LaVan Stuart

BULLETIN 3025

Preliminary Edition

DATATRON

ELECTRONIC DATA PROCESSING SYSTEMS

HANDBOOK CARDATRON SYSTEM

Control Model 506 Input Model 507
Output Model 508 Output Model 509

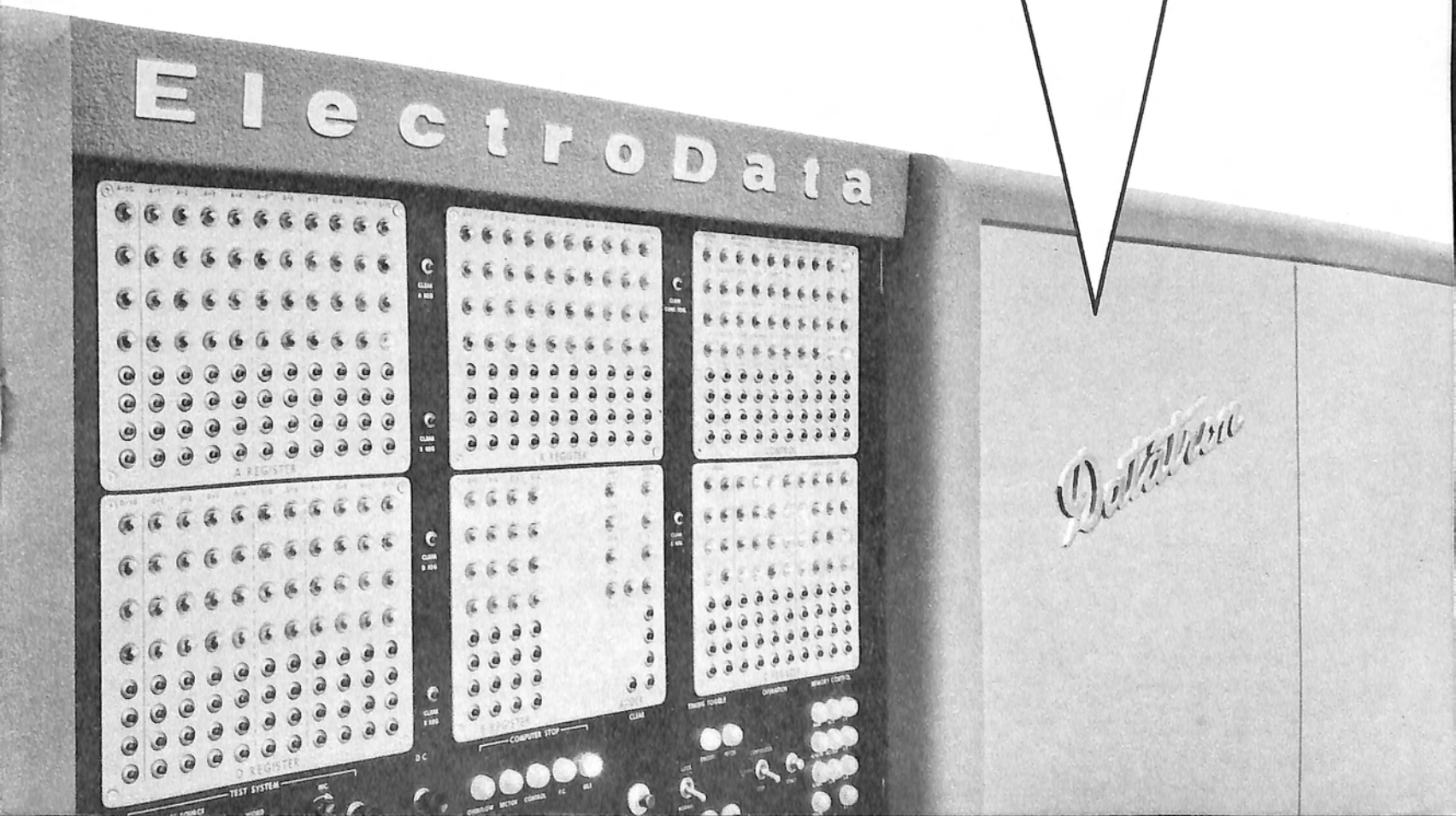
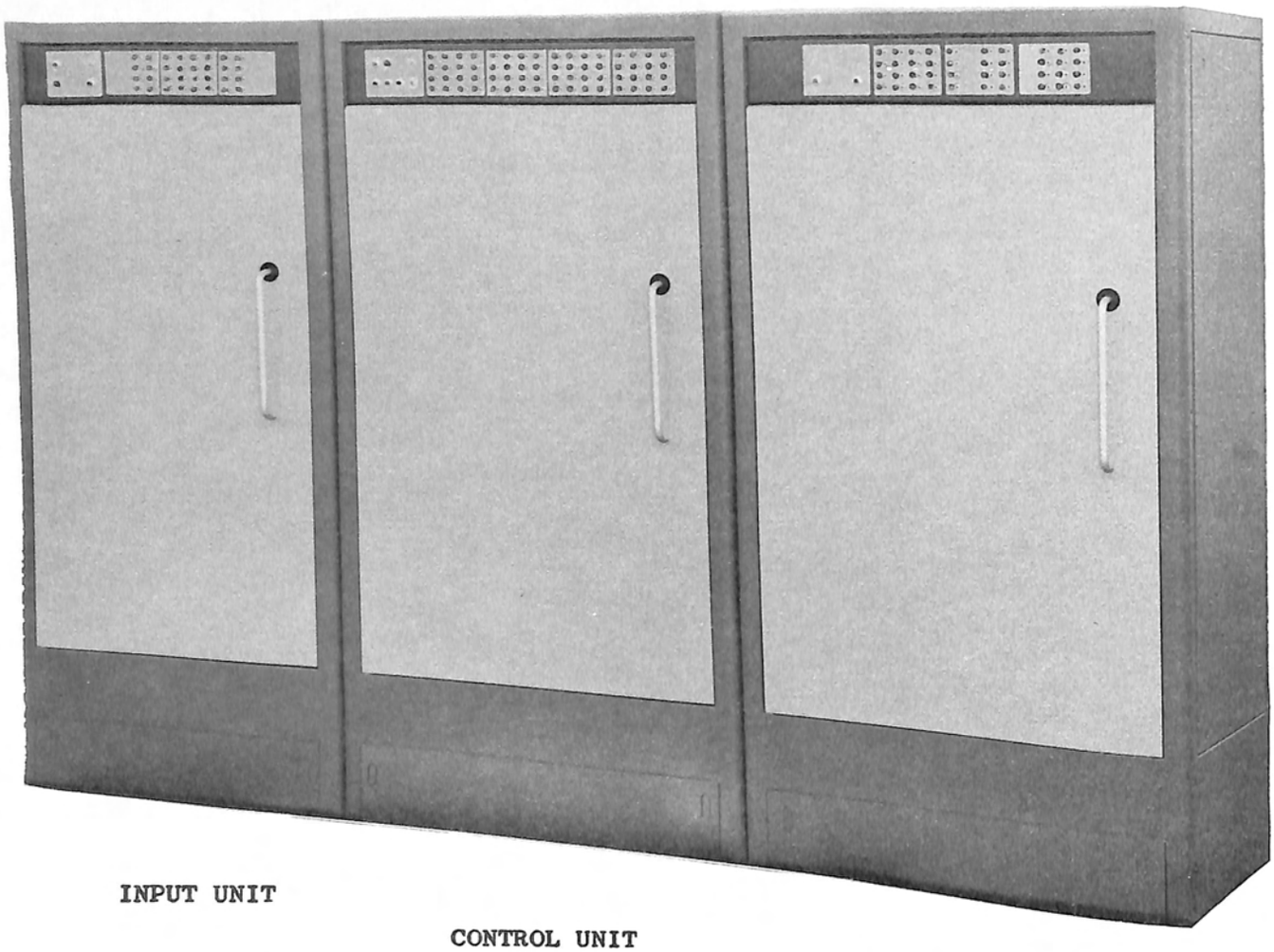


TABLE OF CONTENTS



INPUT UNIT

CONTROL UNIT

OUTPUT UNIT

CARDATRON SYSTEM

GENERAL

The Cardatron System provides a completely flexible means of utilizing standard punch card machinery with the DATATRON Data Processing System.

Designed specifically for general business applications, the Cardatron System offers full buffering and simultaneous multiple input and output. The fully automatic handling of alphabetic information and automatic data editing facilitates simple input-output programming.

The Cardatron System consists of the following components:

One Cardatron Control Unit Model No. 506

One to seven Input Units Model No. 507

One to seven Output Units Model No. 508-509

Input and Output Units may be used in any combination up to seven, i.e., two Input and three Output or three Input and four Output Units, etc.

COMPONENTS

CARDATRON CONTROL MODEL 506

The Control Unit is the heart of the Cardatron System. It governs the activity of the individual Input and Output Units, and provides an information pathway between the Cardatron System and the DATATRON. This unit exercises supervisory control over all punched card machines. The Control Unit is housed in a cabinet 41" by 28" by 78".

CARDATRON INPUT MODEL 507

Each Cardatron Input controls an 80 column punched card reader. The information from the card is converted into decimal digits and stored within the Input Unit on a small magnetic drum. A maximum of seven Input Stations, each consisting of an Input Unit and a card reader, may be used simultaneously. The Input Unit is housed in a cabinet 36" by 28" by 78".

CARDATRON OUTPUT MODELS 508 AND 509

Each Cardatron Output Unit controls a card punch or line printer. Information from the DATATRON drum storage is routed to the Output Unit through the Control Unit. The information from the DATATRON is converted into card codings and stored on a small magnetic drum within the Output Unit. A maximum of seven Output Stations, each consisting of a card punch or line printer and an Output Unit, may be used simultaneously. The Output Unit is housed in a cabinet 41" by 28" by 78".

PUNCHED CARD MACHINES

A variety of standard punched card machines may be used with the Cardatron Input and Output Units. The connection between a punched card machine and its Input or Output Unit is always by standard pluggable cables. The punched card machines may be attached or removed easily, and different combinations can be attached for different jobs.

Input Devices*

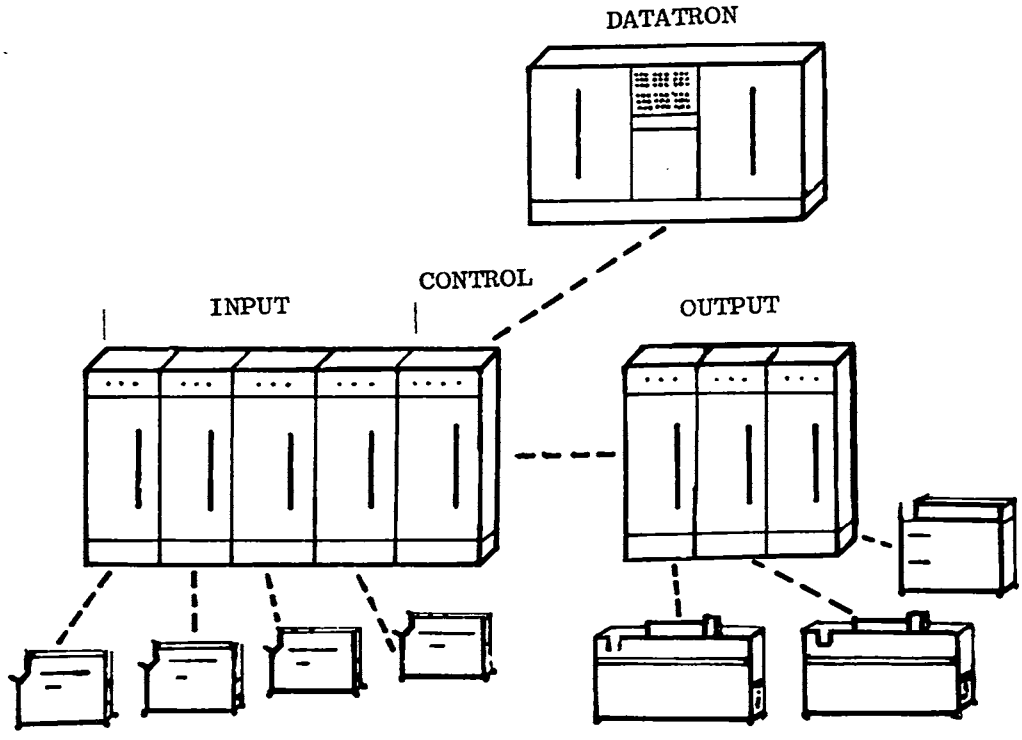
Type 089 Collator:	reads 240 cards per minute
Type 528 Reproducing Punch:	reads 200 cards per minute, and may be used as both input and output.
Type 523 Gang Summary Punch:	reads 100 cards per minute.

Output Devices*

Type 407 Tabulator:	prints 150 lines per minute, both alphabetic and numeric.
Type 419 Tabulator:	prints 150 lines per minute, numeric only.
Type 523 Gang Summary Punch:	punches 100 cards per minute.

* Manufactured by International Business Machines Corporation, New York, N. Y.

FEATURES OF THE CARDATRON SYSTEM



Cardatron System. Figure 1

BUFFERED OPERATION

Within each Input and Output Unit, the small magnetic drum (Figure 5) acts as temporary storage for information, providing completely buffered operation for the DATATRON. The DATATRON receives input information from a buffer drum of an Input Unit and delivers output information to a buffer drum of an Output Unit. Therefore, the computer has no direct contact with the punched card machines. The relatively long time required for mechanical movement of a punched card device is not deterrent to computer operation. (See TIMING.)

The DATATRON can resume useful computation as soon as information is transferred to or from a buffer drum. This transferring time is usually in the order of 20 - 40 milliseconds. The subsequent movement of the punched card device, in filling the buffer drum with new information (input) or emptying a buffer drum (output), is independently controlled by an Input or Output Unit.

SIMULTANEOUS OPERATION

The buffering feature of the Cardatron System permits simultaneous operation of readers, punches, or printers. In a multiple printing situation, the computer can calculate the first set of answers and load the buffer drum associated with the first line printer. Then, while the first printer is operating, the computer can proceed to calculate and load the buffer drums associated with the other line printers one at a time. By the time the first printer has finished printing, the computer will have loaded the other buffer drums and is able to reload the first buffer drum with the next line for that printer. In this way, the computer can utilize up to seven printers continuously, all operating at maximum speeds.

A similar situation exists during input operations. The computer will receive the information from the buffer drum associated with the first of a number of card readers. Then, while this first reader is reading the next card into its buffer drum, the computer can process the data and empty the buffer drums associated with other card readers one at a time. By the time the first card reader has finished reading the next card into its buffer drum, the computer will have completed the emptying of the other buffer drums and will refer to the first buffer drum for additional information. In this manner, the computer can utilize up to seven card readers continuously, all operating at maximum speeds.

AUTOMATIC EDITING

The Cardatron System can perform a variety of editing functions on the information handled. The buffer drum of each Input and Output Unit contains five format bands. These format bands control the scaling and alphanumeric translation of information. Any of the five format bands on a buffer drum may be selected to edit a given card or line of information.

The following are examples of editing functions that can be automatically performed in the Cardatron System.

Deleting Digits. Any characters may be removed on input or output.

Input example:

Information from the card: 1293345678901

Edited computer word: 12945678901

Output example:

Information in computer words: 0000000123

0000000456

Information in output card: 123456

Inserting Zeros. On input only, zeros may be added at the beginning or end of an information field, or inserted between characters in a field.

Example:

Information on input card: 123456789

Edited computer words: 0000000123

0004560000

0700000089

Inserting Blanks. On Output only, blank columns may be added at the beginning or end of an information field, or inserted in the field.

Example:

Information in computer word: 1234567890

Edited output card or line: --123--456--7890

Zero Replacement. On input only, characters on an input card may be replaced by zeros.

Example:

Information on input card:	9876512345
Edited computer word:	0000012345

ALPHANUMERIC OPERATION

The Cardatron System handles both alphabetic and numeric characters on input and output, in any combination. Numeric digits may be used in an alphabetic field.

Alphabetic characters in the DATATRON are represented by two decimal digits each - numeric characters by single digits. In the standard 80 column card code, an alphabetic character is represented by two punches in a card column and a numeric digit by one punch in a column. Certain special characters are represented by three punches in a column. These special characters are represented in the DATATRON by two decimal digits in the same manner as alphabetic characters. Figure 2 is a list of the standard 80 column card coding and the equivalent DATATRON coding. The Cardatron System translates between the two automatically.

CHARACTER	STANDARD 80 COLUMN CARD CODE		DATATRON CODE		
	Zone	Digit	Zone	Digit	
Blank	-	-	0	0	
.	12	8, 3	0	3	
<	12	8, 4	0	4	
&	12	-	1	0	
$	11	8, 3	1	3	
*	11	8, 4	1	4	
-	11	-	2	0	
/	0	1	2	1	
,	0	8, 3	2	3	
%	0	8, 4	2	4	
#	-	8, 3	3	3	
@	-	8, 4	3	4	
+0	12	0	4	0	
A	12	1	4	1	
B	12	2	4	2	
C	12	3	4	3	
D	12	4	4	4	
E	12	5	4	5	
F	12	6	4	6	
G	12	7	4	7	
H	12	8	4	8	
I	12	9	4	9	
−0	11	0	5	0	
J	11	1	5	1	
K	11	2	5	2	
L	11	3	5	3	
M	11	4	5	4	
N	11	5	5	5	
O	11	6	5	6	
P	11	7	5	7	
Q	11	8	5	8	
R	11	9	5	9	
S	0	2	6	2	
T	0	3	6	3	
U	0	4	6	4	
V	0	5	6	5	
W	0	6	6	6	
X	0	7	6	7	
Y	0	8	6	8	
Z	0	9	6	9	
0	0	-	8	-	
1	-	1	8	1	
2	-	2	8	2	
3	-	3	8	3	
4	-	4	8	4	
5	-	5	8	5	
6	-	6	8	6	
7	-	7	8	7	
8	-	8	8	8	
9	-	9	8	9	
+	12	0-9	1	0-9	at sign time only.
-	11	0-9	0	0-9	"

Cardatron System Information Coding. Figure 2

INPUT OPERATIONS

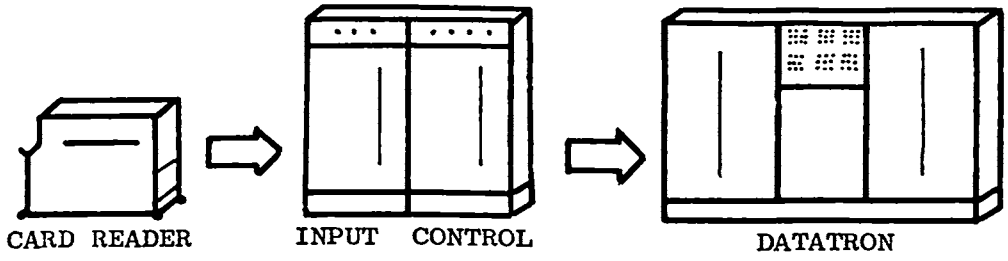


Diagram of Input Operation. Figure 3

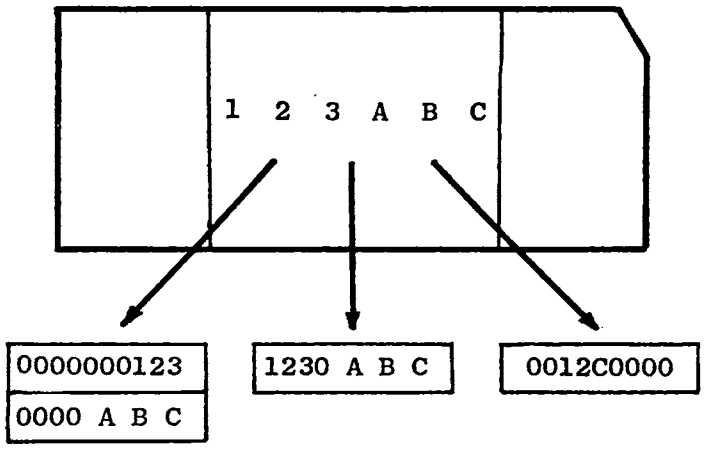
CARDATRON INPUT UNIT

An Input Unit receives information one card at a time from its associated card reader. The read-in is automatic; whenever the card reader is ready and the Input Unit signals that the previous information has been transferred to the computer, the card is automatically read in to the buffer drum. The Input Unit stores the information as long as necessary; then transmits it, on command, to the DATATRON. As soon as the information leaves the Input Unit, the next card reads into the Input Unit automatically.

All the information from the punch card enters the Input Unit, and becomes an "information stream", a serial progression of the characters from the card. The information stream is translated, character by character, into DATATRON codings. Both alphabetic and numeric columns are translated into DATATRON code automatically. Special characters and numbers in a mixed alphanumeric field are converted to pairs of decimal digits.

Certain editing operations are automatically performed upon the information stream as it enters the Input Unit. Zeros can be added to any location in an information field, and unwanted characters can be replaced by zeros or suppressed entirely. Figure 4 gives an example of the use of these functions.

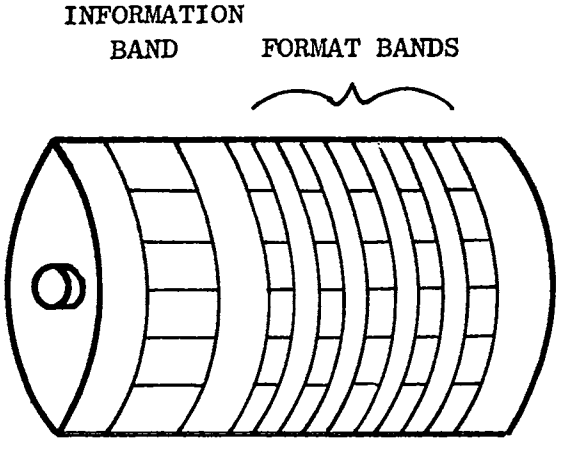
There are two phases to the input operation: (a) from the card reader to the buffer drum, and (b) from the buffer drum to the computer.



Input Editing Possibilities. Figure 4

BUFFER DRUM

Each Input or Output Station contains a buffer drum. This drum is a storage device similar in principle to the main storage drum in the DATATRON. It is two inches in diameter and rotates at 21,600 RPM. The buffer drum is composed of one information band and five format bands (Figure 5).



Buffer Drum. Figure 5

INFORMATION BAND

The information band stores the contents of the input card, after editing and decoding. The editing process may increase the length of the information stream from the card, since zeros may be added to separate, fill, or scale individual information fields. The information band on the buffer drum is 315 decimal digits in length. The maximum number of information digits from one card is 160. Scaling zeros may be interspersed among these. Each card column uses two positions on the information band. These information digits are distributed in sequence to the 315 digit positions on the information band.

When this information is later read into the computer, any part or parts of the information band can be ignored. Figure 6 shows how the expansion and contraction might take place.

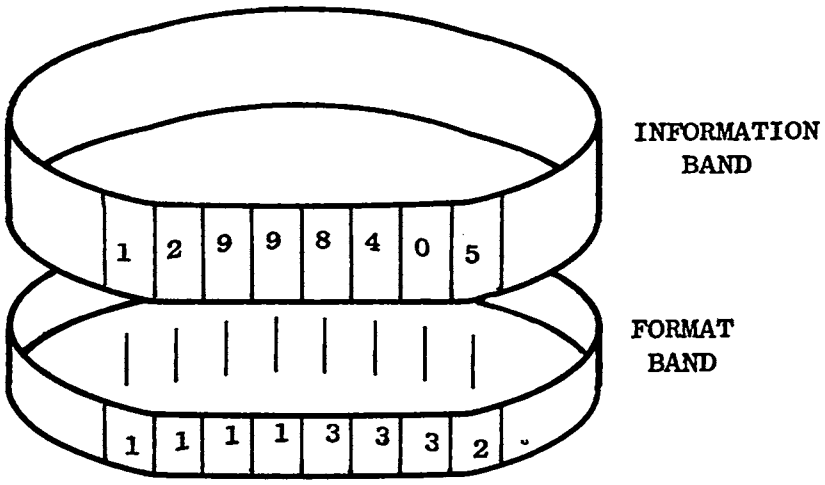
Card	123ABC456
Information Band	000123ABC00456
Computer Word	0001230006

Expansion and Contraction.

Therefore, the information from one input card may be expanded into as many as 28 computer words, or contracted into as few as one.

FORMAT BANDS

All the editing functions, including expansion and contraction, are controlled by a format band. Five format bands are stored on the buffer drum - each the same length as the information band; 315 digits. Any designated punch in the input card, when read by the card reader, determines which of the five format bands is to be used to edit that card. Each card selects its own format band. Different editing formats may be applied to cards in the same file. Each format digit on a format band controls the editing of the corresponding information band digit, 1 through 315.



Schematic Diagram of the Correspondence
of Format Band Digits and Information Band Digits

Figure 6

An alphabetic card column requires two positions on the information band and in the computer. A numeric card column is written on the information band in two digits also, but may be later reduced to one digit in the computer word. Therefore, all card columns require two positions on the information band. Within the computer, alphabetic is <u>always</u> handled as two digits - numeric may be either one or two digits, subject to individual job requirements.

FORMAT DIGITS

<u>Insert Zero</u> Digit "0"

A zero is written in the corresponding information band position. The inserted zero does not replace information from the punch card, but acts as a filler, expanding the card information.

Example:

Card	A A A A
Format Digits	- - 0 0 - -
Information Band	A A <u>0 0</u> A A
Computer Word	A A <u>0 0</u> A A

Transfer Digit Digit "1"

One punch of a card column is written on the corresponding information band position. Transfer Digit is the only format digit which will transfer information punched on the card to a computer word.

Example:

Card	A B C D E
Format Digits	1111111111
Information Band	4142434445
Computer Word	4142434445 = ABCDE

Replace By Zero Digit "2"

The corresponding card column punch is replaced by a zero in the computer word.

Example:

Card	A B C D E
Format Digits	1111221122
Information Band	4142434445
Computer Word	4142004400 = AB00D00

Delete Digit Digit "3"

The corresponding information band digit is omitted from the computer word. Delete Digit contracts the card information and completes the unused portions of the format band.

Example:

Card	A B X 9 C D E
Format Digits	11113333111111
Information Band	41426789434445
Computer Word	4142434445 = ABCDE

Example:

Card	1 2 3 4 5
Format Digits	000003131313131
Information Band	000008182838485
Computer Word	0000012345

SIGN CONTROL

Each DATATRON word is preceded by a sign. A positive sign is the digit 0; a negative sign, the digit 1. The negative sign is provided as a punch on the input card (x or 11). Either a 12 punch or the absence of an x (or 11) punch can indicate a positive quantity. A large amount of input data is nonarithmetic, such as alphabetic description. Normally, data of this type is stored with the digit 0 as a sign. The Insert Zero format digit is used to provide this 0 sign digit.

The position of the x overpunch is normally over the most significant digit of the card field. However, with proper plugboard wiring, the sign may be placed above any card column.

Example:

Card	x 1 2 3 4 5 6 7 8 9 1
Format Digits	11313131313131313131
Information Band	51828384858687888981
Computer Word	11234567891

Normally, the x in a card column translates alphabetically (See Figure 2), but since the x occurs here at the sign time (11th digit), the card column x and 1 will be translated as (-1) instead of an alphabetic J. If the word is to be +1234567891, the overpunch is simply omitted, and the 11 in the format band will translate the card column as (+1).

A second method of indicating signs uses the most significant column of the card field to denote the sign digit. If this digit is one or zero, it can be entered unchanged as the sign digit.

Example:

Card	11234567891
Format Digits	31313131313131313131
Information Band	8181828384858687888981
Computer Word	11234567891

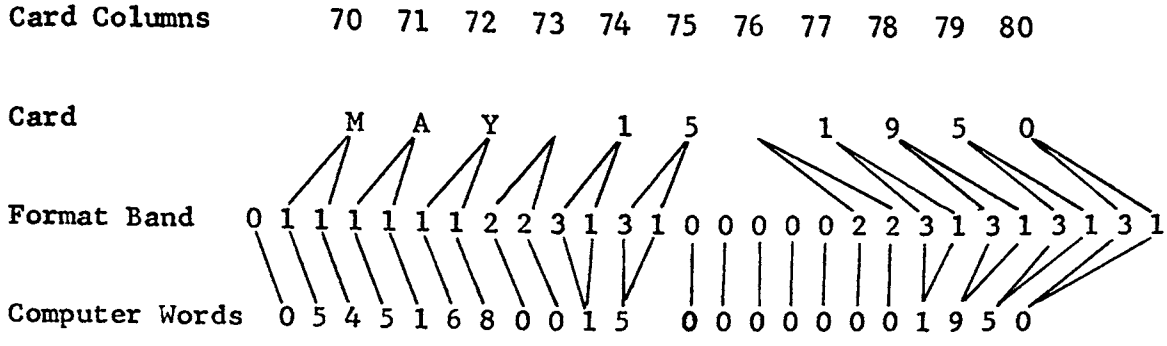
The sign digit is treated just like any other numeric digit, but since it enters the computer at sign time, it will be interpreted as a sign instead of a digit.

SAMPLE PROBLEM

To illustrate the action of the format band digits, a sample is given. Assume that the date "May 15 1950" is to be read into two computer words in the following form:

0 0 0 0 0 0 1 9 5 0

5 4 4 1 6 8 0 0 1 5



Sample Format Band Construction. Figure 7.

The input card will be punched in the usual manner with each alphabetic character represented by a numeric digit with a zone overpunch. A blank column separates the month, day, and year. There are no sign punches provided in the card.

Since each card column produces two decimal digits of information, two format band digits are required to transfer the contents of one card column. The sample computer words have

six zeros in addition to the information transferred from the card. The construction of the format band is shown in Figure 7.

Columns 77 - 80 are numeric information and will be transferred to the computer as such. Transfer Digit 1 will transfer the numeric punch. Since each column must be considered as having two digits (overpunch and underpunch), it will be necessary to delete the overpunch in this numeric field by using a Delete Digit 3. To transfer the figures "1950" requires four sets of 31 digits. The blank space in column 76 is transferred by two Replace by Zero (22) digits. Replace by Zero was used instead of Insert Zero because each card column must be accounted for by format digits other than Insert Zero. The remainder of this first computer word is completed by four Insert Zeros and the sign is provided by another Insert Zero.

The second computer word will begin with columns 74 and 75. Since these columns involve numeric information, they will be transferred in the same manner as the previous example. Two pairs of 31 digits will effect this transfer. Column 73 is blank and will be handled as was column 76 (Replace by Zero). Columns 70 - 72 contain alphabetic punches representing the word "MAY". Each letter is transferred by 11. This accounts for the ten positions of the computer word. The sign of the second word is provided by an Insert Zero. The segment of the format band involving card columns 70 - 80 is complete.

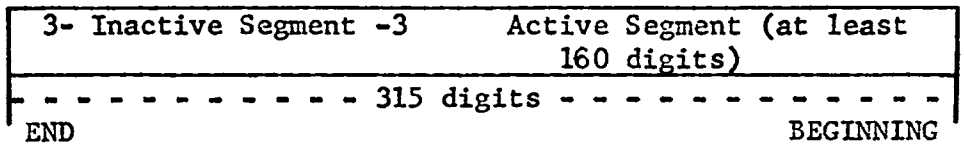
In this example, only columns 70 - 80 were considered. Column 69 will be considered next and on left to column 1. The format digits for all 80 columns compose the "active segment".

The "active segment" is variable in length, depending on the number of format band positions required to edit the information. The minimum length is 160 positions. Each zero not appearing on the card, but required in the computer word, will add one position to the "active segment" length.

The length of the "inactive segment" is the difference between 315 and the "active segment" length and is always filled with Delete Digit 3.

FORMAT BAND CONSTRUCTION

Format bands operate from right to left in editing and transferring information to the computer. The information from the input card is processed from right to left, i.e., column 80 is edited first. Thus, the rightmost digits of the format band edit the rightmost column. The editing proceeds, digit by digit, to the left. The number of format band digits necessary to edit the 80 columns is variable, with a minimum of 160 (two digits per card column). This "active segment" of the format band actually edits the card and appears to the right in the format band (starting with position 1). This is usually less than 315 digits. The remainder of the format band will be placed to the left of the "active segment" filling out the 315 digits. This "inactive segment" will usually consist of 3's causing no information to be entered into the computer.



Input Format Band

Format bands are written on buffer drums from within the computer, so all format bands must initially be stored on the DATATRON drum. Normally, the numbers making up a format band are punched on cards or paper tape. These are entered onto the DATATRON drum into 29 consecutive words. The format band is written exactly as the card is punched reading column 80 first, sign columns included. Finally, the leftmost seven digits of the format band will be entered as the seven least significant digits in the 29th word.

SUMMARY

An input format band will generally be constructed as follows:

(1) The card columns are considered, one by one, from right to left. A desired pair of digits will be written on the buffer drum for each columns. Insert Zero digits can be written between card columns.

(2) After the 80 columns have been written, the format band will be extended to the left until it is 315 digits in total length. Delete Digits (3) will be used for the extension.

Certain pairs of format band digits generally correspond to certain types of card columns. The common pairs can be tabulated as follows:

TYPE OF CARD COLUMN	PAIR OF FORMAT BAND DIGITS	EDITED RESULT
Alphabetic or special character	11	Translated alphabetic character appears as two digits in computer word.
	22	00 appears in computer word.
	33	Column is eliminated from computer word.
Numeric	31	Single numeric digits appear in computer word.
	21	Numeric digit appears in computer word preceded by zero.
	11	Card column is translated alphanumerically; numeric digit appears in computer word preceded by 8.
	33	Column is eliminated from computer word.
Blank	11	Card column is translated alphabetically; 00 appears in computer word.
	22	00 appears in computer word.
	33	Column is eliminated from computer word.

FORMAT BAND SELECTION

Format band selection is performed by digit and/or x selection from the card. The control punch must be read prior to the reading of the information. Any format band may be impulsed (selected) by any card punch, subject to the wiring of the plugboard. Only one format band may be selected per card. Hubs on the plugboard connected to the Format Band Selector within the Input Unit may be impulsed by selected digits from the card in order to activate any desired format band or editing function. (See FIXED EDITING FUNCTIONS below.) Each editing function (3 in total) and format band can be selected by impulsing one of two plugboard hubs: One Card Delay or Two Card Delay. There are then 16 Format Selector hubs on the plugboard.

The Type 089 Collator and Type 528 Accumulating Reproducer, when equipped with a digit selector, may use digits and/or x for control of format band selection. The Type 523 Gang Summary Punch must use x control only since there is only one set of read brushes. If no format band or editing function is selected, the machine will stop.

Once a format band is selected, it cannot be changed during transfer to and from the buffer drum for that card.

FIXED EDITING FUNCTIONS

There are three additional editing actions available. These cannot be changed and are selected in the same manner as a format band.

Numeric Format Editing Function

Numeric Format is available with each of the Input Units. Numeric information can be entered without using any of the five standard programmed format bands. The numeric format reads punches 0 - 9, and requires an eleven column card field for each computer word. This facility provides for initial program input where no format band has been written onto a buffer drum.

The Numeric Format automatically provides the digit pairs 31 and no others. Therefore, a computer digit will result from each pair of format digits. Since there are 157 pairs of format digits, 157 digits would be transferred to the computer. The first 80 are the digits from the card, and the remaining 77 are zeros (blanks from the buffer drum). Therefore, fourteen full words will be stored in the DATATRON - information obtained from the card in the first 8 words, and zeros in the remaining 6 words. The blank words will not normally be wanted. A card indicated signal (to be described

later) is provided to suppress any zeros or unwanted information.

When a computer program is read using Numeric Format, one to seven computer words may be punched on a card (11 to 77 columns). These will load in sequential order, with no blanks, until the "stop read" signal is given from the card. For an example of the use of Numeric Format, see EXAMPLE OF INITIAL INPUT in the chapter on INPUT APPLICATIONS.

Reject Editing Function

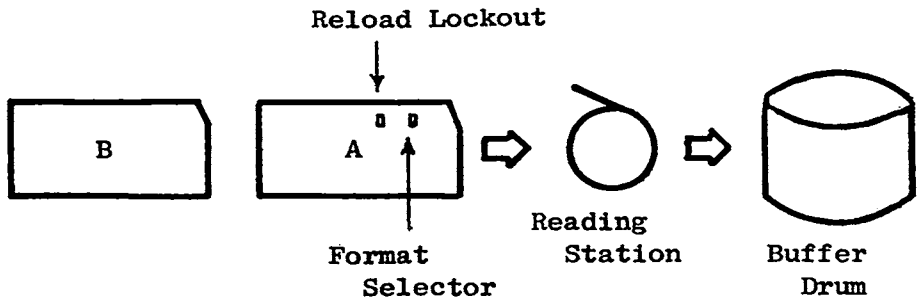
Reject function allows cards to pass through the reader without transfer of information to the computer. Such cards could be headers, index cards, etc., not required for processing. The following card automatically advances in the card reader, and if not another "Reject", will fill the buffer drum.

Reload Lockout Editing Function

The read-in of a card to a buffer drum automatically follows the emptying of the buffer drum. The purpose of reload lockout is to temporarily suspend card reading while the format band(s) is changed. If this reload lockout facility were not provided, a card would be read to the buffer drum on one format band and from the buffer drum to the computer using a differently constructed format band. The information would, of course, be garbled.

The card following the reload lockout card is delayed. The information on the reload lockout card is transferred to the computer using the format band selected by that card. (Note: Two control punches are required on this card, i.e., reload lockout punch and format band selection punch.)

A program previously stored in the computer will change an entire format band. Normally, the last command altering the format bands will also allow the card locked out to read to the buffer drum. For a detailed example, see INPUT APPLICATIONS.



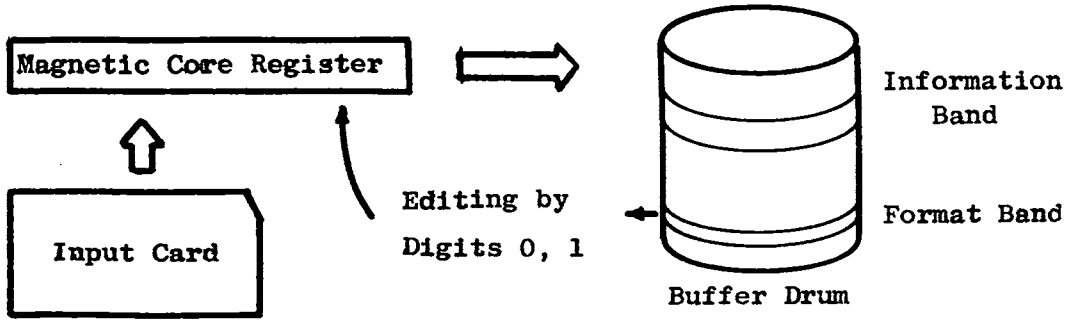
A loads normally, sets reload lockout

B will not load until reload lockout is turned off

Schematic of Reload Lockout. Figure 8

INFORMATION PATH

In Figure 7, the information fields on the punch card were considered from right to left. "1950" entered the first computer word, and "MAY 15" entered the second computer word. The input operation of the Cardatron System always handles information from right to left. The sequence of information digits within a card field will appear in the same order in a computer word.



Schematic of Phase I Input Information Pathway. Figure 9

Input Phase I

As the input card passes under the reading brushes of the card reader, the card is read in parallel; one row of 80 columns at a time. Each of the twelve rows is read separately and the impulses from the reading brushes are sent to the Magnetic Core Shifting Register.

As these 80 impulses leave the register one at a time, they are edited by format band digits 0 and 1. The impulses are converted to binary-coded decimal digits and written on the information band. The information from the card appears on the buffer drum as binary-coded digits, including any inserted zeros. Further editing (Phase II) will occur when the information is transferred to the computer.

Input Phase II

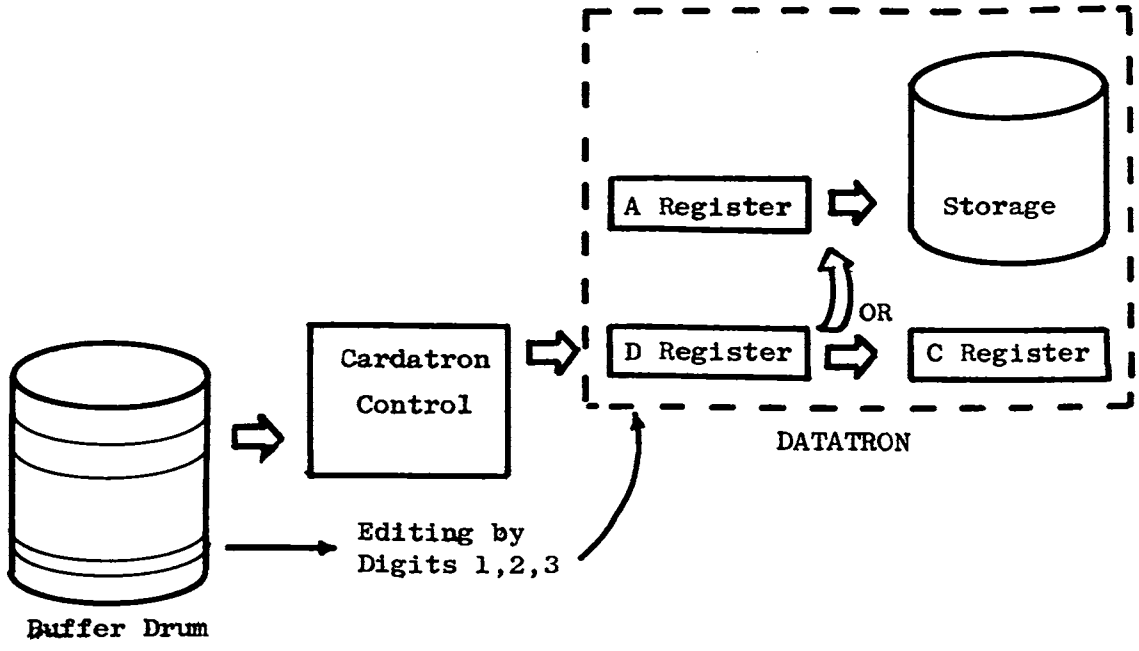
The second phase of the operation will transfer the contents of the buffer drum through the Cardatron Control Unit to the computer. The information enters the computer through the sign position of the D Register. The D Register shifts right until it is filled with eleven digits, at which time the completed word is shifted from the D Register, through the Adder, to the A Register. When the D Register is shifted again for the first of the next 11 digits, the word in the A Register is transferred to main or quick access storage without clearing the A Register. If an extra shift at the end of the "active segment" is not provided, the last word of information will not be stored, but will remain in the A Register. Therefore, if the last word is to be stored, the "active segment" should always include an Insert Zero as the last digit.

This flow of information may be altered by making use of the sign column. This will be discussed in detail in the section on USE OF THE FIRST CONTROL DIGIT.

The input operation is now complete for the first word being transferred from the information band. Subsequent words will follow the same path and are stored in sequence. When all of the information has been transferred, the computer will continue in normal operation.

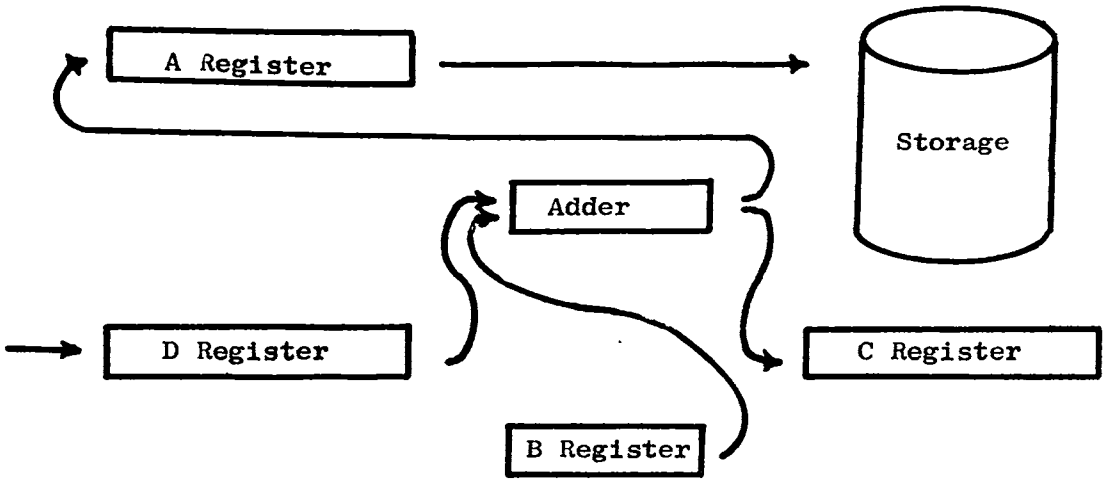
	Phase I	Phase II	
FORMAT BAND DIGIT	CORE REGISTER SHIFTS	INFORMATION TRANSFER	D REGISTER SHIFT
0	No	No	Yes
1	Yes	Yes	Yes
2	Yes	No	Yes
3	Yes	No	No

Schematic of format digit functions. Figure 10



Second phase of input operation. Figure 11

Note that the card fields are stored in right to left order in the DATATRON drum storage. This card field sequence facilitates the use of the B Register in programming. Plugboard wiring may rearrange input or output card formats or tabulations, as desired. Moreover, the field order of the input card is duplicated on output since the output also operates right to left.



Information pathway within DATATRON during input. Figure 12

USE OF THE FIRST CONTROL DIGIT

In the DATATRON, each word of data has a sign of 0 or 1 (plus or minus) associated with it as a digit to the left of the word. If the word is a command, this sign position is called the First Control Digit. Since this is a decimal digit, it may have any value - 0 to 9. Digits 0 and 1 appear as First Control Digits with commands in the computer drum storage. Digits 2 - 7 cause certain operations to be performed when appearing in the First Control Digit position of any word during input.

There are three operations which are caused singly or in combination by these special control digits. They are:

B Modification

As the input word passes through the Adder of the computer on its way to the A Register, the contents of the B Register can be added to the four least significant digits of the word.

Diversion to C Register

An input word can be diverted to the C Register, becoming a command to be executed immediately. Thus, the input information may contain commands for its own special handling. Words diverted to the C Register are not transferred to drum storage.

Control of Information

Another option is available after a word has been diverted to the C Register. The input may continue, if desired, and the next word will be assembled in the D Register for disposition by the new command. Or, after the word has been sent to the C Register, the information transfer can be immediately stopped. This facility is useful when Numeric Format is being used instead of a format band.

Digit 2

Upon input, if a 2 appears as the first control digit of any word, the word will be modified by the addition of the contents of the B Register to the four least significant digits. It will then be sent to memory in the normal manner, but with the 2 changed to a 0 so that the word has a plus sign in storage.

Digit 3

Upon input, if a 3 appears as the first control digit of a word, the word will be modified by addition of the contents of the B Register to the four least significant digits of the word. It will then be sent to storage, but with a 3 changed to a 1, so that the word will have a minus sign in storage. For convenience, the control digits 0 - 3 can be grouped together as referring to "words directed to storage", and presented in tabular form.

WORDS DIRECTED TO STORAGE

Input Control Digit	B Modified	Sign in Storage
0	No	+
1	No	-
2	Yes	+
3	Yes	-

Digit 4

Upon input, if a 4 appears as the first control digit of a word, the word is diverted to the C Register, changing the contents of the Order and Address Registers. The remainder of the input is stored sequentially in drum storage starting with the changed address signified in the Address Register. This word must be another CDR (44) command. Information may be stored in any preselected storage areas controlled by this type word on an input card.

Digit 5

Upon input, if a 5 appears as the first control digit of a word, the word is diverted to the C Register, changing the contents of the Order and Address Registers. The word will be modified by the addition of the contents of the B Register to the four least significant digits. Thus, the quantity appearing in the Address Register is modified. The remainder of the input is stored sequentially in drum storage starting with that modified address. Note: Control digits 4 and 5 are used only with the CDR command.

Digit 6

Upon input, if a 6 appears as the first control digit of a word, the word is diverted to the C Register without modification. The input operation immediately stops and that word (command) is executed.

Digit 7

When 7 appears as the first control digit of a word, the word is diverted to the C Register. The word will be modified by the addition of the contents of the B Register to the four least significant digits. The input is immediately stopped and that word (command) is executed. The digits 4 - 7 can be grouped together as referring to "words directed to C Register" and presented in tabular form.
Note: Control digits 6 and 7 are usually associated with Transfer of Control commands.

WORDS DIRECTED TO C REGISTER

Input Control Digit	B Modified Before Execution	Stops Input Operation
4	No	No
5	Yes	No
6	No	Yes
7	Yes	Yes

CARDATRON INPUT COMMANDS

Three DATATRON commands control the input operation of the Cardatron System. These commands will normally come from a stored program within the computer. However, they can also come directly from the input card if a 6 or 7 appears as the first control digit of the command. A 4 or 5 may be used with a CDR command only.

These commands have the same construction as all DATATRON commands. Each consists of a four-digit address, a two-digit operation code, and five control digits.

CDR 44 Okup 44 xxxx CARD READ

"Read the contents of one card from input u transferring words to consecutive storage cells on the drum starting with xxxx. Reload u with the contents of the next card."

The number of words transferred will depend on the format band configuration used - a maximum of 28. **Digit u** (1 through 7) specifies the Input Unit to be used. Digit p is the breakpoint or skip digit common to all DATATRON commands. (See DATATRON Handbook.)

The instruction address may vary between 0000 and 7999.

Digit k has two functions. First, if digit k is odd, the buffer drum will not refill automatically. This is the Reload Lockout and it is used to permit changing of a format band(s) before another card is read. If digit k is even, a new card will automatically read onto the buffer drum. Second, if digit k is 8 or 9, B modification on input will be ignored. This is called "B Modification Suppress" and is incorporated for the following reason.

All format bands are loaded on the buffer drums from within the computer. A format band is stored sequentially within the computer in 29 computer words. The digits 2 or 3 may appear anywhere in a format band. When a format band is initially loaded into the computer, some of the 29 words entered may have 2's or 3's in the first control digit position. The "B Modification Suppress" is used to allow format bands to enter the computer without changing the 2's and 3's to 0's and 1's and modifying portions of the format digits. Card Read commands which store format bands should then have an 8 or 9 in the digit k positions.

CDRF 48 Ofup 48 xxxx READ FORMAT

"Load Format Band f in input u, transferring words from consecutive storage cells on the drum starting with xxxx."

This command causes an input format band to be changed. Twenty-nine computer words are always transferred to the designated format band. The four most significant digits of the 29th word are meaningless. The digit u may vary 1 - 7.

If a Reload Lockout had been set in the Input Station, it can be turned off or left on by the Read Format command in the following manner:

Digit f in the command specifies the format band to be changed. 0 or 1 selects the first band; 2 or 3, the second; 4 or 5, the third; 6 or 7, the fourth; and 8 or 9, the fifth. If digit f is even, the Reload Lockout will be turned off. In the odd case, the Reload Lockout will be left on, permitting format bands to be changed before the next card is read. Note that k in CDR has the same position and meaning regarding card lockout as does f in CDRF.

Ordinarily, the 29 format band words in the computer should be stored in two quick access loops prior to giving the Read Format command. The address portion of this command would be 4980, 5980, or 6980, so that both loops will be used in transferring the 29 words. Considerable time can be saved by this method. (See section on TIMING.)

CDRI 45 OOup 45 xxxx READ INTERROGATE

"Interrogate Input Station u. If input u is ready to read, clear the R Register. Store in the four most significant positions of the R Register the address (as contained in the Control Counter) of the command next in sequence. Change control to xxxx. If input u is not ready to read, control continues in sequence."

This order facilitates efficient use of the Cardatron System during input. It allows the computer to continue computation if the Input Station has not completed the reading of a card. A series of CDRI commands can be given in the program. When the CDRI command indicates that the Input Unit is ready to read, control can be transferred to a standard card reading routine.

When a CDRI command indicates that a transfer of control is to be carried out, a CUR (21) xxxx is executed.

Examples of the use of these commands will be found in APPLICATIONS.

INPUT TIMING

Execution Time

The execution time for the Card Read command varies since the number of words transferred varies from 1 to 28. Each time the input buffer drum revolves, one word is read and assembled in the D Register. The buffer drum revolves once in 2.78 milliseconds. There will be an initial access time to the buffer drum. Therefore, the time to execute a CDR command is 4.18 (1+.5) revolutions + 2.78 n, where n is the number of words transferred.

As each word is read, it must be stored in drum storage. If it is stored in a quick access loop, a word will be stored every 2.78 milliseconds. (The access time for a quick access loop is 1.7 milliseconds, which is well within the 2.78 millisecond transfer time.) If the information is to be stored in main storage, the access time becomes greater than 2.78 milliseconds/word. The input words will be stored in sequential main storage locations, so the main storage drum must revolve once for each word stored. Therefore, the transfer time requires 17 milliseconds per word, the time for one main drum revolution.

Formulas for execution time of Card Read:

Card Read with input to quick access:

$$T = 4.18 + 2.78\ n$$

Card Read with input to main storage:

$$T = 4.18 + 17\ n$$

T execution time in milliseconds

n number of words transferred

Within the computer, the 20-word contents of a quick access loop can be transferred to main storage in an average of 10.2 milliseconds, using the BF command. Therefore, it will always be more efficient to address a quick access loop and

then block transfer to main storage, even though two commands must be used instead of one.

Example:

12 words from an input card are to be read into main storage locations 3000 - 3011.

Direct Read-In:

Command	Time
CDR 3000	4.17 + (17)(12) = 208.17 ms.

Read-In through quick access loop:

Command	Time
CDR 4000	4.17 + (2.78)(12) = 37.53 ms.
BF4 3000	+ 10.20
	47.73 ms.

The Card Read Format (CDRF) command operates on the same basis as Card Read: one word is transferred to the buffer drum format band per buffer drum revolution.

Including access time for the buffer, the execution time for the CDRF command is 8.65 milliseconds, plus 2.78 milliseconds per word if the words come from the quick access loops. Since the number of words transferred is always 29, the execution time is 89.53 milliseconds. If the words come from main storage, the transfer time is 17 milliseconds per word because the main storage drum must revolve once for each word as before. Therefore, the execution time is 25.50 plus 29 x 17 milliseconds, or 519.50 milliseconds.

Again, considerable time will be saved if the 29 words are transferred to the quick access loops before the CDRF command is executed. Since each loop holds only 20 words, two loops must be used back to back to hold the 29 words of the format band. If this is done, the address of the CDRF command will be 4980, 5980, or 6980.

Example:

Format Band 1 on Buffer Drum 1 is to be loaded with 29 words from locations 3000 - 3028.

Direct Execution:

Command	Time
0110 CDRF 3000	519.50 ms.

Execution through quick access loops:

Command	Time
BT4 3000	10.20 ms.
BT5 3020	10.20
0110 CDRF 4980	89.53
	109.93 ms.

Card Reader Operating Time

Recommended Device	Time to Read One Card
Type 089 Collator	250 milliseconds
Type 528 Accumulating Reproducing Punch	300 milliseconds
Type 523 Gang Summary Punch	600 milliseconds

Since all of the input devices take more time to read a card than the computer requires to read the information on a buffer drum, the computer will be free to operate during part of each card read cycle. Control can either return to internal computation, or to reading another buffer drum. But, if successive CDR commands call for cards from the same reader, the computer loses time in waiting for the buffer drum to reload. Therefore, it is more efficient to arrange a program so that successive references to the same buffer drum have other operations between then, either program steps or references to other buffer drums.

INPUT APPLICATION

The management of a manufacturing firm desires a breakdown of project costs, daily and to-date, by each project currently in production. For purposes of this problem, two major elements of cost will be considered: labor amount and material amount expended for each project. Management feels that cost control necessitates a daily compilation of these figures.

The various accounting procedures use punched cards. However, the two types of information required are maintained by different departments. Due to the varying requirements of each department, the sources of information do not appear on the same card form. Therefore, the material card form does not agree with the labor card form although it will be necessary to use them together in the preparation of this problem. This necessitates the use of two format bands on the input device so that similar information may be read from different card forms.

Since costs to date are required, it will be necessary to maintain a file to accummulate these costs. This file is stored in the main storage. The company has 1000 current projects which are stored in locations 1000 - 1999.

Summary:

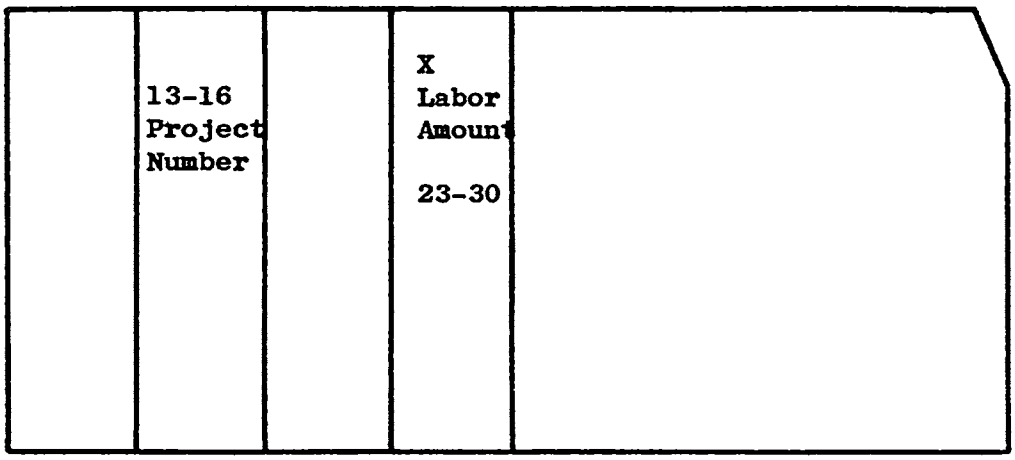
(1) 100 current project costs are maintained.

(2) Material and labor costs are added to each project daily.

FORMAT BANDS

The punched card form for labor amount is as follows:

The project number is four numeric digits and appears in columns 13 - 16. The labor amount appears in columns 23 - 30. Since provisions must be made for adjusting the labor charges between the various projects, a credit is provided as an X punch in the high-order position of the amount field (column 23). The other columns in the card may or may not be punched, but for this application , they will be ignored.

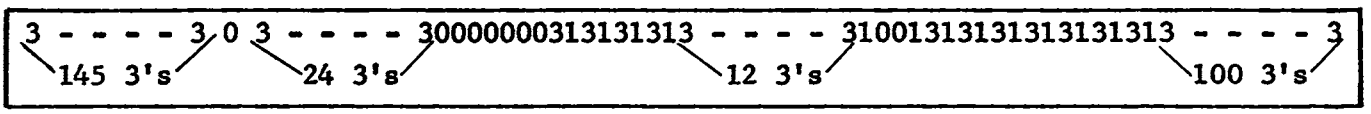


Card Format for Labor Amount Cards. Figure 13

Construction of the format band starts from the right end of the punched card. Columns 31 - 80 will not be used, so the format band will have 50 pairs of delete digits (33). Columns 23 - 30 are the labor amount with a CR X in column 23. This amount field will be considered as one word in the computer: 10 digits and sign. Reading from right to left, the first 7 digits will be transferred to the buffer drum by 7 pairs of 31. The eighth position contains the sign. However, the sign must appear in the leftmost position of the computer word. Therefore, the numeric value of the eighth position is transferred by a format digit 1. Two Insert Zeros are added to complete the word and then the sign is transferred by a format digit 1. If there is a CR X in the column, it will translate as a 1 in the sign position of the computer word. If there is no CR X in the columns, the sign position of the computer word will be zero. Columns 17 - 22 will not be used, so they will be deleted by using six pairs of delete digits (33) on the format band. Columns 13 - 16 represent the project number, and they will be transferred to the buffer drum by a series of four pairs of 31 digits. Six positions and the sign remain to be filled in this word. The word will assume a positive sign and, therefore, seven Insert Zeros will complete this word.

170 format band digits are used to process the 80 columns of the card. This is referred to as the "active segment" of the format band. The "inactive segment" is comprised of 145 delete digits (3) which are used as filler added to the left end of the "active segment". A single Insert Zero is added to the leftmost position of the "active segment" so that the last word of input will be transferred to storage. (See INFORMATION PATH.)

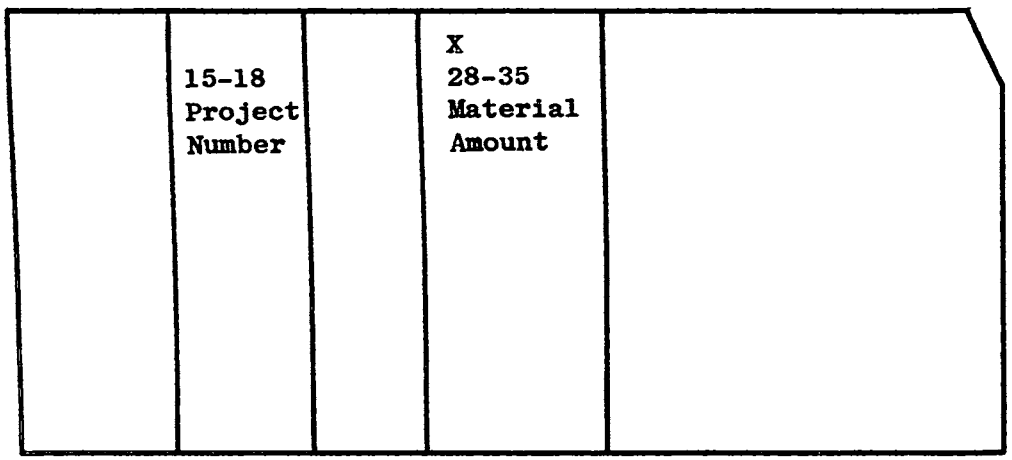
Project No. Labor Amount
X X X X - X X X X X X.X X



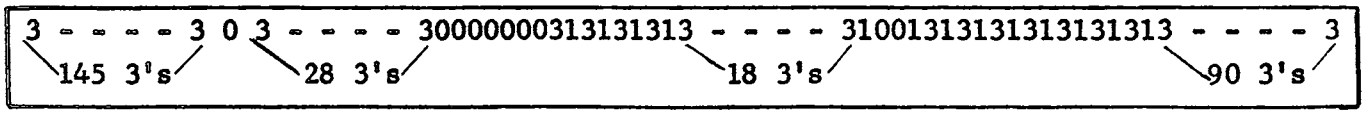
Inactive (145 positions) Active (170 positions)

Format Band for Labor Card Form. Figure 14

The construction of the format band for the material card form is essentially the same. The format band will be constructed in the same manner starting from the right side of the card. Unused spaces will be deleted and the amount field will be transferred by a succession of 31 pairs except for the sign position which will have a 11 pair separated by enough Insert Zeros to complete the 10 digit computer word.. After translating the 80 columns of the card, the remainder of the format band must be filled with delete digits (3).



Card Format for Material Amount Card. Figure 15



Inactive (145 positions) Active (170 positions)

Format Band for Material Card Form. Figure 16

PROBLEM

The accumulated costs for each project are located in storage cells 1000 - 1999. The project number coincides with the storage address so that the contents of any cell is the accumulated cost for that project.

Assume that one card reader will be used as an input device. The program is already in the computer; loaded on loop 6 and loop 7 back to back. The format band for the labor form is loaded on the buffer drum of Input Unit 1. The second format is stored in location 3060 - 3088. A change to the second format band will be necessary. It will be assumed that the same band, No. 3, on the buffer drum must be used. Amount will be stored in 4000 and project number in 4001. Five hundred labor cards and 500 material cards are to be processed. A sample program is shown below.

```
6980            SB    6982
6981   0010     CDR   4000
6982            BA    0498
6983            STC   2000     Process 499 cards of first format.
6984            SB    4001
6985 -          CAD   (0000)
6986            AD    4000
6987 -          STC   (0000)
6988            SB    2000
6989            DB    6981
6990   0110     CDR   4000
6991            SB    4001
6992 -          CAD   (0000)   Process 500th card with reload lockout.
6993            AD    4000
6994 -          STC   (0000)
6995            BT4   3060
6996            BT5   3070     Change format.
6997   0410     CDRF  4980
6998            SB    7000
6999   0010     CDR   4000
7000            BA    0499
7001            STC   2000
7002            SB    4001     Process 500 cards of second format.
7003 -          CAD   (0000)
7004            AD    4000
7005 -          STC   (0000)
7006            SB    2000
7007            DB    6999
7008            STOP
```

Briefly, the program operates in the following manner. The command which reads in the 500th card of the first group has 1's in the second and third control digit positions. The first 1 sets the Reload Lockout which prevents the next

card from being loaded on the buffer drum. This is necessary so that the format band may be changed before the first card of the new group loads on the buffer drum. The second 1 digit indicates that Input Unit 1 will be used.

The new format band could have been loaded directly from the main storage. However, some time is saved by loading it onto loops 4 and 5 first, and then to the format band. (See INPUT TIMING.)

The B Register is being used to accomplish two tasks. In one case, it is being used to look up the appropriate project number in the main storage table. Each part number, after being read in, is sent to the B Register. Then a CAD command is given which has a zero address and a 1 in the first control digit position. Before being executed, this command will have the contents of the B Register added to its address position so that the proper cost will be called from the table. A similar STC command is used to write the new cost figure back into the table after the addition of costs has been made.

The B Register is also being used to tally the number of cards. After each tally, the number in the B Register is stored in location 2000 so that the B Register is free for use in processing the next card.

EXAMPLE OF INITIAL INPUT

In the previous example, it was assumed that the operating program and the format band were already in the computer. A procedure for initial loading of the program and format bands is necessary.

Assume that the costs-to-date file is stored in cells 1000 - 1999. The remainder of drum storage is zero. The format band digits for both formats are on punched cards. These cards are read into the computer. Load the program from punched cards onto loops 6 and 7.

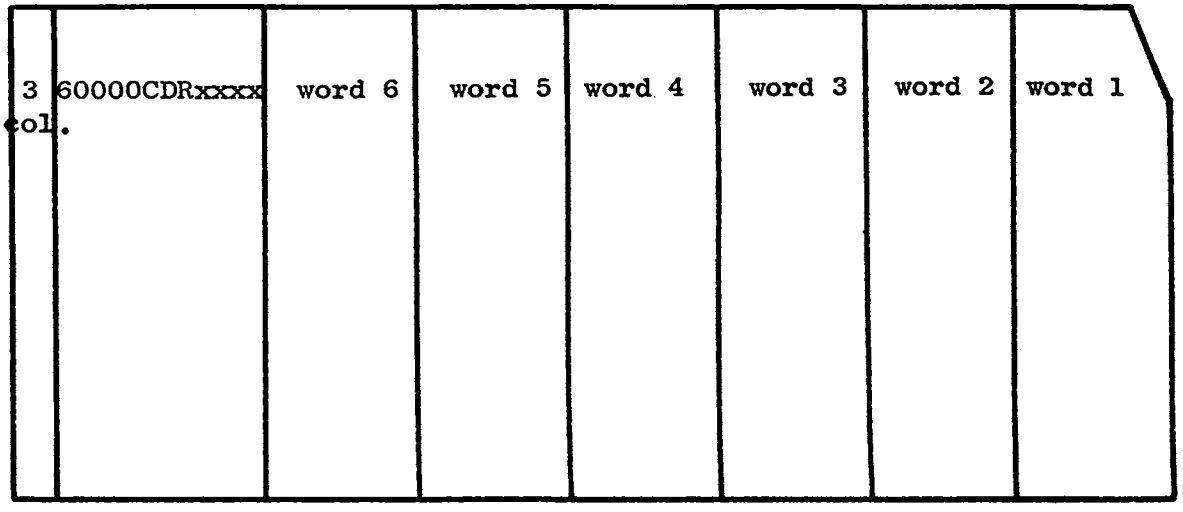
A routine must be provided to

(1) locate the program properly within the computer,
(2) load the format band onto the proper buffer drum, and
(3) start program operation.

The cards to be loaded during this input operation contain the following:

(1) The input locating routine
(2) The input format bands
(3) The program

These cards must be loaded under Numeric Format since the proper format bands have not been written on the input buffer drum. The use of Numeric Format restricts the layout of the input cards. They must be punched as follows:



Input Card for Numeric Format. Figure 17

LOCATING INSTRUCTIONS

An overpunch on the card must select Numeric Format, according to the plugboard wiring of Input Reader 1.

The seventh word on the card is not a word of data, as are the first six. It is the input order calling for the next card, with a 6 in the sign column.

Each card, then, contains the order calling for the succeeding card. The order of operation under this system will be:

(1) An order within the computer calls for the first card. This order is set up manually in the C Register.

(2) Each card calls for the succeeding card in the locating, format, and instruction decks.

On the last card before data, the last instruction transfers to the locating routine. The locating routine writes the format instructions on Format Band 3 and places the program in loops 6 and 7. Control is then transferred to the program.

The information on the cards is loaded as follows:

3016 - 3019	Locating routine (4 words)
3020 - 3048	First Input Format Band (29 words)
3060 - 3088	Second Input Format Band (29 words)
3100 - 3127	Program (29 words)

The locating routine is punched on one card; the format bands on five cards each; and the program on five cards. The last field on each card is an instruction. This field designation is variable. The remaining fields should be blank since they are never read into the computer.

Card No.	Last Used Field	Remarks
1	6 0810 44 3020	Locating routine.
2	6 0810 44 3026	
3	6 0810 44 3032	
4	6 0810 44 3038	Input Format Band 1
5	6 0810 44 3044	B Modification suppressed by 8 in second position of control digits.
6	6 0810 44 3060	
7	6 0810 44 3066	
8	6 0810 44 3072	
9	6 0810 44 3078	Input Format Band 2
10	6 0810 44 3084	B Modification suppressed by 8 in second position of control digits.
11	6 0010 44 3100	
12	6 0010 44 3106	
13	6 0010 44 3112	Program
14	6 0010 44 3118	
15	6 0110 44 3124	Reload Lockout
16	6 0000 20 3016	Transfer control to locating routine.

Locating routine:

```
3016 0410 CDRF 3020    Load input Format Band 3 on Buffer 1.
3017       BT6 3100    Load program on loops 6 and 7.
3018       BT7 3120    Load program on loops 6 and 7.
3019        CU 6980    Transfer control to program.
```

This will complete the input operation and start the program.

SUMMARY

The following steps should be followed for this typical input operation.

(1) Put program deck, followed by data cards, in Card Reader 1. Feed first card past reading station.

(2) Push CLEAR on console.

(3) Push AUTO LOAD on Cardatron Control.

(4) Manually insert 3016 in Address Register.

(5) Push START on console.

The program will now load, position itself, and commence operating automatically.

OUTPUT OPERATIONS

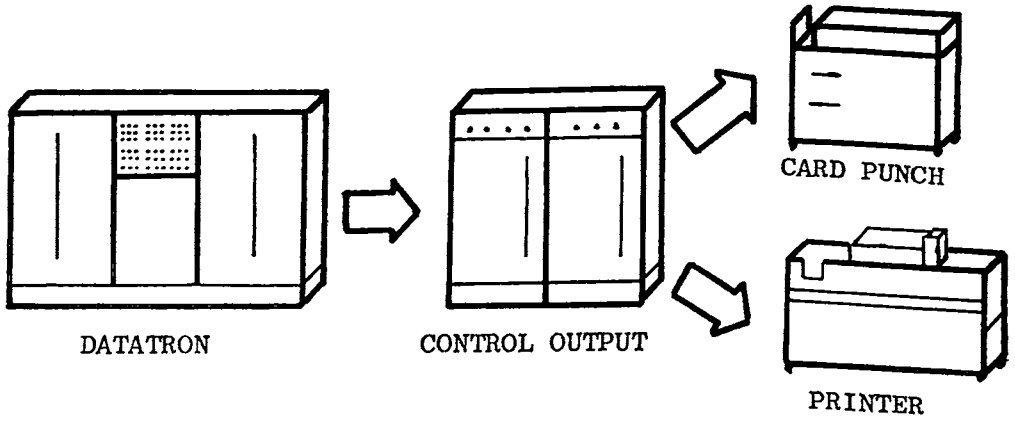


Diagram of Output Operation. Figure 18

OUTPUT UNIT

The Output Unit of the Cardatron System provides a flexible and rapid means for recording information on punched cards or tabulations from the DATATRON. Up to seven Output Units may be employed simultaneously, each with an associated card punch or printer. Simultaneous operation is made possible by the use of a small buffer drum in each Output Unit. The DATATRON will store information on the buffer drum and immediately resume computation. The Output Unit then will independently control the transfer of information to the printer or card punch. As in the case of input, the buffer Control Unit provides a pathway for the information being recorded from the DATATRON.

Output Units are available in two models. One type has a Magnetic Core Register with 80 positions (Model 508). The other type has a Magnetic Core Register with 120 positions (Model 509). Either of these Output Units may be used with a punch or printer. However, if the 80 position Output Unit is used with a printer, only 80 characters per line can be printed. Model 508 may be converted by field modification to Model 509.

AUTOMATIC EDITING

The information for a single card or line of printing may appear in many computer words. Only the pertinent information from each computer word need be recorded.

Example:

Three computer words contain the following:

	Computer Words	Tabulation
Account Number	0000002712	2712--90262----806935
Balance	0000090262	
Value	0000806935	

Only the significant digits need be transferred to the Output Unit. The remaining zeros in each computer word will not be recorded.

The process of repositioning and eliminating information is called "editing". Using the Cardatron System, editing is automatic causing no loss of computer time. Plugboard wiring is recommended as 80-80 for input and output.

AUTOMATIC ALPHABETIC CONVERSION

Alphabetic characters appear as two numeric digits in the DATATRON. (See Figure 2 for complete list of alphabetic and special characters.) On output, the Cardatron System will retranslate automatically to the 80 column card code without loss of computer time. A computer word may contain 12$\underline{48}$345$\underline{67}$6 representing 12$\underline{H}$345$\underline{X}$6 and will be translated automatically. All 80 or 120 characters may be alphabetic if desired, with no limitations.

FORMAT BANDS

Each Output Unit contains a buffer drum composed of five format bands and an information band. The information band will store all the information to be punched in one card or printed on one line. The Card Write command selects the format band before the information is transferred to the Output Unit.

Four digits are used for format bands; 0, 1, 2, and 3. Each performs a specific editing function. The 316 digit format band will be made up of combinations of these four digits.

When information is being recorded on a card punch or printer, each card column or print position will require two signals in the Output Unit: one for the numeric punch of the card column and one for the zone punch. The printer combines the two signals to print a specific character. A card will be punched in the standard 80 column punched code. A format band must provide the two signals, either by two format band digits or by a single format band digit which automatically generates the two required signals.

OUTPUT FORMAT BAND DIGITS

Insert Blank Digit "0"

Insert Blank causes a blank to appear in the output information band. No information is lost from the computer word. "00" must be used if both the numeric and zone punches in a column are to be blank.

Example:

Two spaces are to appear between characters in a printed line.

Computer word:	41	42	43	44	45
Format Band:	--00--00--			--	--
Translation:	A	B	CDE		
Punch-Print Positions:	1	2	3 4	567	

Transfer Alphabetic Digit "1"

Transfer Alphabetic causes a digit on the information band to be transferred to the punched card machine. Normally, "1" is used with alphabetic fields. An alphabetic character is represented in the computer by two decimal positions. When "1" is used with the rightmost position, a numeric (underpunch) signal is produced. When used with the leftmost position, a zone (overpunch) signal is produced.

Example:

Computer word:	4142434445
Format Band:	---1111111111
Translation:	ABCDE
Punch-Print Positions:	12345

Transfer Numeric Digit "2"

Transfer Numeric causes a digit to be transferred exactly as it appears in the computer word. A numeric character is usually represented in the computer by one decimal position. Normally, "2" is used with numeric fields, and produces a single numeric printed digit or single numerically punched card column.

Example:

Computer word:	73914
Format Band:	--22222--
Translation:	--73914--
Punch-Print Positions:	12345

It should be emphasized that the distinction between alphabetic and numeric information is made by the format band. The word (4141414141) can be printed alphabetically as (AAAAA), by the format band digits (1111111111). However, the same computer word can be printed directly as (4141414141) by the format band digits (2222222222). (Note: The action of the format digit pair "01" is exactly that of "2".)

Delete Digit Digit "3"

Delete Digit causes a computer digit to be omitted from the output information.

Example:

Computer word:	1234567899
Format Band:	--2222333222--
Translation:	1234899
Punch-Print Positions:	1234567

SIGN CONTROL

Each DATATRON word has an associated sign. A plus sign is represented by zero; a minus sign by 1.

With punched cards, the sign can be indicated by a numeric punch, 0 - 9, in a separate column to the left of a field, or by an overpunch above the most significant digit of the field. If the sign is to appear in a separate column, it is processed as any other digit. For example, the word (1 1234567899) may be punched with a 1 in a separate sign column using Transfer Numeric. The format band digits will be (2 2222222222).

When the sign is to appear as an overpunch, it must be provided as a zone signal with the leftmost numeric digit of the field. Transfer Alphabetic is required because zone and numeric punches are to appear in a single card column.

Example:

Computer word:	1 7241319826
Format Band:	1 1222222222
	X
Translation:	7241319826
Punch Position:	123456789(10)

The standard printer will print the minus sign, but not the plus sign. If the sign presented to the printer is 1 or 0, the 1 will be printed as a minus sign and the 0 will be suppressed. The printer requires that the sign be translated as a zone signal. Thus, "10" is used rather than "2".

Example:

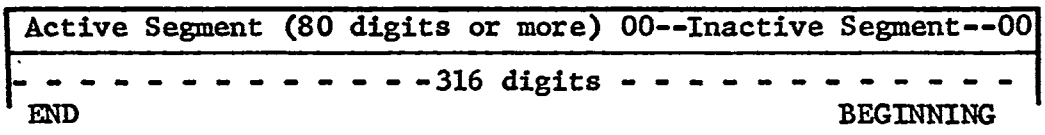
```
Computer word:      1 72413198 2   6
Format Band:       10 22222222 2   2
Translation:        - 72413198 2   6
Print Position:     1 23456789(10)(11)
```

Certain format band digits generally correspond to certain types of output information. The common combinations can be tabulated as follows:

TYPE OF OUTPUT	FORMAT BAND	EDITED RESULT
Alphabetic or special character	11	Translated alphabetic card column.
	33	Deletes output digit pair.
Numeric	2, 01	Numeric column
	10	Overpunch sign with no digit punch
	11	Overpunch sign with digit punch
	3	Deletes single output digit.
Blank	00	Produces a blank card column.

FORMAT BAND CONSTRUCTION

An output format band consists of two sections: "active" and "inactive" segments. The active segment processes the information to be recorded, producing signals for exactly 80 columns or 120 print positions. The inactive segment is simply a series of "filler" digits used to extend the length of the format band to 316 digits. The inactive segment of the format band will be filled with pairs of Insert Blank digits (0's), and will always precede the active segment. It will appear at the right as the first words in computer storage, and as the rightmost digits punched on the first output format card. An input format band, as described previously, has the opposite construction; the active segment follows the inactive segment.



Output Format Band

To illustrate the action of the format band digits, an example of a typical output operation will be given. Two alphanumeric words from the computer will be printed as part of a line on a printer. In this case, the format bands will be the same for punching.

SAMPLE PROBLEM

The date "May 15 1950" is to be printed from two computer words, with spaces between the fields as written. The two computer words contain:

0 0 0 0 0 0 1 9 5 0

and

5 4 4 1 6 8 0 0 1 5

Only the format band segment necessary for dealing with these two words will be considered. Assume that the information is to be placed three positions from the righthand margin of the page.

Since the format band edits from right to left, these three spaces will be the first consideration in the active segment. The Insert Blank digit will be used to provide the spaces; since two of these are needed to deal with each print position, six Insert Blank digits will be used, and the format band will start with (000000).

"1950" is to be printed from the first computer word. Four Transfer Numeric digits (2222) will be required.

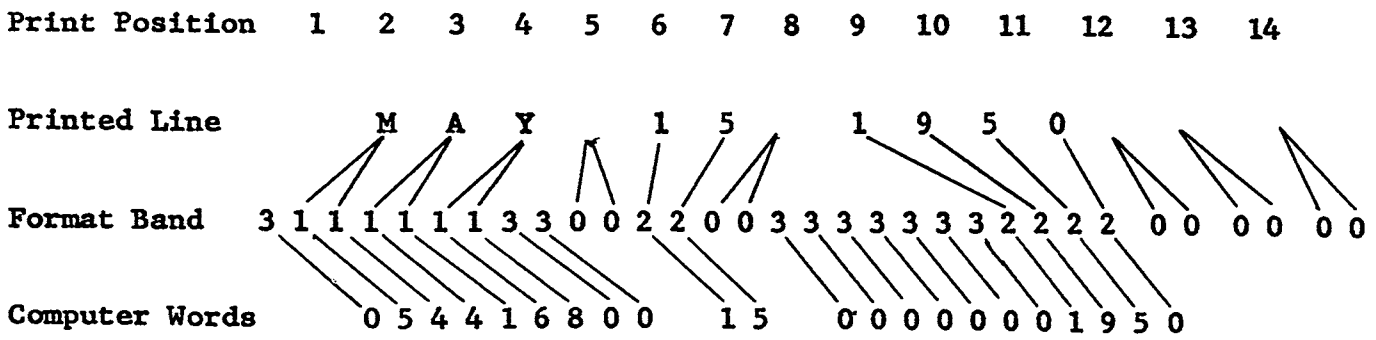
The remainder of the first computer word is six zeros and a plus sign, none of which are needed. These can be eliminated by the Delete Digit. Seven digit positions are to be deleted, including the sign, so that (3333333) will be written in the format band.

A space is needed as the next position on the page. As before, (00) will be used to provide the space.

The second computer word must be edited to provide "MAY 15". The space has already been provided, so the "15" can be transferred by two Transfer Numeric digits (22). Another space is needed after the "15"; (00) will serve as before. Two unwanted zeros remain in the computer word, and these will be deleted as before by two (33's), Delete Digit.

Two Transfer Alphabetic digits are required for each of the letters MAY. Digits (111111) will be used.

The sign of the second word is not required. Delete Digit 3 will be used to suppress the sign.



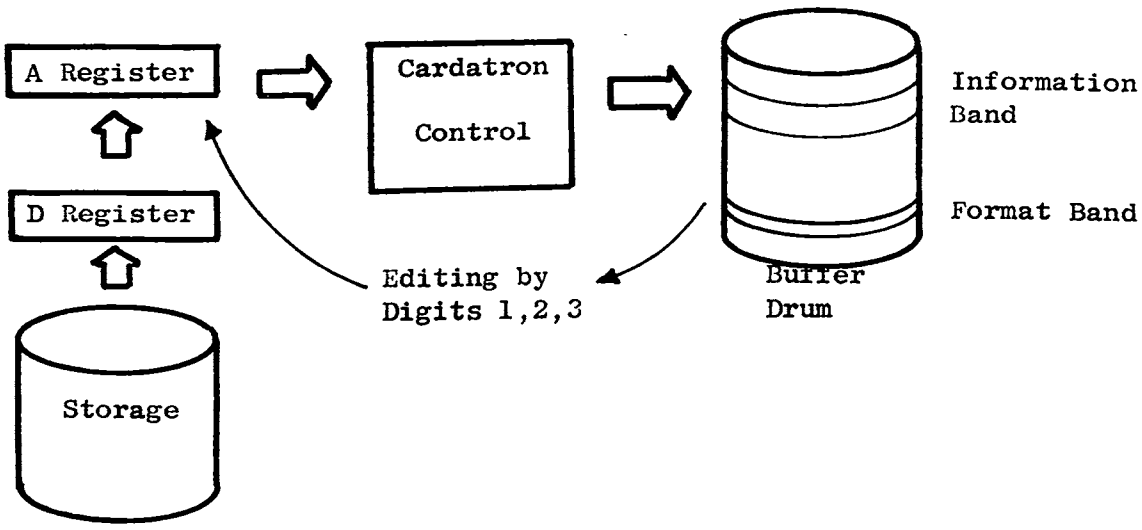
Sample Format Band Construction. Figure 19

INFORMATION PATH

The output operation can be divided into two phases:

(1) The first phase of output concerns the transfer of information from the computer drum storage to the buffer drum in the Output Unit.

(2) The second phase concerns only the transfer of information from the buffer drum to the punched card machine.



First Phase of Output Operation. Figure 20

After the Card Write command is given, the word designated by the instruction address is transferred from the computer storage to the D Register. The word is then directed to the A Register. At this point, the selected format band exercises control.

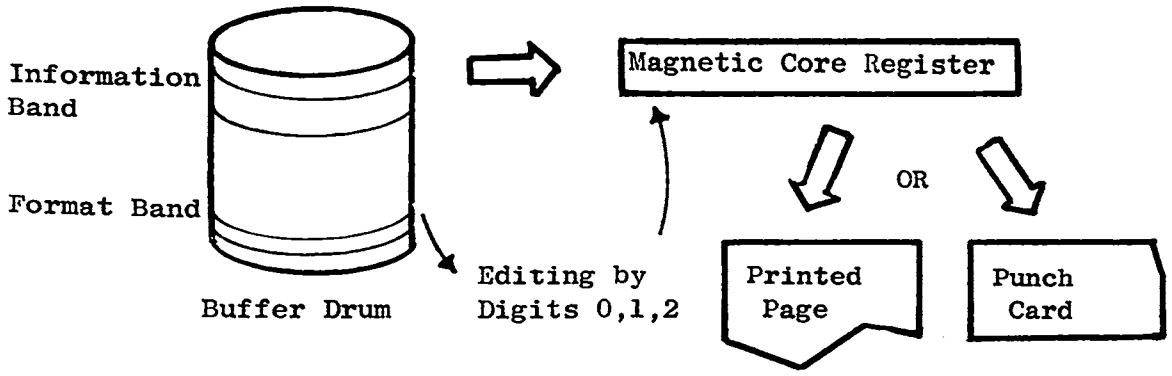
The digits leave from the rightmost position of the A Register. Each time a digit is transferred, the A Register is shifted one place to the right so as to bring the next digit into the exit position.

After eleven digits (ten plus sign) have been transferred, the A Register automatically receives the next word from storage via the D Register, and the process is repeated. The D Register is being filled while the word in the A Register is being transferred to the buffer drum.

The output from the computer occurs one digit at a time. The number of digits transferred (and the number of words) is controlled by the format band selected. The D and A Registers have the function of presenting words and digits in the correct order for transfer, acting as an electronic buffer between the DATATRON drum and the buffer drum.

As each digit leaves the A Register, it passes through the Control Unit. At this point, the characters are translated into card codings and written on the buffer drum of the selected Output Unit - right to left.

The process continues until all 316 digits of the format band have been used. The computer then resumes computation and the first phase is complete. The Output Unit now proceeds to activate the associated card punch or printer, commencing the second phase of the operation.



Second Phase of Output Operation. Figure 21

The Output Unit sends the information from the buffer drum to the card punch or printer. The information is transferred in the same order in which it was written - right to left. The information from the buffer drum enters the Magnetic Core Register from the left and is shifted to the right as each digit enters the register. If there are 80 digits of information, the 80-position register will be filled. If there are 100 digits of information, the first 20 will be shifted out of the right end of the register and lost, while the last 80 remain in the register.

Each (00) pair in the inactive segment causes one "blank" signal to be shifted into the Magnetic Core Register. The number of digits in the inactive segment must be even. If there are 60 (00) pairs, 60 "blanks" will be shifted into the Magnetic Core Register. Following this, the active segment (if properly arranged) will cause exactly 80 digits to be shifted into the register (or 120 digits in the case of a printer). These will force all of the "blanks" created by the inactive segment out of the register. The register will then contain only the desired digits transferred by the active segment.

After one row of information has been sent to the Magnetic Core Register, the output device can be operated. All 80 (or 120) signals are sent simultaneously to the card punch or printer. The Magnetic Core Register will "read out" 12 times for each card or line, refilling between rows.

The first digit taken from the computer is the least significant digit of the first word, and the last digit taken is the most significant digit of the last word. The information appears across the card (or page) with the first word to the right (column 80) and the last word to the left (column 1).

Phase I		Phase II	
FORMAT BAND DIGIT	A REGISTER SHIFT	INFORMATION TRANSFER	CORE REGISTER SHIFT
0	No	No	Yes
1	Yes	Yes	Yes
2	Yes	Yes	Yes
3	Yes	Yes	No

Schematic of output format digit functions. Figure 22

CARDATRON OUTPUT COMMANDS

Three DATATRON commands control the output operation of the Cardatron System. They will be executed from a stored program within the computer, and are constructed in the same form as all DATATRON commands.

CDW tfup 54 xxxx CARD WRITE

"Punch one card (or print one line) from Output Unit u, under the control of format band f. Transfer words from consecutive storage locations starting with xxxx. Control the output device as directed by digit t."

The number of words transferred will depend on the format band selected - a maximum of 28. Digit p is the breakpoint and skip digit common to all DATATRON commands.

Digit t affects the punched card device directly, and can cause any special function of the device to be performed,

such as carriage control, selector operation, etc. Any function of the output device is wired through the plugboard to one of five relays in the Output Unit. These five relays are directly controlled by the digit t. If t is 1, 2, 3, 4, or 5, relay 1, 2, 3, 4, or 5 is transferred, respectively. Digits 6 and 7 cause pairs of relays to transfer. Digit 6 transfers relays 2 and 4; digit 7 transfers relays 3 and 5. Thus, any of the card machine functions can be wired to a relay and directly operated by the CDW command. The relays will drop out at the end of the card machine cycle to which a particular Card Write command applies. Digit t may cause the card machine to perform the function either before or after actual output operation, depending on the function to be performed.

CDWF 0fup 58 xxxx WRITE FORMAT

"Transfer 316 sequential digits including signs starting with cell xxxx to format band f of Output Unit u. This order changes one of the output format bands. Digit 0 is not used, and digit p is the breakpoint and skip digit."

The format band will be written on the buffer drum from right to left, so the rightmost format band digit should be stored in the least significant position of the word in cell xxxx. The format digits are stored actually in 28 consecutive words and the 7 least significant digits of the 29th word on the DATATRON drum. Therefore, 29 computer words are used per format band.

CDWI 00up 55 xxxx WRITE INTERROGATE

"Interrogate Output Unit u. If the buffer drum is prepared to accept information, clear the R Register and store the contents of the Control Counter in its four most significant positions. Change control to xxxx. If buffer drum u is in use (transferring information to a card punch or printer), control proceeds in sequence."

This order facilitates efficient use of the Cardatron System on output. The computer continues computation if the Output Unit is not ready to accept information. A series of CDWI commands can be given in the program; when one is successful, control transfers to a standard output routine.

Since the CDWI is a "record" command, the output routine can use the contents of the R Register to set a command returning control to the main program after the output operation has

been performed. This means that when several CDWI commands appear in the main program, there will be no confusion about which of them caused the transfer.

OUTPUT TIMING

See section on INPUT TIMING. The considerations given for input timing are practically exact for output timing.

CDRF and CDWF are alike.

CDR and CDW are alike except CDW requires one extra buffer drum revolution (2.78 ms.) when the quick access loops are used and 17 milliseconds extra when a main storage address is used.

OUTPUT APPLICATION

An automobile parts depot keeps a file of the current inventories for 1500 parts in the main storage. There is a two-word entry for each part in the following form:

Word 1	000XXXXXXX	Current Inventory
Word 2	XXXXXXXXXX	Alphanumeric Part Number

Periodically, the entire file is recorded on cards. In addition, all quantities with stock levels less than ten are to be listed on a printer as well as punched in cards. Two card punches are connected to Cardatron Output Units 1 and 2, and a printer is connected to Output Unit 3.

The file occupies storage locations 0000 - 2999, and the program is to operate in quick access loops 6 and 7. Both punches are to be used for the master list. The cards need not be in sequence. The printed list of low inventories must be sequential.

Output card form:

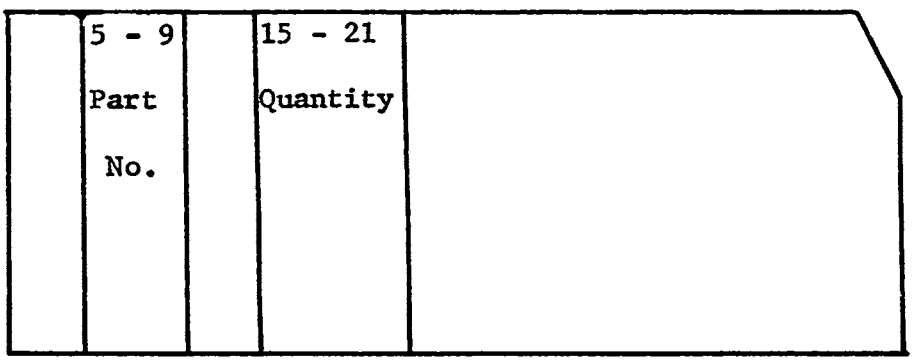
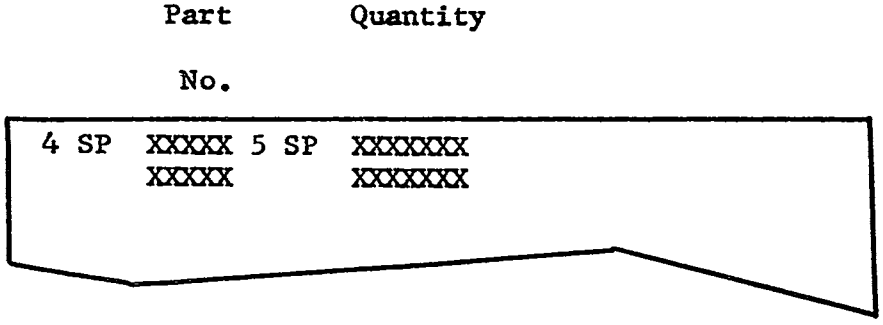


Figure 23



Printed line form. Figure 24

FORMAT BAND

Since the cards and the list have the same format, only one format band need be constructed to serve both. It will be constructed in the usual way, starting at the right end of the active segment.

First, 59 blank columns appear (22 - 80). 59 (00) pairs will provide these. The quantity will then be punched in a 7-column numeric field (15 - 21). (2222222) will punch the seven columns. Three zeros and the sign remain, and these will be deleted by (3333). The five blank columns 10 - 14 are next, and will be provided by five (00) pairs. Then, the alphanumeric part number occupies ten computer digits and will be punched and printed in five alphabetic columns. Five (11) pairs will perform the translation as desired, and the sign of the word will be suppressed by a 3. Finally, the four spaces to the left will be provided by four (00) pairs.

This completes the active segment of the format band - 158 format digits. The inactive segment, 316 - 158 is 158 format digits. This is an even number, so no adjustment is necessary. Therefore, 79 (00) pairs will be written to the right of the active segment - and the format band is complete.

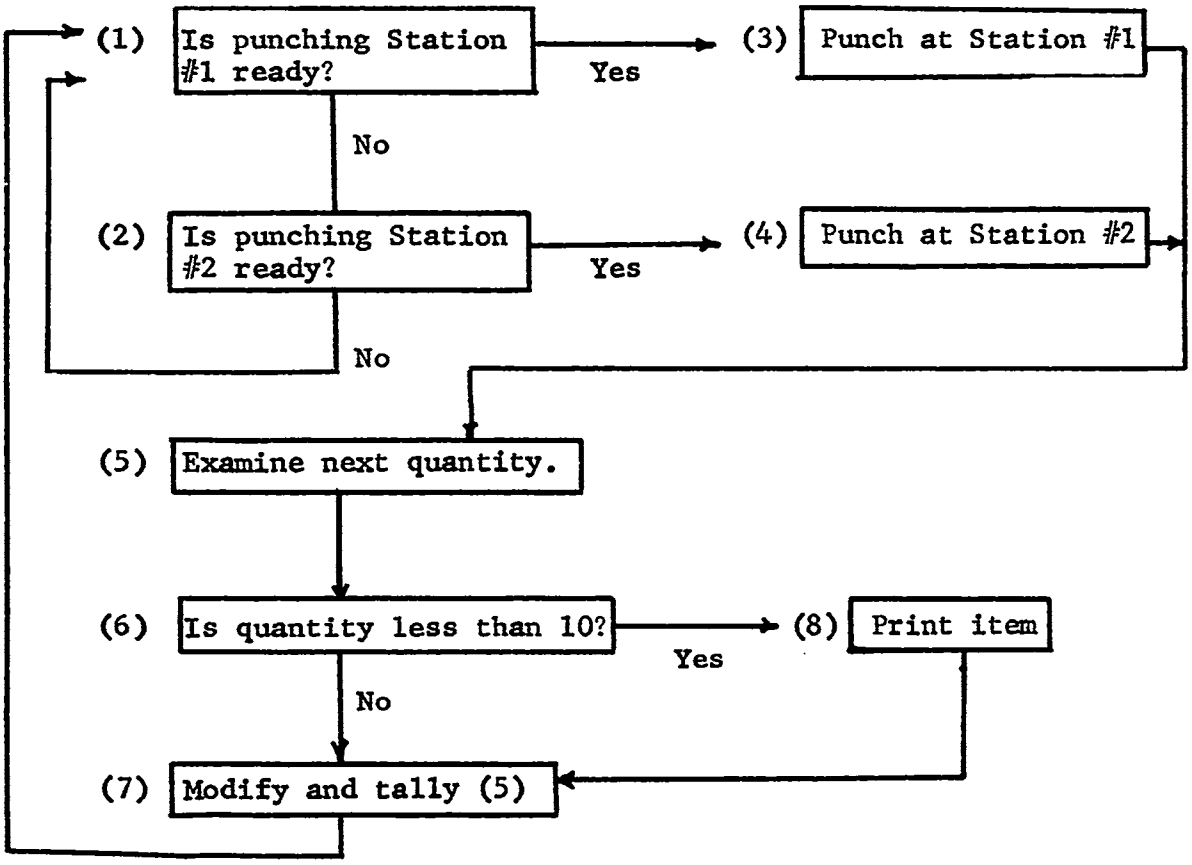
00000000	31111111111	0000000000	33332222222	0-------0 118 0's	0--------0 158 0's
Columns 1 - 4 Blank	Columns 5 - 9 Part No.	Columns 10 - 14 Blank	Columns 15 - 21 Quantity	Columns 22 - 80 Blank	
Active Segment					Inactive Segment

Format Band

PROGRAM

It will be assumed that the format band is already loaded as Format Band 1 of the three buffer drums. Also, it will be assumed that the program is loaded in quick access loops 6 and 7.

A Flow Chart of a possible program is shown in Figure 25.



Flow Chart. Figure 25

Boxes (5), (6), and (8) perform the testing and printing. Box (7) is a standard modify and tally which stops the program after 1500 executions. If the test has indicated that the quantity is less than ten, the print occurs in Box (8).

Boxes (1) through (4) constitute a routine to sequence the two punches automatically, so as to minimize output time. The punches are interrogated in turn by (1) and (2), and whichever is ready first punches the information. This will cause the two punches to fall into an alternating sequence with the computation for each item done during punching time.

The coding corresponding to the Flow Chart is shown below.

6000	00010	CDWI	6003	(1)
6001	0020	CDWI	6005	(2)
6002		CU	6000	
6003	0110	CDW	4000	(3)
6004		CU	6006	
6005	0120	CDW	4000	(4)
6006	8500	BT4	(0000)	(5)
6007		CAD	4000	
6008		SU	6019	
6009		OSGD	6007	(6)
6010		CC	6016	
6011		CAD	6003	
6012		AD	7000	
6013		CC	6018	(7)
6014		STC	6003	
6015		CU	6000	
6016	0130	CDW	4000	(8)
6017		CU	6011	
6018		STOP		
6019	0000	00	0010	
7000	0001	00	0002	

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