1301 Programmers Manual

Section = Part Three

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Part 3

I·C·T 1300 SERIES

programmers reference manual

PERIPHERAL EQUIPMENT

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Part 3

Peripheral Equipment

INTRODUCTION 3.1

The term 'Peripheral Equipment' is used here to define those machines which can be used with 1300-series Computers to facilitate the input or output of data.

All such equipment associated with the 1300-series Computer System is controlled by program. Any program instruction to control a unit of peripheral equipment (other than magnetic tape) is of the form:

F	A
38	00xy

where 38 is the function component that directs that the instruction applies to an input/output unit; and x and y are two numbers, each having a value from 0 to 9, that comprise the address component that specifies the operation to be executed by that unit. The various program instructions for the utilization of this equipment are explained in this section and indications are given of how to combine them into programs. There are, however, standard subroutines available for all units and it is recommended that these should be used. There is also a Print, Punch and Feed (P.P.F.) Program available that controls the programming for the printer, card punch and card reader on a time-sharing basis.

The various units of peripheral equipment are considered separately in sections. Each section is then further broken down into the following parts:

(a) A general description of the unit,
(b) instructions that can be given to the unit,
(c) indicators associated with the unit,
(d) programming,
(e) timings.

With regard to item (d), it is impossible to give a set method of programming because of the variety of requirements that can arise. It is only possible to give some typical examples. Here again it is relevant to make mention of the existence of established subroutines, which are recommended for use. In the examples given, standard flowcharting symbols are used and reference is made to subroutines and modifications. These techniques are discussed in Part 4.

THE CARD READER 3.2

The card reader reads information punched in 80-column cards and stores it in the computer in a coded form. The cards are fed face down, column 80 leading and are read column by column by means of photo-electric reading stations (see Figure 11). The cards are read first by a reading station, and then by a check-reading station (which is situated one column behind the reading station) and the two readings compared automatically for checking purposes. The checked information is read into Register C from where it is stored by program in sets of six column readings.

Each character is represented in the computer by a zone component and a numeric component. A blank column is entered with zone and numeric components both zero. The zone and numeric components for each set of six columns are read successively into Register C, and are stored in I.A.S. by program before being overwritten in Register C by the contents of the next six columns. Figure 12 shows the successive sets of six card columns to occupy Register C, and the disposition of the zone component and the numeric component for each card column.

For the standard punching code, the coded zone component lies in the range 1 to 5, and the numeric component is the same as the numeric punching in the card. The standard code for punching is shown in Figure 13, together with the computer zone component. For alphabetic characters, which are represented by two holes in one column, the upper hole is translated as a number in the range 1 to 5 and the lower hole by its number.

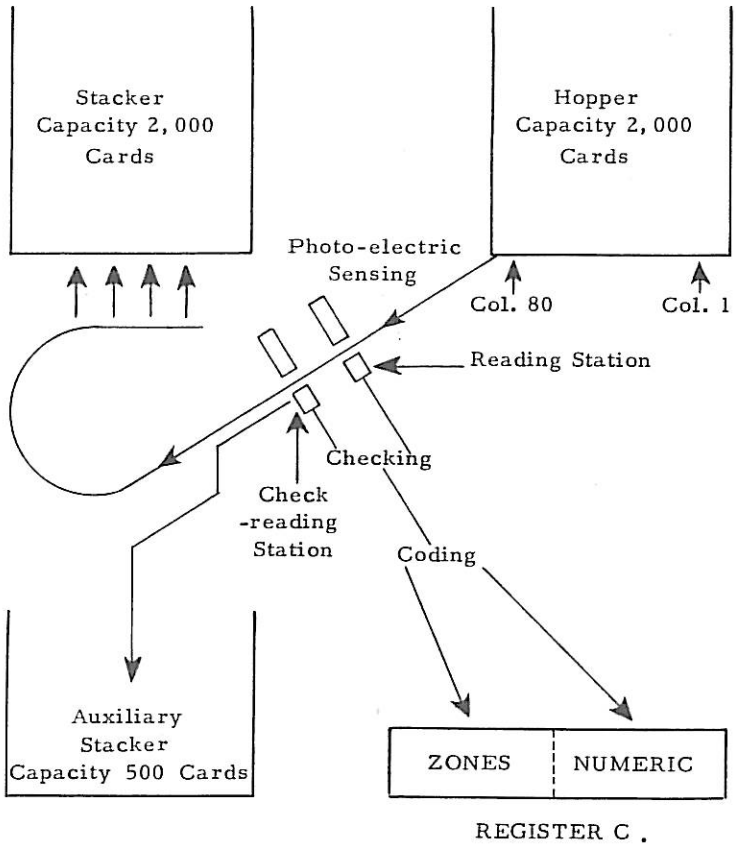


Figure 11: THE CARD READER

REGISTER C POSITIONS											
1	2	3	4	5	6	7	8	9	10	11	12
75	76	77	78	79	80	75	76	77	78	79	80
69	70	71	72	73	74	69	70	71	72	73	74
63	64	65	66	67	68	63	64	65	66	67	68
57	58	59	60	61	62	57	58	59	60	61	62
51	52	53	54	55	56	51	52	53	54	55	56
45	46	47	48	49	50	45	46	47	48	49	50
39	40	41	42	43	44	39	40	41	42	43	44
33	34	35	36	37	38	33	34	35	36	37	38
27	28	29	30	31	32	27	28	29	30	31	32
21	22	23	24	25	26	21	22	23	24	25	26
15	16	17	18	19	20	15	16	17	18	19	20
9	10	11	12	13	14	9	10	11	12	13	14
3	4	5	6	7	8	3	4	5	6	7	8
*	*	*	*	1	2	*	*	*	*	1	2
Zone Component						Numeric Component					

Successive content of Register C during card reading, showing disposition of card columns. No assumption can be made about the contents of positions marked with an asterisk.

Figure 12: CONTENTS OF REGISTER C DURING CARD READING

Card Punching	Numeric No Overpunch	Numeric + 10 Overpunch	Numeric + 11 Overpunch	Numeric + 0 Overpunch	Numeric + 1 Overpunch
10	10				
11	11				
0	0				
1	1	A	J	&	
2	2	B	K	S	%
3	3	C	L	T	¼
4	4	D	M	U	-
5	5	E	N	V	/
6	6	F	O	W	½
7	7	G	P	X	.
8	8	H	Q	Y	@
9	9	I	R	Z	¾
Coded Zone Component	1	2	3	4	5

Figure 13: CARD PUNCHING CODES

Example Suppose that columns 75 to 79 of a card are punched with the characters 10, ½, A, N and Z respectively and that column 80 is blank. The columns will be punched as follows:

Column	75	76	77	78	79	80
Punch Position(s)	10	1 & 6	10 & 1	11 & 5	0 & 9	Blank

Immediately after columns 75 to 80 have been read at the reading station, Register C will be as follows:

	Zone Components						Numeric Components					
Card Column	75	76	77	78	79	80	75	76	77	78	79	80
Contents of Register C.	1	5	2	3	4	0	10	6	1	5	9	0
Digit Positions	1	2	3	4	5	6	7	8	9	10	11	12

Time available for Programming 3.2.1

The card reader is cyclic in operation, one cycle being the time taken to feed and read one card. If the instruction to feed a card is not received within a certain time after the last six columns of the previous card have been read, then a cycle is missed. The card reader unlatches and a full card cycle elapses before the next card can be fed. It follows that the time between successive cards being read is a multiple of the cycle time and that if alternate cycles are consistently missed, the card reader is reduced to half its maximum speed.

Once the instruction has been given for a card to be fed, it is automatically moved through the card reader and the information from the card transferred into Register C. The only program instructions required are those to store Register C at six-column intervals. During the card cycle, therefore, there is a considerable amount of time for which the reader requires no program control and it is possible to use this time to obey other program instructions. This process is known as time-sharing and can considerably speed up the overall time required for processing a job.

Time is available for programming between giving the instruction to feed a card and reading the first six columns, and between reading successive sets of six columns. The actual cycle times and time available for programming are given later in this section. Care should be taken to ensure that the program does not take longer than the time available.

Card Read Instructions 3.2.2

Instruction 380002

Effect This instruction will initiate the feeding of a single card. After the card has been read, card feed automatically stops.

Operation When a 380002 instruction is given, a card is fed into the reader and moved through it. If the instruction does not follow within a given time from the last six columns of the previous card having been read, then the card reader unlatches and a full card cycle elapses before the next card is fed.

Instruction 380007

Effect This instruction causes a card to be ejected into the reject stacker.

Notes Instruction 380007 is provided to enable the program to cause a card to be ejected to the reject stacker if an error arises. For example, a card may be rejected if that card slips during feeding, thus causing a card read error; or if a programmed sequence check fails, thus indicating that the cards are out of order. A 380007 instruction cannot be given until after the first six columns are read, and there is a time limit after which it cannot be given.

Card Read Indicators 3.2.3

Indicator 35 Card Reader Ready

Purpose This indicator is set when the card reader is in a ready condition.

Operation Indicator 35 is unset when a 380002 instruction has been given, but the card has not yet moved far enough for reading to commence. It is also unset when any of the following external conditions arise to cause the reader to be unready (i.e. the Card Reader Interlock is set):

(a) The Emergency Stop button has been operated,
(b) the feed hopper is empty,
(c) there are less than 350 cards in the hopper and the card weight has been removed,
(d) the main stacker is full,
(e) the reject stacker is full,
(f) the power supply to the card reader has been cut off,
(g) a card jam or mis-feed has occurred.

This indicator remains unset until the condition has been remedied and the Start and Reset manual control has been operated.

Notes Indicator 35 should be tested by program prior to giving a 380002 instruction to ensure that none of the above conditions has arisen.

The 380002 instruction unsets indicator 35 and it remains unset until shortly before the first six columns are read, when it is set to indicate to the program that reading is about to commence.

At this stage the indicator is set even if external conditions have arisen which would normally cause it to be unset.

At any stage during the reading of a card another card may be called; indicator 35 will then be unset and remain so until reading is about to commence on the second card.

It is recommended that indicator 35 should be tested again before preparing to read a called card. This will ensure that the card is in the correct position for reading and also that indicators 37 (6 Columns Missed), and 38 (Mischeck) have been unset.

Indicator 36 6 Columns Read

Purpose This indicator is set when six columns have been read into Register C, and indicates to the program that information is ready to be stored.

Operation After the data contained in a set of six card columns has been read into Register C, the register is full. It is required that the contents of this register be transferred to I.A.S. before being overwritten by the data from the succeeding six card columns. When indicator 36 is set, after each six columns is read, it shows that Register C is full and ready for its contents to be transferred to store.

Indicator 36 is unset when tested by program. If the indicator is not tested (and therefore not unset) by program it is unset automatically after a fixed time interval.

Indicator 37 6 Columns Missed

Purpose This indicator is set when the contents of Register C are overwritten without having been transferred to store.

Operation Indicator 37 is unset for each card cycle just before indicator 35 is reset after a 380002 instruction. If indicator 36 is unset automatically, then indicator 37 is set. It follows that if indicator 37 is set, then the program did not test indicator 36 before it was automatically unset; therefore the contents of Register C were not stored before they were overwritten, i.e. six columns have been missed. Indicator 37 is unset when tested by program.

Indicator 38 Mischeck

Purpose This indicator is set if the reading station and the check-reading station make an unsuccessful comparison of data read from one card column.

Operation Indicator 38 is unset for each card cycle just before indicator 35 is reset after a 380002 instruction. Indicator 38 is set if the reading station and the check-reading station have made an unsuccessful comparison; it remains set until tested by program, when it is unset.

Notes Indicator 38 should be tested when the last six columns of a card have been read, to check that a card has been read correctly. Thus, this indicator must be tested before it is unset at the next card cycle and the mischeck indication lost.

If a programmer is using information on the last columns of a card only, it is permissible to start the main program when the required information has been stored, even though the columns will still have to be read into Register C. If this is done, however, it is advisable to wait until the 6 Columns Read indicator is set for the next six columns and then test indicator 38. If this is not done an error may not be detected. However, this technique is not advised as mistakes are often made and the saving in time is small. In particular, care must be taken to ensure that multiplication does not take place before card reading has finished, since both operations make use of Register C.

A Card Read Program 3.2.4

Figure 14 overleaf shows a subroutine to read one card and demonstrates the sequence in which the card read instructions and indicators are used.

This subroutine allows time-sharing between calling a card and reading the first six columns.

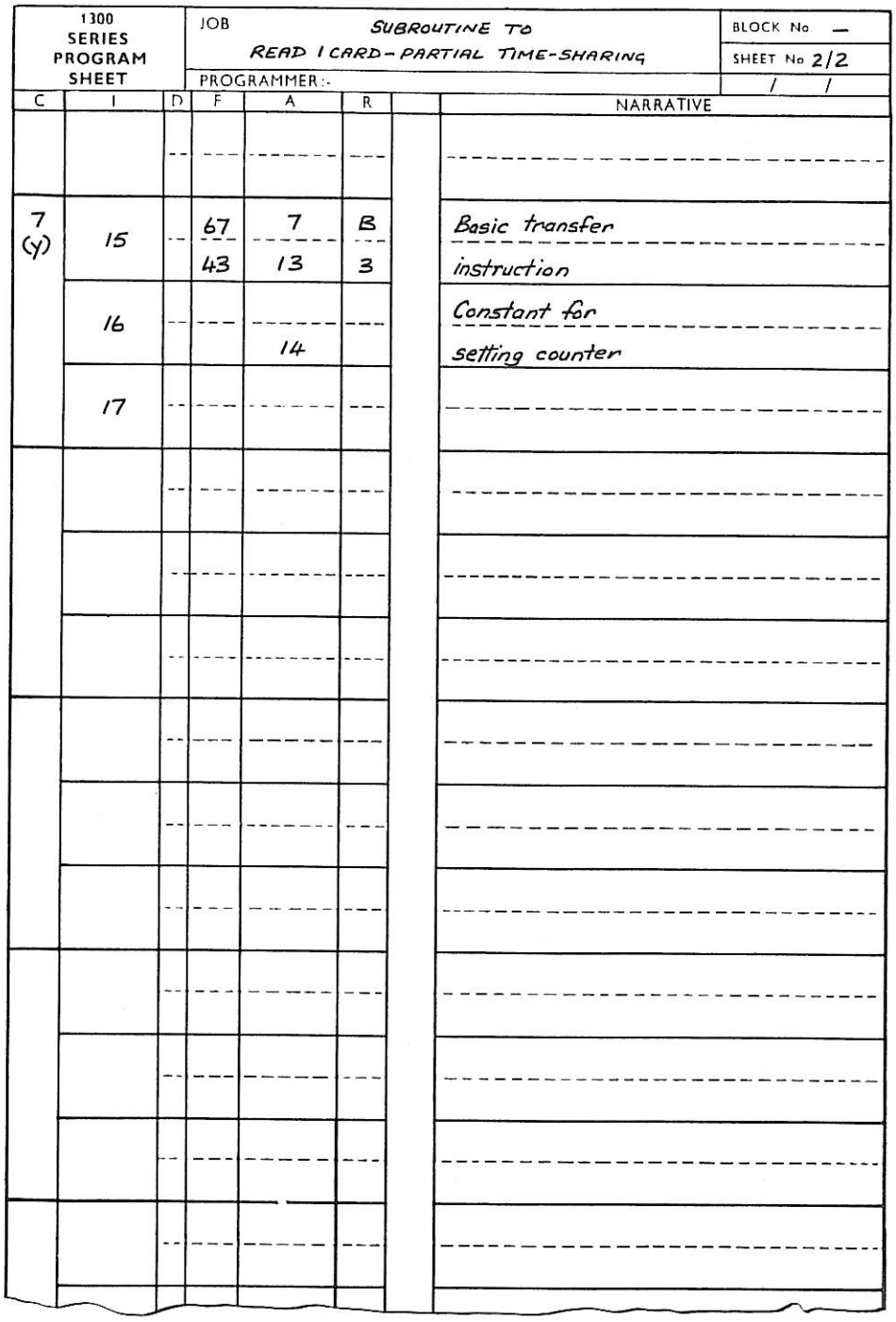
On the first entry indicator 19 must be unset. After the card has been called, control is restored to the main program.

On the second entry the card is read and its contents stored in I.A.S. under relativizer 3 as follows:

I.A.S. Word Relativizer 3	1	2	3	4	5	6	7	8	9	10	11	12
0	*	*	*	*	1	2	*	*	*	*	1	2
1	3	4	5	6	7	8	3	4	5	6	7	8
2	9	10	11	12	13	14	9	10	11	12	13	14
3	15	16	17	18	19	20	15	16	17	18	19	20
4	21	22	23	24	25	26	21	22	23	24	25	26
5	27	28	29	30	31	32	27	28	29	30	31	32
6	33	34	35	36	37	38	33	34	35	36	37	38
7	39	40	41	42	43	44	39	40	41	42	43	44
8	45	46	47	48	49	50	45	46	47	48	49	50
9	51	52	53	54	55	56	51	52	53	54	55	56
10	57	58	59	60	61	62	57	58	59	60	61	62
11	63	64	65	66	67	68	63	64	65	66	67	68
12	69	70	71	72	73	74	69	70	71	72	73	74
13	75	76	77	78	79	80	75	76	77	78	79	80
	Zone Component						Numeric Component					

1300 SERIES PROGRAM SHEET		JOB SUBROUTINE TO READ 1 CARD - PARTIAL TIME-SHARING			BLOCK No. — SHEET No 1/2		
		PROGRAMMER:-					
C	I	D	F	A	R		NARRATIVE
1		B					
2	0		41	11	B		Store Link
			00				
	1	4	35	2	B		Test Card Reader Ready
		4	00	1	B		
	2	4	19	4	B		1st Entry - Unset; 2nd Entry - Set
			38	2			Call Card Feed
3	3	8	19				Set indicator 19
		4	00	11	B		Jump to Link
	4		45	15	B		Transfer basic instruction
			02	7	B		and counter
	5	4	36	7	B		Test 6 Columns Read
		4	37	12	B		Test 6 Columns Missed
4	6	4	00	5	B		
	7		67	7	B		Store Register C
			43	13	3		in I.A.S.
	8		00				Counter
			00	14			
5	9		67	8	B		Subtract 1 from counter
		4	02	5	B		
	10	4	38	12	B		Test Mischeck indicator
		9	19				Unset indicator 19 for next entry
	11						
				0			Link
6	12		38	7			Reject card if error
			11	332			Stop
	13	4	35	14	B		Restart: Test card reader ready
		4	00	13	B		
	14		38	2			Call Card Feed
		4	00	1	B		

Figure 14: AN EXAMPLE OF A CARD READ SUBROUTINE



1300 SERIES PROGRAM SHEET	JOB	BLOCK No —
	SUBROUTINE TO READ 1 CARD - PARTIAL TIME-SHARING	SHEET No 2/2
	PROGRAMMER:-	/ /

C	I	D	F	A	R	NARRATIVE
7 (y)	15		67	7	B	Basic transfer
			43	13	3	instruction
	16					Constant for
				14		setting counter
	17					

Figure 14 continued

If six columns are missed or if an error occurs on reading, the card is rejected and the computer stops with 110333 displayed in CR3. A re-start program is included after the error stop. The rejected card should be replaced at the bottom of the pack in the hopper. When the Start button is pressed the card will be re-read.

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SURBITON, SURREY. KT6 5PL

Two types of card reader are available with the 1300-series Systems. These are identical in specification except that they operate at different speeds. The speeds and timings associated with the card reader are shown for both types in the following table.

Maximum speed at which cards can be read	600 cards a minute (minimum times)	300 cards a minute (minimum times)
Time for one complete card cycle	100 ms	200 ms
Time after 14th *6 Columns Read* in which a Call Card Instruction may be given to maintain continuous running of the reader.	2.44 ms	7.3 ms
Time between calling a card and the first *6 Columns Read* if the card reader has been unlatched. Register C comes into use for card reading before the first *6 Columns Read*.	36.1 ms	70.4 ms
Therefore if multiplication is taking place this should be reduced to:	32.4 ms	60.75 ms
An instruction to call the next card may be given any time during the reading of the current card. When the reader is running continuously the time between the 14th *6 Columns Read* and the 1st *6 Columns Read* of the next card is:	40 ms	80 ms
If multiplication is taking place this should be reduced to:	35.4 ms	70.8 ms
Interval between successive *6 Columns Read*. Multiplication cannot be carried out during this time.	3.18 ms	6.36 ms
Time after 14th *6 Columns Read* during which a Reject Card instruction can be given.	25.4 ms	50.8 ms
Time after which *6 Columns Read* indicator (36) is automatically unset if not previously unset by program.	538 μs	1076 μs

THE CARD PUNCH 3.3

The card punch receives information from the computer, and punches it in 80-column cards. The cards are fed face down, 10-edge leading. Punching is effected by a single row of 80 magnetically-actuated punch knives, punching in each card row in sequence; 10, 11, 0, 1 ..... 9. As each row comes under the knives, the computer sends an impulse to the punch magnets for each column required to be punched with that digit value. The punch magnets are in two groups having separate controls: the Left group effecting punching in columns 1 to 40, and the Right group effecting punching in columns 41 to 80.

Information is sent to the punch from Register B in two transfers of 40 bits (row-binary); 0 signifying *do not punch* and 1 signifying *punch*. Synchronization between the computer and the punch is achieved by means of timing signals from the punch, and their effect on certain indicators (54 to 58) within the computer. This is explained under 3.3.3 Card Punch Indicators.

Checking of Punching 3.3.1

While one card is being punched the previous card is check-read at a brush sensing station. The checking of punching is effected by reading the data in the card just punched, entering it back into the computer and comparing it by program with the I.A.S. information from which the card was punched. The data is read back from the card by a set of 80 brushes, one card cycle behind the punch magnets. The data is read for each row in turn, and is entered into Register B in row-binary form immediately after the corresponding row of the following card has been punched. The contents of Register B are then compared by program with the row-binary information, stored in I.A.S., from which the punching was derived. The punch can be instructed so that in the event of an error being detected it will offset the error card about half an inch lengthways as it is fed to the stacker.

The normal error procedure is as follows: both the cards being processed when the check fails, i.e. the one passing the punch brushes, and the next one, i.e. the one being punched, will be offset in the stacker by program. An attempt will then be made to repunch the same data in the next two cards, and check the punching. If the check fails again this process is repeated. The reason for offsetting two cards and then repunching both, when an error is detected in the first card, is that this method enables the offset cards to be removed without affecting the order of the cards. If only the error card were to be offset and repunched after the card passed the punch magnets, the order of the error card and the following card would have to be reversed on extraction from the stacker.

The relation between the punch magnets, punch brushes, and cards is shown diagrammatically in Figure 15.

It should be noted that when an unsuccessful comparison is made, an error may have occurred either in the punching or in the reading back into the computer; a card which has been offset will not necessarily be wrongly punched.

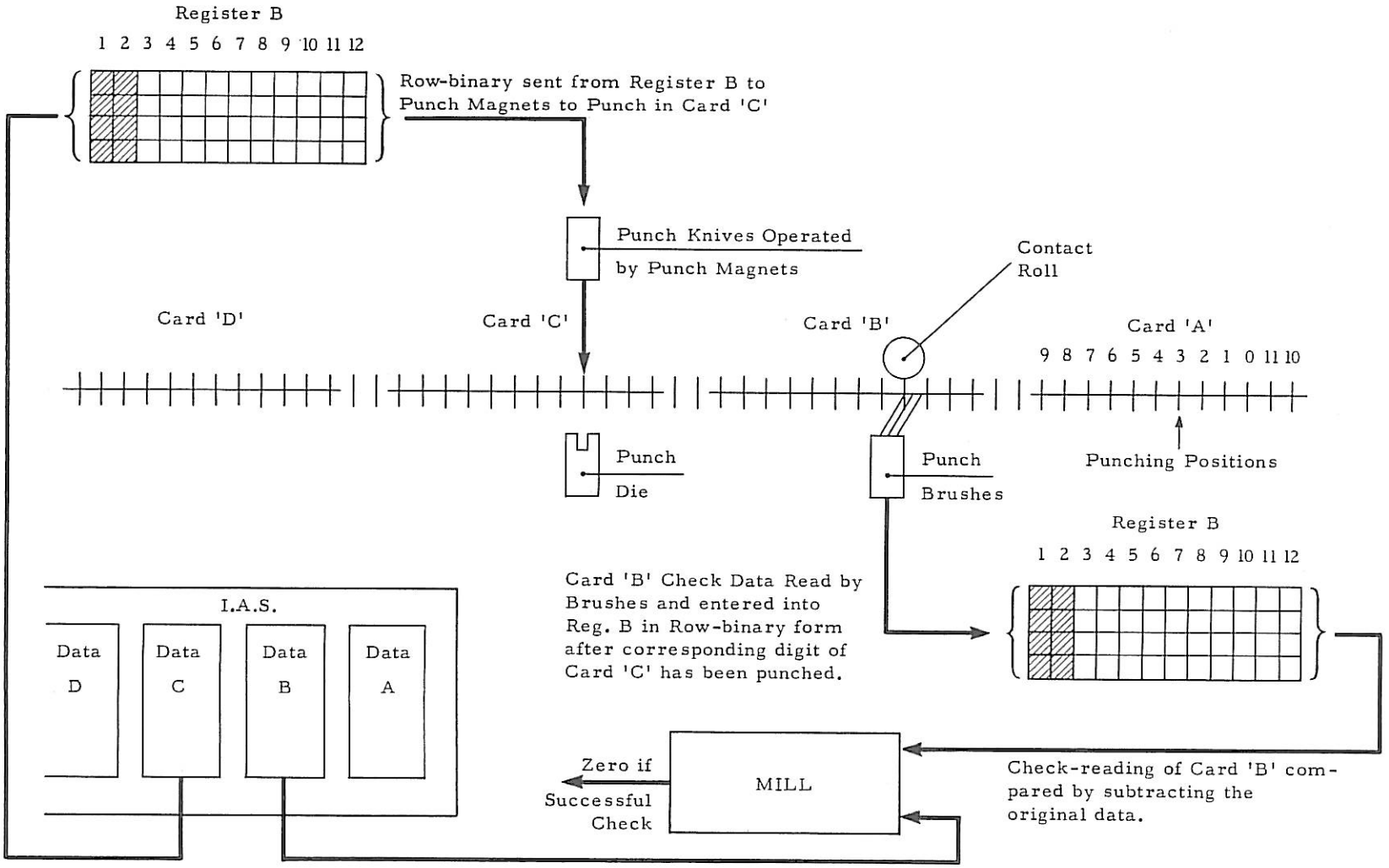

Figure 15: THE CARD PUNCH

Instruction 380042

Effect A 380042 instruction will cause the card feed to operate for one card cycle.

Operation On receipt of the instruction one card will be fed into position under the punch knives, and each card in the card track will move one card cycle towards the stacker. If a 380042 instruction is not given within a certain time after the previous one, the punch motor is automatically switched off. The motor is switched on again automatically when the next 380042 instruction is given.

Instruction 380043

Effect Instruction 380043 causes punching to take place on the Left group of punch knives (columns 1 to 40).

Operation When a 380043 instruction is given the contents of Register B will cause punching to take place in columns 1 to 40. The presence of a 1-bit in any position of Register B will cause the associated punch magnet to be energized. The bit positions of Register B will be associated with punch magnets as shown below.

1	2	3	4	5	6	7	8	9	10	11	12	
		1	2	3	4	5	6	7	8	9	10	1
		11	12	13	14	15	16	17	18	19	20	2
		21	22	23	24	25	26	27	28	29	30	4
		31	32	33	34	35	36	37	38	39	40	8

Instruction 380044

Effect Instruction 380044 causes punching to take place on the Right group of punch knives (columns 41 to 80).

Operation When a 380044 instruction is given, the contents of Register B will cause punching to take place in columns 41 to 80. The presence of a 1-bit in any position of Register B will cause the associated punch magnet to be energized. The bit positions of Register B will be associated with the punch magnets as shown as follows:

1	2	3	4	5	6	7	8	9	10	11	12	
		41	42	43	44	45	46	47	48	49	50	1
		51	52	53	54	55	56	57	58	59	60	2
		61	62	63	64	65	66	67	68	69	70	4
		71	72	73	74	75	76	77	78	79	80	8

Instruction 380045

Effect Instruction 380045 causes one row of data punched in columns 1 to 40 of the card passing the punch brushes to enter Register B for comparison with the originating data.

Operation When a 380045 instruction is given the data holes punched in one row, of columns 1 to 40, are sensed by the punch brushes, and the information is entered into Register B in row-binary form and with the same column-to-bit position pattern as that for instruction 380043.

Notes It is essential to clear Register B before using this instruction.

Instruction 380046

Effect Instruction 380046 causes one row of data punched in columns 41 to 80 of the card passing the punch brushes to enter Register B for comparison with the originating data.

Operation When a 380046 instruction is given, the data holes punched in one row of columns 41 to 80, are sensed by the punch brushes, and the information is entered into Register B in row-binary form and with the same column-to-bit position pattern as that for instruction 380044.

Notes It is essential to clear Register B before using this instruction.

Instruction 380047

Effect Instruction 380047 causes a selected card to be offset lengthways in the stacker by about half an inch.

Operation When a 380047 instruction is given, the card that has just left the punch brushes will be offset when it is fed to the stacker. This instruction must be given before the next 380042 instruction otherwise the wrong card will be offset. The instruction is normally given immediately after the checking of the punch data.

There is a visual indicator above the stacker which glows when one or more cards in the stacker have been offset.

Notes When, during checking of punching, the check-read data and the original data do not correspond, the card at fault can be offset in the stacker by giving a 380047 instruction. Alternatively, the instruction can be used to offset a card if indicator 57 or 58 is tested and found to be set (see Section 3.3.3).

Indicator 54 Punch Ready

Purpose Indicator 54 is set when the punch is available for use.

Operation Indicator 54 is unset by the Card Punch Interlock, and automatically by a 380042 instruction. The Card Punch Interlock will cause the indicator to be unset when any of the following conditions arise:

(a) The hopper is empty,
(b) the stacker is full,
(c) a card jam has occurred,
(d) a misfeed has occurred,
(e) the Emergency Stop manual control has been operated,
(f) the power supply fails,
(g) the die is removed,
(h) the knock-off bar is removed.

The indicator is automatically set at the end of each card cycle.

Indicator 55 Punch Index Point Time

Purpose Indicator 55 is automatically set as each row of punching positions of a card is positioned under the punch knives ready for punching.

Operation As each row is positioned under the punch knives, indicator 55 is automatically set to indicate that the punch magnets are ready to receive the information in Register B in row-binary form. Indicator 55 is unset when tested by program. If the indicator is not unset (by testing) within a certain time, it is unset automatically.

Indicator 56 Check Index Point Time

Purpose Indicator 56 is automatically set as each row of punching positions is positioned over the brushes ready for checking.

Operation As each row is positioned over the brushes, indicator 56 is automatically set to indicate that the checking station is ready to enter data in row-binary form into Register B for checking purposes. Indicator 56 is automatically set a short time after indicator 55 is unset. It is unset when tested by program, or automatically after a certain time if not tested.

Indicator 57 Punch Index Point Time Missed

Purpose Indicator 57 is set in the event of indicator 55 being unset automatically (i.e. it has not been tested by program) indicating that it is too late to punch the associated row.

Operation If within a certain time of being set, indicator 55 is not tested and unset by program, it is unset automatically and indicator 57 is set. This will normally only happen if the program has consumed so much time since indicator 55 was last tested and found to be set, that indicator 55 has been set and unset automatically so that it is too late to punch the associated row. Indicator 57 is unset when tested by program.

Notes The testing of indicator 57 will permit the appropriate error routine to be brought into operation if the index point time is missed. If this indicator is not tested, and an index point time has been missed, the computer will go into a continuous loop after punching the last row. This is because the index point counter has not been reduced to zero by the time the last row has been punched but holds the number of index point rows missed. Since the counter does not show zero the computer goes into a continuous loop, testing indicator 55 which remains unset.

Indicator 58 Check Index Point Time Missed

Purpose Indicator 58 is set in the event of indicator 56 being unset automatically (i.e. it has not been tested by program) indicating that it is too late to check the associated row of punching positions for correct punching.

Operation Except that it is associated with indicator 56, and is concerned with checking instead of punching, indicator 58 corresponds to indicator 57 in operation and use.

Distribution of Punch Data 3.3.4

Before punching information in a card it must first be distributed into words of ten digits, each occupying digit positions 3 to 12 of an I.A.S. location. Successive I.A.S. words represent columns 1 to 10, 11 to 20, 21 to 30 and so on for both zone and numeric components. For each group of 40 punch magnets the data occupy four words with zone components and another four with numeric components. Thus if both groups are to be used, 16 words are required for each card to be punched.

Example

Zone components for card columns	Stored in positions 3 to 12 of I.A.S. locations	Numeric components for card columns	Stored in positions 3 to 12 of I.A.S. locations
1 to 10	200	1 to 10	208
11 to 20	201	11 to 20	209
21 to 30	202	21 to 30	210
'	'	'	'
'	'	'	'
71 to 80	207	71 to 80	215

In this example, position 3 of I.A.S. word 200 and position 3 of I.A.S. word 208 contain the zone and numeric component respectively for data to be punched in column 1.

The suppression of any non-significant zeros should be arranged at this stage. If the punching of non-significant zeros to the left of a number or value is to be suppressed, the position of the most-significant digit must be determined to permit the insertion of the necessary zone components in the words containing the zoning for output, i.e. zeros which are to be punched should be given a zone component of 1 and zeros which are to be suppressed should be given a zone component of 0.

The next step is to convert the information into row-binary form for each of the 12 punching positions. It must be remembered that punching positions 10 will be required to be punched, not only as a numeric digit of 10 (as in 10d.) but also as a zone component of 2 where alpha contents of this zone are concerned. Hence, it is necessary during row-binarizing to combine data for numeric 10 with that for zone 2 into the same row-binary word by use of Logical OR. Similar treatment is required for combining numeric 11 with zone 3, numeric 0 with zone 4 and numeric 1 with zone 5. On completion of the row-binary routine, the data, both zone and numeric combined, comprises 12 words in punching position order for each punch magnet group.

Flowchart of a Punch Program 3.3.5

The flowchart in Figure 16 represents a program to punch and check data which have already been distributed and row-binarized. The flowchart is included here to illustrate the use of the instructions and indicators associated with punching and the action to be taken if an error is detected.

Each card requires 24 words of row-binary, the first 12 containing data to be punched in columns 1 to 40 in index point order 10, 11, 0 and 1 ..... 8, 9, the second 12 containing data for columns 41 to 80.

A further 24 words are required which contain data for checking the last card punched in the previous entry to the program. For the first entry into this routine at the beginning of a job run, these 24 words should contain all $\overline{15}$s since with no card at the check station, check-reading will give a word of $\overline{15}$s. In order that the last card should be checked, an extra entry should be made to the subroutine to punch a blank card after the last data card.

Programmed indicators 11 and 12 are used with the program only; their state on entering the program is immaterial.

The following error actions are taken:-

(a) On failure of the programmed check, punch or check index point missed, the card being checked and the subsequent card are both offset in the stacker, the second card not being checked. Both cards are then repunched in the correct order.

(b) On a second check failure occurring for the card which previously failed the check, the machine will stop. Programmed indicator 12 will then remain set and the corresponding visual indicator will be lit.

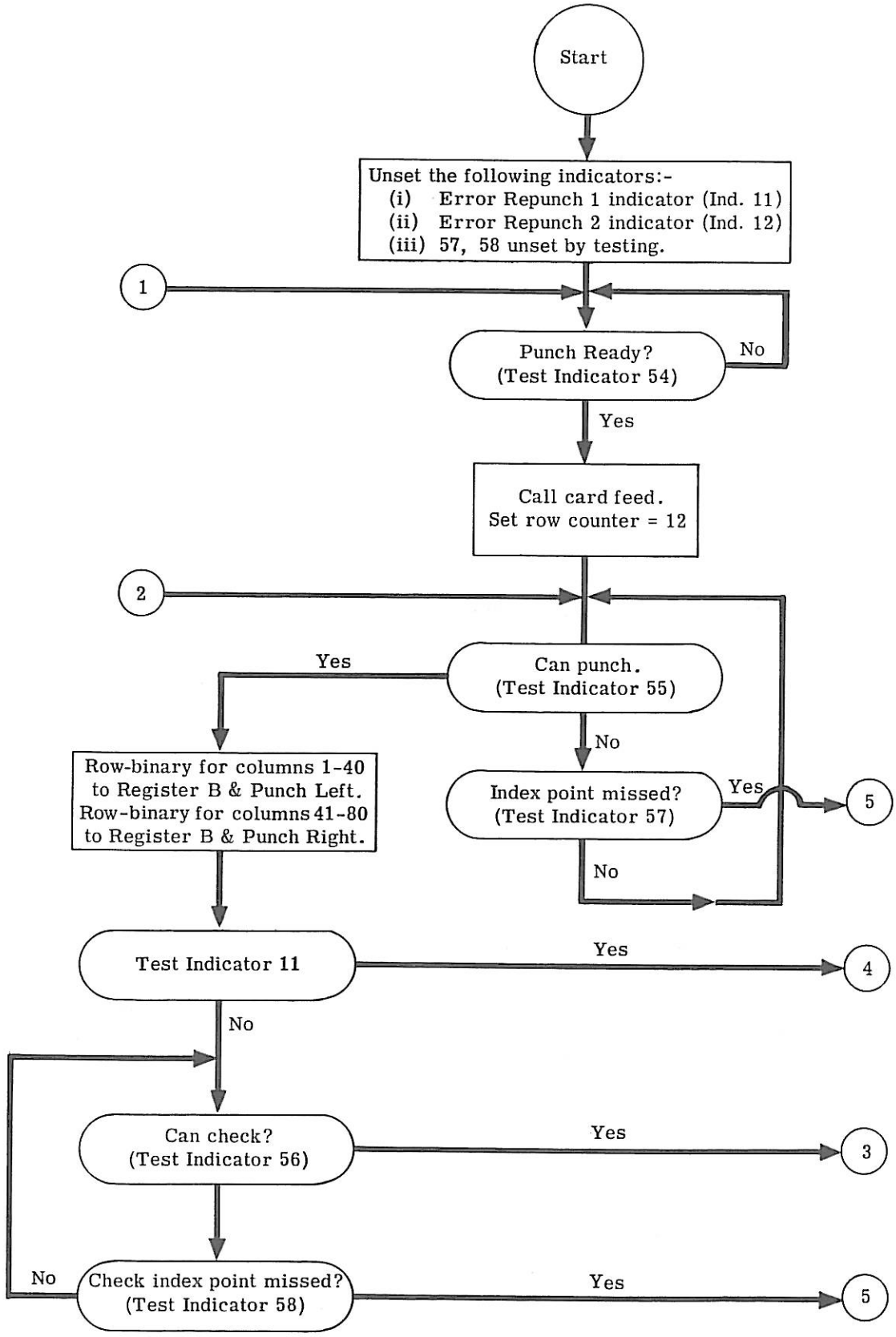

Figure 16: FLOWCHART OF A PUNCH PROGRAM

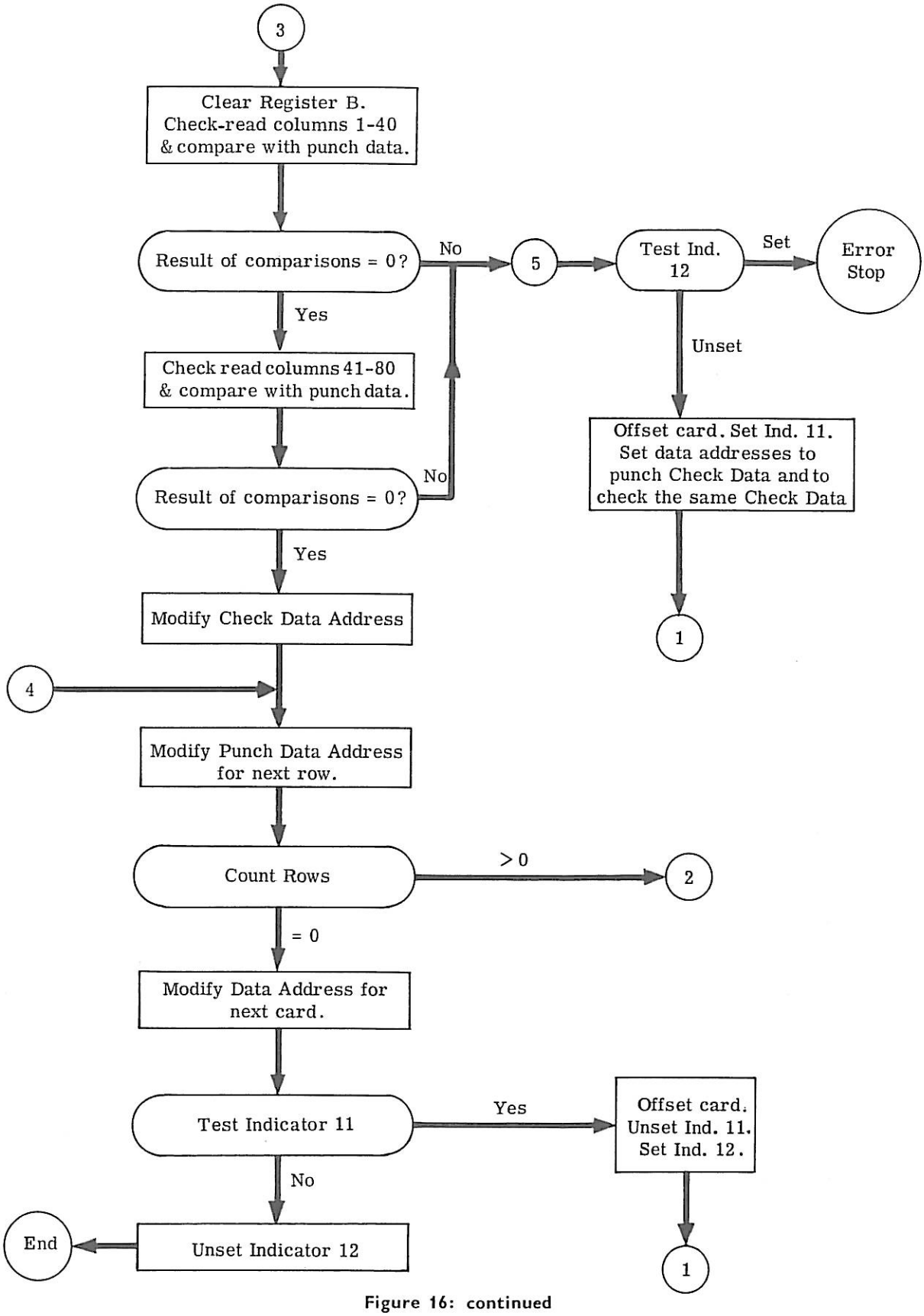

Figure 16: continued

OPERATION	MINIMUM TIME OF OPERATION
Card Punching rate	100 cards a minute
Card Cycle	600 ms
Calling Punch from rest, with motor running, to 1st Punch Index Point Time on.	35.83 ms
Index Point Interval	40.7 ms
Punch Index Point Time indicator (55) duration	6.52 ms
Check Index Point Time indicator (56) duration	14.66 ms
Interval between last setting of indicator 56 to last time to give 380042 instruction for continuous running.	58.22 ms
Interval between last setting of indicator 56 and 1st setting of indicator 55 when feeding continuously	102.2 ms
Time between last setting of indicator 56 and last time to give 380047 instruction	41.94 ms

THE LINE PRINTER 3.4

The line printer basically comprises a print unit, stationery feed mechanism and control logic.

The print unit consists of a print barrel and a number of associated print hammers. The print barrel, with the type characters embossed on it, rotates at high speed. The print hammers, under the control of the computer, strike the stationery momentarily against the print barrel through an inked ribbon located between the stationery and the barrel.

The stationery feed mechanism comprises a tractor-driven, continuous-stationery feeding device which can feed up to four parts of stationery. A reversible carbon ribbon is fitted for the top copy. It must be noted that the stationery and carbon paper employed must conform to specifications that have been laid down. The paper movement (i.e. spacing and throwing) is controlled by a sprag and ratchet wheel mechanism which is operated by control signals generated by the computer program.

The Print Unit 3.4.1

Print Barrel The print barrel has 120 positions and each print position comprises 50 type characters embossed round the barrel. The lateral spacing of printing is ten characters to the inch and the vertical spacing is six characters to the inch.

At every character position in the barrel's position, the computer emits an impulse to the printer for each print position at which a character must be printed.

A line printer is available which has only 80 print positions. Throughout this section however, reference is made only to 120 print positions with the appropriate short qualifying note where necessary.

Print Characters The 50 print characters comprising one print position are arranged round the print barrel in ten sectors with five characters in each sector. The ten sectors and the arrangement of characters within these sectors correspond to the I.C.T. 5-zone card code. This code is shown in Figure 17 and the arrangement of the characters on the barrel is shown in Figure 18. Comparing these two diagrams, it can be seen that the ten sectors correspond to the ten numeric index positions (0 to 9) in the card code and the five characters within these sectors correspond to the five zone positions. For example, $\frac{3}{4}$, Z, R, I, 9 in the sector for index point 9 correspond to numeric 9 zone 5, numeric 9 zone 4, numeric 9 zone 3.....numeric 9 zone 1 respectively. It should be noted that there are only ten index positions and positions 10 and 11 are represented as zone 3-numeric 0 and zone 2-numeric 0 respectively.

Card Code		Zone				
		Numeric	10	11	0	1
Computer Code		1	2	3	4	5
Index Point	0	0	11	10	*	£
	1	1	A	J	&	$
	2	2	B	K	S	%
	3	3	C	L	T	¼
	4	4	D	M	U	-
	5	5	E	N	V	/
	6	6	F	O	W	½
	7	7	G	P	X	.
	8	8	H	Q	Y	@
	9	9	I	R	Z	¾

Figure 17: TABLE OF CODES AND CODED ZONES FOR PRINTING

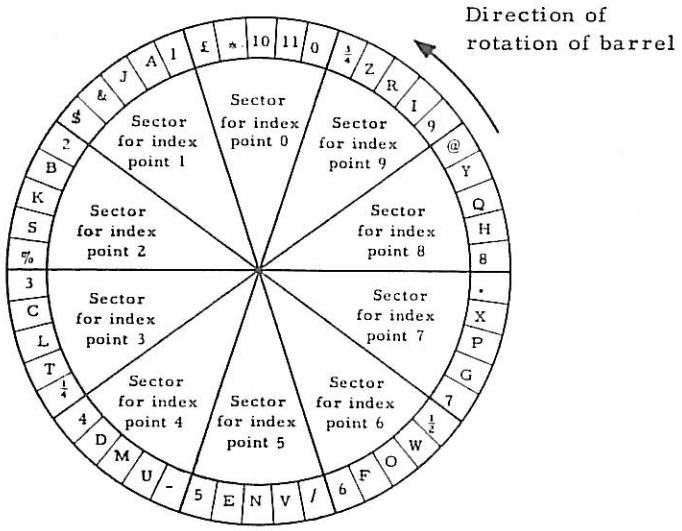

Figure 18: CHARACTER ARRANGEMENT ON PRINT BARREL

Print Hammers There are 120 print hammers fitted, i.e. one for each print position. The 120 print hammers are grouped into three banks of 40 hammers in each bank. The print hammers strike the stationery against the print barrel when the character to be printed is opposite the print hammers. Printing is achieved on each of the three banks of 40 print hammers in turn. This entails up to three transfers (one per print bank) of 40 bits from Register B to activate the print hammers. Each bit will either be 0 or 1; 0 means *do not print* (i.e. do not activate print hammer) and 1 means *print* (i.e. activate print hammer). The 80 print position printer has 80 print hammers arranged in two banks of 40.

Printing Figure 19 shows the relationship between the print unit and Register B.

Data to be printed, that is the zone and numeric components of each character, must be row -binarized (see 2.7) so that it is in the 0 and 1-bit form described above. During printing, positions 3 to 12 of Register B must hold data in row-binarized form. The contents of Register B are transferred to one of the print banks according to the program instruction. Thus the essential

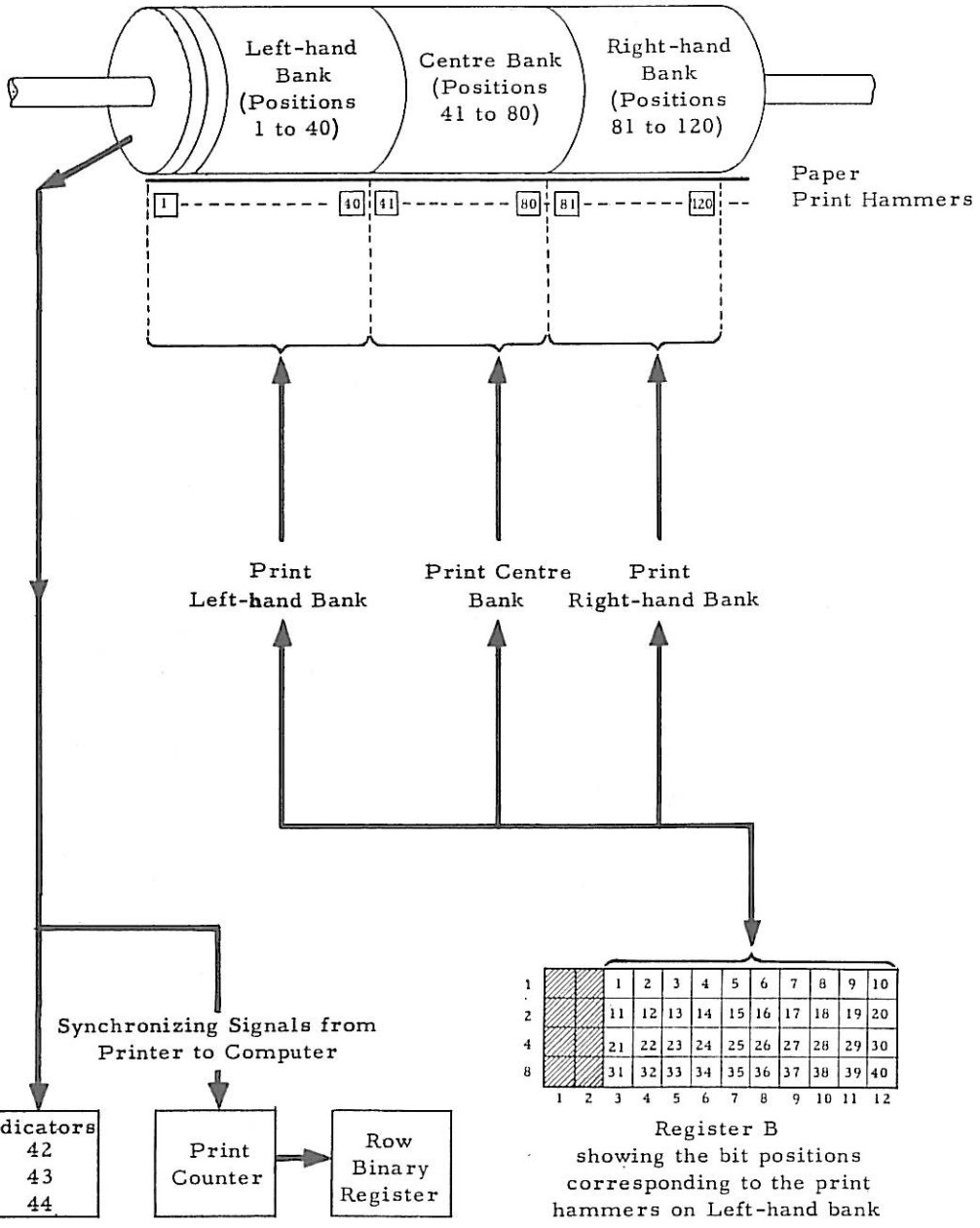

Figure 19: DIAGRAMMATIC REPRESENTATION OF RELATION BETWEEN REGISTER B AND PRINT BARREL ASSEMBLY

part of a printing program is the creation of row-binary, which takes place in two stages: row -binarizing the zone components of print characters and row-binarizing the numeric components of print characters. The zones and numerics are then combined for each character by the Logical AND instruction.

Synchronizing signals are emitted from the printer to the computer and have two main functions: they set various indicators and they set the print counter. The print counter registers which sector of the print barrel is opposite the print hammers ready for printing. This counter is a subtraction counter which counts down from 9 to 0 in steps of 1 and is then reset to 9 at each complete revolution of the print barrel; thus the figure held in this counter is equal to the sector (index point) which is at that moment ready for printing. When a sector is available for printing, the numeric components required for this sector must be row-binarized. To enable this to be done, an instruction can be given which will cause the contents of the print counter to be transferred to the Row Binary Register.

Print Instructions 3.4.2

Instruction 380013

Effect A 380013 instruction will cause the contents of the print counter to set the Row Binary Register.

Operation The Print Counter will register which sector is available for printing. Thus row-binary may be formed for the numeric components prior to printing.

Instruction 380014

Effect A 380014 instruction will cause printing to take place on the left-hand print bank.

Operation When a 380014 instruction is given, the contents of Register B will cause printing to take place on print positions 1 to 40. The presence of a 1-bit in any position of Register B will cause the associated print hammer to be actuated. The bit positions of Register B will be associated with print hammers 1 to 40 as shown below:

1	2	3	4	5	6	7	8	9	10	11	12	
		1	2	3	4	5	6	7	8	9	10	1
		11	12	13	14	15	16	17	18	19	20	2
		21	22	23	24	25	26	27	28	29	30	4
		31	32	33	34	35	36	37	38	39	40	8

Instruction 380015

Effect A 380015 instruction will cause printing to take place on the centre print bank.

Operation When a 380015 instruction is given the contents of Register B will cause printing to take place on print positions 41 to 80. The bit positions in Register B will be associated with print hammers 41 to 80 as shown below:

1	2	3	4	5	6	7	8	9	10	11	12	
		41	42	43	44	45	46	47	48	49	50	1
		51	52	53	54	55	56	57	58	59	60	2
		61	62	63	64	65	66	67	68	69	70	4
		71	72	73	74	75	76	77	78	79	80	8

Note On the 80 print-position printer only the 380014 and 380015 instructions are applicable.

Instruction 380016

Effect A 380016 instruction will cause printing to take place on the right-hand print bank.

Operation When a 380016 instruction is given, the contents of Register B will cause printing to take place on print positions 81 to 120. The bit positions of Register B will be associated with print hammers 81 to 120 as shown below:

1	2	3	4	5	6	7	8	9	10	11	12	
		81	82	83	84	85	86	87	88	89	90	1
		91	92	93	94	95	96	97	98	99	100	2
		101	102	103	104	105	106	107	108	109	110	4
		111	112	113	114	115	116	117	118	119	120	8

Print Indicators 3.4.3

A print program requires the use of six indicators, two of which - indicators 45 and 47 - are used only for spacing and are described in 3.4.8. The remaining four are as follows:-

Indicator 42 Printer Ready

Purpose Indicator 42 is automatically set when the printer is available for printing.

Operation Indicator 42 is unset by the printer interlock if the printer is not available for printing. The printer is not available for printing when one of the following seven conditions arises:

(a) The stationery feed mechanism is moving, i.e. the printer is spacing or throwing.

(b) The automatic paper-feed stop device has operated. This occurs when the paper has been thrown excessively, this being regarded as an error condition. The autostop occurs when the paper throw is about twenty inches.

(c) The print barrel mechanism has been opened.

(d) The Stop Printer button has been pressed.

(e) The Emergency Stop button has been pressed.

(f) No paper i.e. the paper has passed the tensioning device.

(g) The power supply has been cut off.

It must be noted that indicator 42 is *not* unset when tested.

Indicator 43 Print Index Point Time

Purpose Indicator 43 is set when the start of a sector is being positioned for printing.

Operation At every fifth character time, an impulse is emitted from the printer to the computer to denote the start of a new sector. This impulse will cause indicator 43 to be set and the print counter will be stepped down by 1. Indicator 43 is unset when tested by program. If the indicator is not unset (by testing) within a certain time from the start of a sector time, it is unset automatically.

Indicator 44 Print Character Time

Purpose Indicator 44 is set when a character is about to be presented for printing.

Operation In order that the computer program may be aware when a character is about to be presented for printing, impulses are emitted from the line printer to the computer. One impulse is emitted at the start of each character time and this impulse causes indicator 44 to be set. Indicator 44 will be unset when tested by program.

Indicator 49 Print Count Error

Purpose Indicator 49 will be set if the print counter is not in its correct condition when a master synchronizing pulse is emitted.

Operation At each complete revolution of the print barrel, a master (datum) pulse is emitted. If the print counter is not in its correct condition when this pulse is emitted, indicator 49 will be set. This indicator is unset when tested.

Indicator 49 should be tested at regular intervals in the program, for example when a document has been printed.

Whenever a fault occurs that sets this indicator it should be noted and an engineer informed.

A Printing Program

Essentially the process of printing covers the following:

(a) Distributing print data in a correct sequence in I.A.S.

(b) Converting the binary-coded information to the printing code i.e. 4-bit information converted to single-bit information (by creating row-binary) to operate the print hammer triggers.

(c) Presenting the single-bit information to the appropriate print hammer at the correct time.

(d) Above must also include provision for zero suppression and the creation of spaces between print characters where necessary.

Before entering the print program the output information for printing must be arranged in a sequence consistent with the print positions. In addition, the zone digits must be generated for numeric information brought to output from processing where the zone digits will have been discarded.

If data is to be printed on all three print banks (i.e. on all 120 print positions) then the print data should be stored in 24 successive locations of I.A.S. 24 locations are required because each location holds the zone or numeric components of ten print characters in digit positions 3 to 12. 12 successive locations of I.A.S. contain the zone components of the print data and the next 12 successive locations of I.A.S. contain the numeric components of the print data. Thus print data may be stored as shown in Figure 20. Thus, for example, position 3 of I.A.S. word 200 and position 3 of I.A.S. word 212 contain the zone and numeric components for data to be printed on print position 1.

Zone Components for print positions:	Stored in positions 3 to 12 of I.A.S. locations:	Numeric components for print positions:	Stored in positions 3 to 12 of I.A.S. locations:
1 to 10	200	1 to 10	212
11 to 20	201	11 to 20	213
21 to 30	202	21 to 30	214
31 to 40	203	31 to 40	215
'	'	'	'
'	'	'	'
'	'	'	'
111 to 120	211	111 to 120	223

Figure 20: EXAMPLE OF PRINT DATA DISTRIBUTION

If the printing of non-significant zeros to the left of a number or value is to be prevented, the position of the most-significant digit must be determined in order to insert the appropriate zone components into the words containing the zoning for output. For example, suppose that it is required to print a sterling value which may range from zero to £99999-19-11, and that single spaces are required to separate the £, s, and d, then the zone and numeric components for three possible values will be as shown in Figure 21.

	£	£	£	£	£		s	s		d
Numeric -	1	2	3	4	5	0	1	0	0	0
Zone -	1	1	1	1	1	0	1	1	0	2
Printed result:	1	2	3	4	5		1	0		11

(i)

	£	£	£	£	£		s	s		d
Numeric -	0	0	2	0	3	0	0	0	0	0
Zone -	0	0	1	1	1	0	0	1	0	3
Printed Result:			2	0	3			0		10

(ii)

	£	£	£	£	£		s	s		d
Numeric -	0	0	0	0	0	0	0	5	0	2
Zone -	0	0	0	0	0	0	0	1	0	1
Printed result:								5		2

(iii)

Figure 21: EXAMPLE OF STERLING PRINTING

It can be seen from the above examples that several points must be borne in mind when printing sterling values:

(a) The pence position must be tested for 10d. or 11d., the zone components for which are 3 and 2 respectively; for 0-9, the zone component will be 1.

(b) If spaces are required between £, s, and d, the corresponding spaces must be present in the output data (positions 7 and 11 in the example).

(c) The most-significant £'s position must be determined in order to prevent the printing of non-significant zeros, the zone component being 1 for all £'s positions which are to be printed.

(d) Assuming that the units of shillings position must always be printed, the zone component will be 1. The figure in the 10/- position can be either 1 or 0. If it is required to print in both instances the zone component will always be 1. If it is required to print 1 and suppress 0, the 10/- position must be tested to detect which number is present; a zone component of 1 then being inserted for the number to be printed and a zone component of 0 for the number to be suppressed.

Subroutines are available for the zero suppression of decimal or sterling amounts which achieve maximum efficiency in terms of time and storage capacity requirements.

Flowchart of a Print Program 3.4.5

Figure 22 is a flowchart of a program for printing one line. The following three assumptions are made:

(a) Row-binarizing has not been completed before entering the program.

(b) It is required to print on all three print banks.

(c) All data to be printed has been distributed, as described under "Distribution of Print Data".

The letters in brackets beside the paragraphs describing the program relate to the letters shown on the flowchart.

(a) Indicator 42 is tested.

If set proceed to (b).

If unset the printer is not yet ready (probably spacing). Loop back and continue testing until printer is ready.

(b) Enter a 5 into Row Binary Register by means of function 30 and also into an I.A.S. location used as the Row Binary Counter. Set another I.A.S. location, used as the Index Point Counter, to 10.

(c) The instructions to transfer the row-binarized zoning from Register B to I.A.S. (see (d) page 34) are formed by adding the contents of the Row Binary Counter to the basic 42 instructions; e.g. if the row-binarized information is to be stored in words 0 to 17 of block 10, the instructions would be as follows where x is the number in the Row Binary Counter.

D	F	A	R
-	42	0000+x	10

Instruction to store row-binarized zoning for printing on left-hand bank

D	F	A	R
-	42	0006+x	10

Instruction to store row-binarized zoning for printing on centre bank

D	F	A	R
-	42	0012+x	10

Instruction to store row-binarized zoning for printing on right-hand bank

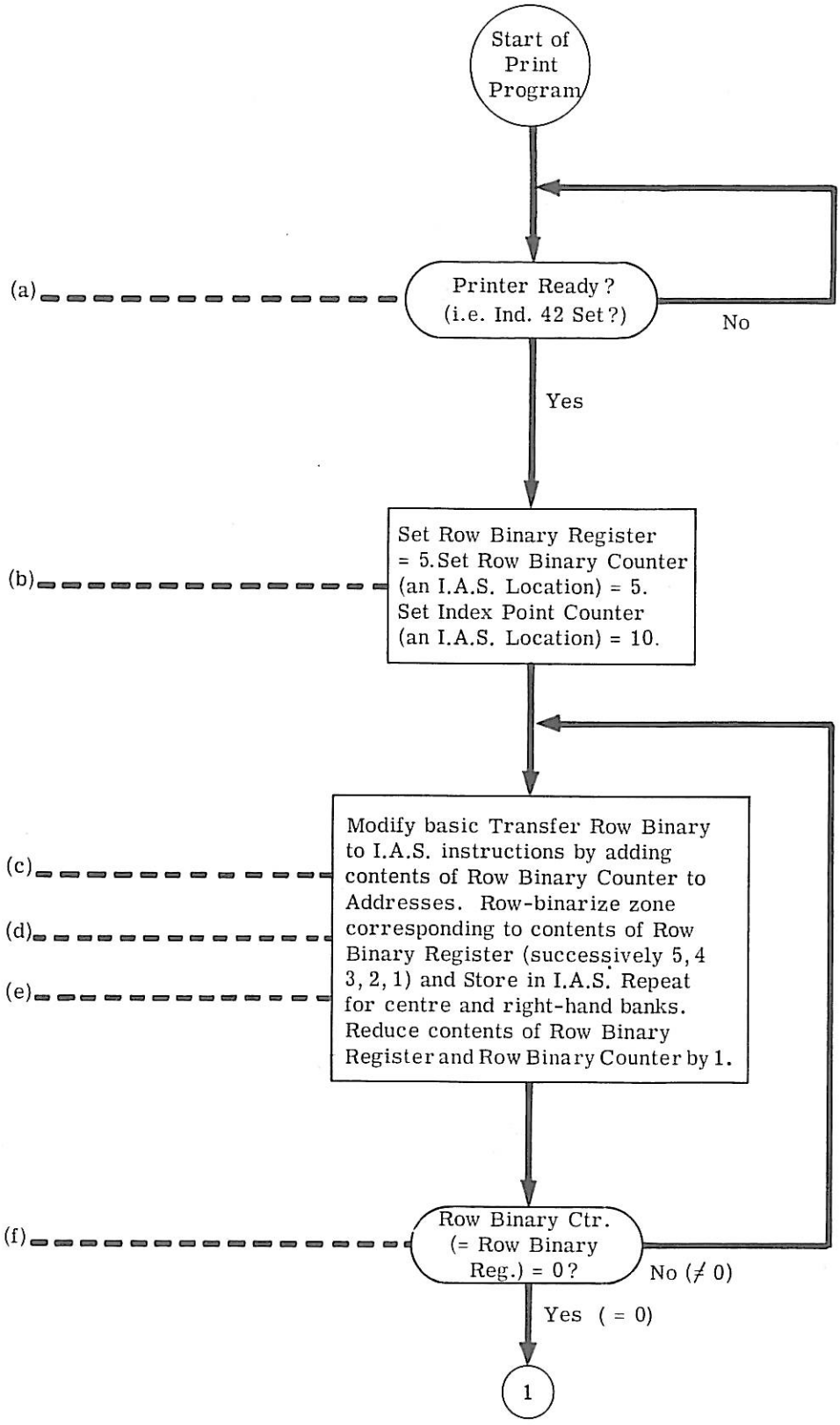

Figure 22: FLOWCHART OF PROGRAM TO PRINT ONE LINE

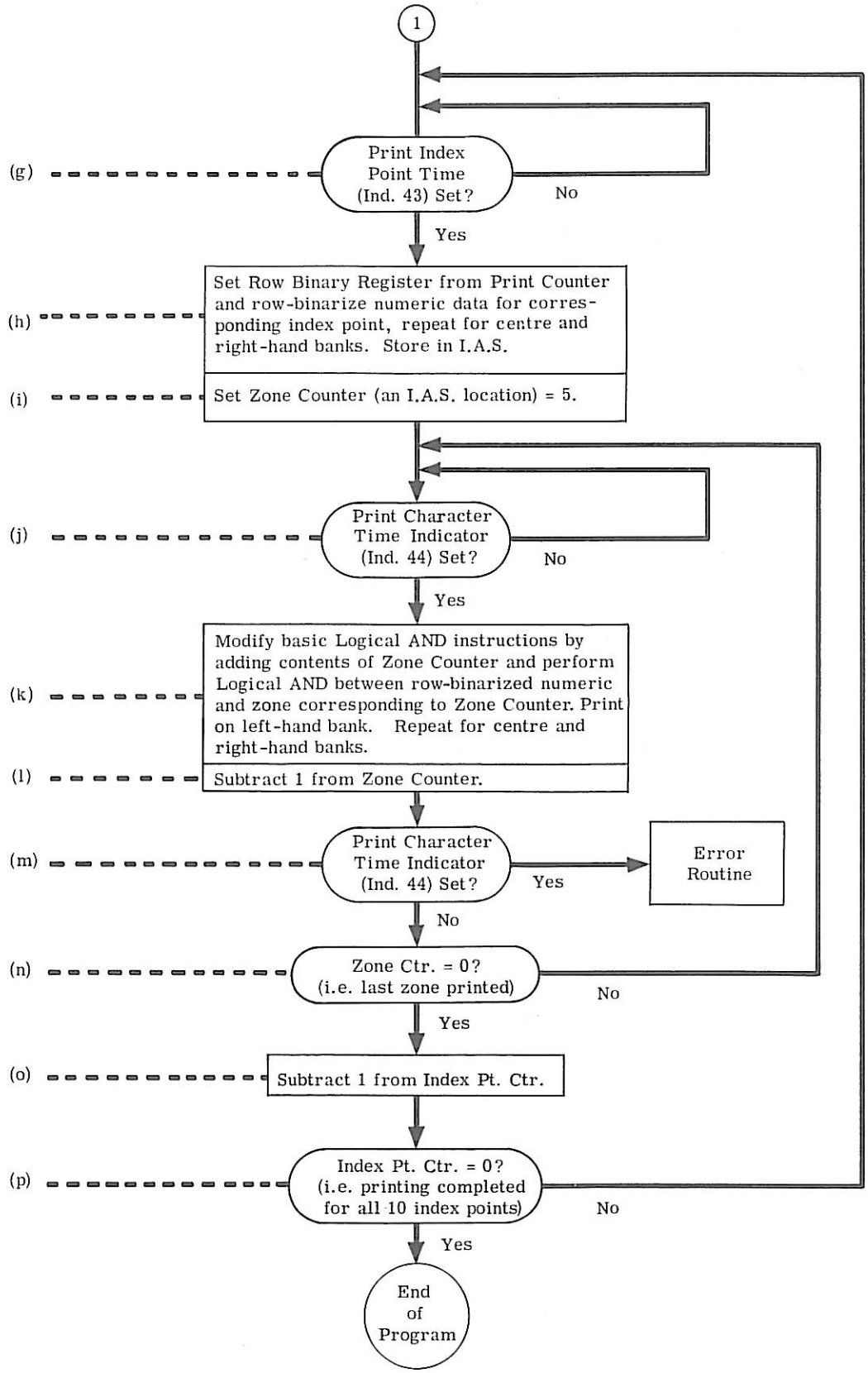

Figure 22: continued

(d) The twelve words of zoning are row-binarized, the actual zone corresponding to the contents of the Row Binary Register. Zone 5 is binarized first, starting with the first four words of data; words 1 to 4 being binarized into the 1, 2, 4 and 8 streams respectively of Register B. The resulting row-binary is then stored in I.A.S. using the instruction created in (c) for storing away row-binary corresponding to the left-hand print bank. This is then repeated for words 5 to 8 (centre bank) and 9 to 12 (right-hand bank).

(e) The contents of the Row Binary Counter are reduced by 1 (causing either indicator 01 or indicator 02 to be set) and the resulting figure is entered into the Row Binary Register.

(f) Indicator 01 is tested to determine whether or not the contents of the Row Binary Register and Counter have now been reduced to zero. If not zero the program loops back to the beginning of (c). In (d) the next zone is row-binarized, the order being 5, 4, 3, 2, 1. After zone 1 has been binarized, the content of the Row Binary Counter is reduced to 0 and the program proceeds to (g).

(g) Indicator 43 is tested to determine whether or not the next sector is ready for printing. If the indicator is not set the program continues to test it until it is, when the program proceeds to (h).

(h) By means of the instruction:

D	F	A	R
–	38	00 13	–

the contents of the print counter, which corresponds to the number of the sector which is currently available for printing, is entered into the Row Binary Register. It will not be known what this number is since the position of the print barrel is also unknown. This will be of no consequence, provided the printing routine is repeated for each of the ten index points; it is not necessary to start with any particular sector. Following the 380013 instruction, the whole of the numeric data is row-binarized. The first four words are binarized into the 1, 2, 4 and 8 streams of Register B respectively, then stored in I.A.S. by means of a basic transfer instruction as used in (c). This is then repeated for words 5 to 8 and words 9 to 12. Row-binarizing is thus completed for printing all five characters of the sector concerned, the location of row-binary in I.A.S. being as shown in Figure 23.

(i) Enter a 5 into an I.A.S. location which is used as the Zone Counter.

(j) Test indicator 44 to determine whether or not a character of the sector is in position for printing. The program repetitively tests the indicator until it is set, when the program proceeds to (k).

(k) Every character to be printed is represented within the computer by numeric and zone components. Consider the letter H (numeric 8, zone 2) about to be printed. Assuming

Row-binary for printing on left-hand bank		Row-binary for printing on centre bank		Row-binary for printing on right-hand bank	
Word No.	Zone/Numeric	Word No.	Zone/Numeric	Word No.	Zone/Numeric
0	Numeric	6	Numeric	12	Numeric
1	Zone 1	7	Zone 1	13	Zone 1
2	Zone 2	8	Zone 2	14	Zone 2
3	Zone 3	9	Zone 3	15	Zone 3
4	Zone 4	10	Zone 4	16	Zone 4
5	Zone 5	11	Zone 5	17	Zone 5

Figure 23: LOCATION OF ROW-BINARY FOR PRINTING IN I.A.S.

the row-binary to be stored in the locations shown in Figure 23, then the binary for the numeric component is in words 0, 6 and 12, and that for the zone component (zone 2) in words 2, 8 and 14. The row-binary for character H is produced by means of Logical AND between words 0 and 2 (left-hand bank), 6 and 8 (centre bank) and 12 and 14 (right-hand bank).

Example: Assume words 0 and 2 contain the following row-binary

Word 0

		0	0	1	0	0	0	0	0	1	0	1
		1	0	0	1	0	1	0	0	0	0	2
		0	1	0	0	0	0	0	0	0	0	4
		0	0	0	1	0	0	1	0	0	1	8

Word 2

		0	1	1	0	1	0	0	1	0	1	1
		1	0	0	1	1	0	0	0	1	0	2
		0	1	0	0	1	1	1	0	0	0	4
		0	0	1	0	0	1	0	0	0	1	8

The contents of word 0 indicate that a character with a numeric component of 8 (i.e. 8, H, Q, Y or @) is to be printed on each of positions: 3, 9, 11, 14, 16, 22, 34, 37 and 40 of the left-hand bank. The contents of word 2 indicate that a character with zone component 2 (i.e. 11 or any letter from A to I) is to be printed on each of positions: 2, 3, 5, 8, 10, 11, 14, 15, 19, 22, 25, 26, 27, 33, 36 and 40 of the left-hand bank. The contents of word 0 are tranferred to Register B and Logical AND is performed between Register B and word 2, resulting in a 1 in any bit position where there was a 1 in the corresponding bit position of both words, thus:

		0	0	1	0	0	0	0	0	0	0	1
		1	0	0	1	0	0	0	0	0	0	2
		0	1	0	0	0	0	0	0	0	0	4
		0	0	0	0	0	0	0	0	0	1	8

This indicates that character H is to be printed on each of positions: 3, 11, 14, 22 and 40 of the left-hand bank.

Immediately following the Logical AND a 380014 instruction is given, and the H's are printed on the left-hand bank. Then the row-binary for the centre bank is produced by Logical AND between words 6 and 8, and character H printed on the centre bank; and similarly for the right-hand bank.

For each sector, the characters with zone component 5 are printed first, followed by those with components 4, 3, 2 and 1.

(l) The zone counter is stepped down by 1.

(m) Indicator 44 is tested.
If unset: continue to (n).
If set: too much time has been consumed in printing character and the following character time has been encroached upon. Program enters the appropriate error routine.

(n) (i) If zone counter positive after (l), program loops back to (j).
(ii) If zone counter contains 0, all five characters on the sector have been printed and the program proceeds to (o).

(o) The index point counter is stepped down by 1.

(p) (i) If the index point counter positive, the program loops back to (g) to print the characters on the next of the ten sectors.

(ii) If index point counter contains 0, printing has been completed for all ten sectors, and therefore the complete line has been printed.

Paper Movement 3.4.6

Continuous stationery employed on the printer is punched with marginal sprocket holes and is tractor driven. Up to 4-part stationery may be used and the stationery and carbon paper must conform to the 1300-series stationery specifications.

Paper movement is controlled by the computer and either paper spacing or paper throwing (i.e. more than five spaces) is possible. The marginal sprocket holes in the stationery are engaged on the upper and lower sets of tractor wheels. These motor driven tractors rotate, thus moving the stationery. The rotating action of the tractors is controlled by a sprag and ratchet wheel mechanism; this mechanism is shown diagrammatically in Figure 24. It can be seen that the mechanism consists of six sprags engaging into a ratchet wheel which has five faces; the ratchet wheel controls the rotation of the tractor wheels and therefore rotates with paper movement. The rotating action of the ratchet wheel is in turn controlled by the lifting and dropping of the six sprags according to the computer program instructions.

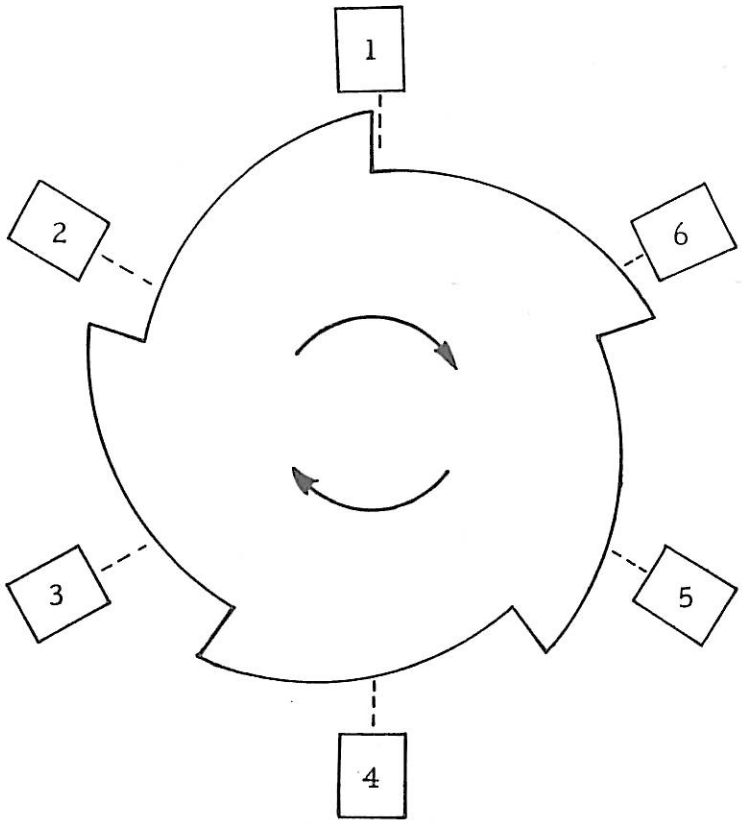

Figure 24: SPRAG MECHANISM

If a sprag is dropped, the rotation of the ratchet wheel is arrested when that sprag makes contact with one of the five faces; thus, paper movement is arrested. If a sprag is lifted and another sprag is dropped, the ratchet wheel will rotate until it is arrested by the dropped sprag; thus, a certain movement of the paper will take place before the paper is again stopped. When it is known which sprag is currently engaged, a single space (a vertical movement of $\frac{1}{6}$ inch) may be achieved by raising that sprag (and all other sprags) and allowing the ratchet wheel to rotate. The next sprag in counterclockwise succession is dropped thus arresting the movement. Similarly, two spaces may be achieved by lifting the engaged sprag and dropping the second sprag in counter -clockwise succession and so on; up to five spaces may be achieved by this method.

An interlock is set up by any paper movement order and will remain set until the paper comes to rest. An automatic stop device is incorporated in the printer which will operate when the paper has been thrown about twenty inches. The device will cause:

(a) The paper feed mechanism to stop, and

(b) an interlock between printer and computer to be set up, and

(c) a visual indicator on the printer to be illuminated and remain so until it is switched off by a manual control on the printer switch panel.

Paper Throw Instructions 3.4.7

Sprag Instructions 380020 to 380026

All paper movement instructions are sprag instructions; that is, they control the lifting and dropping of the sprags. These instructions are shown in the table below.

Function	Address	Description
38	20	Lift all sprags
38	21	Drop Sprag 1 : lift all others
38	22	Drop Sprag 2 : lift all others
38	23	Drop Sprag 3 : lift all others
38	24	Drop Sprag 4 : lift all others
38	25	Drop Sprag 5 : lift all others
38	26	Drop Sprag 6 : lift all others

These instructions are used to control the sprags as explained in the preceding description of the operation of the sprags.

Paper Throw Indicators 3.4.8

Indicator 45 Line Space Time

Purpose Indicator 45 is set when each line space has been completed.

Operation When a line space has been achieved indicator 45 will be set. It will be unset when tested by program. If indicator 45 is not tested (and therefore not unset) within a certain time from it becoming set, then it will be unset automatically.

Notes Indicator 45 will require testing when more than five line spaces are required on a single throw; a further description of the use of this indicator is given under 3.4.9. It is possible to time-share paper throwing with another program by using the time between successive line space indications.

Indicator 47 Paper Trolley Empty

Purpose Indicator 47 is set automatically when the supply of paper in the printer is almost exhausted.