MACHINE METHODS OF ACCOUNTING

MULTIPLYING PUNCHES

THE numerous developments of newer machines for use in the International Electric Accounting Method include an Automatic Multiplying Punch. This machine permits the complete mechanization of many routines which formerly necessitated manual calculating and key punching operations.

The use of this machine in conjunction with the other automatic punches has resulted in the efficient adaptation of the principles of the punched card method of accounting to the work of document preparation due to the fact that each of these machines is capable of transcribing automatically some pertinent information which of necessity must be assembled onto a single unit record from different sources. It has also speeded up the accounting routines for which International Electric Accounting Machines have long been used. Extensions involving earnings, material cost, discounts, physical inventory, and numerous other computations can be effected automatically by the punched cards.

All of the newer units of punching equipment have contributed toward making the punched tabulating card a unique record. By their use it becomes possible for any recorded data to be *automatically* accumulated, reproduced, listed, or multiplied.

Automatic Multiplying Punch

The Type 601 Automatic Multiplying Punch is a high-speed, automatic machine which multiplies factors punched in tabulating cards, adjusts the products to the nearest whole number, punches the resultant products into the cards, and accumulates product totals.

The machine consists of a card reading unit; multiplying, transferring, and storing counters; and a punching unit. The principle underlying the multiplying operation is extremely simple. As each card feeds into the machine, the multiplicand and multiplier are read from the card and are set up in the machine. The multiplication operation is then performed and the card feeds into punching position. The product of the multiplication is transmitted to the punching mechanism and simultaneously is registered in the summary counter. While the card is being punched and ejected, the reading operation is being performed for the next card.

The machine is equipped with an automatic plugboard which makes it entirely flexible for the reading, multiplying, and punching of data as desired. This plugboard incorporates the flexibility and all other features of the former style of plugboard, and in addition, provides for complete changes in machine plugging in a moment's time.

A complete description of the features, functions, and operating principles of the Type 601 machine is contained in the following pages of this booklet. The functions and operations are presented in a sequence of logical development in order to avoid repetition of operating principles and to confine explanations to the particular function being discussed.

Features

The following features, indicated on the operating diagram, are incorporated in the design of the Type 601 machine.

Card Feed

The card feed is of the continuous type similar to that used on the Type 80 Horizontal Sorter. Cards are placed in the feed hopper face down, nines toward the throat.

X-Brushes

The six X brushes are used for controlling the machine under the Group Multiplier Method explained later. They are manually set on predetermined card columns as described in the plugboard section of this booklet.

Reading Unit

The reading unit contains the brushes for reading the factors which are recorded in each card and which are then respectively set up in the counters of the machine.

Punching Unit

The punching unit is similar to that of the Type 516 Duplicator Summary Punch. As the card is received from the reading unit of the machine, it is spaced into punching position by

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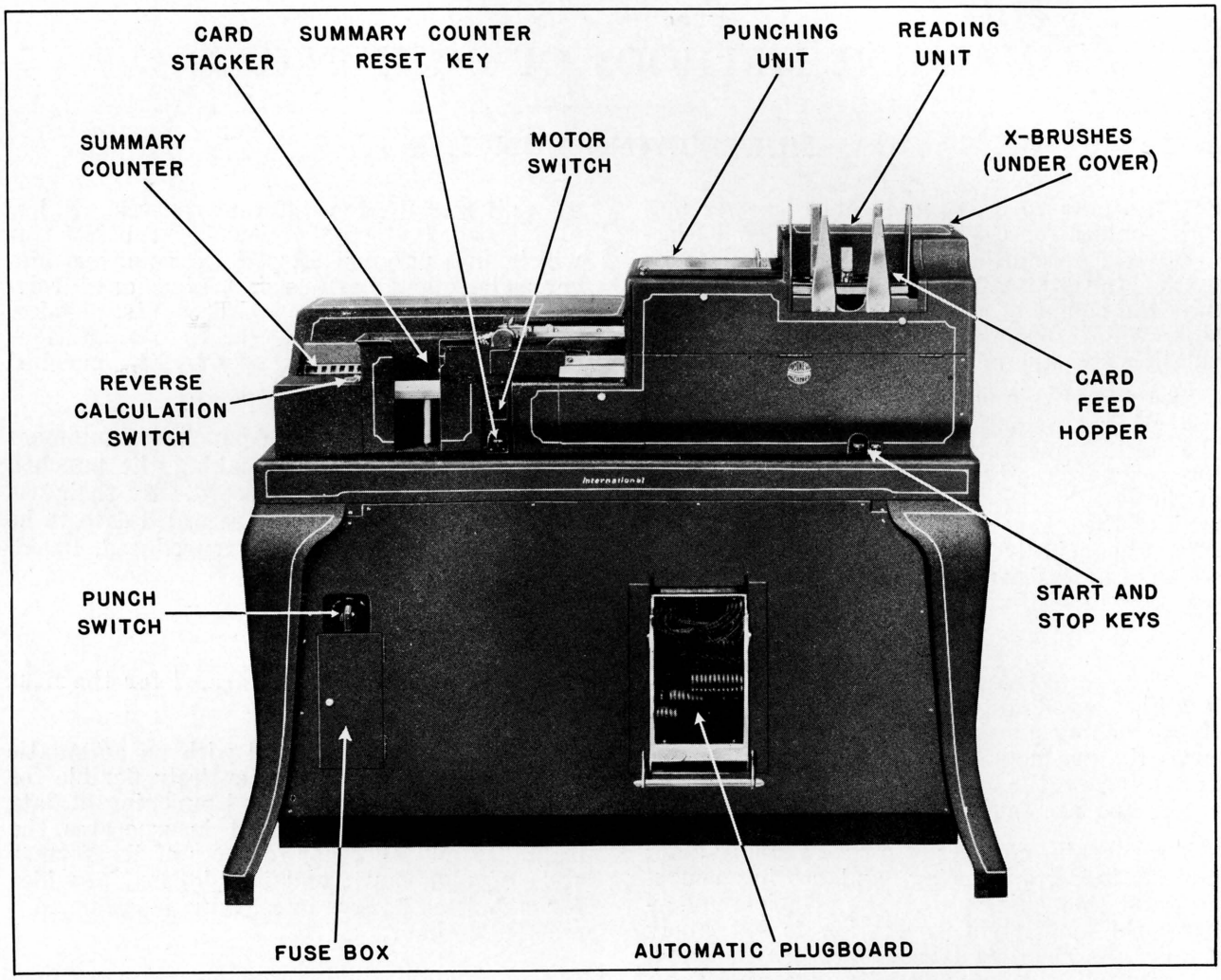


means of the proper automatic skip bar. The card is then punched, the punching mechanism being actuated by electrical impulses received from the counters of the machine. The card is automatically ejected and stacked.

The automatic skip bar used in multiplying punches is a low bar (the same height as an X-bar), the cut portion corresponding to the fields on the card to be punched. This bar should not be confused with the automatic (high) bar used in the summary punch, although it has the same function.

Summary Counter

The products of multiplying operations may be accumulated in a summary counter. This is a visible counter used for checking purposes, as described later. A reset key is provided, as illustrated, for clearing this counter when desired.

Reverse Calculation Switch

This switch is provided to reverse the positions of the multiplicand and multiplier in the multiplying operation without rewiring those fields. When in the Punch position, the switch causes the reading of the multiplicand and multiplier and the punching of the product in the normal manner. When in the Check position, the multiplicand and multiplier factors are reversed and the card in normal operation is fed through without being punched. Speed in ejecting cards, when checking, may be increased somewhat through the use of an uncut skip bar in the punching unit.

When the switch is set to Check, the second run is not just a repetition of the first, but involves a different and entirely independent calculation. Therefore, when cards are re-extended, an error which may have occurred in the first multiplication will be detected in the sec-

ond because a different total will have been accumulated in the summary counter.

Punch Switch

This switch is used to control the action of the punching mechanism and takes precedence over the reverse calculation switch in certain functions.

When this switch is set to Normal, the machine punches or checks as determined by the reverse calculation switch.

When set to Punch, the machine punches the product of every multiplication, regardless of the position of the reverse calculation switch.

When set to Non-Punch, the machine ejects each card without punching it, regardless of the position of the reverse calculation switch.

Automatic Plugboard

A diagram of the automatic plugboard, together with a detailed description of the plugboard units, is contained in the plugboard section at the end of this booklet.

Capacity

The Type 601 machine has the following maximum capacity for multiplying operations:

8 digit multiplicand
8 digit multiplier
16 digit product extension and punching
10 digit product accumulation in the summary counter.

Speed

The speed of this machine for extending and punching products in multiplying operations is shown in the table below. The number of digits in the multiplicand does not affect the speed of multiplication. For this reason, the factor containing the smaller number of digits should be made the multiplier, whenever possible.

SPEED IN CARDS PER HOUR							
COLUMNS PUNCHED IN PRODUCT	DIGITS IN MULTIPLIER OTHER THAN ZERO						
	2	3	4	5	6	7	8
1 TO 7 INCL	1500	1285	1125	1000	900	818	750
8 TO 11 INCL	1285	1125	1000	900	818	750	692
12 TO 16 INCL	1125	1000	900	818	750	692	642

In actual work, the speeds shown will be increased by the presence of zeros in the multiplier positions. For example, a four-digit multiplier which includes a zero would require the same time as a three-digit multiplier.

Current

This machine may be specified for operation on 110 or 220 volts, either direct or alternating current. At 110 DC, 25.0 amperes are required for starting and 4.7 amperes for running; at 110 AC, 30.0 and 7.6 amperes, respectively. Since the starting current requirements of the machine are high, it is advisable not to use a motor generator already supplying current to other machines unless the capacity of the motor generator is sufficient to prevent undesirable fluctuations in the voltage.

Functions

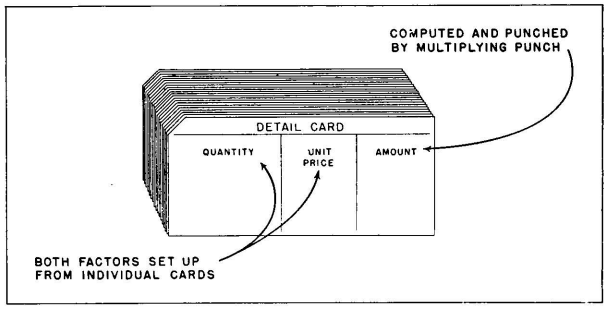
The following paragraphs describe the functions and illustrate the plugging for setting up the machine for various multiplying and checking operations.

Multiplying

In multiplying operations, the multiplicand factor is always set up from individual cards. The multiplier factor, however, may be set up under either the Individual Multiplier Method or the Group Multiplier Method.

Individual Multiplier Method—This method provides for setting up the multiplier factor from the individual cards in the same manner as the multiplicand factor. It is used when the multiplier has been punched in each card. Under this method, the Group Multiplier Switch must be in its OFF (Individual Multiplier) position.

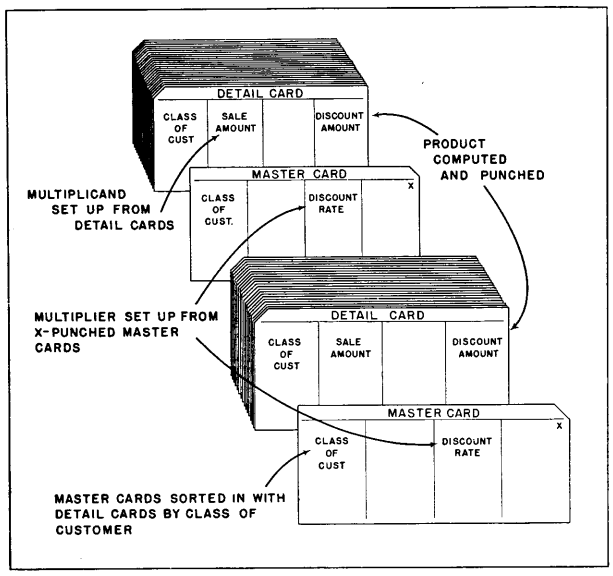
In the accompanying illustration, both quantity and unit price are punched in the individual cards before they are placed in the multiplying punch. The machine reads both factors from each card, performs the extension and punches the product in the card from which the factors were read.



Group Multiplier Method—This method provides for setting up common multipliers for groups of detail cards. The multipliers are set up from X-master cards sorted in front of the groups of detail cards to be extended by the common multipliers. By setting the Group Multiplier Switch ON, the machine is arranged to hold each multiplier until it is cleared out by the X-punch in a new master card.

When the machine runs out of cards, the last group multiplier is retained in the multiplier counter. Therefore, any remaining detail cards of the same group can be extended without making a new multiplier set-up. However, when a new group is to be run, the X-master card must be preceded by a card in order to clear out the previous multiplier.

In the illustration, master cards are sorted in front of the detail cards in the "Class of Customer" sort. The trade discount rate for each



class of customer is set up from the master card and is used as the multiplier for all detail cards for that class of customer.

When using a group multiplier, the two factors to be multiplied must not be in the same or overlapping card fields. However, other information may be punched in the detail cards in the same columns in which the multiplier is punched in the master card, or in the master card in the columns corresponding to the multiplicands in the detail cards. (In the event that it is necessary to punch the multiplier and multiplicand in the same or overlapping card fields, interference can be prevented through the use of a class selector.)

The punching of X's in the master cards and the method of wiring the machine for X-controlling is discussed in detail in the plugboard section at the end of this booklet.

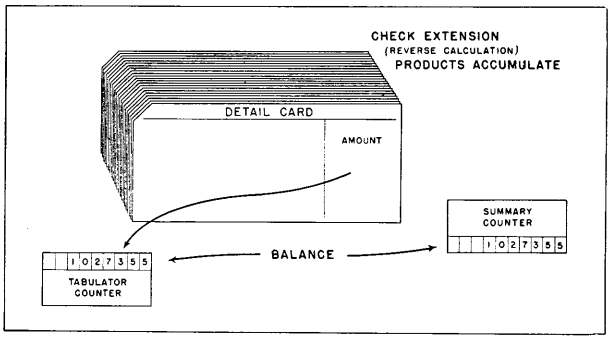
Checking

When it is imperative that the operation of the multiplying punch be checked, one of the following methods is recommended:

1. Reverse Calculation Method for checking extensions.
2. Comparative Check Method for checking extensions and punching.
3. Parallel Balance Method for checking extensions and punching.
4. Digiting Method for checking extensions and punching.
5. Group Total Extension Method for checking extensions and punching where multipliers are set up on a group basis.

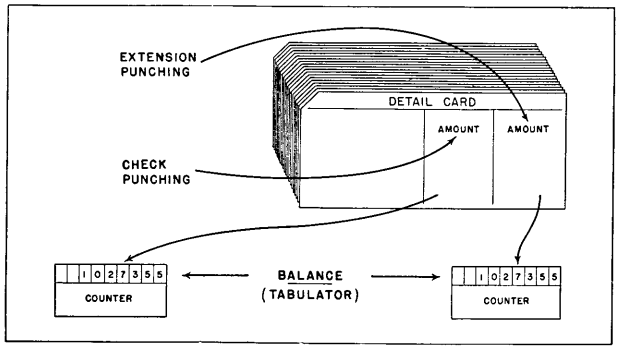
Reverse Calculation Method—The checking feature of this method is described fully in the paragraphs on the Reverse Calculation Switch in the preceding Features section.

Comparative Check Method—Under this method of checking, the detail cards are re-extended with the Reverse Calculation Switch on Check. Comparison of the summary counter totals provides a proof of the extending operation.



The amount accumulated in the summary counter is checked against a tabulation of the punched products in an accounting machine. This provides a proof of the punching operation.

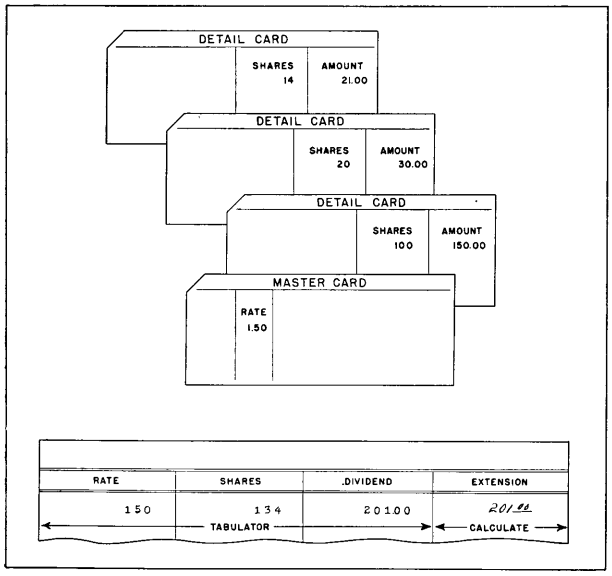
Parallel Balance Method—In this method, the original extending and punching operation is repeated, the product being punched in a different field. In the re-extending operation, the Reverse Calculation Switch is set to Check and the Punch Switch is set on Punch.



The proof of both extending and punching operations is accomplished by balancing the totals of the two product fields in separate counters of an accounting machine.

Digiting Method—Extensions and punching of extensions may be checked simultaneously by either of the two methods known as progressive digiting or digiting without sorting.

Group Total Extension Method—This method of checking may be used where multipliers are set up on a group basis. Under this method, the detail cards are extended only once. For proof of both extending and punching operations, the cards are tabulated in an accounting machine controlling on classification, indicating



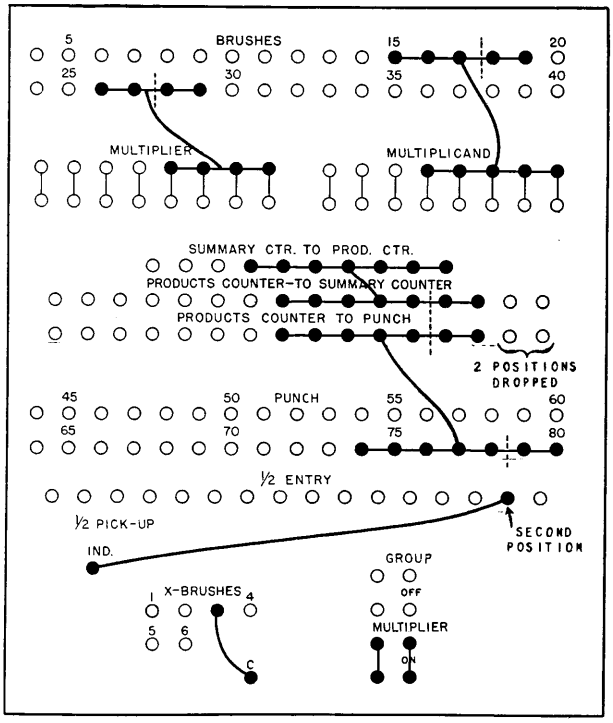
multipliers, and adding multiplicands and products. The totals of the multiplicands are extended by the common multipliers and the results checked against the product totals. This method also provides a proof of the correct insertion of master cards.

Summary cards may be used to advantage in this method of checking. For example, in accounting for stock disbursements, a summary card for each commodity total would be used first in checking the multiplying punch extensions and later for crediting the inventory account for total issues of the commodity.

Elimination of Decimal Positions

Only those decimal positions in the product which are required need be punched or accumulated. The maximum number of digits in the product is equal to the sum of the digits in the multiplicand and the multiplier. The position of the decimal in the product is likewise determined by the sum of the decimal positions in the multiplicand and multiplier.

In the following illustration, the multiplicand contains 3 whole and 2 decimal positions and the multiplier contains 2 whole and 2 decimal posi-



tions. The product could have a possible 9 digits, 5 whole and 4 decimal positions. If only 2 decimal positions were required in the product, the last two digits to the right in the products counter would not be wired for punching or accumulating.

Adjusting Fractions in Product

Where some of the digits at the right of the product are dropped, it may be desirable to adjust the retained product in the units posi-

tion for the fraction dropped. To accomplish this, 5 is added to the first position to the right of the retained amount. In the previous example, where 2 decimal positions of the product are dropped, 5 is added to the unused portion of the product by plugging from the "Individual ½ Pick-Up" hub to the second position of the "½ Entry."

The following illustration shows in A—how the product is adjusted when the dropped portion amounts to 50 or more; and B—how the product is punched when the dropped portion is less than 50:

	A	B
Product computed	10000.0050	10000.0049
Machine adds 5	5	5
Product punched	10000.01⊠	10000.00⊠

Special Operations

The following functions of the Multiplying Punch are special applications of the normal multiplying operations. In some of these functions, the size of the factors which can be handled is limited by the capacity of the machine. By manually calculating one example, it is possible to ascertain whether or not a specific operation can be accomplished. Where the size of the largest digits in the factors can be predetermined, these digits can be used in the calculation. However, by using 9's as the factor digits, the maximum factor sizes for an operation can be determined.

In the following illustrations, letters are used to facilitate discussion, each letter representing a factor obtained from a tabulating card. The small x's in the multiplicand and multiplier represent unplugged positions.

Multiplying Two Factors by a Third

This operation is limited to a total of 8 digits for all three factors. It is necessary to leave as many blank positions between the two multipliers as there are digits in the multiplicand. The following shows the factor arrangement for multiplying C by A and B in one operation.

```
                  99999      (C)
                9xxxxx99     (A;B)
              ----------
                 899991
                899991
           899991
          ----------
(A × C)   899991|9899901  (B × C)
```

Punching the Group Multiplier in Detail Cards

In this operation, it is necessary to have a "1" punched in a designated column of every detail card. The "1" is used as a second multiplicand and the two multiplications are performed in one operation. The sum of the digits of both factors must not exceed 8 digits. The number of blank positions in the multiplicand is one less than the number of digits in the multiplier.

```
                999xxxx1     (B;1)
                   99999     (A)
              ----------
                899100009
               899100009
              899100009
             899100009
            899100009
          ----------
(A × B)   99899001|99999     (A)
```

Performing Two Extensions in One Operation

In the following illustration, a three-digit factor is multiplied by a two-digit factor (A × B), and a two-digit factor is multiplied by a one-digit factor (C × D). Two carry-over positions between factors in the multiplicand are necessary and the number of blank positions in the multiplier is equal to the sum of the digits in the multiplicand.

```
                 99xx999     (D;B)
                 9xxxxx99    (C;A)
               ----------
                 89108991
                89108991
          89108991
         ----------
(C × D)  891|0908901|98901  (A × B)
```

Adding Results of Two Extensions

The sum of the products of A × B and C × D can be obtained by reversing the factors in the multiplier and plugging as shown.

```
                 99xx999     (D;B)
                 99xxxx9     (A;C)
               ----------
                 89108991
          89108991
       89108991
      ----------
         99792          (A × B) + (C × D)
```

Cross-Adding Small Factors

Two or more small factors may be cross-added automatically if the number of digits in the factors plus the necessary number of carry-over positions does not exceed a total of 8 positions.

A common "1" multiplier, set up under the Group Multiplier Method, is multiple-plugged into the multiplier counter in the positions corresponding to the units position of each factor to be cross-added. The following illustration shows the arrangement of factors for cross-adding three 2-digit amounts.

```
99x99x99   (A;B;C)
 1xx1xx1
-------
 99099099
  99099099
99099099
-------
  297          (A + B + C)
```

The location of the units position of the total in the products counter is determined by the position of the left-hand factor in the multiplier counter, the seventh position in the above illustration.

Cross-Subtracting Two Factors

This operation is possible through the use of the complement of "1" as a multiplier factor. The factors are plugged as described for cross-adding with the exception that a "9", read from the master card containing the unit multiplier, is multiple-plugged into the positions corresponding to the digits in the minuend. An extra "9" must be provided for use in designating complement totals, as described under "Capacity" of the cross-footing machine later.

The subtrahend must be plugged to the right in the multiplicand. The factor arrangement for subtracting a two-digit field from a three-digit field is shown below.

```
234x63   (A;B)
999xx1
-------
 234063
2106567
2106567
2106567
-------
  171          (A — B)
```

The location of the units position of the net total in the products counter is determined by the position of the first complement "9" in the multiplier counter, the fourth position in the above illustration.

Division

Division can be performed in this machine by the use of reciprocals, the quotients obtained by dividing "1" by the divisors. Reciprocals can be secured from reciprocal tables, and need not be computed for each operation.

Producing Complements

The complement of any amount in a card, not exceeding 8 digits, can be punched in the card by reading the amount to be converted to a complement into the multiplicand counter and multiplying by 9's. A "9" may be read from a master card under the Group Multiplier Method, and multiple-plugged to as many positions as there are digits in the multiplicand.

Repunching Amounts in Same Cards

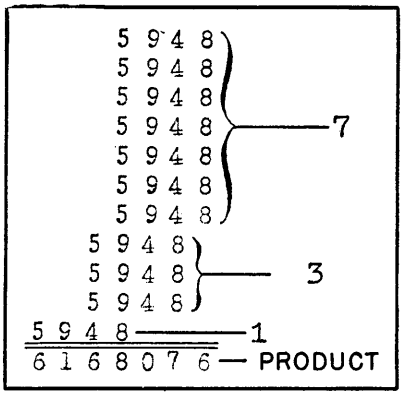
This operation is accomplished by multiplying the amounts by "1" under the Group Multiplier Method.

Operating Principles

Multiplication in the Type 601 machine is based on the principle of accumulation of partial products, instead of the more generally used repeated addition method.

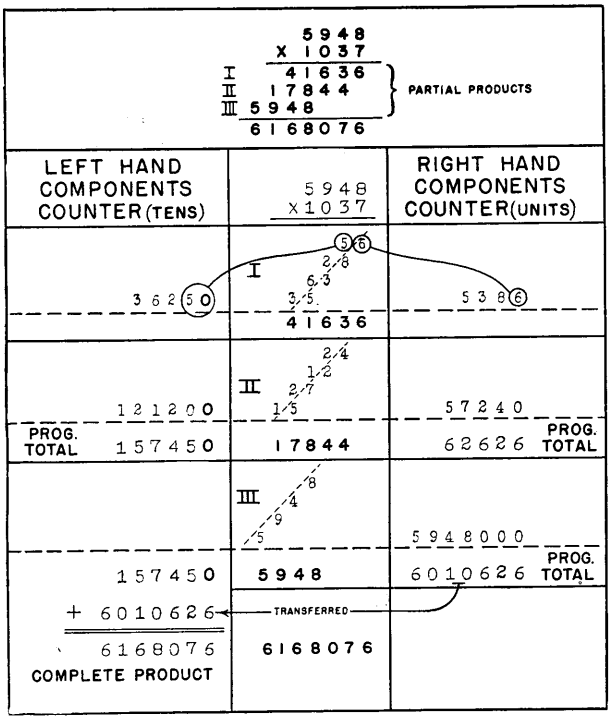
The repeated addition method is based on the repeated adding of the multiplicand, the number of times it is added depending upon the value of each digit of the multiplier. For example, in multiplying 5948 by 1037, the multiplicand 5948 would be added 11 times, as illustrated.

In the partial products method, a partial product is the amount secured by the actual multiplication of the multiplicand by a single



digit of the multiplier. Each partial product consists of a right-hand component (R.H.C.) and a left-hand component (L.H.C.). The R.H.C. is made up of the units-position digits of the successive products secured by multiplying the single digit of the multiplier by each digit of the multiplicand in turn. The L.H.C. is made up of the tens-position digits of the same successive products. For example, in the extension 7 × 8 equals 56, the 6 is the R.H.C. and the 5 (or 50) the L.H.C.

As shown in the following illustration 41636 (the partial product secured in multiplying 7 times 5948) is broken down into 5386 and 36250, right- and left-hand components, respectively.



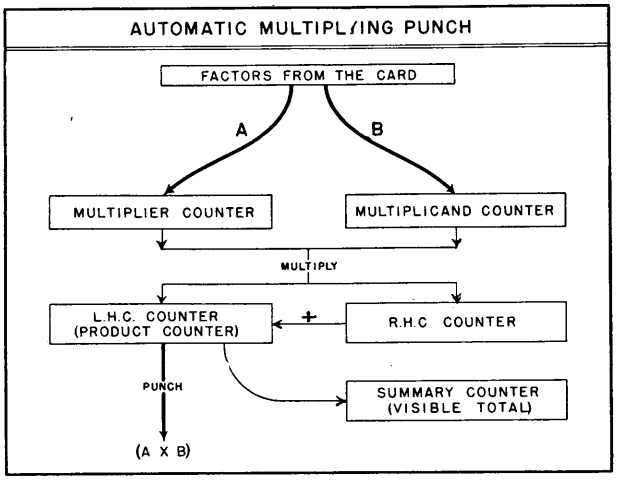
The center column of the illustration shows how the components are formed. Actually, the complete R.H.C. and L.H.C. are calculated and added into their respective counters in one machine cycle.

As each successive digit of the multiplier is used in the product extension, a shift of one position to the left is made automatically before the components are added into their counters. Zeros occurring in the multiplier cause the machine to shift over additional positions automatically, thus eliminating unnecessary machine cycles.

When the partial products for each significant digit of the multiplier have been computed, a progressive total of all the R.H.C.'s and L.H.C.'s of the partial products will be standing in their respective counters. The complete product is formed automatically by transferring and adding the amount standing in the R.H.C. counter into the amount in the L.H.C. counter, as illustrated.

At the end of this operation, the complete product is contained in the L.H.C. counter (products counter), from which the punching mechanism is actuated and from which the amount may be added into the summary counter.

The diagram below illustrates the factor plugging and the relation of the counters of the machine to each other in multiplying operations.



In calculating the product of 5948 multiplied by 1037 under this method, only 4 machine cycles are required, as compared to the 11 adding cycles required under the repeated addition method. After the multiplier and multiplicand have been read into the machine, three machine cycles are used in multiplying 5948 by 7, 3, and 1 (the zero being skipped) and the fourth cycle is used in transferring the amount in the R.H.C. counter into the L.H.C. counter.

During the multiplying operation, the card has advanced from the reading unit to the punching unit of the machine and has been properly spaced to the first position to be punched on the card. The card is then punched and ejected.

Automatic Cross-Footing Multiplying Punch

The Type 601 Automatic Cross-Footing Multiplying Punch is a high-speed, automatic machine which has all the features and performs all the functions of the Type 601 Automatic Multiplying Punch previously described. In addition, it is arranged to perform certain cross-adding and cross-subtracting operations, either in combination with multiplying operations, or separately, as required. The results of such computations are punched in the cards, and totals or net totals of the results may be accumulated in the summary counter.

Descriptions of the features, functions, and operating principles which are additional to those of the machine previously described are contained in the following paragraphs.

Features

Summary Counter

In addition to accumulating products in multiplying operations, this counter may be used to total the results of cross-footing, or of combinational multiplying and cross-adding operations.

Capacity

The capacity of the Cross-Footing Multiplying Punch for multiplying operations has been described previously. In cross-footing operations, two 12-digit amounts and one 8-digit amount may be cross-added or cross-subtracted.

In the event that a total may be a complement figure, when cross-subtracting, provision must be made for designating a complement total. To accomplish this, the last position to the left in the products counter is wired to punch any extra column in the card. If the total is positive, a zero will be punched in this extra column; if a complement, a nine is punched.

Speed

The following table shows the speeds of the cross-footing machine for all operations. The speeds for multiplying operations, as shown, are the same for both models of the Type 601 machine.

The second section in the table shows the speeds of this machine for computing and punching the results of cross-footing, and of combinational cross-footing and multiplying operations.

The third section shows the speeds of the Type 601 machine equipped with the Additional Cross-Footing Device (described later) for combinational cross-footing and multiplying operations.

Note: The Reverse Calculation Switch has the same function for multiplying operations in this machine as for the machine previously described. However, this switch is not operative for cross-footing operations and must remain in the Punch position for all operations involving cross-footing.

SPEED IN CARDS PER HOUR

KIND OF OPERATION	COLUMNS PUNCHED IN PRODUCT	DIGITS IN MULTIPLIER OTHER THAN ZERO						
		2	3	4	5	6	7	8
MULTIPLYING ONLY	1 TO 7 INCL.	1500	1285	1125	1000	900	818	750
	8 TO 11 INCL	1285	1125	1000	900	818	750	692
	12 TO 16 INCL	1125	1000	900	818	750	692	642
CROSS-FOOTING R. H. C. TO L. H. C. AND MULTIPLYING	1 TO 7 INCL	1125*	1000*	900	818	750	692	642
	8 TO 11 INCL	1000*	900*	818	750	692	642	600
	12 TO 16 INCL	900*	818*	750	692	642	600	562
ADDITIONAL CROSS-FOOTING R. H. C. TO L. H. C. TO SUMMARY COUNTER AND MULTIPLYING	1 TO 7 INCL	1000↔	900	818	750	692	642	600
	8 TO 11 INCL.	900↔	818	750	692	642	600	562
	12 TO 16 INCL	818↔	750	692	642	600	562	529

NOTE * THIS IS ALSO THE SPEED OF TWO FIELD CROSS-FOOTING WITHOUT MULTIPLYING
↔ THIS IS ALSO THE SPEED OF THREE FIELD CROSS-FOOTING WITHOUT MULTIPLYING

Functions

In addition to performing the regular multiplying functions, this machine is capable of performing the following cross-footing operations which, for purposes of discussion, are expressed as formulae. The letters A, B, C, and D represent fields in a tabulating card; F represents the total or net total to be computed and punched.

$$\begin{aligned} A + B &= F \\ A - B &= F \\ (A \times B) + C &= F \\ (A \times B) + C + D &= F \\ A + B + C &= F \\ A - B - C &= F \\ A + B - C &= F \end{aligned}$$

In combinational multiplying and cross-adding operations, the factor A may be set up as a group multiplier, as described in a previous section of this booklet.

The following table shows the factor plugging for all cross-footing operations.

OPERATION	FACTORS			
	A	B	C	D
A+B	L.H.C.	R.H.C.		
A−B	L.H.C.	R.H.C.		
(A×B)+C	Multiplier	Multiplicand	L.H.C.	
(A×B)+C+D	Multiplier	Multiplicand	L.H.C.	R.H.C.
A+B+C	L.H.C.	Multiplicand	R.H.C.	
A−B−C	L.H.C.	Multiplicand	R.H.C.	
A+B−C*	L.H.C.	Multiplicand	R.H.C.	

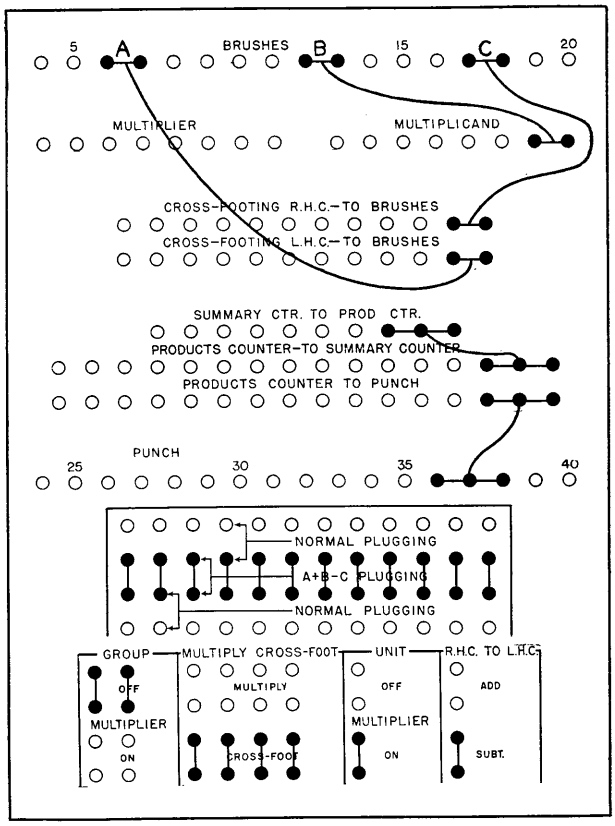
Detailed diagrams, illustrating factor plugging and counter operations for the various cross-footing functions, are shown in the section on operating principles of this machine.

A + B — C Plugging*

In addition to the normal factor plugging for this operation, the Normal—A + B — C plugboard group must be plugged for this special operation, as shown in the next illustration.

Switch Plugging

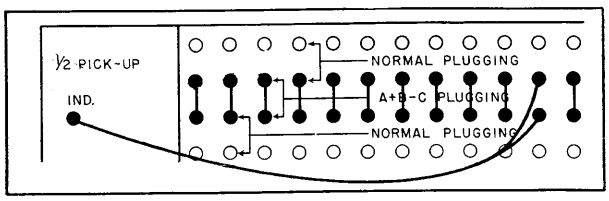
For any operation involving cross-footing, the Multiply—Cross-Foot switch must be on Cross-Foot. For all three-field cross-footing, the Unit Multiplier switch must be ON. Cross-adding and cross-subtracting operations are also under control of the R.H.C. to L.H.C. switch. The operation of these switches is shown in the next illustration and described in further detail in the plugboard section at the end of this booklet.



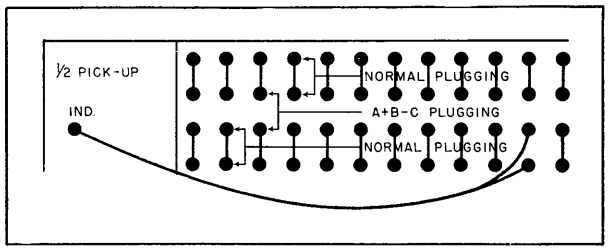
Adjusting Fractions in Total

If one or more of the fields to be cross-added have extra decimal positions which are to be dropped in the total, it is possible to add these amounts and adjust the total to the nearest whole number in the units position. The plugging of the ½ Pick-Up for this operation is the same as that described in a previous section on Adjusting Fractions in Product.

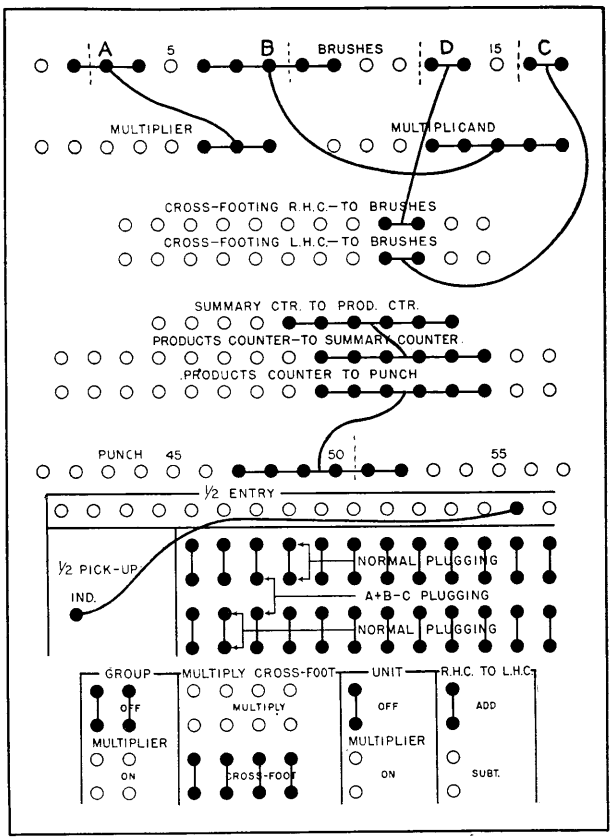
For adjusting net totals in the operation A + B — C, a split wire is plugged from the Individual ½ Pick-Up hub to the proper position in the middle two rows of the Normal — A + B — C, as shown below.



Net totals may be similarly adjusted to the nearest whole number by plugging the ½ Pick-Up to the Normal — A + B — C. The illustration which appears below shows the plugging for the problem A — B — C. Note that the jack-plug is replaced by a split wire from the Individual ½ Pick-Up hub.



The ½ Pick-Up can be used also in problems involving a combination of multiplying and cross-adding. The plugging for the operation (A × B) + C + D and adjusting the totals is illustrated at the diagram to the right.



Special Operations

The cross-footing machine is capable of performing all the special operations described for the other model. However, the newer machine provides greater capacity, and in some cases increased speed, for the following operations because of the ability to plug factors directly into the R.H.C. and L.H.C. counters.

Cross-Footing Small Factors

Four, or more, small factors may be cross-footed in this machine by plugging two factors to the R.H.C. and L.H.C. counters and two or more to the multiplicand counter, as described under special operations of the previous machine. The unit multiplier can be introduced into the multiplier counter automatically by placing the Unit Multiplier switch ON.

Cross-Footing Groups of Small Amounts

When the amounts are small, two or more groups of amounts can be cross-footed in one operation. For example, the following three groups of amounts may be cross-added (A + B) ; (C + D) ; (E + F), or cross-subtracted, by plugging them into the L.H.C. and R.H.C. counters as cross-footing factors (A;C;E) and (B;D;F).

The amounts in the counters cannot be added to or subtracted from each other, but the amounts in the R.H.C. counter can be added to or subtracted from the corresponding amounts in the L.H.C. counter. Sufficient carryover positions must be allowed between amounts to accommodate totals. Amounts cannot be cross-footed in this manner unless the computations in all groups are the same, either all adding or all subtracting.

Producing Complements

This operation can be performed for amounts up to 12 digits by plugging the amounts from the card to the R.H.C. counter and subtracting them from zero in the L.H.C. counter.

Repunching Amounts in Same Cards

This operation can be performed for as many as 12 digits by wiring them directly to one of the cross-footing counters. For amounts of 8 digits or less, this operation can be performed faster by multiplying by "1", as described previously.

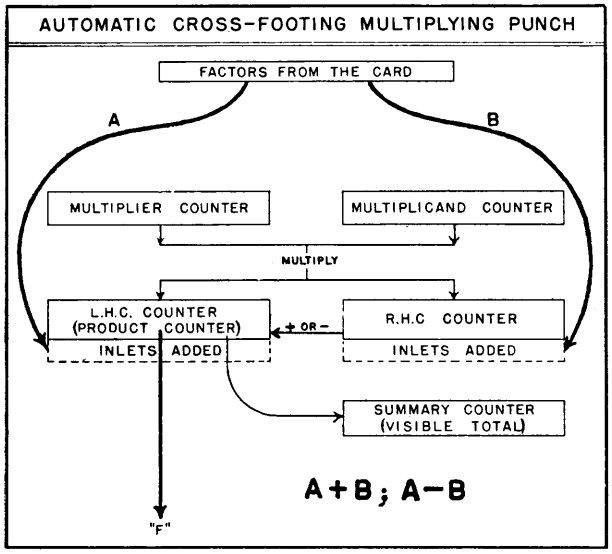
Operating Principles

Cross-footing operations in the Type 601 machine utilize the same counters as used in multiplying operations. Cross-footing factors are read into the counters during the first machine cycle, at the same time that the multiplier and multiplicand factors are read into their respective counters in multiplying operations.

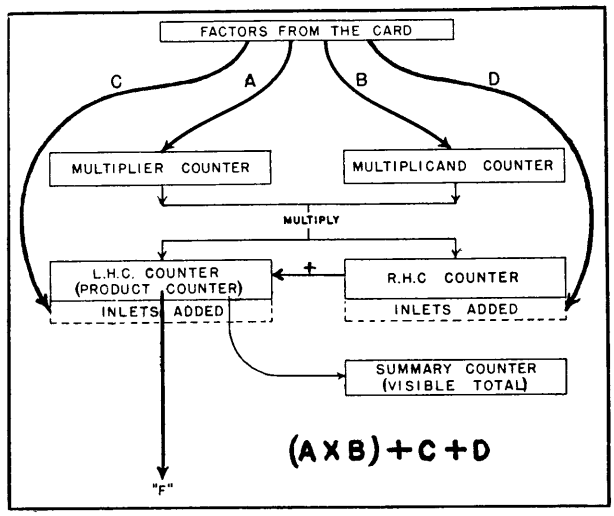
The inlet hubs provided on the plugboard for the R.H.C. counter and L.H.C. counter are used for plugging cross-footing factors into these counters. The "R.H.C. To L.H.C." switch determines whether the amount in the R.H.C. counter is to be added to or subtracted from the amount in the L.H.C. counter during the transfer cycle. Results of cross-footing operations are plugged for punching in the same manner as products of multiplying operations.

The operations A + B and A — B are performed by plugging factor A into the L.H.C. counter and factor B into the R.H.C. counter, and setting the "R.H.C. To L.H.C." switch to either Add or Subtract.

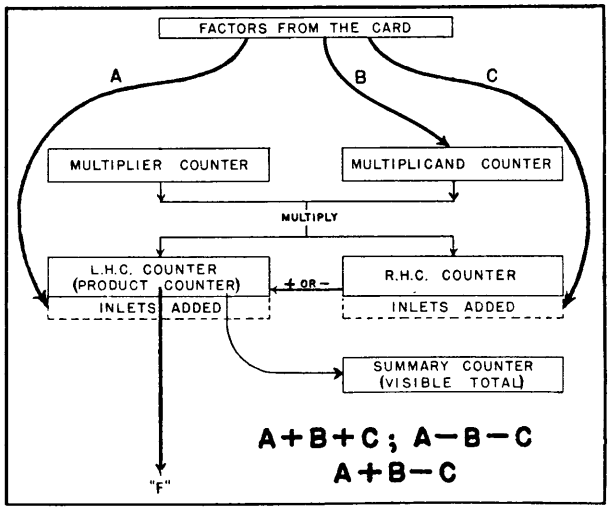
The diagram below illustrates the factor plugging and counter operation for these two-field cross-footing operations.



The operation (A × B) + C + D is performed by combining the multiplying function with the cross-adding function. In combinational operations, the R.H.C. counter contains both the cross-footing factor D and the right-hand component of the product of A times B. As the right-hand components must always be added to the left-hand components in multiplying operations, it is not possible to subtract the amount in the R.H.C. counter from the amount in the L.H.C. counter. Therefore, cross-subtraction in combination with multiplication cannot be performed in this machine.



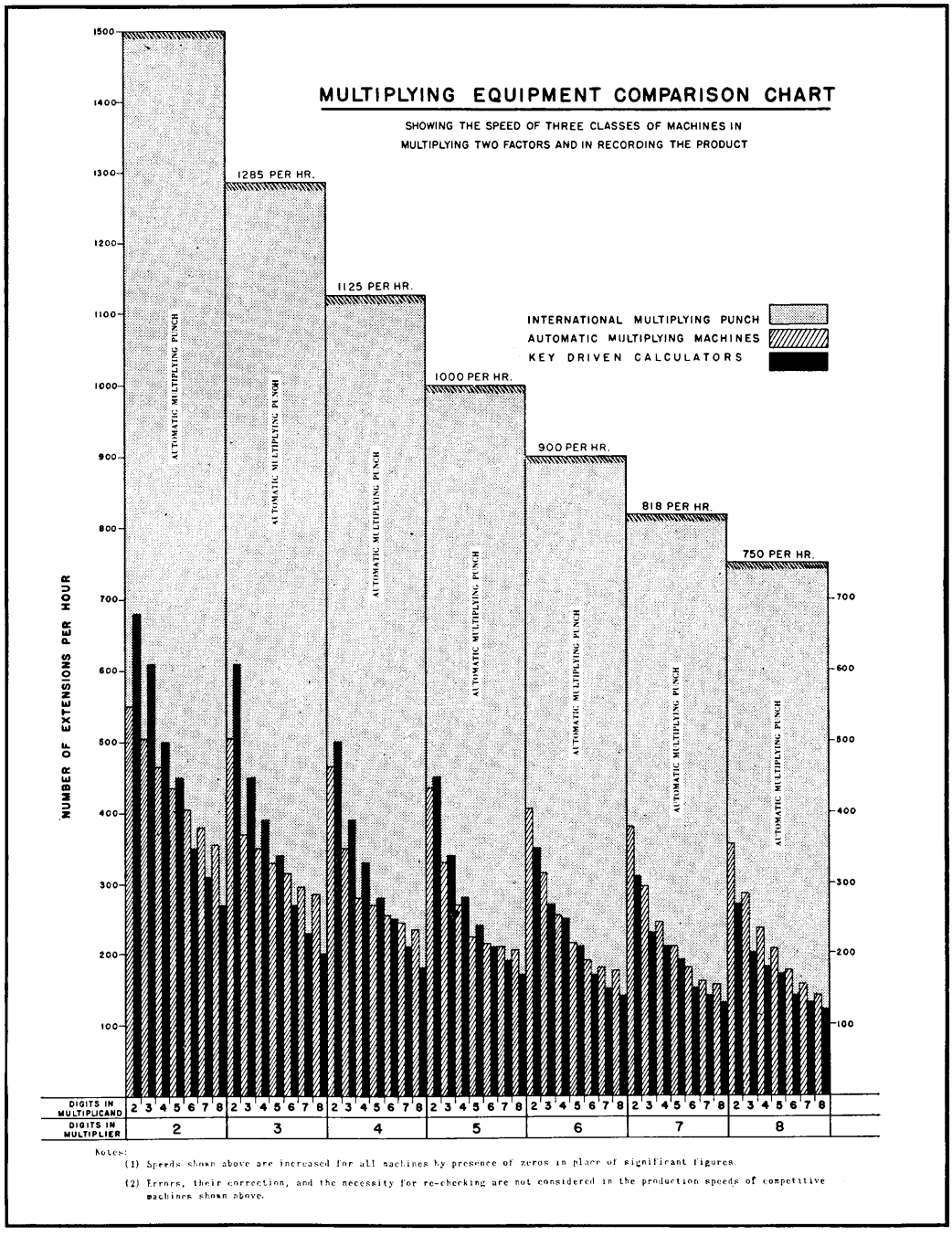
The operations A + B + C, A — B — C, and A + B — C are performed by plugging factor A into the L.H.C. counter, factor B into the multiplicand counter, and the third factor, C, into the R.H.C. counter.



In operations A + B + C and A — B — C, the amount (B) in the multiplicand counter is automatically multiplied by "1" by setting the Unit Multiplier switch ON. This registers the factor B in the R.H.C. counter (as previously described under the partial products method of

multiplying) where it is added to the cross-footing factor C. As the amount in the R.H.C. counter (B + C) is transferred to the L.H.C. counter, it is either added to or subtracted from the amount in the L.H.C. counter, addition or subtraction depending upon the position of the R.H.C. To L.H.C. switch.

The third operation, A + B — C, requires the use of the Normal—A + B — C hubs, as described previously. This plugging causes the amount from the multiplicand counter to register in the L.H.C. counter instead of in the R.H.C. counter. The factors are plugged and the switches are set as for the operation A — B — C. In this case, however, A and B are added together in the L.H.C. counter and C is subtracted from their total at the transfer cycle.



Plugboard

The plugboard diagram illustrated is a combinational diagram showing all the hubs on a complete plugboard for an Automatic Cross-Footing Multiplying Punch equipped with the Additional Cross-Footing Device and the Decimal Accumulating Device.

The dotted hubs on the diagram are the switch hubs for the Decimal Accumulating Device. The portions of the plugboard enclosed with double lines are the hubs for the Type 601 Automatic Cross-Footing Multiplying Punch which are in addition to the hubs of the Multiplying Punch without cross-footing. The portions enclosed with heavy lines are the plugboard hubs which are added to the plugboard of the Type 601 machine for the Additional Cross-Footing Device.

Descriptions of the functions and operations of the units of the plugboard are contained in the following paragraphs.

Brushes—80 hubs which are the outlets for the brushes in the reading unit and are used in plugging the factors from the card to the counters of the machine.

Multiplier—8 pairs of inlet hubs which permit plugging of the multiplier factor from the brushes to the multiplier counter. The two hubs in each pair are common in order to permit multiple plugging from a single card field.

Multiplicand—8 pairs of inlet hubs which permit plugging of the multiplicand factor from the brushes to the multiplicand counter. The two hubs in each pair are common in order to permit multiple plugging from a single card field.

These hubs are also used, on the cross-footing machine, for plugging one of the factors in three-field cross-footing operations from the brushes to the multiplicand counter.

Cross-Footing R.H.C.—To Brushes (Cross-footer)—These 12 inlet hubs are used in plugging cross-footing factors from the brushes to the right-hand components counter.

Cross-Footing L.H.C.—To Brushes (Cross-footer)—These 12 inlet hubs are used in plugging cross-footing factors from the brushes to the left-hand components counter.

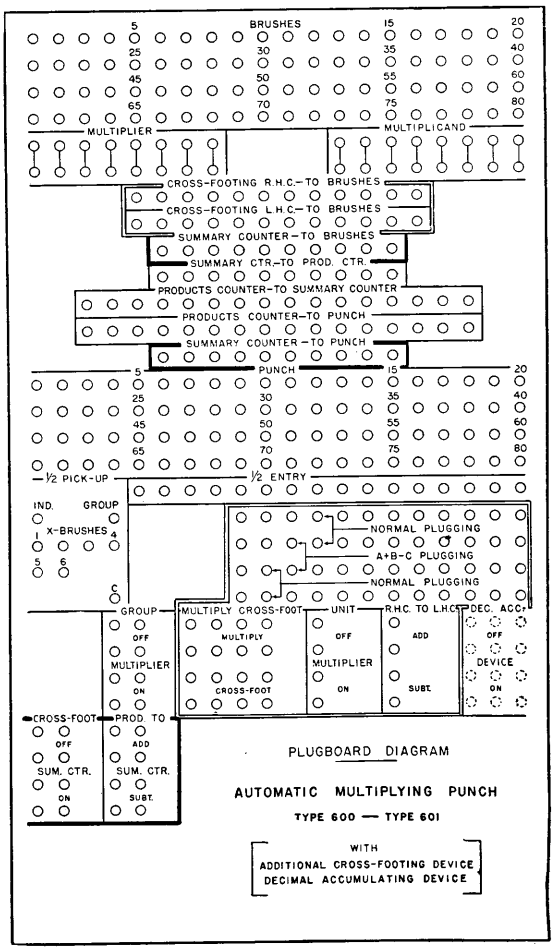
Summary Counter—To Brushes (Cross-footer)—When the Additional Cross-Footing Device is installed on the Type 601 machine, this row of 10 inlet hubs is provided for plugging the additional factor to the summary counter from the brushes.

Summary Counter—To Products Counter—A row of 10 inlet hubs to the summary counter which are plugged from the outlet hubs of the products counter for the purpose of transferring the amount in the products counter into the summary counter.

Products Counter—To Summary Counter—A row of 16 outlet hubs from the products counter used in plugging products, totals, and net totals from this counter to the summary counter.

Products Counter—To Punch—A row of 16 outlet hubs from the products counter used in plugging products, totals, and net totals from this counter to the punch inlet hubs.

Summary Counter—To Punch (Cross-footer)—When the Additional Cross-Footing Device is installed on the Type 601 machine, this row of 10 outlet hubs is provided for plugging the results of additional cross-footing operations from the summary counter to the punch inlet hubs.



Punch—These 80 hubs are the inlets to the punching mechanism and are plugged from the outlet hubs of the products counter or summary counter.

½ *Pick-Up*—These two hubs are outlets for a device which automatically adds 5 to the position of the product or total to which it is plugged. When the hub labelled Ind. (individual) is plugged to the ½ Entry, or Normal—A + B — C, 5 is added to each individual result.

When the Decimal Accumulating Device is installed, the hub labelled "Group" is arranged to add 5 to the group product only when a new X-master card is read into the machine.

Note: When the Decimal Accumulating Device has not been installed, the hub labelled "Group" has the same function as the hub labelled "Ind." This permits the adjusting of two amounts simultaneously.

½ *Entry*—These 16 hubs correspond to the 16 positions in the products counter and are plugged from the ½ Pick-Up for the purpose of adjusting fractions in products or in the results of cross-adding operations.

X-Brushes—This plugboard group of 7 hubs provides a means for plugging six different control X's without manually setting a brush for each different set-up. Six X-brushes are provided in the reading unit with outlets on the plugboard. These brushes can be preset for any six predetermined card columns, the only limitation being that at least two card columns must intervene between any two X-punched columns to be read.

By punching frequently used control X's in the predetermined columns, and plugging from the proper X-hub to the C hub provided in this group, the arranging of the machine for X-controlling on a group multiplier basis is greatly facilitated.

Normal—A + B — C Plugging (Cross-footer)—For all normal operations, the two top rows and the two bottom rows of this unit must be jack-plugged together. For the operation A + B — C and also for adjusting fractions in net totals, special plugging of this unit is required, as illustrated previously.

Switches

The following groups of hubs take the place of the switches used on earlier models of these machines. These switches are operated by special jack-plugs which are plugged in the positions of the switch necessary to turn it ON or OFF, etc.

Group Multiplier—When ON, machine selects multipliers from X-Master Cards. When OFF, machine selects multipliers from individual cards.

Multiply — Cross-Foot (Cross-Footer) — "Multiply" for operations involving multiplying only. "Cross-Foot" for any operations involving cross-footing.

Unit Multiplier (Cross-Footer) — ON when unit multiplier is desired, otherwise OFF. Unit multiplier must be ON for three-field cross-footing operations.

R.H.C. To L.H.C. (Cross-Footer) — "Subtract" when subtracting amount in R.H.C. counter from amount in L.H.C. counter in cross-footing operations. Otherwise, set to "Add."

Decimal Accumulating Device—These hubs are provided only when this device is installed. Set ON for all operations when using this device, otherwise OFF.

When the Additional Cross-Footing Device is installed on the Type 601 machine, the following two switches are provided.

Cross-Foot—Summary Counter—ON when the summary counter is used in additional cross-footing operations. OFF when the summary counter is used for accumulating.

Products To Summary Counter—"Add" when adding amount in products counter to amount in summary counter; "Subtract" when subtracting.

SPECIAL DEVICES FOR MULTIPLYING PUNCHES

Additional Cross-Footing Device

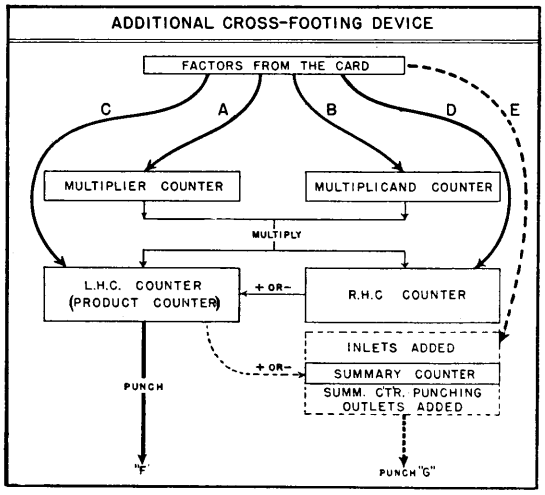
The Additional Cross-Footing Device can be installed on the cross-footing machine to increase the capacity of the machine for cross-footing operations.

This device makes possible the reading of one additional factor E into the summary counter. The product, total, or net total F of regular operations can be added to or subtracted from the additional factor. The operations accomplished through the use of the device may be expressed in the formulae E + F and E — F = G. Both F and G may be punched in the card in one operation.

In addition to the mathematical formulae listed under standard features for cross-footing, the following may be obtained when this device is installed in a machine. It is possible that additional formulae can be worked out:

A + (A × B = C) = total
A — (A × B = C) = net total
A + (B × C = D) = total
A — (B × C = D) = net total
A + B + C + D = total
A + (B + C + D = E) = total
A — (B + C + D = E) = net total
(A + B) — (C + D) = net total
A — [B — (C + D) = E] = net total
A + [(A × B) + C + D = E] = total
A — [(A × B) + C + D = E] = net total
A + [(B × C) + D + E = F] = total
A — [(B × C) + D + E = F] = net total
A + [(A × B) + C = D] = total
A — [(A × B) + C = D] = net total
A + [(B × C) + D = E] = total
A — [(B × C) + D = E] = net total

In any of the above equations any term following an = sign may be punched in the card.



As shown in the illustration, the installation of the Additional Cross-Footing Device provides inlet hubs to the summary counter for plugging the additional factor from the brushes, and outlet hubs from that counter for plugging results of additional cross-footing operations.

Two switches are also provided—one to arrange the summary counter to reset at every card cycle, and the other to cause the result F to be either added to or subtracted from the amount in the summary counter.

The normal accumulating function of the summary counter is sacrificed when it is used in additional cross-footing operations.

Decimal Accumulating Device

The purpose of this device is to accumulate the unused decimals of products and throw them into a product for punching every time the accumulation forms a new significant unit. Thus it is possible to arrive at a group product total which is accurate to within one-half of one unit of the right-hand significant digit. The following example illustrates the operation of the device.

The extensions of six consecutive cards are shown with both actual and punched products. The vertical dotted line divides the significant from the unused positions of the products. The small numbers show the accumulations and carry-overs. The asterisks designate the cards which have a product one unit higher than their normal product, due to the accumulation of the previous decimals.

The example shows that with the accumulating device the group product total is accurate to within one-half of the right-hand significant digit. If the regular ½ Pick-Up had been used, the product total would have been two units too high, and if the multiplication had been made normally, the product total would have been three units too low.

		MULTIPLICAND	GROUP MULTIPLIER	ACTUAL PRODUCT	ACCUM.	PUNCHED PRODUCT
MASTER CARD			0.375		00 50	
DETAIL CARD	– 1	01.0		37.50	50 100	38 *
"	– 2	00.6		22.50	50 50	22
"	– 3	02.5		93.75	75 125	.94 *
"	– 4	00.9		33.75	75 100	.34 *
"	– 5	02.0		75.00	00 00	75
"	– 6	01.0		37.50	50 50	.37
TOTAL		08.0		3.0000	CHECK	3 00

½ PICK UP — CLEARED TO ZERO