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LTSS Livermore Time-Sharing System

Part I: OCTOPUS

Chapter 5: CARD READER/CARD PUNCH

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March 12, 1970 Edition - 1

Lawrence Radiation Laboratory
University of California/Livermore

LTSS-5
Edition 1

LIVERMORE TIME SHARING SYSTEM

Part 1: Octopus

Chapter 5: Card Reader/Card Punch

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CIC LTSS-5-Ed.1

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5.1. CDC 405 CARD READER

5.1.1. Hardware Description

The Control Data 405 Card Reader,[1,2] modified by the Control Data 3649 Card Read Controller,[3] is the primary mechanism for transferring information from a deck of punched cards into the CDC 6600 or CDC 7600 computer. The card reader operates at a maximum rate of 1200 cards per minute. The input and output trays will each hold 4000 cards.

Cards are transported, during a read operation, from the input tray past a dual read station to the output tray. Each card is plucked from the input tray by a vacuum mechanism, and moved to the card-transfer channel. A braking mechanism, operated either manually or by the computer, can stop the card at this point and hold it until the computer is ready to proceed. The card is then moved past the read station by sets of pinch rollers.

The read station consists of two columns of photodiodes, twelve per column. The card is read a column at a time by both sets of photodiodes, and the results are compared. If they agree, the information is stored in one of the eighty 12-bit words of the Card Read Controller's memory. If all columns are read correctly, the information is sent to a peripheral processing unit[4] (PPU) of the computer in groups of twelve bits. Here, any required internal conversion takes place, and the result is stored in a disc file. The name of the disc file and the type of conversion are specified by the user.

Operation of the card reader is under the control of the PPU via twelve *function codes*, which act as instructions to the card reader. The PPU is kept continuously informed about the status of the card reader by a set of twelve *status codes*. These codes are summarized in Figure 5.1.

The card data may be sent to the PPU as it appears in the controller memory (absolute binary format) or in a translated BCD format (Figure 5.2.). In the latter case, two 6-bit Hollerith characters are sent per byte. Further conversion (such as BCD to ASCII) may take place within the computer.

A binary card is detected by the presence of a 7-9 punch in column one; if no such punch is detected, the automatic BCD conversion takes place. However, this conversion may be negated by one of the function codes. If an illegal Hollerith character is read, a translation to a six-bit code takes place anyway. It will be impossible to tell, from the BCD code, what the illegal punch was, and there is no hardware indication of the error.

Function Code	Octal
Connect Reader Controller Channel	N000
Release Channel Reservation	0000
Negate Hollerith to BCD Conversion	0001
Perform Hollerith to BCD Conversion	0002
Stack Card in Secondary Output Tray	0004
Clear All Interrupt Conditions	0005
Set Interrupt on Ready and Not Busy	0020
Release Interrupt	0021
Set Interrupt on End of Operation	0022
Release Interrupt	0023
Set Interrupt on Abnormal End of Operation	0024
Release Interrupt	0025

Status Code	Octal
Reader Ready	XXX1
Reader Busy	XXX2
Binary Card in Reader Memory (7-9 punch, col. 1)	XXX4
File Card (7-8 punch, col. 1)	XX1X
Stacker Full, Jam, or Feed Failure	XX2X
Input Tray Empty	XX4X
End of File	X1XX
Interrupt - Ready and Not Busy	X2XX
Interrupt - End of Operation	X4XX
Interrupt - Abnormal End of Operation	1XXX
Read Compare or Pre-Read Error	2XXX
Reader Reserved for the Other Channel	4XXX

Figure 5.1. CDC 405 Function and Status Codes[3]

	0	1	2	3	4	5	6	7
0	0 0	1 1	2 2	3 3	4 4	5 5	6 6	7 7
1	8 8	9 9	2-8	= 3-8	— 4-8	5-8	6-8	7-8
2	+ 12	A 12-1	B 12-2	C 12-3	D 12-4	E 12-5	F 12-6	G 12-7
3	H 12-8	I 12-9	+0 12-0	. 12-3-8	) 12-4-8	12-5-8	12-6-8	12-7-8
4	- 11	J 11-1	K 11-2	L 11-3	M 11-4	N 11-5	O 11-6	P 11-7
5	Q 11-8	R 11-9	-0 11-0	$ 11-3-8	* 11-4-8	11-5-8	11-6-8	11-7-8
6	(blank)	/ 0-1	S 0-2	T 0-3	U 0-4	V 0-5	W 0-6	X 0-7
7	Y 0-8	Z 0-9	0-2-8	, 0-3-8	(0-4-8	0-5-8	0-6-8	0-7-8

Each box defines the BCD code sent to the PPU for the specified characters or column punches. Thus, an "L" (11-3 punch) is sent as "43".

Figure 5.2. BCD/Hollerith Codes[3]

5.1.2. Input Deck Preparation

Each card deck read into the computer by the card reader is transformed into a disc file by the PPU. It is necessary to tell this PPU who you are, what type of disc file to create, how long to make it, and what to call it. This is done by preceding the deck with a *card-reader identification card.* Note that this card serves to identify the deck to the PPU; the card itself is not put in the disc file.

The identification card has the following format:

Col.	1	4-9	11-20	30	40-45	51-80
	ID	XXXXXX	NAME	X	LENGTH	HSP ID

where:

ID are the letters "ID".

XXXXXX is the six-digit user number with which the file is to be associated.

NAME is the name to be given the resulting disc file. NAME may have no more than ten characters, and must be left adjusted in the field.

X specifies the type of file that is to be created.

X = (blank)	for packed ASCII	(section 5.2.1.)
X = M	for Monitor	(section 5.2.2.)
X = S	for Squoze-Monitor	(section 5.2.3.)
X = A	for Absolute Binary	(section 5.2.4.)

LENGTH specifies the file length (octal, left justified). If the file will be less than 50,000 (octal) words long, LENGTH may be left blank. This will accommodate more than 2000 BCD cards.

HSP ID will cause thirty characters of printer identification to be placed at the end of the file in a format suitable for files to be printed.

More than one deck may be read into the computer at one time. The decks must be separated by a *file card*. This is a card with a "∇" punched in column one, and blanks in columns 2-80. The ∇ character is represented by a 7-8 punch on the card.

If a file already exists on disc with this name and user number, and columns 51-60 of the identification card are blank, then the old file will be destroyed and the new file will be created in its place. If, however, columns 51-60 are not all blank, then the old file is preserved, and the new file's name is systematically altered until an unused name is found.

In either case, a file will be created in which to store the card images. It will be 50,000 (octal) words long initially, unless LENGTH is nonblank. After the entire deck has been stored in the file, the file length is cut back to the nearest multiple of 100 (octal) words that exceeds the actual file length, and some identification data is stored in the last four words. Intervening words are filled with left-adjusted ASCII exclamation marks.

The last four words contain information taken from the identification card.

LW-3	Name of file, as given on the identification card in columns 11-20, right justified.
LW-2	Columns 51-60 of the identification card.
LW-1	Columns 61-70 of the identification card.
LW	Columns 71-80 of the identification card.

5.1.3. Operating Instructions

The card reader is operated directly by the computer user (Figure 5.3.), via four of the switches on the control panel.

A. The card deck is loaded into the input tray, facing the reader. That is, column one of the card is at the right as the cards face the read station entrance.

B. Select the computer you wish to use. Most of the card readers are connected to two computers. Select the one you wish to use by pressing the proper half of the "reserve" button.

C. Press the "motor power" button. The light should come on and the machine should start vibrating. No cards will be read, however.

D. Press "ready" button to begin card feeding. The light should come on. This action may have to be repeated several times before being detected by the computer.

E. Cards are now feeding through the card reader. To halt the reader (to add more cards to the input tray or to remove cards from the output tray, for example), press the "pause" button. Card feeding will stop, but the connection to the computer will be maintained intact. Press the "pause" button again to continue card feeding.

F. When all cards have been read, press the "motor power" button again. This will turn the card reader off, and disconnect it from the computer.

The remaining buttons are of little interest to most users. The "main power" button controls all primary power and the photocell light source; it is always left on. The "auto/man" determines whether the reader is reserved

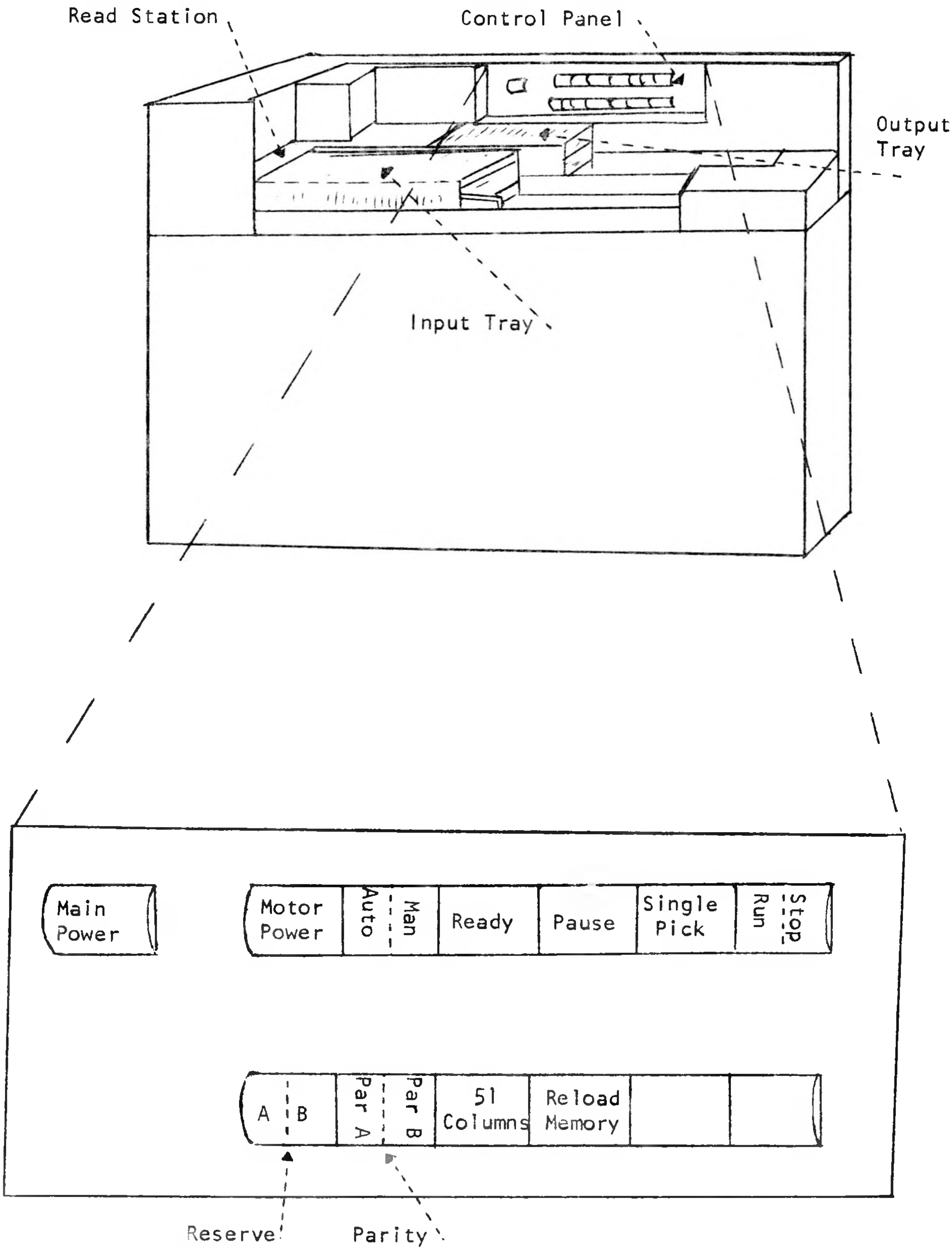


Figure 5.3. CDC 405 Card Reader

for computer use (auto) or manual use (man); it is always left on "auto". The "single pick" button allows a single card to be transported through the reader (no data is read) in the manual mode. The "run/stop" switch controls card processing in manual mode. The "51 column" switch is turned on for short (51-column) cards, which we don't use. The "reload memory" button will feed a card into memory in the automatic mode. The parity light indicates a transmission parity error on one of the two channels.

5.2. CARD READER FILE FORMATS

5.2.1. Packed-ASCII File Format

A *packed ASCII* file is requested by a blank in column 30 of the card reader identification card. This type of file is designed to pack a large number of BCD cards into a few words, by deleting terminal blanks. Binary cards cannot be correctly read into the computer in packed-ASCII format.

Since the cards do not occupy any prespecified number of words each, it is necessary to use a sentinel to signal the end of the information on the card. The exclamation mark (ASCII "01") is used for this purpose; the last word required by the data on the card is filled with exclamation marks. If the data on the card completely fills the last word, then an entire word of exclamation marks is appended.

The data on the card is transferred from the card reader to the computer in the BCD code given in Figure 5.2. It is translated by the computer into ASCII (Figure 5.4.) before being stored in the disc file. Thus, the user may ignore the intermediate step, and think of the process as translating data from holes in cards to ASCII characters in a disc file.

	0	1	2	3	4	5	6	7
0	(blank)	! or ∇ 7-8	" or Δ 11-7-8	# 2-8	$ 11-3-8	% or π 12-2-8	& 11-2-8	' or ∿ 4-8
1	(0-4-8	) 12-4-8	* 11-4-8	+ 12	, 0-3-8	— 11	. 12-3-8	/ 0-1
2	0 0	1 1	2 2	3 3	4 4	5 5	6 6	7 7
3	8 8	9 9	: 0-2-8	; 11-6-8	< 0-5-8	= 3-8	> 11-5-8	? or α 0-7-8
4	@ or ¬ 0-6-8	A 12-1	B 12-2	C 12-3	D 12-4	E 12-5	F 12-6	G 12-7
5	H 12-8	I 12-9	J 11-1	K 11-2	L 11-3	M 11-4	N 11-5	O 11-6
6	P 11-7	Q 11-8	R 11-9	S 0-2	T 0-3	U 0-4	V 0-5	W 0-6
7	X 0-7	Y 0-8	Z 0-9	[6-8	\ or | 12-6-8	] 5-8	↑ or ∧ 12-7-8	← or → 12-5-8

Each box defines the ASCII code stored in the disc file for the specified characters and column punches. Thus, an "L" (11-3 punch) is stored as "54".

Figure 5.4. ASCII Characters

Let us investigate a specific example of a packed ASCII file. The card deck contains ten cards, preceded by a card-reader identification card

ID 123456 DECKA BOX A-11 HSP IDENTIFICATION

After the cards have been processed, a 100 (octal) word file named *DECKA* will exist on the disc, with the contents indicated in Figure 5.5.

In the example, the first card is punched in columns 1-35; hence, four words are required (000-003). Cards 3 and 6-9 are blank, and require only one word each. Card 4 is punched through column 80, and therefore requires nine words (010-020). All words between the end of the tenth card and the beginning of the final identification block are filled with left-justified exclamation marks (words 035-073). The identification occupies the final four words.

These ten cards occupy 29 words, giving a packing ratio of 29/80 = 36%. In general, a deck of N cards will occupy at least N words (if all cards are blank) and no more than 9·N words (if all cards are full), leading to packing ratios between 12.5% and 112.5%. Realistic packing ratios appear to run from 40% to 60%. This, in turn, implies that the file length usually need not be specified on the identification card unless the deck contains more than 4000 cards. Since 100 cards occupy about 3/4 inches, this amounts to about 2-1/2 feet of cards.

Card	Loc.	Contents (ASCII)
1	000	THIS_IS_A_SAMPLE_PACKED_ASCII_DECK.!!!!!
2	004	THE_NEXT_CARD_IS_BLANK.!!!!!!!
3	007	_!!!!!!!!!
4	010	_________________THIS_CARD_BEGINS_WITH_B
		LANKS,_AND_RUNS_TO_COLUMN_80.__123456789
		!!!!!!!!!!
5	021	THIS_IS_THE_LAST_OF_FIVE_CARDS.!!!!!!!!!
6	025	_!!!!!!!!!
7	026	_!!!!!!!!!
8	027	_!!!!!!!!!
9	030	_!!!!!!!!!
10	031	THE_PRECEDING_FOUR_CARDS_WERE_BLANK.!!!!
--	035	!_________!_________!_________!_________
	...	...
--	070	!_________!_________!_________!_________
--	074	_____DECKABOX_A-11__HSP_IDENTIFICATION__

The underline (_) is used to indicate a blank.

Figure 5.5. Example of a Packed ASCII File

5.2.2. Monitor-Compatible File Format

A *monitor-compatible* file is requested by an "M" in column 30 of the card-reader identification card. This type of file is designed to be used by Monitor-402[5] users, and will accommodate both BCD and binary cards. The BCD cards are converted to ASCII (Figure 5.4.).

Each card occupies a fixed number of words — eight for BCD cards and sixteen for binary cards. The card-images are separated by one-word sentinels that give the mode of the following card and the number of words occupied by the preceding and the following cards. Special action occurs whenever a card with the characters "*ID" in columns 1-3 is detected. An end-of-file mark† is inserted before the card (if this is not the first card of the input deck) and an ASCII sequence number is placed in columns 76-78. The input file is terminated by an end-of-file mark and a card reading "* END TAPE".

The sentinel word contains three data fields. Field M gives the mode of the next card, with a zero to indicate BCD and a one to indicate binary. Field X gives the length of the preceding record, and field Y gives the length of the following record.

00000 00MXX XXXXY YYYYY

Let us now investigate an example of a monitor-compatible file containing two *ID cards (Figure 5.6.). There are 27 cards in the input deck, and the resulting file is 500 (octal) words long. Word zero indicates that a BCD card is contained in the next eight words — the *ID card. Note the sequence number in word 010. The flag in word 011 indicates that the preceding card

---

†A record of length zero.

required eight words, and the next card is a BCD card and also requires eight words. The fourth card is blank, but it requires eight words anyway.

The first job ends in word 164. The flag in 165 states that the following card is of length zero, and the flag in 166 states that the preceding card was of length zero. This indicates an end-of-file mark. The *ID card for the second job comes next, with a sequence number in word 176.

Two binary cards are stored in words 331-372, as indicated by the flags in 331 and 352. A binary card is stored top to bottom, left to right. (See section 5.7.) The second job ends with an end-of-file (words 373-374), and the input deck is followed by an "END TAPE" card in 375-403. The usual identification comes at the end.

Each BCD card requires 9 words (including the flag), and each binary card requires 17 words. Thus, a deck with n BCD and m binary cards will require at least (9n + 17m) words. Since the drop-out file length is 50,000 (octal) = 20,480 (decimal) words, the file length need not be specified for a BCD deck of 2200 cards (16-1/2 inches) or a binary deck of 1200 cards (9 inches). Mixed decks will be in between these numbers, and are entirely predictable.

Card	Loc.	Contents (octal and ASCII)
flag	000	00000000 000000 000010
1	001	*ID___123ABC___________________________
		________BOX_A-11__HSP_IDEN_________001__
flag	011	00000000 000010 000010
2	012	C_______THIS_IS_A_SAMPLE_MONITOR_FORMAT_
		FILE,_WITH_TWO_MONITOR_PROGRAMS._________
flag	022	00000000 000010 000010
3	023	THE_NEXT_CARD_IS_BLANK.________________
		____
flag	033	00000000 000010 000010
4	034	____
		____
flag	044	00000000 000010 000010
	⋱	⋱
flag	154	00000000 000010 000010
13	155	______END_______________________________
		____
flag	165	00000000 000010 000000
flag	166	00000000 000000 000010
14	167	*ID___123ABC___________________________
		________BOX_A-11__HSP_IDEN_________002__
flag	177	00000000 000010 000010
	⋱	⋱
25	321	______END_______________________________
		____

Figure 5.6. Example of a Monitor-Compatible File

Card	Loc.	Contents (octal and ASCII)
flag	331	00000001 000010 000020
26	332	(binary card)
flag	352	00000001 000020 000020
27	353	(binary card)
flag	373	00000000 000020 000000
flag	374	00000000 000000 000010
----	375	*_____END_TAPE______________________________
		_______________________________________
flag	404	00000000 000010 000000
----	405	!_________!_________!_________!_________
	. . .	. . .
	470	!_________!_________!_________!_________
	474	_____DECKBBOX_A-11__HSP_IDENTIFICATION__

The underline (_) is used to indicate a blank.

Figure 5.6. Example of a Monitor-Compatible File (continued)

5.2.3. Squoze-Monitor File Format

A *squoze-monitor* file is requested by an "S" in column 30 of the card reader identification card. This type of file is similar to the monitor-compatible file, and will accommodate both BCD and binary cards. The BCD cards are converted to ASCII (Figure 5.4.).

Each card occupies a variable number of words, since terminal blanks are suppressed. The card-images are separated by one-word sentinels that give the mode of the following card and the number of words occupied by the preceding and the following cards. Special action occurs whenever a card with the characters "*ID" in columns 1-3 is detected. An end-of-file mark† is inserted before the card (if this is not the first card of the input deck) and an ASCII sequence number is placed in columns 76-78. The input file is terminated by an end-of-file mark and a card reading "* END TAPE".

The sentinel word contains three data fields. Field M gives the mode of the next card, with a zero to indicate BCD and a one to indicate binary. Field X gives the length of the preceding record, and field Y gives the length of the following record.

00000 00MXX XXXXY YYYYY

Let us now investigate an example of a squoze-monitor file containing two jobs identified by *ID cards (Figure 5.7.). There are 27 cards in the input deck, and the resulting file is 300 (octal) words long. Word zero indicates that a BCD card is contained in the next eight words — the *ID card.

---

†A record of length zero.

Note the sequence number in word 010. The flag in word 011 indicates that the preceding card required eight words, and the next card is BCD and requires seven words. The fourth card is blank, and requires only one word.

The first job ends in word 061. The flag in 062 states that the following card is of length zero, and the flag in 063 states that the preceding card was of length zero. This indicates an end-of-file mark. The *ID card for the second job comes next, with a sequence number in word 073.

Two binary cards are stored in words 141-202, as indicated by the flags in 141 and 162. A binary card is stored top to bottom, left to right. (See section 5.7.) The second job ends with an end-of-file (words 203-204), and the input deck is followed by an "END TAPE" card in 205-206. The usual identification comes at the end.

BCD cards require from two to nine words each (including flags), and binary cards require 17 words each. Experience indicates that BCD cards require an average of 4-5 words. This implies that the file length usually will not need to be specified for BCD decks of less than 4000 cards (about 2-1/2 feet).

Card	Loc.	Contents (octal and ASCII)
flag	000	00000000 000000 000010
1	001	*ID___123ABC____________________________
		________BOX_A-11__HSP_IDEN_________001__
flag	011	00000000 000010 000007
2	012	C_______THIS_IS_A_SAMPLE_SQUOZE_MONITOR_
		FILE,_ALSO_WITH_TWO_PROGRAMS._
flag	021	00000000 000007 000003
3	022	THE_NEXT_CARD_IS_BLANK._______
flag	025	00000000 000003 000001
4	026	__________
flag	027	00000000 000001 000010
5	030	_________________THIS_CARD_BEGINS_WITH_B
		LANKS,_AND_RUNS_TO_COLUMN_80.__123456789
flag	040	00000000 000010 000004
	⋱	⋱
flag	060	00000000 000007 000001
13	061	______END_
flag	062	00000000 000001 000000
flag	063	00000000 000000 000010
14	064	*ID___123ABC____________________________
		________BOX_A-11__HSP_IDEN_________002__
flag	074	00000000 000010 000004
	⋱	⋱
25	140	______END_

Figure 5.7. Example of a Squoze-Monitor File

Card	Loc.	Contents (octal and ASCII)
flag	141	00000001 000001 000020
26	142	(binary card)
flag	162	00000001 000020 000020
27	163	(binary card)
flag	203	00000000 000020 000000
flag	204	00000000 000000 000002
----	205	*_____END_TAPE______
flag	207	00000000 000002 000000
----	210	!_________!_________!_________!_________
	. . .	. . .
	270	!_________!_________!_________!_________
	274	_____DECKCBOX_A-11__HSP_IDENTIFICATION__

The underline (_) is used to indicate a blank.

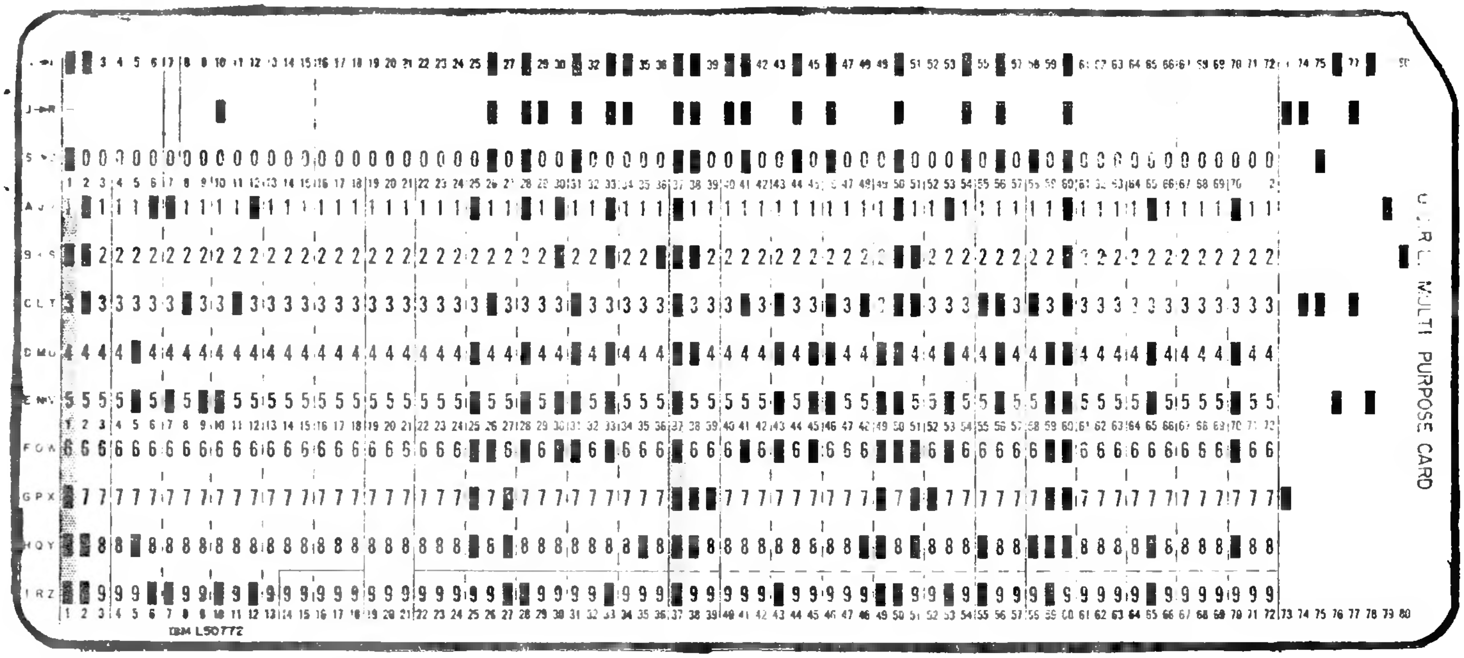
Figure 5.7. Example of a Squoze-Monitor File (continued)

5.2.4. Absolute-Binary File Format

An *absolute binary* file is requested by an "A" in column 30 of the card-reader identification card. This type of file is used to obtain a complete image of each card in the input deck.

Each card occupies 16 words, and there are no intervening sentinels. This card image is stored top to bottom, left to right, with a one representing a punch and a blank representing a nonpunch. Thus, if column 1 has punches in the 12-0-2-7-8-9 positions, the first word occupied by this card would begin 5207 (octal). Figure 5.8. gives an example of the full transformation of a card.

Since each card requires 16 words, the length need not be specified on the card-reader identification card for less than 1200 cards (about 9 inches).



Storage

Word	Contents (card column given above contents)				
	1 2 3	4 5	6 7 8	9 10	(columns)
00	5207470300	0000000062	0401042101	0000202021	
	11 12 13	14 15	16 17 18	19 20	
02	0100040100	0000000000	0000000000	0000000000	
	21 22 23	24 25	26 27 28	29 30	
04	0000000000	0000000476	7110000774	7120000630	
	31 32 33	34 35	36 37 38	39 40	
06	7170000066	7160000002	0200777772	4600046000	
	41 42 43	44 45	46 47 48	49 50	
10	7110000001	7170000070	7160000001	0200777771	
	51 52 53	54 55	56 57 58	59 60	
12	0316000404	7170000103	7160000011	0200777776	
	61 62 63	64 65	66 67 68	69 70	
14	0000000000	0000000463	0000000000	0000000472	
	71 72 73	74 75	76 77 78	79 80	
16	0000000020	0421001100	4020210040	2004000200	

Figure 5.8. Example of an Absolute-Binary Card Transformation

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