Punched Card Data Processing Principles

Section 2: The IBM Sorter

IBM Personal Study Program

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The IBM Personal Study Program offers the opportunity to develop an understanding of and an appreciation for the tools of data processing, their operation and application. In recent years, the use of automatic data processing equipment has been extended into almost every area of business, government and science. As a result, the need for people knowledgeable in the subject has multiplied manifold—and is continuing to multiply.

The purpose of the IBM Personal Study Program is to help satisfy this need by providing simplified self-study texts covering the fundamentals of data processing. With the background these texts provide, the interested student will be prepared to delve further into those areas of greatest interest to him and his career.

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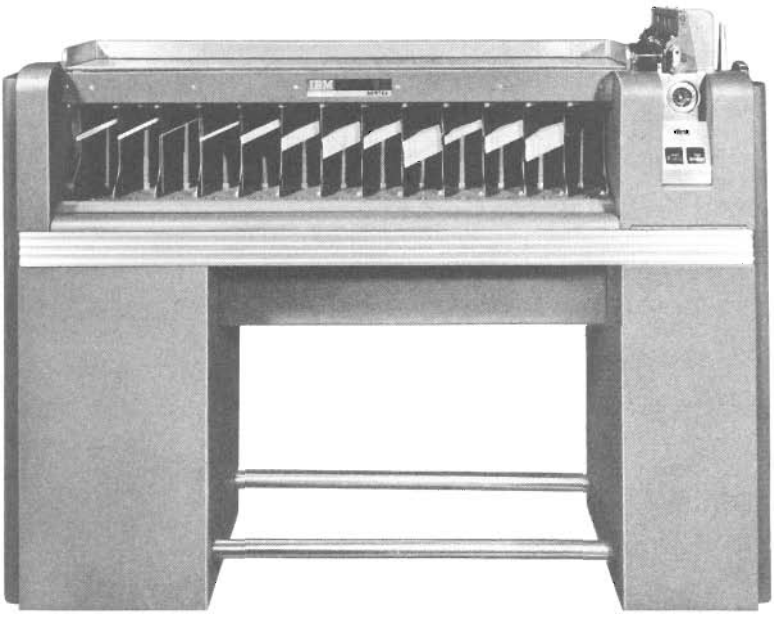


IBM 82 Sorter

Section 2: The IBM Sorter

Generally speaking, the end result of machine accounting is a printed report. The information in these reports is invariably grouped according to some definite sequence. For example, most companies require sales reports to assist them in determining sales trends. The sales transactions which make up the reports are usually grouped according to one of the following sequences for printing (Figure 1):

1. Customer number. (All sales to a given customer appear together. A report printed in customer-number sequence facilitates analysis of customer buying habits.)

2. Salesman number. (All sales by a particular salesman appear together. Sales reports are printed in this sequence to permit a rapid appraisal of each salesman's activities and results.)

3. Product number. (All sales of a specific product appear together. A report of sales in this sequence indicates product popularity.)

All of the required information for each of these reports can easily be contained in IBM cards of one format (Figure 2).

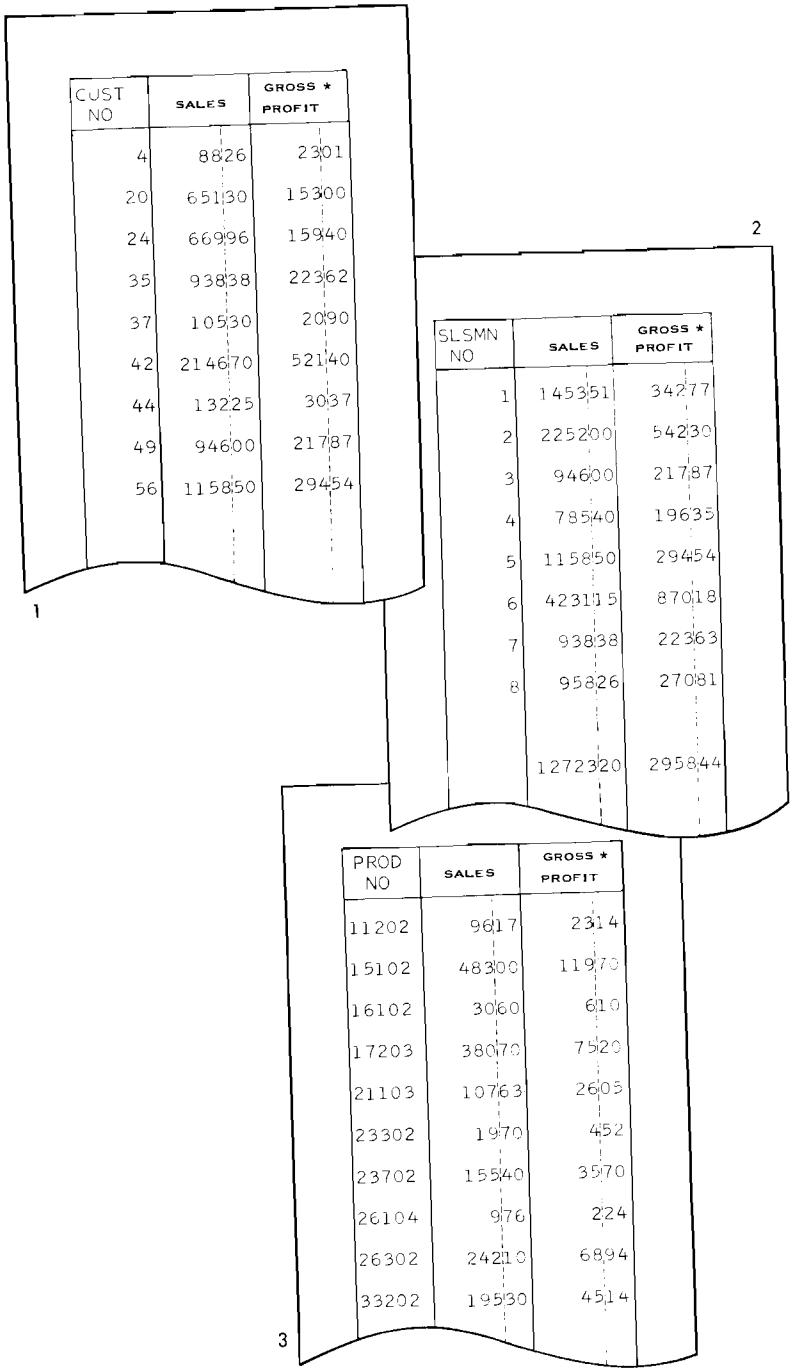
As the cards are produced by card punch operators they probably are not in sequence by either customer number, salesman number, or product number. Thus, before any of the three sales analysis reports can be printed, the cards must be in sequence by the desired category.

For purposes of illustration, assume that sales analysis reports are printed once a week from cards representing 20,000 sales transactions. In order to print each of the sales analysis reports the 20,000 cards must be regrouped three times by some kind of sorting procedure. Hand-sorting 20,000 cards into one group would take an unreasonable amount of time—hence a machine sorter.

There are several models of IBM sorters, differing only in speed and special devices. Pictured in the frontispiece is one of the most commonly used models, the IBM 82 Sorter. This machine will arrange IBM punched cards into numerical and alphabetic sequence. It can also be used to select cards with a specific punched hole from a deck of cards.

One of the features noted when seeing a sorter for the first time, is that there are thirteen slots or pockets. As you will recall from Lesson 1, each column of a card has twelve rows. Thus each row of any single column has a corresponding pocket. The thirteenth pocket is for those cards which do not have a hole in any row of the column being examined and is called the *REJECT* pocket (Figure 3).

Since the numerical characters 0-9 are represented by only one punch



1

CUST NO	SALES	GROSS * PROFIT
4	8826	2301
20	65130	15300
24	66996	15940
35	93838	22362
37	10530	2090
42	214670	52140
44	13225	3037
49	94600	21787
56	115850	29454

2

SLSMN NO	SALES	GROSS * PROFIT
1	145351	34277
2	225200	54230
3	94600	21787
4	78540	19635
5	115850	29454
6	423115	87018
7	93838	22363
8	95826	27081
	1272320	295844

3

PROD NO	SALES	GROSS * PROFIT
11202	9617	2314
15102	48300	11970
16102	3060	610
17203	38070	7520
21103	10763	2603
23302	1970	452
23702	15540	3570
26104	976	224
26302	24210	6894
33202	19530	4514

Figure 1. A summary report prepared by an IBM Accounting Machine.
*GROSS PROFIT represents SALES-COST.

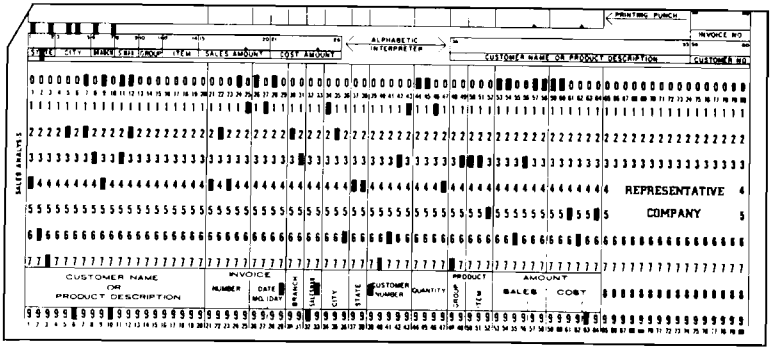


Figure 2.

per column, it follows that the pockets 0 to 9 are sufficient for sorting cards into numerical sequence. How the 26 alphabetic characters, each represented by two holes per column, can be sorted with only *twelve* pockets available, will be discussed in a later section.

Numerical Sorting

Numerical sorting, as the name implies, means that the cards are to be sorted on a field of information which contains only the punched holes, 0-9. To arrange cards in numerical order, each column in the field requires one sort. In other words, the cards must pass through the machine once for each column of numerical information to be sorted (Figure 4). Sorting progresses column by column from right to left across the field. For example, when cards are sorted on a two-column salesman-number field, the right-hand or *units column* (also referred to as the low-order position) is sorted first.

1. *If the rightmost column of a field is called the units position, what are the other positions called?**

Cards sorted in the 0 pocket contain all the salesman numbers ending in zero, for example, salesman numbers 10, 50, 40, 30, 90, etc. Cards sorted in the 1 pocket contain all the salesman numbers ending in a 1, for example, 21, 31, 91, 41, 81, 01, etc. Other cards fall in their respective pockets (Figure 5). The cards are then removed from the sorter pockets, sight-checked (Figure 6) to assure accuracy, and placed in ascending numerical sequence so that the zeros will be first, followed by 1, 2, 3, etc.

*Review questions have been interspersed throughout the text. If, as in this case, the question is marked with an asterisk, the answer is supplied at the end of the book. If the question is not marked with an asterisk, the answer can be found in the text preceding the question. When the book is completed, answer all questions again—this time without using the book. Then compare your answers with those in the book.

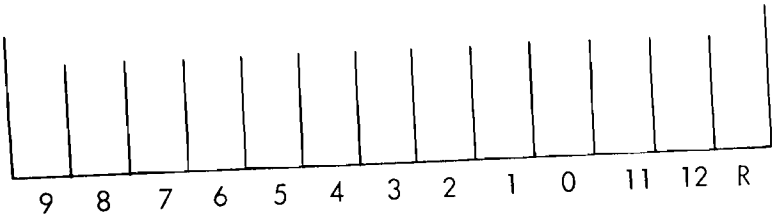


Figure 3.

*2. What is the purpose of sight checking?**

To complete the numerical arrangement the cards must be sent through the sorter a second time—to read the numerical digits in the tens position column. Those cards which fell into the 0 pocket on the previous sort feed through the machine first, followed by the 1s, then the 2s, and so on. During the second run, cards sorted into the 0 pocket contain salesman numbers 01-09 in sequence; cards sorted into the 1 pocket contain the salesman numbers 10-19 in sequence; cards sorted into the 2 pocket contain the salesman numbers 20-29 in sequence; and so on.

The cards are removed and placed into one stack, face down, so that the cards from the 0 pocket are on the bottom, the cards from the 1 pocket on top of the cards from the 0 pocket, the cards from the 2 pocket on top of the cards from the 1 pocket, etc. The entire deck of cards is now in numerical sequence (Figure 7).

Another procedure for removing cards from the sorter pockets is to start with the 9 pocket and progress to the 0 pocket. As the cards are removed from a pocket, they are placed *under* those already removed. Both procedures produce the same result.

For sorting larger fields, this procedure must be repeated for the third and subsequent columns. For example, in order to get the cards in sequence by customer number (columns 39-43 of the card in Figure 2), the cards would have to pass through the sorter five times.

As you will recall from Lesson 1, it is the usual practice to punch all columns of numerical fields—that is, those columns which do not contain significant digits are punched with zeros. Hence, in recording a two-digit *number* in a five-column field, the ten thousands, thousands, and hundreds columns would be punched with zeros and the *number* would be punched in the tens and units columns (for example, 00025). *In a strictly numerical sort, no cards should fall in the 11, 12 or reject pockets.*

*3. If a card does fall into the reject pocket, what can be assumed?**

Numerical Sorting of More Than One Field

In certain sorting operations, the desired sequence or order involves more than one field. For instance, it may be desired to arrange the cards

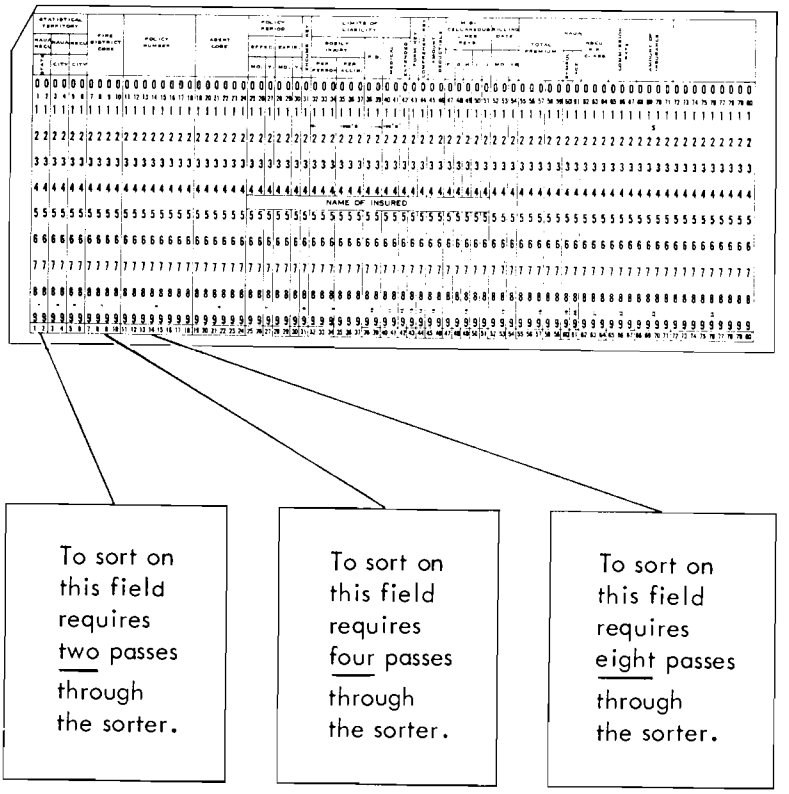


Figure 4.

in state order and in county order within each state. Such an arrangement is required for printing a report showing total sales by each county within a state as well as totals by each state. Arranging the cards into this sequence is known as a major and a minor sort. Because the county is a subdivision of the state, the county field is considered the minor sort, and the state field the major sort (Figure 8).

Minor sorts in a small file of cards are always made first. Upon completion of the minor sort the units column of the major field is sorted, followed successively by the next higher order columns of the major field.

Time Requirements and Considerations

The IBM 82 Sorter reads cards at the rate of 650 per minute. Sorting 650 cards on one column, therefore, requires one minute; sorting 650 cards on two columns requires *two* minutes. In order to calculate the amount of sorting time in minutes, the number of cards is multiplied by the number of columns to be sorted, and divided by the sorter reading speed, usually given in cards per minute. For example, if 1,300

(a) Indicating the original sequence of cards before first sort on a 2 column.

66
90
63
65
01
38
17
81
32
79
30
14
25
61
17
83
40
91
47
18
22
31
50
10
59
19
21
47
63

(b) At the end of the first sort which was made on the units position, the cards are in the pockets as follows:

9	8	7	6	5	4	3	2	1	0	11	12	R
		17						01				
								81	90			
								61	30			
79		17				63		91	40			
59	38	47		65		83	32	31	50			
19	18	47	66	25	14	63	22	21	10			

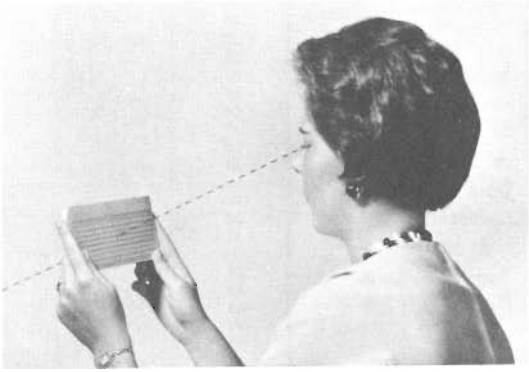
These cards are removed so that the 0 cards are on the bottom, the 1 cards on top of the 0 cards, etc. This may be done by removing the cards from the 0 pocket first, placing the cards from the 1 pocket on top, etc.

(c) Cards as removed from the pockets after the first sort.

79
59
19
38
18
17
17
47
47
66
65
25
14
63
83
63
32
22
01
81
61
91
31
21
90
30
40
50
10

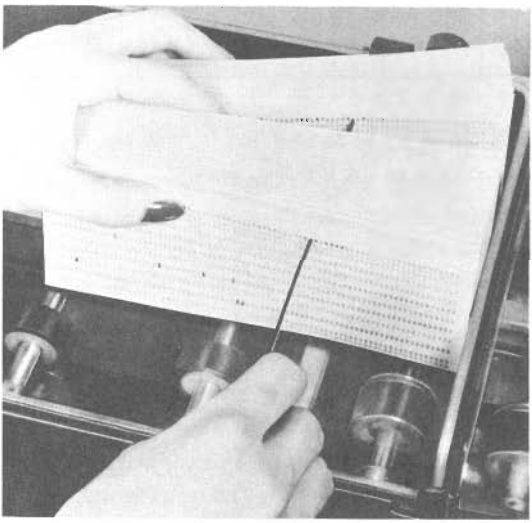
OBSERVE THE NUMERICAL SEQUENCE OF THE RIGHT-HAND COLUMN!

Figure 5.



Sight Checking

After the cards are removed from the pocket, they are aligned and held up to the light. Cards which should not have entered this pocket will not have the proper punched hole and will therefore obstruct a "peek" through the tunnel of holes.



Needle Checking

Hole checking can also be accomplished by using a thin metal shaft referred to as a sorting needle. After the cards are removed from the pocket and aligned, the needle is gently inserted into the tunnel of holes. The unobstructed needle verifies the sorter operation.

Figure 6.

(a) Indicating the sequence of the cards as removed from sorter pockets after first sort on a two-column field.

79
59
19
38
18
17
17
47
47
66
65
25
14
63
83
63
32
22
01
81
61
91
31
21
90
30
40
50
10

(b) At the end of the second sort which was made on the tens position, the cards are in the pockets as follows:

9	8	7	6	5	4	3	2	1	0	11	12	R
91	83		66			38		19				
90	81	79	65	59	47	32	25	18	01			
			63	50	47	31	22	17				
			63		40	30	21	14				
			61					10				

These cards are removed so that the 0 cards are on the bottom, the 1 cards on top of the 0 cards, etc.

(c) Cards as removed from pockets after the second sort.

91
90
83
81
79
66
65
63
63
61
59
50
47
47
40
38
32
31
30
25
22
21
19
18
17
17
14
10
01

OBSERVE THE NUMERICAL SEQUENCE OF THE LEFT-HAND COLUMN!

Figure 7.

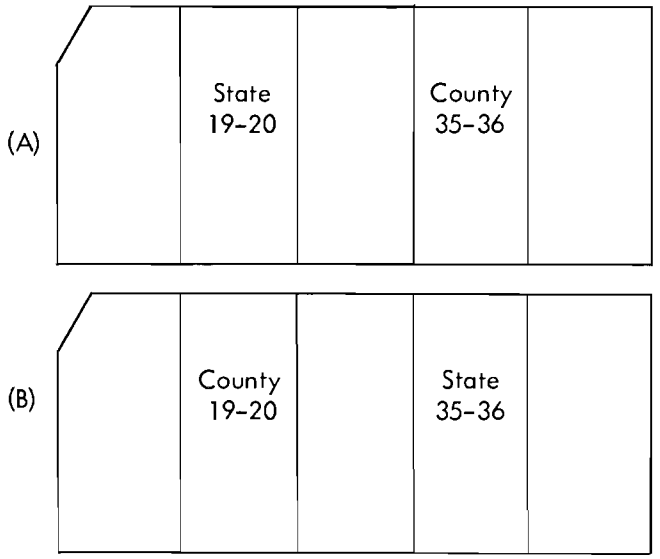


Figure 8. The figure shows two possible card formats for both state field and county field. Although the major field is usually to the left of the minor field, this is not necessary. For example, the sequence in which the columns would be sorted in (A) is 36-35-20-19. In (B), the sequence is 20-19-36-35.

cards are sorted on a five-column field, the amount of sorting time is

$$\frac{1{,}300 \text{ cards} \times 5 \text{ columns}}{650 \text{ cards per minute}} = 10 \text{ minutes}$$

It is not infrequent by any means that 20,000 and more cards require sorting before some other machine accounting operation can commence. On a five-digit field, such as customer number in the cards shown in Figure 2, two hours and 34 minutes is required to sort 20,000 cards. If the amount of time for handling the cards (approximately 25% of the sorting time, in this case about 40 minutes) is added, the entire sorting operation takes about three hours and 15 minutes for these 20,000 cards.

4. *How long does it take to sort a nine-digit numerical field for 35,100 cards using the* IBM *82 Sorter? Assume 25% of the running time for handling time.**

The 25% factor used for determining card-handling time is not unreasonable for a sorting operation. (For a novice operator it may be higher, whereas for an experienced operator it is considerably lower.) The factor is higher for sorting than for most other machine operations.

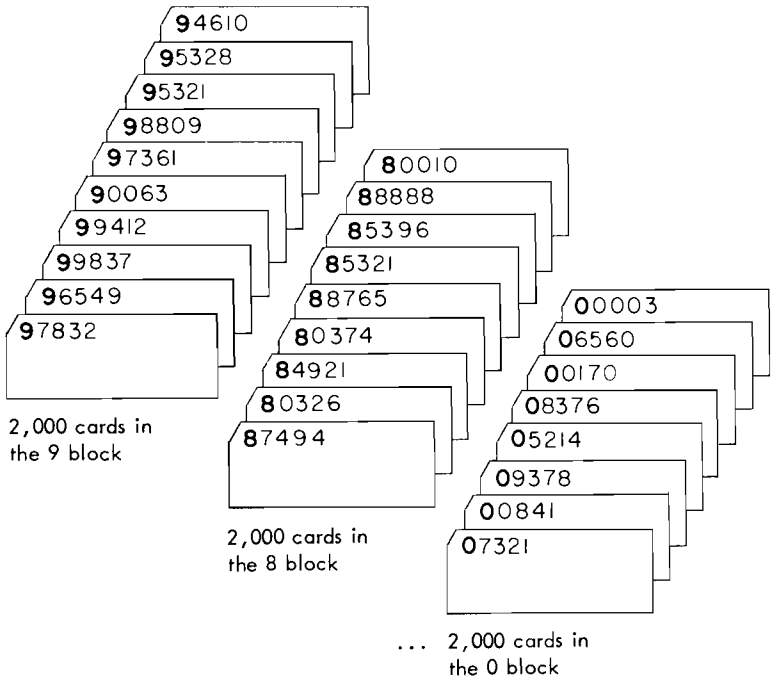


Figure 9.

This is because the stack of cards in each pocket has to be removed before the sorter can handle more cards. Then, before passing through the sorter again, the stack of cards should be "squared off" and fanned to minimize jamming. Also, after each pass, the cards should be sight-checked.

Block Sorting

"Block sorting" is a technique used to first select a specific block of cards from a deck and then sort the selected block into sequence.

For example, a procedure for block-sorting the 20,000 cards shown in Figure 2 on the five-digit customer-number field could be done as follows:

1. Sort on column 39. Assuming that there is an even distribution of all the high-order digits, there will be ten blocks of cards: 2,000 cards in the 0 pocket, 2,000 cards in the 1 pocket, 2,000 cards in the 2 pocket, etc. (Figure 9).

2. Sort the remaining four columns of the 0 block in normal order—that is, columns 43, 42, 41 and 40.

3. Sort the remaining four columns of the 1 block in normal order—columns 43, 42, 41 and 40.

4. Sort the remaining four columns of the 2 block in normal order—columns 43, 42, 41 and 40.

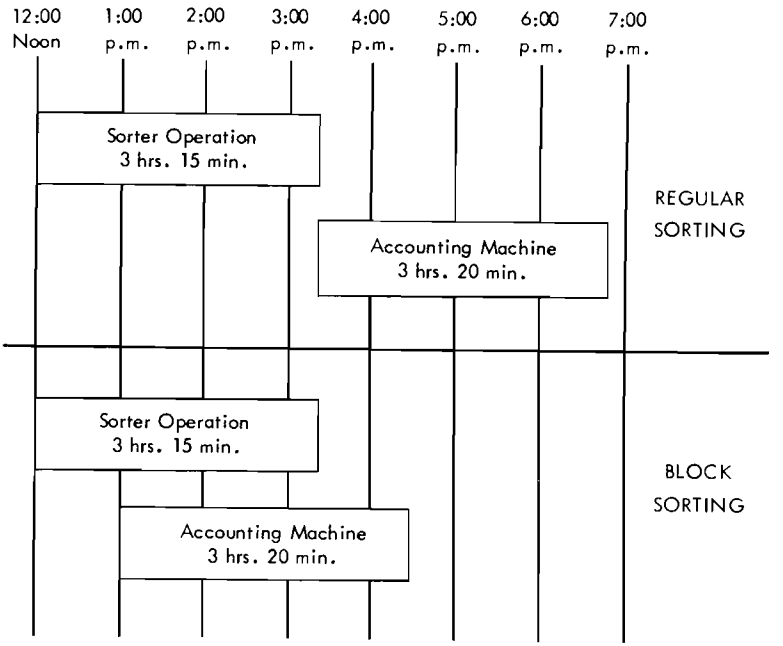


Figure 10.

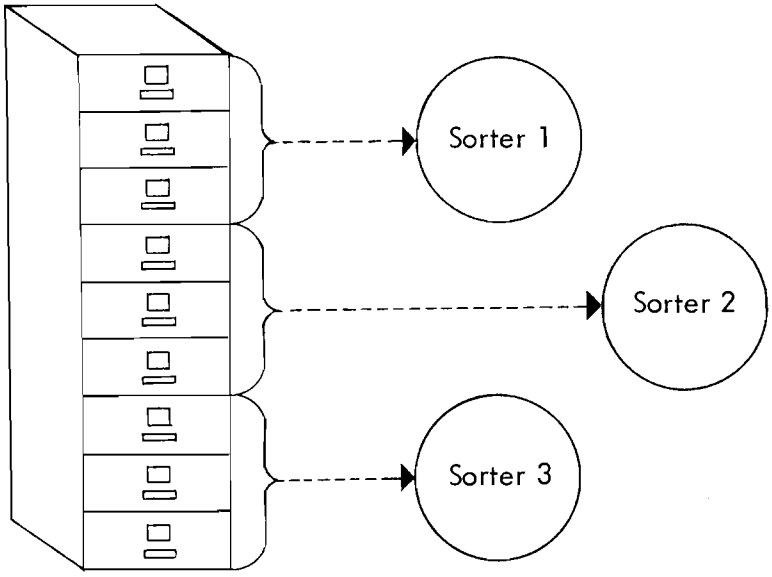
5. Sort each of the remaining blocks separately in normal order—columns 43, 42, 41 and 40.

Block-sorting a deck of cards requires the same amount of time as regular sorting. What, then, is the advantage of block sorting?

Since it takes about three hours and 15 minutes to get the 20,000 cards into customer-number sequence using the regular sorting technique, it means that another machine operation such as preparing a report on the IBM 402 Alphabetical Accounting Machine can not start until all the cards have been sorted. If the report preparation requires three hours and 20 minutes, the total elapsed time from the start of the sorting operation and the completion of the report would be almost seven hours.

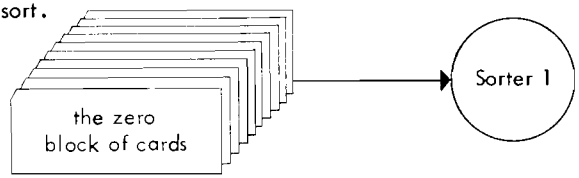
The amount of time required to get the 0 block in sequence is 55 minutes. This result is determined by calculating the amount of time to block-sort the 20,000 cards (40 minutes including handling) and the amount of time to sort the remaining four columns of the 0 block (15 minutes including handling). Allowing five minutes to bring the cards to the accounting machine, it will be just one hour after sorting starts that the report preparation can begin. Then, while the IBM 402 is preparing the report, the rest of the cards are sorted by handling the blocks in a fashion to allow continuous operation by the IBM 402.

Using the block sorting technique for this particular example reduces the overall elapsed time required by more than two hours (Figure 10).

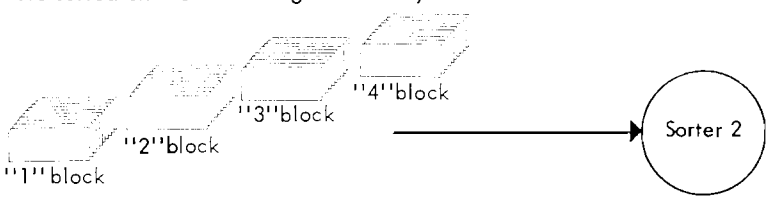


Large file of cards to be sorted one-third of which goes to each sorter for blocking.

Then, after blocking, the cards from the 0 pocket of each of the three sorters are stacked together. These could go to sorter 1 for finishing the sort.



The blocks from each of the three sorters of the 1, 2, 3 and 4 cards are sorted on the remaining columns by sorter 2...



and the blocks from each of the three sorters of the 5, 6, 7, 8 and 9 cards are sorted by sorter 3.

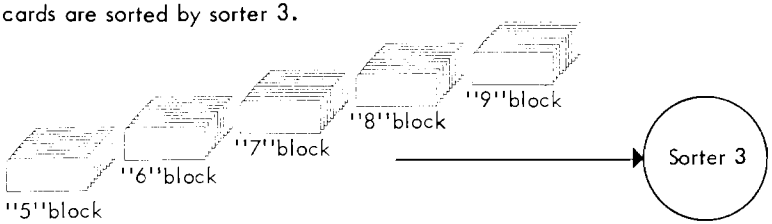


Figure 11.

As you can see from the chart, block-sorting reduces the overall elapsed time required to prepare a report by permitting completed blocks to be processed through another machine while the remaining blocks are still being sorted. Block sorting also permits the use of more than one sorter, not only in establishing the blocks, but in the final sorting as well (Figure 11).

5. *Assume that there are 35,100 cards to be sorted on a six-digit field with an even distribution of digits in each position. There are three* IBM *82 Sorters available. How would the three machines be utilized so that all the cards with a zero in the high-order position (3,510 cards) would be in sequence in the least amount of sorter running time? Disregard handling time for this problem.**

In operations involving more than one field, blocking can be accomplished by first sorting the major field. Each major group can then be treated as a separate unit of the file and sorted according to regular sorting procedures. In block sorting, as in any other sorting operations, cards should be sight-checked as they are removed from each pocket of the machine.

Alphabetic Sorting

Alphabetic sorting requires two sorts on each column because a letter is recorded by two holes punched in a single column.

Each of the letters A through I combines a punch in row 12 with a punch in one of the rows 1 through 9; the letters J-R combine a punch in row 11 with a punch in one of the rows 1-9; and the letters S-Z combine a punch in the 0 row with a punch in the rows 2-9.

In alphabetic sorting, each column is sorted first on the numerical portion of the punching to group them by the digits 1-9, and then sorted on the zone portion. Consequently, on the second sort of the column, the cards fall into either the 12, 11 or 0 pocket. The 12 pocket contains cards punched with the letters A-I, the 11 pocket contains cards punched with the letters J-R, and the 0 pocket contains the cards punched with the letters S-Z, all in alphabetic sequence within each pocket (Figure 12).

6. *Suppose the zone portion of the letters in Figure 12 was sorted first? Show by a schematic similar to the one in Figure 12, how the cards would be aligned after the sort (digit part) of the column.**

Alphabetic sorting, as in the case of numerical sorting, proceeds from right to left in the field. Of course, all cards should be sight-checked when removed from each pocket of the sorter.

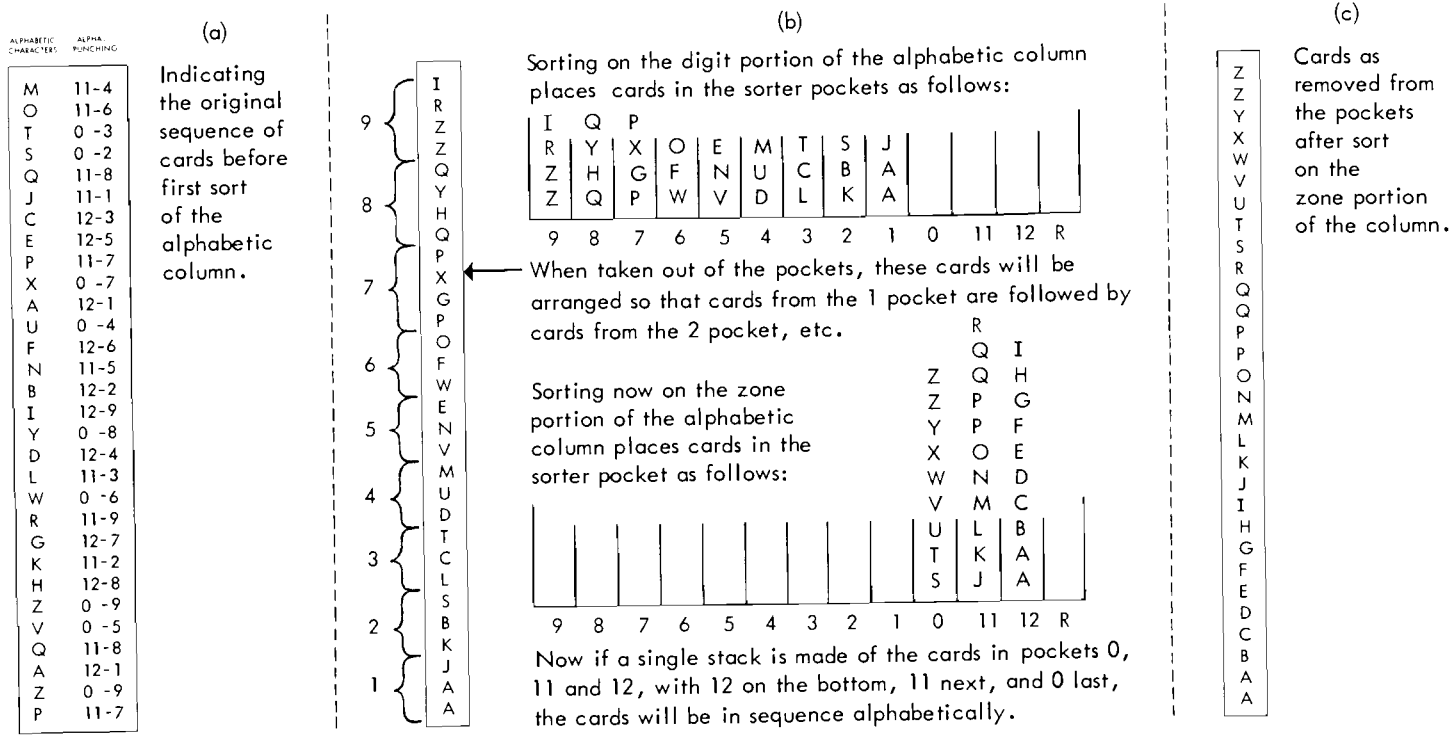


Figure 12. This illustration indicates how 30 alphabetically punched cards will be sorted using the two passes discussed.

Because alphabetic punching can involve word descriptions with spaces between words, the unpunched columns caused by spacing will be sorted into the reject pocket on the first run of the column. It is not necessary to sort the rejected cards through the machine during the second sort of that column, since they will also fall into the reject pocket on the second sort of the column. However, they must be placed in front of all the other cards when proceeding to sort the next column.

What has been said regarding block sorting of numerical fields applies equally to alphabetic fields. Large files of cards can be sorted alphabetically on the first column of the field, after which the block for each letter can be handled as a separate unit of the file (Figure 13).

Operating Principles of the Sorter

Card reading by machines is based on a fundamental principle of electricity—namely, a flow of electricity requires a closed circuit. If a circuit is open, there is no electrical flow. Each IBM sorter has a brush which can detect the presence of a hole. If a hole is present, the brush makes contact with a brass roller (closing the circuit) and the electrical impulse can actuate some machine operation such as causing a particular sorter chute blade to intercept a card and direct it into a pocket. If there is no hole for the brush to read, *no* electrical impulse is available, nothing is actuated and the card is automatically directed to the reject pocket. The supply of electricity for a brush sensing a hole comes from a contact roll (Figure 14).

Most IBM machines feed cards row by row, rather than column by column as in the case of the card punch. There are a number of reasons for this, one of them being that the cards can be read faster row by row. (The ratio of columns to rows is 80-12, or over 6 to 1.)

Timing

The only difference between one hole and another in an IBM card is its position. One hole is distinguished from another by its being at a certain place at a certain time while moving past the reading mechanism. Thus, IBM machines are able to tell what character is punched on the basis of WHEN a hole is sensed as the card passes through the reading mechanism.

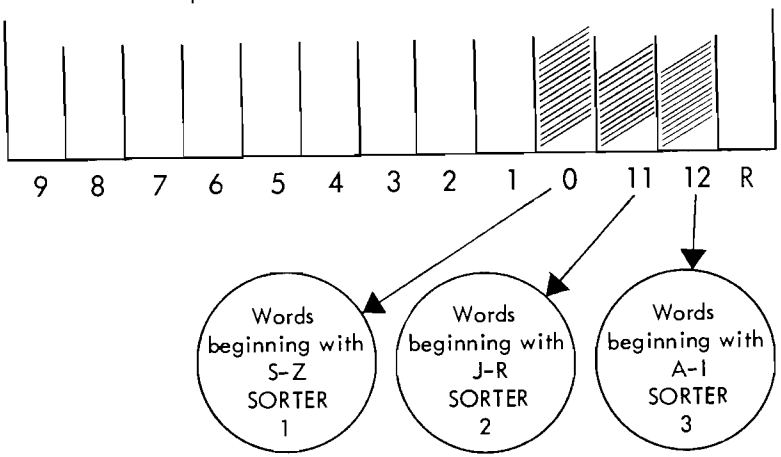
In reading a card row by row, the amount of time taken to pass from a given spot of one card to the same spot in the next card, is called a *card cycle* (Figure 15).

Cards enter IBM machines either 9 edge first or 12 edge first. As a card passes under the brushes, the 9 row of each column is read simultaneously, then the 8 row, the 7 row, etc. When the 9 row is being examined for holes by the brushes, the card is said to be at 9 time. When the 8 row is being examined for holes, the card is at 8 time, etc.

The exact method of alphabetic block sorting to be used depends, of course, on several factors — for example, the number of sorters available, the number of cards to be sorted, and the average length of the alphabetic word. Two ways in which alphabetic block sorting may be done are:

ONE PASS

Sort cards on zone of first column of the field. This places the cards into three zone groups.



Each group can then be sorted on a separate sorter.

TWO PASSES

Sort cards on digit and then on zone of first column of the field. This places the cards into 26 letter groups.

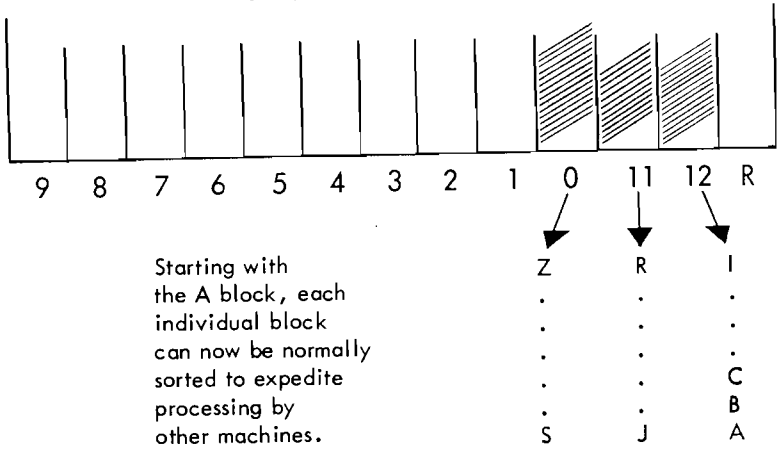
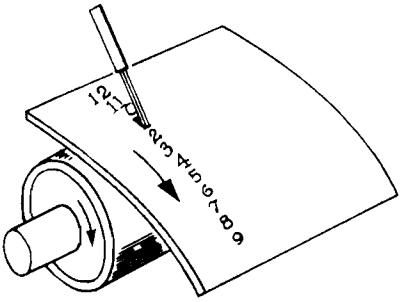
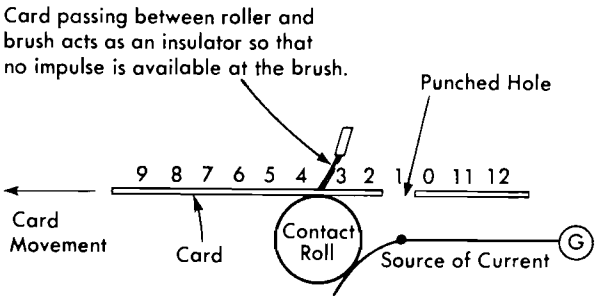


Figure 13.



BRUSH MAKES CONTACT WITH ROLLER



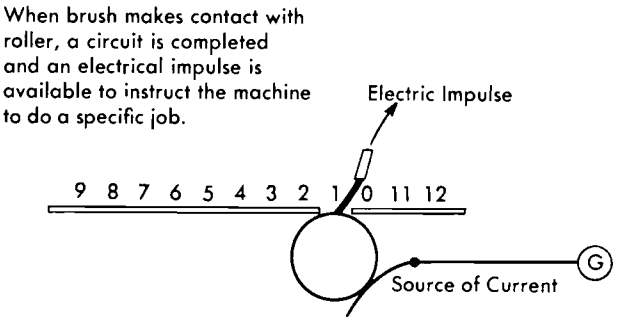


Figure 14.

The cycle of the card can be represented by a clocklike mechanism (Figure 16). For purposes of illustration, the cycle clock of the sorter has twelve points representing the rows of the card plus four points representing the space between the 12 row of one card and the 9 row of the following card, which, incidentally, is equivalent to four rows in length. The movement of the cards under the reading brush is synchronized with this "master cycle timer." Therefore, if a brush senses a hole when the "master cycle timer" is at 7 time, the impulse represents a 7.

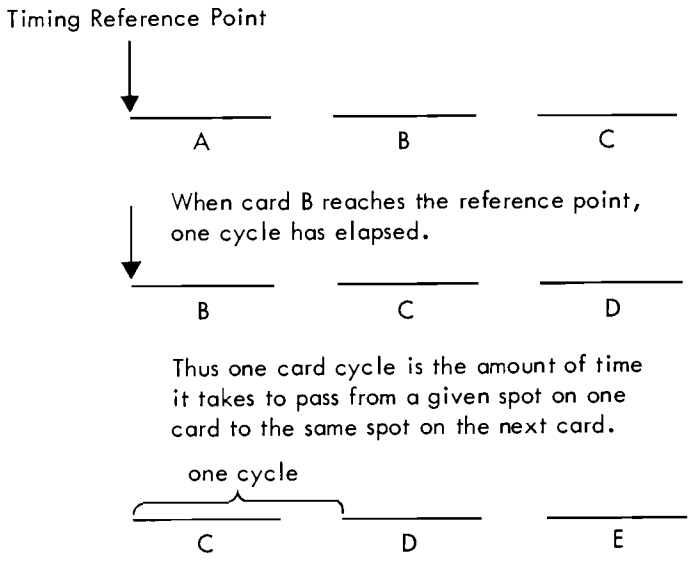


Figure 15.

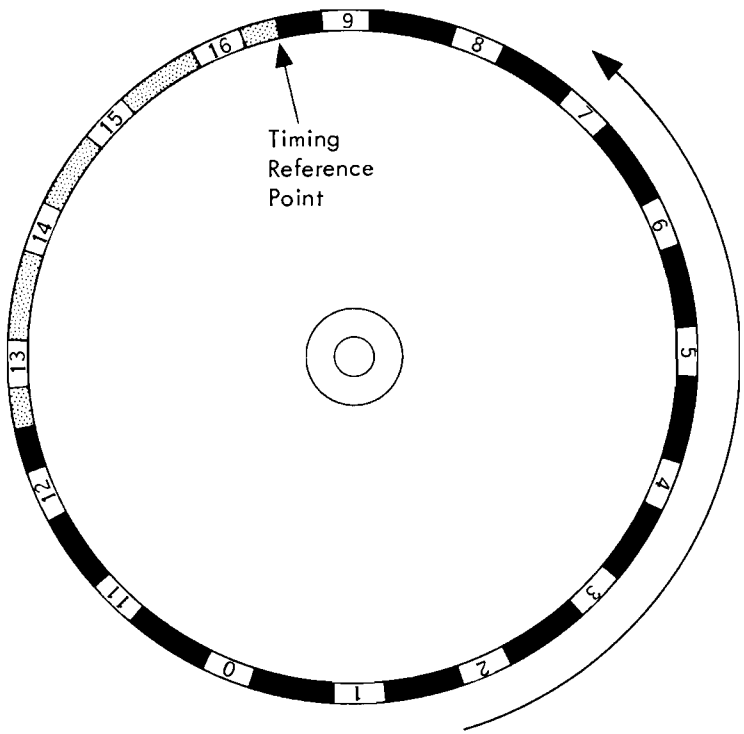


Figure 16.

Selecting the Column to Be Sorted

On the IBM 82 Sorter, as on all conventional sorters, there is one brush. Therefore, in order to sort on a given column, the brush must be moved to that column. Moving the brush to the column to be sorted is a very simple manual operation. The brush is connected to the column indicator which in turn is connected to a cranking device (Figure 17). It can be cranked until the indicator (Figure 18) shows that the brush is resting over the desired column. If many columns separate the initial and desired location of the brush, the cranking operation can be replaced by a quicker method. This involves raising the crank handle to its uppermost position, depressing the finger lever (Figure 18), and sliding the entire sorter brush assembly to the required location, then turning the crank to its bottom-most position to secure the brush.

Selecting Special Cards with the Sorter

Occasionally the requirement exists whereby cards punched in a certain row of a specific column are the only ones required from an entire file. For example, the management of a manufacturing company might want a report containing the name, occupation code and birth date of only those male employees who are single. In order to write this report, the appropriate cards must be selected from the personnel file, which normally is kept in employee-number sequence (Figure 19).

By placing the file of cards in the sorter and sorting on column 37, there will be, at the end of the sorting operation, cards in pockets 1-8. Those cards which went into pocket 1 are selected for printing the desired report. The other cards are returned to the file temporarily, pending completion of the printing job. After the report has been prepared the 1 cards are to be combined (collated) with the others.

> 7. *If the 1 cards are placed in front of the temporarily filed cards, will the entire file be in sequence by employee number?**

As has been implied in the answer to the above question, it would indeed be desirable if the cards not required for the report would remain in employee-number sequence to take advantage of the collator. IBM sorters have been designed with this in mind.

Sort Selection Switches

Figure 20 shows the selection switches on the IBM 82 Sorter. There are thirteen switches in all, twelve of them corresponding to the twelve rows of a card column. Notice that the grouping of the twelve switches corresponds exactly to the "cycle clock" in Figure 16. The thirteenth switch corresponds to the 1-9 rows as one group. When a switch is moved to the center of the switch assembly, it is on. *When a switch is on,*

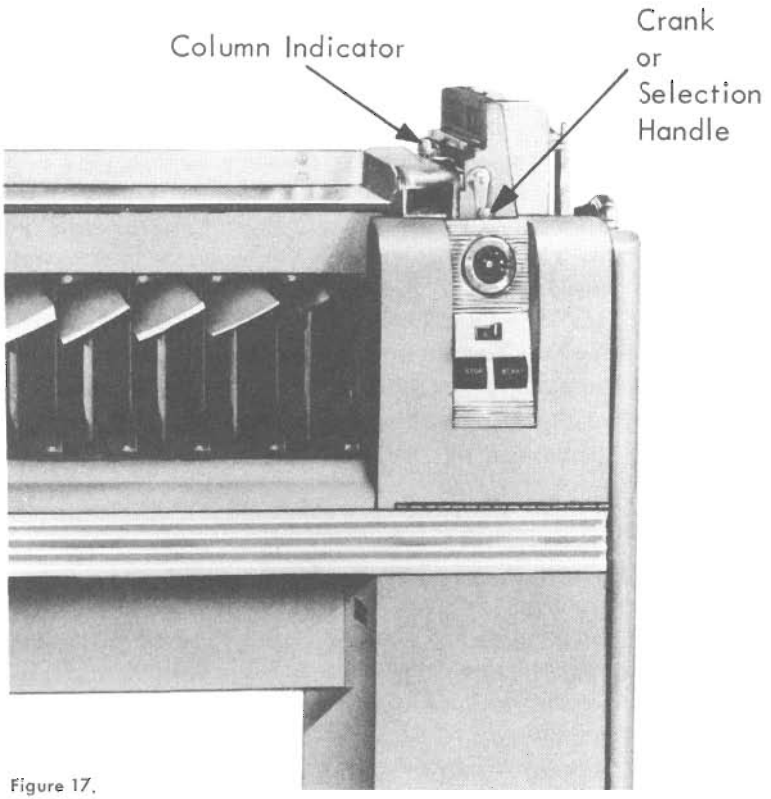


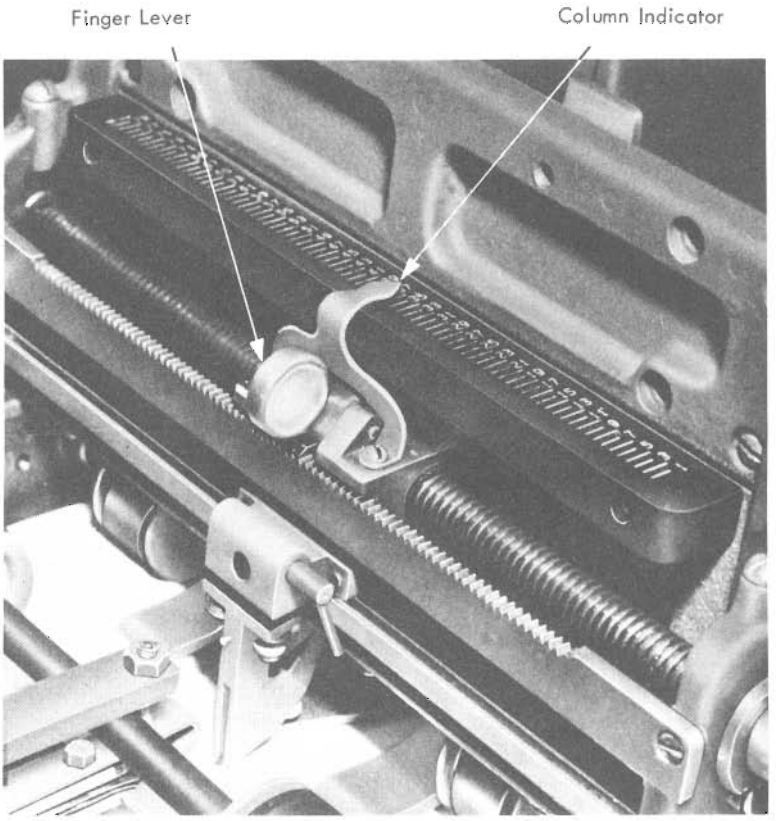
Figure 17.

it causes the brush to disregard the hole detected in that row. Therefore, if the 5 switch is pushed toward the center, all cards punched with only a 5 in the row being sorted will be rejected just as though there were no hole punched. Thus, in the example, to keep the cards not required for the report undisturbed (that is, directed to the reject pocket) in employee-number sequence while selecting out the 1 cards, it is necessary to move to the center the switches for the 9, 8, 7, 6, 5, 4, 3 and 2 rows.

8. *Suppose it is required to select, from a file, those cards which have a 3 or a 7 or an 8 in column 50. What switches should be pushed in toward the center and which ones should be left out?*

Alphabetic Sorting Switch

Alphabetic sorting requires that the cards be sorted twice on each column, first for the digits 1-9 and then the zones 12, 11 and 0. Since the 82 Sorter recognizes the first hole in a column which it encounters, the digits 1-9 must be "eliminated" on the second sort so that the zone punches will be recognized.



Note: Crank Handle is in UP Position

Figure 18.

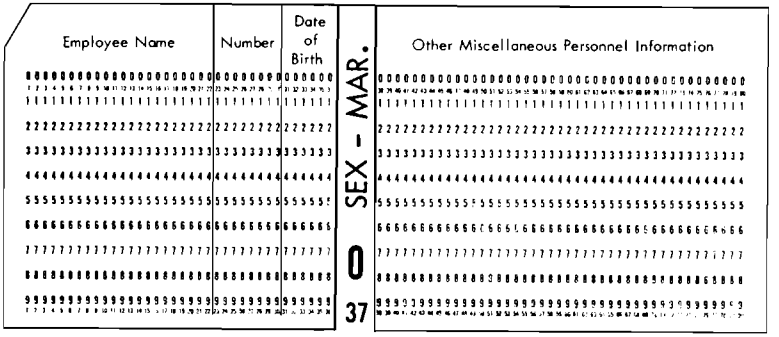
*9. If there is more than one hole in a column, which one controls the card's entry into the chute?**

"Eliminating" the 1-9 digits could be effected by pushing in the switches 1-9. To make this a simple operation, a single switch combining the effects of the nine individual switches is provided. Pushing it to the center serves the same function as pushing in the nine individual switches.

*10. How long would it take to sort 1,000 cards into alphabetic sequence by last name only, if the last name field were ten columns and the last name contained an average of seven characters?**

Card Path

The cards to be sorted are placed in the hopper 9 edge first, face down. As the cards are read by the brush, they are directed into a chute whose



CODE

1. Male, Single
2. Male, Married, No Children
3. Male, Married, Children
4. Male, Widowed or Divorced
5. Female, Single
6. Female, Married, No Children
7. Female, Married, Children
8. Female, Widowed or Divorced

Figure 19.

path ends in one of the sorter pockets. The diagram in Figure 21 shows a card (C) with a 4 punch, passing between the brush (A), and the contact roll (B). Note that the card has passed under the chute entry for pockets 9, 8, 7, 6 and 5. These chutes are thin metal bands which form channels to the sorter pockets. The entry is curved so that while the plate (E) is up, the card will slide underneath without encountering the chute.

The diagram in Figure 22 shows that the 9 edge of the card has just passed the 5 chute blade while the brush is detecting the hole punched in the 4 row. This detection of the hole causes a current to flow from the roll through the brush and to the magnetic coils (D). These magnets become energized and pull the plate (E) down, so that the edge of the card cannot slide under chute 4. This causes the card to enter the chute 4 channel. Once in the channel, the card is carried along by the carrier rolls until it falls into the 4 pocket.

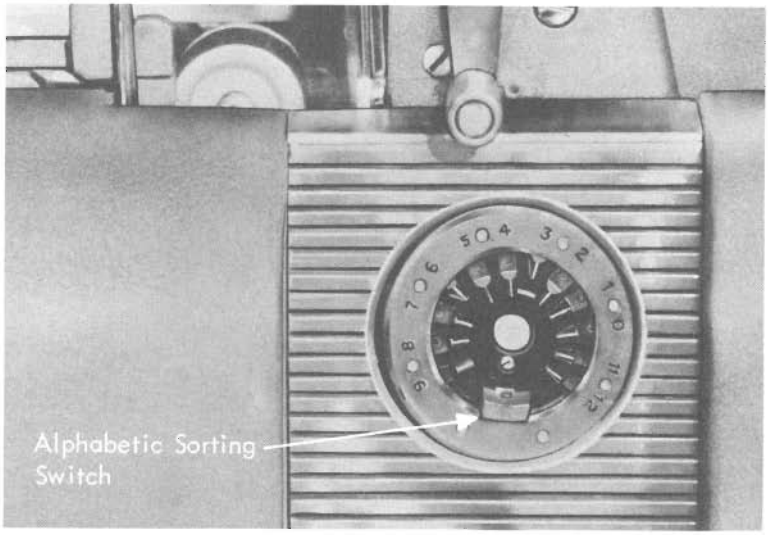


Figure 20.

Look at Figure 21 again. Notice that if no punched hole has been sensed, the plate (E) would not have dropped and the card would have passed under all of the chute blades, consequently dropping into the reject pocket. This is what happens if the column is blank or if reading of the 4 punch has been suppressed by the selector switch.

11. How are cards placed in the hopper of the sorter?
12. How many brushes are on the IBM *82 Sorter?*
*13. What happens to a deck of cards punched with 0-9 only if the alphabetic sorting switch is on?**

Other IBM Sorters

Two other sorters are the IBM 83 and IBM 84. The first operates at a speed of 1,000 cards per minute and the second operates at a speed of 2,000 cards per minute. The IBM 83 detects holes with a brush, just like the IBM 82. The IBM 84 uses a photoelectric device for hole-sensing.

Both incorporate a feature which improves the sorting operations. It is an edit feature for detecting invalid punching.

Numerical sorting is accomplished in the same way as on the IBM 82. Alphabetic sorting, however, follows a somewhat different procedure. The main advantage is in the reduction of card-sorting time. On the first sort of the alphabetic column, the letters A-I are directed into pockets corresponding to the letter's digit punch; letters with zero zone punching (S-Z) are directed to the zero pocket; and letters with eleven zone punching (J-R) are directed to the eleven pocket. Because the

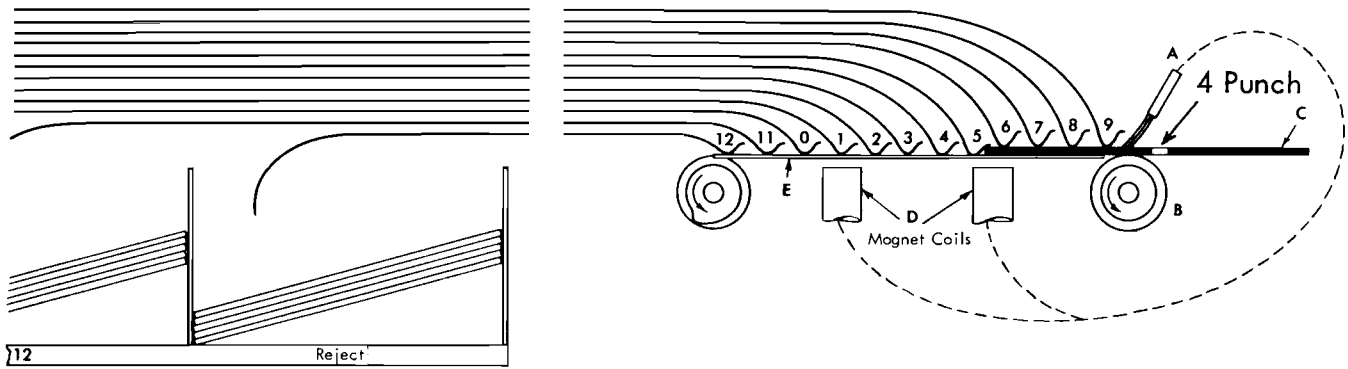


Figure 21.

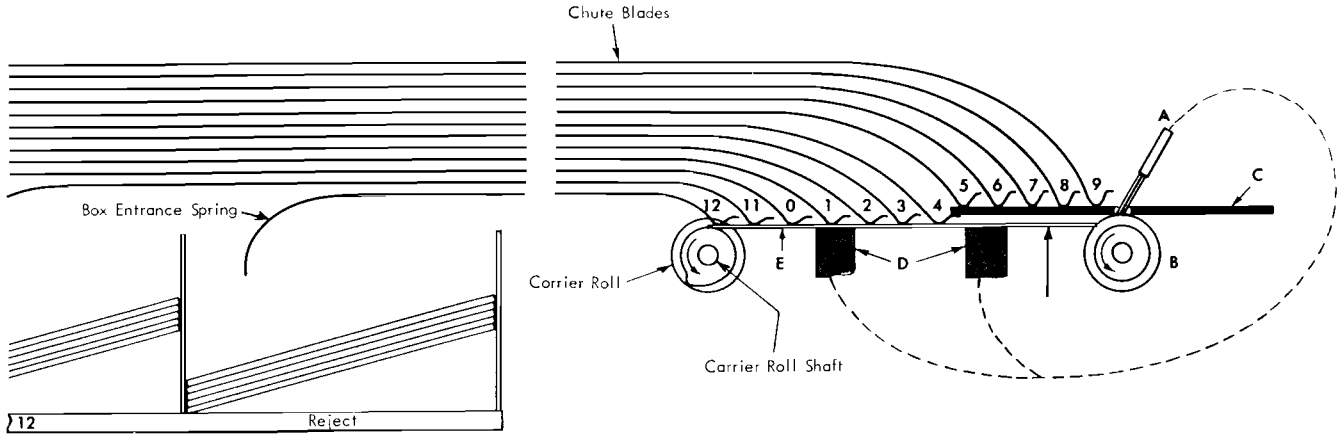

Chute Blades
Box Entrance Spring
12
Reject
12 11 0 1 2 3 4 5 6 7 8 9
A
B
C
D
E
Carrier Roll
Carrier Roll Shaft

Figure 22.

Pockets

9	8	7	6	5	4	3	2	1	0	11	12	R	
I	H	G	F	E	D	C	B	A	S-Z	J-R			1st Pass
R	Q	P	O	N	M	L	K	J					2nd Pass
Z	Y	X	W	V	U	T	S						3rd Pass

Figure 23.

cards in pockets 1-9 (letters A-I) are in sequence, they do not require a second pass. The eleven zone cards and the zero zone cards are kept separate for the second pass. After each zone is sorted (the eleven zone first), the cards are removed from the pockets and placed behind those already sorted (Figure 23).

Answers to Asterisked Questions

1. Each column has a positional value. The rightmost digit is always the units digit. In this seven-digit example the positional values are:

millions	hundred thousands	ten thousands	thousands	hundreds	tens	units
7	3	0	9	8	0	5

In this example there is a

5 in the units position
0 in the tens position
8 in the hundreds position
9 in the thousands position
0 in the ten thousands position
3 in the hundred thousands position
7 in the millions position

2. For a number of reasons the reading brush of the sorter shortens in time. Some conditions can cause even a new brush to shorten very rapidly. When the brush becomes sufficiently shortened, it fails intermittently to detect the hole. Sometimes, as a result, the card is rejected; other times it is sorted into the wrong pocket. Thus it is rather imperative to sight-check after sorting each column.

3. If a card falls into the reject pocket, one of two things can be assumed:

a. The column was not punched.
b. The reading device (sorter brush) failed to detect the hole. Whatever the case, the reason for rejection should be immediately determined and corrective action taken.

4. Sorting takes $\frac{35{,}100 \times 9}{650} = 486$ min., or 8 hours and 6 min.

Handling is 25% of 486 min. = 122 min., or 2 hours and 2 min.

Total sorter time is = 608 min., or 10 hours and 8 min.

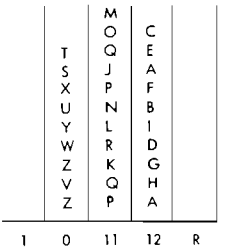
5. Sort one-third of the cards on each of the three sorters on the high-order digit—(one-third of 35,100 is 11,700)—requires

$$\frac{11{,}700}{650} = 18 \text{ minutes}$$

There will then be 1,170 cards in each of the 0 pockets, or a total of 3,510 cards. Sorting these cards on the remaining columns will require one of the sorters $\frac{3{,}510 \times 5}{650} = 27$ minutes.

Thus all the cards with a zero in the high-order position are in sequence in 18 plus 27 = 45 minutes.

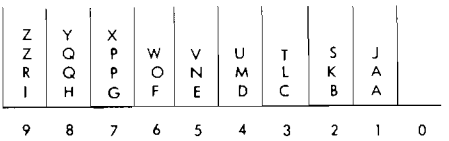
a) Sorting on the zone portion of the alphabetic column first, places the cards in the sorter pockets as follows...



b) When taken out of the pockets the cards would be arranged as...

T S X U Y W Z V Z M O Q J P N L R K Q P C E A F B I D G H A

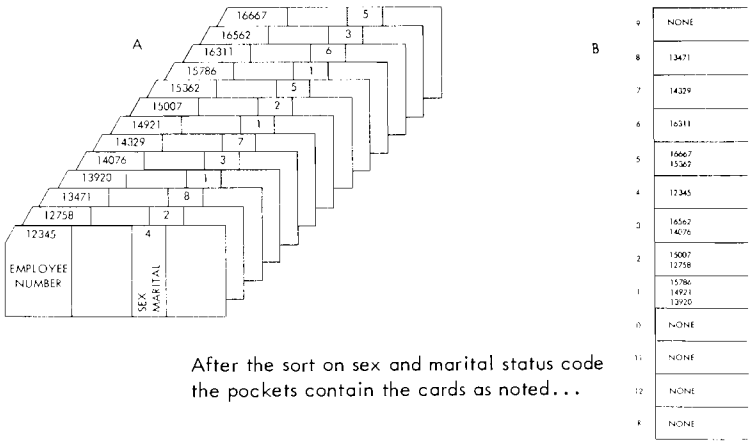
c) Sorting on the digit position places the cards in the sorter as follows...



d) Now if a single stack is made of the cards in pockets 1 - 9 with the 1 cards on the bottom, 2 cards on top of the 1 cards, etc., the cards are not in alphabetical sequence ...

Z Z R I Y Q Q H X P P G W O F V N E U M D T L C S K B J A A

7. Before the sort on column 37 was started, the cards were all in employee-number sequence, as in the illustration below:



After the sort on sex and marital status code the pockets contain the cards as noted...

As can be seen from the sorter pockets (B), when the cards are removed and temporarily filed, the file is no longer in employee-number sequence. Thus, before the cards used for the report can be recombined with the temporarily filed cards, the temporarily filed cards would have to be sorted on employee number again. If the number of cards is 20,000, then sorting them back into original sequence will require over three hours.

NOTE: In section 4 you will see how the IBM collator can collate these cards with the temporarily filed cards, in about one and a half hours, provided these cards are in proper sequence.

9. Refer to the schematic in Figures 21 and 22. Notice that as soon as a hole is detected, the magnetic coil is energized. This attracts the plate and thus causes the card to enter the chute. Thus, even if a column were punched in all twelve rows, the card would go to the 9 pocket.

10. Alphabetic sorting requires two passes through the sorter for each column of the field. If a column is blank, only one sort for that column is required. Of course, prior to the sort of each column, it is not known whether the column is blank. Thus, ten columns have to be sorted once, and seven columns must be sorted a second time, making a total of 17 effective passes. The amount of time, then, to sort 1,000 cards on ten alphabetic columns averaging seven characters is:

$$\frac{1{,}000 \times 17}{650} = 26 \text{ minutes plus a fraction}$$

Adding six and one-half minutes for handling time indicates that a total of 33 minutes is required.

13. Since the alphabetic sorting switch causes the punches 1-9 to be disregarded, all the cards punched with 1-9 are rejected. The cards punched with a zero are sorted, however, to the proper pocket.

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