SUBJECT:	DATE: December 29, 1966
	FROM: D. A. Kerr

MESSRS. F. R. MICHAEL:
   V. A. VYSSOTSKY:

Attached is a copy of USASI Document X3.2/476, A Card Code Proposal. This document will be submitted in the immediate future for X3.2 letter ballot. I would appreciate it if you would review it and give me your comments and/or those of your associates.

Please note that this is a preliminary draft and is full of obvious editorial errors. We trust these will be corrected before the final document is issued for ballot. However, many of them are in critical areas and will need to be watched carefully, so please feel free to comment on such problems if you wish.

HO-3142-DAK-MG

D. A. KERR

Att.
As above

USA

PROPOSED AMERICAN STANDARD

HOLLERITH CARD CODE

- .2 -

FOREWORD

(This Foreword is not a part of the American Standard BCD Card Code.)

This American Standard presents the standard BCD Card Code method.

Other standards will specify the dimensions and quality of punched paper cards, and the dimensions and locations of the holes punched in the cards.

The coded representation on the twelve row punched card was developed from research, review of historical work and careful consideration of the use of punched cards in information processing and communication. Resolution of several conflicting requirements is reflected in the standard representation.

This standard was approved as American Standard by the American Standards Association on

Suggestions for improvement gained in the use of this standard will be welcome. They should be sent to the American Standards Association, Incorporated, 10 East 40th Street, New York, New York 10016.

The ASA Sectional Committee on Computers and Information Processing, X3, had the following personnel at the time of approval:

At the time the proposal was developed and processed through ASA X3.2 Subcommittee, the Subcommittee membership was as follows:

At the time this standard was processed by X3.2.3, the Task Group membership was as follows:

CONTENTS

PROPOSED -4- 12-ROW

AMERICAN STANDARD ~~HOLLERITH~~ CARD CODE

X3.2.3/159
12/Dec/66
(rev. X3.2.3/141)
(rev. X3.2.3/144)

1. SCOPE. This standard specifies the Punched Card Code for "Hollerith" environments as used in 12 row standard punched cards.

2. STANDARD CARD CODE

	0	1	2	3	4	5	6	7
0	NUL 12-0-9 8 1	DLE 12-11-9 8-1	SP No Punches	Ø 0	@ 8-4	P 11 7	` 12-0	p 12-11 7
1	SOH 12-9 1	DC1 11-9 1	! 12 8-7	1 1	A 12 1	Q 11 8	a 12-0 1	q 12-11 8
2	STX 12-9 2	DC2 11-9 2	" 8-7	2 2	B 12 2	R 11 9	b 12-0 2	r 12-11 9
3	ETX 12-9 3	DC3 11-9 3	# 8-3	3 3	C 12 3	S 0 2	c 12-0 3	s 11-0 2
4	EOT 9 7	DC4 9 8-4	$ 11 8-3	4 4	D 12 4	T 0 3	d 12-0 4	t 11-0 3
5	ENQ 0-9 8-5	NAK 9 8-5	% 0 8-4	5 5	E 12 5	U 0 4	e 12-0 5	u 11-0 4
6	ACK 0-9 8-6	SYN 9 2	& 12	6 6	F 12 6	V 0 5	f 12-0 6	v 11-0 5
7	BEL 0-9 8-7	ETB 0-9 6	' 8-5	7 7	G 12 7	W 0 6	g 12-0 7	w 11-0 6
8	BS 11-9 6	CAN 11-9 8	(12 8-5	8 8	H 12 8	X 0 7	h 12-0 8	x 11-0 7
9	HT 12-9 5	EM 11-9 8-1	) 11 8-5	9 9	I 12 9	Y 0 8	i 12-0 9	y 11-0 8
10	LF 0-9 5	SUB 9 8-7	* 11 8-4	: 8-2	J 11 1	Z 0 9	j 12-11 1	z 11-0 9
11	VT 12-9 8-3	ESC 0-9 7	+ 12 8-6	; 11 8-6	K 11 2	[12-3-2	k 12-11 2	{ 12-0-3-2
12	FF 12-9 3-4	FS 11-9 8-4	, 0 8-3	< 12 8-4	L 11 3	\ 12-11	l 12-11 3	| 11-0-3-2
13	CR 12-9 8-5	GS 11-9 8-5	- 11	= 8-6	M 11 4	] 11-8-2	m 12-11 4	} 12-11-3-2
14	SO 12-9 8-6	RS 11-9 8-6	. 12 8-3	> 0 8-6	N 11 5	^ 11 8-7	n 12-11 5	~ 11-0
15	SI 12-9 8-7	US 11-9 8-7	/ 0 1	? 0 8-7	O 11 6	_ 0 8-5	o 12-11 6	DEL 9-12-11-0

NOTE: In this standard, the phrase "the Code Table" refers to the above table.

3. NOTATION

3. 1 The standard row positional order and notation for the twelve row punched card reading from top to bottom of the card are row 12, row 11, row 0, row 1, row 2, row 3, row 4, row 5, row 6, row 7, row 8 and row 9. The presence of 12, 11, 0, 1, 2, 3, 4, 5, 6, 7, 8, or 9 in the body of the Code Table corresponds to a punch in row 12, 11, 0, 1, 2, 3, 4, 5, 6, 7, 8, or 9, respectively, of the card.

3. 2 This standard specifies the BCD hole-pattern representation of the American Standard Code for Information Interchange (   ) when punched in the standard twelve-row punched card, hereafter referred to as the BCD representation. A single hole-pattern (such as 12-2, or such as 11-8-6, or such as 11-9-8-6) is to be punched in a single column of the standard twelve row punched card.

4. LEGEND

4. 1 A particular hole-pattern may be referred to as being in Code Table position x/y, where x is the table column and y is the table row. The vertical columns (x) in the body of the Code Table (not to be confused with columns on a punched-card) are designated column 0, 1, 2, 3, 4, 5, 6, and 7 for reference purposes only. The horizontal rows (y) in the body of the Code Table (not to be confused with rows on the punched-card) are designated row 0, 1, 2, 3, ---, and 15 for reference purposes only.

Example 1:   Hole pattern 11-9-8-4 is in table position 1/12

5. QUALIFICATIONS

5.1 The standard does not include any redundancy or define techniques for error control.

5.2 It does not specify a standard card sorting sequence.

5.3 The standard does not specify bit-patterns. The control and graphic characters for this standard are from the American Standard Code for Information Interchange (   ), and are arranged in the code table in the same code positions, that is, with the same row-numbers and column-numbers as in ASCII.

5.4 The size, shape, and location of the holes and the physical characteristics of the card are specified in separate standards.

5.5 In practice, with respect to card codes, "BCD" and "Hollerith" are used synonomously.

5.6 Deviations from the standard may create serious difficulties in general information interchange. Such deviation should be used only with full cognizance of the parties involved. The use of hole-patterns not defined in this standard is considered a deviation from the standard.

5.7 The appendices to this standard cover criteria, evaluation, design considerations, vocabulary, related standards.

APPENDIX A - SPECIFIC CRITERIA

A.1 INTRODUCTION·

This Appendix contains the criteria on which the design of the code was based. Not all criteria have been entirely satisfied, some are conflicting. The characteristics of the representation are an acceptable compromise of these divergent criteria.

A.2 CRITERIA

The code, when punched in a card, shall not appreciably weaken the card, that is, the code shall cause a minimum number of holes to be punched. Another way of stating this is that the code shall be designed for:

(a) Minimum hole density per unit area
(b) Minimum hole density per column
(c) Minimum hole density per row

The code shall be compatible with the common de-facto standard (Hollerith) code.

The code shall be compatible with international card standards.

The code shall be designed to be compatible with existing equipment.

The code shall provide for error detection (parity).

The code shall represent the full ASCII character set.

The code shall require minimum translation to and from ASCII.

The code shall provide for logical and orderly expansion to larger sets.

The code shall not decrease the present character storage capacity of the card.

The code shall preserve the logical arrangement of the ASCII columns.

The codes for the numerics shall be readily sight readable.

No more than one column shall be used to represent one character.

All hole-patterns in the set shall require the same number of punchable positions.

The code shall be such as to require the minimum number of passes in mechanical sorting.

The code shall be capable of being implemented in the standard card.

Character representation shall be independent of column location.

APPENDIX B - EVALUATION

B.1 INTRODUCTION

A number of different card code concepts were studied. Eventually,
attention was devoted chiefly to three types of card coding:

> (a) Direct Binary Representation
> (b) Twelve Row Representation of
>   ASCII (Decimal ASCII)
> (c) BCD Representation

The Direct Binary Representation is one in which b_1 of ASCII is punched in
row 1 of the card, b_2 in row 2, etc.

The BCD Representation is an extension (and modification) of the common
de-facto-standard Hollerith punched card code.

The Decimal ASCII representation is a compromise representation using
some of the features of the Hollerith code with some of the translation
features of the binary representation.

B.2 EVALUATION OF CRITERIA

This standard is an extension of the common de-facto-standard Hollerith
punched card code. This section describes the degree to which the criteria
presented in Appendix A are satisfied by this standard.

The following criteria are clearly satisfied by the BCD representation:

1) The code should represent the full ASCII character set.

2) No more than one column shall be used to represent one character.

3) Character representation should be independent of column location.

4) The code must be capable of being implemented in the standard card.

5) The code should not decrease the present character storage capacity
of the card.

6) All hole-patterns in the set should require the same number of
punchable positions.

7) The codes for numerics should be readily sight-readable.

The following criteria are satisfied in part. with the degree of compliance as indicated:

1) The code should be compatible with the common de-facto-standard domestic code (Hollerith).

   The BCD representation of the numerics and the upper-case alphabet are exactly the same as the de-facto-standard. The lower-case alphabetics, controls and special graphics were not available in general usage to the extent of establishing a de-facto-standard. Code assignments were devised for these characters (See Appendix C).

2) The code, when punched in a card, should not appreciably weaken the card. That is, the code should cause a minimum number of holes to be punched.

   In the BCD representation, the most frequently used characters require the least number of holes: only one hole for the numerics and only two holes for the upper case letters.

3) The code should be capable of being used with existing equipment.

   Numeric, upper-case alphabetic and some of the special graphics can be used with existing equipment. Some modifications are required to handle the full ASCII character set.

4) The code should provide for logical and orderly expansion to larger sets.

   The BCD representation can be expanded to a larger set than the 128 characters specified in ASCII.

5) The code should require the minimum number of passes in mechanical sorting.

   For numeric-only data, the BCD representation requires only one pass per column. For a single-case of alphabetics, two passes per column are required. Some recognition circuitry is required to provide the minimum number of passes for data using the full character set.

The following criteria are not satisfied by the BCD representation:

1) The code should provide for error detection (parity).

    The BCD representation requires all twelve rows and therefore cannot provide for a parity hole punch. However, equipment checks such as double-punch and blank-column detection for numeric fields, and system/procedure control techniques have been successfully employed for error detection. This standard continues the requirement for such practices.

2) The code should require minimum translation to and from ASCII.

    The BCD representation does not provide for minimum translation.

3) The code should preserve the logical arrangement of the ASCII columns.

    Since the original Hollerith code pre-dated ASCII, there is not a logical relationship to the ASCII columns, except for Columns 1 and 2.

4) The code should be compatible with international card standards.

    At present there is no international punched card code, but there are a number of punched card codes in use internationally which use the 80-column card. The numerics are represented in these codes by the same ten unique punches as in this standard.

APPENDIX C - DESIGN CONSIDERATIONS

C.1 INTRODUCTION

The standard BCD representation was designed to provide for representation of the full ASCII character set in punch cards, in a code which incorporated and extended the de-facto standard code. Such a code would thus permit continued use of existing equipment, files, tabulating procedures and data code structures based on a subset of the full ASCII. The inherent benefits of capability for full interchange of cards and data from users of the subset to the full set and limited interchange in the reverse direction are thus extended to the large body of producers and users of current card equipment.

The punch card is unique as an input/output medium for data processing systems, in the variety of types of usage to which it is put. In some applications it serves as the unit record for storage of data, being created, processed, stored and reprocessed repeatedly over a long life cycle in a single machine facility and handled exclusively by trained operators. In other applications it is punched solely for the purpose of a single reading into an electronic data processing system, and having served that purpose is immediately destroyed. In a different situation, it is punched as a result of a data processing operation, distributed to clerical staffs or the general public and after considerable manual handling is returned to a data processing facility, not necessarily its originator, to serve as an input medium to further processing. The 80 column cards used for these various purposes have to date been punched with the Hollerith code, which had thus acquired the status of a de-facto standard. The ability of the code to serve this variety of purposes, together with the large investment in hardware and software based on the code, warrants its extension to provide capacity for interchange between the ASCII world and the de-facto standard Hollerith world.

C.2 DE-FACTOR STANDARD HOLLERITH

The Hollerith code in general usage had many requisites of a standard specification. The majority of 80 column punched card equipments and hence the applications employing them had a set of 48 characters. This set provided:

Blank or space	-	1 character
Numerics 0-9	-	10 characters
Letters A-Z	-	26 characters,

for a total of 37 characters, leaving eleven character positions for assignment to punctuation or other special symbols. For the basic 37 characters there was almost complete uniformity in the hole-pattern assigned to each graphic.

For the eleven positions in the set remaining for special symbols there were a number of different subsets developed by producers and users. However the majority of applications were found to use one of two common groupings of special symbols, as follows:

Set A	SP	0-9	A-Z	.	,	*	/	-	$	&	@	#	%	¤
Set H	SP	0-9	A-Z	.	,	*	/	-	$	÷	'	=	(	)

These are frequently identified in the literature as Set A and Set H. The same eleven hole patterns were assigned in all cases, but between these two sets, the last five of the graphics listed were different for the same hole pattern.

In addition to these 48, some punched card equipments had sets containing as many as 16 additional, for totals up to 64 characters. These varied widely, both in the graphics and in the hole-patterns assigned in the extensic to the basic set.

C.3 EXTENSION

Since there were almost no deviations in the hole-pattern assignments to the numerics and letters, these code assignments were placed directly in the BCD representation.

Surveys of existing installations showed the single most widely used grouping of special symbols to be Set A. Accordingly, the hole-patterns assigned to these symbols were incorporated in the standard. However, since the lozenge � is not an ASCII character, the hole-pattern assigned to it in Set A has been assigned to the ASCII character ⟨ .

Further assignments of hole-patterns were then made to accommodate the remaining ASCII graphics. The de-facto Hollerith had not contained the ASCII control characters. Since new hole-patterns had to be devised for all characters in ASCII columns 0 and 1, the hole patterns for these two columns were developed with a logical relationship to the ASCII table.

Further, to accommodate the requirements of 8-bit environments to provide 256 hole patterns, a 256 character chart follows, in which the 128 hole-patterns and character assignments of the chart in Section 2 of this standard are embedded, and in which 128 additional hole-patterns, as yet unassigned, are shown.

PROPOSED AMERICAN STANDARD CARD CODE

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
	9	9	9	9	9	9	9	9									
	12			12	12		12	12	12			12	12				
		11			11	11	11		11	11	11		11				
			0		0		0	0	0		0	0			0		
0 / 8-1	NUL (1)	DLE (2)	(3)	(4) SP (5)	& (6)	- (7)	(8)		±	o	(9)	/ (10)	≠ (11)	0 (12)			8-1 / 0
1 / 1	SOH	DC1				/ (13)		a	j	\	¹	A	J	(14)	1		1 / 1
2 / 2	STX	DC2		SYN				b	k	s	²	B	K	S	2		2 / 2
3 / 3	ETX	DC3						c	l	t	³	C	L	T	3		3 / 3
4 / 4								d	m	u	⁴	D	M	U	4		4 / 4
5 / 5	HT		LF					e	n	v	⁵	E	N	V	5		5 / 5
6 / 6		BS	ETB					f	o	w	⁶	F	O	W	6		6 / 6
7 / 7	DEL		ESC	EOT				g	p	x	⁷	G	P	X	7		7 / 7
8 / 8		CAN						h	q	y	⁸	H	Q	Y	8		8 / 8
9 / 8-1		EM						i	r	z	⁹	I	R	Z	9		9 / 9
10 / 8-2				¢	!	(15)	:	{	}	‐	≠	)					8-2 / 10
11 / 8-3	VT			.	$	,	#	⌐	⌐	⌐	⌐						8-3 / 11
12 / 8-4	FF	FS		DC4	<	*	%	@	{	+	}	—					8-4 / 12
13 / 8-5	CR	GS	ENQ	NAK	(	)	—	' /	←	⌐	↑	∧					8-5 / 13
14 / 8-6	SO	RS	ACK		+	;	>	=	\	≤	′	o					8-6 / 14
15 / 8-7	SI	US	BEL	SUB	∥	∥	^⌐	?	"	∧	o						8-7 / 15
	9	9	9	9									9	9	9	9	
	12				12				12	12		12	12	12		12	
		11				11			11	11	11		11	11	11		
			0				0		0		0	0	0		0	0	

1	12-0-9-8-1	6	12
2	12-11-9-8-1	7	11
3	11-0-9-8-1	8	12-11-0
4	12-11-0-9-8-1	9	12-0
5	No punches	10	11-0
11	0-8-2		
12	0		
13	0-1		
14	11-0-9-1		
15	12-11		

Card Hole Patterns

In the 16 x 16 Table, the heavy lines partition the table in four blocks as follows:

1	3
2	4
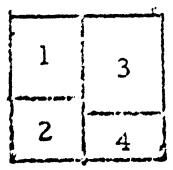
Block 1: Zone punches at top, digit punches at left, of table.
Block 2: Zone punches at bottom, digit punches at left, of table.
Block 3: Zone punches at top, digit punches at right, of table.
Block 4: Zone punches at bottom, digit punches at right, of table.

APPENDIX D - RELATED STANDARDS

D.1   Proposed Revised American Standard Code for Information Interchange: X3.2/206, January 21, 1965.

D.2   Proposed American Standard Specification for General Purpose Paper Cards for Information Processing: X3.2/76, February 3, 1964.

D.3   Proposed American Standard Specification for Rectangular Holes in Twelve-Row Punched Cards.

EXPOSITORY REMARKS

ON THE

PROPOSED AMERICAN STANDARD

BCD CARD CODE

CONTENTS

SECTION I

SUBCOMMITTEE REPORT

The X3.2 Subcommittee was assigned the responsibility for developing recommendations for: (1) a standard coded character set and recording formats for the general interchange of information among information processing systems, communications systems and associated equipment, and (2) the representation of the standard coded character set in the principal media (punched tape, magnetic tape and punched card) of general information interchange.

The standard code character set achieved the status of an American Standard (Document X3.2-1963) on June 17, 1963. At the present time, there are three X3.2 task groups actively developing proposals for the representation of the American Standard Code for Information Interchange (ASCII) in the three principle media. These are: X3.2.1, Magnetic Tape; X3.2.2, Punched Paper Tape, and X3.2.3, Punched Card.

Task Group X3.2.3 held its first meeting on December 12, 1961. Subsequent to the formation of this Task Group, the development of standards for punched cards was transferred to the Joint Working Group on Punched Card, drawing together members from X3.2.3, X4-A4, and EIA TR 27.6.1, the first meeting was held on May 15, 1962. After a period of Joint Working Group activity, the responsibility for the development of a proposed American Standard for punched cards was reassigned to X3.2.3, the first meeting of the reactivated Task Group was held on March 6, 1963.

The development of this punched card standard was agreed upon after a detailed review and analysis of existing punched card codes as well as several alternate representations which included (1) binary representations of ASCII and (2) a decimal-ASCII representation. These alternate representations are described in Section II on Code Development. The extended Hollerith represenation was selected rather than one of the alternate representations because it provides (1) maximum compatibility with the punched card codes in widespread use today and (2) the most convenient punched card interface between the Hollerith environment of data processing systems and the ASCII environment.

A proposed standard describing the physical requirements for the Twelve-row punched cards to be used with this punched card code is now in the X3 publication interval.

SECTION II

CODE DEVELOPMENT

1. DIRECT BINARY

In the direct binary representation the bits of the ASCII were placed in the corresponding numbered rows of the card, i.e., b_1 of ASCII in row 1, b_2 in row 2, etc. The "check" or "parity" bit included for error control would be placed in row 8. The bit for expansion to a 256 character code set would be placed in row 0.

The primary considerations which guided this arrangement were:

1) It requires minimum, if any, hardware translation to and from media using the ASCII code.

2) This placement leaves the top of the card free for printing. Applications exist which require the top area of the card to be without a concentration of punched holes. However, future consideration of the "Unassigned Area" of the ASCII code may affect this choice.

3) The arrangement of the bits in card rows 1-7 with parity in row 8 conform to 1 inch eight track paper tape being proposed by the perforated Tape Task Group.

A strong disadvantage of this arrangement is the serious weakening of the punched card due to a large increase in the number of holes and the lacing caused by always having rows 5 and 6 punched for numeric data.

The punched card is unique as an input/output media for data processing systems. Paper tape and magnetic tape are continuous media which are normally only handled by trained operators. The punched card, however, is an individual unit record and is physically handled by many types of people, both trained operators and the general public. After human handling. the card is placed in feeding mechanisms where it must be fed from a deck of cards, aligned, rapidly accelerated past reading stations and/or punching stations and finally stacked in a selected pocket all without reading or punching errors and without jamming along the card transport. To achieve the required reliability over the humidity range of 10% to 80% requires that the card be physically as strong as possible. To insure maximum reliability of card handling and to minimize the wear of the punch and die units, the card should have as few holes placed in it as possible for the data to be recorded.

A second approach to Direct Binary representation was also considered in order to minimize the disadvantage above. This method was inverting the 5 and 6 bits to zero when bit 7 was a zero. Some relief is obtained, but overall the problems caused by the increase of punched holes remain.

2. TWELVE-ROW PUNCHED CARD CODE - DECIMAL ASCII REPRESENTATION

Another punched card code representation for ASCII which was considered is the Decimal-ASCII representation which is shown in Figure 1.

In this code the numerics are represented by a single punch in a column of the card. To accomplish this, no zone punches in the card were associated with column 3 of the ASCII Code Table (the column which contains the numerics). The numerics in Decimal-ASCII are represented in the punched card in the same manner that the numerics are represented in the Hollerith representation.

The upper case alphabetic data which is the next most significant data to be placed in punched cards is represented by a single zone punch in combination with one or two digit punches. The lower case alphabet is obtained by placing a second zone and the one or two digit punches used to represent the corresponding upper case alphabetic characters.

A primary consideration which guided the arrangement of the decimal-ASCII punched card code was the objective to achieve minimal translation between the representation of ASCII in punched cards and its representation in other media. Decimal-ASCII requires less translation than the Hollerith representation and more translation than the Direct Binary.

Although Decimal-ASCII has a translation advantage compared with the Hollerith representation when conversion is from one ASCII media to another, this advantage was not sufficient to depart from the de-facto Hollerith punched card code. Although Decimal-ASCII retained the representation of the numerics, it assigned new card representations for the alphabetic and commonly used special symbols. In unit record card handling equipment such as keypunches, sorters, collators, interpretors where translation is not employed, the advantages favor the retention and continued use of the Hollerith punched card code. By retaining the basic Hollerith representation in punched cards for ASCII it is practical for the punched card to provide the interface between the Hollerith based data processing system

FIGURE 1. Decimal ASCII Twelve-Row Punched Card Code Table

PUNCH POSITIONS ⟶

Zone Area		b7	0	0	0	0	1	1	1	1
	Bit 8	b6	0	0	1	1	0	0	1	1
		b5	0	1	0	1	0	1	0	1

Zone Area punch positions by column: Col 0: 12 11 0; Col 1: 12 11 0; Col 2: 12 11; Col 3: 0; Col 4: 12; Col 5: 11; Col 6: 12 0; Col 7: 11 0

Digit Area 1 2 3 4 5 6 7 8 9	Bits b4 b3 b2 b1	COL / ROW	0	1	2	3	4	5	6	7
	0 0 0 0	0								
1	0 0 0 1	1			☆					
2	0 0 1 0	2			☆					
3	0 0 1 1	3								
4	0 1 0 0	4								
5	0 1 0 1	5								
6	0 1 1 0	6								
7	0 1 1 1	7								
8	1 0 0 0	8								
9	1 0 0 1	9								
2 8	1 0 1 0	10								
3 8	1 0 1 1	11								
4 8	1 1 0 0	12								
5 8	1 1 0 1	13								
6 8	1 1 1 0	14								
7 8	1 1 1 1	15								

The characters contained in the ASCII Code Table are to be placed here.

☆ Exceptions:

ASCII Code		Card Code	Graphic
2/0	0100000	No Punch	Space
3/0	0110000	0	0 (Zero)

Note 1: The row, column and bit notations shown correspond to the row, column and bit notation of the ASCII Code Table

Note 2: The zone and digit punch positions identify the individual rows in the 12-row punched card.

and the ASCII information interchange systems. The Hollerith representation provides for compatibility across the complete range of punched card applications from small self-contained systems to international information interchange systems. The total systems advantages provided by the Hollerith representation resulted in its adoption rather than the Decimal-ASCII representation for the punched card code.

3. BCD

The Hollerith punched card code was not developed in its entirety at one time, but rather it has been developed in conjunction with the system and application requirements placed on it. In the beginning, the code consisted merely of twelve individual punches which represented the ten numeric digits and provided for two control signals. Recently the punched card code had grown to represent as many as 256 characters. A summary of the development of the Hollerith punched card code from the representation of ten numerics to the 128 characters of ASCII follows.

1. SPACE (BLANK)
    The absence of any data in a given column of the card is called a "blank" or "blank column." The blank is used to provide separation between data fields and to space printers and punches one position without printing or punching. In addition, a field containing no data is left blank. It is always possible, therefore, to add data to a blank field field during a later operation. The fact that the punched card is typically a formatted record with pre-determined locations for recording data makes it possible and desirable to use the blank column as a separator between alphabetic words, as well as to reflect the absence of data in an entire field.

2. NUMERALS·
    The first phase in the development of the Hollerith punched card code was the placement of the ten numeric digits in ten separate rows of the cards. Two additional rows were assigned for control functions. Even today, punched cards containing Hollerith codes are frequently referred to as "twelve-row" punched cards, based on the original design of the card for twelve individual rows of data. The use of an individual punch for each numeric digit facilitated the development of equipment to physically sort and collate the cards as well as an aid in the sight verification of numeric fields. In addition, the use of individual rows for numeric digits has permitted the development of mark-sensed cards and manual single hole punching using the same size card.

3. <u>LETTERS</u>

A. Capital

In order to store alphabetic data for names and addresses, descriptions of parts, mixed alpha-numeric fields, etc., it was necessary to develop a coding system to represent the 26 upper case alphabetics. This was accomplished by placing two punches in a given column of the card, a numeric digit punch and a zone punch. The pattern selected is:

    12 zone plus 1-9 digit for alphabetics A-I
    11 zone plus 1-9 digit for alphabetics J-R
    0 zone plus 2-9 digit for alphabetics S-Z

This representation in the punched card for the alphabetic characters has been traditionally referred to as the "Hollerith Representation." The Hollerith method of representing alphabetic characters by zone punches over digits makes it very easy and economical to adapt numeric sorting machines to the sorting of Hollerith alphabetic characters.

B. Small

In recent years, there has been an increasing interest in equipment and systems capable of handling business correspondence as well as business records. Business correspondence requires the use of both upper and lower case alphabetic characters. The ASCII code includes both cases of the alphabet. The addition to the Hollerith punched card code to accommodate the lower case alphabetics was accomplished by adding a second zone punch to the codes already used for the upper case alphabetics as shown below:

    12-0 zones plus 1-9 digit for alphabetics a-i
    12-11 zones plus 1-9 digit for alphabetics j-r
    11-0 zones plus 2-9 digit for alphabetics s-z

4. SPECIAL SYMBOLS

A. In the printing of normal accounting records, invoices, cheques, etc., it was necessary to provide a selected number of special graphic symbols. The ones initially selected and the code assignments given them are:

Card Code	Graphic	Card Code	Graphic
12	&	12-8-3	.
11	-	12-8-4	⌻
0-1	/	11-8-3	$
8-3	#	11-8-4	*
8-4	@	0-8-3	,
		0-8-4	%

The above 11 special symbols, the 26 alphabetics, the 10 numerics and Space comprise the initial 48 character set of the Hollerith punched card code. Eventually, the punched card was applied to scientific computing applications in addition to commercial accounting type applications. The scientific users wanted some different graphic symbols than were previously provided for accounting applications. Initially, those graphics were provided by substituting them for several of the eleven shown above. The most common pairing or dualing were:

Card Code	Basic Graphic	Scientific Graphic
12	&	+
8-3	#	=
8-4	@	'
12-8-4	⌻	)
0-8-4	%	(

Numerous other variations also exist. The Hollerith punched card code no longer had a unique graphic associated with each code pattern.

With the development of ASCII and data processing systems capable of handling 7- and 8-bit codes, it was desirable and feasible to separate the duals shown above. The graphics shown under the scientific graphic option were assigned new card codes as follows:

Card Code	Graphic
8-5	'
8-6	=
12-8-5	(
12-8-6	;
11-8-5	)

B. Additional Special Symbols. In ASCII there are a
number of additional special symbols and national usage
graphics included beyond the special symbols described
above. The card codes assigned to these graphics use
the remaining 8-zone combinations. These are:

Card Code	Graphic	Card Code	Graphic
11-0	[	0-8-5	—
12-11-0-8-4	\	11-8-6	;
0-8-2	]	0-8-6	>
12-11-8-7	~		|
11-8-7	^	0-8-7	?
8-2	:	8-7	"
12-0	\	12-11-8-1	}
		11-0-8-1	{

5. CONTROL CHARACTERS

The operation of communications systems and equipment
requires the use of a number of special control characters.
ASCII has made provision for 32 unique control characters.
To accommodate these controls in the BCD representation,
it was determined that the use of the 9-punch as an additional
zone control would be used. This is similar to the method
used with the 8-punch as a zone to obtain additional special
symbols. The codes selected are shown in columns 0 and 1
of the chart.

III CONCLUSIONS

The preponderance of punched card equipment in use today employs the Hollerith card code, or variations of it. The preponderance of data processing punched card applications today are based on Hollerith card equipment; viz., manual card punching and verifying, manual single hole-punching, sorting, collating, mark conversion, interpreting, report or document preparation, summarizing, calculating, paper tape conversion, card-to-card transmission, statistical counting-editing, card readers and punches as input/output for computers, data collection.

In the assignment of graphics to card characters, most manufacturers' equipments agree for numerics, alphabetics, and some specials. There are variations in different manufacturer's equipment in the assignment of many of the specials to card characters. See the chart "Comparison of 12 Row Punched Card Codes and Graphic Assignments" that follows. These variations have developed because there has been no official Hollerith standard in the past.

This standard for the BCD representation of ASCII will provide a blueprint for the industry so that punched card equipment with a common Hollerith code can be produced and the interchange of cards between these equipments will be easily and economically accomplished. The establishment of this standard fulfills an objective of the X3.2.3 Task Group to develop a punched card code standard which would serve the best interests of users, manufacturers and general interest groups. The BCD representation has the advantage of providing the link between the many Hollerith card applications which have developed over the years and the information interchange environment of ASCII in the future.

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ASCII Code Table Position (Column/Row)	ASCII Symbol and Meaning		Current Common Language
2/1	!	Exclamation Point	
2/2	"	Quotation Marks	
2/3	#	Number or Pound	073
2/4	$	Dollar	33
2/5	%	Percent	E30
2/6	&	Ampersand	0-33
2/7	'	Apostrophe	T
2/8	(	Left Paren.	T58
2/9	)	Right Paren.	E58
2/10	*	Asterisk	E48
2/11	+	Plus	T0
2/12	,	Comma	038
2/13	-	Minus or Hyphen	E
2/14	.	Period	T38
2/15	/	Slash	01
3/10	:	Colon	58
3/11	;	Semicolon	E58
3/12	<	Less Than	T68
3/13	=	Equal	053
3/14	>	Greater Than	69
3/15	?	Question Mark	28
4/0	@	At	
5/11	[	Left Bracket	T48
5/12	\	Reverse Slash	
5/13	]	Right Bracket	068
5/14	^	Circumflex	
5/15	_	Grave	48
6/0	@	At	
7/11	{	Left Brace	
7/12	|	Vertical Line	
7/13	}	Right Brace	
7/14	¬	Logical Not	
TOTAL			

NOTES:

(1) Only those codes relating to ASCII Symbols are shown.

(2) Column 17 reflects the proposal in document X3.2.3/75, January 18, 1964.

(3) For brevity, T stands for 12 and E stands for 11.

FIGURE 2 SOME HOLLERITH RELATED CARD CODES IN USE TODAY

Excerpted from document X3.2.3/69/Nov. 10, 1964

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