

ON METHODS OF HANDLING ALGEBRAIC SIGNS ON THE HOLLERITH MULTIPLIER

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The usual method of indicating quantities belonging to different groups, but punched in the same field on the Hollerith card, is by means of what are known as 'designations'. In accounting work for instance, a credit value may be designated 3 and a debit value designated 4. These designations are punched in assigned columns of the card along with the respective values. Thus in a five-column field a credit value of 1472 will be punched as 31472 and a debit value of 39 as 40039. So also, designations are used to distinguish between positive and negative numbers.

On the Hollerith Rolling Total Tabulator (*i.e.*, the punched-card adding and subtracting machine) arrangements are there which take algebraic signs into account; that is, all values designated by one figure can be added and all values designated by another subtracted. On the Hollerith multiplying machine, however, while two factors are read from the card, multiplied and their product punched on the same card, there is no provision to take into account the signs of the factors during the multiplying operation and to indicate the sign of the product by designation or otherwise. It becomes necessary, therefore, while multiplying two variables x and y from a series of cards, to sort the cards according to designations of x and y into at least two groups, one corresponding to positive products and the other to negative products, and deal with these groups separately. If with further tabulation or other work in view, it is desired to denote the signs of the products also by designations, then punching by hand or gang-punching has to be resorted to.

Problems in Hollerith work involving multiplication of positive and negative quantities, though less common in Accounting, are frequently met with in statistical and certain other mathematical calculations (*e.g.*, calculation of coefficient of correlation between departures from normal of characters like temperature and rain-fall).

Two methods are given below which show how the use of certain particular designations and a little additional plugging on the machine, enable the signs to take care of themselves during multiplying operations and permit the products to be prefixed with their appropriate 'signs'.

The type of machine referred to in detailing these methods is either the Hollerith Decimal Multiplying Punch or the Hollerith Decimal Cross-footing Multiplying Punch, each with multiplier and multiplicand counters of eight digit capacity.

SIGNS ON HOLLERITH MULTIPLIER

Method I :—Designate positive factors by 1 and negative factors by 0. Multiply designations also along with the factors and use the unit-place of the designation-product to designate the product of the factors.

Thus if $+ = 1$ and $- = 0$, then,

$$\begin{aligned} + \times + &= 1 \times 1 = 1 = + \\ + \times - &= 1 \times 0 = 0 = - \\ - \times - &= 0 \times 0 = 0^* 1 = + \end{aligned}$$

(Plugging :—For factors, plug as usual. For signs, plug designation columns of multiplicand and multiplier factors from 'Brushes' sockets to the 8th (last) sockets of multiplicand and multiplier counters respectively. Plug 15th socket of product counter to designation column of product in the 'Punch' sockets.)

This method requires that the multiplicand and multiplier should not together have more than seven digits, as otherwise partial products caused by designations would interfere with the required products.

<i>Example.</i>	To multiply	— 9786 and — 898	
	Punch factors :	99786 and 9898	
	Multiplicand counter :	90009786	
		×	
	Multiplier counter :	0000898	
	Product counter :	<i>81009615687828</i>	
	Punch product :	18787828	
	Read :	+8787828	Answer.

Method II :—Designate positive factors by 0 and negative factors by 5. Add designations alone by cross-foot†, while factors are multiplied. Use unit-place of sum of designations to designate the product of the factors.

Thus if $+ = 0$ and $- = 5$, then

$$\begin{aligned} + \times + &= 0 + 0 = 0 = + \\ + \times - &= 0 + 5 = 5 = - \\ - \times - &= 5 + 5 = 10 = + \end{aligned}$$

(Plugging : For factors, plug as usual. For signs, plug designation columns of multiplicand and multiplier from 'Brushes' sockets to the 12th (last) sockets of cross-footing R.H.C. and cross-footing L.H.C. respectively. Plug 12th socket of product counter to designation column of product in the 'Punch' sockets.)

*Positions where figures in italics occur are not to be plugged for.

†Cross-footing is a feature on certain types of Hollerith Multipliers, by which figures can be cross-added to or cross-subtracted from the product of two factors, i.e., it allows operations of the type $u + v + xy$

In this method the multiplier and multiplicand should be such that their product does not exceed eleven digits.

<i>Example.</i>	To multiply	+ 895768 and -- 95863	
	Punch factors :	0803768 and 503863	
	Multiplicand counter :		895768
			x
	Multiplier counter :		95863
	Cross-footing R.H.C. :		0
			+
	Cross-footing L.H.C. :		5
	Product counter and punch product :		585871007784
	Read :		-- 85871007784 Answer.

When factors are of more digits than specified above or when the counters are to be used to full capacity, it is still possible to obtain the signs by either of the above methods, provided the signs are obtained and punched in an additional run of the cards.

REFERENCES

1. Comrie, L. J. and Hudson H. G. (1937): The application of Hollerith equipment to an agricultural investigation. *J.R.S.S. Supp.* 4, 210-224
2. Eckert, W. J. (1940): *Punched card methods in scientific computation.* Columbia University Press.
3. McPherson, J. C. (1942): Mathematical operations with punched cards. *Journal of American Statistical Association*, 37, 275-281.

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