IBM

ELECTRIC PUNCHED CARD

ACCOUNTING MACHINES

PRINCIPLES OF OPERATION

ELECTRONIC CALCULATING PUNCH

Type 604

INTERNATIONAL BUSINESS MACHINES CORPORATION

NEW YORK, NEW YORK

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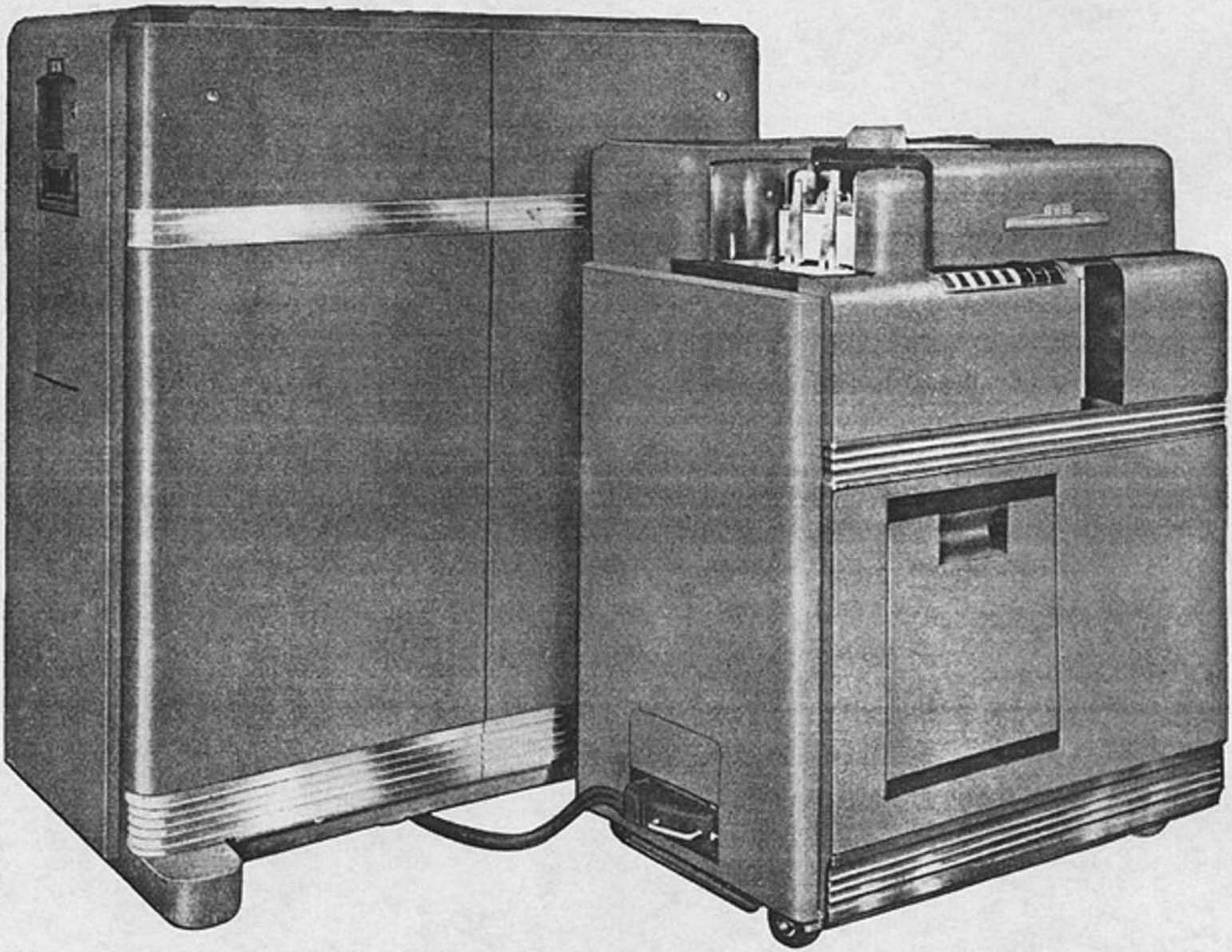


IBM Electronic Calculating Punch

Type 604

IBM ELECTRONIC CALCULATING PUNCH

TYPE 604

THE IBM Electronic Calculating Punch, Type 604, uses electronic methods for performing all basic types of calculations. Factors are read from IBM cards, the calculations are made by an electronic calculating unit in a fraction of a second, and the results are punched automatically in the cards.

The Type 604 adds or subtracts amounts punched in the same cards or in successive cards; it multiplies; it divides; and it performs these operations repetitively and in combination as required for punching results for all general types of calculating problems.

Whether single, repetitive, or combination operations are required, and whether one or more results are punched in each card, the calculations are performed at a constant operating speed—100 cards per minute.

Information is read from a card and held in the machine until it has served its purpose in the calculation. Several results may be calculated and held in the machine until they are punched. As many as 21 digits can be read from a card for calculating, and up to 29 digits can be punched for results. The number of digits read from a card can be increased up to a total of 37 by making a corresponding reduction in the number of positions used for punching.

For basic multiplication, an 8-digit multiplicand is multiplied by a 5-digit multiplier to produce a 13-digit product, but larger factors can be calculated by one or more multiplication recalculations, without reducing operating speed. For basic division, an 8-digit dividend can be divided by an 8-digit divisor to produce a 5-digit quotient, but additional dividend positions and additional quotient positions can be calculated in a single operation.

Group multiplication can be performed with either the multiplier or multiplicand as the group factor. Many other group operations can also be performed, such as the accumulation of factors from a group of cards and the punching of summarized or calculated results in the last card of a group.

Other information can be gang punched into cards as they are being punched with the results of calculations. Straight gang punching of common information into all cards, interspersed gang punching, and offset gang punching can be performed, either in combination with calculation or as an independent operation.

All calculations and punching are checked in a separate operation or, in some cases, in the same operation to insure accuracy. When the factors are reversed, the cards can be recalculated and the result can be punched a second time. A double-punch and blank column detection feature is used to check for the punching of all positions on the first calculation as well as for a difference in punching during the checking operation. If neither blank columns nor double-punched columns occur in either operation, the calculation is proved to be correct. Another checking method is based on the calculation of a zero balance. A second calculation of a result is subtracted from the original punched result and the balance is automatically tested for a zero balance to prove agreement between the two calculations. Any discrepancy preventing a zero balance will cause the machine to stop or the card to be offset in the stacker, if the offset stacker feature is specified.

THE Electronic Calculating Punch consists of two basic units:

1. Punch Unit (Type 521)
2. Electronic Calculating Unit (Type 604)

The punching unit is similar to an IBM Gang Punch, which punches information successively from one card to another, punching all 80 columns of the card simultaneously. An extra 80-column reading station (instead of X brushes) precedes the punching station in the punch unit (Figure 1) for the purpose of reading factors from the card. A second reading station follows the punching station, as in a regular gang punch. Thus, in one cycle a card passes a reading station where the factors are read and transferred by cable to the calculating unit. On the next cycle, the calculated result is transferred back over the cable and punched into the cards; at the same time, the next card is being read. On the following cycle the punched result may be read at the second reading station for checking. Factors are read, calculated results are punched, and the cards may be checked as they move continuously past the three stations.

All calculations whether simple or complex are made in the time that it takes the card to move from the first reading station to the punching station as shown in Figure 1.

The electronic calculating unit is cable-connected to the punch and is the unit in which all calculations are performed. It consists of six basic parts:

1. Factor Storage
2. General Storage
3. Multiplier Quotient
4. Electronic Counter
5. Shift Unit
6. Program Unit

The first three parts may be used to store information from the card until it is ready to be used in a calculation, or to store the results of a calculation until they are ready to be used again. The principal functions of the multiplier quotient unit are to store the multiplier factor when multiplying or to develop the quotient when dividing.

All adding, subtracting, multiplying or dividing must be done in the 13-position electronic counter. Factors to be calculated are moved by programs into and out of the counter or storage unit over a single 8-position channel, which means that only one function can be performed at any one time in the calculation. Since this function is performed at electronic speed, a complex problem involving many steps may be calculated in the same length of time as a simple problem requiring two steps.

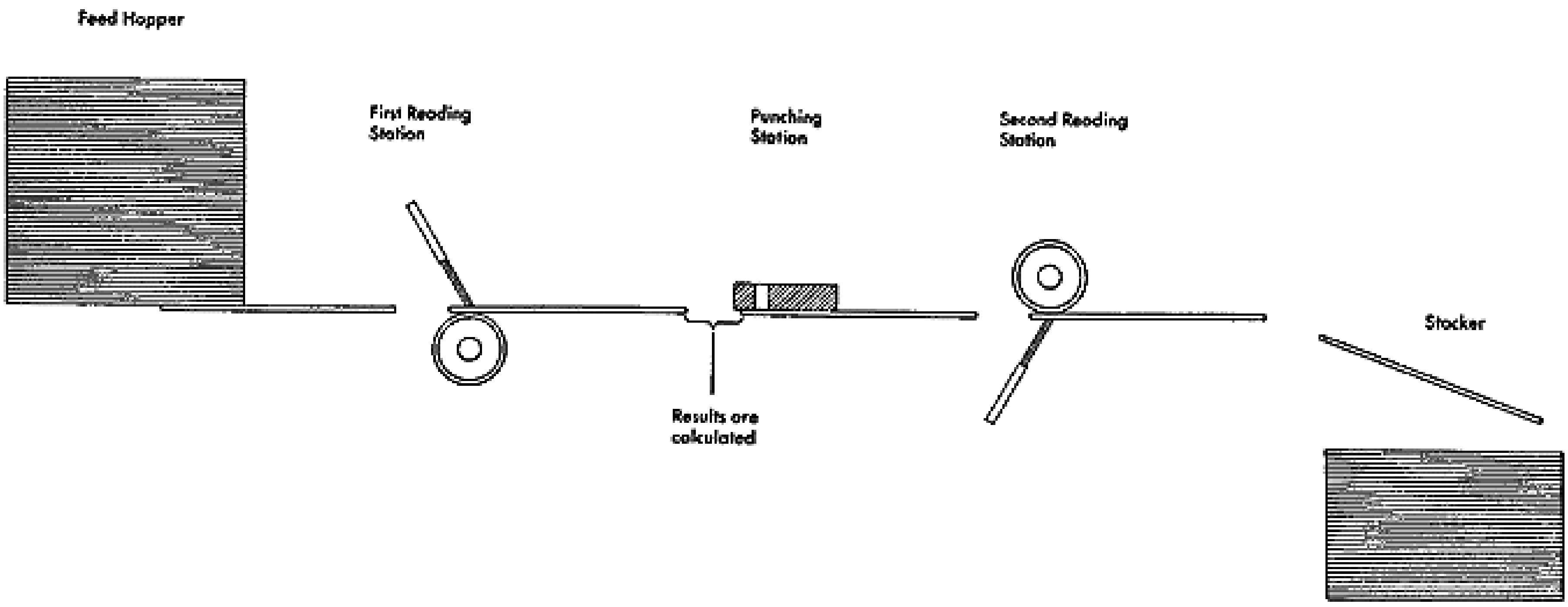


FIGURE 1. CARD STATIONS

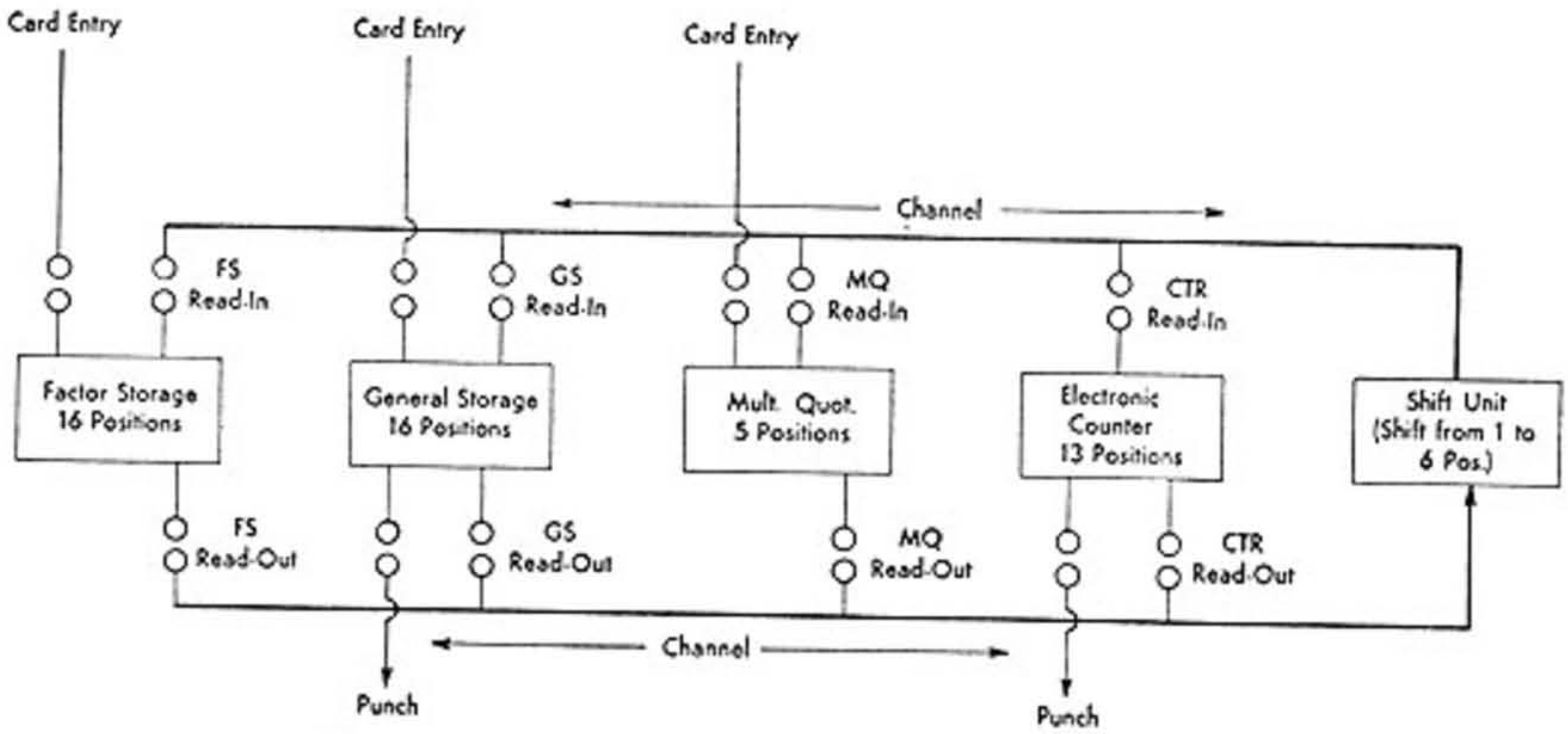


FIGURE 2. SCHEMATIC DIAGRAM OF OPERATIONS

The same 8-position channel is used to move factors from any one unit to any other unit during a calculation. This may easily be seen by reference to Figure 2 which shows pluggable connections into (read in) and out of (read out) factor storage, general storage, multiplier quotient, and the counter. The heavy line identifies the 8-position channel over which the factors travel, and is connected to a shift unit through which the factors must pass when going from one unit to another. The purpose of the shift unit is to allow a shift of the units position to as many as five positions to the left as a factor enters or leaves the counter. The shifting is limited either to entry or exit and may not be done for both at the same time.

The schematic diagram also shows the pluggable connections for entry of information from the card into factor storage, general storage or the multiplier quotient as well as the pluggable connections for punching from general storage or the counter.

OPERATING FEATURES OF THE PUNCH UNIT (FIGURE 3)

Main Line Switch

When the main line switch on the punch is turned on and the ON button on the calculate unit is depressed, power is supplied to both units. Operation may be started approximately one minute later, during which time the electronic tubes heat. The green idling light on the punch and the green run light on the calculate unit turn on when the machine is ready to operate. When the punch unit is being used independently, operation may be started as soon as the main line switch is turned on.

Start Key

The start key is depressed to feed the cards and to start calculation. This key is effective only when both the idling light and the run light are turned on. If the punch unit is used independently, the start key may be depressed as soon as the main line switch is turned on.

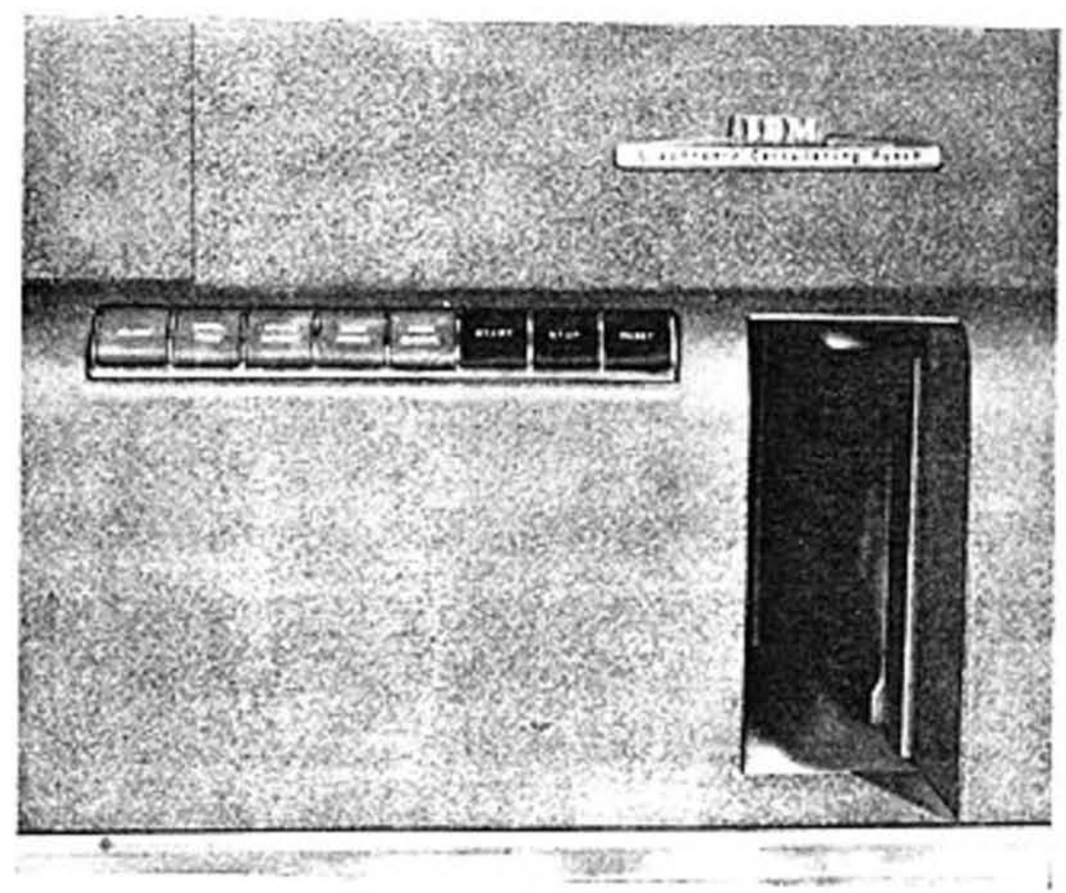


FIGURE 3. OPERATING FEATURES

Stop Key

The stop key stops the operation of both the punch and the calculate unit when depressed.

Reset Key

When an error is signalled by one of the four lights located on the punch, the machine may not be restarted until the reset button is depressed.

Idling Light

The green idling light turns on as soon as the machine is ready to operate. This light turns off as cards are passing through the machine and turns on again when the machine stops. It also turns off when the control panel on either machine is removed.

Unfinished Program Light

The red unfinished program light turns on, the machine stops, and all punching is suppressed in those rare instances when a calculation cannot be completed in the time that it takes for the card to move from the first reading station to the punch station. This light is operated by control panel wiring.

Double Punch-Blank Column Light

The red double punch-blank column light turns on and the machine stops whenever a double punch or a blank column is sensed. This light is operated by control panel wiring and is normally used in conjunction with checking operations.

Zero Check Light

The red zero check light turns on and the machine stops if, in a checking operation, the punched result subtracted from the recalculated result does not equal zero. This light is operated by control panel wiring.

Product Overflow Light

The red product overflow light turns on and the machine stops if the result of a calculation exceeds the number of card columns to be punched. This light is operated by control panel wiring.

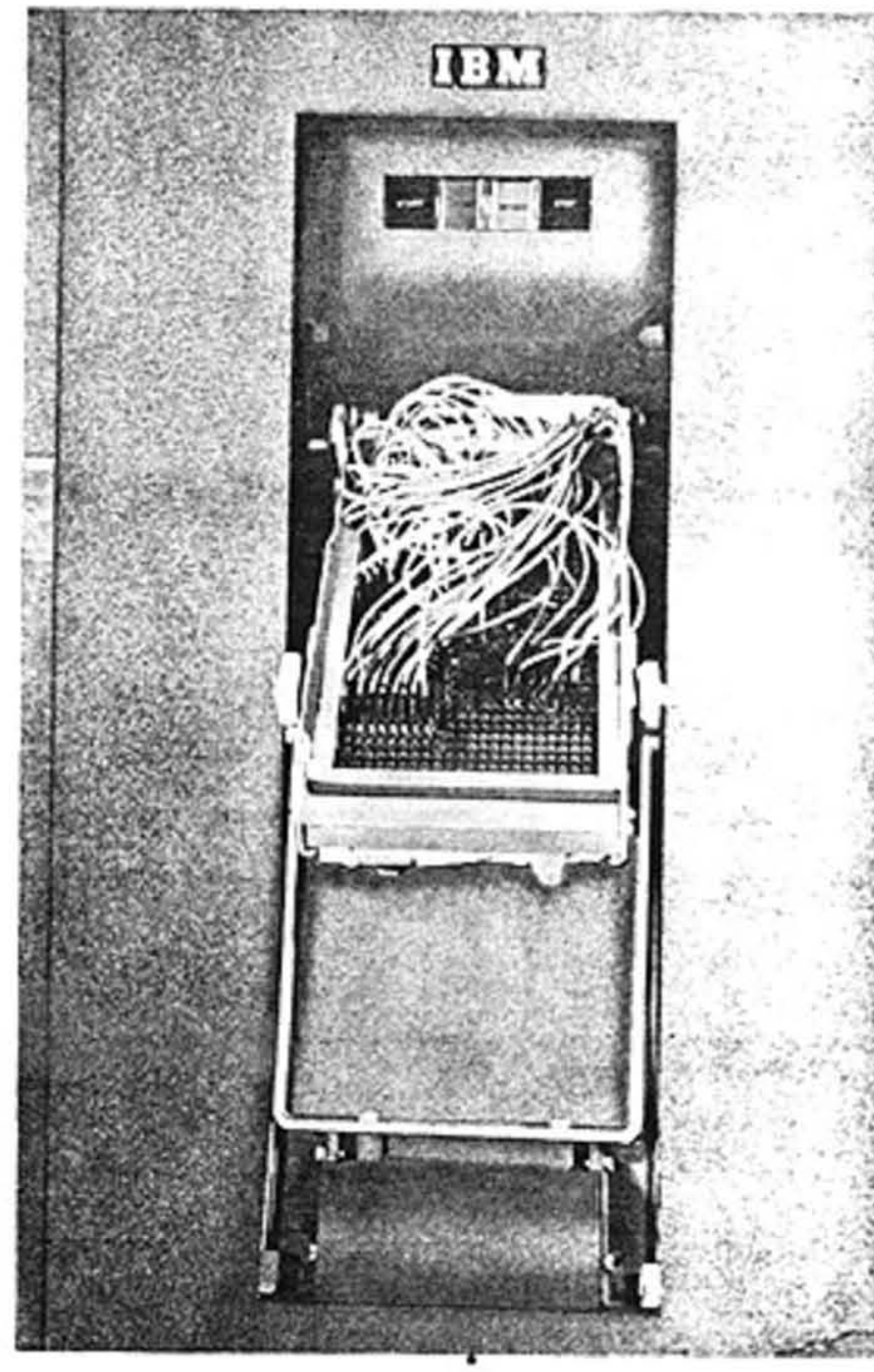


FIGURE 4. CALCULATE CONTROL PANEL

OPERATING FEATURES OF THE CALCULATE UNIT (FIGURE 4)

Start Key

When the start key is depressed, the start light turns on immediately, power is supplied to the electronic tubes, and the run light turns on after 60 seconds, providing the main line switch on the punch is on.

Run Light

The green run light turns on approximately one minute after the main line switch on the punch is turned on and the start key on the calculate unit is depressed. The light turns off as cards are passing through the machine and turns on again when the machine stops. It also turns off when the control panel on the calculate unit is removed.

Start Light

The red start light turns on as soon as the start key is depressed and remains on until the stop key is depressed.

Stop Key

The stop key may be depressed at any time to stop the operation of both machines. When this key is depressed, the power on the calculate unit is turned off as well as all the lights. The machine is turned on again by depressing the start key.

OPERATION

THE machine is prepared for operation by inserting properly wired control panels in each unit, by turning on the main line switch, located on the punch, and by depressing the start key on the calculate unit. The electronic tubes require approximately one minute to heat before the machine is ready to operate.

Cards are placed in the hopper of the punch unit face down, 12's edge first. In this machine a 12 or an X punch can be used to control the reading of information from the card and, consequently, these positions must be read before the factors are read.

The punching unit start key is depressed to feed the cards and start calculations. The green idling light on the punch and the run light on the calculate unit turn off as cards are calculated, punched, and moved into the stacker continuously. The machine stops and the green lights turn on again when the hopper is empty, the stacker becomes full, the stop key is depressed, or an error or other condition is recognized through control panel wiring.

The operation of the Type 604 is fully explained in the examples that follow with a detail description of the control panel hubs preceding their use in each example. For a clear understanding of the capabilities of the machine as well as a thorough knowledge of the wiring principles, each example should be studied in the sequence presented.

CONTROL PANELS

A SEPARATE control panel (Figure 5) is required for the punch unit and for the calculate unit. All functions that concern card reading or card punching are wired on the punch control panel and all functions concerning the actual calculation are wired on the calculate control panel.

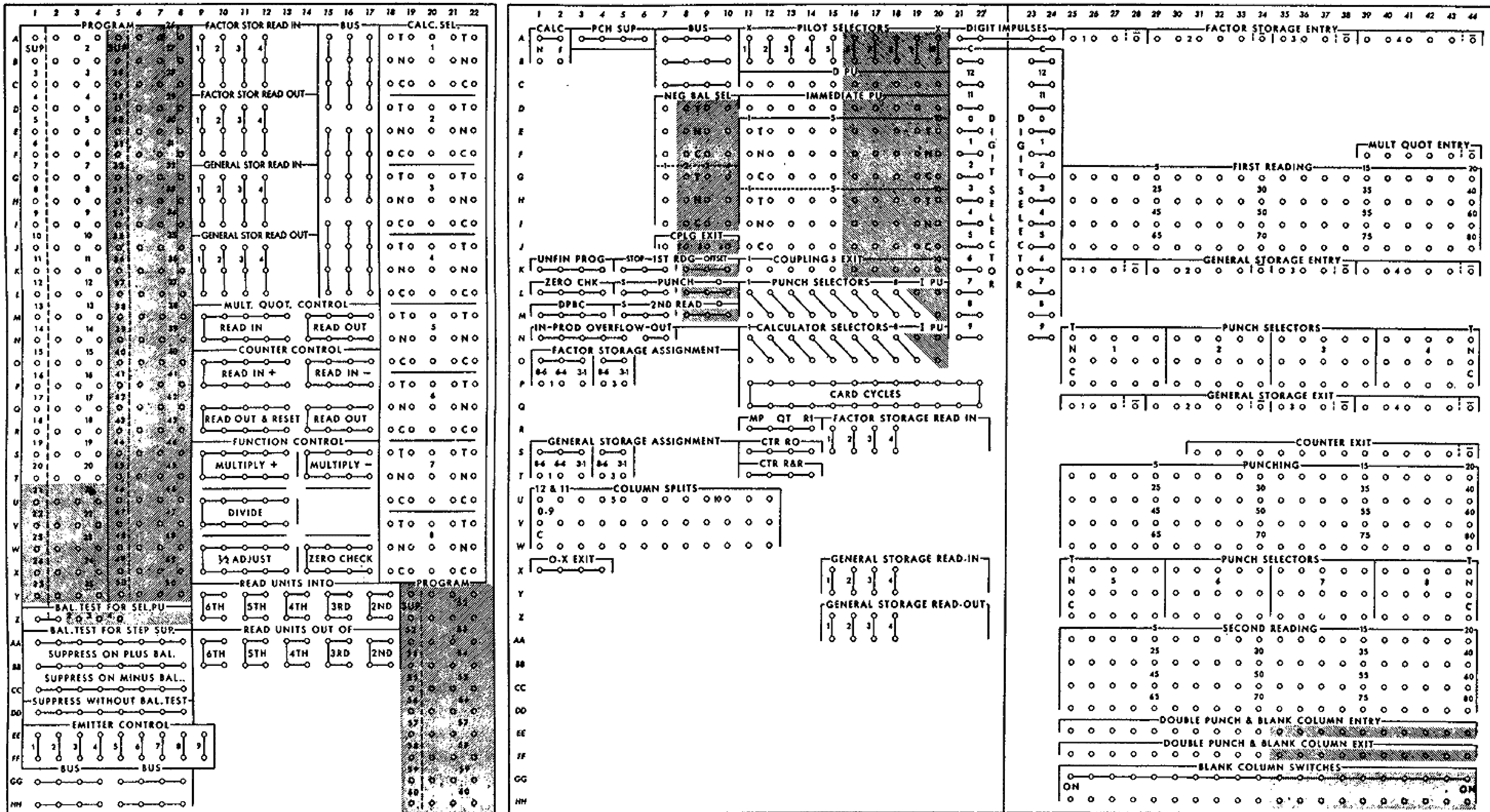
The punch unit has a double panel and the calculate unit a single panel. Letters down the side and numbers across the top of each panel facilitate reference to specific hubs which in the text will be preceded by *Cal* for the calculate control panel or *Pch* for the punch control panel.

Some hubs are entries and some are exits. Exit hubs are always connected to entry hubs either directly or by selection and the wiring may be changed to suit each new application.

Hubs that are connected by a vertical, diagonal, or horizontal line are alike, or common. Their purpose is to eliminate the need for split wiring.

All hubs performing similar functions are grouped together and labelled with their general title. Within each group they are numbered or named according to their specific function.

The control panel for the punch is positioned in the lower left front of the punch unit, and the control panel for the calculate unit is positioned on the upper left side of the calculate unit.



Calculate Control Panel

Punch Control Panel

FIGURE 5. TYPE 604 CONTROL PANEL

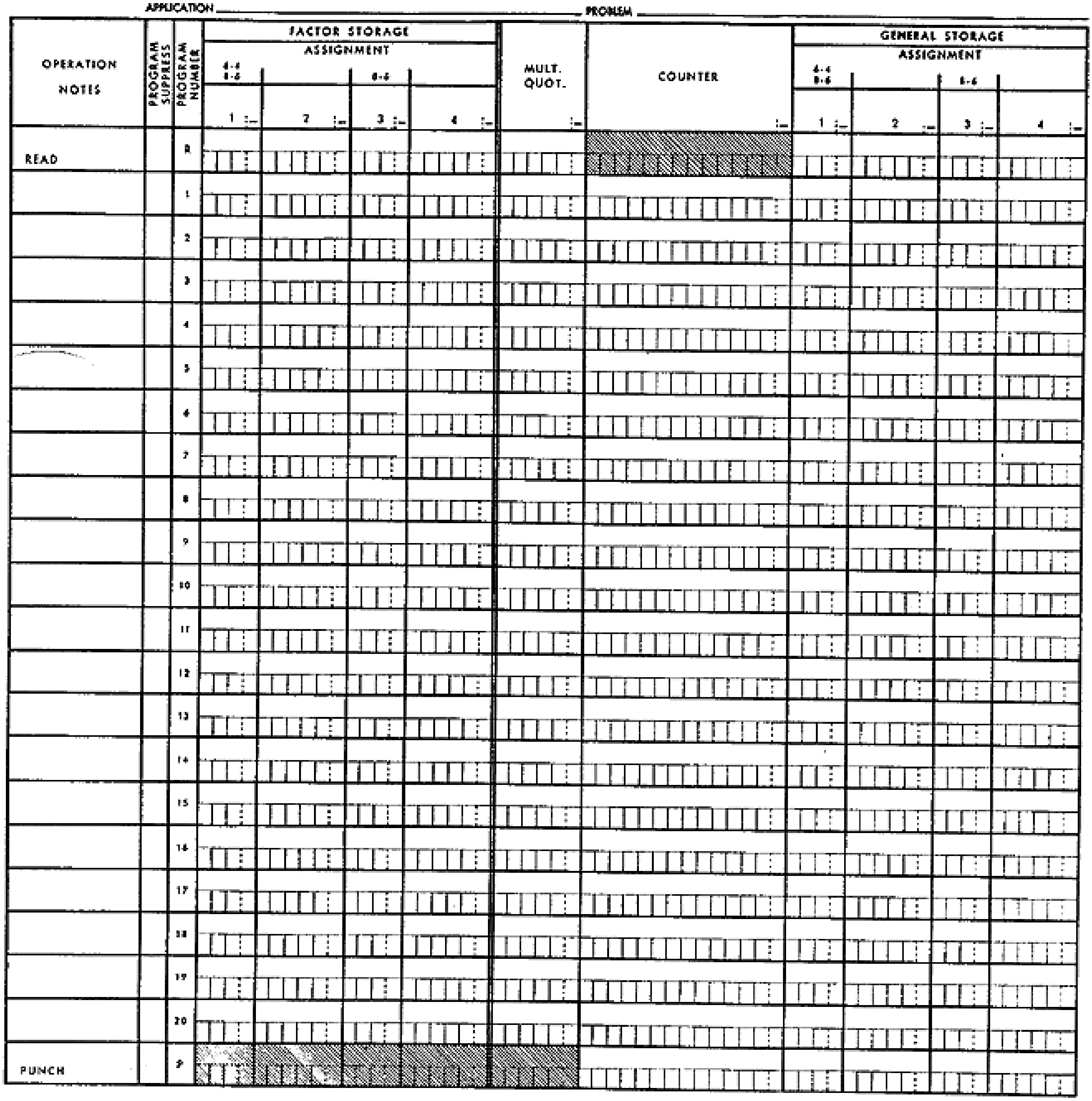


Figure 6. Planning Chart

PLANNING THE OPERATION

A problem to be calculated on the 604 should first be studied to determine the most logical arrangement of the steps to be taken by the machine, before any attempt is made at control panel wiring. The steps taken by the machine after the card is read, start off automatically from step 1 to step 20 on the standard machine and are referred to as "programs." Since only one function can be performed on each program step, lack of proper planning could easily result in using all of the program steps without completing the problem.

To assist in planning the operation a planning chart (Figure 6) has been devised with a vertical arrangement of the read cycle and 20 program steps and a horizontal arrangement of the units into which factors may be entered. The chart is divided as follows:

Operation Notes. One space is allowed for each of the steps that the machine takes, including the read and punch cycles. This column is reserved for making explanatory notes about the particular operation being performed.

Program Suppress. Some problems require that certain program steps be suppressed or made inactive. This column is reserved for identifying the condition under which suppression of the program step is required (X, D, + or − balances).

Program Number. This column identifies the read cycle, each of the 20 program steps and the punch cycle, which on this machine is the same as the read cycle.

Factor Storage. The four factor storage units are represented in this column, two of them having 3 positions and two having 5 positions. Activity in or out of these units is indicated on the proper program step.

Mult. Quot. This column is used for indicating the multiplier, quotient or other information that is stored in the multiplier quotient unit.

Counter. This column represents the 13-position electronic counter.

General Storage. The four general storage units are represented in this column, two of them having 3 positions and two having 5 positions. Activity in or out of these units is indicated on the proper program step.

The upper half of the area alloted to each program step is used for writing symbols, letters or words to identify a factor. The lower half of the area identifies the number of positions each unit contains and is used for writing actual figures resulting from the manual calculation of a representative problem.

The position to the right of the dotted line, in each unit, is used exclusively for sign control and is not to be used as the units position.

The counter is shaded on the read cycle to indicate that it cannot be read into at that time. The factor storage and the multiplier quotient units are shaded on the punch cycle to indicate that they cannot be used for punching.

The control panels may be wired directly from the planning chart for the chart is, in effect, a step by step analysis of the wiring to be done. This is especially true of the calculate control panel which is so closely related to the planning chart that a single explanation will serve for both.

The following sequence will be followed in discussing each of the problems:

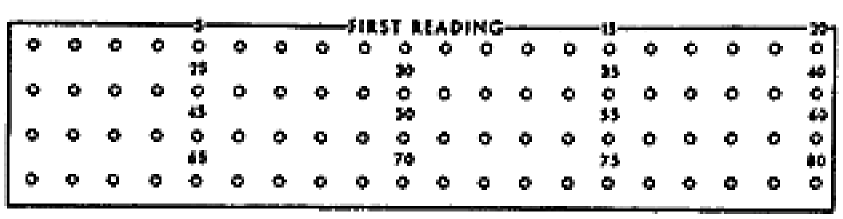
1. Explanation of the control panel hubs to be used in the problem and not previously used in a preceding example.
2. Read cycle wiring under the heading *Read.* This wiring concerns only the punch unit.
3. Program wiring under the program number itself. This wiring concerns only the calculate unit.
4. Punch and other wiring on the punch control panel not previously described.

CROSSFOOTING

A − B = ± T

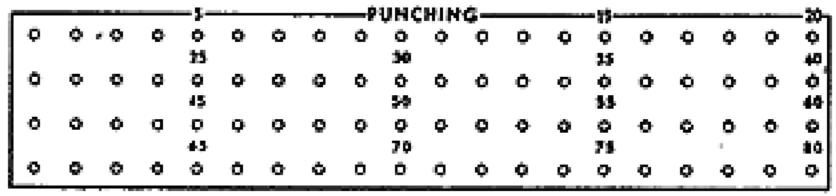
The number of factors that may be crossfooted is limited only by the number of factors which may be stored in the machine on the read cycle. This example shows a simple crossfooting operation in which factor B is subtracted from A to give a plus or minus result T. If T is minus, the Type 604 will punch it as a true figure and identify it as minus by punching an X over the units position.

Factor Storage Entry (*Pcb A, 25-44*). These hubs are entries to the factor storage units for factors read from the card. They are normally wired from first reading, second reading or from the digit selectors. Factors read into the factor storage units may be held until required in the calculation, but may not be punched from these units. Entry to factor storage during calculation is controlled from the calculate punch.

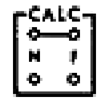


First Reading (*Pcb G-J, 25-44*). These hubs are exits for factors read from the 80 columns of the card at the first reading station.

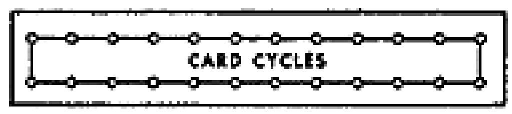
Counter Exit (*Pcb S, 31-44*). The result of a calculation is always obtained in a 13-position electronic counter. The counter receives impulses only during a calculation, not from the card. Results can be punched from the counter exit hubs.



Punching (*Pcb T-W, 25-44*). The punching hubs are entries for punching results in any assigned columns of the card. These hubs are wired for all punching, including gang punching.



Calc (*Pcb A-B, 1-2*). The calculate switch must be wired ON whenever the calculate and punch units are used together. It must be wired OFF when the punch unit is used independently of the calculate unit for gang punching operations.



Card Cycles (*Pcb P-Q, 11-22*). The 24 common card cycles hubs emit an impulse on each card reading cycle. Since card movement is synchronized, a card cycles impulse may be used to control functions at all three stations at the same time.

Factor Storage Read In (*Pcb R-S, 15-18*). Each factor storage unit has a pair of common read in hubs which accept only an X impulse to perform two functions:

1. Clear out the previous reading.
2. Enter a new reading.

They are normally wired from card cycles to enter factors from the card. The card cycles hubs emit an X impulse as well as a digit impulse.

Ctr R & R — Counter Read Out and Reset (*Pcb T, 11-14*). The four common counter read out and reset hubs accept X impulses to read information out of a counter for punching and to reset the counter. They are normally wired from card cycles.

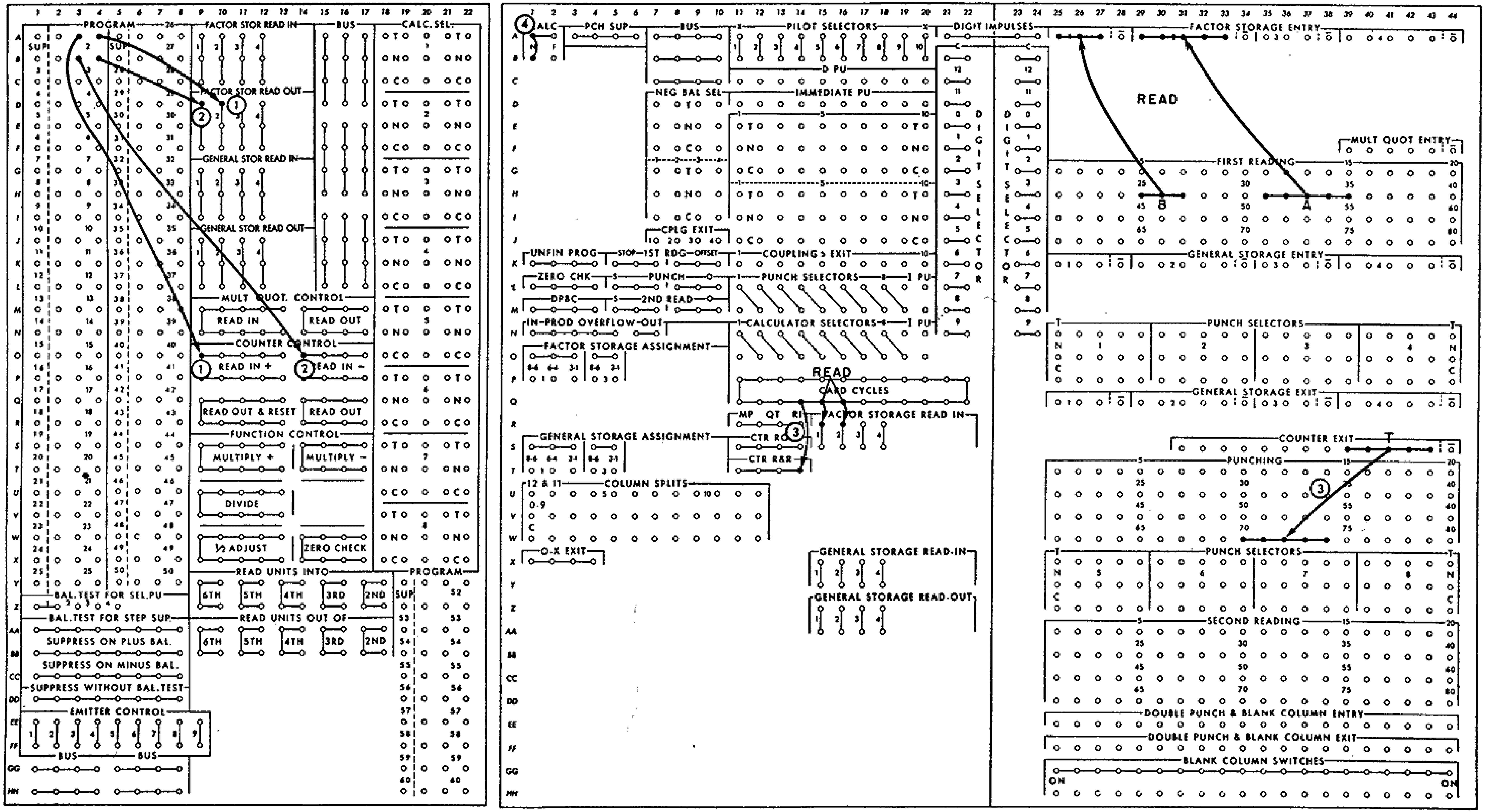
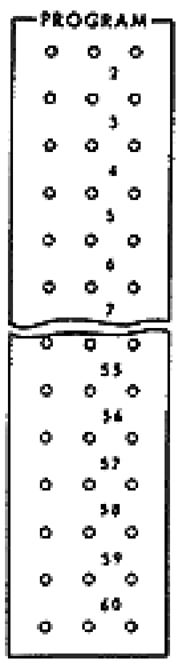


FIGURE 7A. CROSSFOOTING

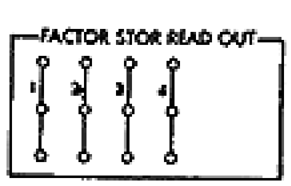
APPLICATION *Crossfooting* PROBLEM *A - B = T*

OPERATION	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT 6-4 8-6 1	2	8-4 3	4	MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT 6-4 8-4 1	2	8-4 3	4
READ		R	B	A								
Transfer A To Counter		1		RO				+A				
Transfer B To Counter		2	RO					-B =T				
PUNCH		P						R + R				

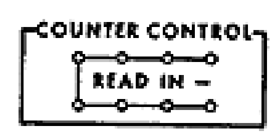
FIGURE 7B.



Program (Cal A-Y, 2-4; 6-8; Y-HH, 20-22). After one card is read and before the next card is read, the machine starts through a series of 20 program steps (standard). These program steps are electronic cycles which occur successively, and during each the machine can be controlled to perform a specific part of a required calculation. All of the program steps are taken in a calculation whether or not they are actually used. Each program step has three independent outlets.



Factor Stor Read Out (*Cal D-F, 9-12*). Information may be read out of any factor storage unit during calculation, by impulsing the factor storage read out hubs on the calculate control panel. They are always wired from program steps.



Counter Control Read In +, Read In – (Cal O-P, 9-17). The 10 common read in + hubs on the calculate control panel accept program impulses to cause the counter to add during a calculation. The 8 common read in – hubs on the calculate control panel accept program impulses to cause the counter to subtract during a calculation.

PLANNING CHART AND WIRING DIAGRAM (FIGURE 7A, 7B)

READ. Factors B and A are wired to factor storage units 1 and 2 from first reading. A card cycles impulse is wired to the corresponding read in hubs to clear out the previous reading and enter the new factors A and B from the card.

1. Factor A is added in the counter by wiring program 1 to factor storage 2 read out and to counter read in +.

2. Factor B is subtracted in the counter by wiring program 2 to factor storage 1 read out and to counter read in –. The difference between A and B now stands in the counter ready to be punched.

3. The result is wired from counter exit to punch in columns 70-74. The counter is read out and reset from card cycles. If the result is negative it will be punched as a true figure with an X over the units position.

4. The calculate switch is turned ON for all calculating operations.

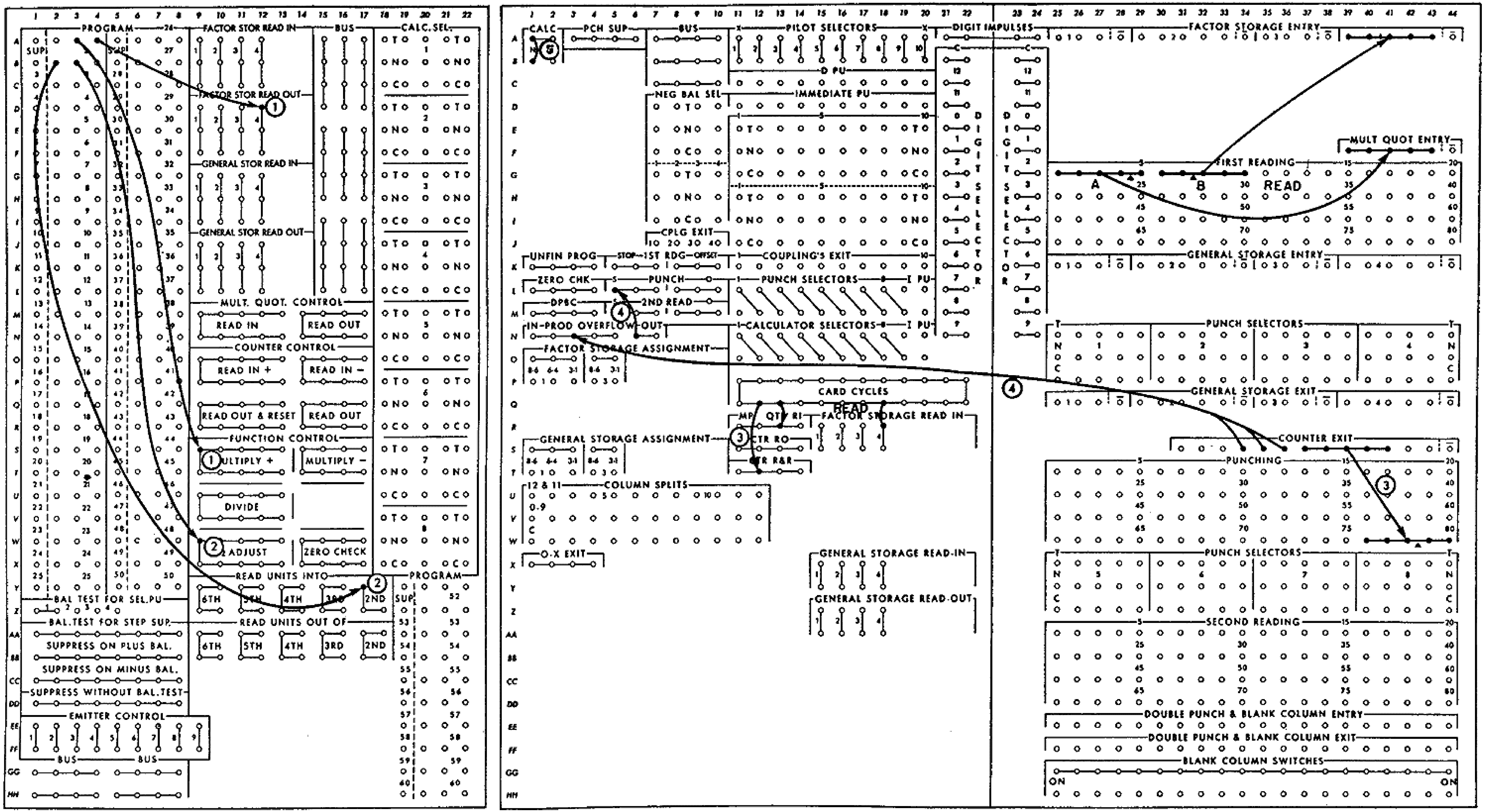


FIGURE 8A. MULTIPLICATION

APPLICATION *Hours X Rate = Amount* PROBLEM *A X B = P*

OPERATION	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT 1	2	3	4	MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT 1	2	3	4
READ		R				(Rate) B 01255	(Hrs) A 00600					
Multiply		1				RO		753000				
½ Adj. RI 2nd		2						5				
PUNCH		P						R + R 7530				

FIGURE 8B.

MULTIPLICATION

Hours × Rate = Earnings

A × B = P

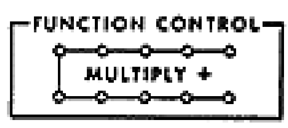
MULTIPLICATION is performed on the Type 604 by entering one of the factors directly into the multiplier quotient unit and the other factor into any storage unit and by impulsing the machine to multiply on a program step.

Mult Quot Entry (*Pch G, 39-44*). The multiplier quotient hubs are entries to a special 5-position storage unit into which the multiplier must be entered for multiplication operations. Factors can be entered into the MQ unit from the card or transferred to and from it during calculation. Results cannot be punched from the unit. The use of these hubs as quotient entries will be explained under *Division*.

Mult Quot RI (*Pch R, 11-14*). These are the read in control hubs for entering information from the card into the MQ unit. They accept only X impulses and are normally wired from card cycles.

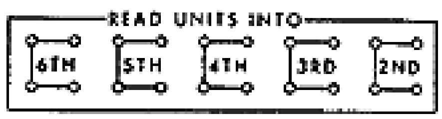
Product Overflow In-Out (*Pch N, 1-7*). The product overflow IN hubs are normally wired from one or more counter or general storage exit hubs that are in excess of the number of hubs wired to punch the result. If any digit other than zero is sensed, product overflow OUT will emit an X impulse which may be used to stop the machine or offset the card in the stacker.

Punch Stop-Offset (*Pch L, 5-10*). The hubs labelled S (stop) are entry hubs that accept X impulses to stop the machine for a condition that is recognized at the punching station. The hubs labelled O (Offset) are entries to offset the card in the stacker instead of stopping the machine and are optional. Whenever the S hubs receive an impulse, the machine stops after the card causing the stop reaches the stacker.



Multiply + (*Cal S-T, 9-13*). The multiply plus hubs, located on the calculate control panel, receive impulses to cause the machine to develop a plus product in the counter.

½ Adjust (*Cal W-X, 9-13*). The half adjust hubs are wired from program steps to add or subtract a 5 automatically according to the sign of the product, in the units position of the counter. To enter a 5 into any position other than the units, shift entry must be impulsed (read units into).



Read Units Into (*Cal Y-Z, 9-18*). Shifting from one to five positions may be done on any program cycle, and the shift unit will return to normal at the completion of the program step. Half adjustment (5), zero check (1), and the units position of a factor in storage may enter the 2nd, 3rd, 4th, 5th or 6th position of the counter during calculation, by wiring a program step directly to the read units into hubs and by impulsing the counter at the same time. Also, the units position of a factor in one storage unit may be shifted when entering another storage unit.

PLANNING CHART AND WIRING DIAGRAM

(Figures 8A and 8B)

READ. Factor A is wired to MQ, and B to FS4. Both of these units are impulsed to receive the factors by wiring card cycles to FS 4 and MQ read in.

1. The plus product of A × B is developed in the counter by wiring program 1 to read out factor B from FS 4 and to the multiply + hubs. Multiplication on the Type 604 is accomplished by repetitive addition requiring that the multiplicand B be automatically added and properly offset internally in the counter the number of times called for by the multiplier A.

2. There are 3 decimals in rate and 1 decimal in hours. Only 2 decimals are to be punched making it necessary to correct for the dropped decimals. This is done by wiring program 2 to one of the half adjust hubs and also to read units into 2nd. The 5 will add automatically into the 2nd position of the counter thereby correcting position three.

3. The product with two positions dropped is wired out of the counter to punch in columns 76-80. A card cycles impulse is wired to read out and reset the counter.

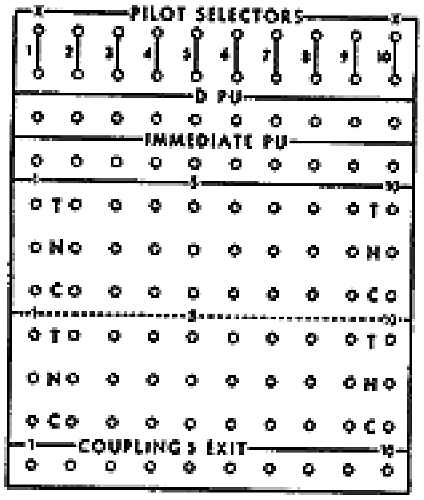
4. Provision has been made for a 7 position product, two of which are dropped. The remaining three positions that are possible when multiplying 5 digits by 5 digits, are wired to product overflow IN. Product overflow OUT is wired to punch stop. If the product exceeds the five positions expected, the machine will stop when the card in error reaches the stacker and the product overflow light will turn on. Any digit impulse reaching product overflow IN will cause an X impulse to be emitted from the OUT hub which in turn reaches punch stop. The punch stop hubs are used because a product overflow is recognized at the punch station. The signal light is turned off by pressing the reset key.

5. The calculate switch is wired ON.

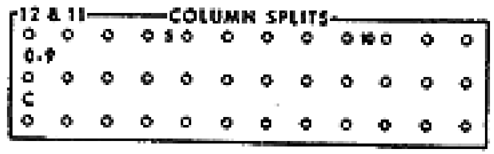
GROUP MULTIPLICATION

EITHER the multiplier or the multiplicand may be used as the group factor. The card containing the group factor must be designated by an X punch and that X, instead of the card cycles impulse, will be wired to control the group factor read in, whether it be the MQ or another storage unit.

Both the planning chart and the calculate control panel wiring are exactly the same as in the previous problem. Only the punch control panel will be explained.



Pilot Selectors (*Pch A-J, 11-20*). There are five 2-position pilot selectors standard, each having an X, digit and immediate pickup. The X and digit pickup will transfer the selector for the following card cycle. The immediate pickup will transfer the selector immediately upon reception of the impulse. Once transferred the selector will hold for only one card cycle. When a selector is not transferred, there is a common connection between C and N. The coupling exit emits an impulse when the pilot selector transfers and it is normally wired to pick up punch or calculate selectors. When storage read in, storage read out, counter read out, and counter read out and reset are controlled by a card cycles impulse through the normal points of a pilot selector, the pickup impulse must be a 12 punch. This is necessary because a card cycles impulse originates at X (or 11) time.



Column Splits (*Pch V-W, 1-12*). There are 12 column splits on the standard machine, each having a C hub, 0-9 and 12-11 hub. There is a common connection between C and 0-9 as the 0-9 punching is read from the card; between C and 12-11 as the 12 and 11 punches are read from the card. They are used to separate digit punching from 11 and 12 punching.

Punch Sup (*Pch A, 3-6*). Complete suppression of all punching for any one card may be accomplished by wiring any digit or X punch to punch suppress from first reading. If an X is punched over a digit, a column split must be used.

WIRING DIAGRAM — PUNCH CONTROL PANEL ONLY (Figure 9)

READ. Factor A is wired to the MQ unit and factor B to factor storage unit 4. Both factors are wired from first reading.

The multiplier is the group factor and enters the MQ unit only from X65 master cards by wiring column 65 from first reading to MQ read-in. It is wired through the common X pickup hubs of pilot selector 1 to avoid split wiring. The MQ read in will accept only X impulses.

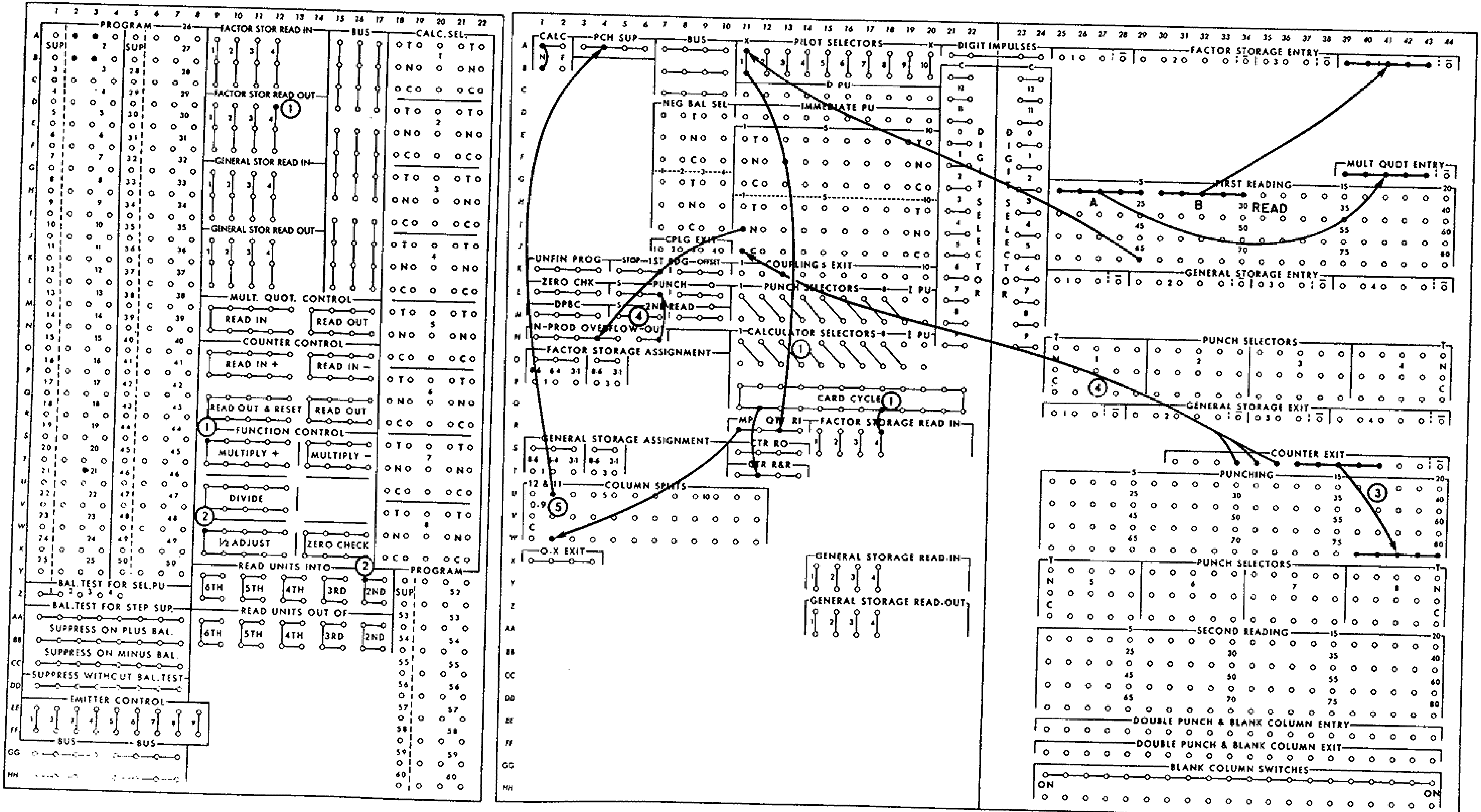


FIGURE 9. GROUP MULTIPLICATION

The multiplicand is read into FS 4 on every card by wiring card cycles to FS 4 read in.

1. A and B are multiplied by reading out FS 4 and by impulsing multiply +.

2. The product is half adjusted on program 2.

3. The product with two positions dropped is wired out of the counter exit to punch in columns 76-80.

4. The overflow positions of the product are wired from counter exit to product overflow IN, through the normal side of pilot selector 1. The selector is picked up by an X in column 65 to prevent the product overflow from being impulsed for a master card. Overflow OUT is wired to punch stop, to stop the machine whenever the product exceeds the field capacity.

The selector is necessary when the group master card is punched with other information in the columns set aside for the multiplicand factor in the detail card:

MP	MC	
15	99999	X Card
	25	NX Card

In the above example 15 is the group multiplier and is to be multiplied by 25 in the detail card. The master card, however, contains other punching in the same field in which the 25 is punched in the detail cards. Multiplication will take place and although punching will be suppressed, product overflow will not. If 15 x 99999 exceeds the field capacity and product overflow is not selected, the machine will stop unnecessarily.

5. The master card may or may not be calculated and punched. If it is not to be punched, the master card X must be wired to the punch suppression hubs. A column split is used to prevent any other digits from reaching punch suppress.

DIVISION

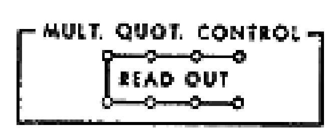
Total Pay ÷ Hours = Average Hourly Rate

$A \div B = Q$

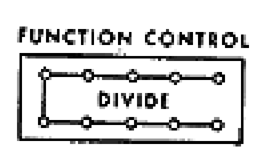
BASICALLY, the Type 604 provides a 13-position counter for the dividend, an 8-position storage unit for the divisor, and a 5-position storage unit for the quotient. If the dividend and the divisor are such that the quotient will exceed five positions, the operation must be done in parts (quotient expansion) which will be explained in a later problem. In the example 1234567 ÷ 012, the result will exceed five positions, and without quotient expansion the program step used for impulsing the divide switch will be cancelled, resulting in an answer of zero. However, 1234567 ÷ 112 gives a 5-position quotient and may be performed in a single operation.

Both the dividend and divisor must enter storage from the card. The dividend is then transferred to the counter so that the decimal point lines up according to the number of decimals in both the quotient and the divisor.

In order to half adjust the quotient, the dividend must be shifted over an extra position in the counter, so that the 5 may be added to the extra quotient position on a separate program step.



Mult. Quot. Read Out (*Cal M-N, 14-17*). Factors are read out of the multiplier quotient unit by impulsing multiplier quotient read out with a program step. This unit does not need to be reset since it clears upon entry of a new factor.



Divide (*Cal U-V, 9-13*). When these hubs are impulsed by a program step, the machine will divide and the MQ unit clears to prepare for the new quotient about to be developed. This set of hubs is sometimes referred to as the divide control switch.

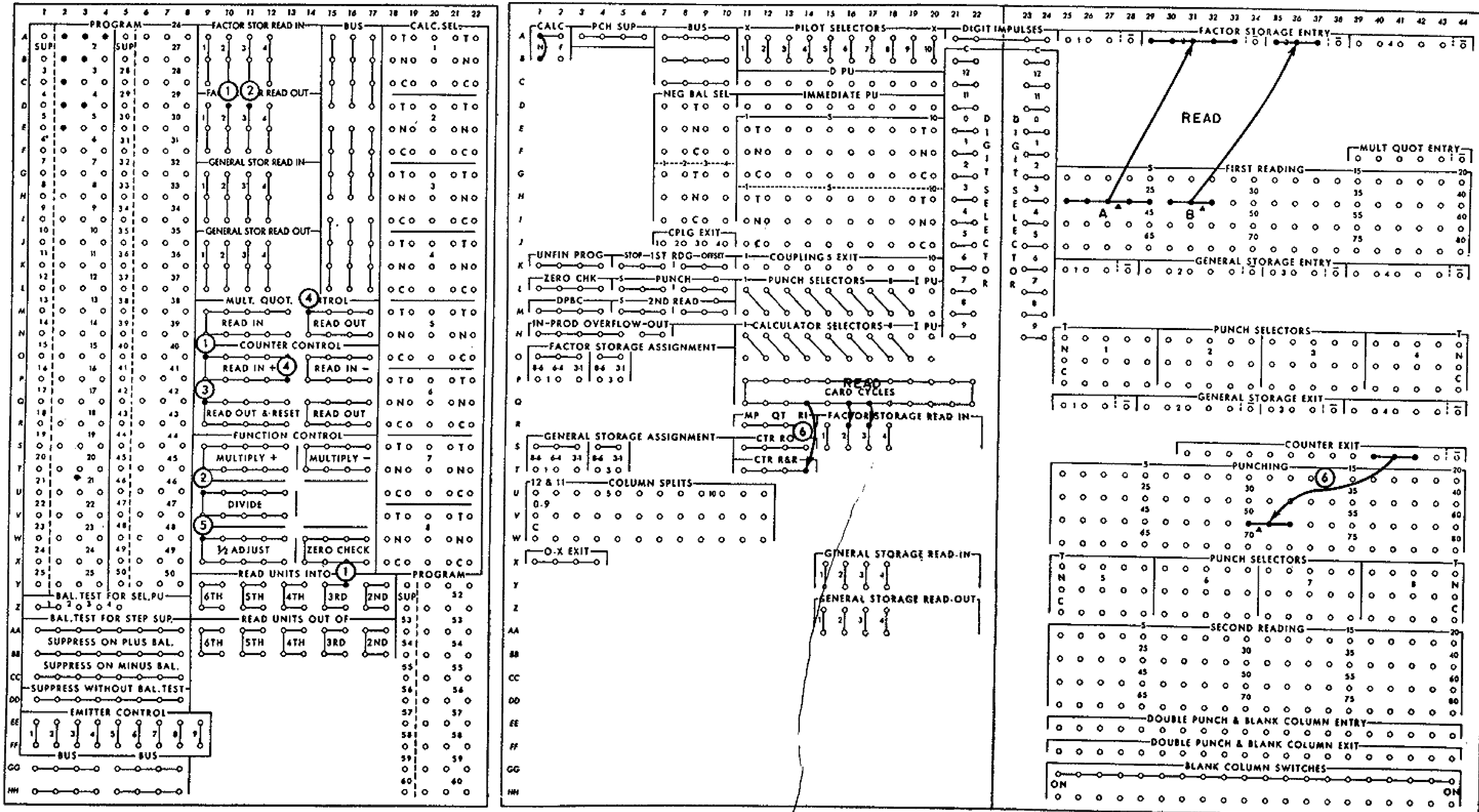
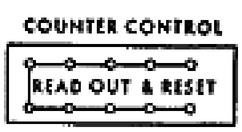


FIGURE 10A. DIVISION

APPLICATION *Total Pay ÷ Hours = Aver Hourly Rate* PROBLEM *A ÷ B = Q*

OPERATION	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT 1	2	3	4	MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT 1	2	3	4
READ		R		A 09575	B 409							
RI 3rd		1		RO				A 9575				
Divide		2			RO		Q 2341					
		3						Remainder R&R				
		4					RO	2341				
½ Adj.		5						5 2346				
PUNCH		P						R&R Q 234				

FIGURE 10B



Counter Read Out and Reset (*Cal Q-R, 9-13*). A program step wired to these hubs will cause the counter to read out and reset. Unlike the storage units the counter only clears when impulsed to clear and not upon entry of another factor.

PLANNING CHART AND WIRING DIAGRAM

(Figures 10A and 10B)

READ. Factor A is read into FS 2 and B into FS 3.

1. The dividend A is read out of FS 2 into the counter on program 1. The rule for placing the dividend in the counter may be stated as follows. Point off, in the counter, the number of places equal to the number of decimals in the divisor plus the number of decimals expected in the quotient plus one position for quotient half adjustment. In this example the divisor has one decimal, the quotient two decimals, and the quotient is to be half adjusted, making a total of four places to point off in the counter. Since the dividend has two decimals, it must be entered into the counter, shifted two positions, making the units position of the dividend enter the 3rd position of the counter.

2. The divisor B is read out of FS 3 and the divide hubs are impulsed on program 2. Division on the Type 604 is the process of reducing the dividend by subtracting the divisor the number of times that it takes to reduce the dividend until the remainder is less than the divisor. This is an automatic operation once the divisor has been impulsed to read out and the divide hubs are impulsed. The quotient will automatically enter the MQ unit.

3. The dividend remainder in the counter is cleared out by wiring program 3 to counter read out and reset.

4. The quotient is read out of MQ and added into the counter on program 4, so that the half adjustment can be made. An extra position was developed in the quotient for this purpose.

5. Half adjustment is made by wiring program 5 to ½ adjust. The adjustment will be made in the units position of the counter.

6. The quotient, with one position dropped, is wired from counter exit to punch in columns 50-52. A card cycles impulse is wired to counter R & R.

SUCCESSIVE CALCULATION

(Pieces $\times$ Unit Standard Time $=$ Total Standard Time) $\div$
Actual time $=$ % over or under Standard

$$(A \times B = P) \div C = R$$

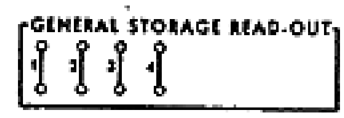
SUCCESSIVE calculations may be made for any number of re-multiplications, re-divisions, or combinations of both, within the capacity of the machine to store the factors at read time and the results during calculation.

Results of each calculation may or may not be punched. Since punched results require storage space, the capacity depends largely upon how many of the results are to be punched.

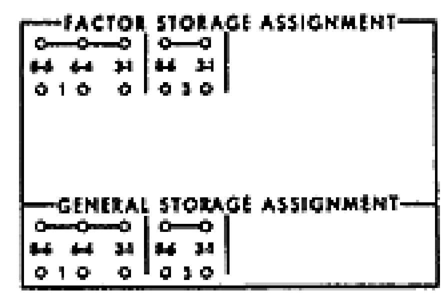
General Storage Entry (*Pcb K, 25-44*). These hubs are entries to the general storage units for factors read from the card. They are normally wired from first reading, second reading or from digit selectors. Entry to general storage during calculation is controlled from the calculate panel. Factors read into the general storage units may be held until required in a calculation and results may be punched from these units.

General Storage Exit (*Pcb Q, 25-44*). These hubs are exits from the general storage units for punching results into the card. They are always wired to the punch hubs either directly or through selectors.

General Storage Read In (*Pcb X-Y, 15-18*). The general storage units are controlled to read in factors from the card or from the digit selectors, by wiring only an X impulse to general storage read in. Card cycles include the X impulse and may be wired to these hubs. The general storage units clear automatically when wired to read in a new factor.



General Storage Read Out (*Pcb Z-AA, 15-18*). General storage read out hubs accept only X impulses to read factors out of the general storage units for punching. A card cycles impulse, which emits at X time, is normally wired to these hubs.



Storage Assignment; Factor (*Pcb O-P, 1-5*) *General* (*Pcb S-T, 1-5*). Transfer of information to and from the electronic counter and between storage units is possible because the storage units and the counter are connected together internally. Normally, the units position of each storage unit including the MQ unit is connected to the units position of every other unit. Similarly, the tens position and all other positions are connected together. This normal arrangement permits the use of factors of from 3 to 5 digits in a calculation. Factors of 6 and 8 digits can be entered from the card or stored as results by assigning a 3-position unit to the left of either a 3-position or a 5-position unit. This may easily be seen by reference to Figure 11.

A. All storage units (factor or general) are normal.

B. The assignment of storage unit 1 has been changed from a units, tens and hundreds (1, 2, 3) position unit to a thousands, ten thousands and hundred thousands (4, 5, 6) position unit. This is done by jackplugging the hub labelled 6-4 for storage 1 to one of the three hubs above it. This wiring makes possible the use of storage units 1 and 3 for six digit factors.

C. The assignment of storage unit 1 has been changed from a units, tens and hundreds unit

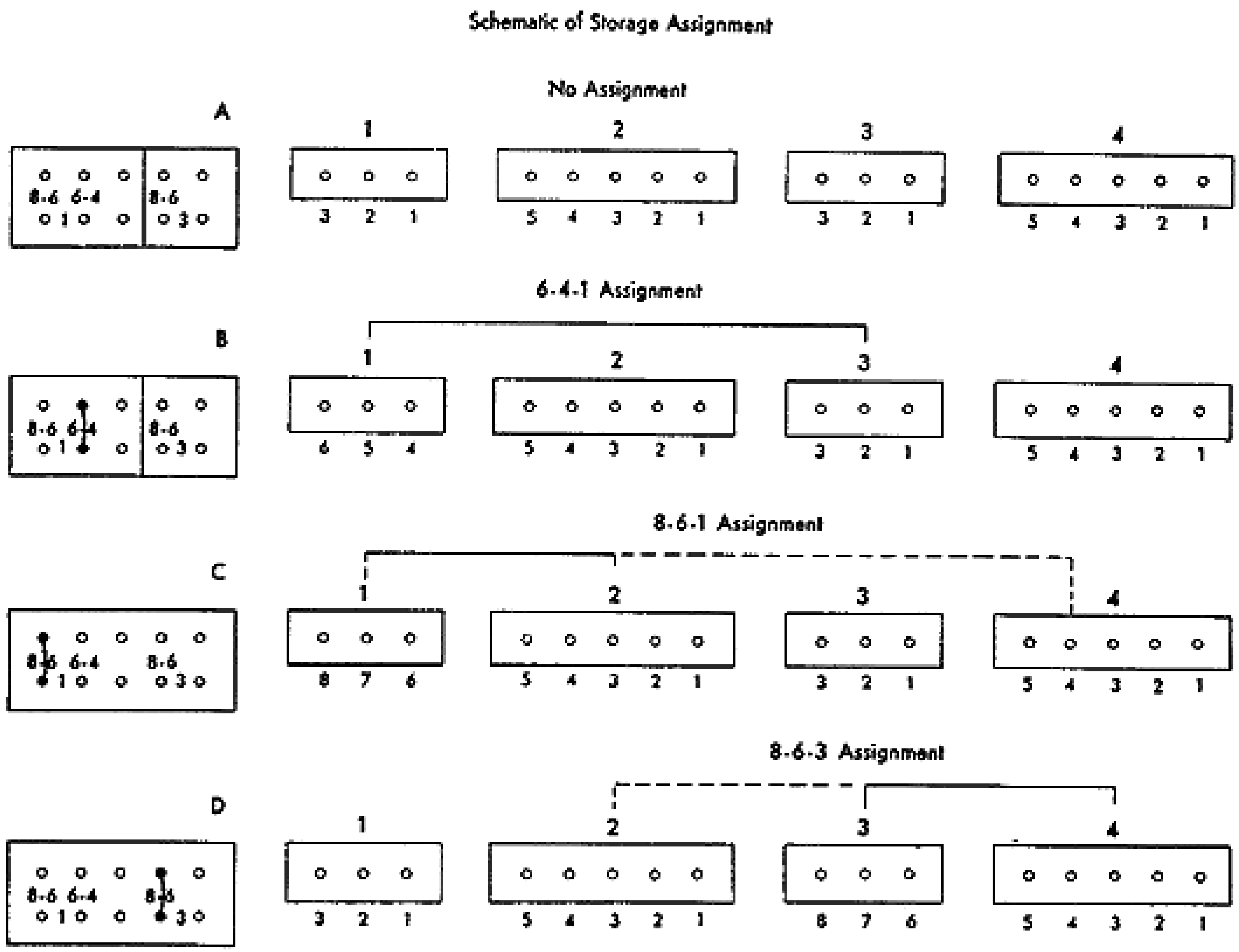


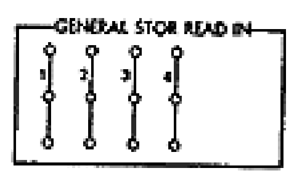
FIGURE 11. SCHEMATIC OF STORAGE ASSIGNMENT

(1, 2, 3) to a hundred thousands, millions and ten millions unit (6, 7, 8). This is done by jack-plugging the hub labelled 8-6 for storage 1 to one of the hubs above it. This wiring makes possible the use of storage units 1 and 2 or 1 and 4 for eight digit factors.

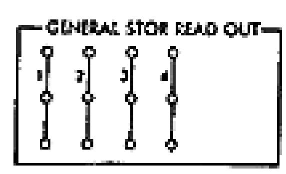
D. The assignment of storage unit 3 has been changed from a units, tens and hundreds unit (1, 2, 3) to a hundred thousands, millions, and ten millions unit (6, 7, 8). This is done by jackplugging the hub labelled 8-6 for storage 3 to one of the hubs above it. The wiring makes possible the use of storage units 3 and 4 or 3 and 2 for eight digit factors.

A 6-4-1 assignment means that storage unit 1 has been assigned to the 4th, 5th and 6th channel positions to be used in conjunction with storage unit 3. An 8-6-1 assignment means that storage unit 1 has been assigned to the 6th, 7th and 8th channel positions to be used in conjunction with storage units 2 or 4.

An 8-6-3 assignment means that storage unit 3 has been assigned to the 6th, 7th and 8th channel positions to be used in conjunction with storage units 2 or 4.



General Storage Read In (Cal G-I, 9-21). Information is read into the general storage units during calculation by impulsing the general storage read in hubs from a program step. The general storage units are cleared automatically upon entry of a new factor.



General Storage Read Out (Cal J-L, 9-12). Information is read out of the general storage units during calculation by impulsing the general storage read out hubs from a program step.

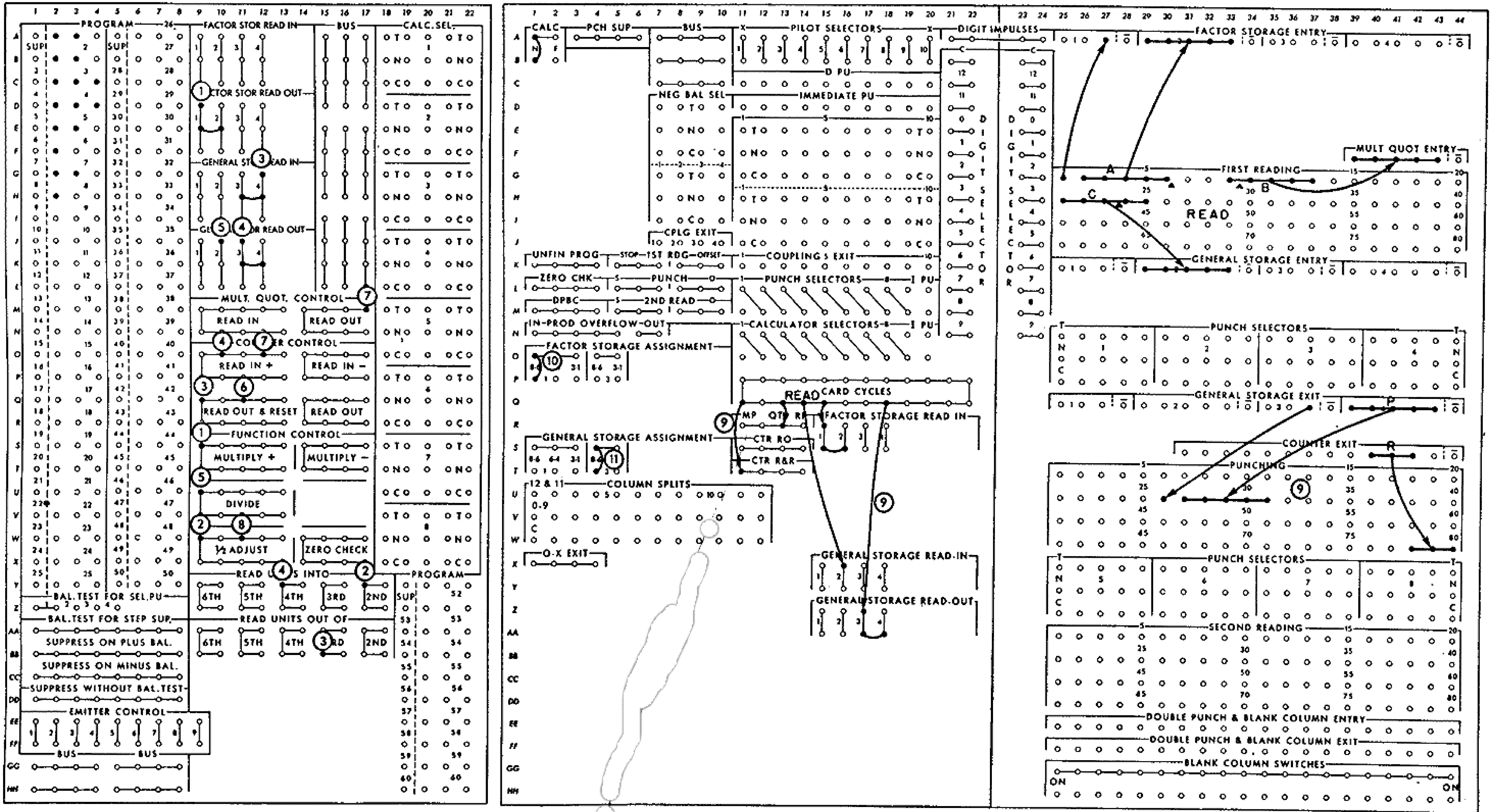


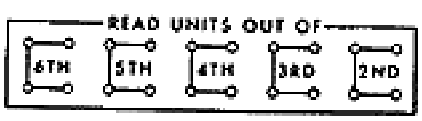
FIGURE 12A. SUCCESSIVE CALCULATION

APPLICATION: Pieces X Unit Standard Time = Total Standard Time; Total Standard Time ÷ Actual Time = % Over or Under Standard

PROBLEM: (A X B = P) ÷ C = R

OPERATION	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT 1	2	3	4	MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT 1	2	3	4
READ		R	0	A 01000			B 00234			C 2220		
Multiply		1	RO	RO				P 0234000				
½ Adj. RI 2nd		2						5 0234050				
RO 3rd		3						R & R			0	P 02340
RI 4th		4						2340			RO	RO
Divide		5					R 1054%			RO		
		6						Remainder R & R				
		7					RO	1054				
½ Adj.		8						5 1059				
PUNCH		P						R 105%				P 2340

FIGURE 12B



Read Units Out Of (*Cal AA-BB, 9-18*). Shifting from one to five positions may be done on any program cycle, and the shift unit will return to normal at the completion of the program step. Information may be read out of the counter starting with the 2nd, 3rd, 4th, 5th, or 6th positions by impulsing one of the read units out of hubs from a program step. This information will enter the storage unit starting with the units position. The read units out of cannot be used when transferring out of storage.

PLANNING CHART AND WIRING DIAGRAM

(Figures 12A and 12B)

READ. A is read into FS 1 and 2, B into the MQ unit, and C into GS 2.

1. A is multiplied by B on program 1 by reading out FS 1-2, and impulsing multiply +. Since there are four decimals in B and none in A, there will be four decimals in the product.

2. Only two decimals are required in the result which is half corrected on program 2 by impulsing ½ adjust, and read units into 2nd. This causes a 5 to add in the second position of the counter.

3. Since the problem is not completed, the product must be stored until ready to be punched. It is read out of the counter on program 3, with two decimals dropped, into GS 3 and 4. The decimals are dropped by impulsing read units out of 3rd.

4. The product is ready to be divided by C. It is read out of GS 3-4 into the counter on program 4. Two decimals in the quotient, plus two in the divisor, plus one for half adjustment, make it necessary to place the decimal in the fifth position of the counter. The product having only two decimals is entered into the dividend counter offset 4 positions to line up with the predetermined decimal point, by wiring program 4 to read units into 4th.

5. P is divided by C on program 5 by impulsing the divide hubs and reading out C from GS 2. The quotient is developed in the MQ unit.

6. The dividend remainder is cleared out of the counter on program 6.

7. The quotient is read out of MQ into the counter on program 7, so that it may be half corrected.

8. The quotient is half adjusted by impulsing ½ adjust on program 8 which automatically adds a 5 to the units position of the counter.

9. The product of A x B is punched from GS 3-4 into columns 26-31. General storage read out 3 and 4 are impulsed from card cycles. The quotient of P ÷ C is punched from the counter, with one position dropped, into columns 78-80. Counter R & R is impulsed from card cycles.

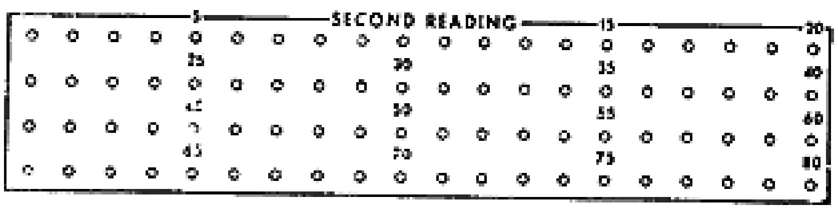
10. The six digit factor A exceeds the capacity of any one factor storage unit and it is necessary to make an assignment. FS 1 is assigned to the 6th, 7th, and 8th positions of the channel and can be used in conjunction with either FS 2 or FS 4, each of which is connected to the first five positions of the channel.

11. The six digit product P exceeds the capacity of any one general storage unit and it is necessary to make a further assignment. GS 3 is assigned to the 6th, 7th and 8th positions of the channel and can be used in conjunction with either GS 2 or GS 4, each of which is connected to the first five positions of the channel.

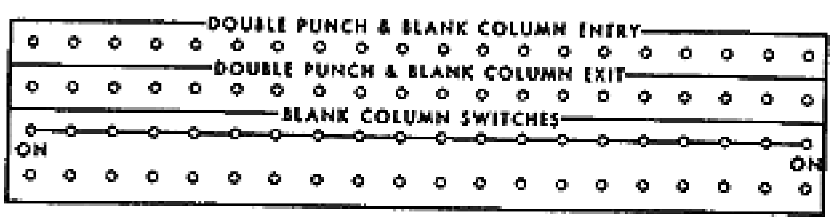
CHECKING MULTIPLICATION

Double Punch-Blank Column Detection Method

MULTIPLICATION may be checked on the Type 604 by repeated calculation if the result is punched in exactly the same columns on the second run as it was the first. A double punch will result in any column containing an error. A blank column, always an error, is detected in conjunction with double punch detection under control panel wiring. When the double punch and blank column method is used for checking, it should also be used in the original run since the wiring remains the same for both.



Second Reading (*Pcb AA-DD, 25-44*). These hubs are exits for reading the 80 columns of the card at the 2nd reading station. They are normally used for gang punching, or for reading results to be checked.



Double Punch and Blank Column Entry — Exit (*Pcb EE-FF, 25-44*). The double punch and blank column entry hubs check the presence of double punching. They also detect blank columns if the blank column switches are wired. The double punch entry hubs are normally wired from second reading and, when a double punch or blank column is sensed, they cause an X impulse to be emitted from the DPBC hubs (*M, 1-4*).

Double Punch and Blank Column Exit Hubs (*FF, 25-44*) are used to eliminate the need for split wiring for checking a gang punch operation. The normal wiring for gang punching is from the second reading brushes to the punch hubs. To check this operation the wiring would be from second reading to double punch column entry and from double punch blank column exit to the punch hubs. In the event of a double punched column, the double punch exit hubs will transmit only the low digit punch, i. e., if 9 and 6 were punched, only the 6 would be transmitted for gang punching. Ten positions are standard.

Blank Column Switches (*Pcb GG-HH, 25-44*). These switches function only when the corresponding double punch hub is wired. When they are wired and a blank column is sensed, they cause an X impulse to be emitted from the DPBC hubs (*Pcb M, 1-4*). Ten positions are standard.

DPBC (*Pcb M, 1-4*). These four double punch and blank column hubs emit an X impulse when the DPBC unit *(EE-FF 25-44)* is properly wired and a double punch or a blank column is sensed. They are normally wired to 2nd read stop to stop the machine and turn on the DPBC error light. The offset feature is optional.

Second Read Stop-Offset (*Pcb M, 5-10*). The hubs labelled S (stop) are entry hubs that accept X impulses to stop the machine for an error condition that is recognized at second reading. The machine stops after the card causing the stop, reaches the stacker. The hubs labelled O (Offset) are entries to offset the card in the stacker instead of stopping the machine and are optional.

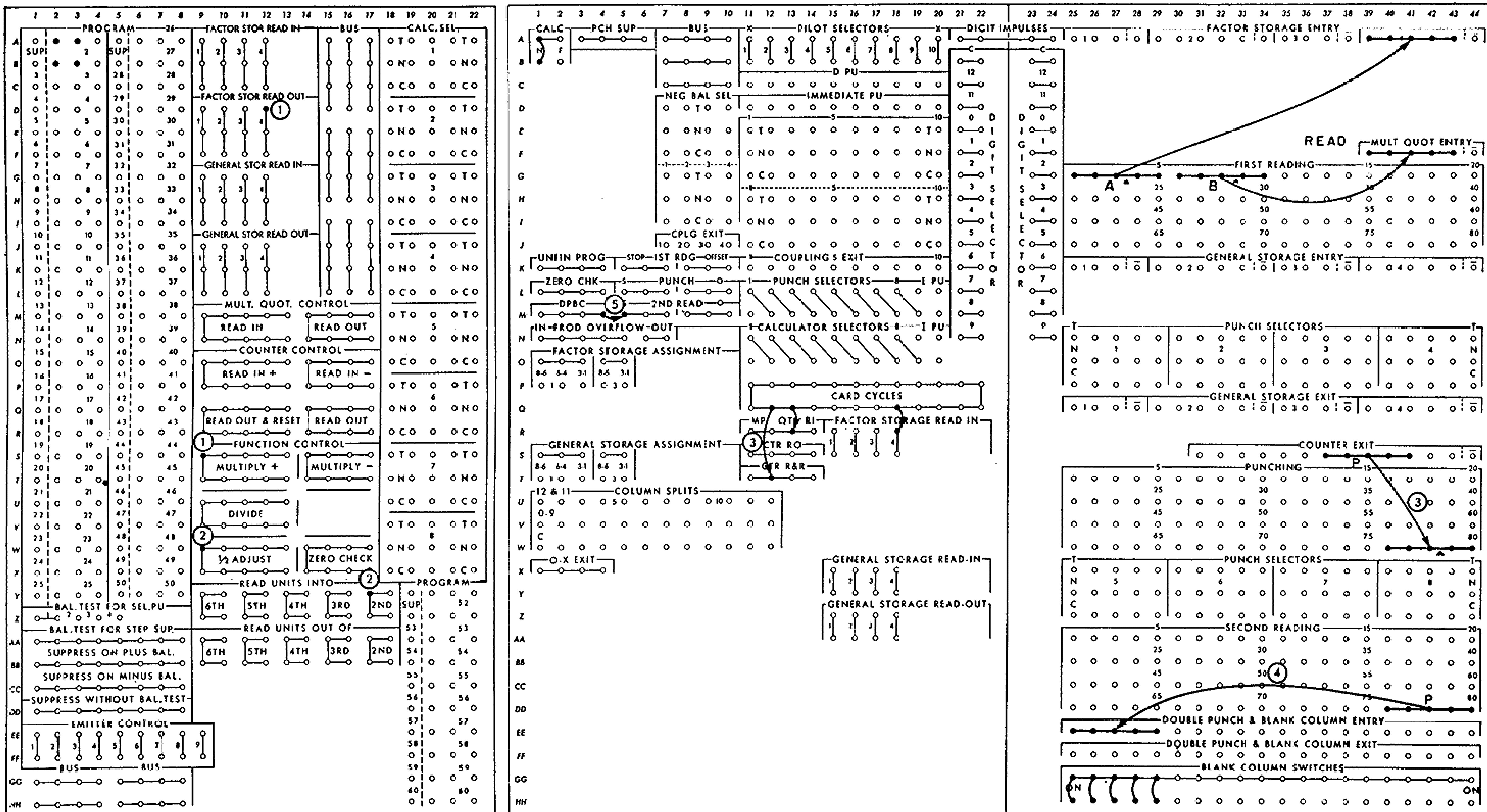


FIGURE 13. DOUBLE PUNCH-BLANK COLUMN METHOD OF CHECKING MULTIPLICATION

WIRING DIAGRAM

(Figure 13)

THE PLANNING chart for this operation is not shown since it is sufficiently represented in the original multiplication chart (Figure 8B).

READ. The factors in the original multiplication are reversed so that A enters FS 4 and B enters MQ.

1. Program 1 impulses the multiply hubs and the read out of FS 4. The product is developed in the counter.

2. The half adjustment is added in the second position of the counter on program 2.

3. The product of A x B, with two positions dropped, is wired out of the counter to punch again in column 76-80. If it differs from the first product, double punching will result.

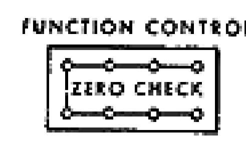
4. Double punching will be detected by wiring the product field from second reading to double punch and blank column entry. If blank columns are to be detected, the corresponding blank column switches must be wired.

5. If there is an error, the DPBC hubs will emit an X impulse which may be used to stop the machine or to offset the card in the stacker by wiring it to second reading stop or offset hubs. The second read hubs are used because the error is detected at the second reading brush station.

Zero Balance Method

When sufficient storage capacity is available, results can be recalculated in a second run, subtracted from results in the first run, and tested to prove that the balance is zero. When one result is subtracted from another and the balance is zero, all positions in the counter stand at 9.

By impulsing the zero check hub on the calculate control panel a "1" is entered into the units position of the counter and causes all positions to stand at zero. If they do not, an error is indicated. In cases where decimals must be skipped in the recalculation, the "1" may be shifted to enter any position of the counter up to the 6th.



Zero Check (Cal W-X, 14-17). When these hubs are impulsed by a program step, a 1 is entered into the units position of the counter. If the amount subtracted equals the amount added on a previous step, all positions of the counter stand at 9. When zero check is impulsed, the 1 adds to the 9's changing them to zeros. The 1 may be shifted in the counter by impulsing the read units into hubs in cases where decimals are to be dropped as shown below. In the first example the zero check starts in the units position of the counter and in the second example it starts in the hundreds position. The units and tens positions are ignored in the second example.

First Example

```
0000000000025 ( -25)*
9999999999974 (+25)*
_____________
9999999999999
            1
_____________
0000000000000
            ↑
check begins here
```

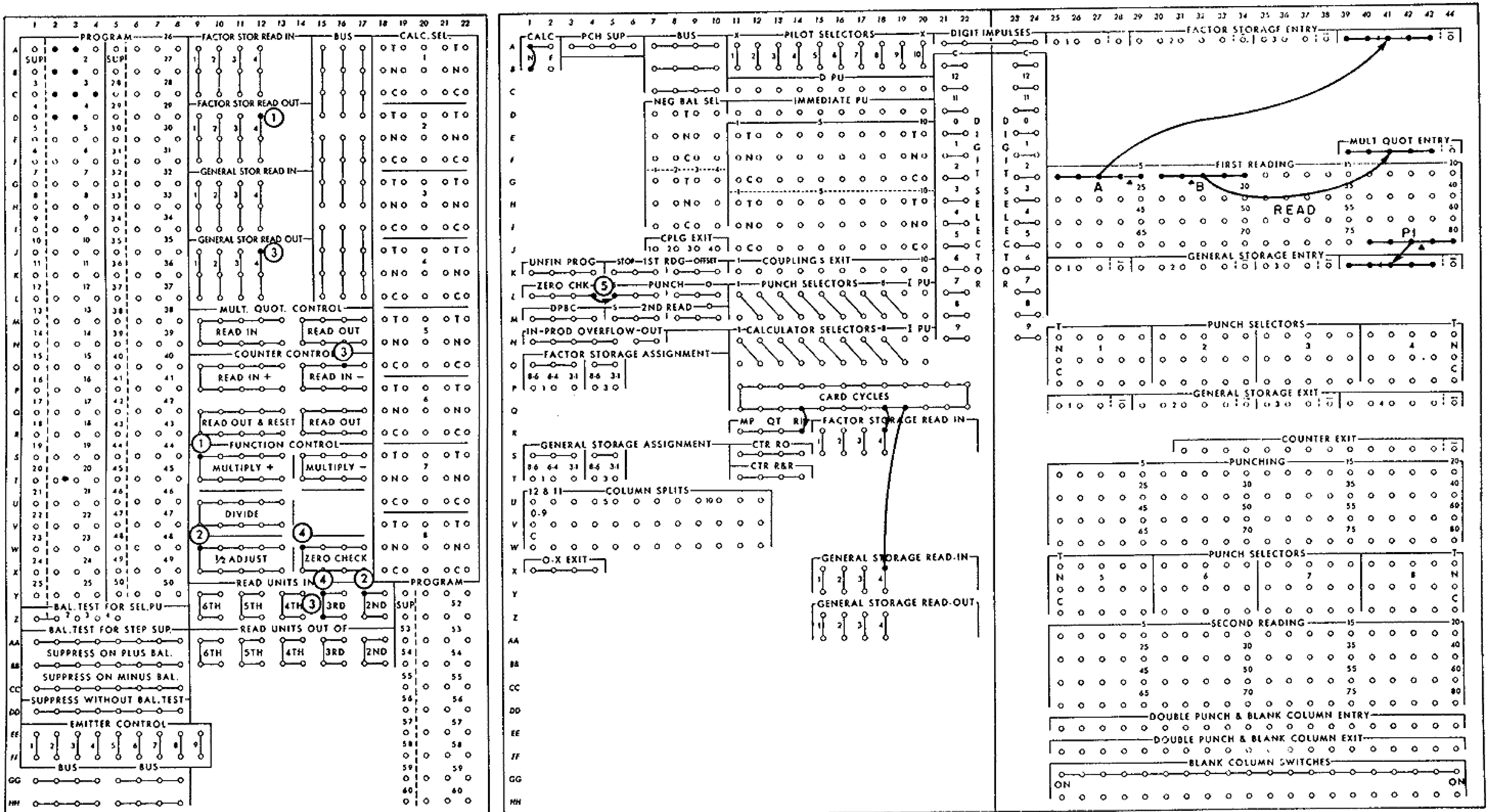


FIGURE 14A. ZERO BALANCE METHOD OF CHECKING MULTIPLICATION

APPLICATION Checking Mult. Zero Balance Method PROBLEM A x B = P − P = Check

Operation	Program Suppress	Program Number	Factor Storage Assignment 1	2	3	4	Mult. Quot.	Counter	General Storage Assignment 1	2	3	4
Read		R				A 00600	B 01255					P1 7530
Multiply		1				RO		P2 753000				
½ Adj. RI 2nd		2						5 753050				
Subt Prev Prod		3						− 7530 9999999999949				RO
Zero Check RI 3rd		4						1 0000000000049				
		5										

FIGURE 14B.

Second Example

```
00000000025.00 ( −25.00)*
99999999974.23 (+25.76)*
──────────────
99999999999.23
            1
──────────────
00000000000.23
             ↑
     check begins here
```

* Minus factors enter the counter as true figures. Plus factors enter the counter as 9's complement figures.

ZERO CHK

Zero Check. (*Pcb L, 1-4*). When the counter positions being checked do not balance to zero after the 1 has been added, an error is indicated and the zero check hubs on the punch control panel emit an X impulse. This impulse may be wired to punch stop to cause the machine to stop and the zero check error light to turn on or to the special feature punch offset. Punch stop is used because the error is recognized at the punch station. The X impulse may also be wired directly to the punching hubs to punch an X for error cards. The counter resets automatically after each zero check.

PLANNING CHART AND WIRING DIAGRAM (Figures 14A and 14B)

READ. A is entered into FS4, B into MQ and P1 into GS 4.

1. A is multiplied by B by wiring program 1 to FS 4 read out and to multiply +. This is a recalculation of A x B, the first product having already been punched.
2. The result of the recalculated multiplication (P2) is half adjusted by wiring program 2 to ½ adjust and to read units into 2nd.
3. The punched product P1 (less the dropped decimals) is subtracted from the recalculated product P2 by wiring program 3 to GS 4 read out, counter read in −, and to read units into 3rd.
4. P2 − P1 should equal zero except for the two unwanted decimal positions, and all zero positions should stand at 9 (complement of 0). By adding 1 to the 3rd position of the counter the 9's turn to zeros. This is done by wiring program 4 to zero check and to read units into 3rd.
5. If the counter does not stand at zero from the third position to the extreme left position, in this example, an error is indicated and an X impulse is emitted from the zero check hubs on the punch control panel. This impulse is wired to punch stop, to stop the machine and turn on the zero check error light. It may also be wired to one of the punching hubs to punch an X in the error card.

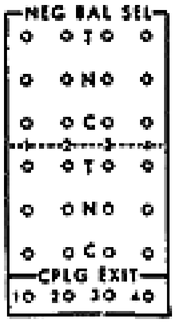
The counter automatically clears after each zero check.

CHECKING DIVISION

$$-A + (Q \times B) + .5B - .1 - B = \text{Check}$$

MULTIPLICATION may be used to check division by determining that the product falls within a range of numbers, any of which are correct. For example, any number from 26 to 29 inclusive, divided by 4, produces a correct quotient of 7. If the above formula is followed, the dividend A is subtracted from the product of the quotient times the divisor (QxB) plus half the divisor (.5B). From the result .1 is subtracted and a test is made at this point to determine the sign of the result. If a positive balance is obtained on this test, the quotient is not too small. A negative balance on this test would mean that the quotient is too small. The reason for subtracting .1 before making the test is that a zero balance (always wrong) is recognized by the machine as a positive balance. The .1 subtraction changes the zero result to a negative balance and an error is thus indicated. The divisor is then subtracted (–B) and a second test is made to determine that the quotient is not too large. If the balance on the second test is negative the quotient is correct. If the balance is positive the quotient is too large and therefore wrong. This principle of checking division is illustrated below.

Bal. Test For Selector Pickup (Cal. Z, 1-8). A negative condition may be recognized on the following punching operation by wiring the program step during which the test is to be made, to the balance test for selector pickup hubs. The test occurs at the end of the program step. These hubs serve as pickup hubs on the calculate control panel for negative balance selectors on the punch control panel. A selector may be picked up only once during a calculation. Only one selector is standard.

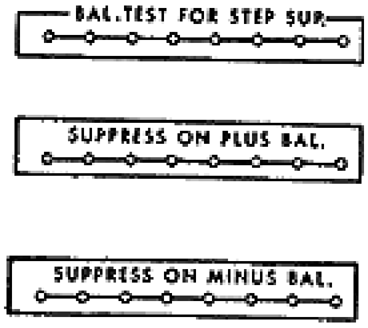


Negative Balance Selectors (Pch D-J, 7-10). One negative balance selector is standard. When the balance test for selector pickup hubs on the calculate panel are impulsed, the selector transfers before punching starts and remains transferred until the card is punched. It offers a method of controlling functions on the punch control panel from a condition arising during calculation. The coupling exit below the selector can be used to pick up either a punch or calculate selector. The coupling exit emits only one impulse per card.

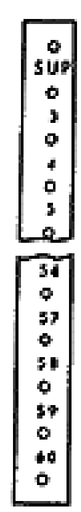
PRINCIPLE OF CHECKING DIVISION

	Dividend Low Limit	Dividend High Limit	Dividend Below Low Limit	Dividend Above High Limit
Q	7 OK	7 OK	7 Error	7 Error
B|A	4|26	4|29	4|25	4|30
–A	–26.0	–29.0	–25.0	–30.0
+(QxB)	28.0	28.0	28.0	28.0
	+ 2.0	– 1.0	+ 3.0	– 2.0
+(.5B)	+ 2.0	+ 2.0	+ 2.0	+ 2.0
	+ 4.0	+ 1.0	+ 5.0	+ 0.0
–.1	–.1	–.1	–.1	–.1
First Test	+ 3.9 OK	+ .9 OK	+ 4.9 OK	–.1 Error
–B	– 4.0	– 4.0	– 4.0	
Second Test	–.1 OK	– 3.1 OK	+ .9 Error	

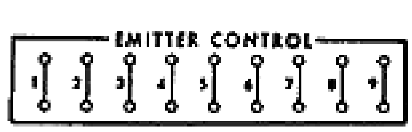
RULE: Plus on first test and minus on second test, quotient is correct.
Plus on first test and plus on second test, quotient is too large.
Minus on first test, second test is not required, and quotient is too small.



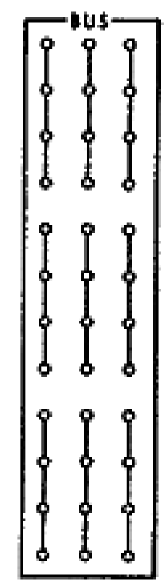
Balance Test For Step Suppression (*Cal AA-CC, 1-8*). Three rows of hubs are supplied to recognize negative or positive balances as they occur on any program step, by impulsing the balance test for step suppress hubs from a program exit. If a balance is negative, the suppress on minus balance hubs become active until the end of the problem or until tested by another program step. Similarly, the suppress on plus balance are active for plus balances.



Sup (*Cal A-Y, 1; A-Y, 5; Y-HH, 19*). A program step may be suppressed by impulsing the SUP hub for that step, from either the suppress on plus balance, or the suppress on minus balance hubs, providing the balance test for step suppression had been previously impulsed. SUP hubs may be wired from suppress without balance test, usually through calculate selectors. The program step is not eliminated but the exit hubs are made inactive.



Emitter Control (*Cal EE-FF, 1-9*). The emitter can be used to enter a single digit into the counter, any storage unit, or the MQ unit on a program step. Multiple digits can be entered into the counter only. They are entered one at a time on as many program steps as there are digits. Multiple digits cannot be entered into the storage units because the entry of the second digit would clear out the first; entry of the third digit would clear out the second and so on. Digits are emitted and read into a unit by wiring a program step to the specific digit hub in the emitter and by impulsing the unit to read in. The digit normally goes to the units position but may be shifted by wiring the read units into hubs.



Bus (*Cal GG-HH, 1-8; A-L, 15-17; Pch A-C, 7-10*). There are 13 sets of four position bus hubs on the calculate control panel and 3 sets on the punch control panel. They are entries and are used to expand other entries or exits. The primary purpose of bus hubs is to eliminate split wires.

PLANNING CHART AND WIRING DIAGRAM

(Figures 15A and 15B)

READ. The dividend (A) is read into FS 2, the divisor (B) into the M-Q unit, and the quotient (Q) into FS 4. Card cycles impulses are wired to the read in of each of these units.

1. The quotient is read out of FS 4 into the counter, shifted one position to the left, on program 1.

2. The (½B) part of the equation is taken care of by adding a 5 to the right of the units position of the quotient, before multiplying by B (divisor). The 5 is obtained from the emitter control during calculation by wiring program 2 direct to

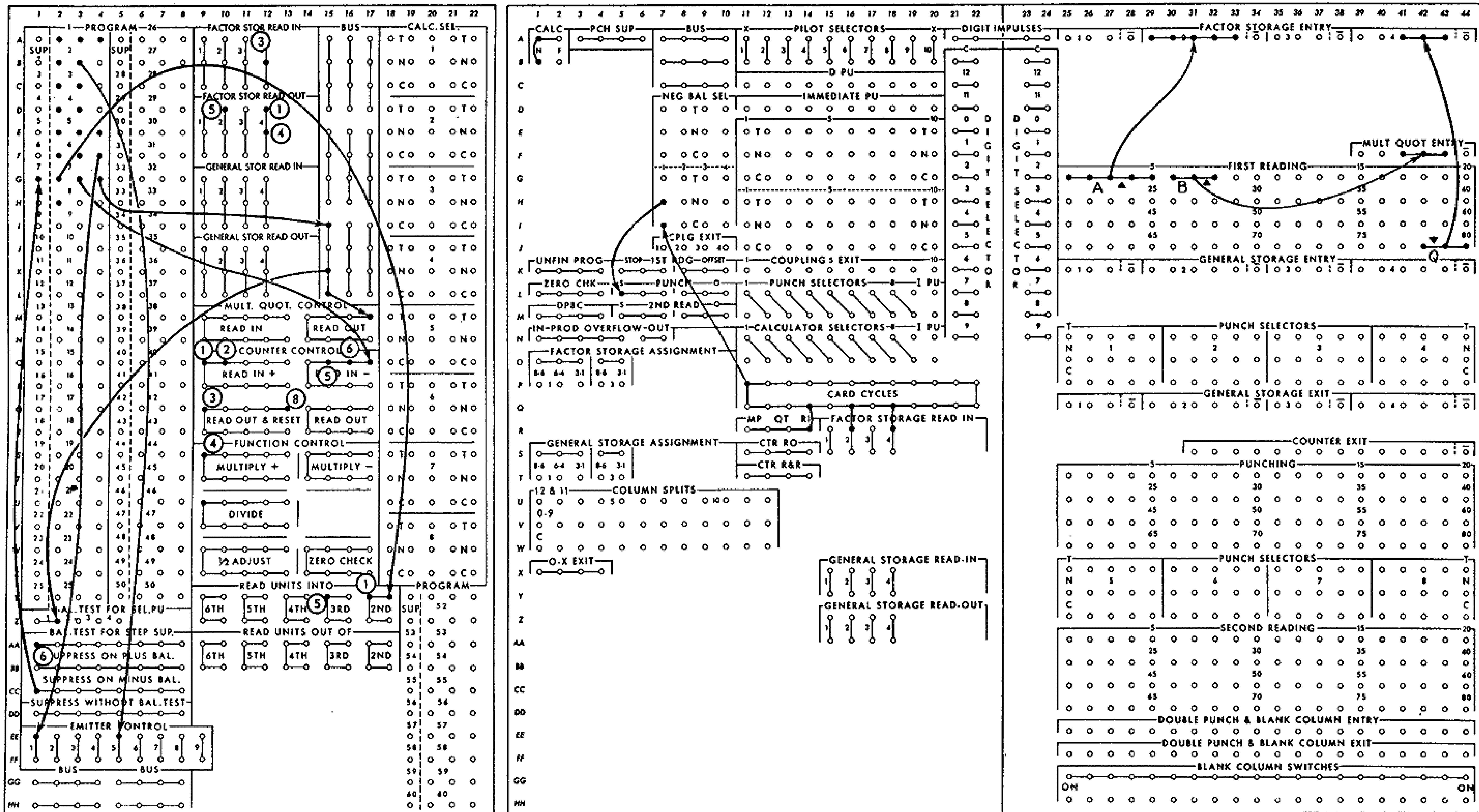


FIGURE 15A. CHECKING DIVISION

APPLICATION *Division Checking* PROBLEM *-A+(QxB)+.5B-.1-B = Check*

OPERATION	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT 1	2	3	4	MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT 1	2	3	4
READ		R		A 9575		Q 234	B 409					
R.I. 2nd		1				RO		234				
5 from Emitter		2						5 (Q+.5) 2345				
		3				2345		R+R				
Multiply		4				RO		(QxB+.5B) 959105				
R.I. 3rd Subtract A		5		RO				-9575 1605				
1 from Emitter Test for Step Sup.		6						-1 +1604				
R.I. 3rd Test for Sel. P.U.		7					RO	-409 -2486				
		8						R+R				

FIGURE 15B

the 5 emitter control hub, and is entered into the counter by impulsing counter +. When the 5 is placed in this position, .5 of B is automatically added to the product of Q x B. All other decimals are ignored for this part of the equation.

3. The quotient, with the 5 added, is read out of the counter and entered into FS 4. The counter is also reset at this time.

4. The quotient is multiplied by the divisor by reading out FS 4 and impulsing multiply +. The product satisfies the following part of this equation: (Q x B) + .5B.

5. The dividend is read out of FS 2 and subtracted from the product of (Q x B) + .5B in the counter. It is entered into the counter starting with the third position to line up the decimals.

6. A .1 is subtracted from the result and a test is made at this point to determine the positive or negative condition of the counter for, if it is negative, the quotient is too small and therefore wrong. When program 6 is wired to balance test for step suppression, the suppress on minus balance hubs will be active on each of the following program steps if the counter is minus on program 6.

7. The divisor B is subtracted from the amount remaining in the counter as if it were a whole number, and the amount in the counter has only one decimal (.5B). A second test is made. If the result is plus, the answer is wrong. If the result is minus, the answer is correct. Program 7 is wired to balance test for selector pickup number 1. If the counter is negative at this time (correct result), the negative balance selector on the punch control panel will be picked up just prior to punching and the card cycles impulse wired through its normal points cannot reach punch stop. If the counter is positive at this time (wrong result), the selector will not be picked up and the card cycles will reach punch stop, causing the machine to stop. If the counter was negative on program 6 (wrong result), program 7 will be suppressed, the selector will not pick up and the machine will stop. Thus, a check is obtained on a positive basis since the selector transfers for correct results but not for wrong results. There is no light for this type of error but the machine stops when the error card is at the second reading station. One more cycle is required to move the

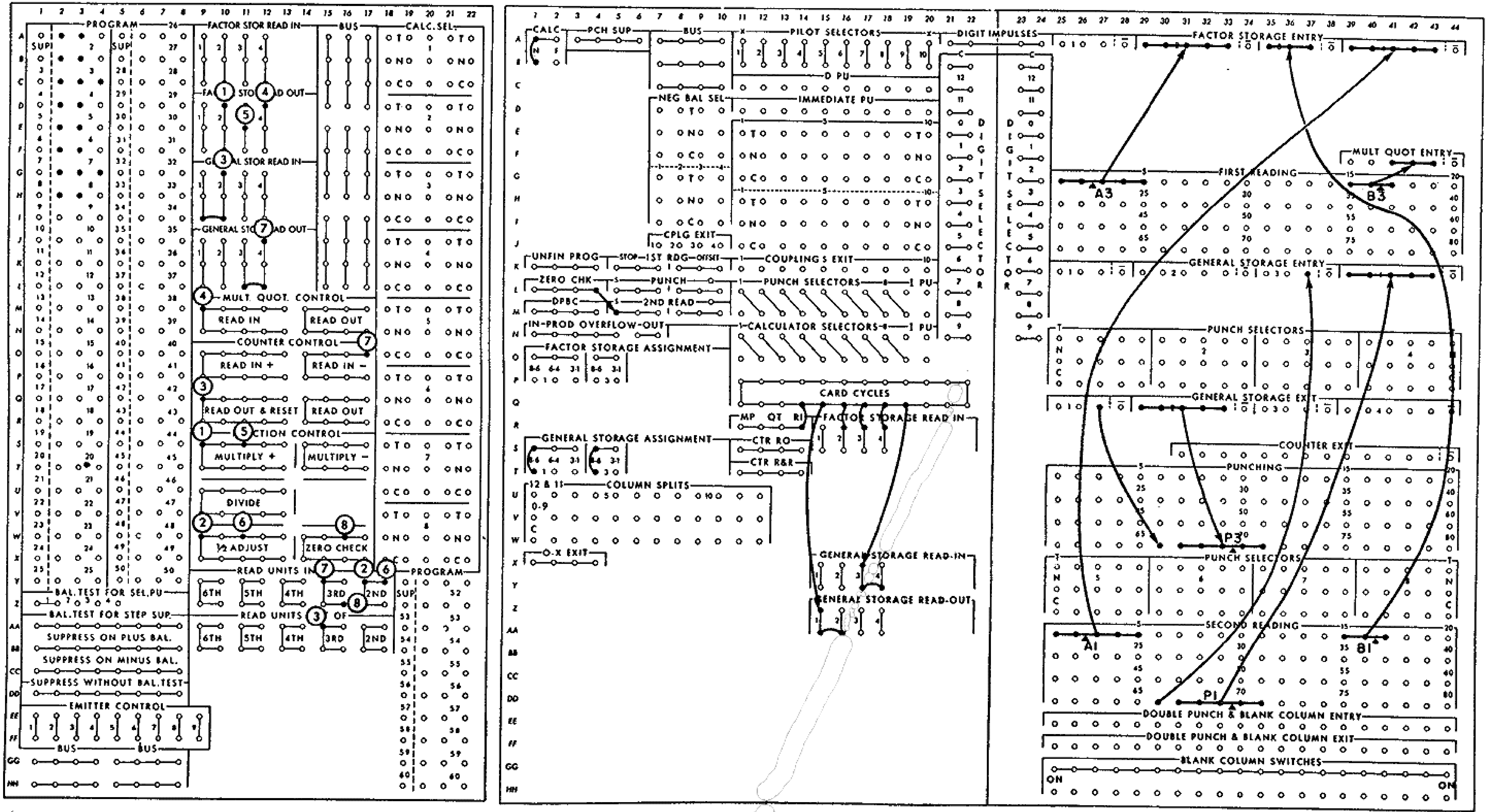


FIGURE 16A. SIMULTANEOUS MULTIPLICATION AND CHECKING card to the stacker. The reset key must be depressed before restarting.

On the run-in, the machine will stop three times because the card cycles impulse passes through the normal points of the negative balance selector. This unnecessary stopping on the run-in can be prevented by depressing the reset key and start key simultaneously for the first three cycles.

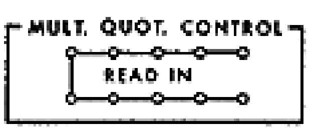
8. The counter is reset.

SIMULTANEOUS MULTIPLICATION AND CHECKING

ONE 5-digit factor may be multiplied by one 3-digit factor, and the result can be punched and checked by reverse calculation in the same operation. Reference to the schematic diagram in Figure 16B will show that as card number 3 is at the first reading station, card number 1 is at the second reading station and card number 2 is being punched.

Following this read cycle (before card 3 reaches the punch station), calculation of A x B in card 3 takes place on the first three program steps, and calculation of B x A in card 1 takes place on the next three program steps. On the last two program steps the punched product in card 1 (calculated after it was read at the first station) is subtracted from the recalculated product of card 1 to obtain a zero balance.

Two planning charts are shown, one for each reading station. Although the operations are simultaneous, a better understanding of the problem may be gained by treating each separately.



Mult Quot. Read In (*Cal M-N, 9-13*). The multiplier quotient read in hubs must be impulsed from a program step whenever a factor is to be read into the MQ unit during calculation.

PLANNING CHART 1 AND WIRING DIAGRAM
(Figures 16A and 16B)

READ (First Station). Factor A3 from card 3 is read into FS 2 and B3 from card 3 is read into MQ.

1. FS 2 is read out and A3 is multiplied by B3.
2. The result is adjusted for dropped decimals.
3. The counter is read out and reset and P enters GS 1-2 for punching.

PLANNING CHART 2 AND WIRING DIAGRAM

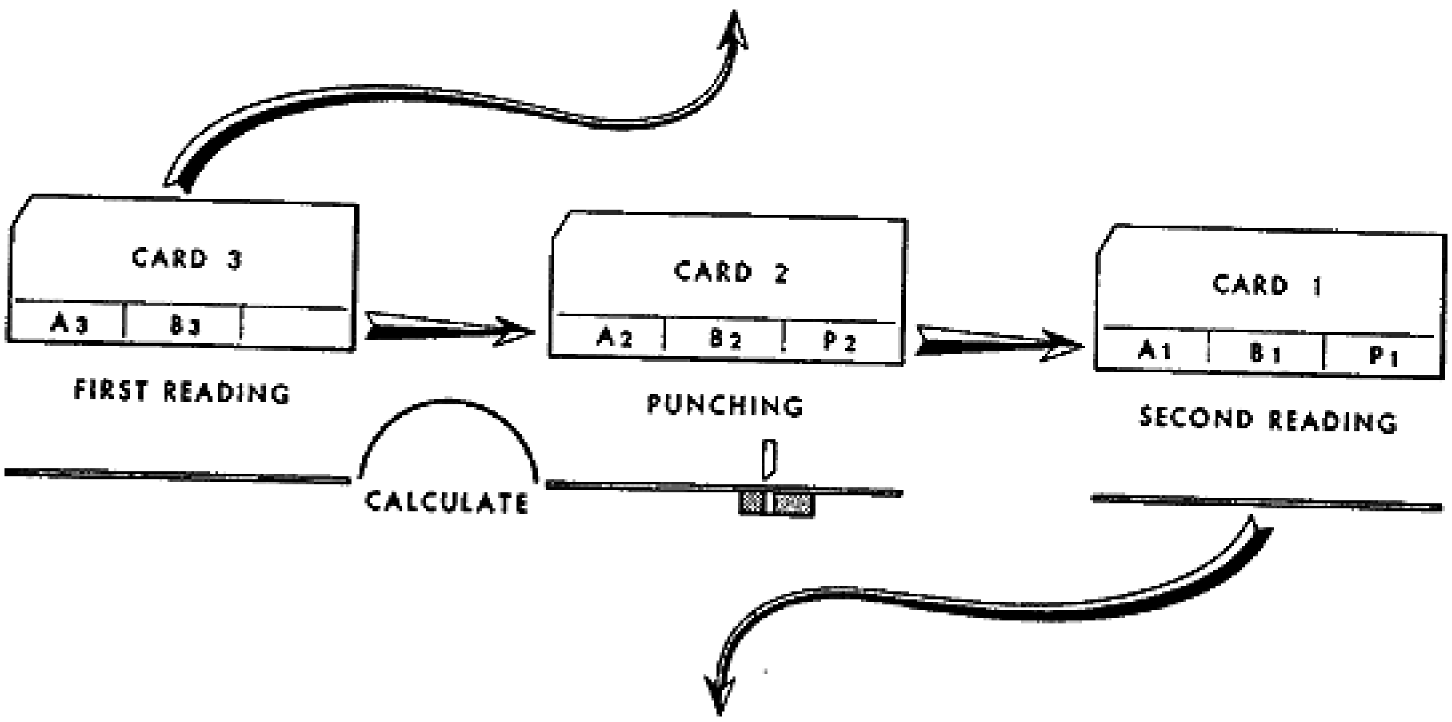
READ (Second Station). Factor A1 from card 1 is read into FS 4 and B1 from card 1 is read into FS 3. The punched product on the first card is read into GS 3-4.

4. A1 is read out of FS 4 into MQ.
5. FS 3 is read out and B1 is multiplied by A1 a second time.
6. The result is adjusted for dropped decimals.
7. The punched product of card 1 is read out of GS 3-4 and subtracted from the recalculated product in the counter. Except for dropped decimals, the result should be zero.
8. Zero check is impulsed so that the 1 enters the 3rd position. Since an error would be recognized at the 2nd reading station, the zero check error signal is wired to 2nd read stop.

The counter is cleared automatically when zero checking.

APPLICATION *Hours X Rate = Amount Chart 1* PROBLEM *A X B = P; B X A - P - P = Check*

Operation	Program Suppress	Program Number	Factor Storage Assignment 1 (6-4, 8-6)	2	3 (8-6)	4	Mult. Quot.	Counter	General Storage Assignment 1 (6-4, 8-6)	2	3 (8-6)	4
1st Read Station		R		A3 01255			B3 1600					
Multiply		1		RO				P3 007530000				
½ Adj. R.I. 2nd		2						5 007530050				
RO 3rd		3						R + R	0	P3 07530		
PUNCH		P								P3 0 07530		



APPLICATION *Hours X Rate = Amount - Chart 2* PROBLEM *A X B = P; B X A - P - P = Check*

Operation	Program Suppress	Program Number	Factor Storage Assignment 1 (6-4, 8-6)	2	3 (8-6)	4	Mult. Quot.	Counter	General Storage Assignment 1 (6-4, 8-6)	2	3 (8-6)	4
2nd Read Station		R			B1 412	A1 01273						P1 5245
		1										
		2										
		3										
		4				RO	A1 01273					
Multiply		5			RO			524476				
½ Adj. R.I. 2nd		6						5 524526				
R.I. 3rd		7						− 5245 7999999999973				RO
Zero Check R.I. 3rd		8						Zero Check 1 ← 0 →				
		9										

Figure 16B

MULTIPLICATION FACTOR EXPANSION

12 digits × 10 digits = 22 digits

It is possible to expand the multiplier and the multiplicand or both beyond the 8 digits by a 5 digit combination used in the basic multiplication problem. Both the multiplier and the multiplicand are calculated in parts and the results of the parts combined to obtain a final product. The following example will show a step by step analysis of the machine operation,

	B2 | B1	
	999999|888888	
A2	77777|66666	A1
7777765801796790207408	= product to be calculated and punched	

Six digits of the multiplicand B1 are multiplied by five digits of the multiplier A1.

888888	B1
x66666	A1
592586(07408)	Numbers in parenthesis represent digit positions 1-5 of final product.

As many digits will be correct and ready to store as there are digits in the multiplier A1. The 07408 part of the product is stored while the remaining digits are moved to the right of the counter to be added to the result of A1 x B2, with the product shifted one position.

999999	– B2
x66666	A1
66665933334	– Product
+592586	Remaining digits from A1 x B1
66665992 5926	

This result is left standing in the counter to be added to the product of A2 x B1. Whenever the second part of the multiplicand (B2) is multiplied by either part of the multiplier, the product must be shifted as many positions to the left as the difference between the number of digits in the right part of the multiplier and the right part of the multiplicand. In the above example there are 5 digits in the multiplier (A1) and 6 in the multiplicand (B1), therefore the product of A1 x B2 will be shifted one position.

888888	B1
x77777	A2
69135041976	Product
666659925926	Amount in counter
7357949(67902)	Numbers in parenthesis represent digit positions 6-10 of final product

The last five digits of this result are stored. The remaining digits are moved to the right of the counter and added to the result of A2 x B2, with the product shifted one position.

999999	– B2
X77777	A2
77776922223	= Product
7357949	Remaining digits from A2 x B1
777776580179	Digit positions 11-22 of final product.

The product of A2 x B2 is shifted one position or the difference between the number of digits in the right part of the multiplier and the right part of the multiplicand. The above result represents the 12 left-hand positions of the whole product which, when combined with 67902 and 07408 from storage, make up the final product.

Unfinished Program (*Pch K, 1-4*). On rare occasions, a calculation may not be completed in time to punch the card, in which case no punching will take place and an X impulse will be emitted from the unfinished program hubs. To stop the machine and turn on the unfinished program error light, one of these hubs must be wired to first read stop, since the error condition is recognized at the first reading station. The

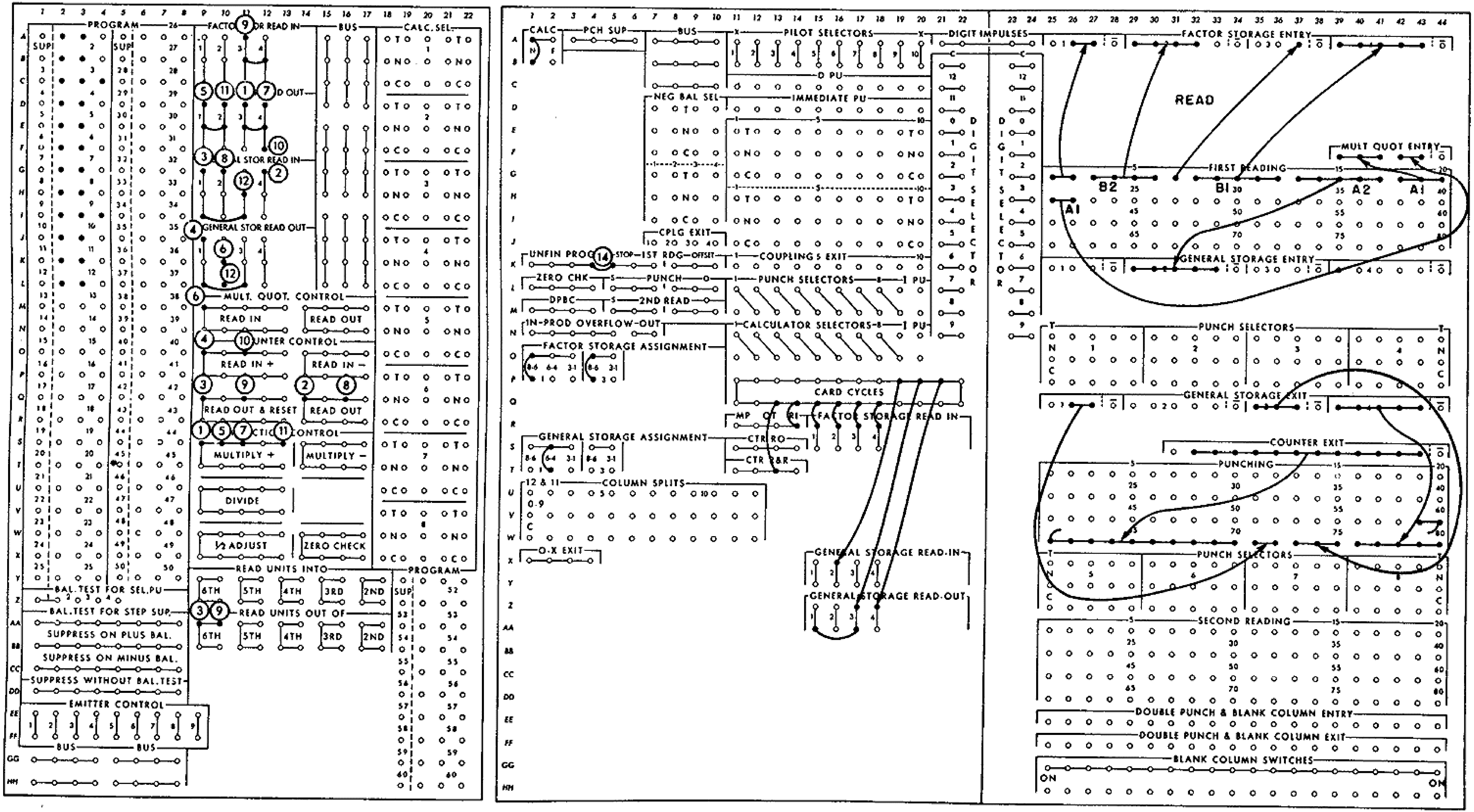


FIGURE 17A. MULTIPLICATION FACTOR EXPANSION

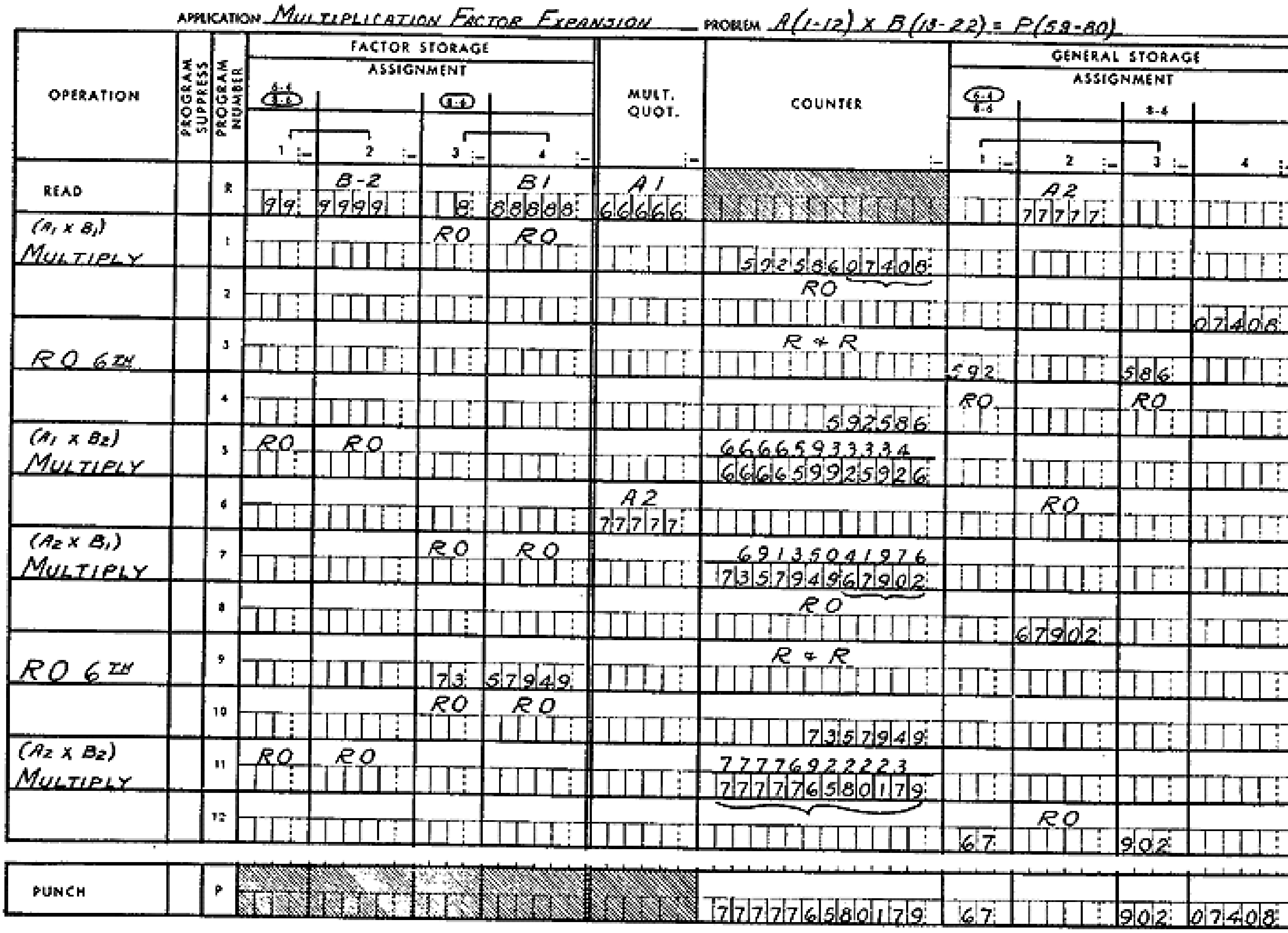
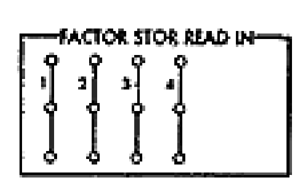


Figure 17B.

machine will stop when the error card reaches the stacker. In such cases, cards not punched can be re-run, and by pressing the stop key after each card feeds, ample time will be allowed to complete the calculation.

First Reading Stop-Offset (*Pch K, 5-10*). These stop and offset hubs are entries to stop the machine or to offset a card whenever an error condition is recognized at the first reading station. The offset hubs are optional.



Factor Stor Read In (*Cal A-C, 9-12*). Factors may be entered into the factor storage units during calculation by impulsing the factor storage unit read-in hubs from a program exit. This feature is available only on machines with serial numbers 10053HL and higher.

Counter Control Read Out (*Cal Q-R, 14-17*). The counter may be read out without resetting by impulsing the counter control read out from a program exit.

PLANNING CHART AND WIRING DIAGRAM

(Figures 17A and 17B)

READ. The multiplicand B is entered into the machine in two parts. The first six positions of B (B1) are entered into FS 3 and 4. FS 3 is assigned to the 6th, 7th, and 8th channels. The second half of B (B2) is entered into FS 1 and 2 offset one position. FS 1 is assigned to the 6th, 7th, and 8th channels. The result of any multiplication involving the second half of the multiplicand must be offset as many positions as the difference between the number of digits in the right-hand multiplier and the digits in the right-hand multiplicand. In this problem it is one.

The multiplier A is also entered into the machine in two parts. The first five positions of A (A1) are entered into MQ and the second five positions of A (A2) into GS 2.

1. B1 is multiplied by A1 by impulsing FS 3 and 4 read out, and the multiply + hubs.
2. The counter is read out and the right-hand five positions are stored in GS 4.
3. The six left-hand positions of the product of A1 x B1 are read out of the counter and stored in GS 1 and 3. GS 1 is assigned to the 4th, 5th and 6th channels. The counter is reset.
4. The six positions in GS 1 and 3 are entered into the counter starting with the units position, to be added to the result of the next multiplication.
5. A1 and B2 are multiplied by impulsing FS 1-2 read out and multiply plus.
6. The second half of the multiplier (A2) is read out of GS 2 into MQ, clearing out the previous multiplier.
7. A2 and B1 are multiplied by reading out FS 3 and 4 and by impulsing multiply plus. This product as developed will add to the result already standing in the counter.
8. The counter is read out and the right-hand five positions are stored in GS 2. A2 standing in the storage unit will automatically clear out.
9. The seven left-hand positions are read out of the counter and stored in FS 3 and 4 so that they may be moved to the right of the counter on the next cycle.
10. The amount in FS 3 and 4 is read into the counter, starting with the units position, to be added to the result of the next multiplication.
11. B2 is multiplied by A2 and the result, offset one position, is added to the amount already standing in the counter. The result in the counter at this time represents the 12 high order positions of the final product.
12. The part of the result stored in GS 2 must be moved to GS 1 and 3 before it can be punched, since GS 2 is being read into from the card.
13. The 12 left-hand positions of the final product are punched from the counter. The next 5 positions are punched from GS 1 and 3. The last 5 positions are punched from GS 4.
14. Unfinished program is wired to 1st read stop so that if a calculation is not completed before it is time to punch, the machine will stop and the unfinished program error light will turn on.

QUOTIENT EXPANSION

THE NUMBER of quotient digits that may be calculated in any one division problem is limited only by the capacity of the machine to store the dividend and the divisor at read time and the quotient for punching. In this problem a 15-digit dividend will be divided by a 6-digit divisor to obtain a 10-digit quotient. Five digits at a time will be introduced into the counter to be divided by the 6-digit divisor, and the resulting quotient will be stored for punching as part of the whole result. This process is repeated until the problem is complete.

PLANNING CHART AND WIRING DIAGRAM

(Figures 18A and 18B)

READ. The dividend (A) is punched in columns 1-15. The first five columns are stored in FS 1 and 3, columns 6-10 are stored in FS 2, and columns 11-15 in FS 4. The divisor (B) is punched in columns 50-55. Columns 50-52 are stored in GS 1 and 53-55 in GS 3. FS 1 and GS 1 are assigned to the 4th, 5th, and 6th channels.

1. Columns 1-5 of the dividend are read into the counter from FS 1 and 3.

2. A (1-5) is divided by B by reading out GS 1 and 3 and by impulsing the divide hubs. The quotient is developed automatically in MQ.

3. The amount in MQ is only part of the quotient and is read out into GS 2 where it is stored. For the example shown, the quotient, of 99999 divided by 111111, is zero.

4. The remainder standing in the counter must be shifted to the left of the next part of the dividend. To do this, it must first be read out of the counter, temporarily stored in FS 1 and 3 and re-entered into the counter (starting with the 6th position) on the next program.

5. The remainder is read from FS 1 and 3 into the counter starting with the 6th position.

6. The next five positions of the dividend are read out of FS2 into the counter, starting with the units position. The counter now contains the remainder from the preceding division operation and A (6-10) side by side.

7. The second part of the quotient is developed by reading out GS 1 and 3, and by impulsing the divide hubs.

8. The second part of the quotient is stored in GS 4.

9. The remainder standing in the counter must be shifted to the left of the next part of the dividend. To do this, it must first be read out of the counter, temporarily stored in FS 1 and 3 and re-entered into the counter (starting with the 6th position) on the next program.

10. The remainder is read from FS 1 and 3 into the counter starting with the 6th position.

11. The last five positions of the dividend are read out of FS 4 into the counter, starting with the units position. The counter now contains the remainder from the preceding dividing operation and A (11-15) side by side.

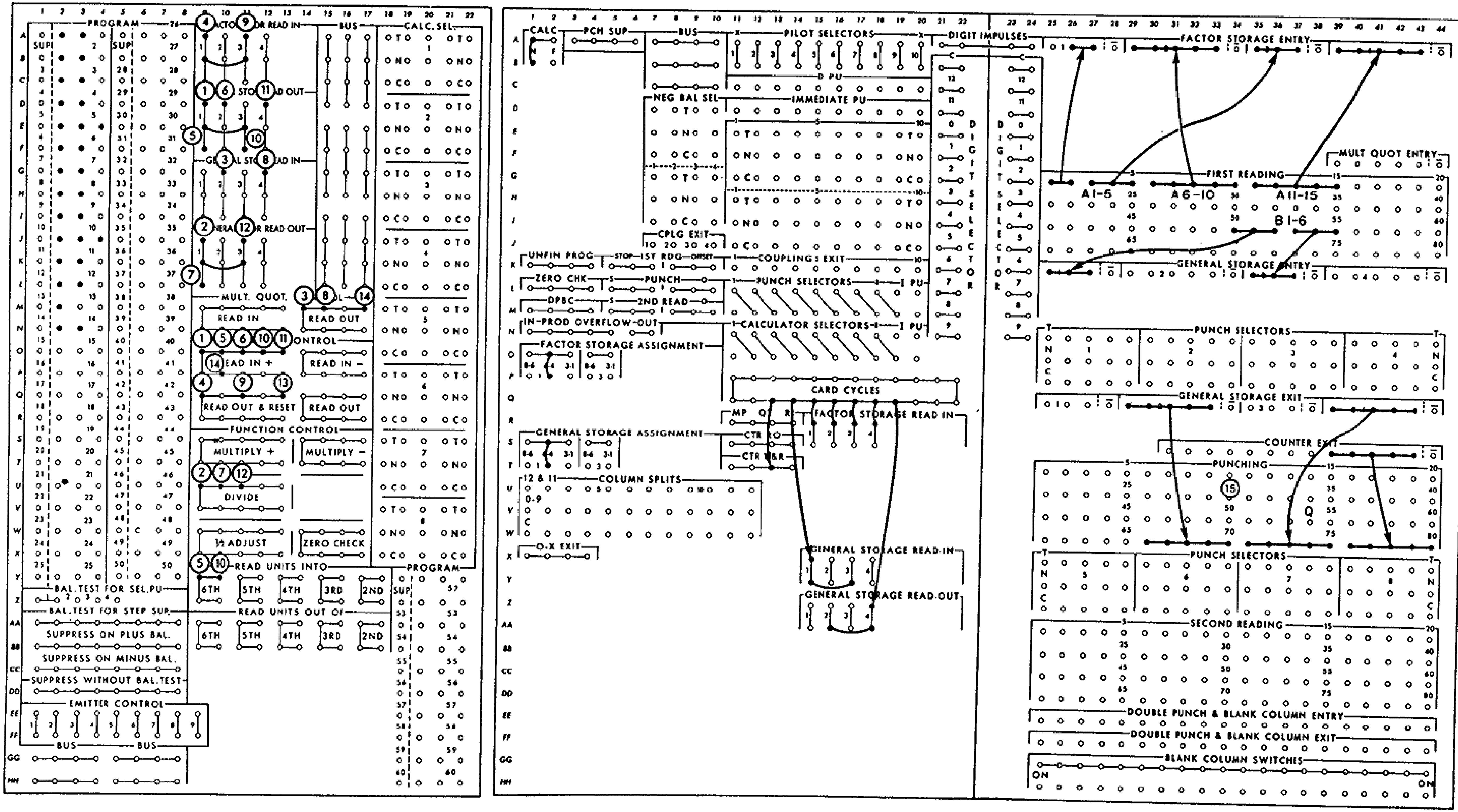


FIGURE 18A. QUOTIENT EXPANSION

APPLICATION *Quotient Expansion* PROBLEM *A(15 Digits) ÷ B(1-6 Digits) = Q(10-15 Digits)*

OPERATION	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT 1	FACTOR STORAGE 2	FACTOR STORAGE 3	FACTOR STORAGE 4	MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT 1	GENERAL STORAGE 2	GENERAL STORAGE 3	GENERAL STORAGE 4
READ		R	(A 1-2) 99	(A 6-10) 88888	(A 3-5) 999	(A 11-15) 77777			(B 1-3) 111		(B 4-6) 111	
		1	RO		RO			(A 1-5) 99999				
Divide		2					(Q 1-5) 00000		RO		RO	
		3					RO			(Q 1-5) 00000		
		4	REM 99		REM 999			R & R				
RI 6th		5	RO		RO			REM 99999				
		6		RO				(A 6-10) 88888				
Divide		7					(Q 6-10) 89999		RO		RO	
		8					RO					(Q 6-10) 89999
		9	REM 109		REM 999			R & R				
RI 6th		10	RO		RO			REM 109999				
		11				RO		(A 11-15) 77777				
Divide		12					(Q 11-15) 98999		RO		RO	
		13						R & R				
		14					RO	(Q 11-15) 98999				
PUNCH		P						76-80 98999		(66-70) 00000		(71-75) 89999

FIGURE 18B

12. The last part of the quotient is developed by reading out GS 1 and 3 and by impulsing the divide hubs.

13. The remainder is cleared from the counter.

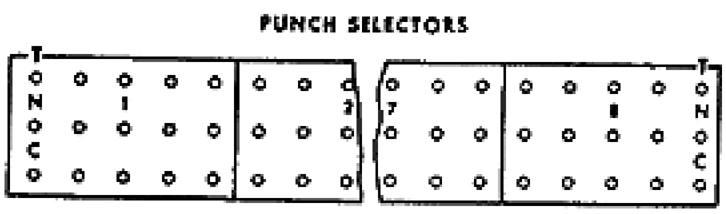
14. The part of the quotient standing in MQ is moved to the counter so that it may be punched.

15. The whole quotient is punched from GS 2, GS 4 and the counter in that order.

SUMMARY PUNCHING

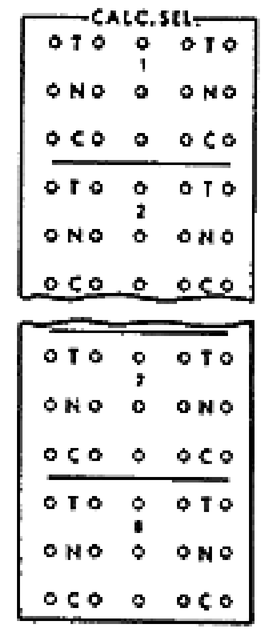
CALCULATIONS can be made for the sum of a group of cards as well as for the individual cards. In this problem, unit price is multiplied by quantity to punch billing amount in each card. As the extensions are made, they are added progressively to obtain the total invoice amount. An X punched total card filed at the end of each group contains the discount rate by which the invoice amount is multiplied to obtain discount amount. The discount amount is subtracted from the invoice amount to obtain net amount and all three results — invoice, discount, and net amounts — are punched in the X punched total card.

For ease in explanation, the operation is shown in three parts, the first two for NX cards and the third for X cards.



Punch Selectors (*Pch N-P, 25-44; X-Z, 25-44*). There are eight 5-position punch selectors standard on the Type 604. Each has a row of C (common), N (normal) and T (transferred) hubs. When a selector is transferred, there is a common connection between the C and the T hubs. When a selector is not transferred(normal), there is a common connection between the C and N hubs. The pickup hubs (*L-M, 11-18*) accept X, 12, or coupling exit impulses to transfer the selectors. The selectors transfer immediately and hold for the rest of the cycle.

The punch selectors are normally used: to select factors entered into the storage units from the card by wiring an X or 12 from first reading direct to the selector pickup; to select factors to be punched from either the counter or the general storage units by wiring an X, 12, or digit from first reading to a pilot selector X or D pickup and the coupling exit of the pilot selector to the punch selector pickup; and to select card cycle impulses. Whenever a punch selector is picked up from the coupling exit of either a negative balance selector or a pilot selector, it transfers and drops out with the selector that picked it up. When storage read in, storage read out, counter read out, and counter read out and reset are controlled by a card cycles impulse through the normal points of a punch selector, the pickup impulse must be a 12 punch. This is necessary because a card cycles impulse originates at X or 11 time.



Calculate Selectors (*Cal A-X, 18-22*). There are eight 5-position calculate selectors standard on the Type 604. Their pickup hubs are located on the punch control panel, (*N-O, 11-18*) but the selectors are located on the calculate control panel. Calculate selectors operate exactly like punch selectors both in the method of picking them up and in the time that they hold. They differ only in use. They are transferred from any punch in a card to control program steps during calculation.

Suppress Without Balance Test (*DD, 1-8*). These hubs emit impulses on every program step and are normally wired through calculate selectors to suppress specific program exits for either X or NX cards. Several program exits can be suppressed by the same impulse by the use of bus hubs.

CTR RO (*Pch S, 11-14*). These counter read out hubs are impulsed whenever the counter is to be read out without resetting, as in progressive totaling or summary punching.

PLANNING CHART AND WIRING DIAGRAM (Figures 19A and 19B)

READ 1ST NX CARD. The quantity A is read into FS 1 and 2. FS 1 is assigned to the 6th, 7th and 8th channels. The price B and discount C are wired through punch selector 1 to MQ. The selector is picked up by an X in column 21 wired through a column split. The column split prevents interference from digit punching. The discount will enter MQ on all X cards and the price on all NX cards.

1. Quantity is multiplied by price by impulsing FS 1 and 2 read-out and multiply +.

2. The product is half adjusted by impulsing ½ adjust. The 5 enters the units position of the counter.

3. The product of A x B is read out of the counter, with one decimal dropped, into GS 3 and 4 from which the individual products are punched. GS 3 is assigned to the 6th, 7th, and 8th channels. The counter is not reset and the amount standing in the counter will be added to the sum of the previous products on the following step.

4. This program step is described in the second planning chart.

5. The product is read out of the counter, with one decimal dropped, into GS 1 and 2. GS 1 is assigned to the 6th, 7th and 8th channels. The counter is also reset. Program steps 6 through 10 are suppressed on NX cards as these steps will be used for X cards only.

Read 2nd and following NX cards. Factors A and B are entered as described on the first planning chart. The product of A x B from the preceding card or cards stands in GS 1 and 2 and is shown encircled.

Program steps 1, 2 and 3 remain the same as those described on the first planning chart.

4. The product of the preceding card or cards is read out of GS 1 and 2 to be added in the counter on all NX cards except the first NX card of each group. As the first NX card is being calculated, the total of the individual products still remains in GS 1 and 2 and cannot be allowed to read out into the counter. Program 4 is therefore selected through the normal side of calculate selector 1 which is picked up from the coupling exit of pilot selector 1. Pilot selector 1 picks up one cycle after the X is read at first reading and will therefore be transferred for the first card of the next group, since the X card is the last card of the preceding group. When the amount from GS 1 and 2 reads into the counter, it is offset one position to line up the decimals.

5. The total of the individual products (sum of the P's) is read out of the counter with one decimal dropped, into GS 1 and 2. The counter is also reset.

Read X card. The discount % C is read into MQ through the transferred side of punch selector 1. The sum of the Ps (R) stands in GS 1 and 2 and is encircled on the chart.

Program steps 1-5 used for NX cards are suppressed on X cards.

6. R is multiplied by C to obtain discount amount (S) by reading out GS 1-2 and by impulsing multiply +.

7. The product of R x C (S) is ½ adjusted in the second position.

8. S is read out of the counter with two decimals dropped, into GS 3 and 4 from where it will be punched. The counter is also reset.

9. The sum of the Ps (R) is read out of GS 1 and 2 and added into the counter.

10. The discount amount (S) is read out of GS 3 and 4 and subtracted from R in the counter. The net invoice amount stands in the counter from where it will be punched.

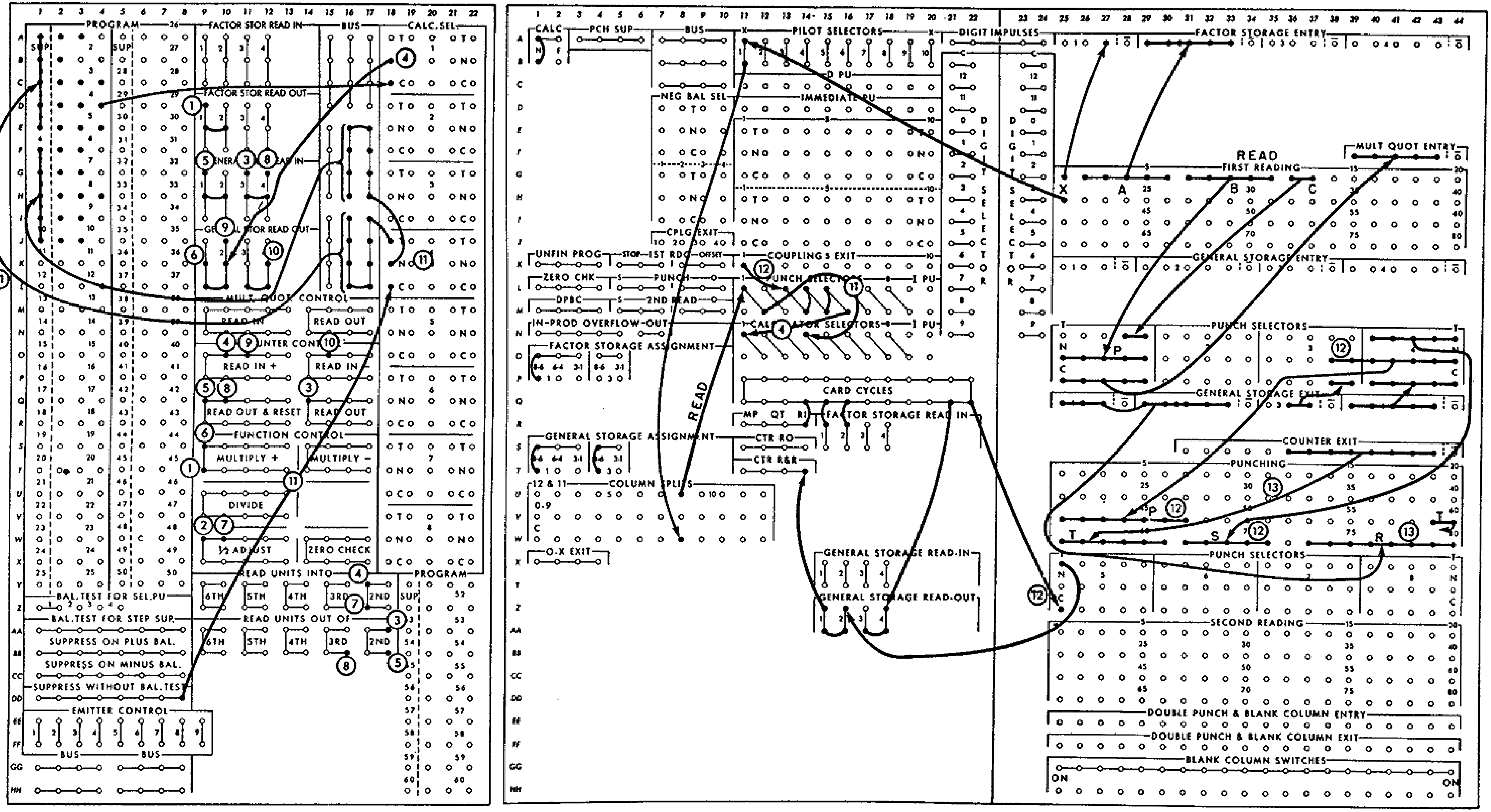


FIGURE 19A. SUMMARY PUNCHING

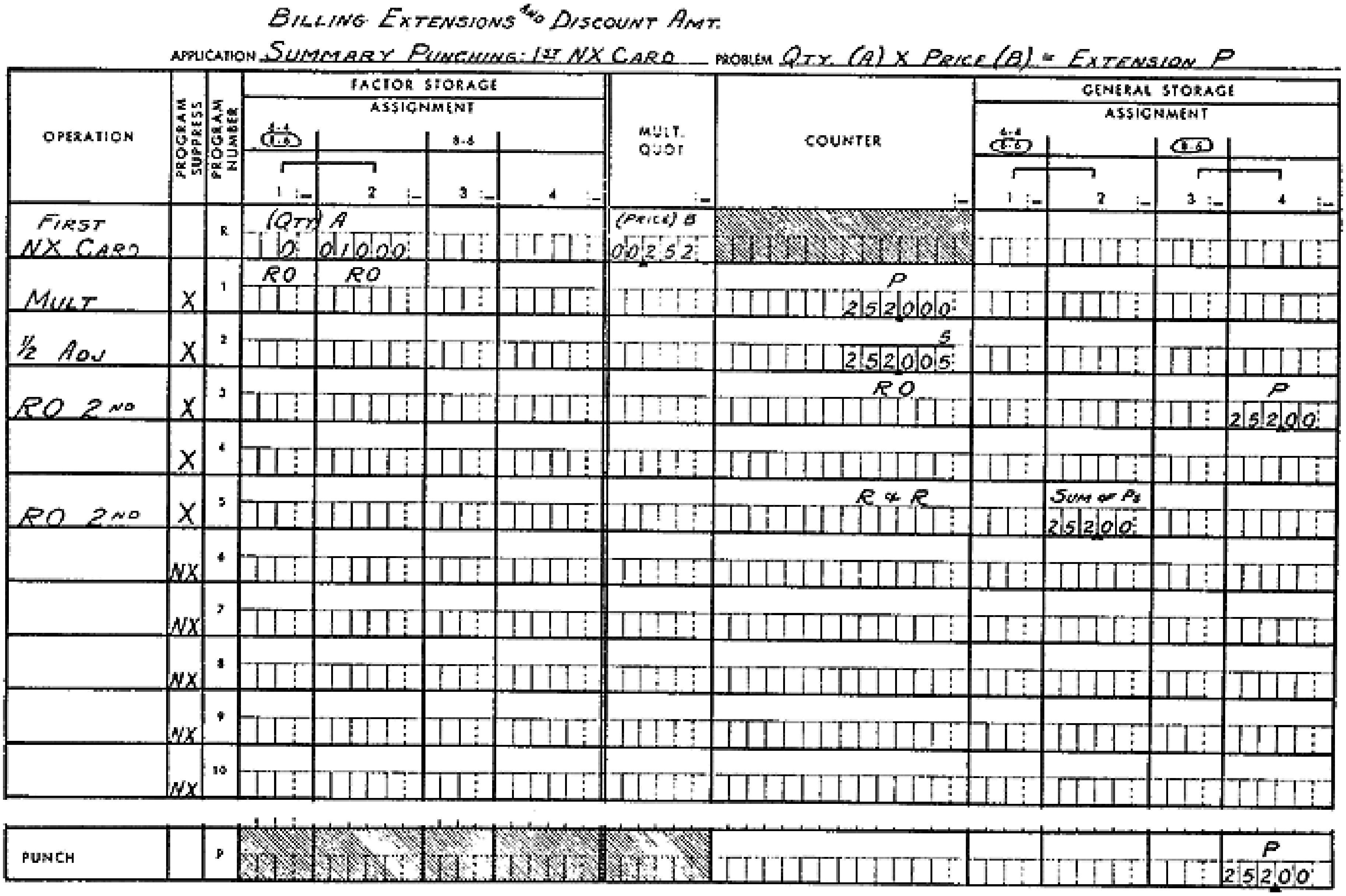


FIGURE 19B

11. Program steps 1-5 are suppressed on X cards by wiring suppress without balance test through the transferred side of calculate selector 4 to the suppress hubs of the first 5 programs. The calculate selector is picked up from an X at first reading.

Program steps 6-10 are suppressed on NX cards by wiring suppress without balance test through the normal side of calculate selector 4 to the suppress hub of programs 6-10. In both cases, bus hubs are used.

12. Both P on the NX card and S on the X card are punched from GS 3 and 4. Since they are punched in different fields, P is selected through the normal side of punch selectors 3 and 4 to columns 41-47 and S through the transferred side of the same selectors to columns 67-71. Punch selectors 3 and 4 are picked up from the coupling exit of pilot selector 1 which in turn is transferred one cycle after the X is read at the first reading station.

13. T is punched from the counter and R from GS 1 and 2. Both units are read out by a selected card cycles impulse wired through the transferred side of punch selector 5. The punch selector is picked up from the coupling exit of pilot selector 1.

The run should be preceded by a blank X card.

BILLING EXTENSIONS AND DISCOUNT AMT. QTY (A) X PRICE (B) = EXTENSION (P)

APPLICATION SUMMARY PUNCHING; 2ND FOLLOWING NX CARDS PROBLEM SUM OF Ps = INVOICE TOTAL (R)

OPERATION	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT 1 (6-4 / 8-6)	2	3 (8-6)	4	MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT 1 (6-4 / 8-6)	2	3 (8-6)	4
2ND AND FOLLOWING NX CARDS		R	0	A 02000			B 00175			PREV. PROD 25200		
MULT	X	1	RO	RO				350000				
½ ADJ.	X	2						5 350005				
RO 2ND	X	3						RO				P 35000
RI 2ND	X	4						25200 602005		SEL. RO		
RO 2ND	X	5						R & R		R(SUM OF Ps) 60200		
	NX	6										
	NX	7										
	NX	8										
	NX	9										
	NX	10										
PUNCH		P										P 35000

FIGURE 19C

BILLING EXTENSIONS AND DISCOUNT AMT. INVOICE TOTAL (R) X DISCOUNT % (C) = DISCOUNT AMT. (

APPLICATION SUMMARY PUNCHING; X CARD PROBLEM INVOICE TOTAL (R) - DISCOUNT (S) = NET INV AMT. (T)

OPERATION	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT 1 (6-4 / 8-6)	2	3 (8-6)	4	MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT 1 (6-4 / 8-6)	2	3 (8-6)	4
READ X CARD		R					C 15%			R(SUM OF Ps) 60200		
	X	1										
	X	2										
	X	3										
	X	4										
	X	5										
MULT.	NX	6						(S) 903000	RO	RO		
½ ADJ. R.I. 2ND	NX	7						5 903050				
RO 3RD	NX	8						R & R				(S) 9030
	NX	9						(R) 60200	RO	RO		
	NX	10						- 9030 (T) 51170			RO	RO
PUNCH		P						R & R (T) 51170		(R) 60200		(S) 9030

FIGURE 19D

SIGN CONTROL

$(\pm A) - (\pm B) = \pm T;\ (\pm T) \times (\pm C) = \pm R;$

$(\pm R) \div (\pm D) = \pm Q$

MULTIPLICATION or division of factors identified by plus or minus signs can be performed automatically. This permits the use of the Type 604 machine for many types of engineering, statistical, and technical calculations.

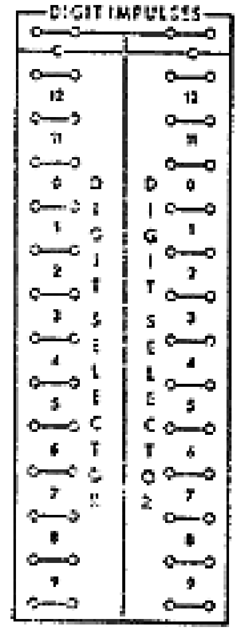
The signs of factors are entered, together with the factors, in any of the units which accept information from the card. If the signs are represented by X's over the units position of the amount, no special wiring whatever is required for sign control operation. If an X is punched in any other column of the card, the column is wired through a column split to segregate the X, which is then wired to the sign control position for each unit.

The extreme right-hand position of each unit is a sign control position. It will accept any digit or an X to identify the positive or negative value of a factor. By an internal column split, an X punch over the units position of a factor is automatically entered in the sign control position of the unit, with no wiring required. A digit can be selected for use as a sign by wiring from the column containing the digit through the digit selector.

The calculation of a positive or negative result as required by the combination of signs is completely automatic, including the transfer of factors or results from one unit to another. There is a ninth path in the transfer channel for the transfer of signs.

The problem illustrated in Figure 20A shows different methods for introducing the signs of factors and for punching the signs of results.

Digit Selectors — Digit Impulse (*Pcb A-N, 21-24*). There are two digit selectors standard on the Type 604. When the common hubs are wired from first or second reading, impulses



from the digit hubs will be available as the corresponding digits are read from the card. When the common hubs are wired from the digit impulse hubs, the selector becomes an emitter, each digit hub emitting its corresponding digit impulse on every card cycle.

0-X Exit (*Pcb X, 1-4*). These hubs emit both a zero and an X impulse on every card cycle. They are normally wired through column splits to separate the two, before wired to punch.

PLANNING CHART AND WIRING DIAGRAM

(Figures 20A and 20B)

READ. Both FS 1 and GS 1 are assigned to the 4th, 5th and 6th channels. Factors are wired to units as indicated. Factor A has an X for a negative value punched over the units position, and consequently requires no special sign wiring. This is indicated in the planning chart by an arrow connecting the units and the sign control positions. Factor B has the X punched over the first column of the factor and, therefore, is wired through a column split which distributes digits to the proper position of the storage unit and the X to the sign control position. Factor C is identified as being negative by a digit 3 in column 40. This column is wired through a digit selector to the sign control

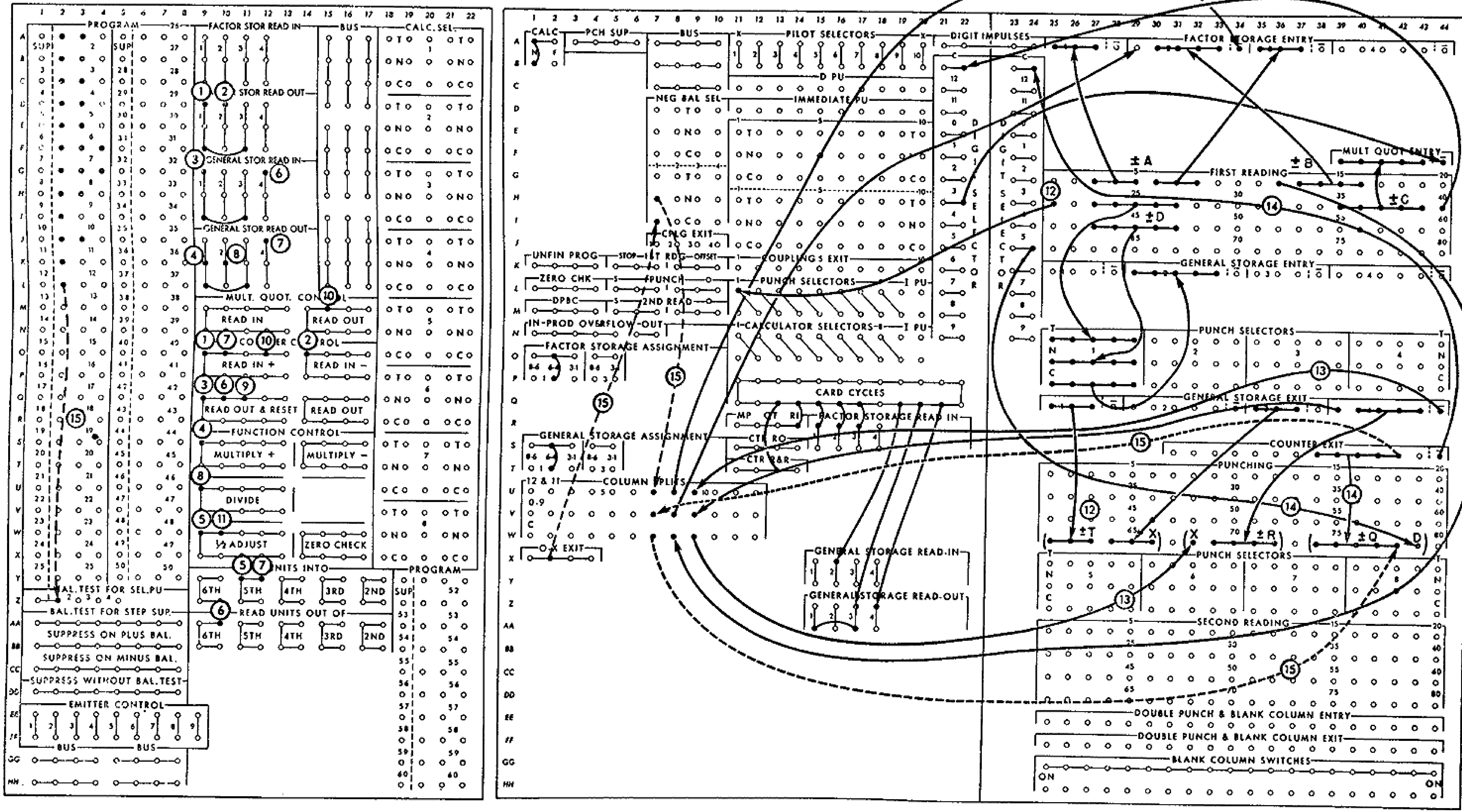


FIGURE 20A. SIGN CONTROL

APPLICATION Sign Control PROBLEM (±A)−(±B)=±T; ±T×±C=±R; ±R÷±D=±Q

OPERATION	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT 1	2	3	4	MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT 1	2	3	4
READ		R	±A 257	±B 57618- x	±A 618-		±C 22222- 0			±D 40000-		
Add ±A		1	RO		RO			+A 257618-				
Subtr. ±B		2		RO				±B 576.18+ ±T 200000-				
Store		3						R & R	T 200		T 000-	
Multiply Plus		4						±R 444440000	RO		RO	
½ Adj 5th		5						5 44444 +				
Store ±R		6						R & R				±R 44444+
Add ±R 5th		7						+(±R) 44444 +				RO
Divide		8					+(±Q) 11111-			RO		
Reset Remain.		9						R & R				
Transfer ±Q		10					RO	±Q 11111-				
½ Adj 5th		11						5 11116-				
PUNCH		P						±Q 11111-	T 200		T 000-	±R 44444+

FIGURE 20B

position of the MQ storage unit. Factor D has the sign control X in the units position, like factor A, but it is punched in two different fields and requires field selection for entry into GS 2. The selection of a sign requires that selector 1 be transferred from a 12 punch in order to transfer before the X position of the card is read. The 12 in this example is punched in column 21.

1. Factor A is read out of FS 1 and 3 and added in the counter.

2. Factor B is read out of FS 2 and subtracted in the counter.

3. The total (T) is read out of the counter into GS 1 and 3. The counter is reset. If T is negative, the sign as well as the total is transferred to the storage unit for punching over the units position (or in another position if it is so wired).

4. The total ± T is multiplied by the multiplier C by wiring to multiply + and to read out GS 1 and 3. The product is determined as positive or negative in the counter. An uneven number of minus signs produces a negative result; an even number of minus signs with any number of plus signs produces a positive result.

5. The product, R, is adjusted to the nearest whole number by wiring ½ adjust into the 5th position of the counter. The 5 adds or subtracts as required by the sign of the product.

6. The product R, with its resulting sign, is read out of the counter with all decimals dropped into GS 4 to be stored for punching. The units position of R is the 6th position in the counter.

7. The result, R, is returned to the proper position in the dividend counter by reading out GS 4.

BLANK

adding in the counter, and reading units into the fifth position. If R is negative, the sign also transfers.

8. The quotient is calculated by wiring to divide and reading out GS 2.

9. The counter is read out and reset to clear the remainder.

10. The quotient is transferred to the counter for ½ adjustment by wiring read out of MQ and counter +. The sign also transfers.

11. The quotient is adjusted by wiring ½ adjust.

12. The result, T, is punched from GS 1 and 3 and, if it is negative, and X is punched automatically over the units position.

13. The X sign is punched over the high order position of result R by the use of the column split. The X would still punch over the units position unless it is eliminated by another column split.

14. In this problem, a 5 is to be punched in column 79 to indicate a negative Q. The sign control position of the counter or a storage unit is a source for all digit impulses when the unit contains a negative result. The sign control position is wired through a digit selector to segregate 5 as a minus sign.

15. The dotted lines show how an X can be punched in the units position of Q for positive balances instead of negative balances. A balance test of the counter is made on any program cycle following the calculating operation. If the counter contains a negative amount, a negative balance selector will be transferred when the card is punched. The X is obtained from the 0-X hubs filtered through a column split.

CALCULATING AVERAGE HOURLY RATE AND GROSS EARNINGS

GIVEN base pay, total hours worked, and weekly and daily premium hours, the Type 604 will divide the base pay by the number of hours worked to obtain the average hourly rate, multiply the rate by the greater of weekly or daily premium hours to obtain premium earnings and add premium earnings to base pay to obtain gross pay. From these results, calculations of withholding tax, OASI and net pay may be accomplished in another operation.

PLANNING CHART AND WIRING DIAGRAM
(Figures 21A and 21B)

READ. Weekly premium hours, base pay, daily premium hours, and total hours are read into FS 1, 2, 3, and 4 respectively.

1. The decimal point in base pay is offset five places in the counter according to the decimal rule; one decimal in the divisor, plus four decimals in the quotient equals five decimals in the dividend.

2. Base pay is divided by total hours to determine average rate, which is developed in MQ.

3. The remainder is cleared from the counter.

4. The average rate is moved to the counter for adjustment.

5. The average rate is adjusted for dropped decimals.

6. Average rate is read into MQ to be multiplied by daily or weekly premium hours, whichever is the greater.

7. Daily premium hours are read out of FS 3 and added into the counter.

8. Weekly premium hours are read out of FS 1 and subtracted in the counter. If the result is minus, the weekly premium hours are greater than the daily premium hours. If the result is plus, the daily premium hours are greater than the weekly premium hours. The counter is balance tested.

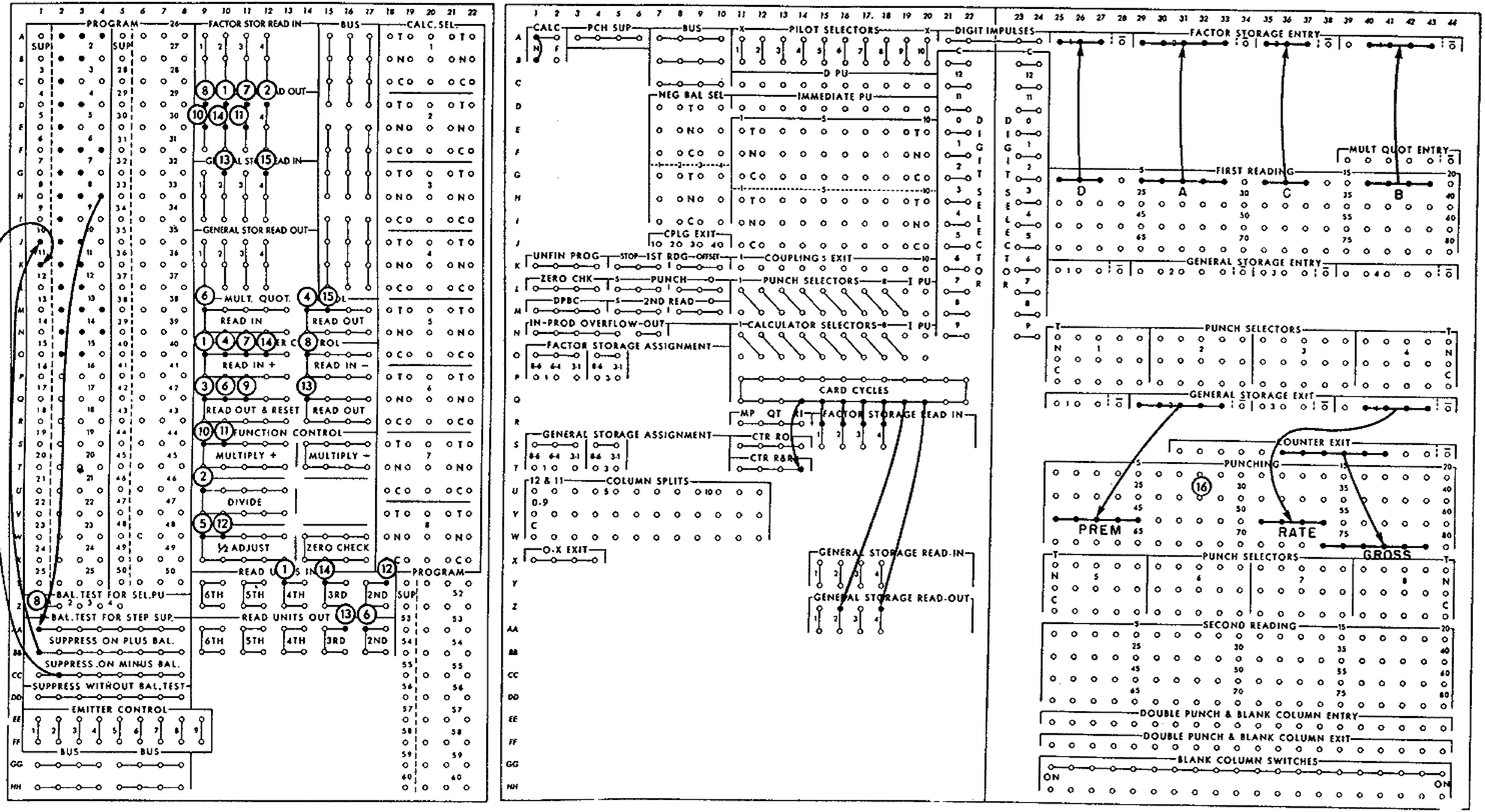


FIGURE 21A. CALCULATING AVERAGE HOURLY RATE AND GROSS EARNINGS

$A \div B = Q$ (AVER. RATE)

$C - D = \pm T$ (BAL. TEST) $\left\}\begin{array}{l} D \times Q = P \text{ (PREM EARN) IF } T \text{ IS } + \\ C \times Q = P \text{ (" ") IF } T \text{ IS } - \end{array}\right.$

APPLICATION AVER. HRLY. RATE AND GROSS EARNINGS PROBLEM $A + P = S$ (GROSS EARN)

OPERATION	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE 1 (6-4 8-6) D	FACTOR STORAGE 2 A	FACTOR STORAGE 3 (8-6) C	FACTOR STORAGE 4 B	MULT. QUOT.	COUNTER	GENERAL STORAGE 1 (6-4 8-6)	GENERAL STORAGE 2	GENERAL STORAGE 3 (8-6)	GENERAL STORAGE 4
READ		R	WKLY PREM. 60	BASE PAY 11700	DLY PREM. 40	TOT. HRS. 520						
RI 4TH		1		RO				BASE PAY 11700				
DIVIDE		2				RO	Q(AVE RATE) 22500					
REMAINDER		3						R & R				
		4					RO	22500				
1/2 ADJ		5						5 22505				
RO 2ND		6					RATE 2250	R & R				
		7			RO			DLY. PREM. 40				
BAL. TEST		8	RO					WKLY. PREM. −60 −20				
		9						R & R				
MULT. + IF CTR. −	+	10	RO					135000				
MULT. + IF CTR. +	−	11			RO							
1/2 ADJ 2ND		12						5 135050				
RO 3RD		13						RO		PREM. EARN 1350		
RI 3RD		14		RO				BASE PAY 11700 1305050				
		15					RO					RATE 2250
PUNCH		P						GROSS 13050		PREM. 1350		RATE 2250

FIGURE 21B

9. The counter is reset.

10. If the balance test shows that the counter was negative on program step 8, FS 1, containing the weekly premium hours, is read out and multiplied by the average rate. If the counter was positive, this step is suppressed.

11. If the balance test shows that the counter was positive on program step 8, FS 3, containing daily premium hours, is read out and multiplied by average rate. If the counter was negative, this step is suppressed.

12. The result is adjusted.

13. With two decimals dropped, the product (premium pay) is stored in GS 2. The counter is not reset, however.

14. Base pay is added in the counter, which already contained premium pay. The sum will be the gross.

15. Average hourly rate is read out of MQ and stored in GS 4 for punching.

16. Gross pay is punched from the counter. Premium pay is punched from GS 2, and rate is punched from GS 4.

CALCULATING WITHHOLDING TAX, OASI, AND NET PAY

THIS problem illustrates calculation of withholding and OASI taxes from gross earnings, and cross-footing the miscellaneous deduction amount to punch net pay, with X identification of gross earnings which have reached the OASI tax limit of $3,000.00.

Multiply Minus (*Cal S-T, 14-17*). The multiply minus hubs receive program impulses to cause a negative product to be developed in the counter.

PLANNING CHART AND WIRING DIAGRAM

(Figures 22A and 22B)

READ. Number of dependents gross pay, withholding tax rate and miscellaneous deduction amount are read into FS 1, 2, 3, and 4, respectively. The dependent deduction rate on the basis of a semi-monthly pay period is $28.00, and is entered into the MQ unit from digit selector 2 wired as a digit emitter.

Earnings to date, which includes the current gross pay, are entered into GS 1 and 2, thereby requiring that GS 1 be assigned to the 6th, 7th and 8th channels. The $3,000 tax limit will be identified by entering in the left-hand position of GS 3 a "3" from the digit emitter which, when moved four places on a later program step, will read as the full amount, $3,000.00.

1. The number of dependents is read out of FS 1 to be multiplied negatively by the dependent rate ($28.00). The result in the counter will be negative.

2. Gross pay is read out of FS 2 and added into the counter. The difference between the gross pay and dependent deduction amount may be plus or minus. If it is minus, withholding tax should not be computed. To recognize this condition, the program step on which the negative balance will occur is wired to one of the 8 common balance test for step suppression hubs.

Program 2 is wired to balance test for step suppression, and if the dependent deductions are greater than the gross pay, the suppression on minus balance hubs will be active to suppress program steps 4 and 5.

3. The counter is read out and reset, and the tax base is stored in MQ.

4. Program 4 may or may not be taken. If the counter was negative, withholding tax need not be calculated, and programs 4 and 5 will be suppressed. If the counter was plus, the tax base will be multiplied by 15% by reading out FS 3 and impulsing multiply +. The result will be the withholding tax amount.

5. Like program 4, this step will be suppressed if the counter was negative on program 2. If the counter was positive, the withholding tax amount will be adjusted by wiring ½ adjust and read units into 2nd.

6. Withholding tax is read out of the 3rd position of the counter and is stored in GS 4.

7. Program steps 7 through 13 deal with the $3,000.00 OASI tax limit and the calculation of OASI. Earnings to date in excess of $3,000.00 will be X punched by the machine at the time the limit is reached, as explained in step 9. The next time earnings are calculated, the X punch will suspend all programs relating to OASI, through a suppress without balance test wired through the transferred side of calculate selectors 1, 2 and 4 to program suppress. The calculate selector is transferred by an X in column 54, wired to the immediate pickup hubs. If digits are punched in column 54 of any other card, a column split should be used.

If the earnings to date have not yet reached $3,000.00, program step 7 will read out 300 from GS 3 into the 4th, 5th, and 6th positions of the counter, making it $3,000.00.

8. Earnings-to-date are read out of GS 1 and 2 and subtracted into the counter. The difference between the $3,000.00 limit and the earnings-to-date will be negative if the tax limit has been exceeded. Balance test for step suppression is again impulsed for use on program step 10.

9. Program 9 will pick up balance test for selector 1. This selector will transfer on the punch cycle, at which time an X from the 0-X exit will punch in column 54, if the tax limit is exceeded during the operation along with the left-hand position of OASI. A column split is used to punch both the X and the digit in column 54.

If the tax limit is not exceeded during the operation, the counter will be plus on program 9 and the negative balance selector would remain normal, allowing the OASI to punch without the X.

10. If the tax limit has been exceeded during the operation, the total tax payable will be 1% of the difference between the amount of earnings-to-date in excess of $3,000.00, and the gross pay. For example, if earnings-to-date including gross were $3,050.00 and the gross pay were $175.45, the OASI tax would be 1% of $125.45:

+3000.00	Tax limit
−3050.00	earnings-to-date
− 50.00	difference
+ 175.45	gross pay
125.45	taxable at 1%

In such a case, the counter which contains −$50.00 on program 10 should not be reset. Program 8 impulsed the balance test for program suppression, making it possible to suppress program 10 and thereby prevent the counter from resetting. This suppression is accomplished through the normal side of calculate selector 4, picked up on X54. Suppress without balance test is wired through the transferred side of the selector to suppress the program step for all X54 cards. The $50.00 remaining in the counter will be subtracted from $175.45 on the next step, and the tax would be based on the difference of $125.45. This amount represents the difference between $3,000.00 and $2,874.55 which was the previous earnings-to-date. If the counter were positive on program 8, indicating that the limit had not been reached, it would be cleared, and the whole gross amount of $175.45 would be subject to the 1% tax.

11. The gross pay is read out of FS 2 and added into the counter.

12. The gross pay becomes OASI by adjustment of the second position, giving the effect of offsetting one position.

13. OASI is read out of the 3rd position of the counter and stored in GS 3. The counter is reset.

14. Gross pay is again read out of FS 2 into the counter from which the deductions will be made to obtain net pay.

15. Withholding tax is read out of GS 4 and subtracted in the counter.

16. OASI is read out of GS 3 and subtracted in the counter. This program is suppressed for X54 cards by wiring suppress without balance test through the transferred side of selector 2 to program suppress.

Miscellaneous deductions are read out of FS 4 and subtracted in the counter.

18. OASI cannot be punched from GS 3, which receives information on the read cycle; therefore, it is transferred to the left-hand positions of the counter. This program is suppressed for X54 cards by wiring suppress without balance test through the transferred side of selector 2 to program suppress.

19. OASI and net pay are punched from the counter and withholding tax from GS 4.

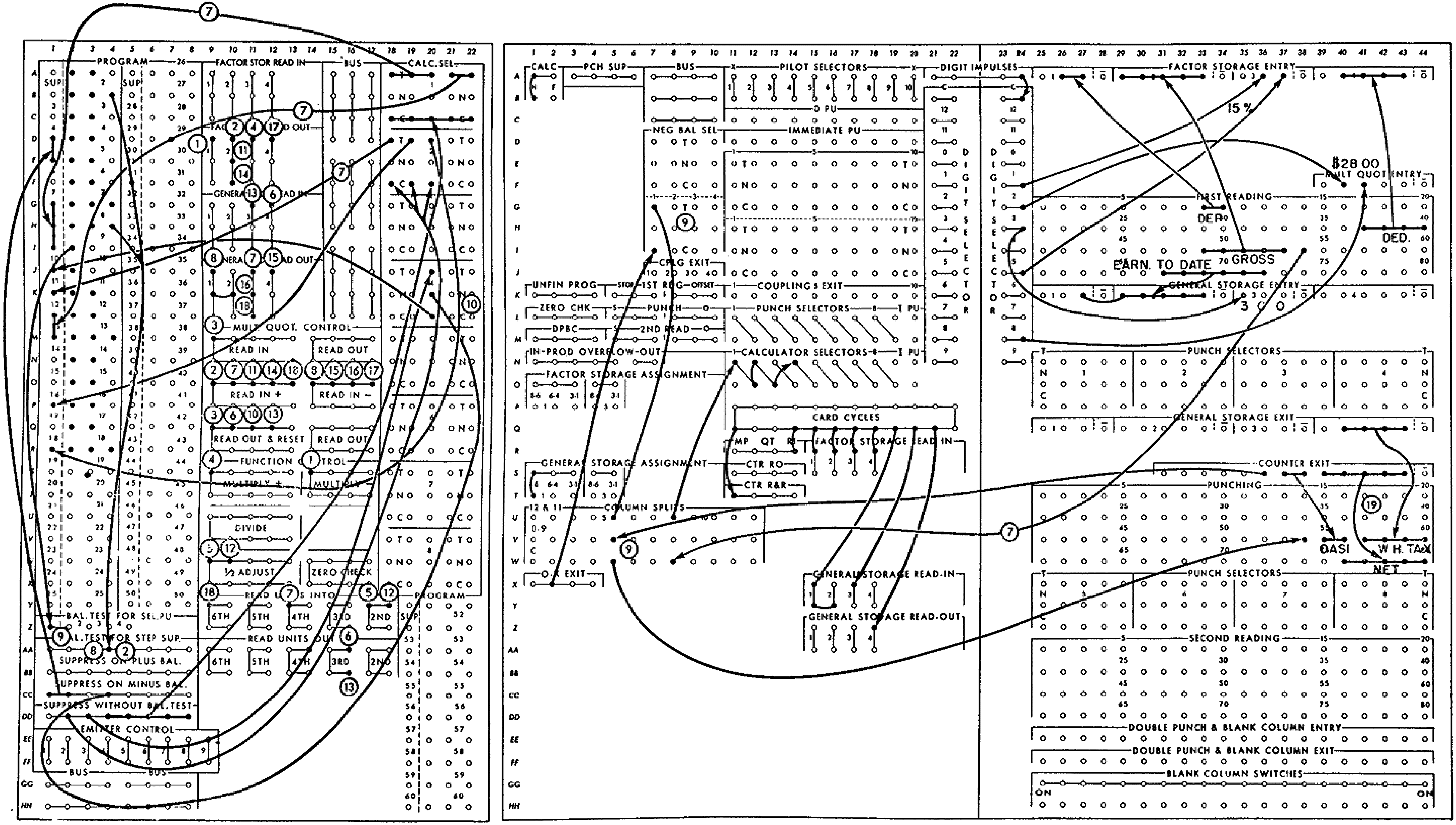


FIGURE 22A. CALCULATING WITHHOLDING TAX, OASI, AND NET PAY

No. of Dependents X Dependency Rate = Exemption Amount
Gross Exempt Am't = ± Taxable Am't (If −, No W. H. Tax)
+ Taxable Am't X Tax Rate = Withholding Tax Amount.
OASI Tax Limit − Earnings To Date = ± Tax Signal.
If Tax Signal +, 1% of Gross = OASI.
If Tax Signal −, 1% of Gross − Tax Signal = OASI.

APPLICATION Calculating W. H. Tax, OASI and Net — PROBLEM Gross − Withholding Tax − OASI − Misc. Deductions = Net Pay

Operation	Program Suppress	Program Number	Factor Storage 1 (6-4, 8-6)	Factor Storage 2	Factor Storage 3 (8-6)	Factor Storage 4	Mult Quot.	Counter	General Storage 1 (6-4, 8-6)	General Storage 2	General Storage 3 (8-6)	General Storage 4
READ		R	No. Dep 02	Gross 17545	Tax Rate 15%	Deduct 02500	Dep. Rate 2800		Earn. To 3	Date 05000	Tax Limit 300	
Mult. (−)		1	RO					−5600				
Bal. Test		2		RO				17545 / 11945				
		3					Tax. Am't 11945	R & R				
Suppress if Ctr Neg on Prog 2 — Mult. +	B	4			RO			179175				
Not Subject to Tax — ½ Adj. R.I. 2nd	B	5						5 / 179225				
RO 3rd		6						R & R				W.H. Tax 1792
RI 4th	X	7						300000			RO	
Bal. Test	X	8						− 305000 / − 5000	RO	RO		
X 54 Suppress For — BT for Sel. P.U. Punch X for over 3000.00	X	9										
Cards over $3000.00 — Suppress if Ctr is Neg.	X B	10						R & R if +				
Limit	X	11		RO				+ 17545 / 12545				
½ Adj. RI 2nd	X	12						5 / 12595				
RO 3rd	X	13						R & R			OASI 125	
		14		RO				17545				
		15						− 1792 / 15753				RO
	X	16						− 125 / 15628			RO	
		17				RO		− 2500 / 13128				
R I 6th	X	18						OASI 125			RO	
		19										
		20										
PUNCH		P						OASI 125 Net 13128				W.H. Tax 1792

FIGURE 22B

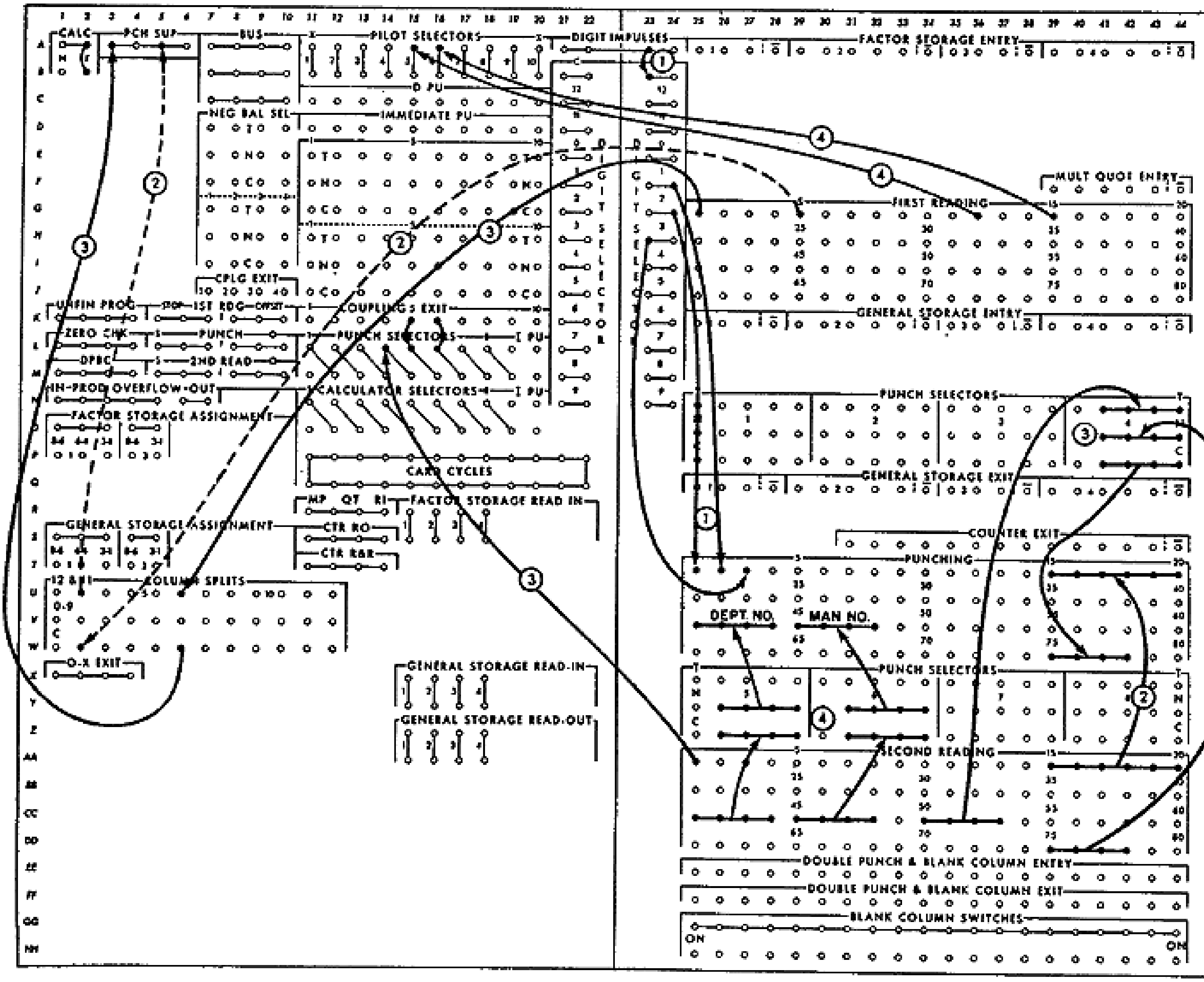


FIGURE 23. GANG PUNCHING

GANG PUNCHING

(Figure 23)

GANG punching may be done separately or as a part of the regular calculation. If it is done independently, the calculate switch on the control panel must be wired OFF to use the punch unit alone. The cable between the two units need not be disconnected.

1. *Emitter Gang Punching.* Digits may be punched from the digit selector, wired as a digit emitter.

2. *Straight or Interspersed Gang Punching.* Gang punching from a master card may be repetitive for all cards by wiring the field to be gang punched from 2nd reading to punch, column for column. Each card becomes a master card for the card following, as it reaches 2nd read.

Information to be gang punched from interspersed master cards is accomplished by suppressing the punching of master cards as shown by the dotted wiring. As the master card passes 1st reading, punch suppression is impulsed and one cycle later, as the master card passes the punch station, punching will be suspended.

3. *Offset Gang Punching.* When the gang punch field in the master card is different from that in the detail cards, gang punching must be offset. The master card field is selected through a punch selector so that the offset field in the master card will read to the punch station only when the X card reads at the 2nd reading station. The punch selector is transferred by wiring the X

impulse to the pickup from the second station. Punching is suppressed for all master cards by wiring the master card X from the first station to punch suppress. Column split is required when the master card X is punched over a digit in the same column.

4. *Major and Minor Gang Punching.* Major and minor gang punching may be done by the use of two pilot selectors coupled with punch selectors. The major field, such as department number, is wired through the normal side of punch selector 5, and the minor field, such as man number, is wired through the normal side of punch selector 6. Punch selectors 5 and 6 transfer when pilot selectors 5 and 6 transfer. Pilot selectors 5 and 6 transfer one cycle after major or minor X's are read at the first reading station.

DETERMINING CALCULATOR CAPACITY

ALTHOUGH storage capacity is a primary consideration when planning a complex problem, it is sometimes necessary also to consider calculating capacity. The calculating capacity is the number of electronic cycles that are available from the time the card has been read until it is ready to be punched as shown in Figure 1 on page 6. There are 252 electronic cycles available for calculation, regardless of the number of program steps with which the machine is equipped. These cycles start shortly after 9's are read from one card and continue until 12's are read from the next card. This interval is represented largely by the space between cards. One program step may be made up of one or more electronic cycles. For all operations except multiplication and division, one program step equals one electronic cycle. When multiplying or dividing one program step may consist of several electronic cycles, depending upon the number and value of the digits being calculated. For example, when multiplying 796 x 25, twelve electronic cycles are needed even though only one program step is used. When dividing 72 ÷ 6 thirteen electronic cycles are needed, even though only one program step is used.

Multiplication is performed by repetitive addition and the number of electronic cycles required may be determined by the methods used in the following example:

$$\begin{array}{r} 796 \\ \times 25 \\ \hline \end{array}$$

One test cycle is required for every position of the MQ unit	= 5	electronic	cycles
One cycle is required for each digit value in the multiplier (2+5 = 7) (The maximum could be 5 x 9 or 45)	= 7	"	"
One program step	12	"	"

The number of electronic cycles required in dividing operations may be determined by the methods used in the following example:

$$\frac{72}{6} = 12$$

An overdraw cycle and a correction cycle are required for each position of the MQ unit (5 x 2 = 10)	=10	electronic	cycles
Sum of the digits in the quotient (1 + 2 =3)	= 3	"	"
One program step	13	"	"

In combination problems where crossfooting, multiplication and division are combined and it is desired to compute the number of electronic cycles, it is best to write them down beside the program step. It is also advisable to assume that the value of each multiplier or quotient digit is 9, except in those cases where it is definitely known to be less. If the total number of electronic cycles computed is 252 or less, the unfinished program need not be considered.

The unfinished program hubs should be wired to first read stop on the punch control panel, whenever there is danger of the problem exceeding the calculating capacity. This is a protective measure and results in stopping the machine and turning on the unfinished program error light when such a condition arises. Under *Unfinished Program* on page 41, it is suggested that the cards causing the machine to stop, can be re-run one cycle at a time (depressing first the start then the stop keys). This allows more time between reading and punching and thus increases the number of electronic cycles available for calculation.

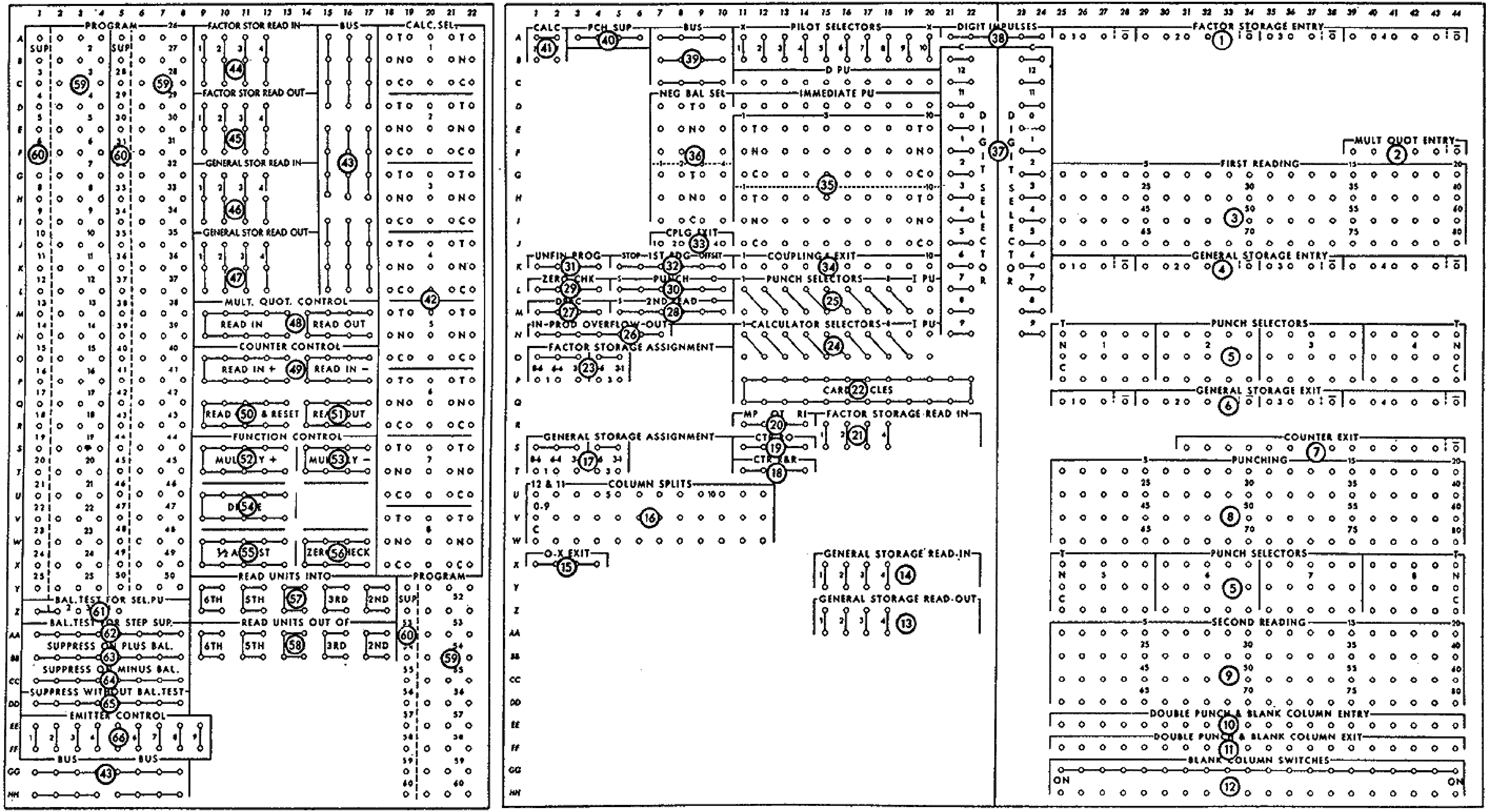


FIGURE 24. CONTROL PANEL SUMMARY

CONTROL PANEL SUMMARY

1. *Factor Storage Entry.* These hubs are entries to the factor storage units for factors read from the card or from the digit selector. They are normally wired from first reading, second reading or from the digit selectors. Factors read into the factor storage units at read time or during calculation may be stored until required in the calculation. These units cannot be used for punching.

2. *Mult Quot Entry.* These hubs are entries to the multiplier quotient unit for factors read from the card or from the digit selector. A multiplier must be entered into this unit but other factors may be stored there for later transfer in a calculation. Results cannot be punched from this unit.

3. *First Reading.* These hubs are exits from the 80 columns of the card at the first reading station.

4. *General Storage Entry.* These hubs are entries to the general storage units for factors read from the card or from the digit selectors. Factors read into the general storage units at read time or during calculation may be stored until required in the calculation. These units can be used for punching results if they are not required to accept factors from the cards.

5. *Punch Selectors.* There are eight 5-position punch selectors standard on the Type 604. Their pickup hubs are located on the second panel. When impulsed the selectors transfer immediately and remain transferred until the end of the card cycle.

Punch selectors are normally wired from first reading, to select factors from the card entering a storage unit. To select results to the punch hubs they are normally wired from storage exits or counter exits. Punch selectors are also used for interspersed or offset gang punching and are normally wired from second reading.

6. *General Storage Exit.* These are the exits from the general storage units for punching stored results. They are always wired to the punching hubs either directly or through selectors.

7. *Counter Exit.* The result of a calculation is always obtained in a 13-position electronic counter. The counter receives impulses only during calculation and never from the card. Results may be punched from the counter exits directly or through selectors.

8. *Punching.* The punching hubs are entries for punching results in any assigned columns of the card. They are normally wired from counter exits or general storage exits. They are wired from second reading for gang punching.

9. *Second Reading.* These hubs are exits from the 80 columns of the card at the second reading station. They are normally used for gang punching, for reading factors to be recalculated and checked, or for double punch and blank column detection.

10. *Double Punch & Blank Column Entry.* Ten double punch and blank column entry hubs are standard. They are entries for checking the presence of blank columns or double punching and are normally wired from second reading.

11. *Double Punch & Blank Column Exit.* Ten double punch and blank column exit hubs are standard. They are exits from the double punch and blank column entry hubs and are normally wired to the punching hubs when gang punch checking. In the event of a double punch only the lowest digit punched will be available, i. e., if 9 and 6 were punched, only the 6 would be available.

12. *Blank Column Switches.* These switches function only when the corresponding double punch hub is wired. When they are wired, blank columns are checked.

13. *General Storage Read Out.* These hubs accept only X impulses to read factors out of the general storage units for punching. They are normally wired from card cycles.

14. *General Storage Read In.* These hubs accept only X impulses to read factors into the general storage units at read time. They are normally wired from card cycles.

15. *0-X Exit.* These hubs emit both an X and 0 impulse every card cycle. The 0 and X may be separated by means of column splits.

16. *Column Splits.* Twelve column splits are standard. They are used to separate 0-9 punches from 11 and 12 punches.

17. *General Storage Assignment.* General storage unit 1 may be assigned to either 6th, 7th, and

8th channels or 4th, 5th and 6th channels by connecting the 8-6 or 6-4 to the common hubs above. General storage unit 3 may be assigned to the 6th, 7th and 8th channels by connecting the 8-6 to the common hubs above. The 3-1 hubs are inactive. A more detailed explanation of storage assignment will be found on page 24.

18. Ctr R & R. The counter read out and reset hubs are entries for card cycle impulses for reading out and resetting the counter at punching time.

19. Ctr RO. The counter read out hubs are entries for card cycle impulses for reading out without resetting the counter at punching time.

20. MP QT RI. The multiplier quotient read in hubs accept only X impulses, to cause a factor to enter the MQ unit from the card or from the digit selectors. When wired from card cycles, read-in is permitted on each card cycle. When wired from a reading brush, X impulses permit read in only from an X card.

21. Factor Storage Read-In. These hubs accept only X impulses to read factors into the factor storage units at read time. They are normally wired from card cycles.

22. Card Cycles. The 24 common card cycles hubs emit an impulse on each card reading cycle from X through 9. Since card movement is synchronized, a card cycles impulse may be used to control functions at all three stations at the same time.

23. Factor Storage Assignment. Factor storage unit 1 may be assigned to either the 6th, 7th and 8th channels or 4th, 5th, and 6th channels by connecting the 8-6 or the 6-4 to the common hubs above. Factor storage unit 3 may be assigned to the 6th, 7th and 8th channles by connecting the 8-6 to the common. The 3-1 hubs are inactive. A more detailed explanation of storage assignment will be found on page 24.

24. Calculator Selectors I PU. These are the pickup hubs for the calculate selectors located on the calculate control panel. When impulsed, they transfer the selector immediately. They are normally wired from first reading or from the couple exit of a pilot selector.

25. Punch Selector I PU. These are the pickup hubs for the punch selectors. When impulsed they transfer the selector immediately. They the normally wired from first or second reading or from the couple exit of a pilot selector.

26. In-Product Overflow-Out. The product overflow IN hubs are normally wired from one or more counter or general storage exit hubs that are in excess of the number of hubs wired to punch the result. If any digit other than zero is sensed, product overflow OUT will emit an X impulse which may be used to stop the machine or offset the card in the stacker.

27. D P B C. These double punch-blank column hubs emit an X impulse when the DPBC unit (10, 11, 12) is properly wired and a double punch or blank column is sensed. They are normally wired to 2nd read stop.

28. 2nd Read Stop-Offset. The hubs labelled S (stop) are entry hubs that accept X impulses to stop the machine for an error condition that is recognized at second reading. The machine stops after the card in error reaches the stacker. The offset hubs are optional. When these hubs are impulsed, the error card is offset in the stacker.

29. Zero Check. The zero check hubs emit an X impulse when the counter does not balance to zero on a checking step. They are normally wired to punch stop.

30. Punch Stop-Offset. The hubs labelled S (stop) are entry hubs that accept X impulses to stop the machine for an error condition that is recognized at the punch station. The machine stops after the card in error reaches the stacker. The offset hubs are optional. When these hubs are impulsed, the error card is offset in the stacker.

31. Unfin Prog. On rare occasions a calculation may not be completed in time to punch the card, in which case, no punching will take place and an X impulse will be emitted from the unfinished program hubs. This impulse is normally wired to first read stop.

32. Ist Rdg Stop-Offset. The hubs labelled S (stop) are entry hubs that accept an X impulse to stop the machine for an error condition that is recognized at the first reading station. The machine stops after the card in error reaches the stacker. The offset hubs are optional. When these hubs are impulsed, the error card is offset in the stacker.

33. *Cplg Exit (Neg Bal Sel)*. The couple exit hubs emit an impulse when the corresponding negative balance selector is transferred and are normally used to pick up punch or calculate selectors. Only number 1 is standard.

34. *Coupling Exit (Pilot Selectors)*. The couple exit hubs emit an impulse when the corresponding pilot selector is transferred and are normally used to pick up punch or calculate selectors. The first five are standard.

35. *Pilot Selectors.* There are five two-position pilot selectors standard, each having an X, D and immediate pickup hub. When the X or D pickup hubs are impulsed, the selector transfers on the following card cycle and returns to normal at the end of that cycle. When the I pickup hubs are impulsed, the selector transfers immediately and returns to normal at the end of the same cycle.

36. *Neg Bal Sel.* There is one negative balance selector standard. Its pickup hubs are located on the calculate control panel and are always wired from a program step during calculation. When the pickup hubs are impulsed, the selector transfers just prior to punching time and may be used to control functions on the punch control panel from certain conditions arising during calculation.

37. *Digit Selector.* Two digit selectors are standard. When the common (C) hubs are wired from first or second reading, impulses from the digit hubs will be available as the corresponding digits are read from the card.

38. *Digit Impulses.* When a digit selector is wired from a digit impulse hub, the digit selector becomes an emitter, each digit hub emitting its corresponding digit impulse on every card cycle.

39. *Bus.* These hubs are used to eliminate split wiring on the punch control panel.

40. *Pch Sup.* Complete suppression of all punching for any one card may be accomplished by wiring any digit or X punch to punch suppress, from first reading. If an X is punched over a digit, a column split must be used.

41. *Calc.* The calculate switch must be wired ON whenever the calculate and punch units are used together. It must be wired OFF when the punch unit is used independently of the calculate unit for gang punching operations.

42. *Calculate Selectors.* There are eight 5-position calculate selectors standard. Their pickup hubs are located on the punch control panel. When impulsed from first reading a calculate selector holds through calculation and is used to control program steps during calculation.

43. *Bus.* These hubs are used to eliminate split wiring on the calculate control panel.

44. *Factor Storage Read In.* Information may be read into factor storage units during calculation by wiring a program exit to factor storage read in. These units clear automatically on the read in.

45. *Factor Storage Read Out.* Information may be read out of a factor storage unit during calculation by wiring a program exit to factor storage read out.

46. *General Storage Read In.* Information may be read into general storage units during calculation by wiring a program exit to general storage read in. These units clear automatically on the read in.

47. *General Storage Read Out.* Information may be read out of a general storage unit during calculation by wiring a program exit to general storage read out.

48. *Mult Quot Control Read In – Read Out.* A factor may be read into or out of the MQ unit during calculation by impulsing the corresponding read in or read out hubs with a program exit.

49. *Counter Control Read In + Read In –.* The counter is impulsed to add or subtract during calculation by wiring a program exit to counter read in + or counter read in –.

50. *Counter Read Out and Reset.* The counter is impulsed to read out and clear during calculation by wiring a program exit to these hubs.

51. *Counter Read Out.* The counter may be impulsed to read out without clearing by wiring a program exit to these hubs.

52. *Multiply +.* These hubs accept program impulses to cause the machine to multiply on a positive basis.

53. *Multiply –.* These hubs accept program impulses to cause the machine to multiply on a negative basis.

54. *Divide.* These hubs accept program impulses to cause the machine to divide.

55. ½ *Adjust.* When the ½ Adjust hubs are impulsed from a program step, a 5 is added or subtracted in the units position of the counter (normally), according to whether the product is plus or minus.

56. *Zero Check.* These hubs accept program impulses to add a 1 into the units position of the counter (normally), which will result in a zero balance if every counter position previously stood at 9.

57. *Read Units Into.* Shifting from one to five positions may be done on any program cycle and the shift unit will return to normal at the completion of the program step. The units position of a factor in storage may enter the 2nd, 3rd, 4th, 5th or 6th position of another storage unit or counter during calculation by wiring a program step directly to the read units into hubs. Positioning of the ½ adjustment or zero check impulses are controlled by wiring read units into from a program step.

58. *Read Units Out Of.* Shifting from one to five positions may be done on any program cycle, and the shift unit will return to normal at the completion of the program step. Information may be read out of the counter starting with the 2nd, 3rd, 4th, 5th, or 6th position by impulsing one of the read units out of hubs, from a program step. The information will enter the receiving unit starting with the units position. This feature is normally used when transferring from counter to storage with decimals dropped.

59. *Program.* After one card is read and before the next card is read, the machine starts through a series of program steps. These program steps are electronic cycles which occur successively, and, during each, the machine can be controlled to perform a specific part of a required calculation. Twenty programs are standard. All of the program steps are always taken in a calculation, whether or not they are actually used. Each step has three independent outlets.

60. *Sup (Program Suppression).* A program step may be suppressed by impulsing the SUP hubs for that step from either the suppress on plus or minus balance hubs, or from the suppress without balance test hubs.

61. *Bal Test For Sel PU.* These are the pickup hubs for the negative balance selector located on the punch control panel. Only the first one is standard. They are always wired from a program exit and will cause the selector to pick up if the counter is negative on that program step.

62. *Bal Test For Step Sup.* When these hubs are wired from a program exit, the suppress on plus balance hubs will be active if the counter is plus and the suppress on minus balance hubs will be active if the counter is minus. These hubs will continue to be active until another program impulse reaches the balance test for step suppression.

63. *Suppress On Plus Bal.* When the balance test for step suppression hubs are impulsed, the counter is either positive or negative. If it is positive, the suppress on plus balance hubs will be active and may be used to suppress succeeding program steps.

64. *Suppress On Minus Bal.* When the balance test for step suppression hubs are impulsed, the counter is either positive or negative. If it is negative, the suppress on minus balance hubs will be active and may be used to suppress succeeding program steps.

65. *Suppress Without Bal Test.* These hubs emit on every program step and are normally wired through calculate selectors to suppress certain program steps for specific cards.

66. *Emitter Control.* The emitter can be used to enter a single digit into the counter, any storage unit or the MQ unit on a program step. Multiple digits can be entered into the counter only, one at a time, on as many program steps as there are digits. Digits are emitted and read into a unit by wiring a program step to a specific digit hub in the emitter and by impulsing the unit (counter, MQ, FS, GS) to read in. The digit normally goes to the units position but may be shifted up to 5 positions.

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