AN/UYK-1

A "STORED LOGIC" MULTIPLE PURPOSE COMPUTER

AN/UYK-1 (TRW-130) PROGRAM ASSEMBLER FOR PAPER TAPE SYSTEM

M250-2U20

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CONTENTS

1.0 INTRODUCTION

The Program Assembler is a program for the AN/UYK-1 (TRW-130) Computer. It translates operational programs from symbolic language specified by the programmer to the binary language used in the Computer.

In principle, the Program Assembler resembles a bilingual dictionary. By use of certain internal program-control instructions it initiates table-search operations. These determine the machine-language equivalent of each programmer-language step in the operational program. Since the Program Assembler requires that each symbol in a program be defined with that program, the "dictionary" is revised for every program assembled. The programmer can use any symbology he prefers.

With the 8,192-word memory of the AN/UYK-1 (TRW-130), the Program Assembler requires two passes to assemble a program. During the first pass, the symbol table "dictionary" is compiled. During the second pass, the program is assembled.

The actual operations in each of the Program Assembler's two passes are uncomplicated. However, to provide a fuller understanding of how this program operates, the theory of operation is discussed in detail below.

Use of the Program Assembler requires that the program be prepared on punched paper tape. One way to do this is to write the program, using the logramming sheets described below, punch the program on cards, then convert the cards to punched paper tape by use of an IBM 063 or equivalent card-to-tape converter. (See Figure 6.5 for plugboard wiring.) "Cards" mentioned in this discussion refer to the cards involved in this step. (See Figure 3.1 for typical operation.)

As the program is assembled, it is output, as directed by setting toggle switches or by use of pseudo-operation PCH, onto punched paper tape for future use. It may also be typed out as printed copy. Type-out may be suppressed by toggle switch setting or by use of pseudo-operation SUP.

2.0 INPUT TO THE PROGRAM ASSEMBLER

Each card prepared for Assembler input is divided into six fields, as follows:

a. Location Field (columns 1 through 6)
b. Operation Field (columns 7 through 10)
c. Address Option Field (columns 11 and 12)
d. Control Field (column 13)
e. Secondary Field (columns 14 through 30)
f. Remarks Field (columns 30 through 60)

The fields located in columns 7 through 30, inclusive, are recognized as AN/UYK-1 (TRW-130) Logand fields. The remaining two fields on each card (location and remarks) provide control and information functions necessary to operation of the Program Assembler.

2.1 LOCATION FIELD

The location field controls the "dictionary-revision" function mentioned in paragraph 1.0. Each symbol used in the program must appear in the location field of one card, and only one, in the input deck. If a symbol does not appear in any location field, it is said to be undefined. If it appears in more than one location field, it is said to be multiply-defined. Either situation results in an error alarm (see Table 7.2). The location field of a card may be blank; in fact, most location fields in a typical input deck are blank. If the location field is used, it must contain a single symbol (a symbol is any sequence of one to six non-blank characters, at least one of which is non-numeric). A special case is the inclusion of an asterisk in column 1. When this symbol is encountered, the entire card is interpreted as a remark and its contents are not included in the operational program. The field is terminated at column 6 or a blank, whichever occurs first.

2.2 REMARKS FIELD

The remarks field does not affect assembly of the program. Its function is to preserve notes which indicate the programmer's intentions, and to print these out during the printout portion of the run.

2.3 AN/UYK-1 (TRW-130) LOGAND FIELDS

The four Logand fields have certain special characteristics. These characteristics are primarily concerned with the translating abilities of the Program Assembler. Information in these four fields is entered alphanumerically; numeric quantities are written in the decimal system unless otherwise specified. The Assembler recognizes certain pseudo-operations (see Table 7.4) in addition to the primary commands (Table 7.3), address options (Table 7.5), control field entries (Table 7.8), and secondary commands (Table 7.6). When pseudo-operations are used, columns 11 through 30 control and extend their functions.

2.3.1 Operation Field

The operation field contains alphabetic characters; these represent either the AN/UYK-1 (TRW-130) primary commands (Table 7.3) or the pseudo-operations listed in Table 7.4. Each primary command causes the location counter to be incremented by one, keeping the program in sequence. Pseudo-operations may or may not cause the location counter to be incremented; the increment may be greater than one.

2.3.2 Address Option Field

The address option field contains alphanumeric characters that represent Computer address options (Table 7.5) or it may also control certain pseudo-operations.

2.3.3 Control Field

The control field may be blank or alphanumeric. It represents the Computer logand control field, and extends the function of certain pseudo-operations. (Refer to Table 7.8.)

2.3.4 Secondary Field

The secondary field may contain Computer secondary commands, test conditions, scratchpad addresses, operands for some pseudo-operations, or symbols. (Refer to paragraph 2.1 for definition of the term "symbol".) If a primary command occurs in the operation field, symbols or scratchpad addresses are permitted only if the address option is IL or DL. If a shift-type primary command occurs in the operation field, the secondary field must contain either the letter "R" or the letter "L" to specify direction of shift, and a decimal integer between 0 and 15 inclusive, specifying the number of shifts. When symbols are used, they may be combined in any one of six ways: "ABC±5", "5±ABC", or "ABC±LMN", where letters represent symbols and integers represent fixed numerical quantities.

The special symbol * is defined as "the present value of the instruction counter". Another special symbol, **, representing binary zero, may also be used.

The range of address magnitude allowed in the scratchpad for the secondary field is 00-63 when the operation field includes a primary command. If scratchpad addresses exceed these values, only the least-significant six bits of the binary equivalent are retained.

3.0 USE OF THE PROGRAM ASSEMBLER (See Figure 3-1)

3.1 INPUT PREPARATION

In using the Program Assembler, the programmer must first prepare his program. A "Logramming Sheet," similar to that shown in Figure 5-1 is convenient for this purpose. After the logands necessary to perform each ultimate machine operation are determined and logrammed, each logram may be assigned a symbol. The symbols used may be arbitrarily chosen by the programmer, and need only satisfy the requirement that at least one character be non-numeric and that no character be an asterisk, a dollar sign (except in the case of system symbols that use the dollar sign) a plus, or a minus. The next step in preparing the program is to arrange the symbolic lograms in the desired sequence to accomplish the aim of the program, and then to have cards punched for input to the Program Assembler.

Each program for assembly must contain, in order, a title card, an origin card, the logand cards which contain the symbolic program, and an end-of-assembly card. These cards must all be supplied by the programmer. (See Figure 3-2.)

The title card, which supplies the name of the program for printing on the final listing and punching on paper tape, contains the title desired by the programmer.

The origin card (actually the first or second logand card) contains the pseudo-operation ORG and the desired starting location of the program.

The end-of-assembly card contains the pseudo-operation END and the desired starting address of the program.

When the input deck has been punched and converted to tape, it is run through the Program Assembler.

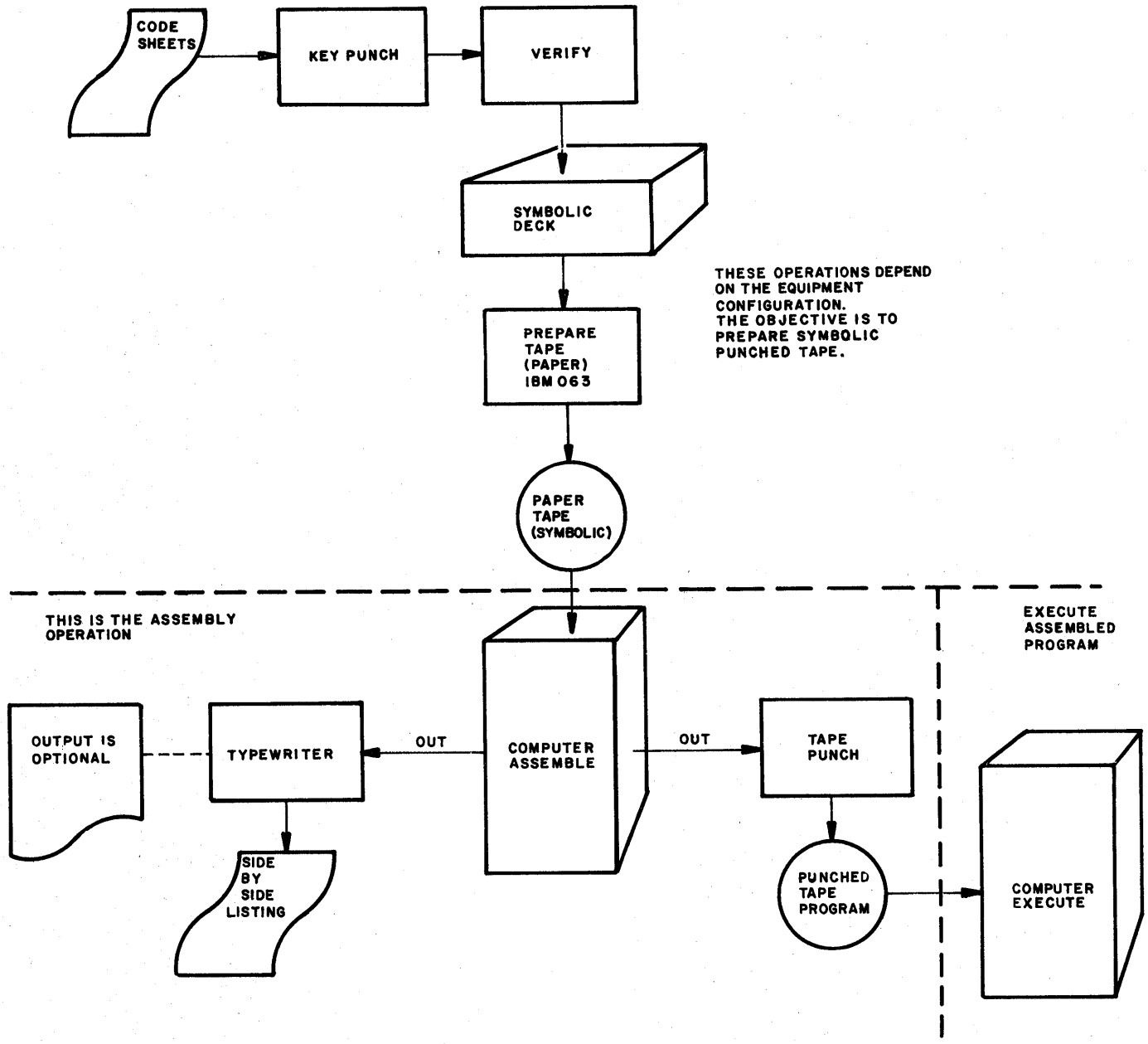
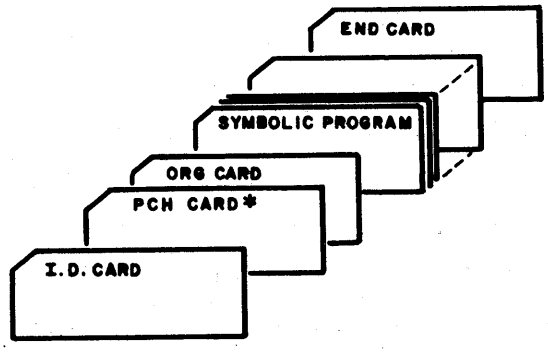

CODE SHEETS
KEY PUNCH
VERIFY
SYMBOLIC DECK
THESE OPERATIONS DEPEND ON THE EQUIPMENT CONFIGURATION. THE OBJECTIVE IS TO PREPARE SYMBOLIC PUNCHED TAPE.
PREPARE TAPE (PAPER) IBM 063
PAPER TAPE (SYMBOLIC)
THIS IS THE ASSEMBLY OPERATION
EXECUTE ASSEMBLED PROGRAM
OUTPUT IS OPTIONAL
TYPEWRITER
OUT
COMPUTER ASSEMBLE
OUT
TAPE PUNCH
SIDE BY SIDE LISTING
PUNCHED TAPE PROGRAM
COMPUTER EXECUTE

Figure 5.2



The first card is an identification card.

*The next card is an optional card. If included, it will control punching the output. Following the PCH card if included, or the I. D. card if the PCH card is not included, are the symbolic program cards. The first card of the symbolic program deck is the "ORG" pseudo-operation and the last card of the symbolic program deck must be an "END" pseudo-operation.

Figure 3-2. Typical Symbolic Deck

3.2 SYSTEM SYMBOLS

Certain "system symbols" have been included in the Program Assembler; these symbols are denoted by a dollar sign ($) as the leading character of the symbol. Many of these symbols provide internal instruction to the Program Assembler, but others may be used by the programmer within the operational program. These symbols are permanently defined, and so need not be defined for each individual program; thus, they may appear only in the secondary field of logand cards. (See Table 7.1 for system symbols.) However, the contents of these cells are not loaded. A total of 1015 symbols may be generated (including system symbols).

3.3 ERROR ALARMS

Seven different error alarms are provided in the Program Assembler. Errors, if present, are indicated only on the printout program listing; program assembly is continued despite an error. Error alarms and their meanings are listed in Table 7.2.

4.0 OUTPUT OF THE PROGRAM ASSEMBLER

Output of the Program Assembler is a printout listing of the program as assembled, including all remarks, and all error alarms developed. If a PCH pseudo-operation is included in the symbolic deck, the punched paper tape is also output at this time. The listing may be inspected to insure accuracy of the punched-tape program, and to determine the causes of any error alarms.

Two punched-tape output formats are possible. One is a five-level teletype code; the other is an eight-level binary code. Toggle switch four controls the selection of format.

5.0 SAMPLE PROGRAM

To illustrate in detail the use of the Program Assembler, a sample program is shown in Figures 5-1 and 5-2 and is discussed in the following paragraphs.

The problem which this program is designed to solve is expressed in words as follows: "Multiply the sum of three parameters by a fourth parameter, storing for future reference the sum of the first two, the sum of the three, and the final product."

Algebraically, the problem may be stated: "Find Z (A + B + C), storing (A + B), (A + B + C), and the final product."

From the algebraic statement of the problem, the programmer decides that lograms for computing (A + B), for adding C to the sum, for multiplication, and for storing results, suffice. He then, by use of a logram library, "lograms" sequences of logands which accomplish these four operations.

By reference to the logram library, he finds that the necessary lograms are: AD1, LD1, MP1, and ST1.

In addition to these four symbols, which roughly correspond to the "operation codes" of other types of computers, other symbols must also be defined. These symbols include G1, G2, G3, and G4, representing the locations of the four parameters of the problem; H1, H2, and H3 representing the locations for storage of the results; and START, representing the start of the program.

With all symbols chosen, the programmer's next step is the writing of his program. This results in the following symbol sequence:

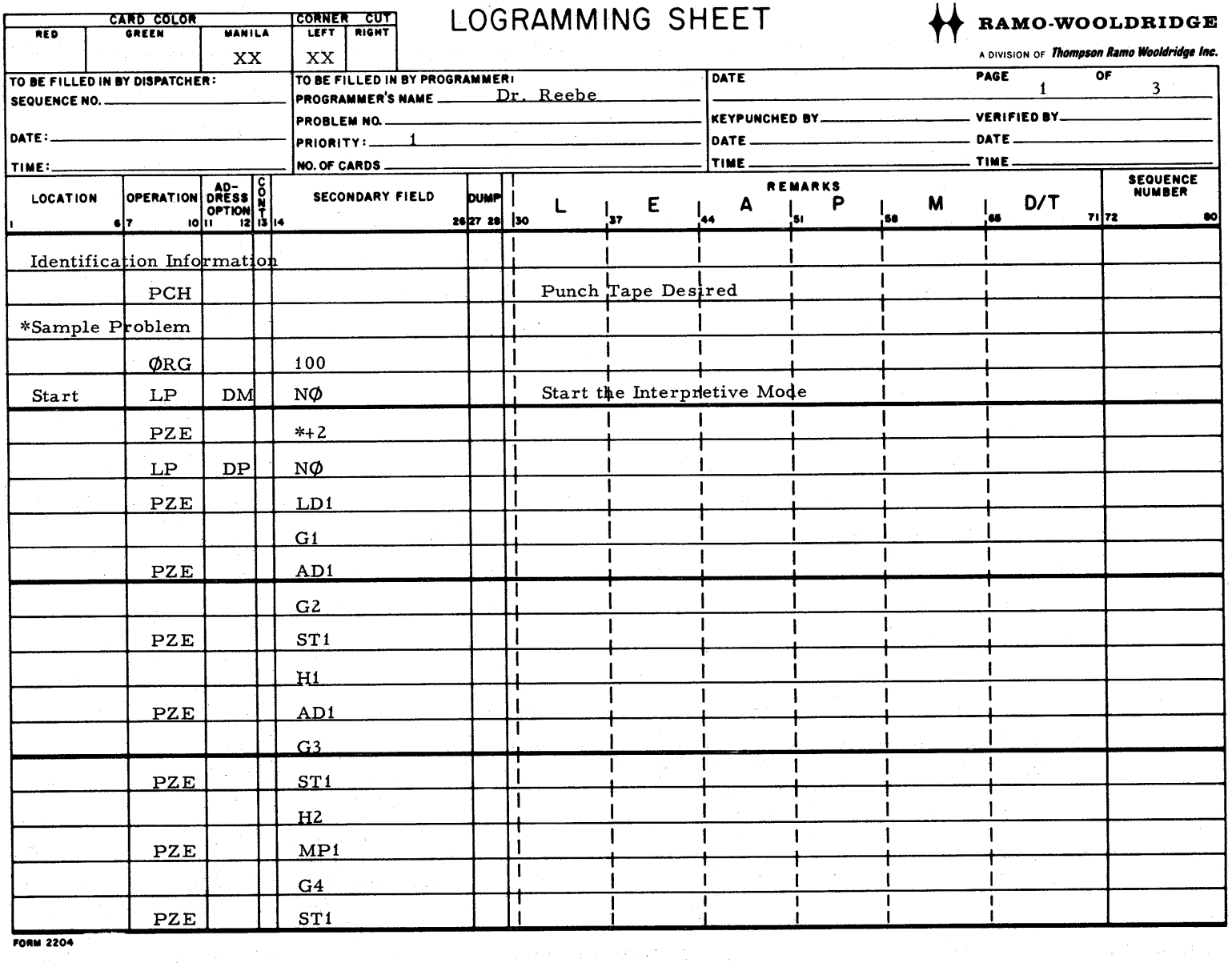
OPERATION	QUANTITY or LOCATION
LD1	G1
AD1	G1 + G2
ST1	at H1
AD1	G3
ST1	at H2
MP1	by G4
ST1	at H3

The programmer is now ready to prepare his input deck. As described in paragraph 3.1, certain additional cards must be added to the above symbol sequence. The listing, which the input deck generates, is shown in Figure 5-2. It has been prepared on the "Logramming Sheet" of Figure 5-1, on which each line represents a single card and field division is indicated.

A punched tape is prepared from the logramming sheets. This tape is then run through the Program Assembler. Assuming that the second logand card contains the pseudo-operation PCH, and printing has not been suppressed with a SUP card, output from the assembler is the printout listing and the punched paper tape. The printout listing contains the information on the output punched paper tape, the information entered on the input cards, and diagnostic information in case of errors. The printout listing for the sample problem is shown in Figure 5-2.

The column at the extreme left of Figure 5-2 shows the memory locations assigned to each line; addresses of these locations are expressed in octal notation. The column of numerals appearing second from the left is the Computer program punched in the paper tape; on the tape, it appears as a sequence of octal digits rather than being broken up five digits to a line as it is in the printout. The other entries, for the most part, duplicate the card entries shown in Figure 5-1.

One entry which does not duplicate Figure 5-1 is that on line 31, sheet 1, identified by "PAC" at the extreme left of the line. This is an error alarm. The entry, "ILLEGAL", appearing in the operation field of this card is not an allowable entry. As a result, the error alarms were set.



CARD COLOR: RED | GREEN | MANILA: XX
CORNER CUT: LEFT: XX | RIGHT

LOGRAMMING SHEET

RAMO-WOOLDRIDGE
A DIVISION OF Thompson Ramo Wooldridge Inc.

TO BE FILLED IN BY DISPATCHER:
SEQUENCE NO.
DATE:
TIME:

TO BE FILLED IN BY PROGRAMMER:
PROGRAMMER'S NAME: Dr. Reebe
PROBLEM NO.
PRIORITY: 1
NO. OF CARDS

DATE
PAGE 1 OF 3
KEYPUNCHED BY — VERIFIED BY
DATE — DATE
TIME — TIME

LOCATION (1–6)	OPERATION (7–10)	ADDRESS OPTION (11–12)	CONT (13)	SECONDARY FIELD (14–26)	DUMP (27–29)	REMARKS (30–71)	SEQUENCE NUMBER (72–80)
Identification Information							
	PCH					Punch Tape Desired	
*Sample Problem							
	ØRG			100			
Start	LP	DM		NØ		Start the Interpretive Mode	
	PZE			*+2			
	LP	DP		NØ			
	PZE			LD1			
				G1			
	PZE			AD1			
				G2			
	PZE			ST1			
				H1			
	PZE			AD1			
				G3			
	PZE			ST1			
				H2			
	PZE			MP1			
				G4			
	PZE			ST1			

FORM 2204

Figure 5-1

CARD COLOR: RED | GREEN | MANILA — CORNER CUT: LEFT | RIGHT

LOGRAMMING SHEET

RAMO-WOOLDRIDGE
A DIVISION OF Thompson Ramo Wooldridge Inc.

TO BE FILLED IN BY DISPATCHER:
SEQUENCE NO. _____
DATE: _____
TIME: _____

TO BE FILLED IN BY PROGRAMMER:
PROGRAMMER'S NAME _____
PROBLEM NO. _____
PRIORITY: _____
NO. OF CARDS _____

DATE _____ PAGE 2 OF 3
KEYPUNCHED BY _____ VERIFIED BY _____
DATE _____ DATE _____
TIME _____ TIME _____

LOCATION (1–6)	OPERATION (7–10)	ADDRESS OPTION (11–12)	CONT (13)	SECONDARY FIELD (14–26)	DUMP (27–29)	REMARKS (30–71)	SEQUENCE NUMBER (72–80)
				H3			
	PZE			*+1			
	BR	DM	F	UN			
G1	ØCT			5			
G2	ØCT			6			
G3	PZE			4			
G4	BCIH	1		AB			
H1	BCIS	--		A			
H2	BCIT	1		4			
H3	NAD			Start			
	Illegal Operation Code						
*Load - Single							
LD1	NØ	IP		NØ			
	SE	DL		$AL			
	SP	DL		$IC			
	LP	DP		NØ			
*Store Logram							
ST1	LA	DM		$AL			
	SE	IP		NØ			
	SP	DL		$ICI			

FORM 2204

Figure 5-1. continued

CARD COLOR			CORNER CUT	
RED	GREEN	MANILA	LEFT	RIGHT

LOGRAMMING SHEET

RAMO-WOOLDRIDGE
A DIVISION OF Thompson Ramo Wooldridge Inc.

TO BE FILLED IN BY DISPATCHER:	TO BE FILLED IN BY PROGRAMMER:	DATE	PAGE 3 OF 3
SEQUENCE NO.	PROGRAMMER'S NAME		
	PROBLEM NO.	KEYPUNCHED BY	VERIFIED BY
DATE:	PRIORITY:	DATE	DATE
TIME:	NO. OF CARDS	TIME	TIME

LOCATION (1–6)	OPERATION (7–10)	ADDRESS OPTION (11–12)	CONT (13)	SECONDARY FIELD (14–26)	DUMP (27–28)	REMARKS (30–71)	SEQUENCE NUMBER (72–80)
	LP	DP		NØ			
*Add Logram							
AD1	NØ	IP		NØ			
	AS	DL		$AL			
	SA	DL		$AL			
	SP	DL		$ICI			
	LP	DP		NØ			
MP1	NØ	IP		CC			
*The Multiply Logram Would Be in Here							
* The Code Is Left Out							
	LP	IL		$ICI			
	END			START			

FORM 2204

Figure 5-1. continued

```
                    *       IDENTIFICATION INFORMATION
                            PCH                         PUNCH TAPE DESIRED
                      *SAMPLE PROBLEM
          00144             ORG       100
00144     62000     START   LP  DM      NO              START THE INTERPRETIVE
00145     00147             PZE       *+2             MODE
00146     62200             LP  DP    NO
00147     00177             PZE       LD1
00150     00167                       G1
00151     00207             PZE       AD1
00152     00170                       G2
00153     00203             PZE       ST1
00154     00173                       H1
00155     00207             PZE       AD1
00156     00171                       G3
00157     00203             PZE       ST1
00160     00174                       H2
00161     00214             PZE       MP1
00162     00172                       G4
00163     00203             PZE       ST1
00164     00175                       H3
00165     00166             PZE       *+1
00166     20060             BR  DM F  UN
00167     00005     G1      OCT       5
00170     00006     G2      OCT       6
00171     00004     G3      PZE       4
00172     02122     G4      BCIH1     AB
00173     00537     H1      BCIS 1    A
00174     66504     H2      BCIT1     4
00175     77634     H3      NAD       START
PAC       00176     60000             ILLEGA L  OPERATION CODE
                      *LOAD - SINGLE
00177     60600     LD1     NO  IP    NO
00200     52162             SE  DL    $AL
00201     42171             SP  DL    $IC
00202     62200             LP  DP    NO
                      *STORE LOGRAM
00203     75162     ST1     LA  DL    $AL
00204     52600             SE  IP    NO
00205     42171             SP  DL    $IC
00206     62200             LP  DP    NO
                      *ADD LOGRAM
00207     60600     AD1     NO  IP    NO
00210     73162             AS  DL    $AL
00211     50162             SA  DL    $AL
00212     42171             SP  DL    $IC
00213     62200             LP  DP    NO
00214     60607     MP1     NO  IP    CC
                      *THE MULTIPLY LOGRAM WOULD BE IN HERE
                      *THE CODE IS LEFT OUT
00215     62571             LP  IL    $IC
          00144             END       START
```

Figure 5-2

6.0 DETAILS OF OPERATION

The purpose of the Program Assembler is to translate a computer program from an arbitrary language specified by the user into the machine language of the AN/UYK-1 (TRW-130) Computer. This purpose is accomplished through "dictionary look-up" techniques.

As mentioned earlier, memory size requires that the assembler operate in two "passes". During the first pass, the "dictionary", or symbol table, is compiled by sorting out all definition entires and listing them in memory. During the second pass, all "translation" is accomplished and the program is assembled as a series of octal numbers which specify the Computer actions desired in the operational program. The actions occurring during each pass are described in detail below.

Since it may be undesirable to have any "splices" in the final punched tape, a "tape copy" routine is included in the Program Assembler. The purpose of this tape copy routine is to read a "load" routine and punch the "load" routine on the output tape. Toggle switch five controls the selection of this routine.

6.1 PASS ONE

The first step of Pass One is to read, print out, and punch out the first entry on the input tape. This is invariably the "heading card", which contains the title of the program being assembled, and any other information deemed pertinent by the programmer.

The assembler then reads in the second entry on the tape and inspects the operation field to see if this is a PCH card. If it is, a flag is set which causes the output to be punched out on paper tape during Pass Two; "PCH" is printed out; and the assembler enters a loop which begins with the reading of the next card. Note that in order to get punched output, the PCH card must be the second entry on the input tape.

If the first non remarks card is not an ORG card, the comment "no ORG Card", along with the contents of the card is printed out, the location counter is set to 64, and the card is processed.

The assembler checks each card for the presence of an asterisk in card column 1, indicating a remarks card. With a remarks card the assembler merely skips back to read the next entry.

A table search is made to determine if each card contains one of the following pseudo-operations:

a. Read
b. Dump
c. PRT
d. PCH
e. SUP
f. ORG
g. DECD
h. BCIH, BCIS, BCIT
i. RES
j. EQU, EQUB
k. END
l. PAUS

If the entry is one of the first five in the table above, it is skipped over and the next entry is read in,

If the entry is an ORG card, the secondary field is inspected. If the secondary field is an allowable entry, it is converted to its octal equivalent, then stored in the location counter. If the secondary field is not an allowable entry, the secondary field error code S is printed out, along with the contents of the card, and the location counter is set to 64. In either case, the next action is to jump out of this loop to process the rest of the cards.

On a DECD entry, the location counter is incremented by two.

On a BCIH, BCIS, or BCIT entry, the location counter is incremented by the value in the address option field of the card.

A RES entry causes the location counter to be incremented by the value in the secondary field.

If the entry is either EQU or EQUB, the location counter is not modified, and the symbol in the location field is entered in the symbol table equated to the value in the secondary field.

In all cases, the location field is checked and any symbols detected there are inserted in the symbol table. If the symbol table is full when an entry is attempted, a cell which is normally clear is filled with the address of the first symbol that failed to load in the symbol table.

A PAUS pseudo-operation causes the Computer to stop. Processing is continued when the operator presses the FLAG button. The location counter is unchanged.

When the END card is detected, all multiply-defined symbols are printed out, and if the symbol table is full, the address of the first symbol that failed to load is also printed out.

Any errors detected during this pass result in the contents of the card being printed out, along with a code S, A, or L, designating whether the error was in the secondary field, address option field, or location field of the card.

Before each entry is read from the symbolic tape, toggle switches 15 and 1 are interrogated. If both switches are up, this assembly is terminated, and the computer will await the next assembly.

6.2 PASS TWO

The second pass performs three functions before entering its loop. In order, the second pass sets the location counter to 64, reads the first entry (title card) and sets the "Print" switch to "on". It then enters its loop by initializing.

The first step of the loop is to zero the data word cell and error alarm cells. The next entry is then read into memory. If toggle switch 15

is "up" (1), the assembler interrogates toggle switch 1. If one is up, the assembler transfers to the end pseudo-operation routine. If an asterisk code is present in the first card column, the entire entry is printed and the loop is closed.

If the asterisk code is not present, the assembler checks the location field for a permissible symbol. If the symbol is not permissible, error alarm L is set. The assembler checks the operation field of the entry for any of the 20 pseudo-operations codes. If any one of the codes is present, the assembler transfers control to the appropriate pseudo-operation routine (Paragraph 1-21).

If none of the codes are present, the assembler checks the code for any of the 54 primary command codes. If none of the codes are present, error alarm "P" is set, and the assembler treats the entry as if it were a "No" primary command.

If a primary command code is present, the appropriate logand code is retrieved from a table of logands and set into the data word cell. The Assembler then transfers to one of eight routines to process one of eight classes of logands.

The eight classes of logands (for purposes of the Program Assembler) are:

a.	Class I	NO, LA, LP, LT, LM, RA, RP, RT, RM, AP, AT, ZE, XA, MA, XE, ME, DX, CS, CC, CH, SE, SA, SP, ST, HA, HP, HT, HM, WI, WØ
	Class I_a	Class I address options DM, IM, DP, IP, DA or IA
	Class I_b	Class I address option DL or IL
b.	Class II	AS, AL, AI or AM
c.	Class III	SO, SC, NR, or FL
d.	Class IV	MS, MP, DV
e.	Class V	BR, SK, MV, TB, MH, SR, BI, BØ
f.	Class VI	EF, CF

g. Class VII RC

h. Class VIII IT, TM

6.2.1 Class I Logands

The address option field is checked for one of eight permissible codes: DL, IL, DM, IM, DP, IP, DA or IA. If none of the codes are present, error alarm "A" is set, address option DM is set into the data word, and the assembler proceeds to the class I_a logand routine.

If any of the codes are present, the appropriate machine code is set into the data word cell. If the address option is DL or IL, the assembler transfers to the logand class I_b routine; otherwise, the assembler transfers to the logand class I_a routine.

Class I_a logands - Class I, DM, IM, DP, IP, DA, IA Address Options

The assembler checks the control field of the entry for the presence of a blank, C, B, N, or H code. If none of these codes is present, error alarm "C" is set, and the machine code for "C" (0) is set into the data word (bits 5 and 6). If any of the codes are present, the appropriate machine code is set into the data word.

The assembler then checks the secondary field for a secondary command code. If the code is not permissible, error alarm "S" is set and the machine code for "NO" (00) secondary command is set into the data word (bits 1-4). If the code is permissible, the appropriate machine code is set for the secondary command. The assembler then transfers to the output routine.

Class Ib logands - Class I, Address options DL or IL

The secondary field of this class of logands consists of three quantities: 1) address, 2) operation, and 3) modifier. The address and modifier may be either a symbol or a decimal integer. The operation may be either add or subtract. For example, the secondary field may be x+1, 1+x, x+x, x-1, etc.

If either the address and/or modifier is a symbol, the "dictionary" is searched for the binary equivalent of the symbol. If the symbol is not found in the "dictionary", error alarm "S" is set. If either the address or the modifier is a decimal integer, the integer is converted to an octal integer.

The address and modifier are then combined as indicated by the operation and entered into the data word, modulo 64. The assembler then transfers to the output routine.

6.2.2 Class II Logands - Add Type

The assembler checks the address option field for a permissible code. If the code is not permissible, error alarm "A" is set. If the address option field is IL or DL the assembler transfers to the class I_b logand routine. If the address option is neither a DL nor an IL code, the assembler checks the secondary operation code. If the code is a "NO" secondary operation code, the assembler transfers to the class I_a logand routine. If the code is not a "NO" code, error alarm "S" is set and the assembler transfers to the class I_a logand routine.

6.2.3 Class III Logands - Shift Type

Since the address option field must contain a DM address option, no check is made of the address option field. The logand is always assembled with the DM address option machine code.

The control field is checked for an S or D code. If either is present, the appropriate machine code is set into the data word (bit 6). If neither is present, error alarm "C" is set and the code for S (0) is set into the data word.

The assembler then checks the code in card column 14 of the entry, for an R or an L. If neither is present, error alarm "C" is set and the machine code (0) for a right shift is set into the data word cell. If either is present, the appropriate machine code is set into the data word cell (bit 5).

The assembler then checks the remainder of the secondary field for a decimal integer. This integer is converted to an octal integer and set into the data word cell, modulo 16. If a decimal integer is not present, error alarm "S" is set, and 0 is set into the data word cell. The assembler then transfers to the output routine.

6.2.4 Class IV - MS, MP or DV Logands

This class of logands is assembled with a DM address option regardless of the contents of the address option field of the entry. The secondary field is checked for a decimal integer. If no decimal integer is found, error alarm "S" is set, and zero is set into bits 1-4 of the data word cell. If a decimal integer is present, it is converted to an octal integer, and set into the data word cell, modulo 16. The assembler then transfers to the output routine.

6.2.5 Class V - Logands Requiring a Condition in the Secondary Field

The assembler checks the address option field for a permissible code (DM, IM, DA, IA, DP or IP). If the code is not permissible, error alarm "A" is set. If the logand is an MV, SR, TB, BI, BØ, or MH, address option IP is set into the data word cell; if the logand is a BR or SK address option, DM is set.

If the address option field is permissible, the appropriate address option machine code is set. For this class logands, DL and IL address options are not permissible.

The assembler then checks the control field for a blank code or an F code. If neither code is present, error alarm "C" is set and the machine code (0) for a blank is set into the data word cell (bit 6). Finally, the secondary field is checked for a permissible condition code. If a permissible code is not found, error alarm "S" is set and the machine code (00) for an "UN" code is set into the data word cell. If a permissible code is found, the appropriate code is set into the data word cell. The assembler transfers to the output routine.

6.2.6 Class VI - CF or EF Logands

The address option field is checked for a permissible code. If the code is not permissible, error alarm "A" is set. If a permissible code is present, the appropriate machine code is set into the data word cell.

The logand is then treated as a Class I_b logand.

6.2.7 Class VII - RC

The logand is assembled as a regular (Class I) logand, except that a decimal integer must be found in the secondary field.

6.2.8 Class VIII - IT or TM Logands

Since these logands require an IL address option, the address option field is not checked. The secondary fields of these logands are treated as the class I_b logands.

The output routine accomplishes the following functions: 1)prints the hard copy listing of the assembled program; 2) punches a paper tape of the assembled program; 3) adds one (modulo 8192) to the location counter. At the conclusion of these functions, the assembler transfers to the beginning of its loop and initilizes for the next entry.

6.2.9 Pseudo-Operation Subroutines

If pseudo-operations are used by the programmer, they are indicated by special coding in the operation field of each entry. Upon detecting this coding, the assembler transfers to the appropriate subroutine of the following twenty.

6.2.9.1 ORG

If an "ORG" code is present, the next action is to check the secondary field. If the entry is permissible, the location counter and data word cells are set to the value contained in the entry. The routine

then prints output, clears any alarm indicators, clears the data word cell, and closes the loop by reading the next entry.

If the secondary field entry is not permissible, the S error indicator is set and the program jumps to "LOOP CLOSE". If the entry is undefined, the U error indicator is set and the jump to "LOOP CLOSE" made. The entry is treated as ORG 64 on any error alarm.

6.2.9.2 EQU or EQUB

If either an "EQU" or an "EQUB" code is present, the location field is then checked. If its entry is permissible, the address is set into the data word cell. The routine then performs the "LOOP CLOSE" subroutine except that the location counter is not incremented.

If the location field entry is either blank or is not permissible, the L error indicator is set, the output is printed, and loop is closed by reading the next entry.

6.2.9.3 RES

If a "RES" code is present, the contents of the location counter are set into the data word cell. The secondary field is then checked. If its entry is permissible, the location counter is incremented by the value contained in the secondary field, printed and punched, the alarm indicators and the data word cell are cleared, and the loop is closed by reading the next entry.

If the secondary field entry is not permissible or is undefined, the appropriate indicator is set as described in subroutine "ORG" and the routine jumps to "LOOP CLOSE".

6.2.9.4 OCT or DEC

If either "OCT" or a "DEC" code is present, the secondary field is checked. If it is in any way erroneous, the S error indicator is set and the routine jumps to "LOOP CLOSE". If the code is proper, its value is set in the data word cell and the routine jumps to "LOOP CLOSE".

6.2.9.5 DECD

If a "DECD" code is present, the secondary field is checked. If it is in any way erroneous, the S error indicator is set, the location counter is incremented by two, and the loop is closed by reading the next entry. If the field entry is proper, the first part of the secondary field value is set into the data word cell and the second part is placed in temporary storage. Then, the output is printed and punched, the alarm indicator is cleared, the data word cell is cleared, the location counter is incremented by one, the second part of the entry is set from temporary storage into the data word cell, and the routine jumps to "LOOP CLOSE".

6.2.9.6 PZE or BLANK

If a "PZE" or "BLANK" code is present, the secondary field is checked. If the entry is undefined, the S error indicator is set and the routine jumps to "LOOP CLOSE". If the entry is not permissible, the S error indicator is set and the routine jumps to "LOOP CLOSE". If the entry is proper, the data word cell is set to the value contained in the secondary field, the loop is closed in the same manner as described in "ORG".

6.2.9.7 NAD

If a "NAD" code is present, the secondary field is checked. Any errors are treated as described above under "PZE". If the entry is proper, the two's complement of the secondary field value is set into the data word cell and the sign bit of the symbol table address checked and the loop closed as described under "ORG".

6.2.9.8 END

If an "END" code is present, the secondary field is checked. If it is undefined, the S error indicator is set and the program halts. If

it is too large, the S error indicator is set and the program halts. If it is not permissible, the S error indicator is set and the program halts. If the entry is proper, the secondary field value is set into the data word cell, the output printed and punched, any alarm indicators cleared, the data word cell cleared, the location counter incremented by one, and the program halts with an option to continue for the next assembly.

6.2.9.9 PAUS

If a "PAUS" code is present, the assembler stops. When the "ELAG" switch is depressed, the assembler reads the next entry. This pseudo-operation permits the assembling of more than one reel of paper tape.

6.2.9.10 PRT

If a "PRT" code is present, the "PRINT" switch is set to "on" and the assembler reads the next entry.

6.2.9.11 SUP

If a "SUP" code is present, the "PRINT" switch is set to "off" and the assembler reads the next entry.

The above two pseudo-operations permit the programmer to print under program control. The "PRINT" switches are altered each time either of the pseudo-operations are encountered, thus the programmer may print certain portions of his assembly.

6.2.9.12 PCH, READ, DUMP

If any of these codes are present, PASS TWØ ignores the entry. If a PCH is present, the PCH switch is set to "on" during Pass 1. The READ and DUMP pseudo-operations are used during simulation and are meaningless on the machine.

6.2.9.13 BCIH, BCIS, BCIT

These three pseudo-operations permit the programmer to enter binary coded information into memory. The basic difference between these pseudo-operations is the final code set into memory. The BCIS pseudo-operation packs Soroban code and the BCIT pseudo-operation packs teletype code. The BCIH pseudo-operation packs Hollerith code. (See Table 7.9.)

The assembler first checks the address option field for a decimal integer. If a decimal integer is not found, error alarm "A" is set, and one word of the BCI information will be formed.

If the pseudo-operations code is BCIH, two characters of Hollerith code are packed in each word. The first character occupies bits 7-12 and the second bits 1-6.

If the pseudo-operation is BCIS, or BCIT, three 5 bit characters are packed per word into bits 11-15, 6-10, and 1-5. The code packed is either Soroban or teletype code. Character shifts are emitted as necessary.

6.3 INPUT-OUTPUT

The I-0's of the Program Assembler are written so that they are as independent of the assembler as possible. The input routines must convert from one code (teletype) to another (Hollerith). The output routines convert from Hollerith code to either Soroban code for the typewriter or teletype code for the tape punch. The I-0 routines were written as lograms so that a logram is executed each time an input or an output is desired.

6.3.1 Input Routine

Upon entry to the input routine, the routine reads a punched paper tape. The data it reads represents the information contained on one symbolic logand card. The format of each tape entry is as shown in Figure 6-1. The routine converts from teletype code to Hollerith code

The symbolic tape format produced by the IBM 063 using the control panel of Figure 6-5 is as follows:

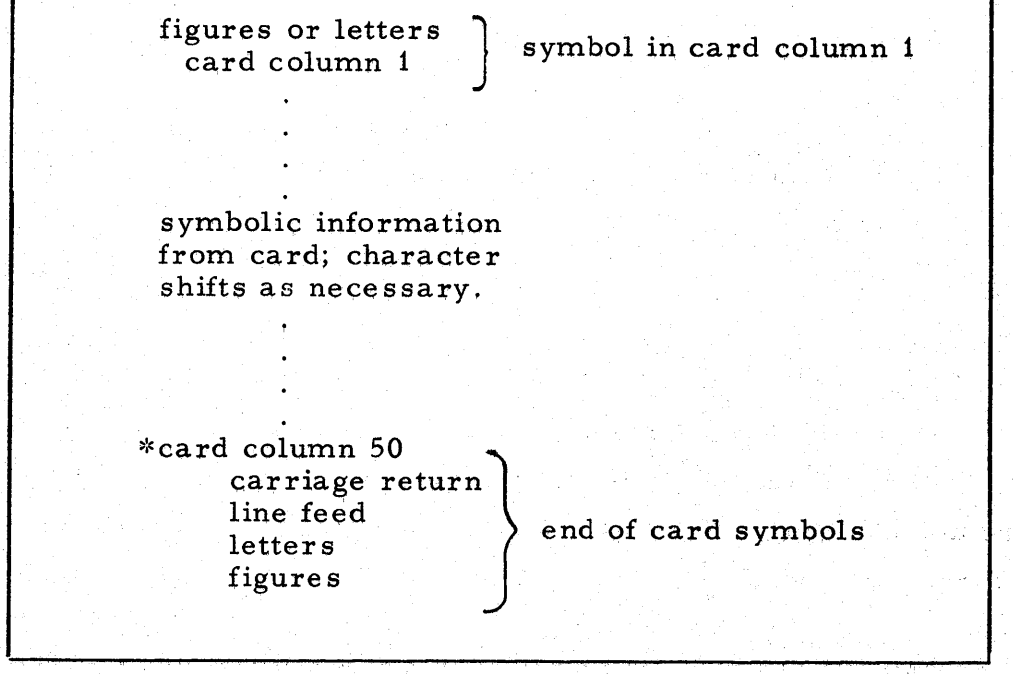


Figure 6-1. Symbolic Tape Format

*This card column is controlled by Hub A in the Figure 6-5 plugboard which produces the last column read by the assembly program.

and creates a card "image" in core. Each cell in the image contains the character of (right adjusted) one column on the input card. The Program Assembler operates on this image after return from the input routine.

6.3.2 Output

Output from the Program Assembler is typed on hard copy listings, or is punched on tape. The Program Assembler enters each routine, as necessary, to produce output. The output routines check to see if output is desired.

6.3.2.1 Typed Output Routine

When the Program Assembler enters this routine, it checks the toggle switches to see if output is desired. If toggle switches 15 and 2 are up, no output is desired, so the Program Assembler exits from the routine.

If 2 is down, the routine checks the print switch. If the print switch has been set (as a result of the PRT pseudo-operation), the routine prints the current entry. If the print switch is off (as a result of the SUP pseudo-operation) no printing is desired, so an exit is made.

Two entrances to the typed output routine can be made. If one entry is made, the routine outputs an entire entry, including the symbolic information and the computer-generated data. If the second entry is taken, the location counter is not printed. If the routine detects an asterisk code in card column 1, only the symbolic information is typed.

6.3.2.2 Punched Tape Output

Upon entry to this routine, the "punch" switch is checked. If it is "on", (as a result of a PCH pseudo-operation as the second logand), a punched tape is to be prepared. If it is "off", a punched tape is not to be prepared.

Two tape formats can be punched. If toggle switch 4 is down, the five level teletype format described below is punched. If toggle switches 4 and 15 are up, the eight level format described below is punched.

6.3.2.2.1 Five Level Teletype Format. The three entrances to this routine are: 1) normal, 2) reserve, and 3) end of assembly.

At the normal entry, the above check is made. If output is not desired, an exit is made. If output is desired, the output word is saved until 10 words have been accumulated. If the previous entry to the routine produced output, the location of the entry is saved. In either event, the check sum is formed.

When 10 data words have been accumulated or when a reserve entrance has been made, the routine punches a tape. Up to 10 data words, the location of the first data word and the check sum are punched in the format shown in Figure 6-2.

After the tape has been punched, the routine checks the toggle switches to see if further punching is desired. If toggle switches 15 and 3 are up, the punch switch is turned off. If either is down, the punch switch is left as it is.

If the end of assembly entrance is made, the routine outputs 40 letter shift codes (37). Then the end or branch control card is punched as shown in Paragraph 1-27.

In addition to teletype control characters, the punched paper tape contains the following:

a. An ID block containing in teletype code the information punched on the ID card, followed by:

b. A series of program blocks, each of which has the following format:

Characters	1 - 3:	$DB
Character	4:	Space
Characters	5 - 6:	The data word count
Characters	7 -11:	The octal address into which the first data word on the card is to be stored.
Character	12:	Space

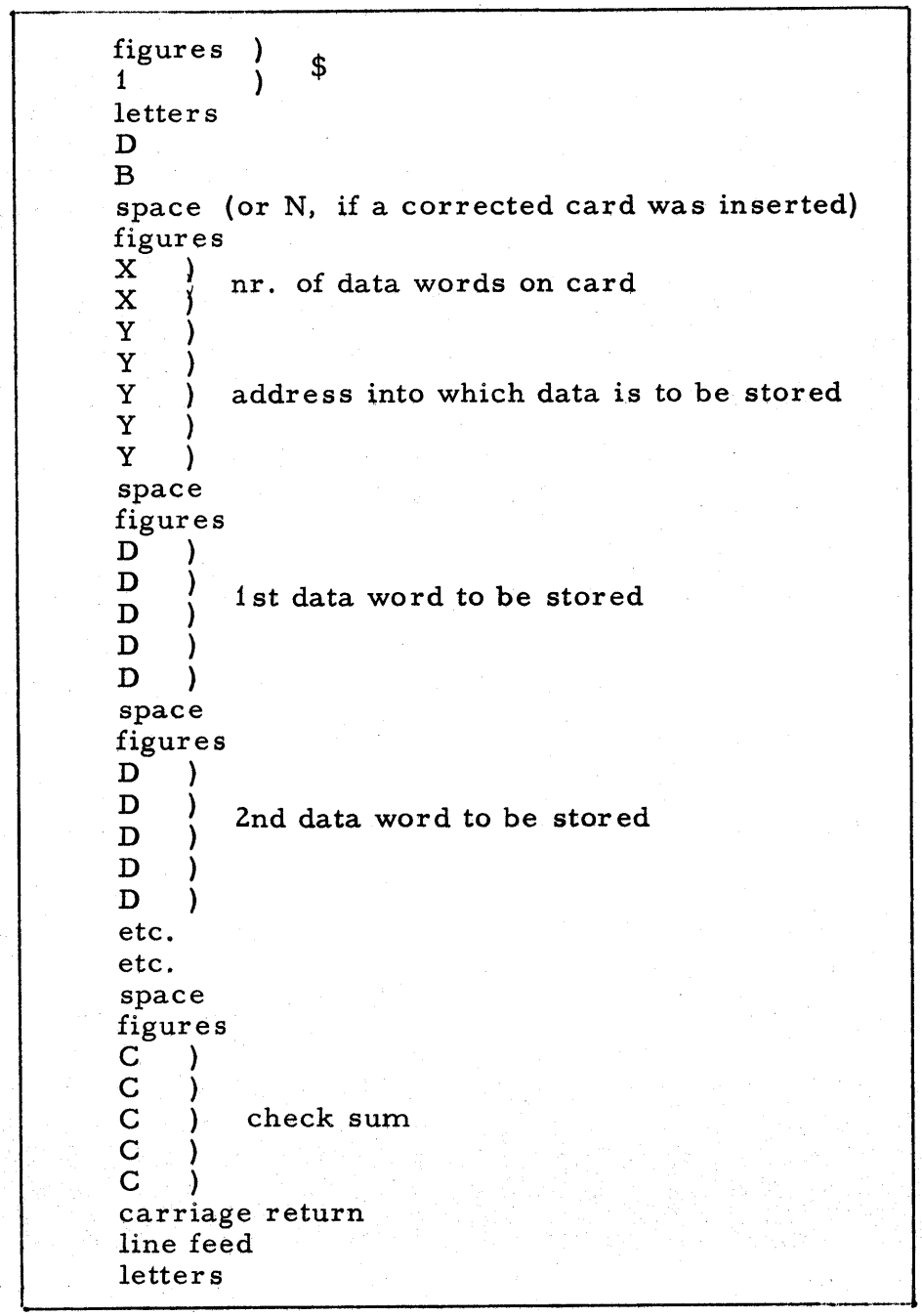


Figure 6-2. Punched Output Tape Format

Characters 13 - 72: Up to ten words of data in octal follows character 12. Each word is five octal digits and is followed by a space. If less than ten words of real data are in the card, the check sum will follow the last data word. Note that characters 5-6 give the count of real data words.

Characters 73 - 77: A check sum formed by summing the octal address in characters 7-11 and the words of real data, treating each as a 15-bit positive number with end carry from bit 15 into bit 1. This check sum was formed while the words were still in binary form.

c. The last program block is followed by an end (or transfer) block which contains $S as characters 1 and 2, followed by four spaces and the location address (in octal) of the first logand to be executed.

The paper tape contains this information in teletype code. An AN/UYK-1 (TRW-130) loader and translator is available to load this program tape into the Computer and convert it into binary. Thus, the paper tape can be used as input to the Computer or to produce IBM cards through the use of the 047. If cards are produced from the paper tape, the deck consists of an ID card followed by program cards, with the last card being a transfer card. Punching an "N" in column 4 of any program card causes the check sum to be ignored. Correction cards can be hand punched and added before the transfer card. If an octal deck is to be used on the Computer, the ID card must be the head of the deck, when the cards are translated to paper tape via the 063. When the 063 card-to-tape machine reaches column 80 of the input octal card, the following teletype codes are automatically punched on the tape:

Carriage Return	(02)
Line Feed	(10)
Letters	(37)

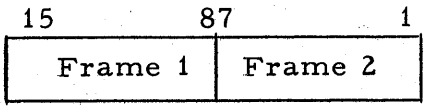
Translation of the next card begins in column 1, and the card image on tape appears as: (See Figure 6-4 for Assembled Card Input Format 063 Plugboard.)

6.3.2.2.2 Eight Level Binary Format. The same process described under the teletype section is performed, except as noted.

At normal entry, more than 10 words are accumulated. The core memory following the symbol table is filled with the data words. When the storage area is filled, the tape is punched. Since this storage area allotment varies from one assembly to the next, it is impossible to tell how many words will be punched. The format of the tape is shown in Figure 6-3.

At the end of assembly entrance, the routine simply outputs the segment to that point, then outputs a final segment.

Each word on tape is as follows



That is, each 15 bit AN/UYK-1 (TRW-130) word occupies two frames on the tape. The first frame contains the high order 8 bits. The second frame contains the low order 7 bits, with the high order bit of that frame being zero.

The tape consists of N+1 segments. The first n segments consist of M_n+4 words. The last segment consists of 2 words. The format of the i^{th} segment is as follows:

3 7 7 7 6	Identification Word
$B_i B_i B_i B_i B_i$	Beginning Address of Segment
$E_i E_i E_i E_i E_i$	Ending Address of Segment
D D D D D . . . D D D D D	M_i Data Words
$C_i C_i C_i C_i C_i$ . . .	Check Sum of the Data Words 4 Inch Gap (40 Frames of Zero Words)

The N+1 st segment is as follows:

3 7 7 7 7	Identification Word
S S S S S	Address of Program Execution

Figure 6-3. Eight Level Binary Format

IBM 63 CARD-CONTROLLED TAPE PUNCH

CONTROL PANEL

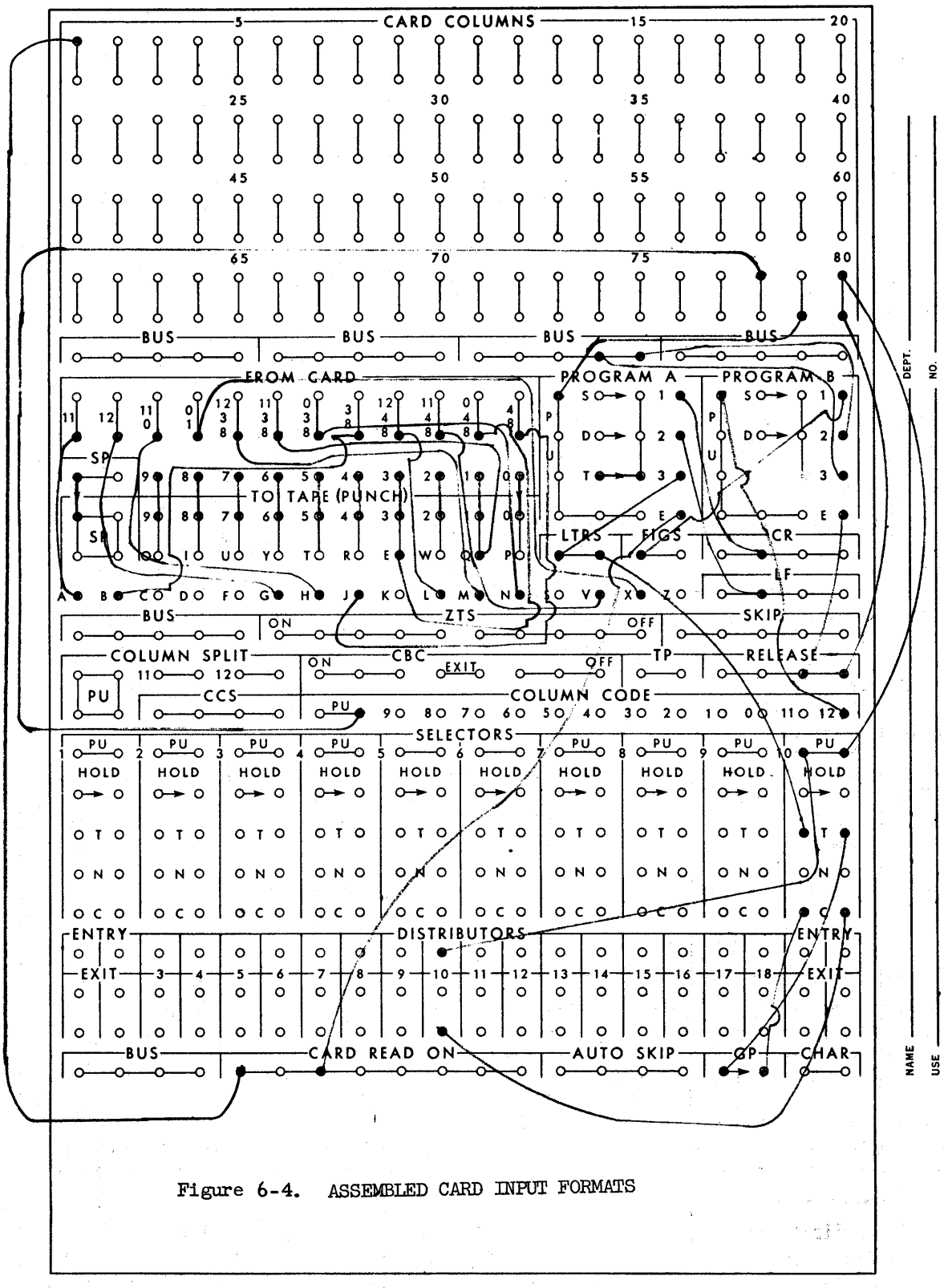
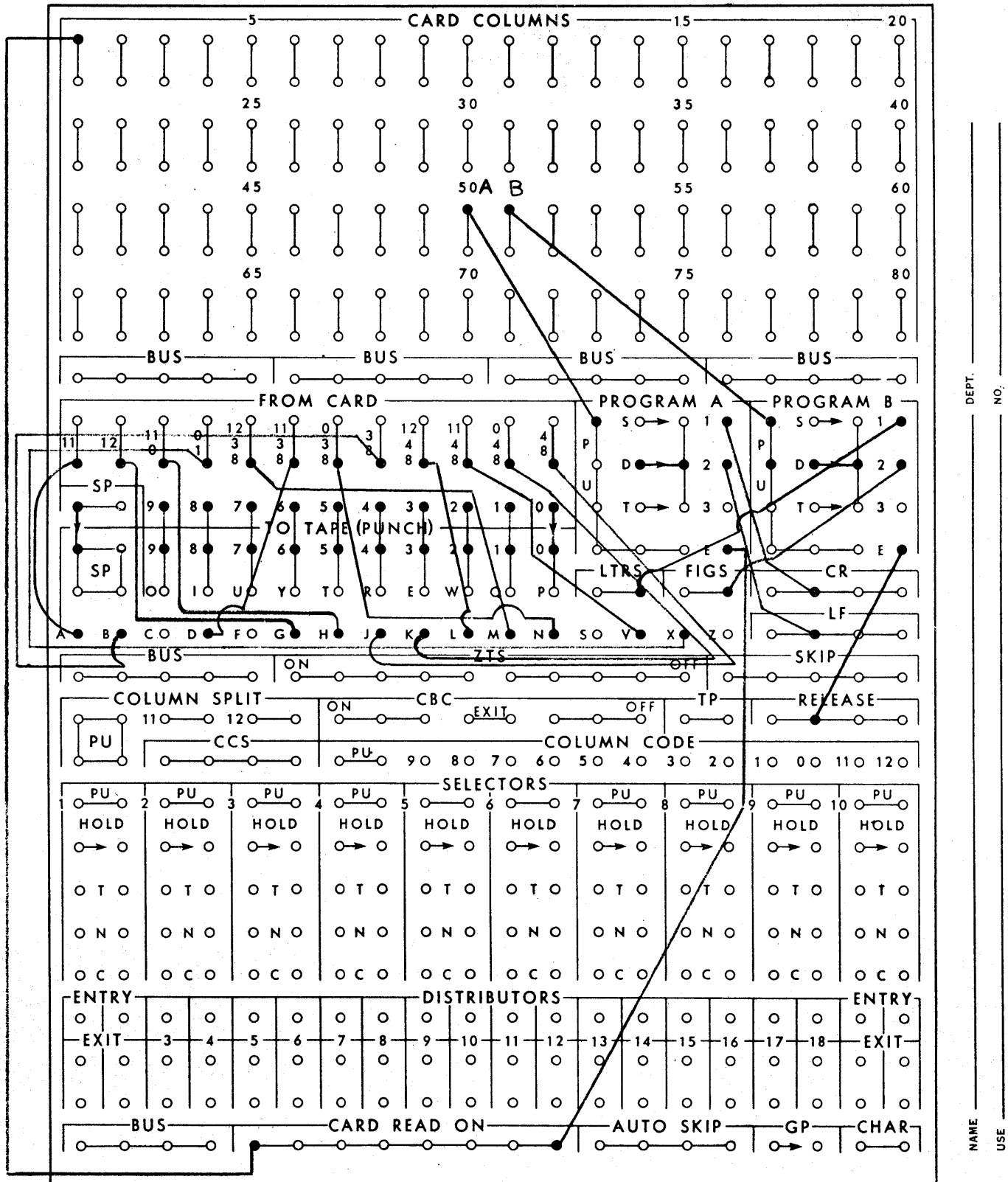


Figure 6-4. ASSEMBLED CARD INPUT FORMATS

IBM 63 CARD-CONTROLLED TAPE PUNCH

CONTROL PANEL



This diagram shows the wiring for card to taping 50 columns of information. If n columns are desired place wire A to the top of the hub n. This causes a carriage return, line feed. Then place wire B to the top of hub M+1. This causes letter, figure codes.

Figure 6-5. IBM Card-Controlled Tape Punch

7.0 Tables

Table 7.1. AN/UYK-1 (TRW-130) Scratchpad Allocation

Octal Location	System Symbol	Use
00	$MIA	Interrupt Control registers for Type II
01	$MIB	(Miscellaneous) Interrupts
02	$PFA	BR/DM/F/UN
03	$PFB	PZE 00002
04	$ØCA	Interrupt Control registers for Type I
05	$ØCB	Output Channel Interrupts
06	$ICA	Interrupt Control registers for Type I
07	$ICB	Input Channel Interrupts
10	$MIT	Miscellaneous interrupt temporary storage (Type II)
11	$ØCT	Output Channel interrupt temporary storage (Type I)
12	$ICT	Input Channel interrupt temporary storage (Type I)
13	$T1	
14	$T2	
15	$T3	
16	$T4	
17	$T5	
20	$T6	
21	$T7	
22	$T8	
23	$T9	
24	$T10	
25	$T11	Logram Temporary Storage
26	$T12	
27	$T13	
30	$T14	
31	$T15	
32	$T16	
33	$T17	
34	$T18	
35	$T19	
36	$T20	
37	$T21	
40	$T22	
41	$T23	
42	$T24	
43	$T25	

Table 7.1. AN/UYK-1 (TRW-130) Scratchpad Allocation (Continued)

Octal Location	System Symbol	Use
44	$C1	
45	$C2	
46	$C3	
47	$C4	
50	$C5	
51	$C6	
52	$C7	Common Storage for Operational Programs
53	$C8	
54	$C9	
55	$C10	
56	$C11	
57	$C12	
60	$C13	
61	$AE	AC exponent for Floating Point
62	$AL	
63	$AR	AC
64	$AT	Least Significant Part of AC for Triple Precision
65	$QE	MQ exponent for Floating Point
66	$QL	
67	$QR	MQ
70	$QT	Least Significant Part of MQ for Triple Precision
71	$IC	Instruction Counter - Primary
72	$IC2	Instruction Counter - Second Level Lograms
73	$RET	Interpretive Return Address
74	$ØV	Pseudo Overflow Indicator
75	$DK	Divide Check Indicator
76	$ØNE	00001 (plus one)
77	$MØN	77777 (minus one)

Table 7.2. Error Alarms

Alarm	Meaning
M	Multiply defined address; supplied when the second definition for a previously defined symbol appears. .
U	Undefined address; supplied when an address appearing in a secondary field does not appear in any location field.
P	Operation field error; supplied when the operation field does not contain a legal code.
A	Address option field error; supplied when the address option field does not contain a legal address option.
C	Control field error; supplied when the control field does not contain an allowable control-field character.
S	Secondary field error; supplied when the secondary field contains some nonallowable combination of characters.
L	Location field error.

Table 7.3. Primary Command Mnemonics*

Mnemonic Code	Machine Code Bits (11-15)	Function	Mnemonic Code	Machine Code	Function
NØ	60	No operation	ST	40	Store T
LA	75	Load A	HA	51	Hold A
LP	62	Load P	HP	43	Hold P
LT	70	Load T	HT	41	Holt T
LM	72	Load M	HM	53	Hold M
LA	55	Replace A	BR	20	Branch
LP	47	Replace P	SK	24	Skip
LT	45	Replace T	SØ	11	Shift Open
LM	57	Replace M	SC	03	Shift Closed
AP	66	Exchange A and P	NR	13	Numeric Right
			FL	01	Float Left
AT	64	Exchange A and T	RC	07	Repeat Count
			MP	15	Multiply
ZE	44	Clear E	MS	17	Multiply Signed
XA	76	Extract TØ A	DV	05	Divide
MA	74	Merge TØ A	MV	32	Move
XE	46	Extract TØ E	MH	30	Match
ME	54	Merge TØ E	TB	36	Table Search
DX	56	Double Extract	SR	34	Sort
AS	73	Add Single	CF	25	Control Function
AL	63	Add Least	EF	21	External Function
AI	61	Add Intermediate	WI	27	Word Input
AM	71	Add Most	WØ	23	Word Output
CC	65	Complement, Clear	BI	37	Block Input
CS	67	Complement, Set	BØ	33	Block Output
CH	77	Complement Hold	IT	00	Interrupt
SE	52	Store E	IM	10	Terminate Input
SA	50	Store A			
SP	42	Store P			

*Primary Command Mnemonics recognized by the Program Assembler. The mnemonic code occupies card columns 7 and 8.

Table 7.4. Pseudo-Operations

Code	Name	Operation
ORG	Origin	Sets location counter to value indicated in secondary field of card. If no legal quantity exists in secondary field, location counter is set to 64.
EQU	Equals	Defines symbol appearing in location field of card to have value specified in secondary field, and enters definition in symbol table. Secondary field may contain either a previously defined symbol or a decimal integer. Symbols may be combined as specified in paragraph 1-5.
EQUB	Equals (Octal)	Same as EQU except that secondary field contains an octal integer rather than a symbol or a decimal integer.
READ DUMP	Used for 7090 Simulation Program	READ and DUMP cards are ignored, i.e., they are treated as if they did not exist.
RES	Reserve	Reserves a block of cells within object program. Number of cells reserved is specified by secondary field; if no number or legal symbol appears in secondary field, only one cell is reserved.
PZE	Plus Zero	Clears one memory cell and enters into it a 15-bit maximum address specified by secondary field.
OCT	Octal Data	Converts number in secondary field to binary and enters it in cell specified by present value of location counter. Leading zeros need not be supplied. Secondary field may contain maximum of five digits, each within range 0-7, and the sign + or -; absence of sign indicates +. If sign is -, two's complement of number is entered in cell. -0 is assembled as 40000.

Table 7. 4. Pseudo-Operations (Continued)

Code	Name	Operation
BCIH	Binary-Coded Information, Code Hollerith	Enters up to 23 words of binary coded information: number of words to be entered must be specified in address option field as decimal integer between 1 and 23. Binary coded information itself consists of continuous string of any set of Hollerith characters, including blanks. Two 6-bit Hollerith codes are packed per word in bits 12 - 1.
BCIS	Binary-Coded Information, Soroban Code	Enters up to 14 words of binary-coded information using Soroban Code. Three 5-bit Soroban Codes are packed per word.
BCIT	Binary-Coded Information, Teletype Code	Enters up to 14 words of binary-coded information using five-level teletype code. Three 5-bit teletype codes are packed per word. If, in any of the BCI operations, the word count in the address option field is one digit only, this digit may be punched in either column 11 or column 12.
DEC	Decimal Data	Converts number in secondary field to binary and enters it in cell specified by present value of location counter. Number in secondary field must be entered as fraction and exponent: for example, 2450E3 = 245. 0; and 2450E-2 = 0. 002450. Actual binary scale factor to control position of word in machine must be indicated by a letter B and a number between 29 and -29 inclusive which specifies number of bits to be allowed for integral portion of number, starting from bit 14. (Bit 15 is the sign bit.) If signigicant high-order bits would be lost from the left as a result of scaling, error indication is given and the word is entered as all zeros. Secondary field may contain a maximum of five decimal digits; decimal exponent is restricted to range ±9. Binary scale is restricted to range ±29.

Table 7.4. Pseudo-Operations (Continued)

Code	Name	Operation
DECD	Double Precision Decimal	Same as DEC except that word length is extended to 29 bits plus sign.
NAD	Negative Address	Provides word containing full 15-bit two's complement of address specified in secondary field, so that one address may be "subtracted" from another to obtain zero.
PAUS	Pause	Program Assembler stops. Used if the symbolic tape consists of more than one reel of tape. This pseudo-operation generates no data.
BLANK	None	This pseudo-operation causes the same effect as a PZE.
END	End of Assembly	Indicates end of object program. This card must be last card of an assembly. Secondary field contains starting address of program.
PCH	Punch	If this pseudo-operation is the second card of the symbolic deck, the Program Assembler punches a binary tape.
PRT	Print	This pseudo-operation causes the print switch to be set to "on". That is, the Program Assembler prints the side-by-side listing.
SUP	Suppress Printing	This pseudo-operation causes the print switch to be set to "off". That is, the Program Assembler stops the printing of the side-by-side listing.

Table 7.5. Address Option Mnemonics*

Mnemonic Code	Machine Code (Bits 7 - 9)	Description
DM	0	Direct M
DL	1	Direct L
DP	2	Direct P
DA	3	Direct A
IM	4	Indirect M
IL	5	Indirect L
IP	6	Indirect P
IA	7	Indirect A

*Address Option Mnemonics recognized by the Program Assembler. The mnemonic codes must occupy card columns 11 and 12.

Table 7.6. Secondary Command Mnemonics*

Mnemonic Code	Machine Code (Bits 1 - 4)	Description
NO	00	No Operation
LA	15	Load A
LP	02	Load P
LT	10	Load T
LM	12	Load M
AP	06	Exchange A and P
AT	04	Exchange A and T
XA	16	Extract to A
MA	14	Merge to A
AS	13	Add Single
AL	03	Add Least
AI	01	Add Intermediate
AM	11	Add Most
CC	05	Complement Clear
CS	07	Complement Set
CH	17	Complement Hold

*Secondary Command Mnemonics recognized by the Program Assembler. The mnemonic codes must occupy card columns 14 and 15.

Table 7.7. Condition Mnemonics*

Mnemonic Code	BR or SK Octal Code (Bits 1-5)	Other's Octal Code (Bits 1-4)	Description
UN	20	-	Unconditional
AD	21	-	A Odd
PY	25	-	Parity Error
AZ	24	-	A Zero
NV	23	03	Never
EQ	26	06	Equal
NQ	27	07	Not Equal
EN	30	10	E Negative
ØV	31	-	Overflow
CY	32	-	Carry
TL	33	-	T Register in Use
AN	34	-	A Negative
AP	35	-	A Positive
NH	36	16	Numeric High
NL	37	17	Numeric Low

*Mnemonic Codes for Conditions recognized by the Program Assembler. The mnemonic codes must occupy card columns 14 and 15.

Table 7.8. Control Field Mnemonics

Mnemonic Code	Card Columns	Octal Code (Bits 5, 6)	Description
BLANK	13	0	
C	13	0	
N	13	2	No Access
H	13	1	Hold Count
B	13	3	Both No Access, Hold Count
F	13	1 (Bit 6)	FLAG
SR	13, 14	0	Single Right
SL	13, 14	1	Single Left
DR	13, 14	2	Double Right
DL	13, 14	3	Double Left

*Control Field Mnemonics recognized by the Program Assembler. The mnemonic codes occupy card columns as indicated.

Table 7.9. Character Code Sets

Character	Hollerith Code	Teletype Code	Soroban Code	Character	Hollerith Code	Teletype Code	Soroban Code
BLANK	00	04	27	-	40	30	13
1	01	35	01	J	41	32	04
2	02	31	02	K	42	36	25
3	03	20	23	L	43	11	26
4	04	12	04	M	44	07	01
5	05	01	25	N	45	06	20
6	06	25	26	Ø	46	03	31
7	07	34	07	P	47	15	16
8	10	14	10	Q	50	35	33
9	11	03	31	R	51	12	11
#	12	05	24		52		
=	13	23		$	53	22	05
@	14	26		*	54	17	12
%	15	24	06		55		
	16				56		
:	17	16	22	Carr Ret	57	02	15
+	20	13	32	0	60	15	20
A	21	30	12	/	61	27	16
B	22	23	35	S	62	24	24
C	23	16	22	T	63	01	36
D	24	22	05	U	64	34	07
E	25	20	30	V	65	17	03
F	26	26	06	W	66	31	27
G	27	13	14	X	67	27	21
H	30	05	32	Y	70	25	13
I	31	14	10	Z	71	21	17
'	32	32	36		72		03
.	33	07	34	,	73	06	34*
)	34	11	23*	(	74	36	02*
"	35	21	17		75		35
&	36		14		76		33
figures	37	33	37	letters	77	37	00

*These are lower case figures.

APPENDIX I
PROGRAM ASSEMBLER
OPERATIONAL PROCEDURES

PROGRAM ASSEMBLER
OPERATING INSTRUCTIONS

1. AN/UYK-1 System Power Settings.
   - 1.1 Turn computer power switch to ON.
   - 1.2 Move lever on underside of right front corner of typewriter to turn on the typewriter.
   - 1.3 TRW-140 System switch settings.
     - 1.3.1 Tape Reader
       - 1.3.1.1 Power: on
       - 1.3.1.2 Forward-Rewind: forward
     - 1.3.2 System
       - 1.3.2.1 Code-Convert: off
       - 1.3.2.2 On-Line, Off-Line: on-line
       - 1.3.2.3 Power: on
       - 1.3.2.4 Rotary Switch: paper tape
     - 1.3.3 Paper Tape
       - 1.3.3.1 Binary
       - 1.3.3.2 Reader power on
       - 1.3.3.3 Punch power on
     - 1.3.4 Keypunch
       - 1.3.4.1 Power Off
     - 1.3.5 Typewriter
       - 1.3.5.1 Echo check: off
       - 1.3.5.2 Power on
     - 1.3.6 Send-Receive Set
       - 1.3.6.1 Power off

2. Output Equipment Check
   - 2.1 Check for sufficient tape in paper tape punch.
   - 2.2 Check for sufficient paper in typewriter.
   - 2.3 Set typewriter margins to allow for at least 87 type positions.

3. Computer Console Settings

3.1 Set Continuous-Interrupt switch to Interrupt.

3.2 Set Stop-Run switch to Stop.

4. Loading Procedure

4.1 Mount program assembler program reel in the tape reader.

4.2 Raise Load switch on computer to Load, then release.

4.2.1 The bootstrap loader will now be loaded into core.

4.2.2 The M Register should read 00002.

4.3 Press the Flag button on the computer.

4.3.1 The loader for the program assembler will be read into core.

4.3.2 Upon completion of loading, the M Register should read 00101.

4.4 Press Flag button.

4.4.1 The program assembler will now be read into core.

4.4.2 The M Register should read 15417 upon completion of loading.

4.4.3 The loading procedure is now completed. Rewind and remove the program assembler tape from the tape reader.

5. Pass I Operation

5.1 Check toggle switches for desired setting.

Switch 15 down - ignore switch settings.

Switch 15 up - interrogate switches 1 through 5.

Switch 1 up - abort run.

Switch 2 up - suppress printing.

Switch 3 up - suppress punching.

Switch 4 up - punch output in 8-level binary.

Switch 5 up - bypass copying loader.

5.2 Loader Copy Procedure

5.2.1 If a loader is to be copied on to the output tape, mount loader tape on tape reader, ensure that toggle switches 15 and/or 5 are down, and press Flag. The loader will be read, punched, then stop with 4334 in the M Register. A block of 275 words will be copied.

5.2.2 To bypass this loader copy procedure, set toggle switches 15 and 5 up, and proceed to step 5.3.

5.3 Mount Symbolic Tape on Tape Reader

5.4 Press Flag Button

5.4.1 The assembler will now read and process one entry at a time from the symbolic tape.

5.4.2 The punch will punch the contents of the first entry on the symbolic tape for 5-level paper tape output; no punching will occur during Pass I for 8-level paper tape output.

5.4.3 The typewriter will type the contents of the first entry, then only those entries where an error was detected by Pass I.

5.4.4 Program stops.

5.4.4.1 00601 in the M Register indicates that Pass I is complete. Rewind the symbolic tape and proceed to Pass II.

5.4.4.2 04057 in the M Register indicates that this is an intermediate reel of a multi-reel symbolic tape. Remove this reel and mount the following reel on the tape reader. Press Flag to resume Pass I.

6. Pass II Operation

6.1 If this is an assembly of a multi-reel symbolic tape, mount the first reel on the tape reader.

6.2 Press Flag Button.

6.2.1 The assembler will now read, process and type each entry on the symbolic tape.

6.2.2 Punching.

6.2.2.1 5-Level Tape: Punching will occur at approximately every tenth instruction.

6.2.2.2 8-Level Tape: Punching will occur in various length segments.

6.2.3 Printing and punching may be suppressed under program or toggle switch control.

6.2.4 Program stops.

6.2.4.1 15417 in the M Register indicates that Pass II is completed. Remove printout and punched output. Proceed to execute Pass I if another program is to be assembled.

6.2.4.2 02013 in the M Register indicates that this is an intermediate reel of a multi-reel symbolic tape. Remove this reel, then mount the next reel on the tape reader. After tape is positioned press Flag to resume Pass II.

7. Error Procedures

7.1 Computation may be stopped at any time by depressing the Logand button on the computer. Any corrections can now be made to the peripheral gear. To resume processing, press Flag.

7.2.1 Stop while loading program assembly tape. (See 9.2.3.3 for more detail.)

7.2.1.1 Indicates check sum or illegal character error.

7.2.1.2 Note contents of A Register which displays location where error was detected.

7.2.1.3 Rewind tape approximately one foot to try section again. Press Flag to continue. Upon completion of loading, verify the next 10 cells beginning with the location displayed in the A Register at stop.

7.2.1.4 If stops continue, rewind the program assembler tape and attempt loading again. If stops persist, it indicates mechanical malfunctions.

7.2.2 Stop while executing Pass I or Pass II.

7.2.2.1 Rewind symbolic tape.

7.2.2.2 Set toggle switches to:
a. 15416 if stop in Pass I.
b. 00600 if stop in Pass II.

7.2.2.3 Depress in order, SW→E, E→M, and Display buttons.

7.2.2.4 Reset toggle switches to desired setting.

7.2.2.5 Depress Flag.

7.2.2.6 If stop persists, reload program assembler tape and attempt to execute assembly again.

7.2.2.7 If condition does not clear up, it indicates a machine malfunction.

7.3 Typewriter attempting to type is inhibited.

7.3.1 Generally indicates margins not set wide enough, or typewriter power is off. Correct, then reload program assembler.

7.3.2 If condition persists, it indicates a machine malfunction.

8. Input to the Program Assembler

8.1 The symbolic input to the Program Assembler must be five level teletype coded information on paper tape, generally produced from cards through an IBM 063 or other suitable card to tape equipment.

8.2 The first card of the symbolic deck must be an identification card.

8.3 Instruction card format.

8.3.1 Location field (columns 1-6)

8.3.2 Operation field (columns 7-10)

8.3.3 Address option field (columns 11, 12)

8.3.4 Control field (column 13)

8.3.5 Secondary field (columns 14-29)

8.3.6 Remarks field (columns 30-60)

8.4 Card to tape operation.

8.4.1 A wiring diagram for the IBM 063 is attached (Figure 6.5)

9. Output from the Program Assembler

9.1 Typewriter output.

9.1.1 Format - 5 fields.

Error alarm field.

Five digit location counter field.

Five digit instruction field.

Symbolic instruction field.

Remarks field.

9.2 Punched paper tape output.

9.2.1 5-level teletype or 8-level binary tape is produced.

9.2.2 These tapes may then be loaded for execution on the AN/UYK-1.

9.2.3 5-level Loader (Appendix II).

9.2.3.1 The loader is designed to load job programs in teletype code into the computer, convert the teletype codes to binary and store them in the specified locations. Programs to be loaded must be prepared in the format specified.

The load programs for lower and upper core are identical in the symbolic program. Only the origin is different.

9.2.3.2 Core usage.
The origin of the low core loader is 200 (octal) and extends to location 550 (octal). The high core loader occupies cells 17055 (octal) through 17425 (octal).

9.2.3.3 Program specifications.

1. Operating instructions.
The Loader is read into core by the wired-in-bootstrap. This is done by setting the RUN-STOP BUTTON to STOP, raising the LOAD BUTTON and depressing the FLAG BUTTON. When the loader has been read in, the computer then stops on a flag branch to symbolic address BCOV of the load program (octal location 200 for lower core and 17055 for upper core). The M Register will be reading 201 and 17056, respectively. To proceed, depress the flag button and the loader will load in the job program and stop on a flag branch to the address specified by the job program (on the END card).

2. Special program stops.

   a. Illegal check sum.
   The load program makes use of two special halts, or flag branches. If an illegal check sum is obtained during the loading process, the program disconnects the reader from the computer, displays in the A Register, the last address in which an input data word was stored, and stops on a flag branch (octal location 423 for lower core, 17300 for upper core) to the next instruction.

To continue loading regardless of the error, depress the flag button. The program reconnects the reader to the computer and continues.

b. Illegal characters.
If an illegal teletype code is detected by the program during the load operation, the program disconnects the reader from the computer, displays, in the A Register, the last address in which data was stored, and halts on a flag branch (octal location 471 for the low core loader, 17346 for the upper core loader). To continue loading regardless of the error, depress the flag button. The program reconnects the reader to the computer, ignores the remainder of that card (or block) and searches for the next card.

9.2.4 8-Level Loader (Appendix III)

9.2.4.1 This loader is designed to load and store in specified locations job programs punched in the 8-level binary format specified by the Program Assembler.

The load programs for lower and upper core are identical in the symbolic program. Only the origin is different.

9.2.4.2 Core Usage

The origin of the low core loader is 200 (octal) and extends to 326 (octal). The high core loader occupies cells 17055 (octal) to 17203 (octal).

9.2.4.3 Program Specifications

1. Operating instructions.
The loader is read into core by the wired-in-bootstrap. This is done by setting the Run-Stop button to stop, raising the Load button and depressing the Flag button. When the loader has been read in, the computer then stops on a flag branch to symbolic location LOAD of the load program (octal location 200 for lower core and 17055 for upper core). The M Register will be

reading 201 and 17056, respectively. To proceed, depress the Flag button and the loader will load in the job program and stop on a flag branch to the address specified by the job program (on the END card).

2. Illegal check sum stop.
If an illegal check sum is obtained during the loading process, the program disconnects the reader from the computer, displays in the A Register the beginning address of the segment, and halts on a flag branch (octal location 215 for lower core, 17072 for upper core). To continue loading regardless of the error, depress the Flag button. The program reconnects the reader to the computer and continues.

APPENDIX II
5-LEVEL LOADER

```
      00200          ORG       128                                                    1070010
                      1PLC1070 0 B1      ,LOWER CORE LOADER.                 00232    1070000
00200 75000  BCOV    LA   DM C  NO              INHIBIT INTERRUPT TYPE 2              1070020
00201 00204          PZE       BCOV1                                                  1070030
00202 50101          SA   DL   $MIB                                                   1070040
00203 00500          IT   IL   0                                                      1070050
00204 67015  BCOV1   CC   DM   LA                                                    1070060
00205 00210          PZE       BCOV2                                                  1070070
00206 50107          SA   DL   07                                                     1070080
00207 00506          IT   IL   06                                                     1070090
00210 25110  BCOV2   CF   DL   8                 CHANNEL SELECT                     1070100
00211 21010          EF   DM   8                 TIE COMMAND                        1070110
00212 40001          OCT       40001           PAPER TAPE CONNECT                   1070120
00213 27173  BCOV5   WI   DL   $RET            READ A CHAR                          1070130
00214 75173          LA   DL   $RET            LOA REG A WITH A CHAR                1070140
00215 20427          BR   IM   NQ              =                                    1070150
00216 77775          OCT       77775           CARRIAGE RETURN (OCT 02)             1070160
00217 00213          PZE       BCOV5                                                  1070170
00220 27173  BCOV7   WI   DL   $RET            READ A CHAR                          1070180
00221 75173          LA   DL   $RET            LOAD CHAR INTO REG A                 1070190
00222 20427          BR   IM   NQ              =                                    1070200
00223 77744          OCT       77744           FIGS (OCT 33)                        1070210
00224 00220          PZE       BCOV7           NO                                   1070220
00225 27173  BCOV8   WI   DL   $RET            READ A CHAR                          1070230
00226 75173          LA   DL   $RET            LOA A CHAR INTO REG A                1070240
00227 20427          BR   IM   NQ              NOT=                                 1070250
00230 77742          OCT       77742           Q ,OCT 35 .                          1070260
00231 00456          PZE       BCONTD          BRANCH NOT EQUAL TO ERROR            1070270
00232 27173  BCOV9   WI   DL   $RET            READ A CHAR                          1070280
00233 75173          LA   DL   $RET            LOA A REG WITH THE CHAR              1070290
00234 20427          BR   IM   NQ              =                                    1070300
00235 77740          OCT       77740           LETTERS (OCT 37)                     1070310
00236 00456          PZE       BCONTD          BRANCH NOT EQUAL TO ERROR            1070320
00237 27173  BCOV10  WI   DL   $RET            READ A CHAR                          1070330
00240 75173          LA   DL   $RET            LOAD REG A WITH THE CHAR             1070340
00241 20426          BR   IM   EQ              =                                    1070350
00242 77755          OCT       77755           D=OCT 22                             1070360
00243 00251          PZE       BCOV11                                               1070370
00244 20426          BR   IM   EQ                                                   1070380
00245 77753          OCT       77753           IF S BRANCH                          1070390
00246 00426          PZE       BCOV27          END                                  1070400
00247 20020          BR   DM   UN                                                   1070410
00250 00456          PZE       BCONTD          BRANCH NOT EQUAL TO ERROR            1070420
00251 27173  BCOV11  WI   DL   $RET            READ A CHAR                          1070430
00252 75173          LA   DL   $RET            LOADA A REG WITH THE CHAR            1070440
```

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00253  20427          BR   IM    NQ                                                    1070450
00254  77754          OCT        77754          B= (OCT 23)                            1070460
00255  00456          PZE        BCONTD         BRANCH NOT EQUAL TO ERROR              1070470
00256  27400  BCOV12  WI   IM    NO             READ CHECK SUM INDICATOR               1070480
00257  00371          PZE        BCOV30+1                                              1070490
00260  27173          WI   DL    $RET           FIGS                                   1070500
00261  27173          WI   DL    $RET           FIRST CHAR. OF NO. OF WORDS ON CARD    1070510
00262  75173          LA   DL    $RET                                                  1070520
00263  20426          BR   IM    EQ                                                    1070530
00264  77774          OCT        77774          IS IT=9                                1070540
00265  00213          PZE        BCOV5                                                 1070550
00266  67015          CC   DM    LA             LOAD RETURN ADDRESS                    1070560
00267  00274          PZE        BCOV13                                                1070570
00270  50400          SA   IM    NO             STORE RETURN ADDRESS                   1070580
00271  00455          PZE        BCONTC+2                                              1070590
00272  20020          BR   DM    UN             PERFORM TABLE LOOK UP ON CHAR          1070600
00273  00437          PZE        BCONTB                                                1070610
00274  11023  BCOV13  SO   DM S  L3                                                   1070620
00275  50407          SA   IM    CC                                                    1070630
00276  00307          PZE        BCOV14+1       XXX000=(AL)                            1070640
00277  27173          WI   DL    $RET           READ NEW CHAR                          1070650
00300  75000          LA   DM    NO                                                    1070660
00301  00306          PZE        BCOV14                                                1070670
00302  50400          SA   IM    NO             SET EXIT                               1070680
00303  00455          PZE        BCONTC+2                                              1070690
00304  20020          BR   DM    UN                                                    1070700
00305  00437          PZE        BCONTB                                                1070710
00306  73000  BCOV14  AS   DM    NO                                                    1070720
00307  00000          OCT        0                                                     1070730
00310  67013          CC   DM    AS                                                    1070740
00311  00001          OCT        1                                                     1070750
00312  50400          SA   IM    NO             NR OF WORDS/CARD COMPLEMENTED          1070760
00313  00526          PZE        BCONZ                                                 1070770
00314  44400          ZE   IM    NO             44400                                  1070780
00315  00540          PZE        BCONY                                                 1070790
00316  47407  BCOV15  RP   IM    CC                                                    1070800
00317  00537          PZE        BCONZ1                                                1070810
00320  75162  BCOV16  LA   DL    $AL                                                   1070820
00321  50400          SA   IM    NO                                                    1070830
00322  00335          PZE        BCOV19                                                1070840
00323  73400          AS   IM    NO                                                    1070850
00324  00540          PZE        BCONY                                                 1070860
00325  50400          SA   IM    NO                                                    1070870
00326  00540          PZE        BCONY                                                 1070880
00327  27173  BCOV17  WI   DL    $RET           SPACE                                  1070890
```

```
00330  27173          WI   DL   $RET      FIGS                                1070900
00331  47407          RP   IM   CC                                            1070910
00332  00537          PZE       BCONZ1                                       1070920
00333  75162  BCOV18  LA   DL   $AL       LOAD CONVERTED WORD                 1070930
00334  50400          SA   IM   NO       STORE                               1070940
00335  00000  BCOV19  PZE       0                                            1070950
00336  52400          SE   IM   NO                                            1070960
00337  00335          PZE       BCOV19     INCREMENTED ADDRESS               1070970
00340  73400          AS   IM   NO       ADD TO CHECK SUM                    1070980
00341  00540          PZE       BCONY                                        1070990
00342  50400          SA   IM   NO       STORE AT CHECK SUM LOCATION         1071000
00343  00540          PZE       BCONY                                        1071010
00344  20032  BCOV20  BR   DM   CY       CHECK CARRY                         1071020
00345  00360          PZE       BCOV22     YES, END-AROUND-CARRY             1071030
00346  75400  BCOV21  LA   IM   NO       NO, COUNT NR WDS/CARD               1071040
00347  00526          PZE       BCONZ                                        1071050
00350  73000          AS   DM   NO                                            1071060
00351  00001          OCT       1                                            1071070
00352  20024          BR   DM   AZ       IS IT THE LAST WD ON CARD           1071080
00353  00370          PZE       BCOV30     YES                               1071090
00354  50400          SA   IM   NO       NO, STORE NR BACK                   1071100
00355  00526          PZE       BCONZ                                        1071110
00356  20020          BR   DM   UN                                            1071120
00357  00327          PZE       BCOV17                                       1071130
00360  75400  BCOV22  LA   IM   NO       ADD 1 TO CHECK SUM                  1071140
00361  00540          PZE       BCONY                                        1071150
00362  73000          AS   DM   NO                                            1071160
00363  00001          OCT       1                                            1071170
00364  50400          SA   IM   NO       STORE CHECK SUM                     1071180
00365  00540          PZE       BCONY                                        1071190
00366  20020          BR   DM   UN       RETURN TO LOOP                      1071200
00367  00346          PZE       BCOV21                                       1071210
00370  67015  BCOV30  CC   DM   LA       PERFORM CHECK SUM OR NOT            1071220
00371  00000          PZE       0                                            1071230
00372  20427          BR   IM   NQ                                            1071240
00373  77773          OCT       77773      (04=SPACE)                        1071250
00374  00213          PZE       BCOV5      NO                                1071260
00375  27173  BCOV35  WI   DL   $RET      READ A CHAR                         1071270
00376  75173          LA   DL   $RET      LOAD A REG WITH THE CHAR            1071280
00377  20427          BR   IM   NQ                                            1071290
00400  77744          OCT       77744       IS IT FIGS                       1071300
00401  00375          PZE       BCOV35                                       1071310
00402  47407  BCOV23  RP   IM   CC                                            1071320
00403  00537          PZE       BCONZ1                                       1071330
00404  75407  BCOV24  LA   IM   CC       COMPLEMENT CHECK SUM                1071340
```

```
00405  00540          PZE        BCONY                                                    1071350
00406  50400          SA   IM    NO                                                       1071360
00407  00412          PZE        BCOV25                                                   1071370
00410  75162          LA   DL    $AL          CHECK SUMS=                                 1071380
00411  20426          BR   IM    EQ                                                       1071390
00412  00000  BCOV25   PZE        0            CHECK SUM THIS PROGRAM OBTAINED (COMP)      1071400
00413  00220          PZE        BCOV7        YES, JUMP TO READ NEXT CARD                 1071410
00414  21010  BCOV26   EF   DM    8            ILLEGAL CHECK SUM                           1071420
00415  40000          OCT        40000                                                    1071430
00416  75400          LA   IM    NO                                                       1071440
00417  00335          PZE        BCOV19       NEXT ADDRESS FOR STORAGE                    1071450
00420  20060          BR   DM F  UN                                                       1071460
00421  00422          PZE        *+1                                                      1071470
00422  21010          EF   DM    8                                                        1071480
00423  40001          OCT        40001                                                    1071490
00424  20020          BR   DM    UN                                                       1071500
00425  00220          PZE        BCOV7                                                    1071510
00426  27173  BCOV27   WI   DL    $RET                                                     1071520
00427  75173          LA   DL    $RET         LOAD A REG WITH THE CHAR                    1071530
00430  20427          BR   IM    NQ                                                       1071540
00431  77744          OCT        77744        =FIGS                                       1071550
00432  00426          PZE        BCOV27       NO                                          1071560
00433  47407  BCOV28   RP   IM    CC                                                       1071570
00434  00537          PZE        BCONZ1                                                   1071580
00435  20020  BCOV29   BR   DM    UN                                                       1071590
00436  00541          PZE        BCOV36                                                   1071600
00437  20031  BCONTB   BR   DM    OV           TURN OFF OVFLO                              1071610
00440  00441          PZE        *+1                                                      1071620
00441  75173          LA   DL    $RET         LOAD A WITH SEARCH WORD (03)                1071630
00442  67064          CC   DM B  AT           (T)=$RET (OCT 03) 77742                     1071640
00443  75007          LA   DM    CC           LOAD P WITH LAST ADDRESS AND COMPLEMENT IT  1071650
00444  00540          PZE        BTABL+9      (P)=BTABL+9                                 1071660
00445  66015          AP   DM    LA           LOAD A WITH ADDRESS OF FIRST ENTRY IN TABLE 1071670
00446  00527          PZE        BTABL        (A)=BTABL                                   1071680
00447  36606          TB   IP    EQ           DO TABLE SEARCH                             1071690
00450  20031          BR   DM    OV           CHECK WHETHER EQUALITY FOUND OR NOT         1071700
00451  00456          PZE        BCONTD                                                   1071710
00452  73000          AS   DM    NO                                                       1071720
00453  77250  BCONTC   NAD        BTABL+1                                                  1071730
00454  20020          BR   DM    UN                                                       1071740
00455  00000          PZE        0            EXIT (PRESET)                               1071750
00456  21010  BCONTD   EF   DM    8            ILLEGAL CHARA                               1071760
00457  40000          OCT        40000                                                    1071770
00460  75000          LA   DM    NO                                                       1071780
00461  00476          PZE        BCOVW                                                    1071790
```

```
00462  50400          SA   IM    NO                                                    1071800
00463  00537          PZE        BCONZ1                                                1071810
00464  75400          LA   IM    NO                                                    1071820
00465  00335          PZE        BCOV19                                                1071830
00466  20060          BR   DM F  UN                                                    1071840
00467  00470          PZE        *+1                                                   1071850
00470  21010          EF   DM    8                                                     1071860
00471  40001          OCT        40001                                                 1071870
00472  20020          BR   DM    UN                                                    1071880
00473  00213          PZE        BCOV5                                                 1071890
00474  47407          RP   IM    CC                                                    1071900
00475  00537          PZE        BCONZ1                                                1071910
00476  44162  BCOVW   ZE   DL    $AL        READ AND CONVERT, PACK A WORD              1071920
00477  75000          LA   DM    NO         LOAD NR TIMES TO SHIFT                     1071930
00500  77773          OCT        77773      (4)                                        1071940
00501  50170          SA   DL    56         50170                                      1071950
00502  27173  BCOVW1  WI   DL    $RET       READ A CHAR                                1071960
00503  67015          CC   DM    LA                                                    1071970
00504  00511          PZE        BCOVW2     LOAD RETURN ADDRESS                        1071980
00505  50400          SA   IM    NO                                                    1071990
00506  00455          PZE        BCONTC+2   STORE RETURN ADDRESS                       1072000
00507  20020          BR   DM    UN                                                    1072010
00510  00437          PZE        BCONTB     JUMP TO TABLE LOOK-UP                      1072020
00511  73162  BCOVW2  AS   DL    $AL                                                   1072030
00512  50162          SA   DL    $AL                                                   1072040
00513  75170          LA   DL    56         75170                                      1072050
00514  73000          AS   DM    NO         73000                                      1072060
00515  00001          OCT        1          00001                                      1072070
00516  50170          SA   DL    56         50170                                      1072080
00517  20024          BR   DM    AZ         IS WORD PACKED FULL                        1072090
00520  00474  BCOVW3  PZE        BCOVW-2                                               1072100
00521  75162          LA   DL    $AL        NO                                         1072110
00522  11023          SO   DM S  L3         SHIFT LEFT 3 PLACES                        1072120
00523  50162          SA   DL    $AL                                                   1072130
00524  20020          BR   DM    UN                                                    1072140
00525  00502          PZE        BCOVW1                                                1072150
00526  00000  BCONZ   PZE        0          NR WDS PER CARD                            1072160
00527  00015  BTABL   OCT        15         0                                          1072170
00530  00035          OCT        35         1                                          1072180
00531  00031          OCT        31         2                                          1072190
00532  00020          OCT        20         3                                          1072200
00533  00012          OCT        12         4                                          1072210
00534  00001          OCT        01         5                                          1072220
00535  00025          OCT        25         6                                          1072230
00536  00034          OCT        34         7                                          1072240
```

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00537  00476   BCONZ1  PZE          BCOVW                                  1072250
00540  00000   BCONY   OCT          0          CHECK SUM ADDRESS           1072260
00541  75162   BCOV36  LA     DL    $AL                                    1072270
00542  50400           SA     IM    NO                                     1072280
00543  00547           PZE          BCOV40                                 1072290
00544  21010           EF     DM    8                                      1072300
00545  40000           OCT          40000                                  1072310
00546  20060   BCOV39  BR     DM F  UN                                     1072320
00547  00000   BCOV40  PZE          0                                      1072330
00550  00200           END          128                                    1072340
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        17055           ORG         7725                                        1060010
17055   75000   BCOV    LA    DM C  NO          INHIBIT INTERRUPT TYPE 2        1060020
17056   17061           PZE         BCOV1                                       1060030
17057   50101           SA    DL    $MIB                                        1060040
17060   00500           IT    IL    0                                           1060050
17061   67015   BCOV1   CC    DM    LA                                          1060060
17062   17065           PZE         BCOV2                                       1060070
17063   50107           SA    DL    07                                          1060080
17064   00506           IT    IL    06                                          1060090
17065   25110   BCOV2   CF    DL    8             CHANNEL SELECT                1060100
17066   21010           EF    DM    8             TIE COMMAND                   1060110
17067   40001           OCT         40001       PAPER TAPE CONNECT              1060120
17070   27173   BCOV5   WI    DL    $RET        READ A CHAR                     1060130
17071   75173           LA    DL    $RET        LOA REG A WITH A CHAR           1060140
17072   20427           BR    IM    NQ          =                               1060150
17073   77775           OCT         77775       CARRIAGE RETURN (OCT 02)        1060160
17074   17070           PZE         BCOV5                                       1060170
17075   27173   BCOV7   WI    DL    $RET        READ A CHAR                     1060180
17076   75173           LA    DL    $RET        LOAD CHAR INTO REG A            1060190
17077   20427           BR    IM    NQ          =                               1060200
17100   77744           OCT         77744       FIGS (OCT 33)                   1060210
17101   17075           PZE         BCOV7       NO                              1060220
17102   27173   BCOV8   WI    DL    $RET        READ A CHAR                     1060230
17103   75173           LA    DL    $RET        LOA A CHAR INTO REG A           1060240
17104   20427           BR    IM    NQ          NOT=                            1060250
17105   77742           OCT         77742       Q ,OCT 35 .                     1060260
17106   17333           PZE         BCONTD      BRANCH NOT EQUAL TO ERROR       1060270
17107   27173   BCOV9   WI    DL    $RET        READ A CHAR                     1060280
17110   75173           LA    DL    $RET        LOA A REG WITH THE CHAR         1060290
17111   20427           BR    IM    NQ          =                               1060300
17112   77740           OCT         77740       LETTERS (OCT 37)                1060310
17113   17333           PZE         BCONTD      BRANCH NOT EQUAL TO ERROR       1060320
17114   27173   BCOV10  WI    DL    $RET        READ A CHAR                     1060330
17115   75173           LA    DL    $RET        LOAD REG A WITH THE CHAR        1060340
17116   20426           BR    IM    EQ          =                               1060350
17117   77755           OCT         77755       D=OCT 22                        1060360
17120   17126           PZE         BCOV11                                      1060370
17121   20426           BR    IM    EQ                                          1060380
17122   77753           OCT         77753       IF S BRANCH                     1060390
17123   17303           PZE         BCOV27      END                             1060400
17124   20020           BR    DM    UN                                          1060410
17125   17333           PZE         BCONTD      BRANCH NOT EQUAL TO ERROR       1060420
17126   27173   BCOV11  WI    DL    $RET        READ A CHAR                     1060430
17127   75173           LA    DL    $RET        LOADA A REG WITH THE CHAR       1060440
17130   20427           BR    IM    NQ                                          1060450
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17131  77754          OCT        77754          B= (OCT 23)                                  1060460
17132  17333          PZE        BCONTD         BRANCH NOT EQUAL TO ERROR                    1060470
17133  27400  BCOV12  WI   IM     NO             READ CHECK SUM INDICATOR                     1060480
17134  17246          PZE        BCOV30+1                                                    1060490
17135  27173          WI   DL     $RET           FIGS                                         1060500
17136  27173          WI   DL     $RET           FIRST CHAR. OF NO. OF WORDS ON CARD          1060510
17137  75173          LA   DL     $RET                                                        1060520
17140  20426          BR   IM     EQ                                                          1060530
17141  77774          OCT        77774          IS IT=9                                      1060540
17142  17070          PZE        BCOV5                                                       1060550
17143  67015          CC   DM     LA             LOAD RETURN ADDRESS                          1060560
17144  17151          PZE        BCOV13                                                      1060570
17145  50400          SA   IM     NO             STORE RETURN ADDRESS                         1060580
17146  17332          PZE        BCONTC+2                                                    1060590
17147  20020          BR   DM     UN             PERFORM TABLE LOOK UP ON CHAR                1060600
17150  17314          PZE        BCONTB                                                      1060610
17151  11023  BCOV13  SO   DM S   L3                                                         1060620
17152  50407          SA   IM     CC                                                          1060630
17153  17164          PZE        BCOV14+1       XXX000=(AL)                                  1060640
17154  27173          WI   DL     $RET           READ NEW CHAR                                1060650
17155  75000          LA   DM     NO                                                          1060660
17156  17163          PZE        BCOV14                                                      1060670
17157  50400          SA   IM     NO             SET EXIT                                     1060680
17160  17332          PZE        BCONTC+2                                                    1060690
17161  20020          BR   DM     UN                                                          1060700
17162  17314          PZE        BCONTB                                                      1060710
17163  73000  BCOV14  AS   DM     NO                                                          1060720
17164  00000          OCT        0                                                           1060730
17165  67013          CC   DM     AS                                                          1060740
17166  00001          OCT        1                                                           1060750
17167  50400          SA   IM     NO             NR OF WORDS/CARD COMPLEMENTED                1060760
17170  17403          PZE        BCONZ                                                       1060770
17171  44400          ZE   IM     NO             44400                                        1060780
17172  17415          PZE        BCONY                                                       1060790
17173  47407  BCOV15  RP   IM     CC                                                          1060800
17174  17414          PZE        BCONZ1                                                      1060810
17175  75162  BCOV16  LA   DL     $AL                                                         1060820
17176  50400          SA   IM     NO                                                          1060830
17177  17212          PZE        BCOV19                                                      1060840
17200  73400          AS   IM     NO                                                          1060850
17201  17415          PZE        BCONY                                                       1060860
17202  50400          SA   IM     NO                                                          1060870
17203  17415          PZE        BCONY                                                       1060880
17204  27173  BCOV17  WI   DL     $RET           SPACE                                        1060890
17205  27173          WI   DL     $RET           FIGS                                         1060900
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17206  47407          RP   IM   CC                                          1060910
17207  17414          PZE       BCONZ1                                      1060920
17210  75162  BCOV18  LA   DL   $AL        LOAD CONVERTED WORD               1060930
17211  50400          SA   IM   NO        STORE                             1060940
17212  00000  BCOV19  PZE       0                                           1060950
17213  52400          SE   IM   NO                                          1060960
17214  17212          PZE       BCOV19     INCREMENTED ADDRESS              1060970
17215  73400          AS   IM   NO        ADD TO CHECK SUM                  1060980
17216  17415          PZE       BCONY                                       1060990
17217  50400          SA   IM   NO        STORE AT CHECK SUM LOCATION       1061000
17220  17415          PZE       BCONY                                       1061010
17221  20032  BCOV20  BR   DM   CY        CHECK CARRY                       1061020
17222  17235          PZE       BCOV22     YES, END-AROUND-CARRY            1061030
17223  75400  BCOV21  LA   IM   NO        NO, COUNT NR WDS/CARD             1061040
17224  17403          PZE       BCONZ                                       1061050
17225  73000          AS   DM   NO                                          1061060
17226  00001          OCT       1                                           1061070
17227  20024          BR   DM   AZ        IS IT THE LAST WD ON CARD         1061080
17230  17245          PZE       BCOV30     YES                              1061090
17231  50400          SA   IM   NO        NO, STORE NR BACK                 1061100
17232  17403          PZE       BCONZ                                       1061110
17233  20020          BR   DM   UN                                          1061120
17234  17204          PZE       BCOV17                                      1061130
17235  75400  BCOV22  LA   IM   NO        ADD 1 TO CHECK SUM                1061140
17236  17415          PZE       BCONY                                       1061150
17237  73000          AS   DM   NO                                          1061160
17240  00001          OCT       1                                           1061170
17241  50400          SA   IM   NO        STORE CHECK SUM                   1061180
17242  17415          PZE       BCONY                                       1061190
17243  20020          BR   DM   UN        RETURN TO LOOP                    1061200
17244  17223          PZE       BCOV21                                      1061210
17245  67015  BCOV30  CC   DM   LA        PERFORM CHECK SUM OR NOT          1061220
17246  00000          PZE       0                                           1061230
17247  20427          BR   IM   NQ                                          1061240
17250  77773          OCT       77773     (04=SPACE)                        1061250
17251  17070          PZE       BCOV5      NO                               1061260
17252  27173  BCOV35  WI   DL   $RET       READ A CHAR                       1061270
17253  75173          LA   DL   $RET       LOAD A REG WITH THE CHAR          1061280
17254  20427          BR   IM   NQ                                          1061290
17255  77744          OCT       77744      IS IT FIGS                       1061300
17256  17252          PZE       BCOV35                                      1061310
17257  47407  BCOV23  RP   IM   CC                                          1061320
17260  17414          PZE       BCONZ1                                      1061330
17261  75407  BCOV24  LA   IM   CC        COMPLEMENT CHECK SUM              1061340
17262  17415          PZE       BCONY                                       1061350
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17263  50400          SA   IM    NO                                                    1061360
17264  17267          PZE        BCOV25                                                1061370
17265  75162          LA   DL    $AL          CHECK SUMS=                              1061380
17266  20426          BR   IM    EQ                                                    1061390
17267  00000  BCOV25  PZE        0            CHECK SUM THIS PROGRAM OBTAINED (COMP)   1061400
17270  17075          PZE        BCOV7        YES, JUMP TO READ NEXT CARD              1061410
17271  21010  BCOV26  EF   DM    8            ILLEGAL CHECK SUM                        1061420
17272  40000          OCT        40000                                                 1061430
17273  75400          LA   IM    NO                                                    1061440
17274  17212          PZE        BCOV19       NEXT ADDRESS FOR STORAGE                 1061450
17275  20060          BR   DM F  UN                                                    1061460
17276  17277          PZE        *+1                                                   1061470
17277  21010          EF   DM    8                                                     1061480
17300  40001          OCT        40001                                                 1061490
17301  20020          BR   DM    UN                                                    1061500
17302  17075          PZE        BCOV7                                                 1061510
17303  27173  BCOV27  WI   DL    $RET                                                  1061520
17304  75173          LA   DL    $RET         LOAD A REG WITH THE CHAR                 1061530
17305  20427          BR   IM    NQ                                                    1061540
17306  77744          OCT        77744        =FIGS                                    1061550
17307  17303          PZE        BCOV27       NO                                       1061560
17310  47407  BCOV28  RP   IM    CC                                                    1061570
17311  17414          PZE        BCONZ1                                                1061580
17312  20020  BCOV29  BR   DM    UN                                                    1061590
17313  17416          PZE        BCOV36                                                1061600
17314  20031  BCONTB  BR   DM    OV           TURN OFF OVFLO                           1061610
17315  17316          PZE        *+1                                                   1061620
17316  75173          LA   DL    $RET         LOAD A WITH SEARCH WORD (03)             1061630
17317  67064          CC   DM B  AT           (T)=$RET (OCT 03) 77742                  1061640
17320  75007          LA   DM    CC           LOAD P WITH LAST ADDRESS AND COMPLEMENT IT 1061650
17321  17415          PZE        BTABL+9      (P)=BTABL+9                              1061660
17322  66015          AP   DM    LA           LOAD A WITH ADDRESS OF FIRST ENTRY IN TABLE 1061670
17323  17404          PZE        BTABL        (A)=BTABL                                1061680
17324  36606          TB   IP    EQ           DO TABLE SEARCH                          1061690
17325  20031          BR   DM    OV           CHECK WHETHER EQUALITY FOUND OR NOT      1061700
17326  17333          PZE        BCONTD                                                1061710
17327  73000          AS   DM    NO                                                    1061720
17330  60373  BCONTC  NAD        BTABL+1                                               1061730
17331  20020          BR   DM    UN                                                    1061740
17332  00000          PZE        0            EXIT (PRESET)                            1061750
17333  21010  BCONTD  EF   DM    8            ILLEGAL CHARA                            1061760
17334  40000          OCT        40000                                                 1061770
17335  75000          LA   DM    NO                                                    1061780
17336  17353          PZE        BCOVW                                                 1061790
17337  50400          SA   IM    NO                                                    1061800
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17340  17414          PZE          BCONZ1                                                    1061810
17341  75400          LA    IM     NO                                                        1061820
17342  17212          PZE          BCOV19                                                    1061830
17343  20060          BR    DM F   UN                                                       1061840
17344  17345          PZE          *+1                                                       1061850
17345  21010          EF    DM     8                                                         1061860
17346  40001          OCT          40001                                                     1061870
17347  20020          BR    DM     UN                                                        1061880
17350  17070          PZE          BCOV5                                                     1061890
17351  47407          RP    IM     CC                                                        1061900
17352  17414          PZE          BCONZ1                                                    1061910
17353  44162  BCOVW   ZE    DL     $AL          READ AND CONVERT, PACK A WORD                1061920
17354  75000          LA    DM     NO           LOAD NR TIMES TO SHIFT                       1061930
17355  77773          OCT          77773        (4)                                          1061940
17356  50170          SA    DL     56           50170                                        1061950
17357  27173  BCOVW1  WI    DL     $RET         READ A CHAR                                  1061960
17360  67015          CC    DM     LA                                                        1061970
17361  17366          PZE          BCOVW2       LOAD RETURN ADDRESS                          1061980
17362  50400          SA    IM     NO                                                        1061990
17363  17332          PZE          BCONTC+2     STORE RETURN ADDRESS                         1062000
17364  20020          BR    DM     UN                                                        1062010
17365  17314          PZE          BCONTB       JUMP TO TABLE LOOK-UP                        1062020
17366  73162  BCOVW2  AS    DL     $AL                                                       1062030
17367  50162          SA    DL     $AL                                                       1062040
17370  75170          LA    DL     56           75170                                        1062050
17371  73000          AS    DM     NO           73000                                        1062060
17372  00001          OCT          1            00001                                        1062070
17373  50170          SA    DL     56           50170                                        1062080
17374  20024          BR    DM     AZ           IS WORD PACKED FULL                          1062090
17375  17351  BCOVW3  PZE          BCOVW-2                                                   1062100
17376  75162          LA    DL     $AL          NO                                           1062110
17377  11023          SO    DM S   L3           SHIFT LEFT 3 PLACES                          1062120
17400  50162          SA    DL     $AL                                                       1062130
17401  20020          BR    DM     UN                                                        1062140
17402  17357          PZE          BCOVW1                                                    1062150
17403  00000  BCONZ   PZE          0            NR WDS PER CARD                              1062160
17404  00015  BTABL   OCT          15           0                                            1062170
17405  00035          OCT          35           1                                            1062180
17406  00031          OCT          31           2                                            1062190
17407  00020          OCT          20           3                                            1062200
17410  00012          OCT          12           4                                            1062210
17411  00001          OCT          01           5                                            1062220
17412  00025          OCT          25           6                                            1062230
17413  00034          OCT          34           7                                            1062240
17414  17353  BCONZ1  PZE          BCOVW                                                     1062250
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17415  00000  BCONY   OCT        0                CHECK SUM ADDRESS      1062260
17416  75162  BCOV36  LA   DL    $AL                                     1062270
17417  50400          SA   IM    NO                                      1062280
17420  17424          PZE        BCOV40                                  1062290
17421  21010          EF   DM    8                                       1062300
17422  40000          OCT        40000                                   1062310
17423  20060  BCOV39  BR   DM F  UN                                      1062320
17424  00000  BCOV40  PZE        0                                       1062330
17425  17055          END        7725                                    1062340
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APPENDIX III
8-LEVEL LOADER

```
        00200           ORG     128                                             0890010
00200   75000   HEHL    LA      DM C    NO      INHIBIT                         0890020
00201   00204           PZE             *+3     ALL                             0890030
00202   50101           SA      DL      $MIB    INPUT                           0890040
00203   00500           IT      IL      $MIA    INTERRUPTS                      0890050
00204   67015           CC      DM      LA      AND                             0890060
00205   00210           PZE             *+3     CLEAR                           0890070
00206   50107           SA      DL      $ICB    CARRY.                          0890080
00207   00506           IT      IL      $ICA                                    0890090
00210   25110   HEHL1   CF      DL      8       TIE CHANNEL C                   0890100
00211   21010           EF      DM      8       AND                             0890110
00212   40001           OCT             40001   READER                          0890120
00213   44161           ZE      DL      $AE     0 TO SUM CHECK.                 0890130
00214   27162           WI      DL      $AL     GET NEXT                        0890140
00215   44062           ZE      DM B    LP      CHARACTER.                      0890150
00216   75162           LA      DL      $AL     BITS 8,7,6 IN A                 0890160
00217   11045           SO      DM D    R5      AND 5-1 IN P.                   0890170
00220   20426           BR      IM      EQ      WAIT FOR                        0890180
00221   77773           OCT             77773   ADDRESS                         0890190
00222   00234           PZE             HEHL3                                   0890200
00223   20427   HEHL5   BR      IM      NQ                                      0890210
00224   77772           OCT             77772                                   0890220
00225   00214           PZE             HEHL1+4                                 0890230
00226   20020           BR      DM      UN                                      0890240
00227   00234           PZE             HEHL3                                   0890250
00230   27162   HEHL2   WI      DL      $AL     GET NEXT                        0890260
00231   44062           ZE      DM B    LP      CHARACTER.                      0890270
00232   75162           LA      DL      $AL     BITS 8,7,6 IN A                 0890280
00233   11045           SO      DM D    R5      AND 5-1 IN P.                   0890290
00234   50163   HEHL3   SA      DL      $AR                                     0890300
00235   42164           SP      DL      $AT                                     0890310
00236   20426           BR      IM      EQ      IS IT                           0890320
00237   77770           OCT             77770   7-CODE DELETE                   0890330
00240   00230           PZE             HEHL2                                   0890340
00241   27162           WI      DL      $AL     GET NEXT                        0890350
00242   44062           ZE      DM B    LP      CHARACTER.                      0890360
00243   75162           LA      DL      $AL     BITS 8,7,6 IN A                 0890370
00244   11045           SO      DM D    R5      AND 5-1 IN P.                   0890380
00245   73163           AS      DL      $AR     ASSEMBLED WORD IS               0890390
00246   50163           SA      DL      $AR     STORED                          0890400
00247   66060           AP      DM B    NO      IN                              0890410
00250   11005           SO      DM S    R5      $AT                             0890420
00251   73164           AS      DL      $AT                                     0890430
00252   50164           SA      DL      $AT                                     0890440
00253   27162           WI      DL      $AL     GET NEXT                        0890450
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00254  44062          ZE   DM B  LP      CHARACTER.                    0890460
00255  75162          LA   DL    $AL     BITS 8,7,6 IN A              0890470
00256  11045          SO   DM D  R5      AND 5-1 IN P.                0890480
00257  73163          AS   DL    $AR     SUM OF CONTROL BUTS          0890490
00260  66060          AP   DM B  NO      IN P.                        0890500
00261  11012          SO   DM S  R10                                  0890510
00262  73164          AS   DL    $AT                                  0890520
00263  50164          SA   DL    $AT                                  0890530
00264  63161          AL   DL    $AE     SUM                          0890540
00265  61000          AI   DM    NO      CHECK                        0890550
00266  00000          OCT        0       IN                           0890560
00267  67067          CC   DM B  CC                                   0890570
00270  50161          SA   DL    $AE     $AE.                         0890580
00271  66060          AP   DM B  NO                                   0890590
00272  20024          BR   DM    AZ                                   0890600
00273  00354          PZE        BCOV    0-TELETYPE.                  0890610
00274  20426          BR   IM    EQ                                   0890620
00275  77771          OCT        77771   6-DATA                       0890630
00276  00316          PZE        HEHL6                                0890640
00277  20426          BR   IM    EQ                                   0890650
00300  77763          OCT        77763   14-LOAD ADDRESS              0890660
00301  00325          PZE        HEHL14                               0890670
00302  20426          BR   IM    EQ                                   0890680
00303  77760          OCT        77760   17-BR ADDRESS.               0890690
00304  00332          PZE        HEHL17                               0890700
00305  20426          BR   IM    EQ                                   0890710
00306  77755          OCT        77755   22-SUM CHECK                 0890720
00307  00341          PZE        HEHL22                               0890730
00310  75400          LA   IM    NO      ERROR, CODE                  0890740
00311  00320          PZE        HEHL4   IN 6,7,8 LEVELS              0890750
00312  21010          EF   DM    8                                    0890760
00313  40000          OCT        40000                                0890770
00314  20060          BR   DM F  UN      INVALID. CONTENT OF          0890780
00315  00210          PZE        HEHL1   A=LOCATION.                  0890790
00316  75164  HEHL6   LA   DL    $AT     DATA, SO                     0890800
00317  50407          SA   IM    CC      STORE IN                     0890810
00320  66666  HEHL4   OCT        66666   STORE ADDRESS LOADED.        0890820
00321  52400          SE   IM    NO      BUMP STORE                   0890830
00322  00320          PZE        *-2     ADDRESS.                     0890840
00323  20020          BR   DM    UN                                   0890850
00324  00230          PZE        HEHL2                                0890860
00325  75164  HEHL14  LA   DL    $AT     LOAD                         0890870
00326  50407          SA   IM    CC      ADDRESS SO                   0890880
00327  00320          PZE        HEHL4   RESET STORE ADDRESS.         0890890
00330  20020          BR   DM    UN                                   0890900
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00331  00230           PZE        HEHL2                                    0890910
00332  75164  HEHL17   LA   DL    $AT          FLAG BRANCH                 0890920
00333  50400           SA   IM    NO           TO                          0890930
00334  00340           PZE        *+4                                      0890940
00335  21010           EF   DM    8                                        0890950
00336  40000           OCT        40000                                    0890960
00337  20060           BR   DM F  UN                                       0890970
00340  66666           OCT        66666        BR ADD LOADED.              0890980
00341  75161  HEHL22   LA   DL    $AE          IS SUM                      0890990
00342  44161           ZE   DL    $AE                                      0891000
00343  20426           BR   IM    EQ           OK                          0891010
00344  77776           OCT        77776                                    0891020
00345  00230           PZE        HEHL2        BR IF YES                   0891030
00346  75400           LA   IM    NO           NO                          0891040
00347  00320           PZE        HEHL4                                    0891050
00350  21010           EF   DM    8                                        0891060
00351  40000           OCT        40000                                    0891070
00352  20060           BR   DM F  UN           STOP.                       0891080
00353  00211           PZE        HEHL1+1                                  0891090
00354  20060  BCOV     BR   DM F  UN                                       0891100
00355  00200           PZE        HEHL                                     0891110
00356  00200           END        HEHL                                     0891120
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        17055           ORG         7725                                        0890010
17055   75000   HEHL    LA    DM C  NO        INHIBIT                           0890020
17056   17061           PZE         *+3       ALL                               0890030
17057   50101           SA    DL    $MIB      INPUT                             0890040
17060   00500           IT    IL    $MIA      INTERRUPTS                        0890050
17061   67015           CC    DM    LA        AND                               0890060
17062   17065           PZE         *+3       CLEAR                             0890070
17063   50107           SA    DL    $ICB      CARRY.                            0890080
17064   00506           IT    IL    $ICA                                        0890090
17065   25110   HEHL1   CF    DL    8         TIE CHANNEL C                     0890100
17066   21010           EF    DM    8         AND                               0890110
17067   40001           OCT         40001     READER                            0890120
17070   44161           ZE    DL    $AE       0 TO SUM CHECK.                   0890130
17071   27162           WI    DL    $AL       GET NEXT                          0890140
17072   44062           ZE    DM B  LP        CHARACTER.                        0890150
17073   75162           LA    DL    $AL       BITS 8,7,6 IN A                   0890160
17074   11045           SO    DM D  R5        AND 5-1 IN P.                     0890170
17075   20426           BR    IM    EQ        WAIT FOR                          0890180
17076   77773           OCT         77773     ADDRESS                           0890190
17077   17111           PZE         HEHL3                                       0890200
17100   20427   HEHL5   BR    IM    NQ                                          0890210
17101   77772           OCT         77772                                       0890220
17102   17071           PZE         HEHL1+4                                     0890230
17103   20020           BR    DM    UN                                          0890240
17104   17111           PZE         HEHL3                                       0890250
17105   27162   HEHL2   WI    DL    $AL       GET NEXT                          0890260
17106   44062           ZE    DM B  LP        CHARACTER.                        0890270
17107   75162           LA    DL    $AL       BITS 8,7,6 IN A                   0890280
17110   11045           SO    DM D  R5        AND 5-1 IN P.                     0890290
17111   50163   HEHL3   SA    DL    $AR                                         0890300
17112   42164           SP    DL    $AT                                         0890310
17113   20426           BR    IM    EQ        IS IT                             0890320
17114   77770           OCT         77770     7-CODE DELETE                     0890330
17115   17105           PZE         HEHL2                                       0890340
17116   27162           WI    DL    $AL       GET NEXT                          0890350
17117   44062           ZE    DM B  LP        CHARACTER.                        0890360
17120   75162           LA    DL    $AL       BITS 8,7,6 IN A                   0890370
17121   11045           SO    DM D  R5        AND 5-1 IN P.                     0890380
17122   73163           AS    DL    $AR       ASSEMBLED WORD IS                 0890390
17123   50163           SA    DL    $AR       STORED                            0890400
17124   66060           AP    DM B  NO        IN                                0890410
17125   11005           SO    DM S  R5        $AT                               0890420
17126   73164           AS    DL    $AT                                         0890430
17127   50164           SA    DL    $AT                                         0890440
17130   27162           WI    DL    $AL       GET NEXT                          0890450
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17131  44062          ZE   DM B  LP      CHARACTER.                    0890460
17132  75162          LA   DL    $AL     BITS 8,7,6 IN A               0890470
17133  11045          SO   DM D  R5      AND 5-1 IN P.                 0890480
17134  73163          AS   DL    $AR     SUM OF CONTROL BUTS           0890490
17135  66060          AP   DM B  NO      IN P.                         0890500
17136  11012          SO   DM S  R10                                    0890510
17137  73164          AS   DL    $AT                                   0890520
17140  50164          SA   DL    $AT                                   0890530
17141  63161          AL   DL    $AE     SUM                           0890540
17142  61000          AI   DM    NO      CHECK                         0890550
17143  00000          OCT        0       IN                            0890560
17144  67067          CC   DM B  CC                                    0890570
17145  50161          SA   DL    $AE     $AE.                          0890580
17146  66060          AP   DM B  NO                                    0890590
17147  20024          BR   DM    AZ                                    0890600
17150  17231          PZE        BCOV    0-TELETYPE.                   0890610
17151  20426          BR   IM    EQ                                    0890620
17152  77771          OCT        77771   6-DATA                        0890630
17153  17173          PZE        HEHL6                                 0890640
17154  20426          BR   IM    EQ                                    0890650
17155  77763          OCT        77763   14-LOAD ADDRESS               0890660
17156  17202          PZE        HEHL14                                0890670
17157  20426          BR   IM    EQ                                    0890680
17160  77760          OCT        77760   17-BR ADDRESS.                0890690
17161  17207          PZE        HEHL17                                0890700
17162  20426          BR   IM    EQ                                    0890710
17163  77755          OCT        77755   22-SUM CHECK                  0890720
17164  17216          PZE        HEHL22                                0890730
17165  75400          LA   IM    NO      ERROR, CODE                   0890740
17166  17175          PZE        HEHL4   IN 6,7,8 LEVELS               0890750
17167  21010          EF   DM    8                                     0890760
17170  40000          OCT        40000                                 0890770
17171  20060          BR   DM F  UN      INVALID. CONTENT OF           0890780
17172  17065          PZE        HEHL1   A=LOCATION.                   0890790
17173  75164  HEHL6   LA   DL    $AT     DATA, SO                      0890800
17174  50407          SA   IM    CC      STORE IN                      0890810
17175  66666  HEHL4   OCT        66666   STORE ADDRESS LOADED.         0890820
17176  52400          SE   IM    NO      BUMP STORE                    0890830
17177  17175          PZE        *-2     ADDRESS.                      0890840
17200  20020          BR   DM    UN                                    0890850
17201  17105          PZE        HEHL2                                 0890860
17202  75164  HEHL14  LA   DL    $AT     LOAD                          0890870
17203  50407          SA   IM    CC      ADDRESS SO                    0890880
17204  17175          PZE        HEHL4   RESET STORE ADDRESS.          0890890
17205  20020          BR   DM    UN                                    0890900
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17206  17105          PZE        HEHL2                                        0890910
17207  75164  HEHL17  LA   DL    $AT          FLAG BRANCH                     0890920
17210  50400          SA   IM    NO           TO                              0890930
17211  17215          PZE        **+4                                         0890940
17212  21010          EF   DM    8                                            0890950
17213  40000          OCT        40000                                        0890960
17214  20060          BR   DM F  UN                                           0890970
17215  66666          OCT        66666        BR ADD LOADED.                  0890980
17216  75161  HEHL22  LA   DL    $AE          IS SUM                          0890990
17217  44161          ZE   DL    $AE                                          0891000
17220  20426          BR   IM    EQ           OK                              0891010
17221  77776          OCT        77776                                        0891020
17222  17105          PZE        HEHL2        BR IF YES                       0891030
17223  75400          LA   IM    NO           NO                              0891040
17224  17175          PZE        HEHL4                                        0891050
17225  21010          EF   DM    8                                            0891060
17226  40000          OCT        40000                                        0891070
17227  20060          BR   DM F  UN           STOP.                           0891080
17230  17066          PZE        HEHL1+1                                      0891090
17231  20060  BCOV    BR   DM F  UN                                           0891100
17232  17055          PZE        HEHL                                         0891110
17233  17055          END        HEHL                                         0891120
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