Teleprinter Output unit.

**LOADING
OPTIONS**

The Basic Control System Loader is designed to load one or more tapes containing relocatable programs. The message "LOAD" is typed when an end-of-tape condition is encountered. The user then loads the next tape, indicates loading from the program library, specifies that loading is complete, etc. When all programs are loaded and no undefined external references remain, the Loader types the message "RUN". The user then initiates program execution.

Memory Allocation List

A Memory Allocation List may be obtained for the programs being loaded. The list may include the name, main program bounds, and Base Page bounds for each of the programs. This portion of the list may be followed (at the completion of the loading operation) by a list of all entry points and their absolute addresses, the bounds of the common block, and the bounds of the linkage area. The setting of Switch 15 determines the contents of the list.

To obtain the bounds for each program on a tape, Switch 15 must be set to 0 before the tape is loaded (in response to the "LOAD" message). To bypass the program bounds listing, set Switch 15 to 1 before loading the tape. The switch setting may be altered whenever the "LOAD" message is typed.

To obtain the entry point list, the common bounds, and the linkage area bounds, set Switch 15 to 0 in response to the message "LST" which is printed after all programs are loaded. To bypass this portion of the list, set Switch 15 to 1 when "LST" is printed.

Absolute Binary Output

The user may specify that an absolute binary tape be punched. The process involves a simulated loading operation, however, the absolute program is punched on tape rather than being loaded.

The absolute records produced consist of the relocated programs (including all programs loaded from the Program Library), the Linkage area, all referenced segments of the Basic Control System. These might include:

† See Appendix G for description of Standard units.

‡ See Chapters 2 and 8.

Input/Output control subroutine (.IOC.)
 All input/output equipment drivers
 Other BCS system subroutines
 Memory Table (.MEM.)
 System Linkage Area
 Interrupt Processing area
 Absolute locations 2 and 3

In addition, the Loader Symbol Table, the common and linkage area bounds are punched in ASCII format on the end of the binary tape. Ten inches of feed frames separate the binary instructions and the ASCII data. This feature provides a record of the memory allocation for the absolute program.

At the completion of the "loading" process the Loader types the message "END".

To execute this absolute program, it must be loaded using the Basic Binary Loader. To initiate execution, set 000002 into the P-Register and press RUN.

**OPERATING
 PROCEDURES**

The following procedures indicate the sequence of steps for loading and execution of the Basic Control System Loader: †

- A. Set Teleprinter to LINE and check that all equipment to be used is operable.
- B. Load the Basic Control System tape using the Basic Binary Loader.
- C. Set Switch Register to 000002, press LOAD ADDRESS, and set Switch Register to 000000.
- D. Establish Loader parameters:
 - 1. Set Switch 15 to 1 if no Memory Allocation Listing is desired during first load operation.
 - 2. Set Switch 14 to 1 if an absolute binary tape of the program is to be punched. (Turn on punch device if this option is selected.)
- E. Place relocatable object tape in device serving as Standard Input unit.
- F. Press RUN.

Halts

During the operation of the Basic Control System Loader, the following halts may occur:

<u>Teleprinter Message</u>	<u>Explanation</u>	<u>Action</u>
LOAD (T-Register contains 102001.)	End-of-tape condition on Standard Input device.	1. To load next tape, set Switches 2-0 to 0. If no Memory Alloca- tion Listing of next tape is desired, set Switch 15 to 1. Press RUN to continue load- ing.

† See Chapter 8 for Magnetic Tape System usage

<u>Teleprinter Message</u>	<u>Explanation</u>	<u>Action</u>
		<ol style="list-style-type: none"> 2. To indicate that all programs are loaded and to proceed to the end-of-loading phase, set Switches 2-0 to 1g. Press RUN. † 3. To terminate loading operation set Switches 2-0 to 2g. Press RUN. (This forces execution even though undefined external references have not been matched.) 4. To load from Program Library, set Switches 2-0 to 4g. If no Memory Allocation Listing of library routines is desired, Set Switch 15 to 1. Press RUN to continue loading. When all library routines are loaded, the Loader proceeds directly to the end-of-loading phase.
*LST	The Loader is ready to print the LST, common bounds, and linkage area bounds.	If a list of these items is not desired, set Switch 15 to 1. Press RUN.
*RUN	All programs are loaded and ready for execution.	Check that all I/O devices are ready for operation. Press RUN.
*END	The absolute binary output has been selected and the punched tape is complete.	<p>To execute the program:</p> <ol style="list-style-type: none"> 1. Load binary tape using Basic Binary Loader. 2. Set Switch Register to 000002. Press LOAD ADDRESS. 3. Press RUN.

† A list of any undefined external symbols is typed following a Switch Register reply of 1 or 4 to the "LOAD" message. The message "LOAD" is then repeated. The programs containing the matching entry points should be loaded. Loading of user-programs from Standard Input must be completed before loading of routines from Program Library.

<u>Teleprinter Message</u>	<u>Explanation</u>	<u>Action</u>
*L01	Checksum error: The checksum read on the last record does not agree with the checksum calculated by the Loader.	To re-read record, reposition tape to beginning of record and press RUN.
*L02	Illegal record: The last record read was not recognized as one of the five types accepted by the Loader.	To re-read record, reposition tape to beginning of record and press RUN.
*L03	Memory overflow: The length of the main or Base Page portion of the program or the common block exceeds the bounds of available memory.	Irrecoverable error, program must be revised.
*L04	Linkage area overflow: Linkage words supplied by the Loader for references between pages exceed the size of available base page memory.	If program consists of several subprograms, altering the sequence in which the subprograms are loaded may reduce the number of linkage words. Otherwise, irrecoverable error, program must be revised.
*L05	Loader symbol table overflow: The number of EXT/ENT symbols exceed available memory.	Irrecoverable error, program must be revised.
*L06	Common block error: The length of the common block in the current program is greater than the length of the first common block allocated.	Revise sequence in which subprograms are loaded and reload program. Otherwise, revise program.
*L07	Duplicate entry points: An entry point in the current program matches a previously declared entry point.	A tape has been loaded twice: restart. Otherwise, irrecoverable error, program must be revised.
*L08	No transfer address: The initial starting location (e.g., END statement operand) was not present in any of the programs which were loaded.	To enter the starting address, set the absolute value in the Switch Register, press LOAD A, and press RUN.

Teleprinter
Message

	<u>Explanation</u>	<u>Action</u>
*L09	Record out of sequence: A NAM record was encountered before the previous program was terminated with an END record.	Irrecoverable error, program must be revised.

If the absolute binary output option is selected, the following halts may occur:

<u>T-Register Contents</u>	<u>Explanation</u>	<u>Action</u>
102066	Tape supply low on 2753A Tape Punch which is producing absolute binary output. Trailer follows last valid output.	Place new reel of tape in unit. Press RUN. Leader is produced.
102055	A line is about to be printed on Teleprinter Output device. (See Basic Control System manual.)	Turn punch unit off. Press RUN.
102056	A line has been printed while Teleprinter punch unit off. (See Basic Control System manual.)	Turn punch unit on. Press RUN.

DESCRIPTION

An option of the BCS Relocating Loader allows punching of an absolute tape. The absolute records produced consist of the relocated programs (including all programs loaded from the Program Library), the Linkage area, all referenced segments of the Basic Control System. These might include:

Input/Output Control subroutine (.IOC.)

All input/output equipment drivers

Other BCS system subroutines

Memory Table (.MEM.)

System Linkage area

Interrupt Processing area

Absolute locations 2 and 3

In addition, the Loader Symbol Table, and the common linkage area bounds are punched in ASCII format on the end of the binary tape. Ten inches of feed frames separate the binary instructions and the ASCII data.

**OPERATING
INSTRUCTIONS**

The following procedures indicate the sequence of steps for the execution of a program punched in absolute form by the BCS Relocating Loader:

- A. Set Teleprinter to LINE and check that all equipment to be used is operable.
- B. Load the program tape using the Basic Binary Loader.
- C. Set Switch Register to starting address of program:
000002
- D. Press LOAD ADDRESS.
- E. Press RUN to initiate execution of the program.

DESCRIPTION

The FORTRAN compiler system translates a symbolic source program written according to American Standard Basic FORTRAN specifications into a relocatable object program which can be loaded and executed under control of the Basic Control System.

The FORTRAN Compiler accepts as input paper tape containing a control statement and a source language program. The output produced by the Compiler may include a punched paper tape containing the object program; a listing of the source language program with diagnostic messages, if any; and a listing of the object in program assembly level language.

Control**Statement**

The control statement specifies the output to be produced; it must be the first statement of the source program.

FTN, P₁, P₂, P₃

FTN is a free field control statement. Following the comma are one to three parameters, in any order, which define the output to be produced. The control statement must be terminated by an end-of-statement mark, (CR) (LF) . Spaces embedded in the statement are ignored.

The parameters may be a combination of the following:

- B Binary output: A program is to be punched in relocatable binary format suitable for loading by the Basic Control System loader.
- L List output: A listing of the source language program is to be produced during Pass One.
- A Assembly listing: A listing of the object program in assembly level language is to be produced in the last pass.

Source**Program**

The source program follows the control statement. Each statement is followed by the end-of-statement mark, (CR) (LF) . Specifications statements must precede executable statements. The last statement in each program submitted for compilation must be an END statement. Up to five source programs may be compiled at one time. The last program must be followed by an END\$ statement, if less than six programs are to be compiled. (For complete details see FORTRAN Programmer's Reference manual.)

The control statement, each of the five programs, and the END\$ terminator may be submitted on a single tape or on separate tapes. If more than five programs are contained on a tape, the compiler processes the first five and halts with the T-Register containing 102077. The remaining programs must be compiled separately.

Binary Output

The punch output produced by the compiler is a relocatable binary program. It does not include system subroutines introduced by the compiler, or library subroutines referred to in the program.

OPERATING INSTRUCTIONS

The exact operating procedures for a compilation depend on the available hardware configuration.

One possible allocation of equipment might be as follows:

<u>Compiler Input/Output</u>	<u>Standard Unit Designation</u>	<u>Physical Unit Assignment</u>
Binary output	Punch Output	2753A Tape Punch
List output	Teleprinter Output	2752A Teleprinter
Assembly listing	Teleprinter Output	2752A Teleprinter
Source Tape(s)	Input	2737A Punched Tape Reader

If there are two output devices as shown above, there are two passes (8K memory) or four passes (4K memory). The list output and an intermediate binary tape are both produced during the first pass; the assembly listing and the binary output are both produced during the last pass.

If one output device is available list output and intermediate binary output are written on the same tape during the first pass (the Compiler ignores the list output when reading the binary data during the second pass). The Binary output is then produced in the next to the last pass; and the assembly listing, in the last pass.

Paper Tape System

The following procedures indicate the sequence of steps for compilation of a source program: †

- A. Set Teleprinter to LINE and check that all equipment to be used is operable. If the Teleprinter is the only output device, turn ON punch unit.
- B. Load FORTRAN Pass 1 using the Basic Binary Loader.
- C. If the System Input/Output (SIO) subroutines are on a tape which is separate from FORTRAN Pass 1, load the tape using the Basic Binary Loader.
- D. Set Switch Register to starting address of FORTRAN Pass 1: 000100
- E. Press LOAD ADDRESS.
- F. Place source language tape in device serving as the Standard Input unit (e.g., Punched Tape Reader).
- G. Press RUN.
- H. If more than one source tape, repeat Steps F and G for each tape.
- I. Perform either of the following depending on memory size:

4K Memory

1. At end of Pass 1 (T-Register contains 102077) load Pass 2 using the Basic Binary Loader.
2. Remove binary output from Standard Punch device and place in device serving as the Standard Input unit. (If only one output device, both binary and list output are on the same tape.)

† See page 5-4 for Magnetic Tape System usage.

3. Set Switch Register to: 000100
4. Press LOAD ADDRESS.
5. Press RUN.
6. At end of Pass 2 (T-Register contains 102077), load Pass 3 using the Basic Binary Loader.
7. Remove binary output from Standard Punch device and place in device serving as Standard Input unit.
8. Set Switch Register to: 000100
9. Press LOAD ADDRESS.
10. Press RUN.
11. At end of Pass 3 (T-Register contains 102077), load Pass 4 using the Basic Binary Loader.
12. Remove binary output from Standard Punch device and place in device serving as Standard Input unit.
13. Set Switch Register to: 000100
14. Press LOAD ADDRESS.
15. Press RUN.
16. At end of Pass 4, the relocatable binary object tape is on the Standard Punch unit. Either of the following conditions may exist:
 - a. If the T-Register contains 102077, the compilation is complete. If an assembly listing was requested, it is on the List Output device.
 - b. If the T-Register contains 102001, an assembly listing pass is to be performed:
 - (1) Place binary output from Pass 3 in device serving as Standard Input unit. (Turn off Teleprinter punch unit.)
 - (2) Press RUN.
 - (3) At end of listing pass, T-Register contains 102077.



8K Memory

1. At end of Pass 1 (T-Register contains 102077), load Pass 2 using the Basic Binary Loader.
2. Remove binary output from Standard Punch device and place in device serving as the Standard Input unit. (If only one output device, both binary and list output are on the same tape.)
3. Set Switch Register to: 000100
4. Press LOAD ADDRESS.

5. Press RUN.
6. At end of Pass 2, the relocatable binary object tape is on the Standard Punch unit. Either of the following conditions may exist:
 - a. If the T-Register contains 102077, the compilation is complete. If an assembly listing was requested, it is on the List Output device.
 - b. If the T-Register contains 102001, an assembly listing pass is to be performed:
 - (1) Place binary output from Pass 1 in device serving as Standard Input unit. (Turn off Teleprinter punch unit.)
 - (2) Press RUN.
 - (3) At end of listing pass, T-Register contains 102077.

Magnetic Tape System

Following are the steps for a compilation when using a magnetic tape system:

- A. Set Teleprinter to LINE and check that all equipment to be used is operable. If the Teleprinter is the only output device, turn ON punch unit.
- B. Load FORTRAN Pass 1 using the Magnetic Tape Binary Loader.
- C. Place source language tape in device serving as the Standard Input unit.
- D. Press RUN.
- E. At the end of compilation, the relocatable binary object tape is on the Standard Punch unit. Either of the following conditions may exist:
 1. If the T-Register contains 102077, the assembly listing was requested and is on the List Output device.
 2. If the T-Register contains 102001, an assembly listing pass is to be performed. Turn off Teleprinter punch unit. Press RUN.

BASIC CONTROL SYSTEM LOADER
OPERATING PROCEDURES SUMMARY

The Basic Control System Loader is used to load the object programs generated by FORTRAN and any referenced library routines. Listed below is a summary of procedures for normal loading of relocatable object programs and library routines (and for the printing of a Memory Allocation Listing):†

1. Load the Basic Control System tape using the Basic or Magnetic Tape Binary Loader.
2. Set Switch Register to 000002, press LOAD ADDRESS, and set Switch Register to 000000.
3. Place FORTRAN generated relocatable object tape in Standard Input unit.
4. Press RUN. The loader types "LOAD" it expects another relocatable or library program.
5. If more than one relocatable object tape is to be loaded, repeat Steps 3 and 4 for each. Otherwise, set Switch Register to 000004 to load library routines.
6. Place Program Library tape in device serving as Program Library unit.
7. Press RUN. When the loading operation is complete, the loader types "*LST". Press RUN. The Loader types "*RUN" indicating the program is ready for execution.

Halts

During the operation of the Compiler, the following halts may occur:

<u>T-Register</u>	<u>Explanation</u>	<u>Action</u>
102000	Memory overflow: the program is too long.	Irrecoverable error, program must be revised.
102001	End of binary object tape output, start of assembly listing.	If only one output device, place intermediate binary in Standard Input unit and press RUN.
102007	For all passes except first, unrecognizable record on intermediate binary tape:	If punch error, restart with Pass 1. If wrong tape, restart current pass.
	1) Punch error on previous pass.	a) Load FORTRAN pass.
	2) Wrong tape supplied as input for pass.	b) Set Switch Register to 000100. c) Press LOAD ADDRESS. d) Place previous binary tape in input device. e) Press RUN.

†See Chapter 3 for details and options.

T-Register	Explanation	Action
102010	External Symbol Table overflow: the number of external symbols exceeds 255.	Irrecoverable error; program must be revised.
102011	Checksum error.	Attempt to re-read record (binary records are separated by 4 feed frames). Otherwise, restart with Pass 1.
102017	A tape write error has occurred during Pass 1.	Restart with beginning of Pass 1.
102027	A tape read error has occurred during Pass 2.	Restart with beginning of Pass 1.
102066	Tape supply low on 2753A Tape Punch.	Load new tape and press RUN.
102077	Normal end of pass or compilation	Proceed as indicated in above steps.

Diagnostic messages or halts might also occur for the following:

<u>Operation</u>	<u>System</u>	<u>Reference</u>
Loading FORTRAN compiler or SIO tapes	Basic Binary Loader Magnetic Tape Binary Loader	Chapter 1 Chapter 2
FORTTRAN compilation	FORTTRAN	Appendix A
Loading object programs and library routines	BCS Relocating Loader	Chapter 3
Executing I/O operations during running of object program	I/O system (FRMTR)	Appendix D
Executing Basic External Functions during running of object program	Program Library	Appendix E

DESCRIPTION

The ALGOL Compiler accepts as input, paper tape containing a control statement and a source language program. The output produced by the Compiler may include a punched paper tape containing the object program; a listing of the source language program with diagnostic codes defining the errors, if any; and a listing of the object program. ALGOL requires a configuration including an 8K memory.

CONTROL STATEMENT

The first record that is input to the ALGOL compiler is a control statement. This contains the word HPAL followed by any, or all, of the following symbols, separated by commas:

- L: produce source program listing
- A: produce object code listing
- B: produce object tape
- P: a procedure only is to be compiled
- S: sense switch control

Furthermore, the program name (that is, the NAM record name) may appear in quotation marks. It must be a legitimate identifier with no blanks.

Example:

HPAL, B, P, "INVRT"

Sense Switch Control

If the character "S" is included in the control statement, the B, L, and A options are read by the Compiler from the Switch Register. The switches corresponding to the options:

<u>Switch (up)</u>	<u>Control Statement Equivalent</u>
15	B - produce object tape
14	L - produce source listing
13	A - produce object listing

The switches are read at the beginning of each line so that the list option, for example, may be "turned off" partway through compilation.

COMPILER OUTPUT

Note that the P option, if used, must still be placed in the control statement.

The output from the ALGOL Compiler consists of:

A relocatable binary tape (B) which must be loaded with the BCS Loader.

A listing of the source program, (L) with each line preceded by its sequence number and the value of the program counter (with 2000_8 added) at the time the line is read.

A listing (A) of the binary instructions produced by the Compiler.

Compilation With One Output Device

If only one output device is available, such as a 2752A Teleprinter, ALGOL may still be used, but will require two passes. One pass will be for a binary tape, and the other for a listing. This is accomplished most easily if the S option is used (see above).

OPERATING INSTRUCTIONS

The following procedures indicate the sequence of steps for compilation of a source program:

- A. Set Teleprinter to LINE and check that all equipment to be used is operable.
- B. Load ALGOL compiler using the Basic Binary Loader.
- C. Turn on punch and list units.
- D. Set Switch Register to starting address of ALGOL:
000100
- E. Press LOAD ADDRESS.
- F. Place source language tape in device serving as the Standard Input unit (e. g., Punch Tape Reader).
- G. Press RUN.

The source listing will be produced on the list unit, and relocatable binary tape on the punch unit. This tape may now be loaded using the BCS Relocating Loader (See below).

- H. If another program is to be compiled, return to Step F.
- I. If the computer prints "HPAL??", the control statement is incorrect. To re-start compilation, place corrected control statement in input unit and press RUN.

**BASIC CONTROL SYSTEM LOADER
OPERATING PROCEDURES SUMMARY**

The Basic Control System Loader is used to load the object programs generated by ALGOL and any referenced library routines. Listed below is a summary of procedures for normal loading of relocatable object programs and library routines (and for the printing of a Memory Allocation Listing):†

1. Load the Basic Control System tape using the Basic Binary Loader.
2. Set Switch Register to 000002, press LOAD ADDRESS, and set Switch Register to 000000.
3. Place ALGOL generated relocatable object tape in Standard Input unit.
4. Press RUN. The loader types "LOAD" it expects another relocatable or library program.
5. If more than one relocatable object tape is to be loaded, repeat Steps 3 and 4 for each. Otherwise, set Switch Register to 000004 to load library routines.
6. Place Program library tape in device serving as Program Library unit.
7. Press RUN. When the loading operation is complete, the loader types "*LST". Press RUN. The Loader types "*RUN" indicating the program is ready for execution.

Diagnostic messages or halts might occur for the following:

Operation	System	Reference
Loading ALGOL compiler or SIO tapes	Basic Binary Loader Magnetic Tape Binary Loader	Chapter 1 Chapter 2
ALGOL compilation	ALGOL	Appendix B
Loading object programs and library routines	BCS Relocating Loader	Chapter 3
Executing I/O Operations during running of object program	I/O system (FRMTR)	Appendix D
Executing Basic External Functions during running of object program	Program Library	Appendix E

† See Chapter 3 for details and options.

DESCRIPTION

The Assembler translates symbolic source language instructions into an object program. The object program may be either relocatable or absolute. The Loader of the Basic Control System loads and links relocatable programs. The Basic Binary Loader loads programs in absolute form.

The Assembler accepts as input a paper tape containing a control statement and a source language program. The output produced by the Assembler may include a punched paper tape containing the object program and/or an object program listing.

Control Statement

The control statement specifies the output to be produced:



$$\text{ASMB}, p_1, p_2, \dots, p_n$$

"ASMB," is entered in positions 1-5. Following the comma are two or more parameters, in any order, which define the output to be produced. The control statement must be terminated by an end-of-statement mark, **CR** **LF** .

The parameters may be any valid combination of the following starting in position 6:

- A Absolute: The addresses generated by the Assembler are to be interpreted as absolute locations in memory. The binary output format is that specified for the Basic Binary Loader.
- R Relocatable: The program may be located anywhere in memory. The binary output format is that specified for the BCS Relocating Loader.
- B Binary output: A program is to be punched according to one of the above parameters.
- L List output: A program listing is to be produced according to one of the above parameters.
- T Table print: List the symbol table at the end of the first pass.
- N Include sets of instructions following the IFN pseudo instruction.
- Z Include sets of instructions following the IFZ pseudo instruction.

Either A or R must be specified with any combination of B, L, or T.

The control statement may be on the same tape as the source program, or on a separate tape; or it may be entered via the Teleprinter keyboard.

Source Program

The first statement of the program (other than remarks or a HED statement) must be a NAM statement for a relocatable program or an ORG statement for indicating the origin of an absolute program. The last statement must be an END statement and may contain a transfer address for the start of a relocatable program. Each statement is followed by an end-of-statement mark. (For complete details, see Assembly Programmer's Reference manual.)

Binary Output

The punch output includes the instructions translated from the source program. It does not include system or library subroutines referenced within the source program (arithmetic subroutines, .IOC., .DIO., .ENTR, etc.).†

† If system or library subroutines are referenced, they must be loaded from the FORTRAN library tape when the object program is to be executed.

ASSEMBLY OPTIONS

The exact operating procedures for an assembly depend on the available hardware configuration.

One possible allocation of equipment might be as follows:

<u>Assembler Input/Output</u>	<u>Standard Unit Designation</u>	<u>Physical Unit Assignment</u>
Binary output	Teleprinter Output	2752A Teleprinter
Table print	List Output	2753A Tape Punch
List output		
Source program	Input	2737A Punched Tape Reader

If there are two output devices as shown above, there are only two passes; the binary and list output are both produced in the second pass. If only one output device is available, the binary output is produced by the second pass and the list output by the third pass.

The Assembler automatically provides a leader and trailer for binary output tapes. To suppress this leader and trailer, set Switch 0 to 1 (up) before the start of Pass 2.

In a three-pass assembly, the diagnostic messages and binary output are written on the same unit. To prevent these messages from being punched on the binary tape (they still appear on the printed output), perform the following steps:

1. Set Switch 15 to 1 (up) before start of Pass 2.
2. When the computer halts with the T-Register containing "102055", turn the punch unit OFF, and press RUN.
3. When the computer again halts with the T-Register containing "102055", turn the punch unit ON, and press RUN.
4. At the end of Pass 2, set Switch 15 to 0 (down). Steps 2 and 3 are repeated each time a diagnostic message is produced.

OPERATING PROCEDURES

The following procedures indicate the sequence of steps for assembly of a source program when using a paper tape system: ‡

- A. Set Teleprinter to LINE and check that all equipment to be used is operable.
- B. Load the Assembler using the Basic Binary Loader. †
- C. Set Switch Register to starting address of Assembler:
 1. If control statement is on tape: 000100
 2. If control statement is to be entered via Teleprinter: 000110
- D. Press LOAD ADDRESS.
- E. Place source language tape in device serving as the Standard Input unit (e. g., Punched Tape Reader).

† The appropriate System Input/Output Subroutines (drivers) are assumed to be included with the Assembler.

‡ See next page for Magnetic Tape System usage.


```
ASMB,A,B,L,T
ORG 6000B
CLF 0
LDA DINPR
OTA 10B
CLA
CLB
STF 0
STC 10B,C
ISZ WD1
JMP *-1
INA
LDB WD2
JMP *-4
DINPR OCT 160000
WD1 NOP
ORG 236B
WD2 NOP
END
```


- F. Press RUN.
- G. If control statement is not on tape, enter it via the Teleprinter, following it by **(CR)** **(LF)** .
- H. At end of Pass 1 (T-Register contains 102011), the Symbol Table, if requested, is on the Standard List Output unit. To execute Pass 2, replace the source language tape in the Standard Input unit, turn Teleprinter punch unit ON, and press RUN. †
- I. At end of Pass 2, the binary object tape (absolute or relocatable) is on the Standard Teleprinter Output unit. Either of the following conditions may exist:
 - 1. If the T-Register contains 102077, the assembly is complete. To assemble another program, return to Step C.
 - 2. If the T-Register contains 102023, a listing pass is to be performed. Replace the source language tape in the Standard Input unit (turn Teleprinter punch unit OFF), and press RUN.

Magnetic Tape System

Following are the steps for an assembly using a magnetic tape system:

- A. Set Teleprinter to LINE and check that all equipment to be used is operable.
- B. Load the Assembler using the Magnetic Tape Binary Loader.
- C. Place source language tape in device serving as the Standard Input unit. (If 100 was specified as starting address of Assembler during Prepare Tape System processing, the control statement must be on tape.) If control statement is to be entered from the Teleprinter, set 110 into the P-Register. If only one output device, set Switch 15 up.
- D. Press RUN. †
- E. If 110 was specified as the starting address of Assembler, type in control statement.
- F. At end of assembly, T-Register contains 102077. To assemble another program, return to Step C.

† To halt Pass 2 at any time, set Switch 1 up.

Halts

During the operation of the Assembler, the following halts may occur:

<u>T-Register Contents</u>	<u>Explanation</u>	<u>Action</u>
102011	End of first pass	Go to Step H.
102023	End of second of three passes	a) To perform Pass 3, go to Step I. b) To omit Pass 3 and assemble another program, remove output and return to Step C.
102055	Switch 15 option selected to prevent punching of diagnostics on binary output tape.	See steps previously specified under Assembly Options.
102057	End of source tape section	Place next section in device serving as Standard Input unit and press RUN.
102066	Control statement error	a) If control statement on tape, correct and return to Step E. b) If originally entered from Teleprinter, press RUN, and enter correct statement.
102077	End of assembly	Remove output. To assemble another program, return to Step C. †
102054	Sense switch halt on Switch 1	Press RUN to continue.

OBJECT PROGRAM LOADING

If absolute binary output was specified, the Basic Binary Loader (Chapter 1) is used to load the object program tape.

If relocatable binary output was specified, the BCS Relocating Loader (Chapter 2) is used to load the object program tape. If the program refers to other Assembler or FORTRAN generated object programs, these tapes are loaded by the Relocating Loader at the same time. If the program refers to .DIO. (the FORTRAN Formatter routine), or if it makes use of Arithmetic pseudo instructions, the Program Library tape must be submitted for loading also.

† Several programs may be assembled consecutively without reloading the Assembler. If some of the object programs are to be relocatable and others are to be absolute, the programs that are to be assembled in relocatable form must be processed first. If relocatable program assemblies follow absolute assemblies, an R? diagnostic is output.

Listed below are summaries of procedures for normal loading of object programs:

**BASIC BINARY LOADER
OPERATING PROCEDURES SUMMARY**

- A. Place binary object tape in Standard Input unit.
- B. Set Switch Register to starting address of Basic Binary Loader (e.g., 007700 for 4K memory, 017700 for 8K memory).
- C. Press LOAD ADDRESS.
- D. Set LOADER switch to ENABLED.
- E. Press PRESET.
- F. Press RUN.
- G. When the computer halts with T-Register containing 102077, set LOADER switch to PROTECTED.
- H. Set Switch Register to starting address of object program.
- I. Press LOAD ADDRESS.
- J. Check that all I/O devices are ready and loaded for operation of the program.
- K. Press RUN.

**BASIC CONTROL SYSTEM LOADER
OPERATING PROCEDURES SUMMARY**

- A. Load the Basic Control System tape using the Basic Binary Loader.
- B. Set Switch Register to 000002, press LOAD ADDRESS, and set Switch Register to 000000.
- C. Place Assembler generated relocatable object tape in Standard Input unit.
- D. Place Program Library tape in device serving as Program Library unit.
- E. If more than one relocatable object tape is to be loaded, repeat Steps C and D for each. Otherwise, set Switch Register to 000004 to load library routines.
- F. Place Program Library tape in device serving as Program Library unit.
- G. Press RUN. When the loading operation is complete, the Loader types "*LST". Press RUN. The Loader types "*RUN" indicating the program is ready for execution.
- H. Press RUN to initiate execution.

The Magnetic Tape System provides the capability to store the standard software systems and user programs on an HP 2020A/B Magnetic Tape unit and to access them through a simple loading procedure. The same magnetic tape is also utilized by the software systems for temporary storage of intermediate or scratch files. Auxiliary routines are provided to perform the following functions:

1. Configure SIO drivers and magnetic tape Inter-Pass Loader.
2. Create the absolute and relocatable (Program Library) files on magnetic tape.
3. Exchange the magnetic tape loader for the paper tape loader (Basic Binary Loader).
4. Exchange the paper tape loader for the magnetic tape loader.

The minimum configuration for Magnetic Tape System operation is:

HP 2116A or 2115A Computer with 8K memory
 HP 2752A Teleprinter
 HP 2737A Punched Tape Reader
 HP 2020A/B Magnetic Tape Unit

ALLOCATION OF FILES

The tape consists of two files with the remaining portion used as a scratch file or area.

File 1 (Absolute)	File 2 (Program Library)	Scratch-
-------------------	--------------------------	----------

File 1 is the Absolute File; it may contain any program in absolute binary format:

The four standard software systems may be configured for magnetic tape input/output: FORTRAN, Assembler, Basic Control System and Cross Reference Generator.

Standard Software systems configured for paper tape input/output: FORTRAN, Assembler Basic Control System, Symbolic Editor, etc.

Any user programs in absolute form.

Exchange Magnetic for Paper Tape Loader program (required to re-load Basic Binary Loader when absolute programs are to be loaded from paper tape).

FORTTRAN Processing

The FORTRAN Compiler operating with magnetic tape uses the scratch area for storage of intermediate binary code. Pass 1 of FORTRAN writes the intermediate program. At the end of Pass 1, FORTRAN calls the Inter-Pass Loader; it searches for and loads Pass 2 of FORTRAN. (Pass 2 is identified by the number 177777 which is reserved for this purpose.) Pass 2 spaces forward to the scratch area, processes the intermediate code and produces output on the punch and list devices as requested.

Inter-Pass Loader

The Inter-Pass Loader is used to locate and load the second pass of FORTRAN. It must be configured with the other SIO routines through use of the SIO Dump routine. During this processing, it requires specification of the channel number (lower) of the Magnetic Tape Unit.

The Inter-Pass Loader may also be used by any absolute program to locate program segments on magnetic tape and load them in memory overlaying program segments that have already been executed.

The request to read in a new segment is initiated by performing a JMP instruction with the A-Register containing the identification number of the program segment to be loaded. (The number is assigned to the program segment during Prepare Tape System processing.) When the new program has been located and loaded, the Inter-Pass Loader passes control to it via a JMP 3,I.

The calling sequence of the program segment initially in memory is:

```
LDA <identification>  
JMP 6, I
```

where <identification> is an octal number in the range 1-177776.

The first instructions of the program segment to be loaded by the Inter-Pass Loader might be:

```
ORG 3  
DEF <start of program segment>
```

The Inter-Pass Loader resides in the area 6, X6322 - X6420 (X depends on the size of memory and is always in the last page of memory) and must not be overlaid by new program segments.

Basic Control System Processing

The Basic Control System may be configured to process the Program Library from magnetic tape. When Switch 2 is set up (after the user's relocatable program has been loaded from a paper tape device), it will search File 2 for library routines referenced in the user's program. If, at the end of searching forward through this file, there exist unmatched references (external references for which no entry points could be located), a list of these references is printed on the Teleprinter. If these routines are on magnetic tape (e. g. , a user program near the end of the file referring to a library routine near the beginning of the file), Switch 2 is left in the up position and the RUN switch is pressed; BCS repeats the search of the Library file. If the routines are on paper tape, Switch 2 is set down, the tape placed in the paper tape device, and the RUN switch is pressed. Any number of user programs may be entered via a paper tape device after the library routines have been loaded.

PAPER TAPE OPERATION

The paper tape loader (Basic Binary Loader) can be restored in the protected area of memory through use of the Exchange Magnetic for Paper Tape Loader program. The Exchange Magnetic for Paper Tape Loader program must be stored as part of the Absolute file on magnetic tape.

PREPARE TAPE SYSTEM OPERATING PROCEDURES

Before initiating the preparation of the files on magnetic tape, the Prepare Tape System must be configured; the user supplies the I/O channel numbers for the available devices.

Configuring The Software Systems

The SIO routines, the Inter-Pass Loader and the Basic Control System must be configured prior to being stored as part of File 1. For procedures to configure the SIO routines and the Inter-Pass Loader, see the SIO Dump routine. For procedures to configure BCS, see the Prepare Control System Routine.

Configuring The Prepare Tape System Routine

1. Load the PTS routine using the Basic Binary Loader.
2. Set Switch Register to:
000100
3. Press LOAD ADDRESS.
4. Set Switches 5-0 of the Switch Register to the channel number for the printer/punch unit (the lower numbered of the two assigned channels) of the Teleprinter.



5. Press RUN.
6. The computer prints:
HS INPUT
7. Type channel number of Punch Tape Reader. The reply is terminated by a **(CR)** **(LF)**.
8. The computer prints:
MAG TAPE
9. Type the channel number of the data channel (the lower numbered of the two assigned channels) of the Magnetic Tape Unit. The reply is terminated by a **(CR)** **(LF)**.
10. The computer prints:
LWA MEM?
11. Type in the upper limit of available memory; for an 8K configuration, type:

17677 **(CR)** **(LF)**

Preparing The Magnetic Tape Files

1. Following the type-in of the last word address of available memory, the computer prints:
I. D.
2. Type in the program identification number (1-177777_g) starting in position 1. †
If the tape to be loaded is a continuation tape of the tape that was loaded pre-

† An absolute program may be added to the end of a previously prepared File 1: Type /A in response to "I. D. " The tape is positioned at the end of the file and a new ID number requested. (The previously prepared File 2 will be destroyed and must therefore be recreated.)

viously, (e. g., SIO drivers and Inter-Pass Loader) type an identification number of "Ø". Comments may be appended to the ID number (to the end of the line) providing a space separates the comments from the number. The reply is terminated by a (CR) (LF).

3. The computer prints:

S. A.

4. Type in the absolute starting address of the program (usually 2 or 100). Comments may be appended providing a space separates the comments from the address. The reply is terminated by a (CR) (LF).

5. The computer prints:

LOAD

6. Place the paper tape in the input device and press RUN.
7. Repeat steps 1 through 6 for each absolute tape (steps 3 and 4 are bypassed for continuation tape.)
8. To terminate input for File 1, type:

/E (CR) (LF)

in response to "I. D. "

9. The computer prints:

LIBRARY FILE
LOAD

10. Place the Program Library tape in the input device and press RUN. (Switch 15 should be down).
11. When the Program Library is stored on the tape in File 2, the computer prints:

LOAD

12. The user may then load any relocatable programs that are to be added in File 2. ‡ After each program is loaded, the computer prints:

LOAD

13. To terminate input for File 2, set Switch 15 up. The computer prints:

*END

and rewinds the magnetic tape.

‡ If user program refers to library routines, or if they are accessed more frequently, they should be loaded first.

During operation of Prepare Tape System, the following diagnostics may be printed on the Teleprinter:

Message	Explanation	Action
*EOT	End-of-Tape	Use larger tape or fewer programs. Start over.
*ADDRESS ERROR	The program being written on tape would destroy the loader if loading attempted.	Reposition tape, then press RUN to reread record, otherwise restart.
INPUT ERROR, TRY AGAIN	Identification is illegal.	Retype identification number.
WRITE NOT ENABLED	Write Enable Ring not inserted in reel.	Insert ring and start over.
TAPE UNIT IN LOCAL		Press AUTO button. Then press RUN to continue.
CHECKSUM ERROR	Checksum error occurred while reading paper tape	Reposition paper tape at beginning of record (indicated by four feed frames) and press RUN. Otherwise, restart.

Loading Magnetic Tape Binary Loader

Prior to loading absolute programs from magnetic tape, the paper tape loader (Basic Binary Loader) must be exchanged for the Magnetic Tape Binary Loader. The steps are as follows:

1. Load Exchange Paper for Magnetic Tape Loader program using the Basic Binary Loader.
2. Set Switch Register to starting address of the routine:
000002
3. Press LOAD ADDRESS.
4. Set Switches 5-0 of the Switch Register to the channel number of the data channel (the lower numbered of the two assigned channels) of the magnetic tape unit.
5. Set Loader switch to ENABLED.
6. Press RUN.
7. When the computer halts with 102077 in the T-Register, the Basic Binary Loader has been replaced with the Magnetic Tape Binary Loader.
8. Set Loader switch to PROTECTED.

Loading Absolute Programs From Magnetic Tape

1. Set Switch Register to starting address of Magnetic Tape Loader. For 8K configuration, use 017700.
2. Press LOAD ADDRESS
3. Set absolute program identification number in the Switch Register. (Make sure tape unit is in "AUTO" mode and the proper density has been selected.)
4. Press PRESET.
5. Set Loader switch to ENABLED
6. Press RUN.
7. The computer halts at location 1 with 102077 in the T-Register. The program has been located and loaded.
8. Set Loader switch to PROTECTED.
9. Press RUN to initiate execution of the absolute program.

If the computer halts with 10211 in the T-Register, a locating or loading error has occurred. If the A-Register contains 000200, the requested program can not be located; set correct number in Switch Register and repeat procedure. If the A-Register does not contain 000200, a tape read error (timing or parity) has occurred; restart at step 1.

Restoring The Basic Binary Loader

To load absolute binary programs from paper tape, the Magnetic Tape Binary Loader must be exchanged for the Basic Binary Loader. The steps are as follows:

1. Set Switch Register to starting address of Magnetic Tape Loader. For 8K configuration, use 017700.
2. Press LOAD ADDRESS.
3. Set File 1 identification number of the Exchange Magnetic for Paper Tape Loader program in the Switch Register.
4. Press PRESET.
5. Set Loader switch to ENABLED.
6. Press RUN.
7. The computer halts with 102077 in the T-Register. Set Switches 5-0 of the Switch Register to the channel number of the paper tape input device.
8. Let Loader switch remain in ENABLED position.
9. Press RUN.

10. The computer halts with 102077 in the T-Register indicating that the Basic Loader has replaced the Magnetic Tape Binary Loader. Set Loader switch to PROTECTED.
11. To recopy the Basic Binary Loader in the protected area (e. g., an incorrect channel number was entered), leave Loader switch in ENABLED position and RUN. The program returns to Step 7.

DESCRIPTION

The Symbolic Editor provides facilities for editing and updating symbolic source language programs or files. The input to the Symbolic Editor is a file to be edited, the Symbolic File, and a file of editing information, the Edit File. The output is an altered symbolic file, the Updated File. The Symbolic File and the Updated File contain a series of records, each of which is a statement of 1 to 72 ASCII characters terminated by an end-of-statement mark. The Edit File contains the editing control statements and any source language statements that are to be applied to the Symbolic File.

The Edit File may be entered from either the Standard Keyboard Input unit (e.g., 2752A Teleprinter) or the Standard Input unit (e.g., 2737A Punched Tape Reader) depending on the setting of Switch 15.

The following editing functions are available:

/I,r	Insert one or more records <u>following</u> record r. The records to be inserted follow the control statement.
/D,r ₁ [,r ₂]	Delete record r ₁ , or records r ₁ through r ₂ .
/R,r ₁ [,r ₂]	Replace record r ₁ , or records r ₁ through r ₂ with the records following the control statement.
/CI,r,c	Insert characters <u>following</u> character c of record r. The characters to be inserted follow the control statement.
/CD,r,c ₁ [,c ₂]	Delete character c ₁ , or character c ₁ through c ₂ of record r with the characters following the control statement.
/CR,r,c ₁ [,c ₂]	Replace character c ₁ , or characters c ₁ through c ₂ of record r with the characters following the control statement.
/L	Produce numbered listing of Symbolic File.
/E	Terminates the Edit File. If E is only control statement in Edit File, a copy is made of the Symbolic File.

All sequence numbers must be in ascending order, greater than zero, and unique. A particular sequence number may be used in one statement only in the Edit File.

OPERATING PROCEDURES

The following procedures indicate the sequence of steps for execution of the Symbolic Editor:

- A. Set Teleprinter to LINE and check that all equipment to be used is operable.
- B. Load the Symbolic Editor using the Basic Binary Loader. †
- C. Set Switch Register to starting address of Symbolic Editor: 000100

† The appropriate System Input/Output subroutines (drivers) are assumed to be included on the Symbolic Editor tape.

D. Press LOAD ADDRESS.

E. Specify unit containing the Edit File:

1. If Edit File is to be read from the 2752A Teleprinter keyboard or reader, set Switch 15 to 1 (up) position. The Edit File is printed as it is read.
2. If Edit File is to be read from the Standard Input unit, set Switch 15 to 0 (down) position.

Either type in editing information or place Edit File tape in read unit.

F. Press RUN.

During the reading of the Edit File, the following halts may occur:

<u>Teleprinter Message</u>	<u>T-Register Contents</u>	<u>Explanation</u>	<u>Action</u>
none	102002	Loading of the Edit File is complete.	Place Symbolic tape in the input unit.
END OF TAPE	102001	Physical end of tape has been detected, but /E control statement not encountered.	Place next Edit File tape in reader or, set Switch 15 to up position, to type control statements on Teleprinter keyboard.
EDIT OVERFLOW	102000	Number of records in Edit File exceeds available core; the run is terminated.	Prepare smaller Edit File and restart the run.
CS ERR control statement	102004	a) Illegal control statement code. b) Missing parameter. c) Second sequence parameter less than first.	a) To delete control statement and continue, press RUN. b) To correct control statement: (1) Set Switch 15 to up position. (2) Press RUN. (3) Type correct statement up to but not including (LF). (4) If Edit File is being read from Standard Input unit, set Switch 15 to down position. (5) Type (LF) .
ILLEGAL VALUE	102004	An r or c parameter is not numeric or is greater than 4 digits (r) or 2 digits (c).	See Action for CS ERR.

<u>Teleprinter Message</u>	<u>T-Register Contents</u>	<u>Explanation</u>	<u>Action</u>
SEQUENCE ERROR <control statement>	102004	The sequence numbers in the control statement are less than previous sequence numbers.	See Action for CS ERR.

G. When the Edit File has been read successfully, place Symbolic File tape in input unit and turn on punch unit.

H. Press RUN.

During processing of the Symbolic File, the following halts may occur:

<u>Teleprinter Message</u>	<u>T-Register Contents</u>	<u>Explanation</u>	<u>Action</u>
END OF TAPE	102003	Physical end of tape has been detected for Symbolic File.	a) If all tapes of the Symbolic File have been read, set all switches of the Switch Register to down (0) position. The remaining part of the editing run is to be completed. b) If another tape is to be processed, set any switch of Switch Register to up and place tape in reader.
SEQUENCE ERROR <control statement>	102004	The sequence numbers in the control statement exceed the range of the Symbolic File.	To delete control statement and bypass any related Edit File source records and continue, press RUN.
INSERT ERROR REPLACE ERROR <control statement>	102004	No symbolic statements follow an Insert or Replace (record or character) control statement.	See Action for SEQUENCE ERROR.
CS ERROR <control statement>	102004	A value of a character position parameter in a CI or CR control statement is greater than the number of characters in the record being edited.	To ignore control statement and transfer original record from Symbolic File to Updated File, press RUN.
CHAR OV <control statement>	102004	The new record resulting from character editing exceeds the maximum length of 72 characters.	See Action for CS ERROR.

I. To continue the editing process, press RUN.

- J. On completion of edit run the Symbolic Editor halts with the T-Register containing 102077.
- K. To perform another edit run, start at Step C.

DESCRIPTION

The Cross Reference Table Generator routine processes an Assembler source program and prints a cross reference list of all symbols appearing in the program. The List contains the symbols in alphabetic order. † Each is followed by the 4-digit sequence number of the statement in which the symbol was defined and the sequence numbers of all statements referring to the symbol. If the source program is contained on more than one tape, the tape number follows the statement sequence number. The tape number is determined by the order in which the tapes are submitted to the generator routine; it is not printed for the first tape.

OPERATING PROCEDURES

The following procedures indicate the sequence of steps for execution of the Cross Reference Table Generator:

- A. Set Teleprinter to LINE and check that all equipment to be used is operable.
- B. Load Cross Reference Table Generator using the Basic Binary Loader. ‡
- C. Set Switch Register to starting address of Cross Reference Table Generator:
000100
- D. Press LOAD ADDRESS.
- E. Place source language tape in unit serving as the Standard Input unit (e.g., Punched Tape Reader).
- F. Press RUN.
- G. At the end of each tape other than the last, the message "END OF TAPE" is printed and the computer halts. Repeat E and F.
- H. At the end of the last tape (the tape containing the END statement), the table is printed on the Standard List Output device (e.g., Teleprinter). When the table is printed, the computer halts.

During the operation of the routine, the following may be printed:

<u>Teleprinter Message</u>	<u>Explanation</u>	<u>Action</u>
DD <symbol>	A doubly defined symbol has been encountered. The computer does not halt.	Correct source program after completion of routine.

† If the magnetic tape version of the Cross Reference Table Generator is used, it must be executed immediately after the completion of an assembly. It processes the information written on the scratch area of the tape by the Assembler.

‡ The appropriate System Input/Output subroutines (drivers) are assumed to be included on the Cross Reference Table Generator tape.

Teleprinter
Message

Explanation

Action

TABLE
OVERFLOW

The combined number of symbols and references to them exceeds the capacity of the routine.

Irrecoverable error. If the Table is necessary, the source program must be revised.

DESCRIPTION

The System Input/Output (SIO) Dump routine prepares a single binary tape containing the System Input/Output drivers, the significant locations in the System Linkage area, and, optionally, a standard software system.

The SIO Dump is an absolute program which is loaded by the Basic Binary Loader after the appropriate SIO drivers are loaded and with related channels assigned. If a software system, for example, the Symbolic Editor, the Assembler, or Pass 1 of FORTRAN, is to be included on the tape, it is loaded before executing the SIO Dump routine.

The binary tape always includes the following:

- The System Input/Output drivers
- The contents of locations 101 - 104 and 106
- The contents of location 5



If the standard software system is also included, the tape contains the following additional data:

- The software system (the contents of 107 up to location defined in 105)
- The contents of locations 100 and 105

The binary tape is produced on the device assigned as the Standard Punch Output unit. Multiple copies of the tapes may be obtained if needed.

OPERATING PROCEDURES

- A. Set Teleprinter to LINE and check that all equipment to be used is operable.
- B. Load the Teleprinter driver tape using the Basic Binary Loader.
- C. Set Switch Register to 000002. Press LOAD ADDRESS.
- D. Set Switches 5-0 of Switch Register to the channel number of the device associated with the driver (the lower numbered channel for the Teleprinter).
- E. Press RUN.
- F. Repeat Steps B through E for the Punched Tape Reader driver.
- G. Repeat Steps B through E for the Tape Punch driver.
- H. Load standard software system, if pertinent, using Basic Binary Loader.
- I. Load SIO Dump tape using Basic Binary Loader.
- J. Set Switch Register to 000002. Press LOAD ADDRESS.
- K. Set Switch 15 to 0 if binary tape is to contain SIO drivers and System Linkage only, or set Switch 15 to 1 if software system is also included.
- L. Press RUN.

M. To obtain multiple copies of tape, repeat from Step J.

While the binary tape is being punched the following halt may occur:

<u>T-Register Contents</u>	<u>Explanation</u>	<u>Action</u>
102066	Tape supply low in the 2753A Tape Punch.	Place a new reel of tape in Tape Punch and press RUN to continue.

SYSTEM INPUT/OUTPUT DUMP

(Magnetic Tape)

12

DESCRIPTION

This System Input/Output (SIO) Dump routine prepares a single binary paper tape for use in setting up the Magnetic Tape System. It contains the System Input/Output drivers, the significant locations in the System Linkage area, and optionally, a standard software system. This Dump routine is also used to configure the magnetic tape Inter-Pass Loader.

The SIO Dump is an absolute program which is loaded by the Basic Binary Loader after the appropriate SIO drivers are loaded and with related channels assigned. If a software system, for example, the Symbolic Editor, the Assembler, Pass 1 of FORTRAN or Inter-Pass Loader, is to be included on the tape, it is loaded before executing the SIO Dump routine. †

The binary tape always includes the following:

- The System Input/Output drivers
- The contents of locations 101-104, 106, and 107
- The contents of location 5 and 6

If the standard software system is also included, the tape contains the following data:

- The software system (the contents of 4 up to location defined in 105)
- The System Input/Output drivers

Three software systems are designed for use with the magnetic tape SIO driver; these are the magnetic tape versions of the Assembler, FORTRAN, and the Cross Reference Generator. These are the only systems which require a tape produced by this Dump routine. Increased loading efficiency from tape may be obtained, however, if this routine is used to prepare configured versions of the other standard software systems.

The binary tape is produced on the device assigned, as the Standard Punch Output unit. Multiple copies of the tapes may be obtained if needed.

OPERATING PROCEDURES

To prepare a configured set of SIO drivers (and software system, if desired):

- A. Check that all equipment to be used is operable.
- B. Load the Teleprinter driver tape using the Basic Binary Loader.
- C. Set Switch Register to 000002. Press LOAD ADDRESS.
- D. Set Switches 5-0 of Switch Register to the channel number of the device associated with the driver (the lower numbered channel for two address devices).
- E. Press RUN.

† If the drivers and the Assembler are to be included on the same paper tape, the Assembler must be loaded before the Magnetic Tape Unit driver. Otherwise, the software system may be loaded after all drivers.

- F. Repeat Steps B through E for the Punched Tape Reader driver.
- G. Repeat Steps B through E for the Tape Punch driver.
- H. If tape is being prepared for use with FORTRAN Pass 1, the Assembler, or the Cross Reference Generator, repeat steps B through E for the Magnetic Tape Unit driver. †
- I. If tape is being prepared for use with FORTRAN Pass 1, repeat steps B through E for the Inter-Pass Loader.
- J. Load standard software system, if pertinent, using Basic Binary Loader. †
- K. Load SIO Dump tape using Basic Binary Loader.
- L. Set Switch Register to 000002. Press LOAD ADDRESS.
- M. Press RUN.
- O. To obtain multiple copies of tape, repeat from Step L.

While the binary tape is being punched the following halt may occur:

T-Register Contents	Explanation	Action
102066	Tape supply low in the 2753A Tape Punch.	Place a new reel of tape in Tape Punch and press RUN to continue.

† Assembler must be loaded before Magnetic Tape Unit driver if both are on the same paper tape.

DESCRIPTION

The Prepare Control System (PCS) program processes relocatable modules of the Basic Control System and produces an absolute version designed to work on a specific hardware configuration. It creates operating units from the relocatable object tapes of the Input/Output Control subroutine, .IOC., the equipment driver subroutines, and the Relocating Loader. It also establishes the contents of certain locations used in interrupt handling.

The Prepare Control System is an absolute program which is loaded by the Basic Binary Loader. It operates on a minimum configuration of 4K memory and a 2752A Teleprinter. However, if a 2737A Punched Tape Reader and a 2753A Tape Punch are available, the Prepare Control System will utilize these devices; PCS requests their assignment during the Initialization phase.

After the Initialization phase is completed, each module of BCS is loaded and processed by PCS. The order in which the modules are processed is not significant except that the BCS Loader must be the last module loaded. Two modules, the Input/Output Control subroutine and the Loader, require that parameters be entered via the Keyboard Input unit after being loaded.

Options are available to define the equipment driver modules and other BCS system subroutines as relocatable programs to be loaded with the user's object program.

OPERATING PROCEDURES

The following procedures indicate the sequence of steps for loading and execution of the Prepare Control System:

- A. Set Teleprinter to LINE and check that all equipment to be used is operable.
- B. Load the Prepare Control System tape using the Basic Binary Loader.
- C. Set Switch Register to 002000, press LOAD ADDRESS.
- D. Set Switches 5-0 to the value of the channel number for the printer/punch unit (the lower numbered of the two assigned channels) of the Teleprinter.
- E. Press RUN.

The Initialization Phase is executed. During this phase, the following messages may occur:

<u>Teleprinter Message</u>	<u>Explanation</u>	<u>Action</u>
HS INP?	Request for Punched Tape Reader channel assignment.	Type channel number. If Punched Tape Reader not available, type 0. †
HS PUN?	Request for Tape Punch channel assignment.	Type channel number. If Tape Punch not available, type 0.

† All replies from the keyboard must be terminated by an end-of-statement mark which consists of a carriage return, (CR), and a line feed, (LF). If an error is made in typing a reply, type (RUBOUT) (CR) (LF) and repeat the reply.

<u>Teleprinter Message</u>	<u>Explanation</u>	<u>Action</u>
FWA MEM?	Request for first word of available memory.	Type address of word in Base Page following the locations required for interrupt processing.
LWA MEM?	Request for last word of available memory.	Type address of word preceding protected area.
*ERROR	A non-numeric or illegal character has been entered as a reply.	Type the correct value.

Following the completion of the Initialization Phase the relocatable object tapes of the Basic Control System are to be loaded. Only those modules which are to be included in the absolute tape are loaded; modules which are to be loaded with the user's object program are not submitted. The modules may be loaded in any order provided that the Relocating Loader is last. During this phase, the following halts may occur:

<u>Teleprinter Message</u>	<u>Explanation</u>	<u>Action</u>
*LOAD	PCS is requesting the first or the next BCS module.	Place BCS tape in Punched Tape Reader if available, or Teleprinter reader. Press RUN.
*L01	Checksum error.	To re-read record, reposition tape to beginning of record and press RUN.
*L02	Illegal record: the last record read was not recognized as a valid relocatable record type.	To re-read record, reposition tape to beginning of record and press RUN.
*L03	Memory overflow: the length of BCS exceeds available memory.	Irrecoverable error.
*L04	System linkage area overflow in Base Page.	Irrecoverable error.
*L05	Symbol table for BCS symbols exceeds available memory.	Irrecoverable error.
*L06	PCS interprets the program length of BCS to be zero.	Irrecoverable error.
*L07	Duplicate entry points within BCS.	A tape loaded twice or irrecoverable error.

<u>Teleprinter Message</u>	<u>Explanation</u>	<u>Action</u>
*EOT	End-of-tape.	Place next tape in read unit and press RUN to continue loading.

When the .IOC. module is loaded, PCS requests the EQT and SQT parameters. PCS halts after typing the messages "*TABLE ENTRY? EQT?" If the Teleprinter serves both as the reader and keyboard unit, turn reader off, press RUN. Begin typing response to message. (Turn reader on after all replies have been typed.)

<u>Teleprinter Message</u>	<u>Explanation</u>	<u>Action</u>
*TABLE ENTRY? EQT? †	Request for EQT entry information.	<p>For each I/O device, type:</p> <p>nn, D. ee, [,D] [,Uu]</p> <p>nn - channel number D. ee - driver name: ee = 00 Teleprinter (Use lower channel) = 01 Punched Tape Reader = 02 Tape Punch = 20 Kennedy Incremental Tape Transport = 21 HP2020 Magnetic Tape Unit (Use lower channel) = 40 Data Source Interface = 41 Integrating Digital Voltmeter = 42 Guarded Crossbar Scanner = 43 Time Base Generator = 77 HP 2401C/HP-2911 Scanning Driver (HP 2018 System)</p> <p>D - device uses DMA channel Uu - physical unit number (0-7) if attached to multi-unit controller. Each entry is terminated with <u>CR</u> <u>LF</u>. The order in which the entries are given determines the unit reference number for the device (e.g., first entry becomes unit-reference number 7; the second 10).</p> <p>To terminate EQT input, type /E. <u>CR</u><u>LF</u></p>

† See Appendix G.

<u>Teleprinter Message</u>	<u>Explanation</u>	<u>Action</u>
*ERROR	A non-numeric value has been typed for nn, ee, or u.	Retype the entire correct entry.
SQT? † -KYBD?	Request for EQT unit-reference number of unit serving as Keyboard Input.	Type number.
-TTY?	Request for EQT unit-reference number of unit serving as Teleprinter Output.	Type number.
-LIB?	Request for EQT unit-reference number of unit serving as Program Library.	Type number.
-PUNCH?	Request for EQT unit-reference number of unit serving as Punch Output.	Type number.
-INPUT?	Request for EQT unit-reference number of unit serving as Input.	Type number.
-LIST?	Request for EQT unit-reference number of unit serving as List Output.	Type number.
DMA?	Request for DMA channel numbers.	If one DMA channel, type 6. If two DMA channels, type 6, 7. If no DMA channels, type 0.
*ERROR	A non-numeric parameter or a parameter not equal to 6 or 7 has been entered.	Re-type correct parameter.

After the Relocating Loader is loaded, PCS, requests the information needed to set the interrupt linkage for input/output processing. PCS halts after typing the message "INTERRUPT LINKAGE?" If the Teleprinter is serving both as the reader and the keyboard unit, turn reader off and press RUN. Begin typing response to message.

<u>Teleprinter Message</u>	<u>Explanation</u>	<u>Action</u>
INTERRUPT LINKAGE?	Request for interrupt information.	For each I/O device, type: a ₁ , a ₂ , I. ee a ₁ - interrupt location address a ₂ - location containing absolute address of Interrupt Processor entry point

† See Appendix G.

Teleprinter
Message

Explanation

Action

I. ee entry point name:
ee = 00 Teleprinter
= 01 Punched Tape Reader
= 02 Tape Punch
= 20 Kennedy Incremental Tape Transport
= 21 HP 2020 Magnetic Tape Unit data channel†
= 43 Time Base Generator

If a constant is to be set into the interrupt location, type: a, c

a - interrupt location address

d - 1 to 6 digit octal constant to be stored at a.

Constants should be entered for the following instrument drivers:

Data Source Interface (D.40): 1067sc (CLC sc, H)

Integrating Digital Voltmeter (D.41): Ø(NOP)

Guarded Crossbar Scanner (D. 42): Ø(NOP)

Each entry is terminated with (CR) (LF) .

To terminate linkage input, type /E. (CR) (LF) .

*ERROR

A non-numeric value has been typed for a₁, a₂, a, or c.

Retype the entire correct entry.

*UN NAME

The name I. ee is not defined as an entry point in any I/O driver previously loaded.

a) If the driver name was typed incorrectly, retype the entire correct entry.

b) If related driver is to be loaded with user's program at object program load time, type an exclamation mark (!). ‡ The name is added to the Loader's LST.

c) If the driver should have been loaded, rerun PCS.

† A second entry point must be defined for the command channel for the HP 2020A driver: C. 21.

‡ The Scanning Driver (D. 77) appears in the HP 2018 Library; "!" is the proper reply.

When the Interrupt Linkage parameters have been supplied, PCS performs the following functions:

1. Prints the message "*UNDEFINED SYMBOL" followed by the entry point names of all system subroutines which have been referenced as externals but not loaded. At this point, PCS may be rerun and the missing subroutines loaded or, the symbols may be added to the Relocating Loader's Symbol Table. Undefined symbols are assigned a value of 77777 for an absolute address.
2. Completes the construction of the Loader Symbol Table.
3. Sets the Memory Table (symbolic location .MEM.) in the Relocating Loader to reflect the final bounds of available memory.

Following this, PCS prints a list of all Basic Control System entry points and the bounds of the System Linkage area in the Base Page. As a final step PCS produces the absolute BCS tape which can be loaded by the Basic Binary Loader. During final processing, the following messages may occur:

<u>Teleprinter Message</u>	<u>Explanation</u>	<u>Action</u>
*UNDEFINED SYMBOL <symbol>	An entry point in a BCS module can not be located	1) To enter the symbol in the Loader Symbol Table, press RUN. 2) If the subroutine should have been loaded, rerun PCS.
I/O DRIVER? D.ee	A driver has been named in the EQT parameter entry, but has not been loaded	1) If the driver is to be loaded with user's program at object program load time, type an exclamation mark (!). The name is added to the Loader's LST. 2) If the driver should have been loaded (or if a character other than ! is typed), rerun PCS.
*BCS ABSOLUTE OUTPUT	PCS is ready to punch absolute output tape.	Turn on punch unit and press RUN.
*END	PCS run is complete.	

When the binary tape is punched the following halts may occur:

<u>T-Register Contents</u>	<u>Explanation</u>	<u>Action</u>
102077	BCS tape is punched.	To produce additional copies, set Switch 15 to 1 and press RUN.
102066	Tape supply low on the 2753A Tape Punch.	Place a new reel of tape in Tape Punch and press RUN to continue.

DESCRIPTION

The Punch/Verify routine permits the reproduction of punched paper tape regardless of format, and the verification of the copied tape. Any number of tapes may be reproduced and verified. For verification purposes, a tape may contain up to 15,752 characters (frames) for 8K memory or 7560 characters for 4K memory.

The routine is designed to operate on a configuration including 8K memory, an HP 2737A Punched Tape Reader, and an HP 2753A Tape Punch. Modification of one word in memory allows operation on a 4K memory configuration.

The routine includes equipment driver subroutines for the Punched Tape Reader, and the Tape Punch. The channel assignments for these devices are specified whenever the routine is loaded. If more than one punch or verify operation is to be performed, the channel assignment function of the routine can be bypassed by setting Switch 0 to 1 (up). To reassign channels the routine must be reloaded.

OPERATING PROCEDURES

The following procedures indicate the sequence of steps for execution of the Punch/Verify routine:

- A. Load the Punch/Verify routine using the Punched Tape Reader version of the Basic Binary Loader.

Note: After loading, if 4K system is being used:

- a. Set Switch Register to 000364. Press LOAD ADDRESS.
- b. Set Switch Register to 007700. Press LOAD MEMORY.

- B. To perform a tape reproduction operation:

1. Set Switch Register to 000100. Press LOAD ADDRESS.
2. Press RUN.
3. The computer halts with 102001 in the T-Register. Set Switches 5-0 of the Switch Register to the channel number of the Punched Tape Reader.
4. Press RUN.
5. The computer halts with 102002 in the T-Register. Set Switches 5-0 of the Switch Register to the channel number of the Tape Punch.
6. Place master tape (tape to be duplicated) in the Punched Tape Reader unit. †
7. Press RUN. † The tape in the Punched Tape Reader is copied to the Tape Punch.
8. To reproduce another master tape, set Switch 0 to 1 (up) and return to Step 6.

† A master tape is assumed to have less than 30 consecutive feed frames for a leader and should have at least six inches of feed frames as a trailer. The routine interprets 30 consecutive feed frames as end-of-tape. If more than 30 feed frames appear consecutively anywhere on the master tape, the computer halts. To reproduce the feed frames on the output copy, press RUN each time the computer halts.

- C. To perform a tape verification operation:
1. Set Switch Register to 000200.
 2. Press LOAD ADDRESS.
 - a. If a tape reproduction operation was just completed, set Switch 0 to 1 (up) to bypass channel assignment function.
 - b. If this is initial operation of routine, press RUN. The computer halts with 102001 in the T-Register. Set Switches 5-0 of the Switch Register to the channel number of the Punched Tape Reader.
 3. Place master tape (tape previously duplicated) in the Punched Tape Reader unit.
 4. Press RUN. The master tape is ready into memory.
 5. The computer halts with one of the following in the T-Register:
 - a. If the T-Register contains 102001, the entire master tape is in memory.
 - b. If the T-Register contains 102077, the length of the master tape exceeds available memory. Mark the location on master tape at which reading stopped and remove the tape from Punched Tape Reader; the tape requires two or more verification operations.
 6. Place tape to be verified in the Punched Tape Reader unit.
 7. Set Switch 15 to 1 (up). Press RUN.
 8. When the computer halts with 102002 in the T-Register, the verification operation is complete; no differences were detected.
 - a. To verify another tape (using the same master tape), return to Step C6.
 - b. To perform a verification operation with a new master tape (or the next portion of the current master tape), return to Step C1.
 9. If the computer halts with 102055 in the T-Register, a difference has been detected between the verification tape and the master tape as stored in memory.
 - a. To determine the nature of the discrepancy:
 - (1) The A-Register contains the word from the tape being verified.
 - (2) To display the corresponding word from the master file in the T-Register, set Switch Register to 000362, press LOAD ADDRESS, and press DISPLAY MEMORY.
 - b. To continue verification of the same tape, press RUN. (If the computer continues to halt on 102055 for each word read, a character has probably been lost on the copy being verified.)
 - c. To verify another tape using the same master tape:
 - (1) Set Switch Register to 000200. Press LOAD ADDRESS.
 - (2) Return to Step C6.
 - d. To perform a verification operation with a new master tape, return to Step C1.
 10. If the tape being verified is read through the Reader without a halt, the tape did not have sufficient trailer (30 feed frames).

The Debugging routine provides facilities to aid in program testing. It supervises the operation of a program in the check-out phase through the use of an interpretive mode of execution with simulated A, B, E, Overflow, and P Registers.

The Debugging routine is a relocatable program. It is loaded into memory after the user's relocatable program and before the library subroutines are loaded.

**OPERATOR
COMMUNICATION**

All communication between the Debugging routine and the operator is performed using the Standard Keyboard Input and Standard Teleprinter Output units which are normally assigned to a Teleprinter.

After the program is loaded, the Debugging routine pauses to allow the first type-in. The operator then types one or more control statements to direct the operation of the Debugging routine. The last statement of the set must be a Run statement.

When the operation is completed, a pause occurs (except for the Trace operation). The operator may continue by typing a Run statement, or other control statements may be entered first. To regain control at any other time, Switch 15 must be set up.

**CONTROL
STATEMENTS**

The basic format of the control statement is a single alphabetic character followed by the parameters for the operation separated by commas. The statement is terminated by a **(CR)** **(LF)**. Numeric fields must be in octal; leading zeros may be omitted.

M, a

Defines the absolute origin in memory of the user's relocatable program (as specified on BCS Loader listing). This value allows subsequent reference in other control statements to addresses as shown on Assembler or FORTRAN program listings. If not specified, all control statement addresses must be absolute.

S, a, v₁, v₂, . . . v_n

Sets one or more values into locations defined by first address, a. To specify that an existing value remain unchanged, two consecutive commas are used. The control statement can contain any number of values provided its length does not exceed 72 characters.

W, r, v

Sets the value, v, into register, r.

- r=A, A-Register
- =B, B-Register
- =E, E-Register
- =O, Overflow



D, A, a₁, a₂

D, B, a₁, a₂

Dumps area of memory from a₁ through a₂. To dump one location, enter a₁=a₂. A specifies ASCII listing; B specifies octal.

B, I, a
B, O, a

The first form specifies the address, a, of an instruction breakpoint. Before the instruction and the address is executed, the Debugging routine writes a standard breakpoint message.

The second form is an operand breakpoint. When the Debugging routine detects an effect operand address equal to the value of a, it writes a standard breakpoint message.

One or both breakpoint halts may be selected. Once selected, it remains in effect until a new address is selected, or until an A statement is entered, or until the selection is terminated with one of the following:

B, I, Ø
B, O, Ø

T, a₁, a₂

Traces the execution of every instruction in the area a₁ through a₂. A standard breakpoint message is printed before each instruction is executed. Each time the area is reached, printing resumes.

The area to be traced must not contain calls to .IOC.

The trace area remains in effect until a new area is selected or until the selection is terminated with:

T, Ø

R, [a]

Initiates or continues program execution. If the letter R only is entered, execution starts with the next instruction. To resume at another location the address, a, is specified. To start the program initially, the relative (if M statement entered) or absolute starting address must be specified.

A

Aborts all current debugging operations and clears all input/output operations in progress.

Messages

If a control statement is entered incorrectly, the following message is typed:

ENTRY ERROR

If the Debugging routine encounters 10 consecutive levels of indirect addressing, the following is typed:

INDIRECT LOOP

The standard breakpoint message consists of the following:

<id> P=v₁ I=v₂ A=v₃ B=v₄ E=v₅ OV=v₆ MA=v₇ MC=v₈

id = I, Instruction breakpoint
= O, Operand Breakpoint
= T, Trace
= S, Switch 15 set up
= H, Halt in program
= L, Indirect loop

- P - P-Register
- I - Instruction (contents)
- A - A-Register
- B - B-Register
- E - E-Register
- OV - Overflow
- MA - Effective operand address
- MC - Contents of effective operand address

Dump

The Dump output record format consists of the contents up to 8 consecutive words preceded by the address of the first word:

	addr.	word ₁	word ₂	. . .	word _g
Octal:	aaaaa	000000	000000	. . .	000000
ASCII:	aaaaa	cc	cc	. . .	cc

Octal words consist of 6 octal digits; ASCII words are listed as two ASCII characters. The contents of eight or more consecutive words are not written or they are the same as the last word of the previous record. Instead, a record containing only an asterisk is produced.

OPERATING PROCEDURES

The following procedures indicate the sequence of steps for use of the Debugging routine.

- A. Set the Teleprinter to LINE and check that all equipment to be used is operable.
- B. Load Basic Control System using the Basic Binary loader.
- C. Set Switch Register to 000002, press LOAD ADDRESS, and set Switch Register to 000000.
- D. Establish Relocating Loader parameters, (If relocation base is to be entered during operation of the Debugging routine, the address must be obtained during loading by setting Switch 15 to 0 (down).)
- E. Load relocatable object programs.
- F. Load Debugging program (treated as a relocatable program).
- G. Load Program Library routines.
- H. Press RUN.
- I. The program pauses to allow the operator to type in the control statements.
- J. The program may be restarted at any point by entering the absolute address assigned to the symbolic location DEBRS into the P-Register, and pressing RUN.

Errors detected in the source program are indicated by a numeric code inserted before or after the statement in the list output.

The format is as follows:

E-eeee: ssss + nnnn

eeee The error diagnostic code shown below.

ssss The statement label of the statement in which the error was detected. In unlabeled, 0000 is typed.

nnnn Ordinal number of the erroneous statement following the last labeled statement. (Comment statements are not included in this count.)

<u>Error Code</u>	<u>Description</u>
0001	<p>Statement label error:</p> <ul style="list-style-type: none"> a) The label is in positions other than 1-5. b) A character in the label is not numeric. c) The label is not in the range 1-9999. d) The label is doubly defined. e) The label indicated is used in a GO TO, DO, or IF statement or in an I/O operation to name a FORMAT statement, but it does not appear in the label field for any statement in the program (printed after END).
0002	<p>Unrecognized statement:</p> <ul style="list-style-type: none"> a) The statement being processed is not recognized as a valid statement. b) A specifications statement follows an executable statement. c) The specification statements are not in the following order: <div style="margin-left: 40px;"> <p>DIMENSION COMMON EQUIVALENCE</p> </div> d) A statement function precedes a specifications statement or follows an executable statement.
0003	<p>Parenthesis error: There are an unequal number of left and right parentheses in a statement.</p>
0004	<p>Illegal character or format:</p> <ul style="list-style-type: none"> a) A statement contains a character other than A through Z, 0 through 9, or space = + - / () , . \$ " . b) A statement does not have the proper format. c) A control statement is missing, misspelled, or does not have the proper format.

<u>Error Code</u>	<u>Description</u>
0005	Adjacent operators: An arithmetic expression contains adjacent arithmetic operators.
0006	Illegal subscript: A variable name is used both as a simple variable and a subscripted variable.
0007	Doubly defined variable: <ul style="list-style-type: none"> a) A variable name appears more than once in a COMMON statement. b) A variable name appears more than once in a DIMENSION statement. c) A variable name appears more than once as a dummy argument in a statement function. d) A program, subroutine, or function name appears as a dummy parameter or in a specifications statement. e) A subroutine or program name appears as a variable within the program.
0008	Too many parameters: The dummy parameters for a subroutine or function exceed 63.
0009	Invalid arithmetic expression: <ul style="list-style-type: none"> a) Missing operator. b) Illegal replacement.
0010	Mixed mode expression: Integer constants or variables appear in an arithmetic expression with real constants or variables.
0011	Invalid subscript: <ul style="list-style-type: none"> a) Subscript is not an integer constant, integer variable, or legal subscript expression. b) There are more than two subscripts (i. e., more than two dimensions). c) Two subscripts appear for a variable which has been defined with one dimension only.
0012	Invalid constant: <ul style="list-style-type: none"> a) An integer constant is not in the range of -2^{15} to $2^{15}-1$. b) A real constant is not in the approximate range of 10^{38} to 10^{-38}. c) A constant contains an illegal character.
0013	Invalid EQUIVALENCE statement: <ul style="list-style-type: none"> a) Two or more of the variables appearing in an EQUIVALENCE statement are also defined in the COMMON block. b) The variables contained in an EQUIVALENCE cause the origin of COMMON to be altered. c) Contradictory equivalence; or equivalence between two or more arrays conflicts with a previously established equivalence.

<u>Error Code</u>	<u>Description</u>
0014	Table overflow: Too many variables and statement labels appear in the program.
0015	Invalid DO loop: <ul style="list-style-type: none"> a) The terminal statement of a DO loop does not appear in the program or appears prior to the DO statement. b) The terminal statement of a nested DO loop is not within the range of the outer DO loop. c) DO loops are nested more than 10 deep. d) Last statement in a loop is a GO TO, arithmetic IF, RETURN, STOP, PAUSE, or DO. e) An indexing parameter is not an unsigned integer constant or simple integer variable or is specified as zero.
0016	Statement function name is doubly defined.
0017	A tape write error has occurred while producing intermediate code output during Pass 1.

Syntax errors discovered by the ALGOL Compiler are indicated by five (5) asterisks and an error number on the line below the one containing the error. The symbol "↑" appears below the symbol which caused the error.

Due to the syntactic structure of ALGOL and the Compiler, it is possible for an error to introduce others. Therefore, error messages after the first in a program may be spurious.

<u>Error Code</u>	<u>Description</u>
1	More than 2 characters used in an ASCII constant
2	@ not followed by an octal digit
3	Octal constant greater than 177777
4	Two decimal points in one number
5	Non integer following apostrophe
6	Label declared but not defined in program
7	Number required but not present
8	Missing END
10	Undefined identifier
11	Illegal symbol
12	Procedure designator must be followed by left parenthesis
13	Parameter types disagree
14	Name parameter may not be an expression
15	Parameter must be followed by a comma or right parenthesis
16	Too many parameters
17	Too few parameters
18	Array variable not followed by a left bracket
19	Subscript must be followed by a comma or right bracket
20	Missing THEN
21	Missing ELSE
22	Illegal Assignment
23	Missing Right Parenthesis
24	Proper procedure not legal in Arithmetic Expression
25	Primary may not begin with this type quantity
26	Too many subscripts
27	Too few subscripts
40	Too many external symbols
41	Declarative following statement
42	No parameters declared after left parenthesis
43	REAL, INTEGER, or BOOLEAN illegal with this declaration
44	Doubly defined identifier or reserved word found
45	Illegal symbol in declaration
46	Statement started with illegal symbol
47	Label not followed by a colon
48	Label is previously defined
49	Semicolon expected as terminator
50	Left arrow or := expected in SWITCH declaration
51	Label entry expected in SWITCH declaration
52	Real number assigned to integer
53	Constant expected following left arrow or :=
54	Left arrow or := expected in EQUATE declaration
55	Left bracket expected in array declaration
56	Integer expected in array dimension
57	Colon expected in array dimension

<u>Error Code</u>	<u>Description</u>
58	Upper bound less than lower bound in array
59	Right bracket expected at end of array dimensions
60	Too many values for array initialization
61	Array size excessive (set to 2047)
62	Constant expected in array initialization
63	Too many parameters for procedure
64	Right parenthesis expected at end of procedure parameter list
65	Procedure parameter descriptor missing
66	VALUE parameter for procedure not in list
67	Illegal TYPE found in procedure declaration
68	Illegal description in procedure declaratives
69	Identifier not listed as procedure parameter
70	No type for variable in procedure parameter list
71	Semicolon found in a format declaration
72	Left parenthesis expected after I/O declaration name
73	Right parenthesis expected after I/O name parameters
74	Undefined label reference
75	Switch identifier not followed by a left bracket
76	Missing right bracket in switch designator
77	THEN missing in IF statement
78	DO missing in WHILE statement
79	FOR variable must be of type INTEGER
80	FOR variable must be followed by an assign symbol
81	STEP symbol missing in FOR clause
82	UNTIL symbol missing in FOR clause
83	DO symbol missing in FOR clause
84	Parenthesis expected in READ/WRITE statement
85	Comma expected in READ/WRITE statement
86	Free field format (*) illegal with WRITE
87	Unmatched left bracket in I/O statement list
100	Program must start with BEGIN, REAL, INTEGER or PROCEDURE
999	Table areas have overflowed, program is discontinued

Errors detected in the source program are indicated by a 1- or 2- letter mnemonic followed by the sequence number and the first 62 characters of the statement in error. Entry point errors (Code EN) are printed on the page preceding the listing. The messages may occur during the passes indicated:

<u>Error Code</u>	<u>Pass</u>	<u>Description</u>								
CS	1	Control statement error: <ul style="list-style-type: none"> a) The control statement contained a parameter other than the legal set. b) Neither A nor R, or both A and R were specified. c) There was no output parameter (B, T or L). 								
DD	1	Doubly defined symbol: A name defined in the symbol table appears more than once as: <ul style="list-style-type: none"> a) A label of a machine instruction. b) A label of one of the pseudo operations: <table style="margin-left: 40px; border: none;"> <tr><td>BSS</td><td>EQU</td></tr> <tr><td>ASC</td><td>ABS</td></tr> <tr><td>DEC</td><td>OCT</td></tr> <tr><td>DEF</td><td>Arithmetic subroutine call</td></tr> </table> c) A name in the Operand field of a COM or EXT statement. d) A label in an instruction following a REP pseudo operation. <p style="margin-left: 40px;">An arithmetic subroutine call symbol appears in a program both as a pseudo instruction and as a label.</p> 	BSS	EQU	ASC	ABS	DEC	OCT	DEF	Arithmetic subroutine call
BSS	EQU									
ASC	ABS									
DEC	OCT									
DEF	Arithmetic subroutine call									
EN	<ul style="list-style-type: none"> 0000 symbol > 1 2 	<ul style="list-style-type: none"> An entry point has been defined in the operand field of an EXT or COM statement or has been equated to an absolute value. An entry point specified in an ENT statement does not appear in the label field of a machine or BSS instruction. 								
IF	1	An IFZ or an IFN follows either an IFZ or IFN without an intervening XIF. The second pseudo instruction is ignored.								
IL	1	Illegal instruction: <ul style="list-style-type: none"> a) Instruction mnemonic cannot be used with type of assembly requested in control statement. The following are illegal in an absolute assembly. <table style="margin-left: 40px; border: none;"> <tr><td>NAM</td><td>EXT</td></tr> <tr><td>ENT</td><td>COM</td></tr> <tr><td>ORB</td><td>Arithmetic subroutine calls</td></tr> </table> b) The ASMB statement has an R parameter, and NAM has been detected after the first Opcode. c) Illegal character in a literal. 	NAM	EXT	ENT	COM	ORB	Arithmetic subroutine calls		
NAM	EXT									
ENT	COM									
ORB	Arithmetic subroutine calls									
IL	2 or 3	Illegal character: A numeric term used in the Operand field contains an illegal character (e. g., an octal constant contains A-Z, 8 or 9). <p style="margin-left: 40px;">Illegal instruction: ORB in an absolute assembly.</p>								

<u>Error Code</u>	<u>Pass</u>	<u>Description</u>																																		
M	1, 2, or 3	<p>Illegal operand:</p> <p>a) An operand is missing for an Opcode requiring one.</p> <p>b) Operands are optional and omitted but comments are included for:</p> <p style="padding-left: 40px;">SOC SOS HLT</p> <p>c) An absolute expression in one of the following instructions from a relocatable program is greater than 77₈:</p> <p style="padding-left: 40px;">Memory Reference DEF Arithmetic subroutine calls</p> <p>d) A negative operand is used with an Opcode field other than ABS, DEC, and OCT.</p> <p>e) A character other than I follows a comma in one of the following statements:</p> <table style="margin-left: 40px; border: none;"> <tr> <td>ISZ</td> <td>ADA</td> <td>AND</td> <td>DEF</td> </tr> <tr> <td>JMP</td> <td>ADB</td> <td>XOR</td> <td>Arithmetic</td> </tr> <tr> <td>JSB</td> <td>LDA</td> <td>IOR</td> <td>subroutine</td> </tr> <tr> <td></td> <td>LDB</td> <td>CPA</td> <td>calls</td> </tr> <tr> <td></td> <td>STA</td> <td>CPB</td> <td></td> </tr> <tr> <td></td> <td>STB</td> <td></td> <td></td> </tr> </table> <p>f) A character other than C follows a comma in one of the following statements:</p> <table style="margin-left: 40px; border: none;"> <tr> <td>STC</td> <td>MIB</td> </tr> <tr> <td>CLC</td> <td>OTA</td> </tr> <tr> <td>LIA</td> <td>OTB</td> </tr> <tr> <td>LIB</td> <td>HLT</td> </tr> <tr> <td>MIA</td> <td></td> </tr> </table> <p>g) A relocatable expression in the Operand Field of one of the following: ABS or REP</p> <p>h) An illegal operator appears in an Operand field (e.g., + or - as the last character).</p> <p>i) An ORG statement appearing in a relocatable program includes an expression that is base page or common relocatable or absolute.</p> <p>j) A relocatable expression contains an illegal mixture of program, base page, and common relocatable terms.</p> <p>k) An external symbol appears in an operand expression or is followed by a comma and the letter I.</p> <p>l) The literal or type of literal is illegal for operation code used.</p> <p>m) Operand of EAU shift-rotate instruction = \emptyset or > 16.</p>	ISZ	ADA	AND	DEF	JMP	ADB	XOR	Arithmetic	JSB	LDA	IOR	subroutine		LDB	CPA	calls		STA	CPB			STB			STC	MIB	CLC	OTA	LIA	OTB	LIB	HLT	MIA	
ISZ	ADA	AND	DEF																																	
JMP	ADB	XOR	Arithmetic																																	
JSB	LDA	IOR	subroutine																																	
	LDB	CPA	calls																																	
	STA	CPB																																		
	STB																																			
STC	MIB																																			
CLC	OTA																																			
LIA	OTB																																			
LIB	HLT																																			
MIA																																				
NO	1	<p>No origin definition: The first statement in the assembly containing a valid Opcode following the ASMB control statement and remarks, if any is neither an ORG nor NAM statement. If the A parameter was given on the ASMB statement, the program is assembled starting at 2000; if a R parameter was given, the program is assembled starting at zero.</p>																																		

<u>Error Code</u>	<u>Pass</u>	<u>Description</u>
OP	1	Illegal Opcode following control statement: A valid Opcode has not yet been encountered and the statement being processed does not contain an asterisk in position one. The statement is assumed to contain an illegal Opcode; it is treated as a remarks statement.
OP	1, 2, or 3	Illegal Opcode: A mnemonic appears in the Opcode field which is not valid for the hardware configured in an Assembler being used. A word is generated in the object program.
OV	1, 2, or 3	Numeric operand overflow: The numeric value of a term or expression has overflowed its limit: <ul style="list-style-type: none"> 2^6-1 Input/Output, Overflow, Halt $2^{10}-1$ Memory Reference $2^{15}-1$ DEF and ABS operands; data generated by DEC; expressions concerned with program location counter. $2^{16}-1$ OCT
R?	Before 1	An attempt is being made to assemble a relocatable program following the assembly of an absolute program. The Assembler must be reloaded.
SO	1	There are more symbols defined in the program than the symbol table can handle.
SY	1	Illegal Symbol: A Label field contains an illegal character or is greater than 5 characters. A label with illegal characters may result in an erroneous assembly if not corrected. A long label is truncated on the right to 5 characters.
SY	2 or 3	<ul style="list-style-type: none"> a) Illegal Symbol: A symbolic term in the Operand field is greater than five characters; the symbol is truncated on the right to 5 characters. b) Too many control statements: A control statement has been entered on the Teleprinter and the source tape. The second control statement (on the tape) is interpreted as an illegal label (since it begins in position 1). The binary object tape is not affected by this error; the control statement entered via the Teleprinter is the one used by the Assembler.
TP	1, 2, or 3	An error has occurred while reading or writing magnetic tape, if the T-register contains 102040, an irrecoverable error has occurred; restart assembly. Otherwise, correct condition and resume.
UN	1, 2, or 3	Undefined symbol: <ul style="list-style-type: none"> a) A symbolic term in an Operand field is not defined in the Label field of an instruction or is not defined in the Operand field of a COM or EXT statement.



- b) A symbol appearing in the Operand field of one of the following pseudo operations was not defined previously in the source program:

BSS ASC EQU ORG END

During execution of an object program, diagnostics may be printed on the Standard Teleprinter Output unit by the input/output routine (FRMTR) supplied for FORTRAN and ALGOL programs. † When a halt occurs, the A-Register contains a code which further defines the nature of the error:

<u>Teleprinter Message</u>	<u>A-Register</u>	<u>Explanation</u>	<u>Action</u>
*EQR	Unit Reference Number	Equipment error: End of input tape on 2752A Teleprinter or 2737A Punched Tape Reader; tape supply low on 2753A Tape Punch. B-Register contains status word of Equipment Table entry.	Place next tape in input device, or for Tape Punch, load new reel of tape. Press RUN.
*FMT	000001	FORMAT error: a) Word field does not contain proper digits. b) No decimal point after w field. c) $w-d \leq 4$ for E specification.	Irrecoverable error; program must be re-compiled.
*FMT	000002	a) FORMAT specifications are nested more than one level deep. b) A FORMAT statement contains unequal number of right parentheses and left parentheses.	Irrecoverable error; program must be re-compiled.
*FMT	000003	a) Illegal character in FORMAT statement. b) Format repetition factor of zero. c) FORMAT statement defines more character positions than possible for device."	Irrecoverable error; program must be re-compiled.
*FMT	000004	Illegal character in fixed field input item or number not right-justified in field.	Verify data.
*FMT	000005	A number has an illegal form (e. g., two E's, two decimal points, two signs, etc.).	Verify data.

† The object program need not be generated by FORTRAN or ALGOL; Assembler language programs can refer to FRMTR through the entry point .DIO.

During the execution of an object program referring to the PROGRAM Library routines, the following error codes may be printed on the Teleprinter Output unit when error conditions are encountered by the specified subroutine:

<u>Error Code</u>	<u>Subroutine</u>	<u>Condition</u>
02 UN	ALOG	$x \leq 0$
03 UN	SQRT	$x < 0$
04 UN	.RTOR	$x = 0, y \leq 0$ $x < 0, y \neq 0$
05 OR	SIN, COS	$ x > 2^{14}$
06 UN	.RTOI	$x = 0, i \leq 0$
07 OF	EXP	$ x * \log_2 e > 124$
08 OF	.ITOI	i^j out of range
08 UN	.ITOI	$i = 0, j \leq 0$
09 OR	TAN	$ x > 2^{14}$

During the execution of an object program referring to .IOC, certain error conditions may occur. They are termed irrecoverable and cause a halt.† Diagnostic information is displayed in the A- and B-Registers at the time of the halt.

The B-Register contains the absolute location of the JSB instruction of the request call containing the illegal condition.

The A-Register contains a code defining the illegal condition:

<u>A-Register</u>	<u>Explanation</u>
000000	Illegal request code.
000001	Illegal unit-reference number in request.
000002	The Standard unit requested is not defined as a particular device in the Equipment Table.

† The halt is at the absolute location assigned to the symbol IOERR during Prepare Control System processing.

UNIT-REFERENCE NUMBER ASSIGNMENT

G

The Basic Control System allows reference to input/output equipment through use of unit-reference numbers. The relationship between a unit-reference number and a particular device is established during Prepare Control System processing.

Unit-reference numbers are divided into two categories: Standard units and installation units. The Standard units have "standard" usage among user programs and the standard software systems (Standard unit names are used to describe the operating procedures for the systems). Installation unit numbers are defined for each configuration. An installation unit-reference number and one or more Standard unit-reference numbers may all represent the same physical device; they are linked through tables internal to BCS or defined according to parameters supplied to the SIO Dump routine.

The table below may be used to record the assignment of input/output equipment for a particular configuration.

<u>Unit-Reference Number</u>	<u>Standard Unit Name</u>	<u>Typical Equipment Type</u>	<u>Actual Equipment Type</u>	<u>Channel Number</u>
1	Keyboard Input	2752A Teleprinter	_____	_____
2	Teleprinter Output	2752A Teleprinter	_____	_____
3	Program Library	2737A Punched Tape Reader †	_____	_____
4	Punch Output	2753A Tape Punch	_____	_____
5	Input	2737A Punched Tape Reader	_____	_____
6	List Output	2752A Teleprinter	_____	_____

INSTALLATION UNITS

<u>Unit-Reference Number</u>	<u>Actual Equipment Type</u>	<u>Channel Number</u>
7	_____	_____
10	_____	_____
11	_____	_____
12	_____	_____
13	_____	_____
14	_____	_____
15	_____	_____
16	_____	_____
17	_____	_____
20	_____	_____
21	_____	_____

† For Magnetic Tape System, the Program Library is assigned to the HP 2020A Magnetic Tape Unit.

<u>Unit-Reference Number</u>	<u>Actual Equipment Type</u>	<u>Channel Number</u>
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<u>Unit-Reference Type</u>	<u>Actual Equipment Type</u>	<u>Channel Number</u>
67	_____	_____
70	_____	_____
71	_____	_____
72	_____	_____
73	_____	_____
74	_____	_____

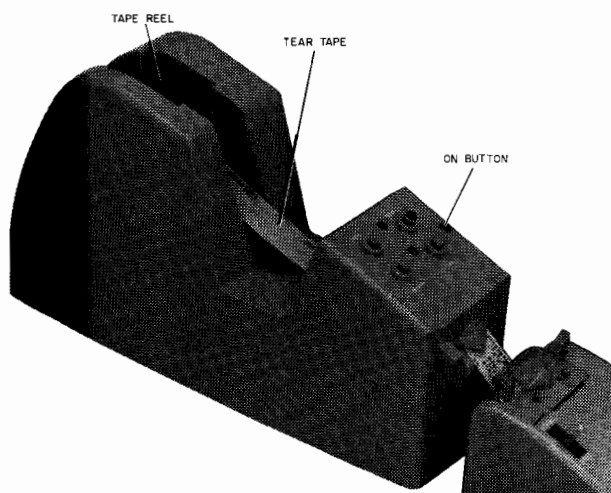


2752A TELEPRINTER OPERATING INSTRUCTIONS

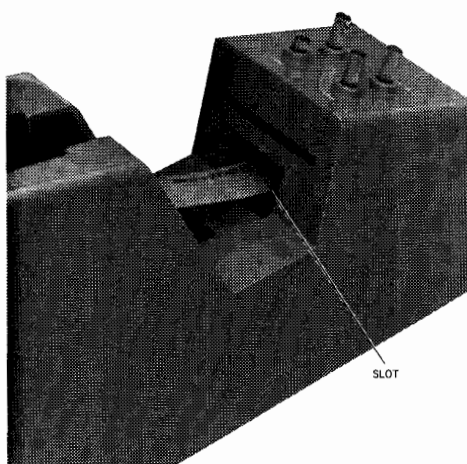
H

A. Loading or replacing paper tape:

1. Set Teleprinter to LOCAL.
2. Press ON button on punch unit.
3. If replacing old reel, tear tape between reel and punch unit, press **HERE IS** to remove remaining tape from punch unit, and lift out old reel.
4. Insert paper tape spindle in new tape reel and place reel into tape slot. Tape should come off top of reel.



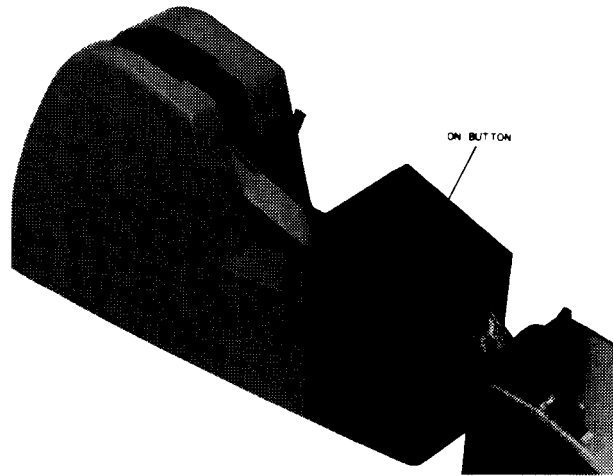
5. Feed tape as far as possible into slot in rear of punch.



6. Press **HERE IS** until tape feeds through punch unit.

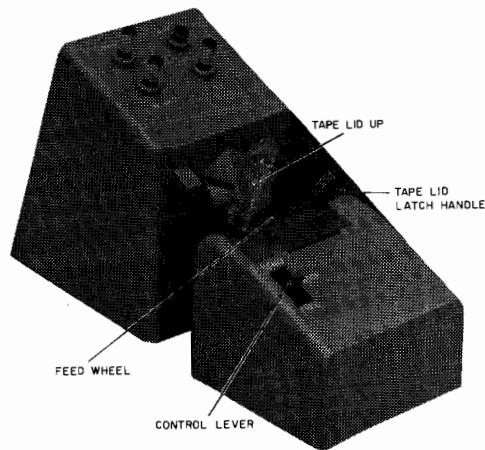
B. Preparing for tape punching:

1. Set Teleprinter to LOCAL.
2. Press ON button on punch unit.
3. Press HERE IS at least twice to produce sufficient leader for tape to be punched.
4. If an input tape is to be punched, set Teleprinter to LOCAL. If computer output is to be produced, set Teleprinter to LINE.

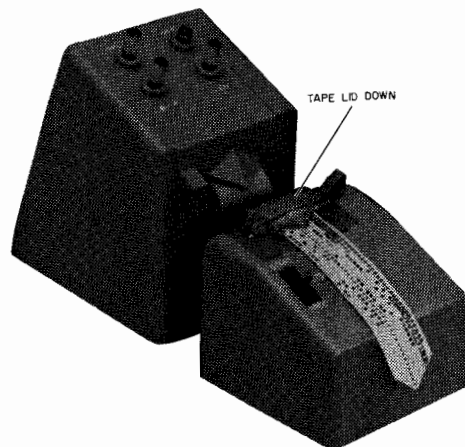


C. Reading a punched tape:

1. Set Teleprinter to LOCAL, press OFF button on punch unit, and set Control Lever to STOP.
2. Release tape lid by pressing tape lid latch handle.



3. Place tape in reader unit with feed holes toward the tape lid hinge and on the feed wheel. The tape should feed into the reader smoothly.
4. Press the tape lid down. †



† With tape lid down, to pull tape through read unit, set control lever to FREE.

5. Set Teleprinter to LINE.
6. Set control lever to START.
7. Initiate program execution.

D. Printing a previously punched tape:

1. Set Teleprinter to LOCAL, press OFF button on punch unit, and set control lever to STOP.
2. Release tape lid by pressing tape lid latch handle.
3. Place tape in reader unit with feed holes toward the tape lid hinge and on the feed wheel. The tape should feed into the reader smoothly.
4. Press the tape lid down.
5. Set control lever to START.

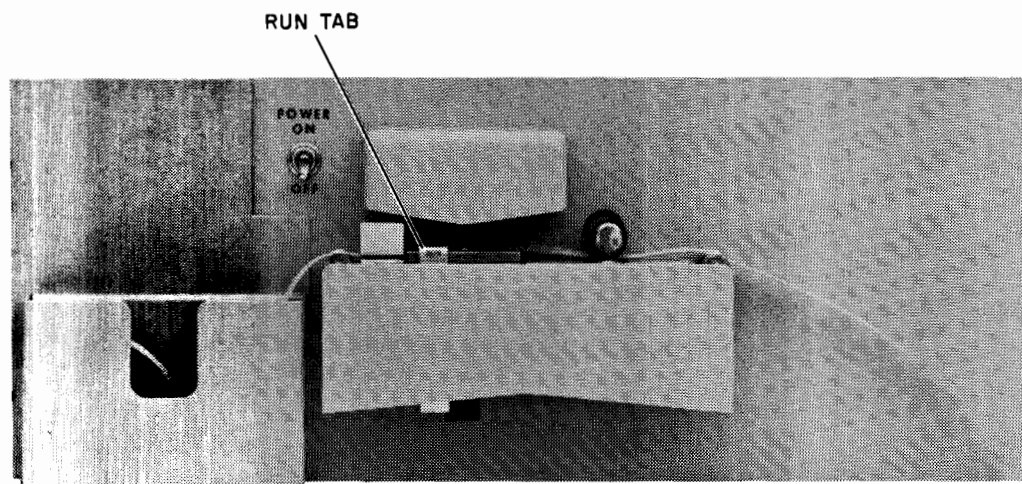
E. Preparing a copy of previously punched tape.

Perform same procedures as for printing, but press ON buffer on punch unit.

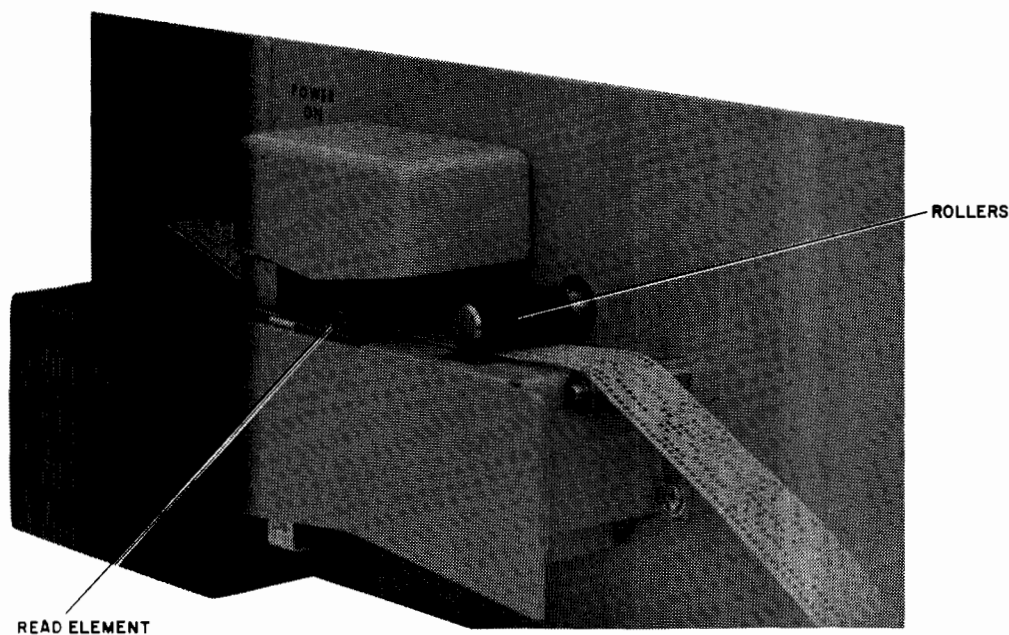
2737A PUNCHED TAPE READER OPERATING INSTRUCTIONS



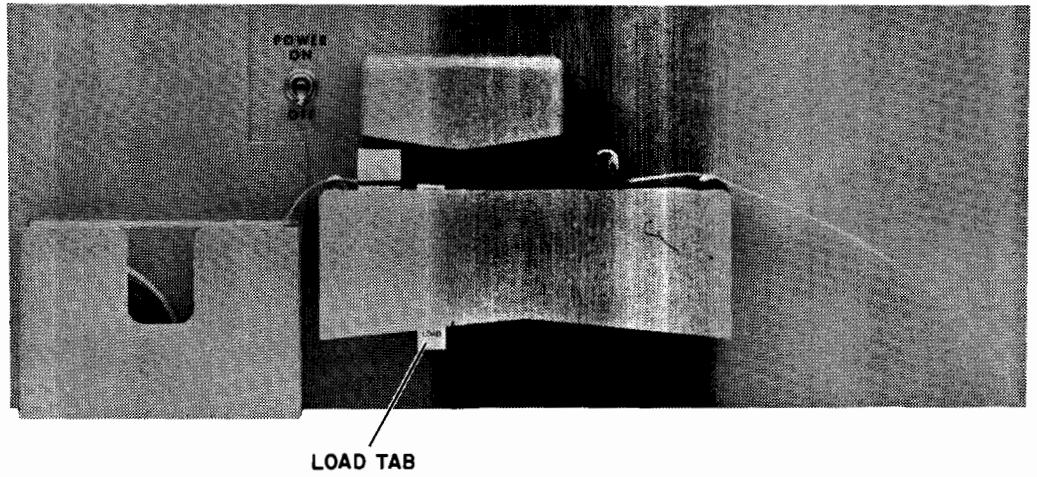
1. Set power switch ON. To prepare for loading tape, place in LOAD position, by pressing RUN tab down.
2. Place tape in holder with feed holes toward the panel and positioned so that the tape will unwind counter clockwise when it is being read.



3. Feed tape through reader from left to right. The first data frames must be to the left of the read element. The tape leader must pass between the rollers on the right.



4. Place in RUN position by pressing up LOAD tab.



5. To unload tape after it has been loaded or read, press RUN tab down and remove tape.

2753A TAPE PUNCH OPERATING INSTRUCTIONS

J

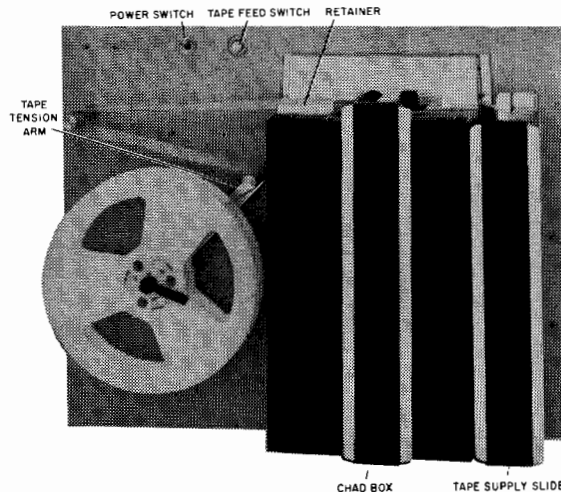
Threading Tape

1. Before running a new roll of tape, always empty the chadbox to avoid clogging the mechanism with chad overflow. Grasp the box near its bottom and pull straight out, then lift the box off its hooks.
2. To insert a new roll of tape in the punch, pull the tape supply slide out of the panel. It is held by a magnetic catch.

Pull the supply reel apart, and replace the old roll with the new one. Place it so the tape comes off the top of the reel. Put the side back on the reel.

Thread the tape under the tape guide roller and back up to the top of the assembly. Hold the end of the tape while sliding the tape supply assembly back into place. The magnetic catch will click as it contacts the assembly.

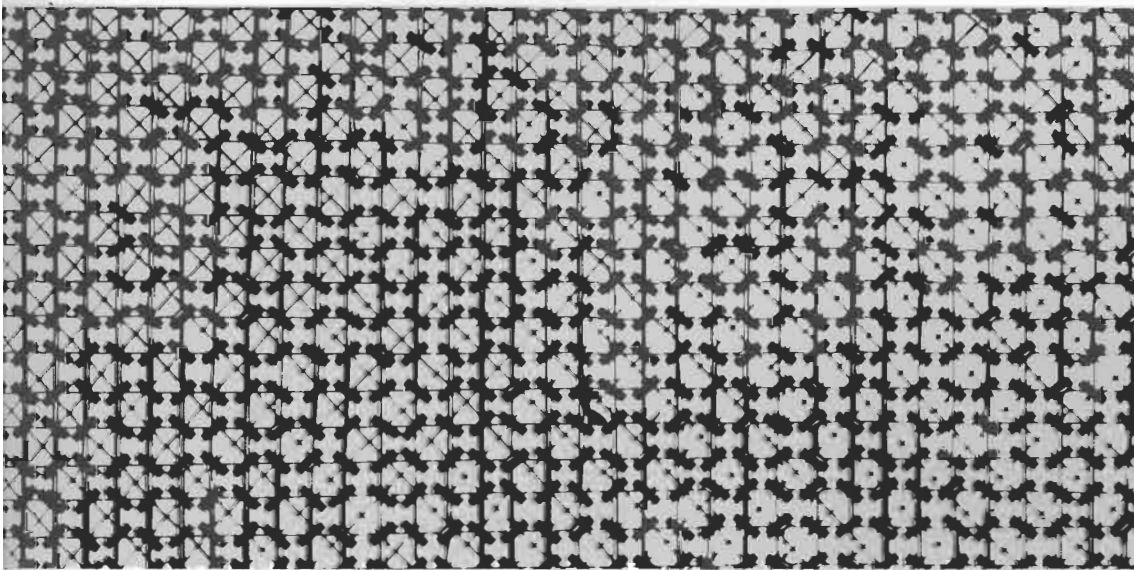
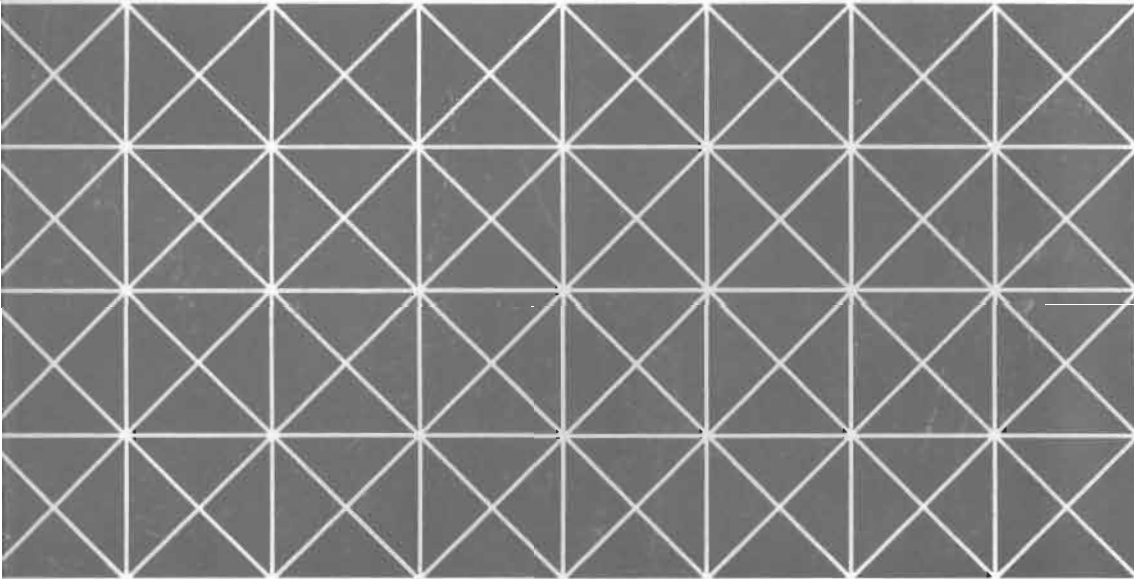
3. Move the tape tension arm on the take-up reel to the left as far as it will go. Do not force it; it will hold in that position. Note: Many units use the Clockwise Reeling option. On these units, the tape tension arm should be moved to the right.
4. Press the retainer release tab, allowing the retainer to move away from the capstan. Twist the tape one-half turn clockwise. To facilitate threading, tear the tape end diagonally, with the longer edge toward the panel. Thread the tape through the tape guide assembly and over the tape guide roller. The tape tension arm is to the left and out of the way at this time. Fasten the tape to the hub of the take-up reel. Feed enough tape into the reel to insure its staying on.
5. Move the tension arm to the right so that it contacts the tape. Push the retainer back against the capstan; it will lock in place.
6. Set power switch on.
7. Press the Tape Feed switch momentarily before starting to record, to provide several inches of sprocket tape. Check to see that the tape pulls smoothly through the punch, without binding or twisting. The punch is now ready for operation.



CONSOLIDATED CODING SHEET

L

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
D/I	AND	001	0	Z/C	← Memory Address →										
D/I	XOR	010	0	Z/C											
D/I	IOR	011	0	Z/C											
D/I	JSB	001	1	Z/C											
D/I	JMP	010	1	Z/C											
D/I	ISZ	011	1	Z/C											
D/I	AD*	100	A/B	Z/C											
D/I	CP*	101	A/B	Z/C											
D/I	LD*	110	A/B	Z/C											
D/I	ST*	111	A/B	Z/C											
0	SRG	000	A/B	0	D/E	*LS	000	CLE	D/E	SL*	*LS	000			
						*RS	001				*RS	001			
						R*L	010				R*L	010			
						R*R	011				R*R	011			
						*LR	100				*LR	100			
						ER*	101				ER*	101			
						EL*	110				EL*	110			
						*LF	111				*LF	111			
			NOP	000			000			000		000			
0	ASG	000	A/B	1	CL*	01	CLE	01	SEZ	SS*	SL*	IN*	SZ*	RSS	
					CM*	10	CME	10							
					CC*	11	CCE	11							
1	IOG	000	A/B	1	H/C	HLT	000	← Select Code →							
				1	0	STF	001								
				1	1	CLF	001								
				1	0	SFC	010								
				1	0	SFS	011								
				1	H/C	MI*	100								
				1	H/C	LI*	101								
				1	H/C	OT*	110								
			0	1	H/C	STC	111								
			1	1	H/C	CLC	111								
				1	0	STO	001			000			001		
				1	1	CLO	001			000			001		
				1	H/C	SOC	010			000			001		
				1	H/C	SOS	011			000			001		
1	EAU	000	MPY**	000	010			000			000		000		
			DIV**	000	100			000			000		000		
			DLD**	100	010			000			000		000		
			DST**	100	100			000			000		000		
			ASR	001	000			0	1						
			ASL	000	000			0	1						
			LSR	001	000			1	0						
			LSL	000	000			1	0					← number of bits →	
			RRR	001	001			0	0						
			RRL	000	001			0	0						
<p>Notes: * = A or B. D/I, A/B, Z/C, D/E, H/C coded: 0/1. **Second word is Memory Address.</p>															



HEWLETT  PACKARD