3-1964

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Karolyn Edwards
Iowa State University

David E. McFarland
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Disciplines
Computer Sciences | Physical Sciences and Mathematics

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AMES LABORATORY

RESEARCH AND DEVELOPMENT REPORT

U.S.A.E.C.

IS-851

Mathematics and Computers (UC-32)
TID 4500, April 1, 1964

UNITED STATES ATOMIC ENERGY COMMISSION
Research and Development Report

1401 MULTIPLE UTILITY PROGRAM WITH SIMULTANEOUS INPUT-OUTPUT PROCESSING

by

Karolyn Edwards and David E. McFarland

March, 1964

Ames Laboratory
at
Iowa State University of Science and Technology
F. H. Spedding, Director
Contract W-7405 eng-82

IS-851

This report is distributed according to the category Mathematics and Computers (UC-32) as listed in TID-4500, April 1, 1964.

Printed in USA. Price $ .75 . Available from the

Office of Technical Services
U. S. Department of Commerce
Washington 25, D. C.

CONTENTS

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INTRODUCTION

The Simultaneous Utility Program for the IBM 1401, POGINOUT, performs both card-to-tape and tape-to-printer/punch operations near-maximum speed. This is done to prepare magnetic tape input for the IBM 7074 and to process magnetic tape output.

The operation to be performed depends on the setting of sense switches. The program was written as a utility program for the POGO system and as a card-to-tape processor for the FLAG system. It could easily be adapted to many executive systems.

SECTION I. INFORMATION SPECIFIC TO PØGINØUT FOR USE WITH PØGØ, PROGRAMMER ORIENTED GENERALIZED OPERATOR

Minimum Machine Requirements

The 1401 system necessary to operate this program includes:

1. IBM 1401 Model C3 (tape system with 4000 storage positions)
2. IBM 1402 Card Read-Punch unit
3. IBM 1403 Printer, Model 2
4. 2 Magnetic tape units: IBM 729 II and IBM 729 IV; or 2 IBM 7330 units.
5. Six additional sense switches
6. Advanced Programming Feature
7. High-Low-Equal Compare Feature
8. Print Storage Feature
9. Early Card Read Feature
10. Read-Punch Release Feature

Input Specifications

1. Specifications for all operations

The object deck of POGINOUT must be immediately followed by a date card. Columns 1-6 are punched with the date. This supplies the date for account cards and header lines. If the date card is blank, no header line will be written when a new page is begun. Also, if the date card is blank one tape mark will signify the end of the reel.

Sense switch A must be on at all times. Sense switch E may be

turned on at any point to stop the current operation. The program will halt normally immediately after being loaded. Sense switch E should be turned on to halt operations rather than pressing STOP. A halt under control of switch E waits until the current operation is finished. Pressing the STOP button does not do this.

2. Tape-to-printer/punch operation

Sense switch G must be on to indicate this operation. The 7074 output tape must be mounted on tape unit # 1. Four tape marks sensed on tape normally terminate the operation. Multiple files per reel will be processed as they are reached.

Code words may be used to control processing. The first character of each printed line acts as forms control unless the code word indicates otherwise. See page 9 for more information on code words and forms control characters.

The maximum block length is 1200 characters. The maximum length record is 132 characters for printing, 80 for punching. The records may be of fixed or variable length and may be blocked. Variable length records require record marks. The output will be processed with one record per card or line. Whether the record is printed or punched depends on the code word preceding the file.

When overflow suppress is not being used and page headings are not being omitted, a segment mark or a tape mark on tape will cause a new page to be printed. "SEGMENT MARK" or "TAPE MARK" is printed on the new page and processing continues. A tape mark also resets the

code-word conditions and looks for a new code word.

All cards punched from the output tape are selected into the 8/2 stacker. This includes account cards and card output. They may be separated later by a special option.

3. Card-to-tape operation

Sense switch F must be on for this operation. The cards to be put on tape must immediately follow the date card. Each card will be put on tape as a card image. The cards read are selected into stacker 1. Each POGO or control card is numbered and a duplicate punched, which is then selected into stacker 4.

The POGO cards are written on tape in card image as well as being punched. Each POGO card is sequentially numbered in columns 71-75 first. Other control cards, FORF, FORN, WTM, and WSM are not written on tape in card image. The WTM and WSM cards cause a tape mark or segment mark respectively to be written on tape. A WTM or WSM card also causes the cards following to be written in alphameric mode. A FORF card causes following cards to be written on tape in alphameric mode until a FORN is encountered. A FORN causes following cards to be written in numeric mode until a FORF or WTM is encountered.

The control cards are punched starting in column 76 and continuing to column 78 or 79. All other columns are left blank. When the last card or the first FLAG card is sensed two tape marks are written on tape as a signal to POGO that the end of the input tape has been reached.

Input cards for the FLAG system may also be taped using this program. Both FLAG and POGO may be put on the same tape. When a <- character is encountered in column 1 only, the card is both punched as a log card and written on tape. When this character is encountered in both columns 1 and 2 a tape mark is written on tape.

When the last card or the first POGO card is sensed, a stop signal is written on tape to tell FLAG that the input tape is finished.

Code Words

Code words are used to indicate to PØGINØUT the form of the following output tape. A code word is effective until the next tape mark is encountered. The code words and their effect are as indicated:

none: Single records will be printed with forms control. A record may or may not be terminated by a record mark. Variable length blocked records, each terminated by a record mark will be deblocked and printed with forms control. FØRTRAN punched output will be processed. This is a record starting with five dollar signs, $$$$$. The dollar signs will be deleted and the following 80 characters (or fewer) will be punched.

FPXXX: Single records with or without record marks will be printed with forms control. The carriage control character will be printed as a blank. Fixed length blocked records without record marks will be deblocked and printed with forms control in lengths of XXX characters per record. The three-digit integer XXX must equal the number of

characters for each line.

FP : Single records with or without record marks will be printed with forms control. The carriage control character will be printed as a blank. Variable-length blocked records, each terminated by a record mark, will be deblocked and printed with forms control.

FP +: Single or variable-length blocked records will be processed as with the FPbbb code word. All alphameric records will be printed with forms control, printing the carriage control character as a blank. All numeric records will be punched. If a numeric record is longer than 80 characters, only the first 80 will be punched.

PRXXX: Single records with or without record marks will be printed with single spacing. Fixed-length blocked records will be deblocked and printed single spaced. Each record, whether single or blocked, must contain XXX characters per record where XXX is the three-digit integer in the code word.

PR : Single records with or without record marks will be printed with single spacing. Variable-length blocked records, each terminated by a record mark, will be deblocked and printed single spaced.

PR +: Single or variable-length blocked records will be processed as with the PRbbb code word. All alphameric records will be printed single spaced. Numeric records will be deblocked, punching the first 80 characters of each record.

KOXXX: Single records with or without record marks and blocked fixed-length records without record marks will be processed. Each record will be printed with forms control and overflow suppression. Overflow suppression occurs when sensing the end of a page does not cause a new page to be started. Printing continues right over the end of a page.

KO : Single records with or without record marks and blocked variable-length records with record marks are processed, deblocking when necessary. Records are printed with forms control and overflow suppression.

KO +: Single records and blocked variable-length records with record marks are processed. Deblocking is done where necessary. Alphameric records are printed with forms control and overflow suppression. Numeric records are punched.

PUXXX: Single records and fixed-length blocked records without record marks are processed, deblocking the blocked records. All records are punched; record length must not exceed 80 characters.

PU : Single records and variable-length blocked records with record marks are processed, deblocking where needed. All records are punched and must not exceed 80 characters.

A printed record must not exceed 132 characters due to the width of the paper used for printing.

Sense Switches

Each time the program is loaded into core it halts to allow checking of sense switch settings. These settings determine the operation to be performed. Whenever a change in operations is desired, setting switch E will cause this same halt. Turning off E and pressing START will resume operations. The settings and the operations caused are as listed.

A - always up. This switch causes the last card read to be sensed.

B - double space output. When this is up all output from tape is double spaced. This is useful when many incorrect carriage controls are being processed.

C - listing. Cards may be placed in the card reader and a list printed as the cards are read.

D - separate output. All punched output from an output tape is selected into a single stacker. Placing this output in the reader and cards of a different color in the punch allows this output to be separated by account. Each time an account card is read it is selected into a different stacker and a blank card is punched in its place in the stacker with the rest of the output. In this way punched output can be manually separated to go to the correct user.

E - normal halt. Used as a stop to change operations or correct a physical condition.

F - input. Whenever this switch is on, cards will be read from the card reader and written on tape.

G - output. Whenever this switch is on, the output tape will be processed. If G is turned off while an output tape is being processed, the computer will halt at the end of the current account.

F & G - simultaneous input and output. When both F and G are on, cards will be written on tape at the same time an output tape is being processed. All this is done at near-maximum speed.

none - log listing. When no switches are on, the POGO or FLAG cards will be numbered and listed. This log listing is used by the 7074 operators.

Operating Speeds

When POGINOUT is performing both input and output functions simultaneously, it operates at nearly the maximum speed of the 1403 printer. Under ideal conditions, the two operations are performed at the maximum of 600 lines of printed output and 600 cards read per minute.

There are several conditions which slow this down to an average of about 565 cards or lines per minute each way. Any forms control other than single spacing causes a delay in the cycle. This occurs normally at least once for every new page. More extensive forms movement takes place under control of the first character of a line. This may be very time consuming as in the case of a full-page skip. The skip-after-print controls are buffered so that they take no extra time. This is done by the arrangement of the order of the card read instruction and the

print instruction. Because no extra processing time is needed, the write instruction may take place during the 21 ms between the start read feed instruction and the read instruction as it may when there is no forms control. When forms control is before the print, the print instruction may not be placed between the start read feed instruction and the read instruction. The time for forms control exceeds the 21 ms maximum allowed.

The reading of a very large block from tape causes a reduction in processing speed. A single record of 132 characters or fewer can be completely contained in the basic loop. However, any block composed of several logical records takes longer. This causes a pause in the cycle each time a block is read from tape and, hence, reduces speed.

The punching of cards causes a considerable delay in the whole cycle. Each punch requires 240 ms of machine time. A small amount of this may be used for processing. In most cases the first part of the card read time is overlapped onto the last 22 ms of the punch cycle. Punching occurs both in the card-to-tape operation and the tape-to-printer/punch operation. Each time a control card is sensed when reading cards it is punched for later use as a log. Various codes and code words indicate that certain records of the output tape are to be punched rather than printed.

In case that only the output is being processed (no card-to-tape operation), speed is increased very little. The only time saved is the time used for punching of control cards. Since this happens only occasionally,

omitting it saves very little time on the print cycle. However, if the processing of the output tape is omitted, the card-to-tape operation is speeded up considerably. In this case the basic cycle is 75 ms. Cards can be processed at the rate of 800 cards per minute maximum.

The punching of control cards cuts this rate a little.

For more explicit timing information see the timing diagrams, Figs. 2-10.

SECTION II. INFORMATION APPLICABLE TO ANY 1401 SIMULTANEOUS UTILITY PROGRAM FOR PERIPHERAL TAPE PROCESSING

Carriage Control

Certain characters located in position 1 of a print line cause specified carriage movement. A digit causes an immediate skip to a specified channel in the 1403 carriage tape. An alphabetic character with a 12-zone causes a skip to a specified channel after the line is printed. An alphabetic character with an 11-zone causes immediate spacing and one with a zero-zone causes spacing after the line is printed. The forms control for each character is shown in Fig. 1.

d	Immediate skip to	d	Skip after print to
1	Channel 1	A	Channel 1
2	Channel 2	B	Channel 2
3	Channel 3	C	Channel 3
4	Channel 4	D	Channel 4
5	Channel 5	E	Channel 5

Fig. 1, (cont.)

d	Immediate skip to	d	Skip after print to
6	Channel 6	F	Channel 6
7	Channel 7	G	Channel 7
8	Channel 8	H	Channel 8
9	Channel 9	I	Channel 9
0	Channel 10	?	Channel 10
#	Channel 11	.	Channel 11
@	Channel 12	)	Channel 12

d	Immediate space	d	After print-space
J	1 space	/	1 space
K	2 spaces	S	2 spaces
L	3 spaces	T	3 spaces

Fig. 1. 1401 Carriage control characters.

Timing

General

When attacking the problem of simultaneous input-output processing on the 1401, it appears that there are two solutions. Without the process-overlap feature a program cannot be written that will run at maximum card read speed (800 cards/min) and maximum printer speed (600 cards/min) simultaneously. One has the choice of 800-535 (cards-lines) or 600-600 (cards-lines). The first one overlaps the print and read cycles

as in Fig. 2, three cards per two lines. Using this method there are 89 ms available in the cycle for housekeeping or 17.8 ms per logical record processed. This housekeeping must include the tape reads and writes (see Fig. 4 for times). The second one appears to be a better one since most installations are print bound, not card bound. The second choice overlaps the print and read cycles as in Fig. 3, one card per one line. Using this method there are 54 ms available in the cycle for housekeeping or 27 ms per logical record processed. This method has considerably more time per logical record processed, 27 ms as compared to 17.8 ms.

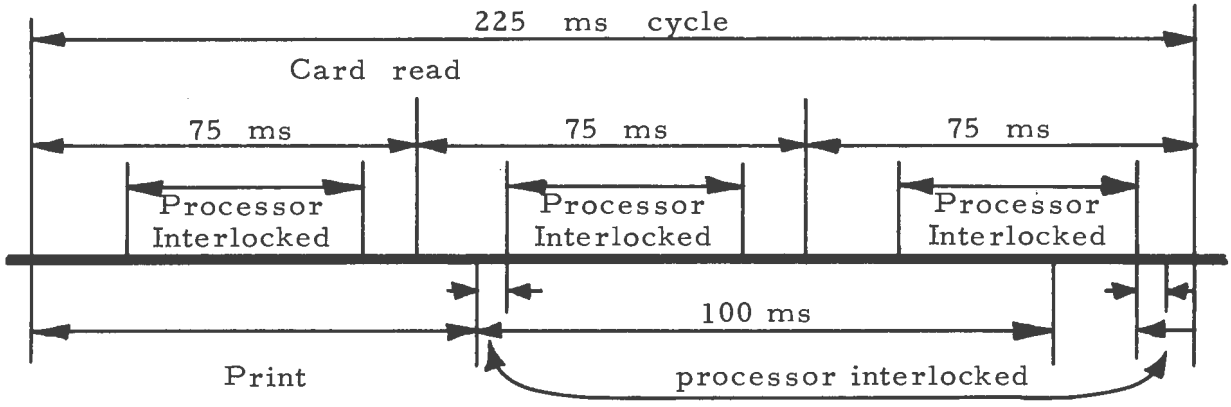


Fig. 2. Simultaneous card read at 800 cards/min and print at 535 cards/min.

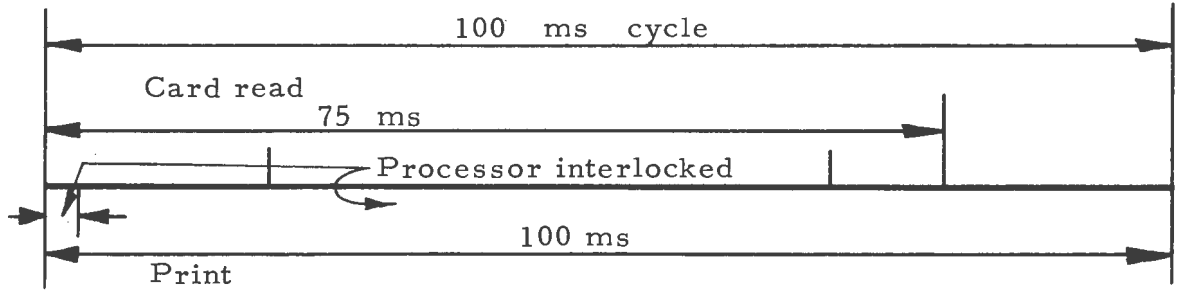


Fig. 3. Simultaneous card read and print at 600 cards/min and 600 lines/min.

800 - 535 (3 cards/2 lines): ~17.8 ms/IO
600 - 600 (1 card/1 line): ~27 ms/IO

# Char/Record	Tape Unit		
	IBM 7830	IBM 729 II	IBM 729 IV
tape write			
80	9.00 ms	9.42 ms	6.28 ms
tape read			
80	11.70 ms	12.42 ms	7.98 ms
120	16.40 ms	13.38 ms	8.62 ms
240	22.40 ms	16.26 ms	10.54 ms
480	34.40 ms	22.02 ms	14.38 ms
960	58.40 ms	33.54 ms	22.06 ms

Fig. 4. Comparative timings (in ms processing unit interlocked) of tape read and tape write operations for various length records and three types of tape units.

Card Read Cycle

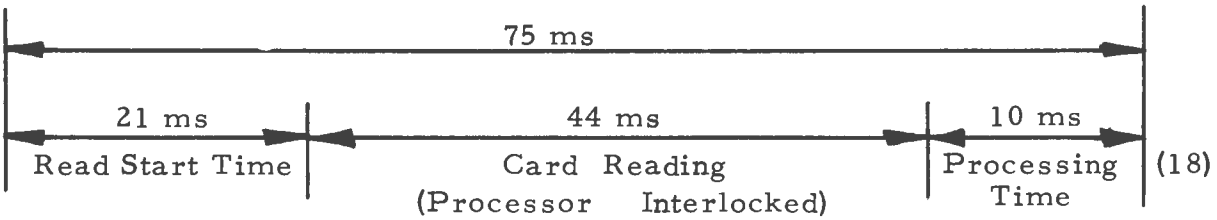


Fig. 5. Card Read Timing.

With the read-punch release feature, 31 ms of the 75 ms cycle may be used for other processing. The 44 ms of card reading time locks the processor so that no other instructions may be executed during this time.

Giving a start read feed instruction (SRF) at point A causes the next card in the hopper to begin to feed into the position to read. The next

21 ms may then be used for other processing. The read card instruction (R) must come before point B or a reader stop will occur on the 1402 card reader. After the read instruction is given, the processor will be interlocked for the remainder of the 21 ms plus the 44 ms of card read time. For example, if the SRF is given at A and the read at B', 5 ms before the point B, the processor will be interlocked from the point B' to C, a total of 49 ms.

Another consideration in planning the read cycle is the timing of the clutch points of the 1402 card reader. These are the points in time when a start read feed may be physically initiated. Any read will interlock the processor from the time it is encountered, but will not actually begin to read a card until the next clutch point is reached. Clutch points come regularly at intervals of 75 ms on a standard 1402. With the early card read feature a clutch point is reached every 25 ms. A start read feed will become active at the first clutch point immediately after the instruction is encountered. The asterisks indicate the points at which the clutch points occur.

Card Punch Cycle

With the punch release feature, 181 ms of the 240-ms cycle are interlocked such that no other instructions may be executed. The 37 ms at the front of the cycle are released for processing by use of the start punch feed instruction. The use of the start punch feed instruction is analogous to the use of the start read feed instruction.

Card Punch Cycle

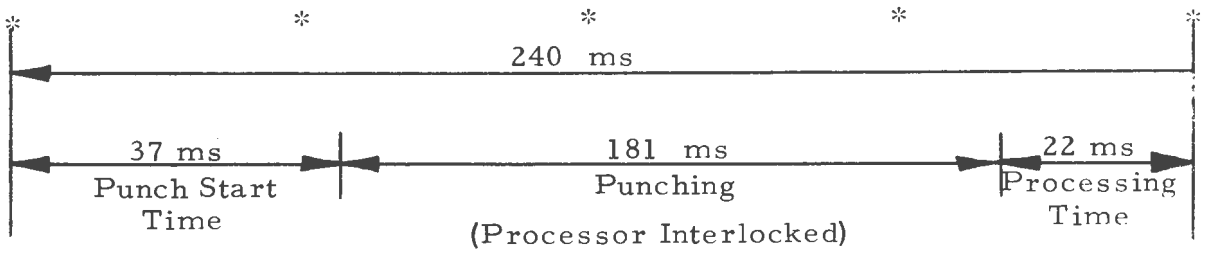


Fig. 6. Card Punch Timing.

Clutch points occur 60 ms apart in the punch cycle. A start punch feed or a punch instruction without start punch feed does not become physically effective until the next clutch point is reached. However, a punch instruction interlocks the processor just as a read instruction does. A punch not preceeded by a start punch feed and that is executed 30 ms before the next clutch point will interlock the processor for a total of 248 ms.

Print Cycle

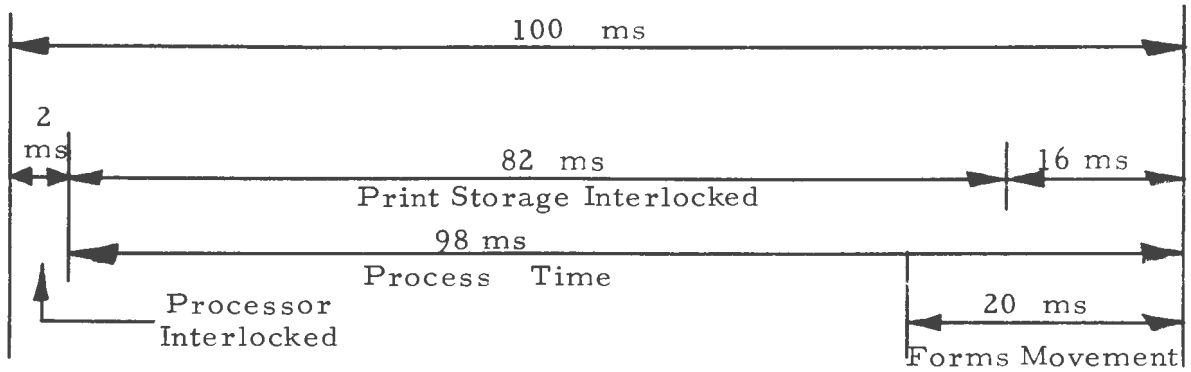


Fig. 7. Print Timing.

Normally the processor is interlocked during 84 ms of the 100 ms cycle. However, with the print storage feature, the processor is interlocked for only 2 ms. This is the time during which the print line is transferred into a special print storage area. The 98 ms at the end is free for any instruction except another print instruction. This would lock up the processor until the entire cycle was completed.

A total of 20 ms at the end of the cycle is used to move the printer carriage one line in order to be ready for the next line. Any extra after-print forms movement is added on to the end but the processor remains available except for a print instruction. A branch-on-carriage-busy instruction must be executed to test for the completion of the forms movement. Any before-print forms movements occur before the cycle starts.

Each additional space of forms movement requires an added 5 ms up to and including seven extra spaces. Each extra space over seven requires an additional 2.3 ms for models B, C, D. Model A requires 5 ms for each space after the first.

There are no clutch points associated with the print cycle. A print instruction is executed as soon as it is encountered provided the previous print and forms movement is completed.

IBM 729 Magnetic Tape Timings

Detailed information is given below for a 729 II used for the tape write operation and a 729 IV used for the tape read operation. The information is representative of all tape operations. Information

concerning the 729 II read time, 729 IV write time and IBM 7330 timings is included in diagram form, accompanying the diagrams of the 729 II write and the 729 IV read.

729 II Tape Write Timing

A 729 II write operation interlocks the processor during the start time and the actual record-write time. Record-write time can be computed as equal to .024 N ms where N equals the number of characters to be written. The tape adapter unit (TAU) is interlocked for an additional 4.2 ms. No tape instruction may be given during this time. An error test given during the 4.2 ms will interlock the processor until the record check time is completed. However, it is available for other processing.

729 IV Tape Read Timing

The processor is interlocked on this operation during the start time and the record-read time. The tape adapter unit (TAU) is interlocked for an additional 0.1 ms. A tape or error check instruction given during this time will not be executed until the time is completed. The remaining 2.0 ms, the stop time, is available for normal processing.

Following are comparative diagrams of the IBM 729 read and write operations on both Model II and Model IV and on the IBM 7330 tape unit.

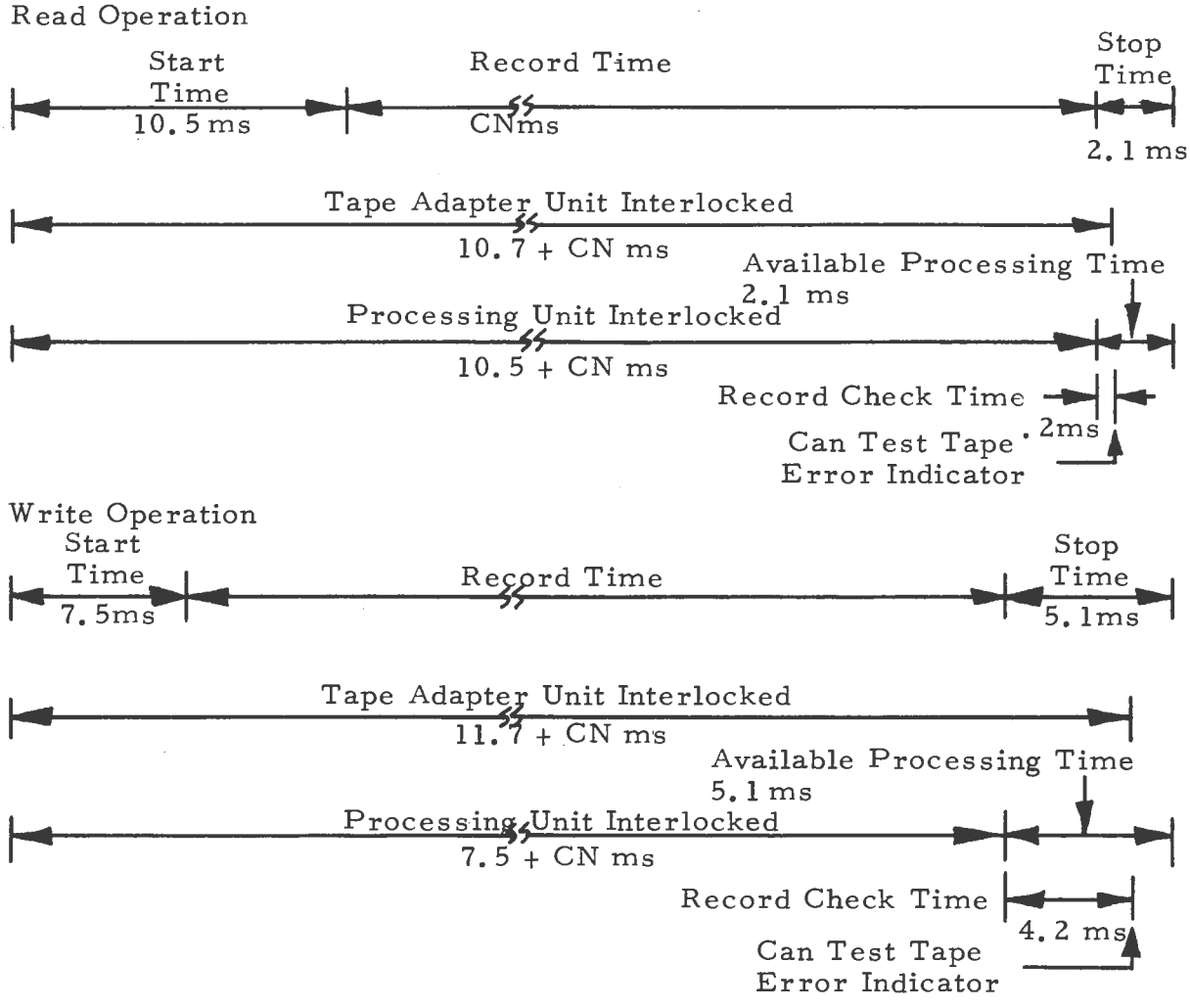


Fig. 8. IBM 729, Model II, Read-Write Operation Timings.

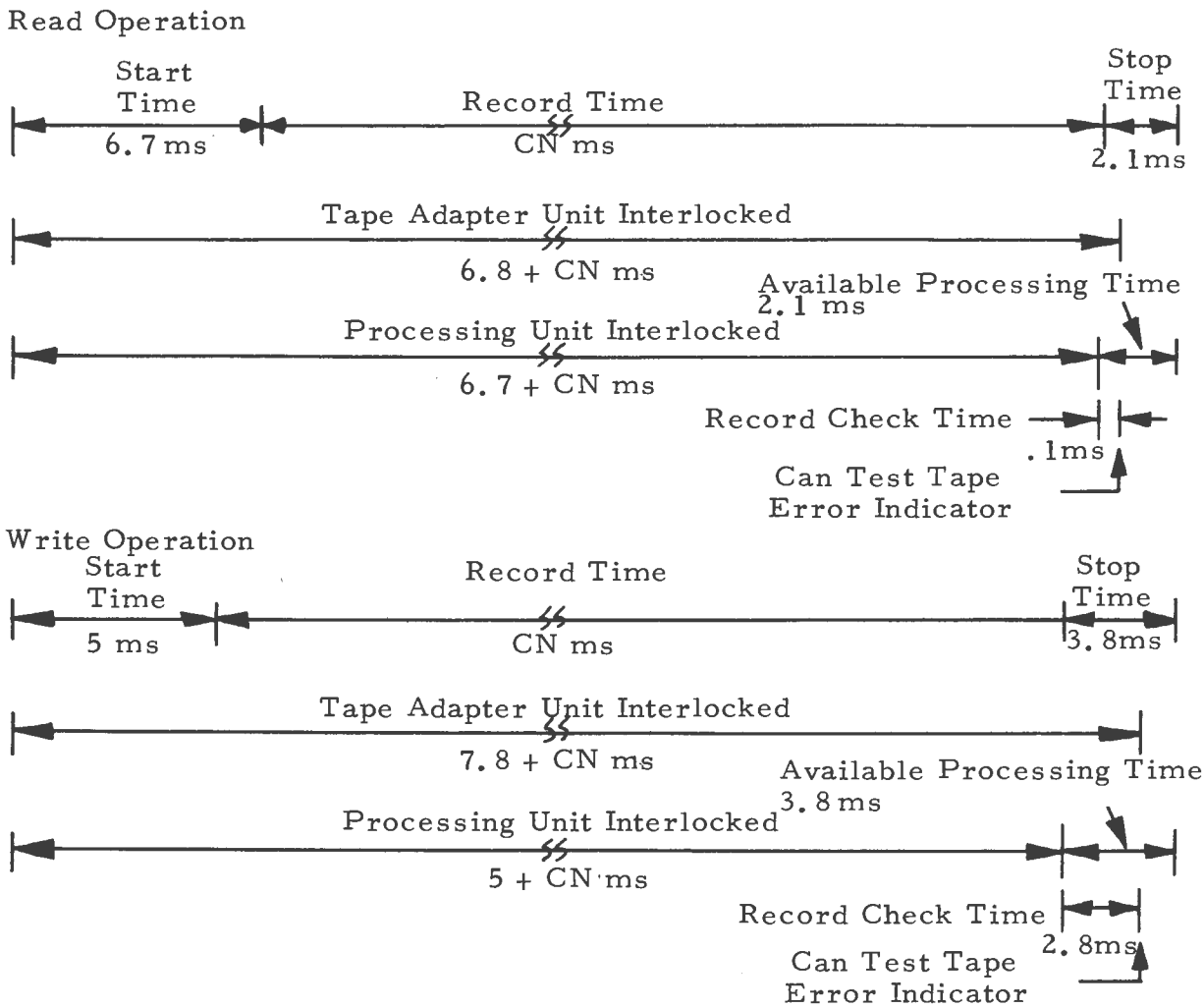


Fig. 9. IBM 729, Model IV, Read-Write Operation Timings.

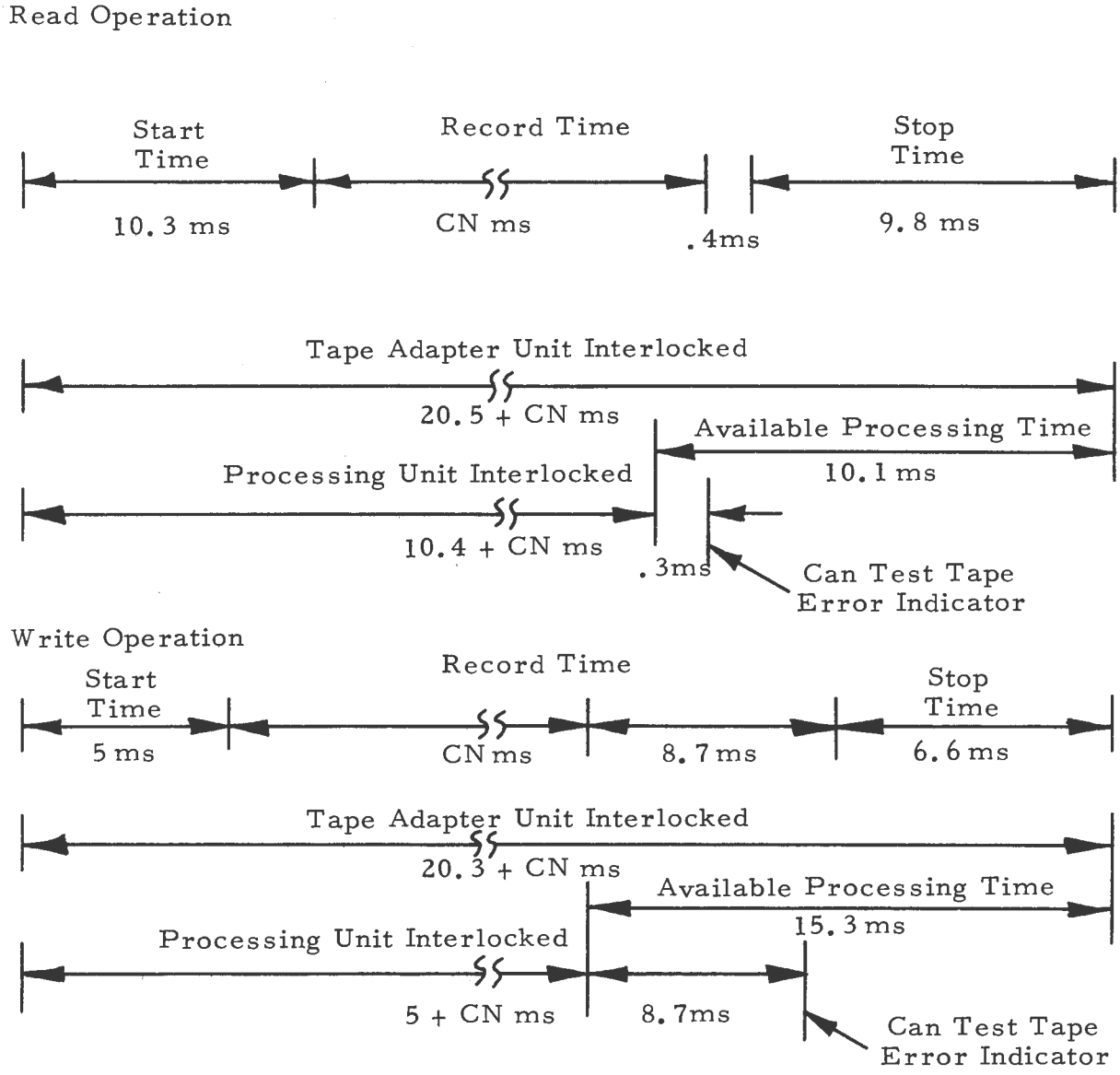


Fig. 10. IBM 7330 Read-Write Operation Timings.

The start time is the time necessary for the tape unit to accelerate to operating speed. Stop time is the time necessary for the tape to decelerate and stop. Record check time is the time necessary to read or write the check character. N is the number of characters in a record, and C is the character rate of transfer in milliseconds. This is based on the density at which the tape is being operated.

Figure 11 shows the character rate, C, of the different units at either density.

729 II	at 200 cpi	= .067 ms
	at 556 cpi	= .024 ms
729 IV	at 200 cpi	= .044 ms
	at 556 cpi	= .016 ms
7330	at 200 cpi	= .139 ms
	at 556 cpi	= .050 ms

Fig. 11. Character rate, C, for tape operations.

Discussion of Possibilities

While POGINOUT is written specifically to be used with the POGO and FLAG systems in use at the I.S.U. Computation Center, the idea behind the program could be readily used in a variety of situations.

There is one basic section of the program which controls all the other sections. The other sections are particular in that they have to do with options found on the POGO or FLAG systems. The main 100-ms loop is as follows:

1. Read a card
2. Write it on tape
3. Read a tape record
4. Start read feed for next card
5. Print the tape record

   Back to the top

The following diagram illustrates the timing of this loop.

Diagram for Discussion of Possibilities:

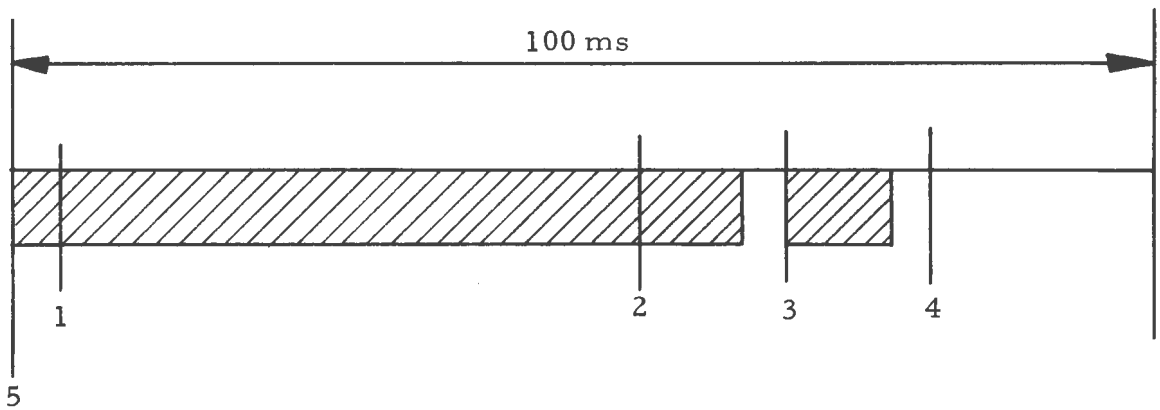
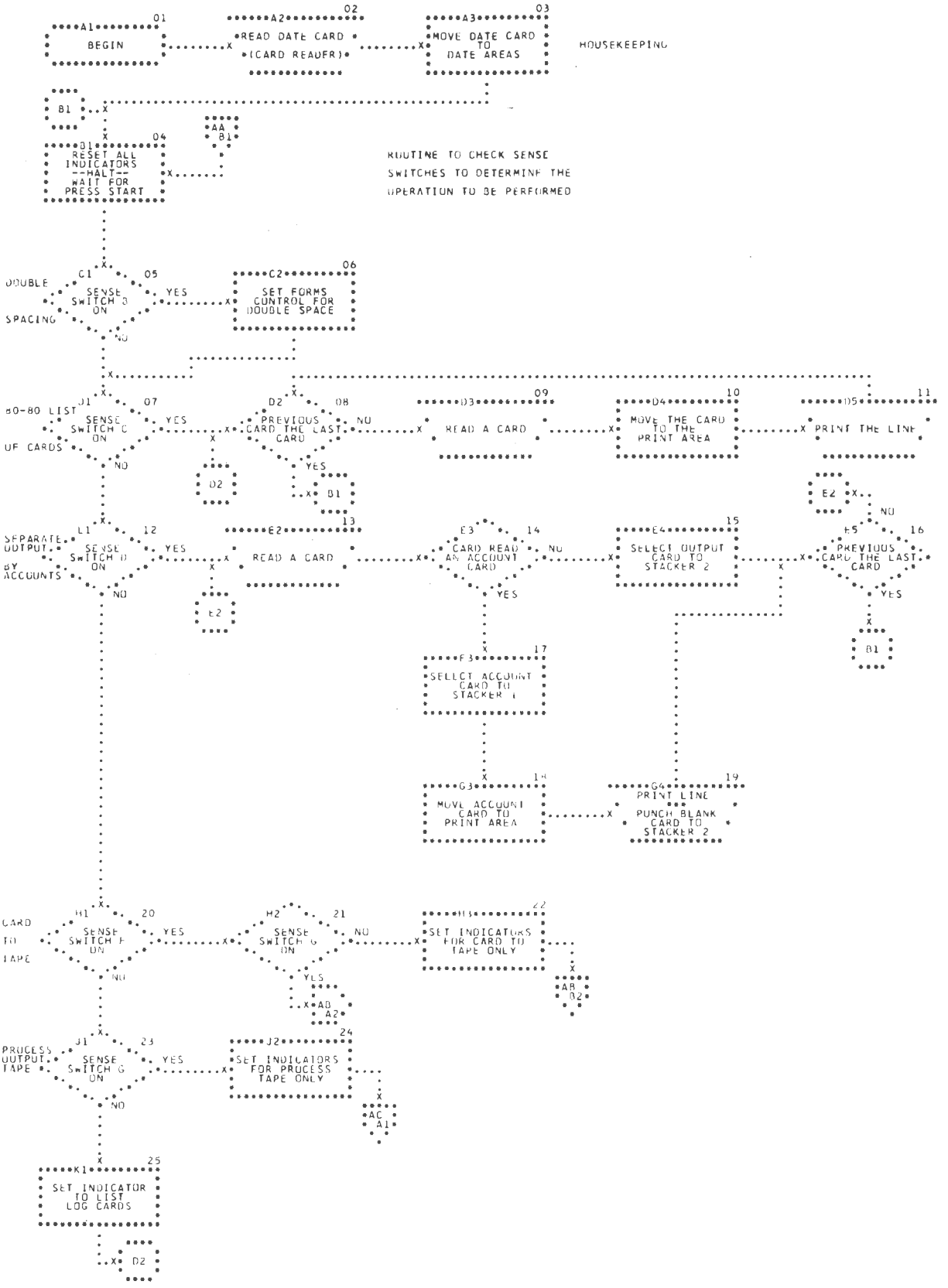


Fig. 12. Timing of the basic loop.

This order is followed if both the card-to-tape and the tape to printer operations are being done. If the end of a tape or the last card is reached, the other part of the operation continues until it, too, is finished.

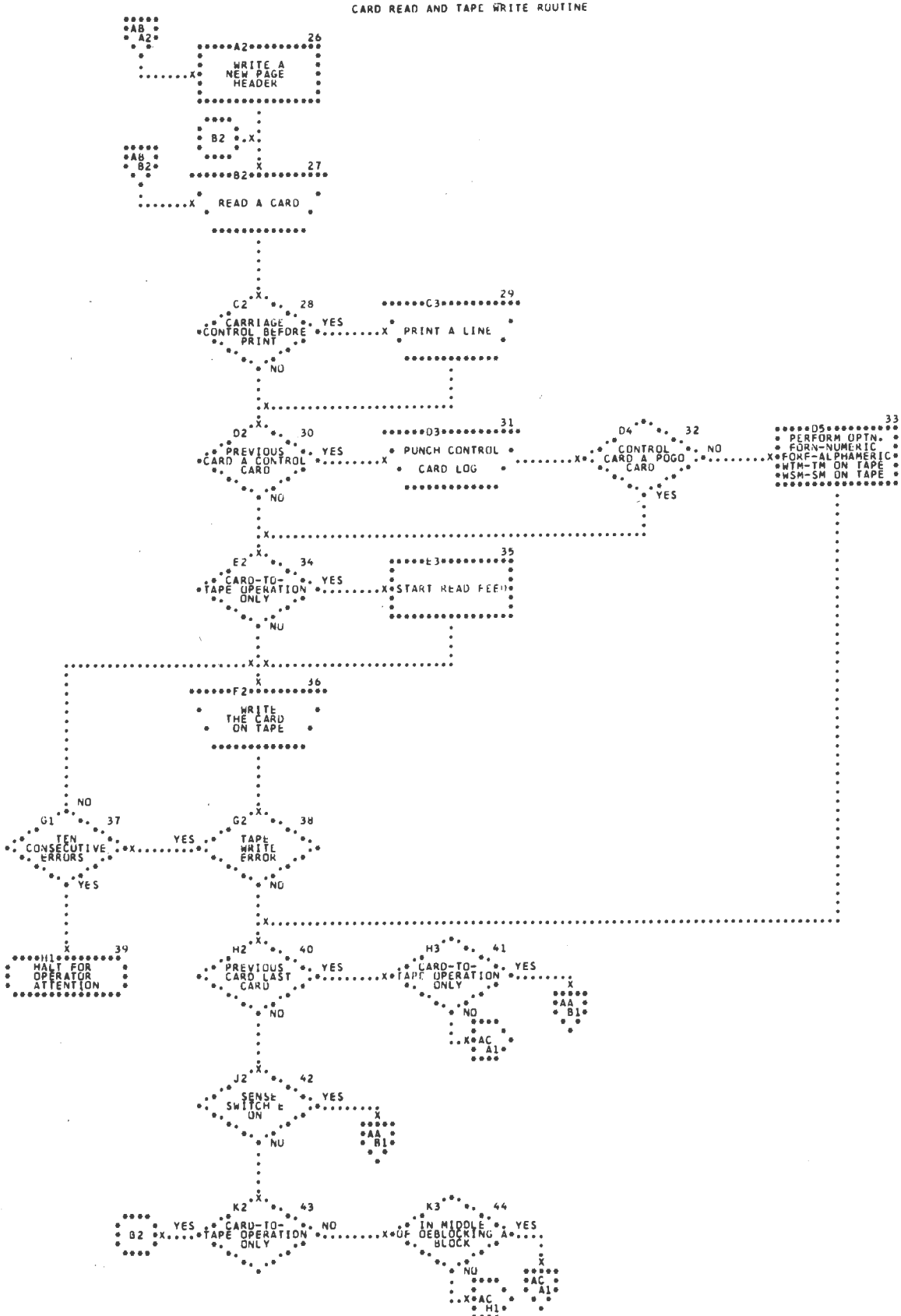
It is apparent that this process could be adapted with ease to any system which writes cards onto magnetic tape using a 1401, processes the tape on a larger machine and writes output on magnetic tape, then

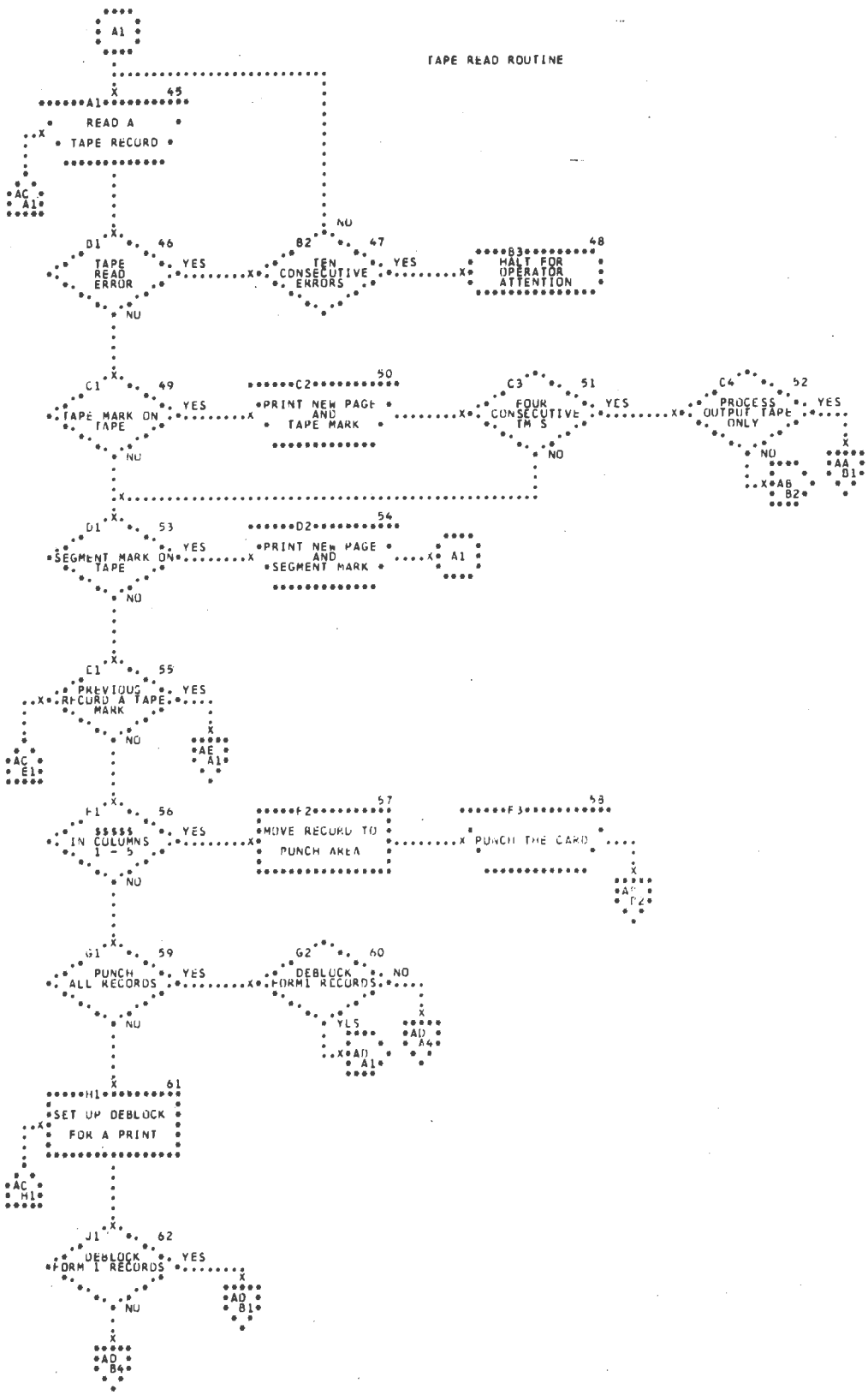
converts the output tape to a printed page using a 1401. Options which may be included or deleted are deblocking of output, separation of a batched output tape, sensing and executing of control cards being put on tape, punching of certain output records, and forms control for printed output. Error routines for the tape operations should be included.


A1
01
BEGIN
A2
02
READ DATE CARD
(CARD READER)
A3
03
MOVE DATE CARD
TO
DATE AREAS
HOUSEKEEPING
B1
B1
04
RESET ALL
INDICATORS
--HALT--
WAIT FOR
PRESS START
AA
B1
ROUTINE TO CHECK SENSE
SWITCHES TO DETERMINE THE
OPERATION TO BE PERFORMED
C1
05
SENSE
SWITCH 3
ON
YES
NO
DOUBLE
SPACING
C2
06
SET FORMS
CONTROL FOR
DOUBLE SPACE
D1
07
SENSE
SWITCH C
ON
YES
NO
80-80 LIST
OF CARDS
D2
08
PREVIOUS
CARD THE LAST
CARD
NO
YES
D2
B1
D3
09
READ A CARD
D4
10
MOVE THE CARD
TO THE
PRINT AREA
D5
11
PRINT THE LINE
E2
E2
NO
L1
12
SENSE
SWITCH D
ON
YES
NO
SEPARATE
OUTPUT
BY
ACCOUNTS
E2
13
READ A CARD
E3
14
CARD READ
AN ACCOUNT
CARD
NO
YES
E4
15
SELECT OUTPUT
CARD TO
STACKER 2
E5
16
PREVIOUS
CARD THE LAST
CARD
YES
B1
F3
17
SELECT ACCOUNT
CARD TO
STACKER 1
G3
18
MOVE ACCOUNT
CARD TO
PRINT AREA
G4
19
PRINT LINE
PUNCH BLANK
CARD TO
STACKER 2
H1
20
SENSE
SWITCH F
ON
YES
NO
CARD
TO
TAPE
H2
21
SENSE
SWITCH G
ON
NO
YES
AD
A2
H3
22
SET INDICATORS
FOR CARD TO
TAPE ONLY
AB
B2
J1
23
SENSE
SWITCH G
ON
YES
NO
PROCESS
OUTPUT
TAPE
J2
24
SET INDICATORS
FOR PROCESS
TAPE ONLY
AC
A1
K1
25
SET INDICATOR
TO LIST
LOG CARDS
D2

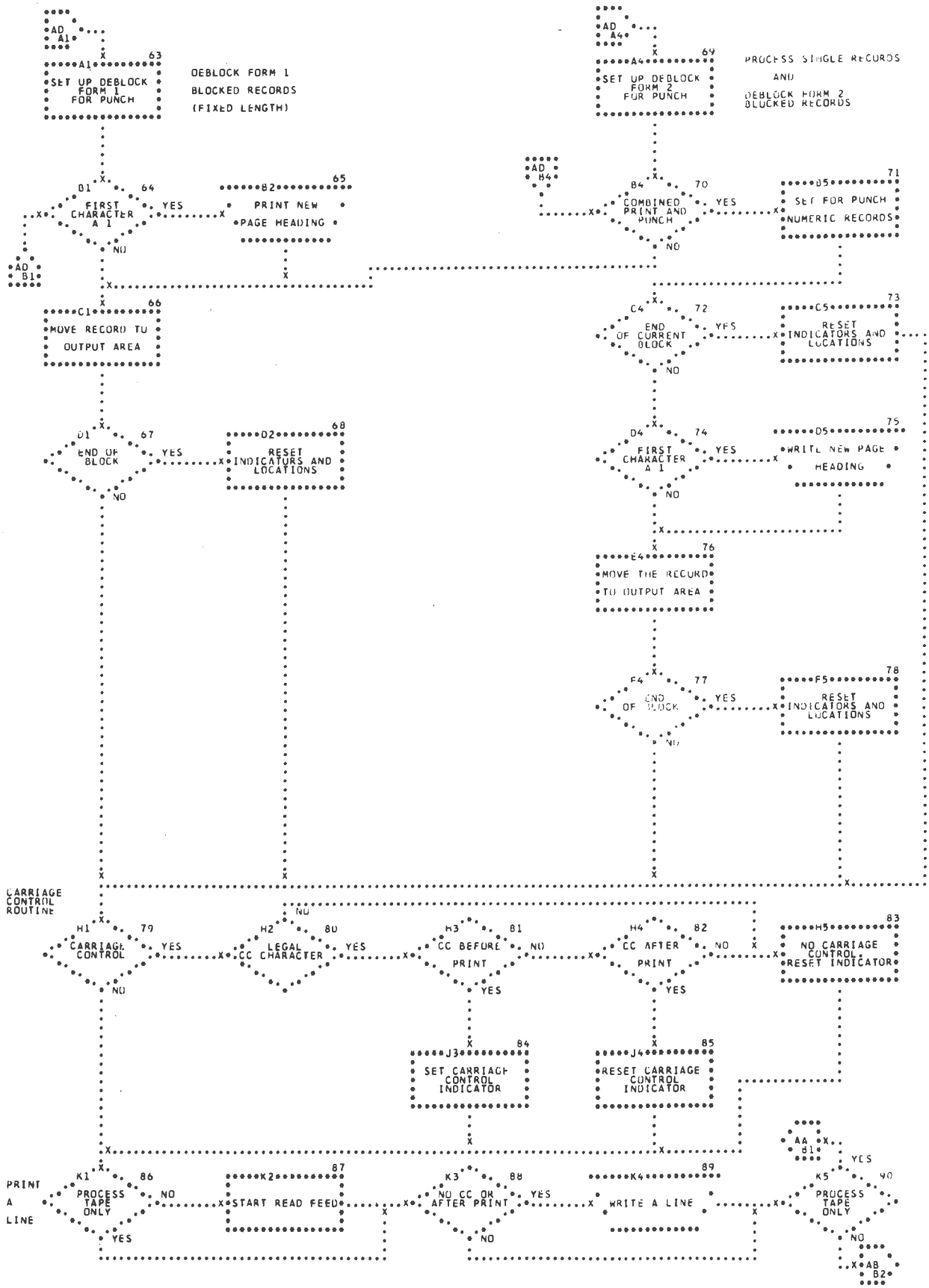
SIMULTANEOUS POGINOUT AUTOCHART

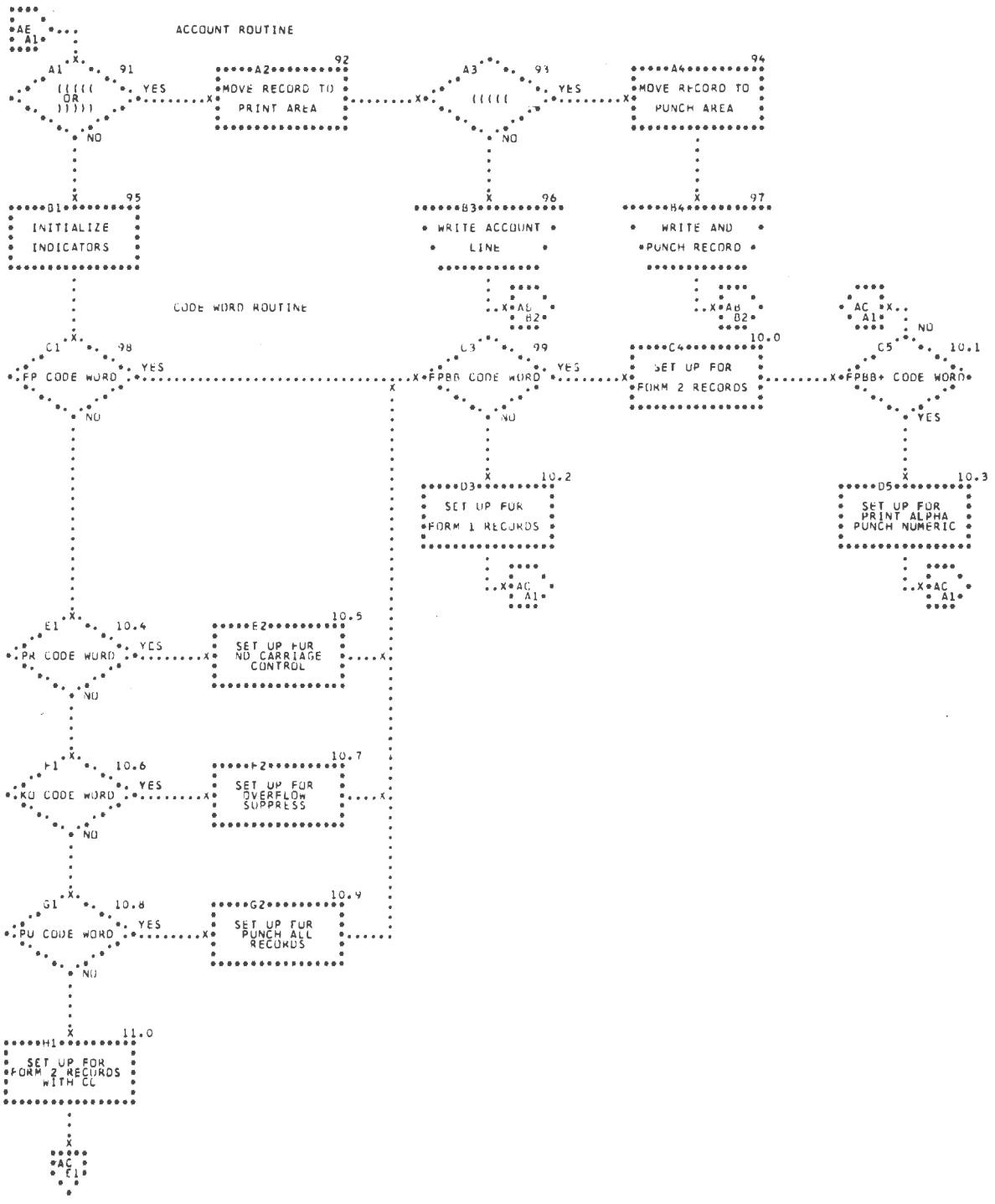
CARD READ AND TAPE WRITE ROUTINE




A1
TAPE READ ROUTINE
A1
45
READ A TAPE RECORD
AC A1
D1
46
TAPE READ ERROR
YES
NO
B2
47
TEN CONSECUTIVE ERRORS
YES
B3
48
HALT FOR OPERATOR ATTENTION
C1
49
TAPE MARK ON TAPE
YES
NO
C2
50
PRINT NEW PAGE AND TAPE MARK
C3
51
FOUR CONSECUTIVE TM S
YES
NO
C4
52
PROCESS OUTPUT TAPE ONLY
YES
NO
AA B1
AB B2
D1
53
SEGMENT MARK ON TAPE
YES
NO
D2
54
PRINT NEW PAGE AND SEGMENT MARK
A1
E1
55
PREVIOUS RECORD A TAPE MARK
YES
NO
AE A1
AC E1
F1
56
$$$$$ IN COLUMNS 1 - 5
YES
NO
F2
57
MOVE RECORD TO PUNCH AREA
F3
58
PUNCH THE CARD
G1
59
PUNCH ALL RECORDS
YES
NO
G2
60
DEBLOCK FORM1 RECORDS
NO
YES
AD A1
AD A4
H1
61
SET UP DEBLOCK FOR A PRINT
AC H1
J1
62
DEBLOCK FORM 1 RECORDS
YES
NO
AD B1
AD B4

SIMULTANEOUS POGINOUT AUTOCHART




AE
A1
ACCOUNT ROUTINE
A1
91
(((((
OR
)))))
YES
NO
A2
92
MOVE RECORD TO
PRINT AREA
A3
93
(((((
YES
NO
A4
94
MOVE RECORD TO
PUNCH AREA
B1
95
INITIALIZE
INDICATORS
B3
96
WRITE ACCOUNT
LINE
B4
97
WRITE AND
PUNCH RECORD
CODE WORD ROUTINE
AB
B2
AC
A1
C1
98
FP CODE WORD
YES
NO
C3
99
FPBB CODE WORD
YES
NO
C4
10.0
SET UP FOR
FORM 2 RECORDS
C5
10.1
FPBB+ CODE WORD
NO
YES
D3
10.2
SET UP FOR
FORM 1 RECORDS
D5
10.3
SET UP FOR
PRINT ALPHA
PUNCH NUMERIC
E1
10.4
PR CODE WORD
YES
NO
E2
10.5
SET UP FOR
NO CARRIAGE
CONTROL
F1
10.6
KO CODE WORD
YES
NO
F2
10.7
SET UP FOR
OVERFLOW
SUPPRESS
G1
10.8
PU CODE WORD
YES
NO
G2
10.9
SET UP FOR
PUNCH ALL
RECORDS
H1
11.0
SET UP FOR
FORM 2 RECORDS
WITH CC
AC
C1