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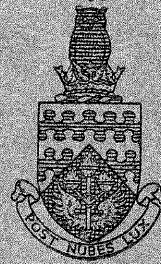
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NOTE ON WORKING SPEEDS OF SOME
BASIC CLERICAL OPERATIONS

by

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Note on working speeds of some basic clerical operations

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SUMMARY

This Note is part of a larger study in the Business Systems Laboratory of the College of Aeronautics on economics of mechanised accountancy. As the subject of performance rates in the clerical operations of adding, multiplying and sorting is of wider interest than by mechanical accountancy, this part of the work is issued separately.

A series of test were carried out to establish some performance standards and these appear in the Appendix. It is unlikely that the relative magnitude of the performance rates given should have a universal significance. They might at least, however, be expected to form a basis for assessing the relative efficiency with which given fundamental clerical operations like adding, multiplying and sorting are being carried out.

Much research still remains to be done in this field of study. A considerable amount has probably already been done in different organisations but the results have not been made generally available. The Laboratory would be pleased to have any further information that could be made public.

The Consideration of Basic Clerical Operations

It is often noticeable that rates of operation of certain basic mental and manual operations involved in clerical work, such as adding columns of figures, vary somewhat with differing conditions. It was decided to investigate certain basic operations of this kind in order to determine average speeds of working, and the effect of various factors on these speeds. The three elemental operations considered in this Note are multiplication, addition and sorting and the summarised results are set out in Appendix I. All the results are quoted for an 'average operator' of reasonable speed and experience, suited and accustomed to the task, but in view of the nature of the operations, considerable variation in the results is only to be expected. The effect on costs of the speed of operation is to some extent counter-balanced by variable rates of pay of clerical workers according to age, but no attempt has been made here to equate operating speeds with costs.

Rates of Multiplication

Tests were carried out in the Business Systems Laboratory at the College of Aeronautics by several methods of multiplication, to discover the relationship between rates of working and the number of digits in the multiplier and the multiplicand. For simplicity the number of digits in the multiplier and multiplicand were equal in each case. The results presented in Fig. 4 show the effect of the number of digits on the speed of multiplication. It is seen that by comptometer or from tables the rates of working is proportional to the number of digits, whilst the speed of the multiplying punch is independent of the number of digits, and by simple arithmetic the time to do one multiplication is roughly proportional to the square of the number of digits. As the number of digits increases the manual method becomes more wasteful in time and it becomes more advantageous to use one of the mechanical methods.

It would seem from the results that it is always quicker to perform the operation of multiplication on punched cards, rather than by any other method, but it should be borne in mind that the information must be in a form acceptable to the machine before multiplication can be affected; in this case the numbers must be punched into the card. As the speed of punching is of the same order as the speed of comptometer operation, assuming experienced operators, and as it is usual to punch and check-punch, or verify, it is not worth while punching cards to perform multiplications only. However, if the figures have already been punched into the cards or other operations are to be performed, the multiplying punch then achieves the speed advantage shown in Fig. 4.

Rates of Addition

Two factors were found to have an effect on the rate of adding together a column of numbers; (1) the number of digits per number or item, and (2) the number of items per column or total. The results of the tests carried out are plotted in Figs. 2 and 3. Figure 3 shows the speed of addition of 4-digit numbers by each of the several methods in relation to the number of items per total, and it is seen that punched cards no longer have the outstanding speed advantage over other mechanical methods seen in multiplication. The intercept at one item per total would appear to be the time required to note down the answer or for the machine to print out the total.

Fig. 1 shows that the time to total ten items bears a linear relationship to the number of digits in each item whichever method used and that the speed of the tabulator is independent of the number of digits. The comptometer works at much the same speed as the tabulator, but it should be remembered that the tabulator will accumulate totals in at least three columns giving a great reduction in time compared with a comptometer when three column addition is applicable. Once again the numbers have to be punched into the cards and so the comptometer may well be more economical if totals only are required. If a permanent record of all the items making up each total is required then the adding-listing machine comes into its own in competing with the tabulator.

The lines on Fig. 2 demonstrate the proportionality of time to the total number of items to be added at a fixed number of digits per item and a fixed number of items per total. With these variables fixed at different values the various methods would take up different positions on the graph and so it is inadvisable to state that any particular method is quicker than another without specifying the number of digits and the items per total.

Rates of Sorting

Three methods of sorting were investigated -

(1) by punched card sorter

(2) by 'Paramount' edge-punched cards and needle (using the '7-4-2-1 method)

(3) manually.

The main variable in sorting a fixed number of cards is the number of digits sorted on. From Fig. 6 it is seen that the time to sort one hundred cards by hand is roughly independent of the number of digits in each number, whereas the time to sort by machine or needle bears a linear relationship to the number of digits.

Fig. 7 shows the effect of the number of cards on the sorting time and the advantage of edge-punched cards over manual sorting can be seen. However, as with punched cards, 'Paramount' cards have to be prepared and when the preparation time is included the relative speeds of the methods are changed, as shown in Fig. 8. This graph shows that it is not an economical proposition to edge-punch cards in order to sort once only. The cards have to be sorted in various ways at least three times before time is saved over manual sorting. The times quoted for preparation are by hand-nippers and certain reductions in times would be achieved by using a special key-punch.

Synthesised Procedure - Analytical Estimating for Clerical Procedures

For some years it has been customary to estimate machine tool process times by synthesis from a set of standard tables of elemental times. The results obtained above are in effect elemental times of certain clerical functions. There seems no reason why these times should not be added together in some way in order to arrive at an overall time for a series of operations such as might be met in accounting practice. In order to test this statement a theoretical procedure was postulated consisting of the multiplication of two 3-digit numbers on cards, sorting on a 4-digit numeral code and adding in groups of 10 the 6-digit numbers obtained from the multiplication. These elements were combined for various methods of working -

- 1) Multiplication, sorting and addition by hand.
- 2) Multiplication by tables, sorting by edge-punched cards and adding by adding-listing machine.
- 3) Multiplication and addition by comptometer and sorting by edge-punched cards.
- 4) On punched cards using an electronic multiplying punch, high speed sorter and tabulator.

Fig. 5 shows the comparative results obtained plotted for a range of numbers of cards, and the time saved by mechanisation in this case is clearly seen.

This procedure of synthesis must be approached with caution for several reasons. Much more data than is given here is required to cover all procedures, for the times of every elemental detail by each method, including such items as handling and checking time, must be measured. This would involve a tremendous amount of study in order to arrive at good average results, for the results quoted here are only based on small samples and are thus open to criticism. Even if good figures were obtained the problem of applying them usefully still remains. It is not suggested that they be used as a basis of an office bonus scheme but they could well provide a yardstick by which firms could assess the efficiency of their office procedures.

APPENDIX I1. Rates of Multiplication

Time in seconds against number of digits in multiplier and multiplicand.

Method	Number of Digits					
	1	2	3	4	5	6
Manual Method	2.5	10	22.5	40	62.5	
Hand Tables		8				24
Comptometer		4		8		12
Multiplying Punch	0.5					0.5

2. Rates of Addition

(a) Time in seconds against number of items per total.

(Four digits per item)

Method	Number of Items		
	5	10	20
Manual Method	15	30	60
Adding-Listing Machine	8.75	15	27.5
Comptometer	5.5	8.5	14.5
Tabulator		9	16.5

(b) Time in seconds against number of digits per item.

(Ten items per total)

Method	Number of Digits		
	2	4	6
Manual Method	15	30	45
Adding-Listing Machine	8.75	15	21.25
Comptometer	5.5	8.5	11.5
Tabulator	9	9	9

(c) Time in minutes against number of additions (i. e. items)
(Four digits per item, ten items per total).

Method	Number of Items	
	100	1000
Manual Method	5.0	50.0
Adding-Listing Machine	2.5	25.0
Comptometer	1.5	15.0
Tabulator	1.42	14.2

3. Rates of Sorting

(a) Time in minutes against number of items sorted, excluding preparation time. (Sorting on four digits)

Method	Number of Items			
	100	250	500	1000
Manual Method	7.5		37.5	
Edge-Punched Cards		6.7		12.3
Punched Cards	0.65			2.9

(b) Time in minutes against number of items sorted, including preparation time. (Sorting on four digits)

Method	Sorting		Preparing		Total	
	100	1000	100	1000	100	1000
Manual Method	7.5	75.0			7.5	75.0
Edge-Punched Cards	5.5	12.3	15.	150	20.5	162.3
Punched Cards	0.65	2.9	6.	60	6.65	62.9

(c) Time in minutes against number of columns sorted on. (100 Items sorted)

Method	Number of Columns			
	2	3	4	5
Manual Method	7.5	7.5	7.5	7.5
Edge-Punched Cards	2.5	4.0	5.5	7.0
Punched Cards	.45	.55	.65	.75

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4. Synthesised Rates of Multiplying, Sorting and Adding Combined

Multiplying 3 digits by 3 digits,
 Sorting on 4 digits,
 Adding in groups of 10, numbers of 6 digits.

Method	Multiply	Sort	Add
1	Hand	Hand	Hand
2	Tables	Edge-Punched Cards	Adding-Listing M/c
3	Comptometer	Edge-Punched Cards	Comptometer
4	Multiplying Punch	High Speed Sorter	Tabulator

(a) Total of 100 operations, time in minutes

Method	Prepare	Multiply	Sort	Add	Total
1	-	37.5	7.5	7.5	52.5
2	15.0	20.0	5.5	3.54	40.0
3	15.0	10.0	5.5	1.92	32.4
4	12.0	0.83	0.65	1.50	15.1

(b) Total of 1,000 operations, time in minutes

Method	Prepare	Multiply	Sort	Add	Total
1		375	75.0	75.0	525.0
2	150	200	13.3	35.4	398.7
3	150	100	13.3	19.2	282.5
4	120	8.33	2.9	15.0	146.2

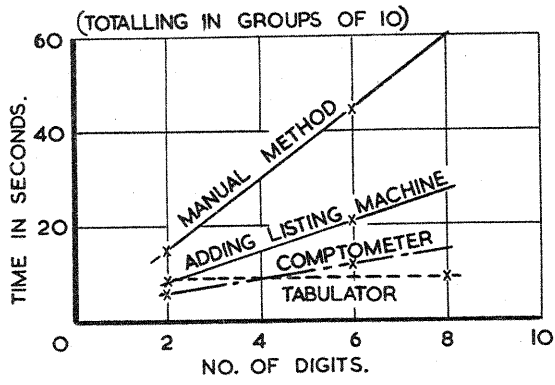


FIG. 1.

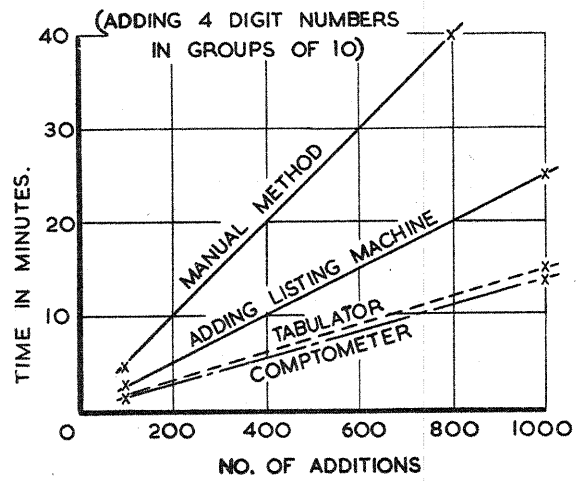


FIG. 2.

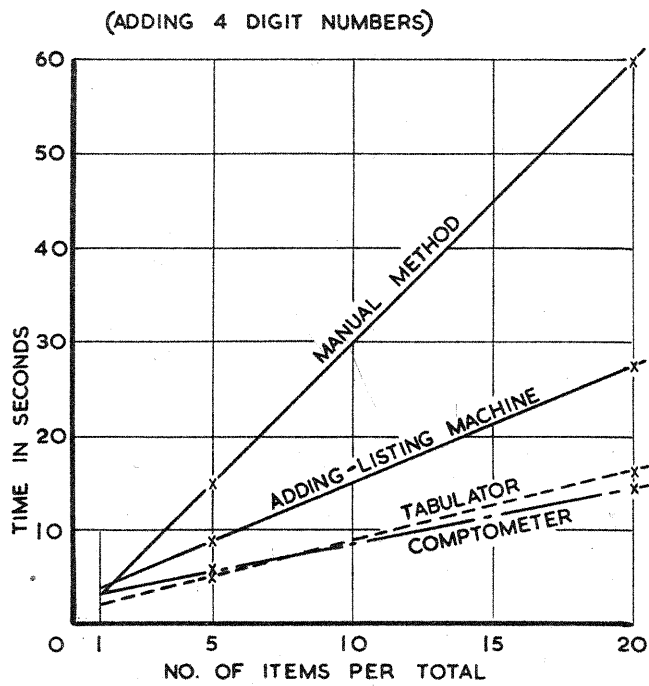


FIG. 3.

RATES OF
ADDITION

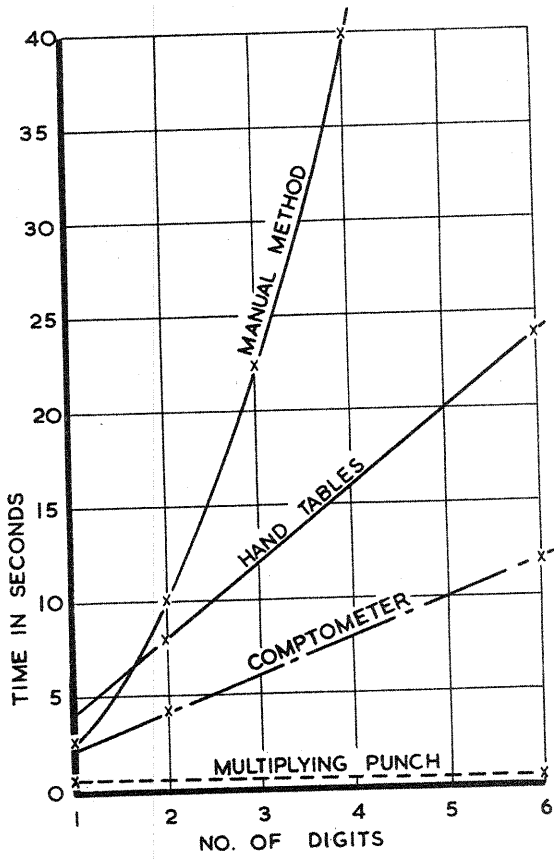


FIG. 4. RATES OF MULTIPLICATION

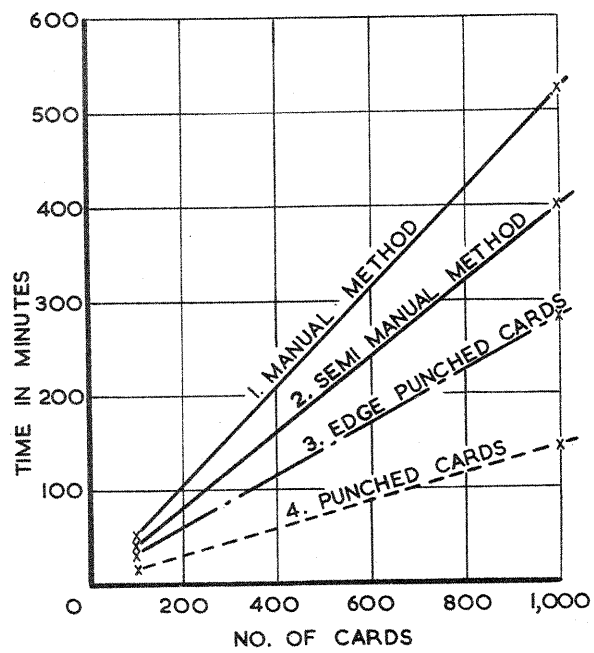


FIG. 5. SYNTHESISED RATES OF MULTIPLYING SORTING AND ADDING COMBINED

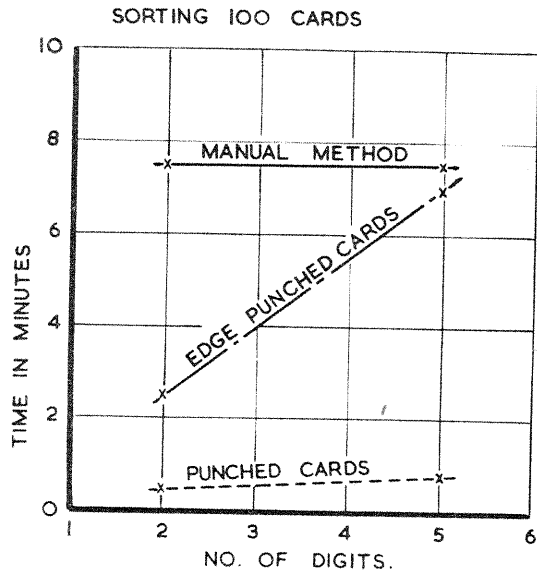


FIG. 6.

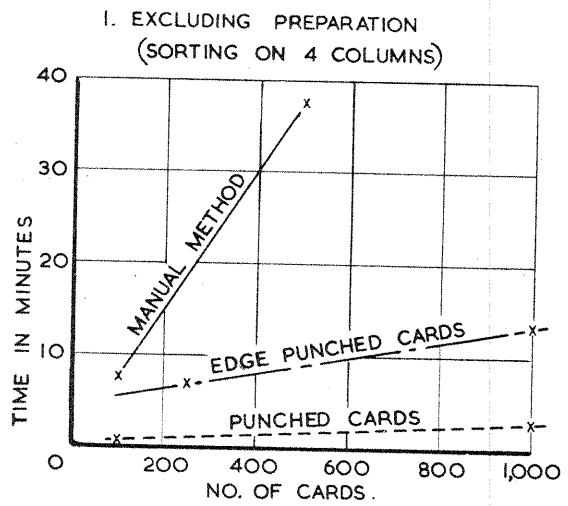


FIG. 7.

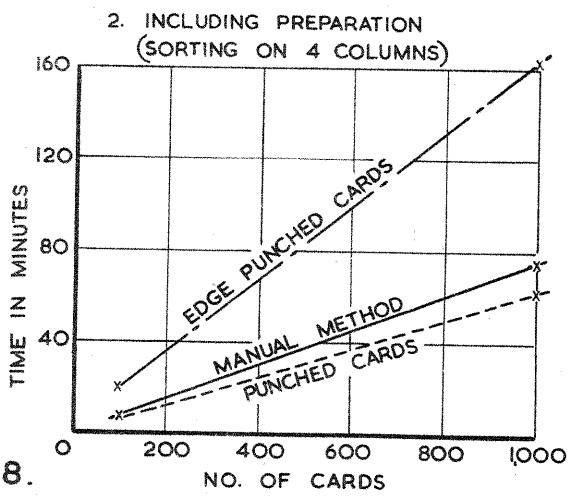


FIG. 8.

RATES OF SORTING