IBM

604

electronic calculating punch

manual of operation

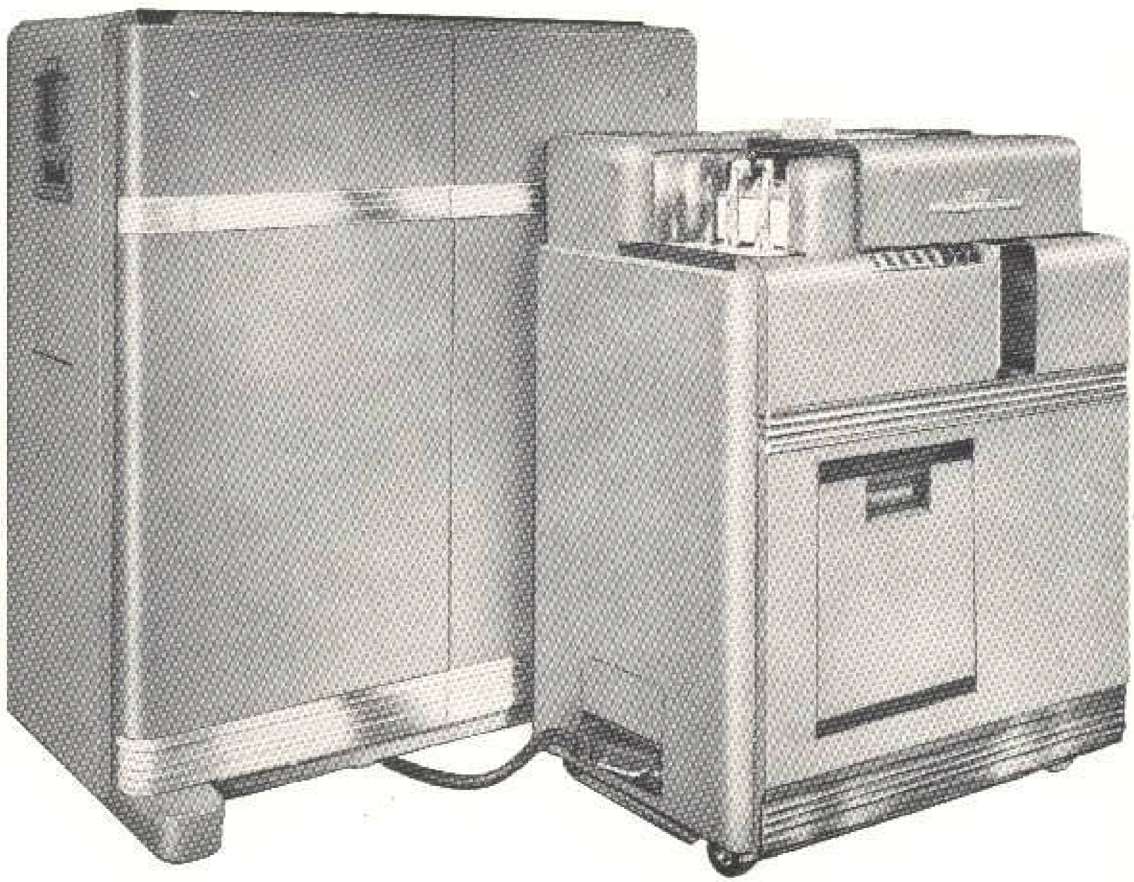
MINOR REVISION

This edition, Form 22-5279-10, is a minor revision of the preceding edition but does not obsolete Form 22-5279-9. Principal changes in this edition are:

PAGE	SUBJECT
7	Signal light operation.
13, 77	New description of X control in factor and general storage.
82	Special devices, control panel summary.

Form 22-5279-10

CONTENTS



IBM Electronic Calculating Punch
Type 604

IBM 604 ELECTRONIC CALCULATING PUNCH

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 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 results of up to 29 digits can be punched. The number of digits read from a card can be increased to a total of 37 by a corresponding reduction in the number of punching positions.

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, a 13-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. An original punched result is subtracted from a second calculation of the result and the difference is tested for a zero balance, to prove agreement between the two calculations. By control panel wiring, any discrepancy can stop the machine, or offset the card in the stacker if that feature is specified.

OPERATING PRINCIPLES

THE Electronic Calculating Punch consists of two basic units, which are connected by a cable:

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

The punch unit (Figure 1) has three card stations: a first reading station, a punching station, and a second reading station. Cards are placed in the hopper face down, twelve edge first. Factors are read from the card and transferred to the electronic calculating unit as the card passes the first reading station. All calculations are made by the calculating unit as the card moves from the first reading station to the punching station. Calculated results are then transferred back to the punch unit and punched in the card as it passes the punching station. At the second reading station, the card may be read for gang punching, recalculation, and double-punch and blank-column checking. Cards feed continuously from one station to the next at the rate of 100 per minute. Thus, while one card is being read for calculation, another card is being punched, and a third card may be read for checking.

The electronic calculating unit performs all calculations. It consists of seven basic parts:

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

Factor storage units store factors read from the card for use in developing results of a calculation, or store the results of a calculation for later use in developing further calculations.

General storage units can be used in the same manner as factor storage units and, in addition, when they are not used to store factors from the card, they may be used to store results of a calculation for punching purposes.

The multiplier-quotient unit is similar to factor storage units and, in addition, it may be used to store the multiplier factor when multiplying or to develop the quotient when dividing.

The electronic counter (13 positions) must be used during calculating time for the four basic arithmetical operations of adding, subtracting, multiplying, or dividing. Factors cannot be read directly from the card into the counter but results may be punched from the counter.

The program unit supplies electronic impulses to control operations, such as read in and read out functions of storage units and the counter, on specific program steps. Twenty program steps are standard, but the number may be increased to 40 or 60.

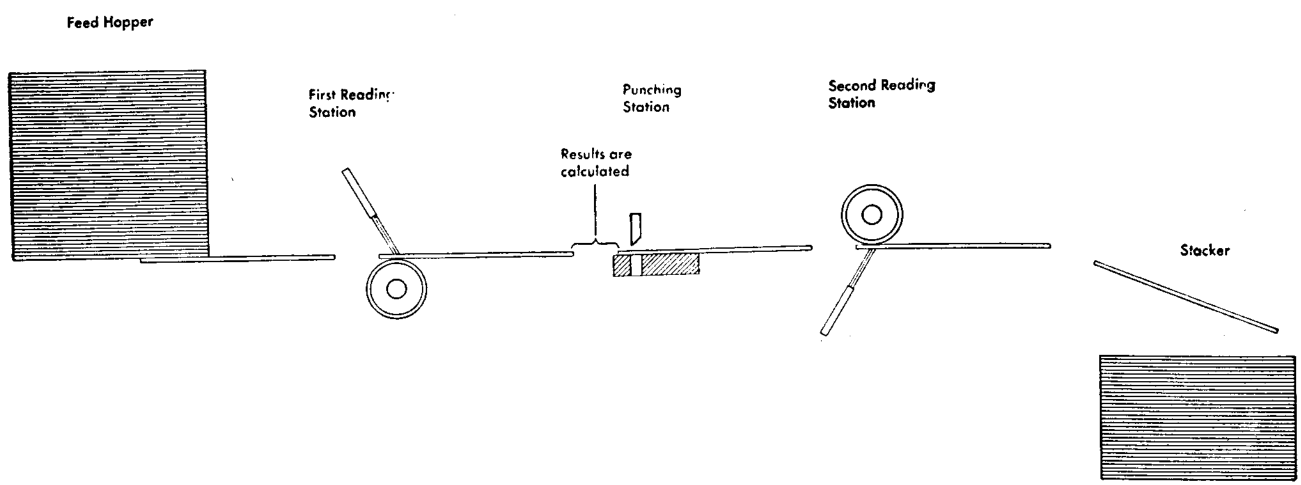


FIGURE 1. CARD STATIONS

Exits and entries of all storage units and the counter are connected together internally by an 8-position channel. This means that only one factor (1 to 8 positions) may be transferred over the channel on any one program step. The only control panel wiring required to effect the transfer is the read in and read out controls of the counter and storage units.

The shift unit permits factors transferred from a storage unit to the counter or from one storage unit to another to be shifted to the left as many as five positions. It also allows as many as five positions to be dropped when transferring results from the counter to a storage unit. This shifting is controlled by control panel wiring, and on any one program step is limited either to read in or to read out, but not both at the same time. The shifting which is inherent in multiplication and division is accomplished automatically by this unit on multiply and divide steps.

A schematic of the channel and shift unit is described in a later section of the manual.

OPERATING FEATURES, 521 PUNCH UNIT

OPERATING FEATURES of the Type 521 Punch Unit are shown in Figure 2.

Main Line Switch

When the main line switch on the punch is turned on and the POWER ON key on the calculating unit is depressed, power is supplied to both units. Operation may be started approximately three minutes later, during which time the electronic tubes heat. The red unlabeled light on the punch turns on when this switch is on.

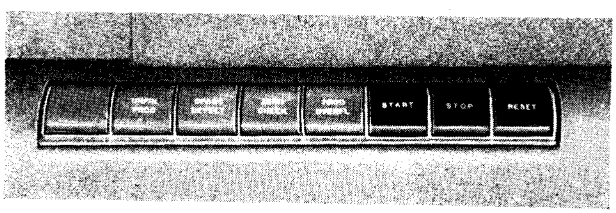


FIGURE 2. KEYS AND LIGHTS, TYPE 521

Start Key

The start key is depressed to feed the cards and to start calculation. This key is effective only when both unlabeled lights 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.

Stop Key

The stop key stops the operation of both the punch and calculating units when depressed.

Reset Key

When an error is signalled by one of the four lights located on the punch, the machine may be restarted after the reset key is depressed.

Light (unlabeled)

This light turns on when the main line switch is turned on. The light turns off as cards are passing through the machine and turns on again whenever the machine stops.

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.

OPERATING FEATURES, 604 CALCULATING UNIT

Operating features of the Type 604 calculating unit are shown in Figure 3.

Power On Key, Power Off Key

The power on and off keys operate like a main line switch for the calculating unit. When the power on key is depressed, power is supplied to the electronic tubes, the starting light turns on immediately, and the unlabelled light turns on after approximately three minutes if the main line switch on the punch unit is on. When the power off key is depressed, power to the calculating unit is turned off.

Starting Light

This red light turns on when the power on key is depressed and turns off when the unlabeled green light comes on.

Light (Unlabeled)

This green light turns on approximately three minutes after the power on key has been depressed. It indicates that the machine is ready to operate provided the main line switch on the punch unit is also turned on. The light turns off when the control panel in the calculating unit is removed.

Program Test Key, Program Test Light

Depressing the program test key makes it possible to operate the 604 one step at a time and causes the program test light to turn on immediately. Depressing the key a second time returns the 604 to high-speed operation.

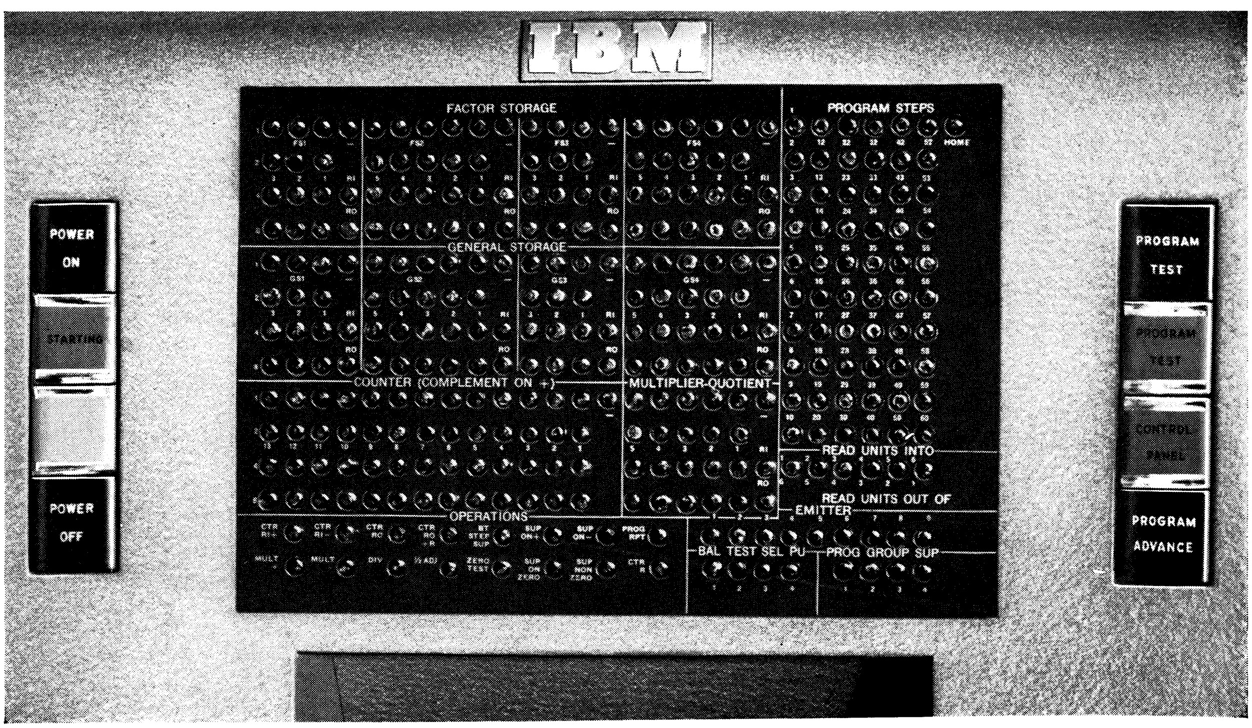


Figure 3. Keys and Lights, Type 604

Control Panel Light

This red light turns on when the control panel is removed from the 604.

Program Advance Key

The program steps (indicated by the PROGRAM STEP lamps on the neon panel) may be advanced one at a time by depressing the program advance key.

The *Indicator Lamp Panel* is described in a later section of the manual.

OPERATION

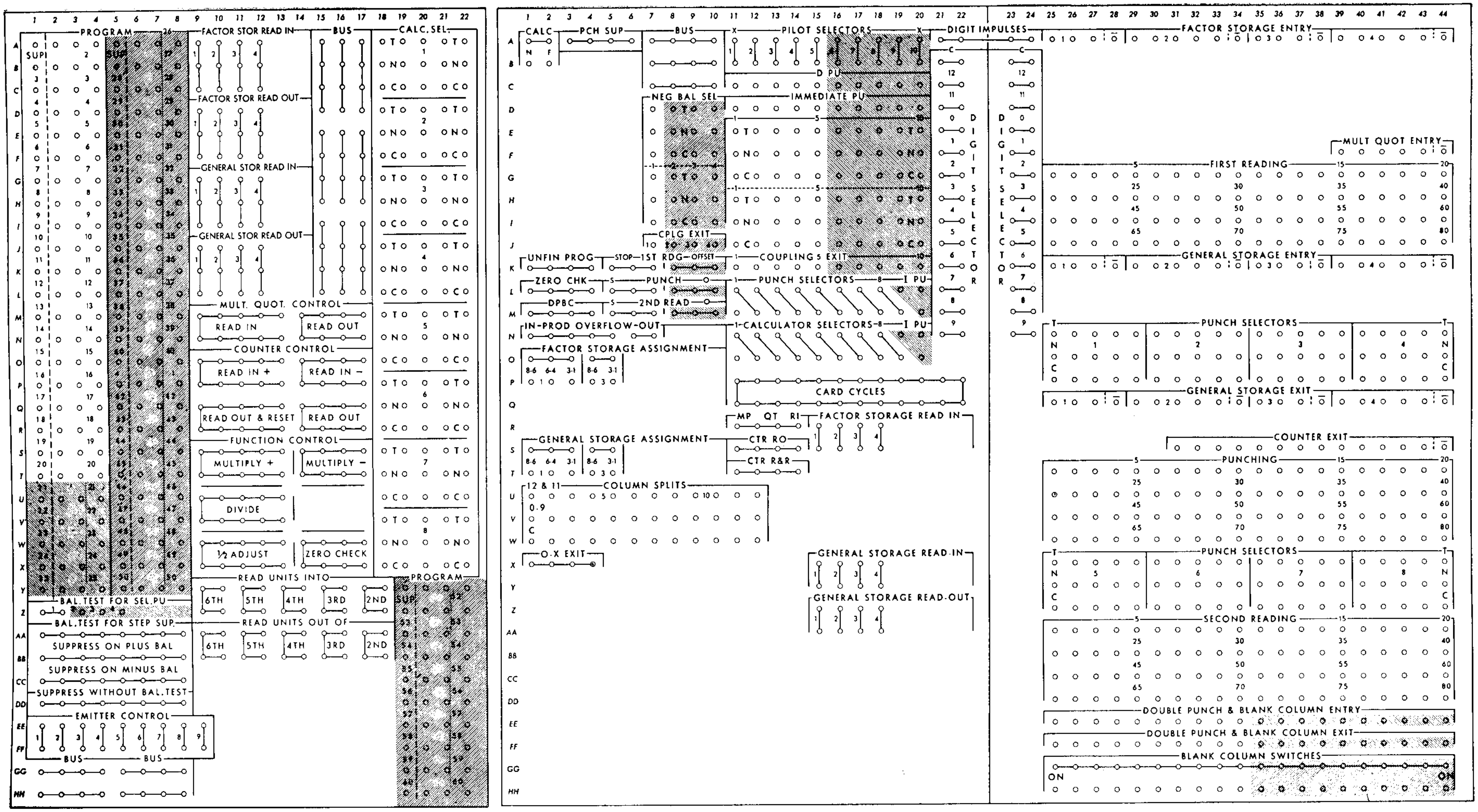
THE machine is prepared for operation by inserting properly wired control panels in each unit, by turning on the main line switch, located on the punch, and by depressing the start key on the calculating unit. The electronic tubes require approximately three minutes to heat before the machine is ready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

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

The punch unit start key is depressed to feed the cards and start calculations. The red unlabelled light on the punch turns off as cards are calculated, punched, and moved into the stacker continuously. The machine stops and the light turns 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.

Scheduling of work on the 604 should call for as continuous operation as possible. Leave the machine turned on if it is to be inoperative for a short period of time (one hour or less). If the calculator is inoperative for a longer period of time, it should be turned off.

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.



Calculator Control Panel, Type 604

Punch Control Panel, Type 521

FIGURE 4. CONTROL PANELS

The shaded hubs represent additional capacity.

A SEPARATE control panel (Figure 4) is required for the punch unit and for the calculating 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 calculator control panel.

The punch unit has a double panel and the calculating 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 calculator 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 calculating unit is positioned on the upper left side of the calculating unit.

Planning the Operation

A problem to be calculated on the 604 should first be studied to determine the most logical use of the storage units and the sequence 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 5) 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 allotted 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.

APPLICATION __________ PROBLEM __________

OPERATION NOTES	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		R										
		1										
		2										
		3										
		4										
		5										
		6										
		7										
		8										
		9										
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		14										
		15										
		16										
		17										
		18										
		19										
		20										
PUNCH		P										

FIGURE 5. PLANNING CHART

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 calculator 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:

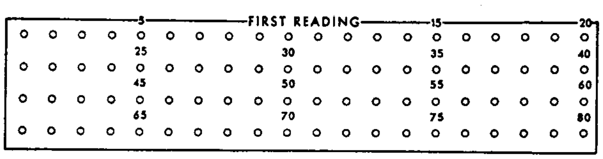
1. Explanation of the control panel hubs to be used in the problem and not previously used in a preceding example.
2. Read cycle wiring under the heading *Read.* This wiring concerns only the punch unit.
3. Program wiring under the program number itself. This wiring concerns only the calculating unit.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

CROSSFOOTING

A − B = ± T

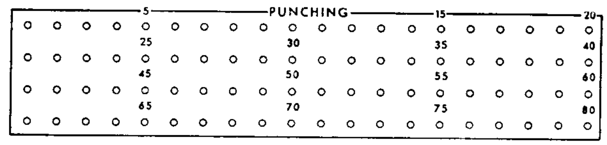
THE NUMBER of factors that may be crossfooted is limited only by the number of factors which may be stored in the machine on the read cycle. This example shows a simple crossfooting operation in which factor B is subtracted from A to give a plus or minus result T. If T is minus, the Type 604 will punch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

Factor Storage Entry (Pch 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. An X punch over any column, or over the units position for reasons other than sign control, must be eliminated by a column split. Without elimination in other than units positions, an incorrect zero may be entered. More than a single digit in a column causes the sum of the digits to enter storage without a carry. Factor storage entry or exit during calculation is controlled by the calculator control panel.

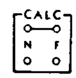


First Reading (Pch G-J, 25-44). These hubs are exits for factors read from the 80 columns of the card at the first reading station.

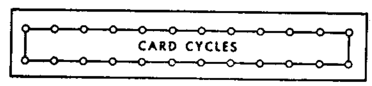
Counter Exit (Pch S, 31-44). The result of a calculation is always obtained in a 13-position electronic counter. The counter receives impulses only during a calculation, not from the card. Results can be punched from counter exit hubs.



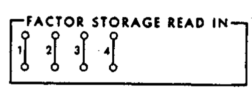
Punching (Pch T-W, 25-44). The punching hubs are entries for punching results in any assigned columns of the card. These hubs are wired for all punching, including gang punching.



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



Card Cycles (Pch P-Q, 11-22). The 24 common card cycles hubs emit an impulse after 12 through 9 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 (Pch 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.

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

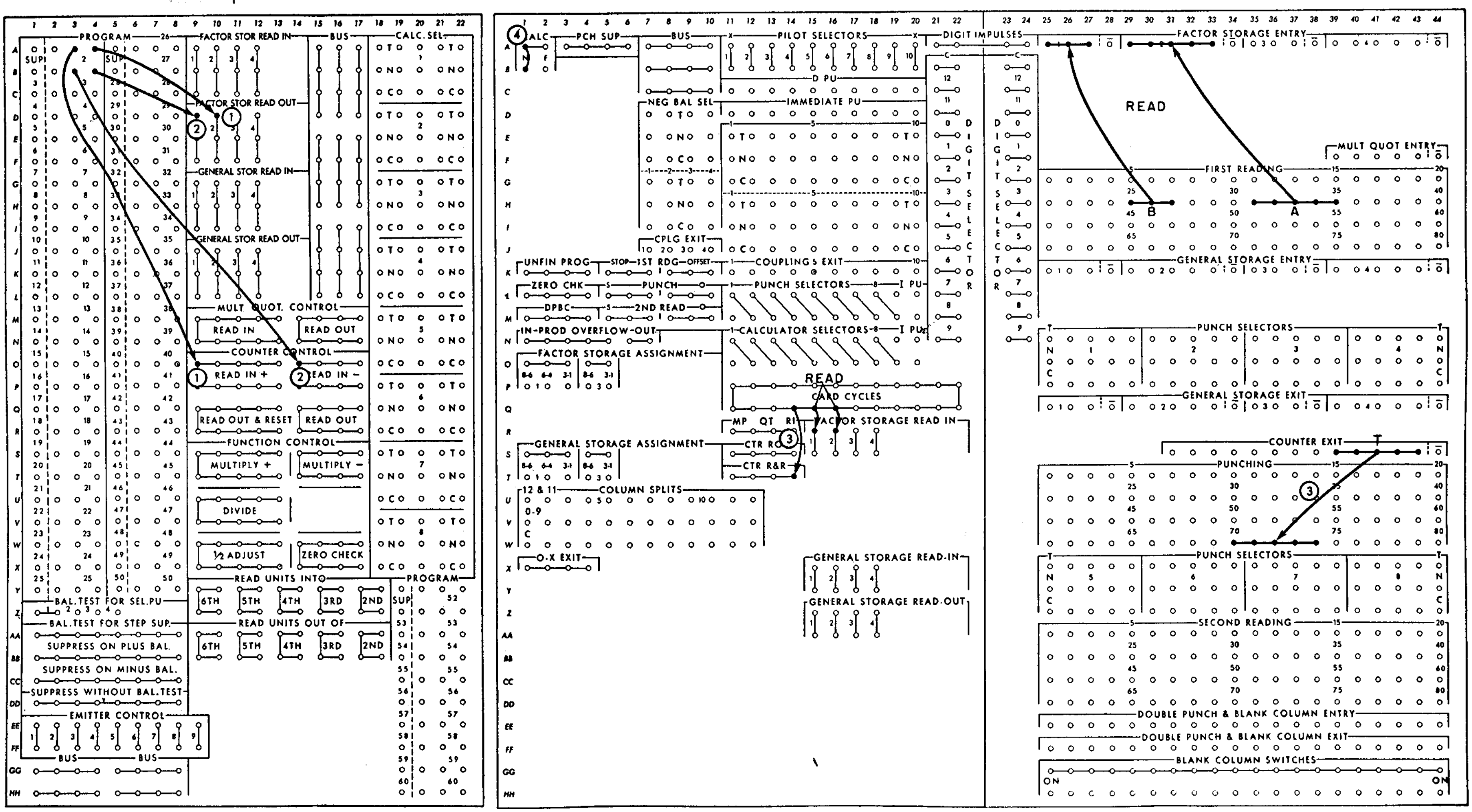
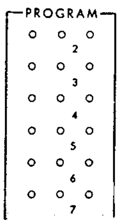


FIGURE 6A. CROSSFOOTING

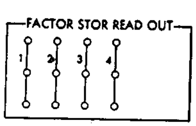
APPLICATION *Crossfooting* PROBLEM *A - B = ±T*

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		R	B 1.23	A 005.70								
Transfer A To Counter		1		RO				+A 5.70				
Transfer B To Counter		2	RO					-B 1.23 / +T 4.47				
PUNCH		P						R + R ± T 004.47				

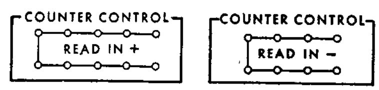
FIGURE 6B



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 exits. *A single program exit hub can be wired to only one function entry hub.* If wired to two or more entry hubs by split-wiring, coupling, or through a bus, the operating voltage of a single program exit hub is reduced so that none of the functions controlled will be performed correctly. *The only exception* to this rule is in the case of a 3-position storage unit which is assigned to operate in conjunction with another storage unit to handle 6-, 7-, or 8-digit factors. In that case the read in or read out hub of both storage units may be impulsed from one program exit.



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 calculator 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 calculator control panel accept program impulses to cause the counter to add during a calculation. The 8 common read in – hubs on the calculator control panel accept program impulses to cause the counter to subtract during a calculation.

PLANNING CHART AND WIRING DIAGRAM
(Figures 6A and 6B)

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.

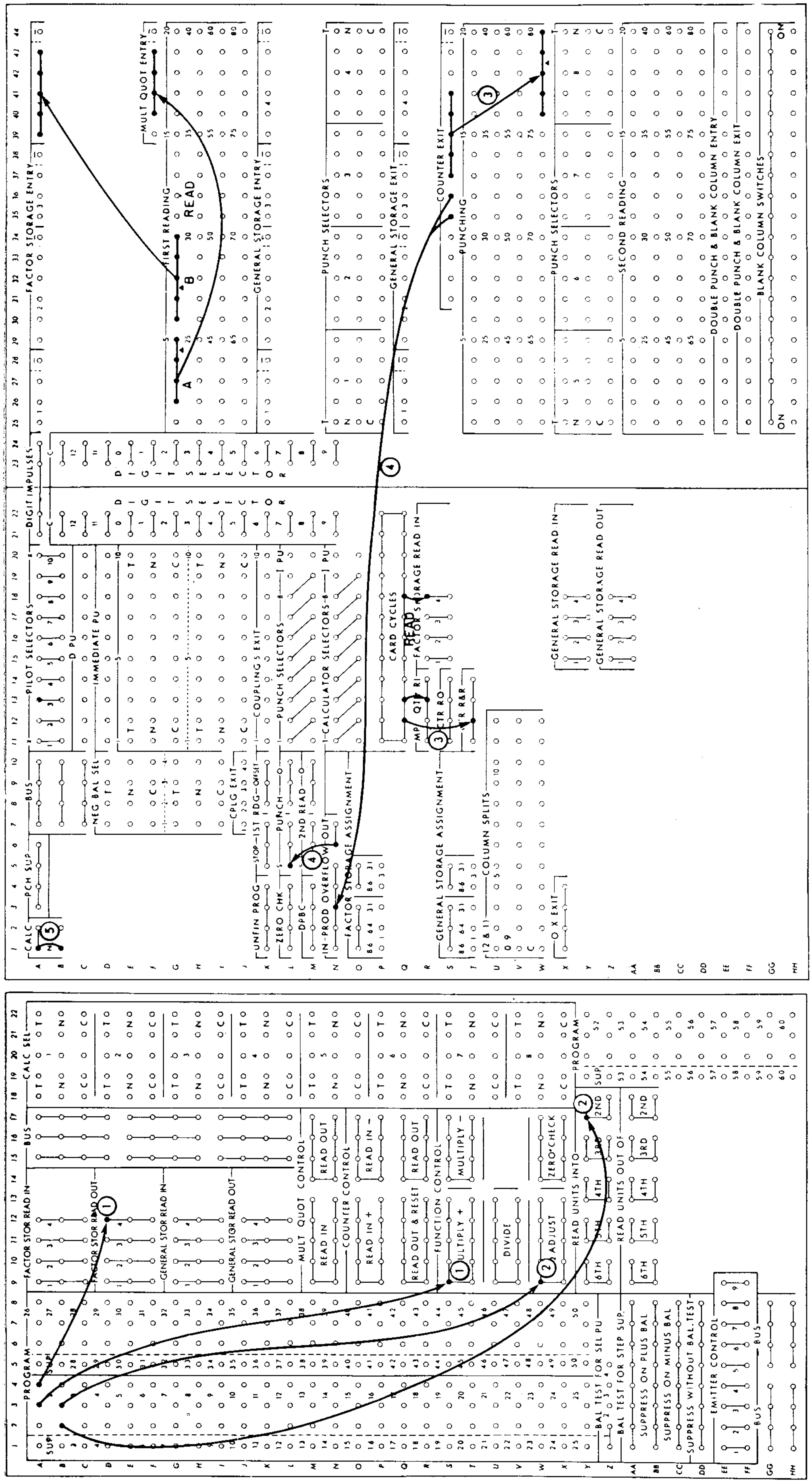


FIGURE 7A. MULTIPLICATION

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

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		R				(RATE) B 01255	(HRS) A 0600					
MULTIPLY		1				RO		753000				
½ ADJ. RI 2ND		2						5				
PUNCH		P						R & R 07530				

FIGURE 7B

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.

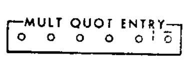
4. The calculate switch is turned ON for all calculating operations.

MULTIPLICATION

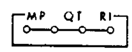
Hours × Rate = Earnings

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.

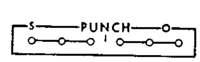


Mult Quot Entry (Pch G, 39-44). The multiplier quotient hubs are entries to a special 5-position storage unit into which the multiplier must be entered for multiplication operations. Factors can be entered into the MQ unit from the card or transferred to and from it during calculation. Results cannot be punched from the unit. An X punched over the units position of any factor for reasons other than sign control must be eliminated through a column split. The use of these hubs as quotient entries will be explained under *Division.*

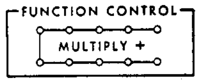


Mult Quot RI (Pch R, 11-14). These are the read in control hubs for entering information from the card into the MQ unit. They accept only X impulses and are normally wired from card cycles.

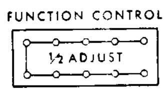
Product Overflow In-Out (Pch N, 1-7). The product overflow IN hubs are normally wired from one or more counter or general storage exit hubs that are in excess of the number of hubs wired to punch the result. While the product is being punched, if any digit other than zero is sensed, product overflow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



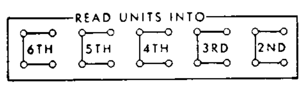
Punch Stop-Offset (Pch L, 5-10). These hubs accept impulses to stop the machine, or offset the card in the stacker (special device). The machine stops at the end of the cycle following the one on which the stop hubs are impulsed. They are normally wired to stop the machine for a condition recognized at the punch station, such as Product Overflow; this stops the machine when the card causing the condition reaches the stacker.



Multiply + (*Cal S-T, 9-13*). The multiply plus hubs, located on the calculator 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 step except when multiplying or dividing, 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 by wiring a program exit 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. READ UNITS INTO cannot be used when transferring factors from counter to storage.

PLANNING CHART AND WIRING DIAGRAM
(Figures 7A and 7B)

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 positions of which are dropped. The remaining two positions that are possible when multiplying 5 digits by 4 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.

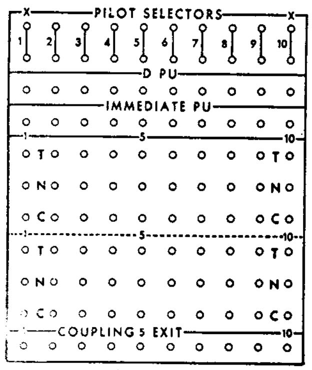
5. The calculate switch is wired ON.

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.

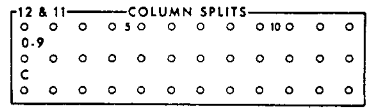
When storage units are controlled to read in directly from an X punched in the card, the X should not be punched over the factor to be stored. If X's are punched over factor fields, they should be eliminated through column splits.

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



Pilot Selectors (Pch A-K, 11-20). There are five 2-position pilot selectors standard, each having X, D (digit), and Immediate pickups. When the X or D pickup hub is impulsed, the selector transfers for the next cycle; when the immediate pickup hub is impulsed, the selector transfers immediately and remains transferred for the rest of that cycle. If the X or D pickup hub is impulsed, the coupling exit will emit an impulse when the selector transfers. It is normally used to pick up punch or calculator selectors. The coupling exit and the immediate pickup of the selector are common.

When a card cycles impulse is wired through the normal side of a pilot selector picked up by its immediate pickup, the pickup impulse must be a 12 punch. This is necessary because a card cycles impulse originates between 12 and 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 8)

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.

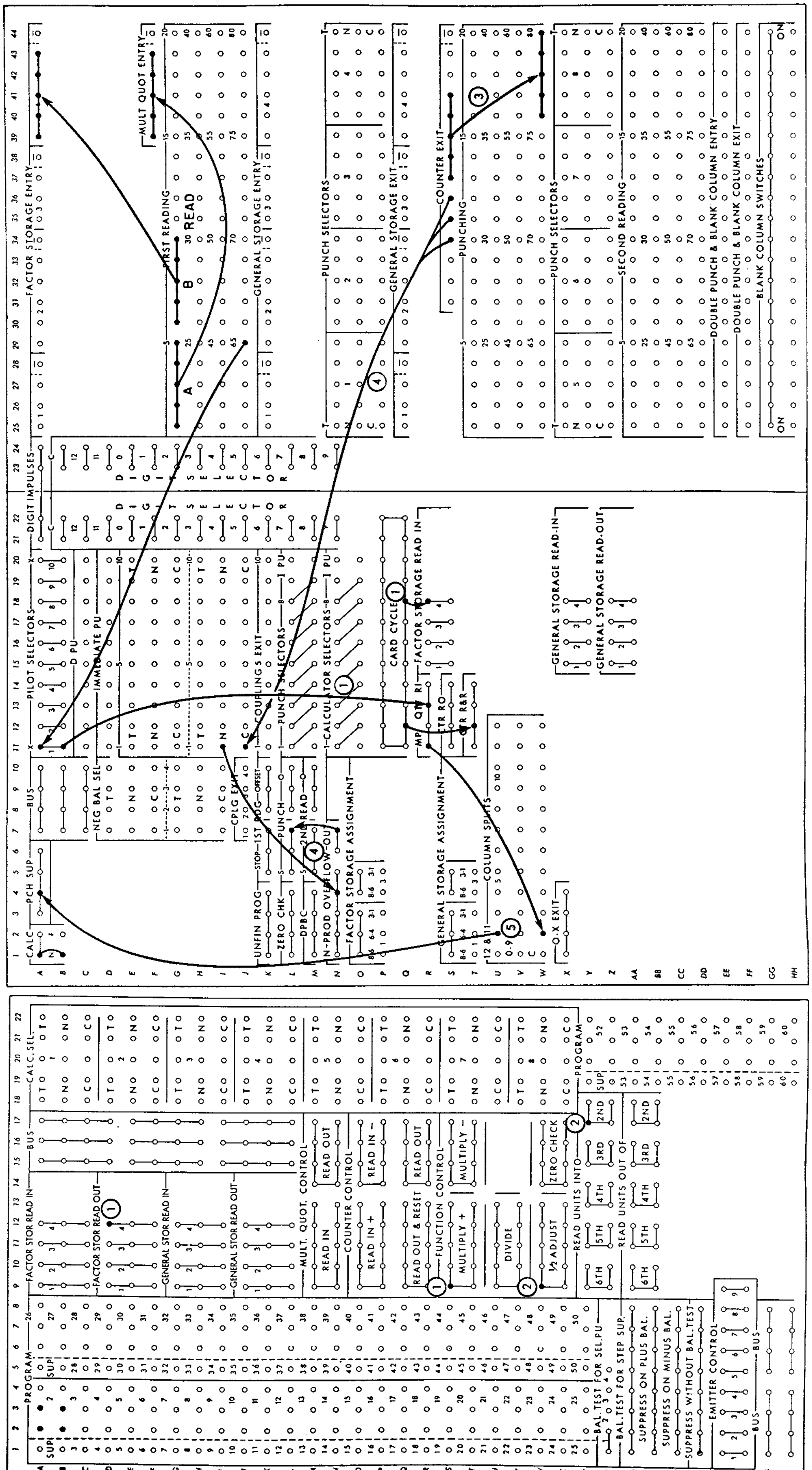


FIGURE 8. GROUP MULTIPLICATION

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

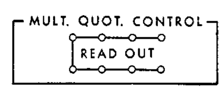
Total Pay ÷ Hours = Average Hourly Rate

A ÷ B = Q

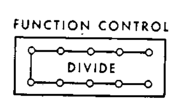
BASICALLY, the Type 604 provides a 13-position counter for the dividend, an 8-position storage unit for the divisor, and a 5-position storage unit for the quotient. If the dividend and the divisor are such that the quotient will exceed five positions, *the operation must be done in parts* (quotient expansion) 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 exit. 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 exit, 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.

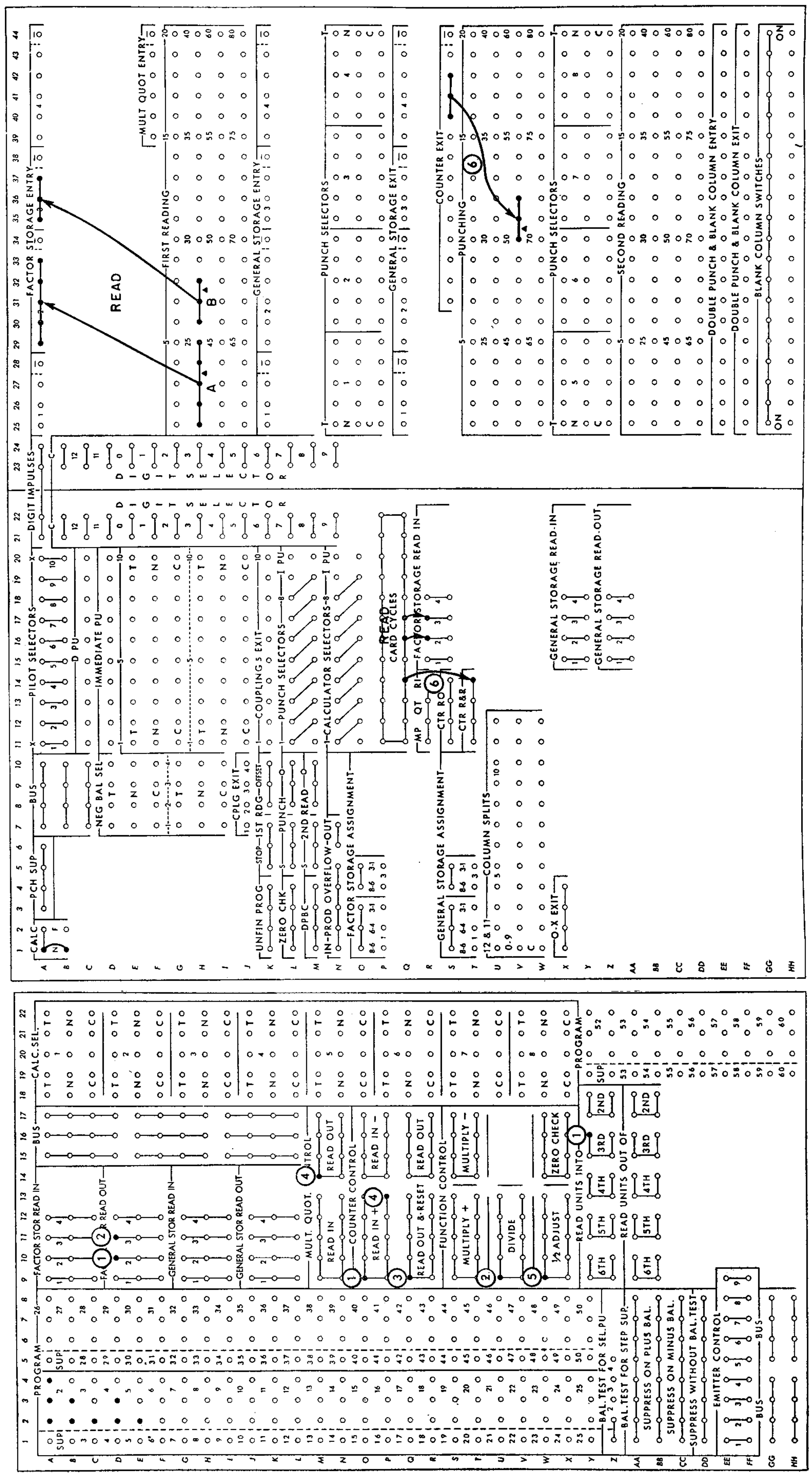
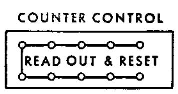


Figure 9A. Division

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

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		R		A 09575	B 409							
R.I. 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 9B



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 clears only when impulsed to clear and not upon entry of another factor.

PLANNING CHART AND WIRING DIAGRAM (Figures 9A and 9B)

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. It is positioned so that its decimal point lines up with the decimal position in the counter as determined by the following rule: the number of decimals in the divisor, plus the number of decimals desired in the quotient, plus one position for quotient half-adjustment determine the decimal position in the counter for the dividend. 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 a 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 × Unit Standard Time = Total Standard Time) ÷ Actual time = % over or under Standard

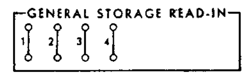
(A × B = P) ÷ C = R

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.

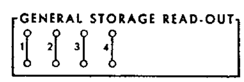
Results of each calculation may or may not be punched. Since punched results require storage space, the capacity depends largely upon how many of the results are to be punched.

General Storage Entry (Pch 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 calculator panel. Factors read into the general storage units may be held until required in a calculation and results may be punched from these units. An X punch over any column, or over the units position for reasons other than sign control, must be eliminated by a column split. Without elimination in other than units positions, an incorrect zero may be entered. More than a single digit in a column causes the sum of the digits to enter storage without a carry. General storage entry or exit during calculation is controlled by the calculator control panel.

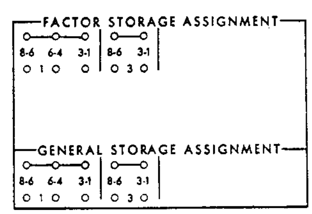
General Storage Exit (Pch Q, 25-44). These hubs are exits from the general storage units for punching results into the card. They are always wired to the punch hubs either directly or through selectors. When a general storage unit is wired to read in for some cards and punch (read out) for others, a selector is required not only to control storage read in and storage read out, but also to select general storage exits to the punch magnets. If general storage exits are wired directly to the punch magnets, X's will punch whenever STORAGE READ IN is impulsed.



General Storage Read In (Pch 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 (Pch Z-AA, 15-18). General storage read out hubs accept only card cycles impulses to read factors out of the general storage units for punching.



Storage Assignment: Factor (Pch O-P, 1-5), General (Pch S-T, 1-5). Normal channel connections between storage units is illustrated in Figure 10A. Under this arrangement channels 6, 7, and 8 are never used. Therefore, the size of factors that can be transferred on one program step is limited to five positions.

By use of storage assignment, three-position storage units (FS 1 and 3, and GS 1 and 3) may be shifted as illustrated in Figures 10B, C, D, E, F, and G, thus permitting the transfer of 6-, 7-, and 8-position factors on one program step. For example, factor storage 1 can be assigned to the left and controlled to operate in conjunction with FS 2, FS 4, MQ (when used for storage only —

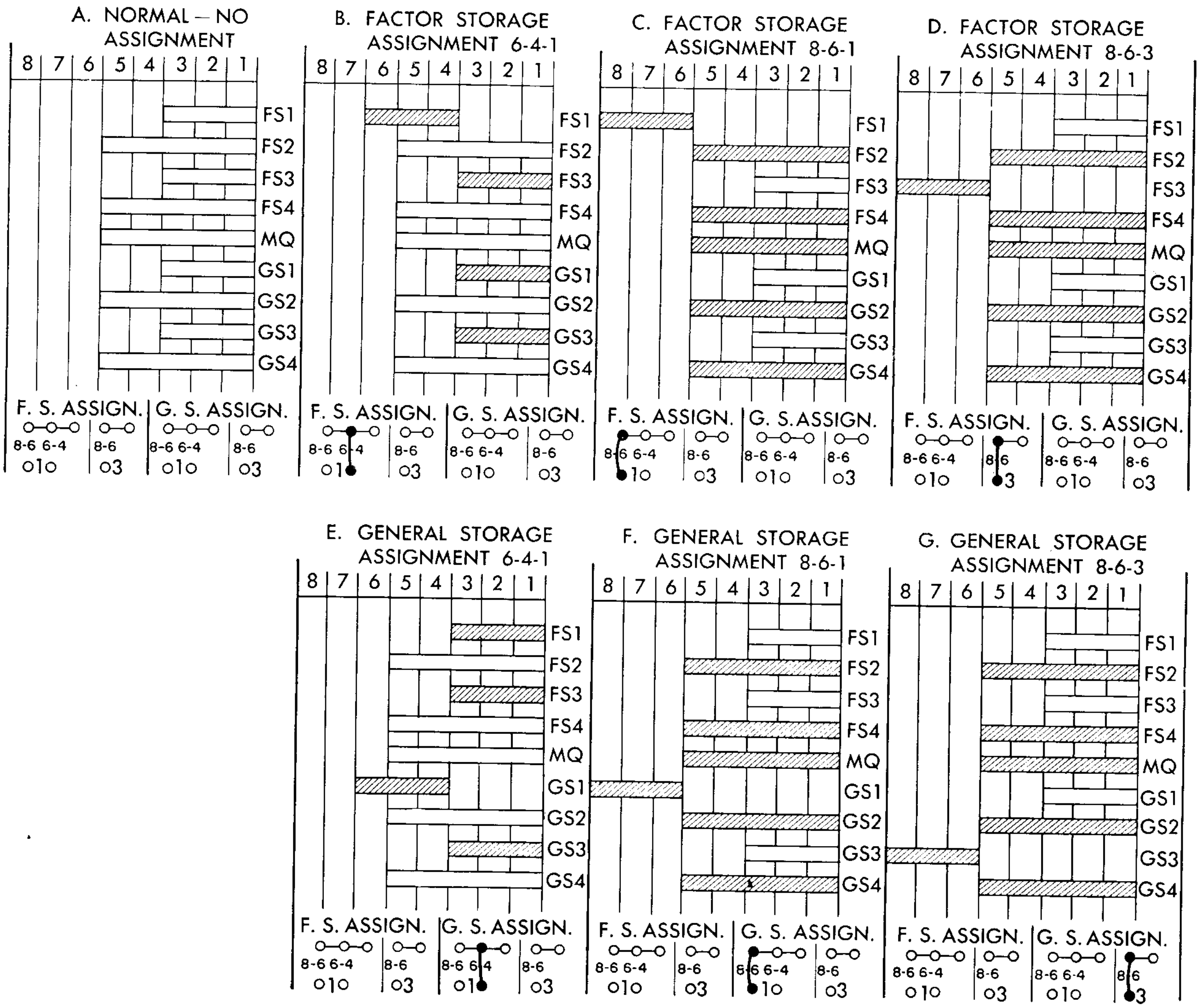


FIGURE 10. SCHEMATIC OF STORAGE ASSIGNMENT

not for a multiplier or quotient), GS 2, or GS 4. Wiring for storage assignment on the control panel merely positions a storage unit internally to the left; to make the unit operate in conjunction with another unit, the READ IN or READ OUT of both units must be impulsed on the same program step. When a storage unit is assigned, its sign control hub is inactive.

In *B* (FACTOR STORAGE 6-4-1 ASSIGNMENT), factor storage unit 1 reads over channel positions 4, 5, and 6, and can be used in conjunction with any other 3-position unit (shown by the shading) for 4-, 5-, or 6-digit factors. This assignment is made by wiring the hub labelled 6-4 for factor storage unit 1 to one of the three common hubs above.

E illustrates the 6-4-1 assignment for general storage which is the same as the 6-4-1 assignment for factor storage.

In *C* (FACTOR STORAGE 8-6-1 ASSIGNMENT) and *F* (GENERAL STORAGE 8-6-1 ASSIGNMENT), storage unit 1 reads over channel positions 6, 7, and 8, and can be used in conjunction with any 5-position unit. This assignment is made by wiring the hub labelled 8-6 for storage unit 1 to one of the three common hubs above.

In *D* (FACTOR STORAGE 8-6-3 ASSIGNMENT) and *G* (GENERAL STORAGE 8-6-3 ASSIGNMENT),

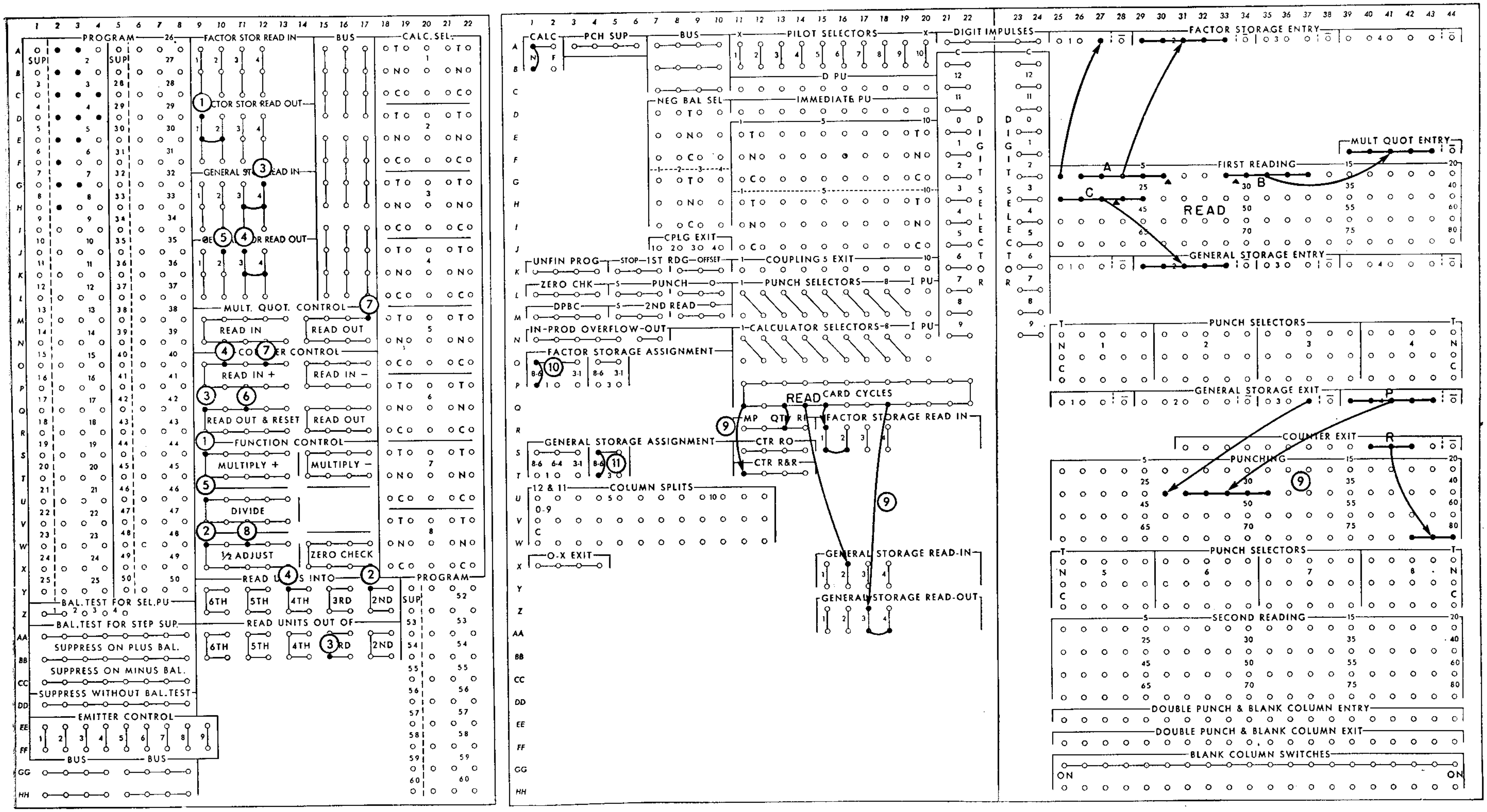


FIGURE 11A. SUCCESSIVE CALCULATION

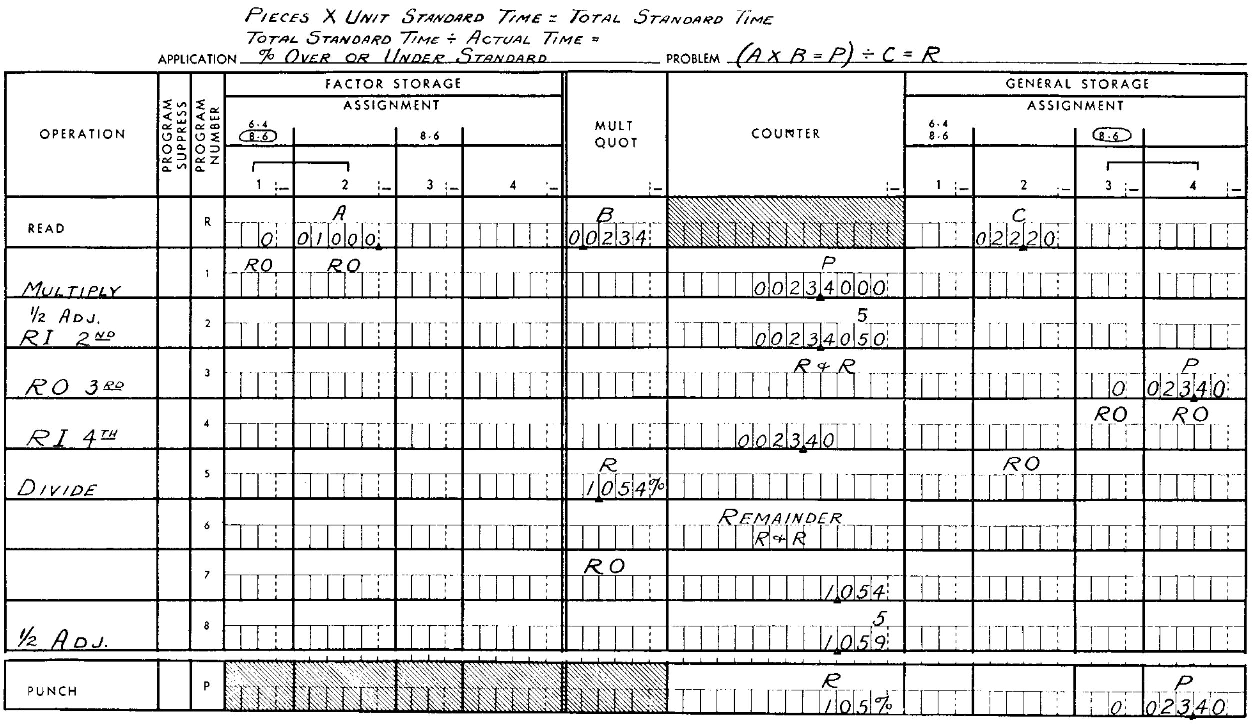
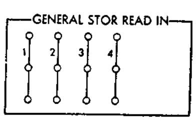
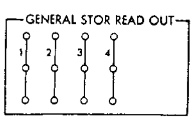


FIGURE 11B

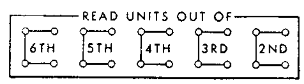
unit 3 reads over channel positions 6, 7, and 8, and can be used in conjunction with any 5-position unit. This assignment is made by wiring the hub labelled 8-6 for storage unit 3 to one of the two common hubs above.



General Storage Read In (Cal G-1, 9-21). Information is read into the general storage units during calculation by impulsing the general storage read in hubs with a program exit. 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 with a program exit.



Read Units Out Of (Cal AA-BB, 9-18). Shifting from one to five positions may be done on any program step except when multiplying or dividing, 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 11A and 11B)

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.

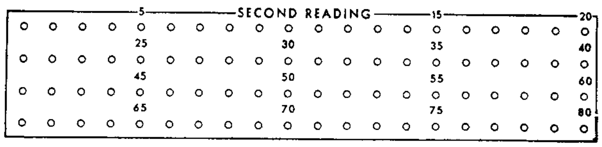
10. The six digit factor A exceeds the capacity of any one factor storage unit and it is necessary to make an assignment. FS 1 is assigned to the 6th, 7th, and 8th positions of the channel, and is used in conjunction with FS 2 which is connected to the first five positions of the channel.

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 is used in conjunction with GS 4 which is connected to the first five positions of the channel.

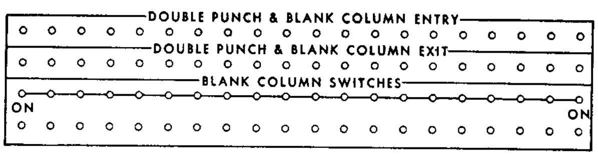
CHECKING MULTIPLICATION

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 (Pch 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.

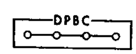


Double Punch and Blank Column Entry (Pch EE, 25-44). The double punch and blank column entry hubs check the presence of double punching. They also detect blank columns if the BLANK COLUMN SWITCHES are wired. The double punch entry hubs are normally wired from second reading and, when a double punch or 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 (Pch FF, 25-44). These hubs 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.

Double punch and blank column exits may be used as entries, in which case only blank columns can be checked. Columns checked for blanks may also be wired for gang punching if desired. In this case, if the information is numerical, double punch and blank column entry may be used as exits to the punch magnets; if the information is alphabetic, split wires are necessary.

Blank Column Switches (Pch GG-HH, 25-44). Columns wired to the double punch and blank column entry or exit hubs are checked for blanks (unpunched) only if the corresponding blank column switches are wired on, and there is a card at the second reading station. If a switch is wired on and a column is blank, an X impulse, which is normally wired to 2nd Read Stop or Offset hubs, is emitted from the DPBC hubs. Ten blank column switches are standard.



DPBC (Pch 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 (Pch M, 5-10). These hubs accept impulses to stop the machine, or offset the card in the stacker (special device). The machine stops at the end of the cycle on which the stop hubs are impulsed. They are normally wired to stop the machine for a condition recognized at the second reading station, such as DPBC; this stops the machine when the card causing the condition reaches the stacker.

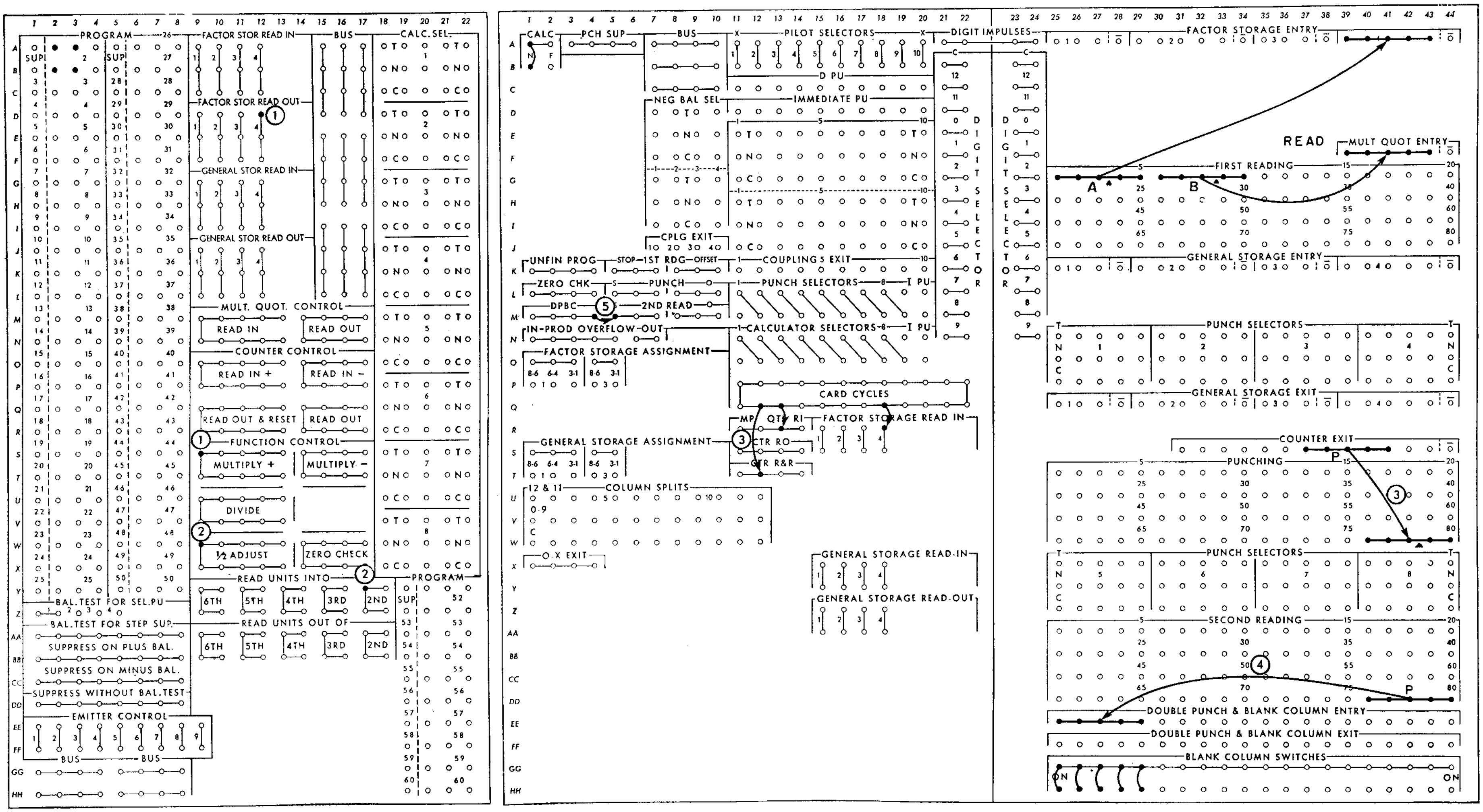


FIGURE 12. DOUBLE-PUNCH BLANK-COLUMN METHOD OF CHECKING MULTIPLICATION

WIRING DIAGRAM

(Figure 12)

The planning chart for this operation is not shown since it is sufficiently represented in the original multiplication chart (Figure 7B).

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 station.

Zero Balance Method

When sufficient storage capacity is available, results punched in one run can be subtracted from results recalculated in a second run to obtain a zero balance. If the two results balance each other, all positions in the counter stand at 9. When the zero check hub on the calculator panel is impulsed from a given program step, a 1 is added in the units position of the counter, thus turning all positions in the counter to zero. If all positions do not turn to zero, an error is indicated.

In cases where decimals are dropped and the result is half-adjusted in the first run, the decimals in the second run can be ignored by simply shifting the zero check impulse so that it enters the counter position immediately to the left of the dropped decimals. The zero check can be shifted and a correct check obtained only if the results of the first run are subtracted from the results of the second run.

In the first example below the zero check starts in the units position of the counter; in the second example it starts in the hundreds position.

First Example

9999999999974	(+25)* Result 2nd run
0000000000025	(−25)* Result 1st run
9999999999999	Result in counter before zero test
1	Zero check begins in units position
(1)0000000000000	Carry indicates zero balance
0000000000001	One in units position result of carry-back #

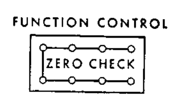
Second Example

9999999997423	(+ .2576)* Result 2nd run
0000000002500	(− .25)* Result 1st run
9999999999923	Result in counter before zero test
1	Zero check begins in hundreds position
(1)0000000000023	Carry indicates zero balance
0000000000024	Units position changed from 3 to 4 as result of carry-back #

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

#Counter resets automatically at the beginning of the next program step.

In problems requiring sign control of factors, the zero balance method can be used only if the decimals dropped in the first run are also dropped in the second run before the zero test is made. In this case, the recalculated result is read out of the counter into storage, dropping the decimals, and then added back into the counter, and the original result, in storage, is subtracted. When this method is used, the zero check impulse is entered into the units position of the counter.



Zero Check (Cal W-X, 14-17). When these hubs are impulsed by a program exit, a 1 is added in the counter. If the position in which the 1 is added and all positions to the left contain nines (zero balance), a carry impulse is emitted from

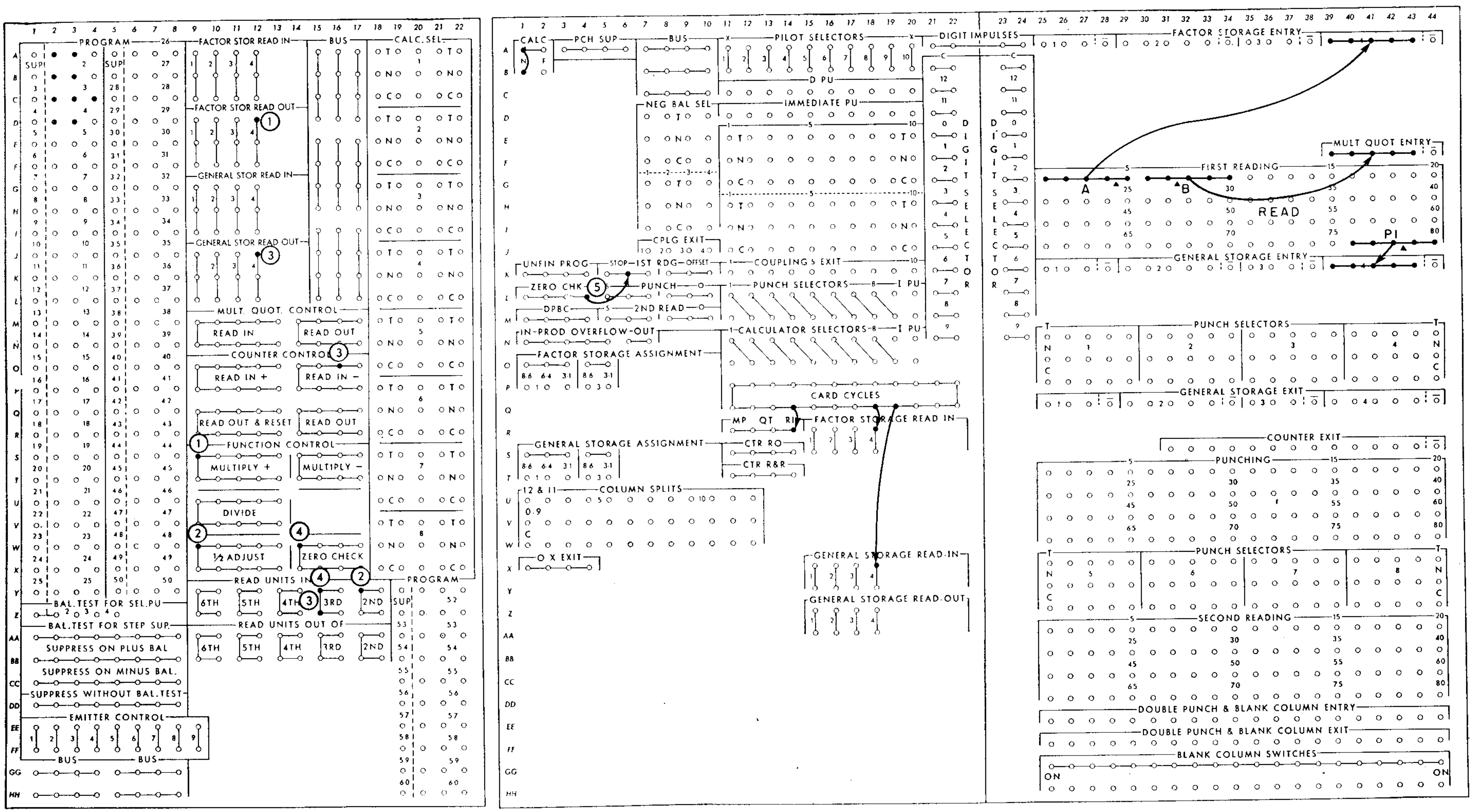


FIGURE 13A. ZERO BALANCE METHOD OF CHECKING MULTIPLICATION

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

OPERATION	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT 1 (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		R				A 00600	B 01255					P1 07530
Multiply		1				RO		P2 753000				
½ Adj. RI 2nd		2						5 753050				
Subt Prev Prod: RI 3rd		3						- 7530 9999999999949				RO
Zero Check RI 3rd		4						1 0000000000050				
		5										

FIGURE 13B

the left of the counter. This carry impulse, therefore, indicates a zero balance; the absence of a carry impulse indicates a non-zero balance. The 1 normally enters the units position of the counter, but it may be shifted as many as 5 positions to the left by impulsing READ UNITS INTO on the same program step.

Zero Check. (Pch 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 1ST READING STOP to cause the machine to stop three cycles later and the ZERO CHECK error light to turn on. It may also be wired to 1ST READING OFFSET, a special feature. First reading stop or offset is used because the error is recognized at the first reading station.

PLANNING CHART AND WIRING DIAGRAM
(Figures 13A and 13B)

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 1ST READING 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.

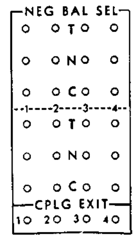
The counter automatically clears after each zero check.

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 is 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 calculator 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 calculator 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 emits only one impulse per card and can be used to pick up either a punch selector for the card just calculated, or a calculator selector for the next 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.

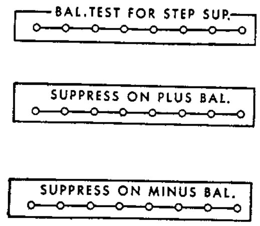
Minus on first test, second test is not required, and quotient is too small.

* This is a simplified version of the actual formula:

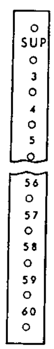
$$-A + B\left(Q + \frac{5}{10^{x+1}}\right) - \frac{1}{10^{y+1}} - \frac{B}{10^{x}} = \text{Check}$$

where, x = Number of decimals in Q

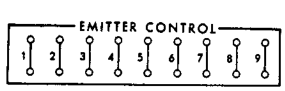
y = Total number of decimals in B and Q



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 with a program exit. If a balance is negative, the suppress on minus balance hubs become active on the following program and remain active until the end of calculate time or until tested on another program step. Similarly, the suppress on plus balance hubs are active for plus balances.

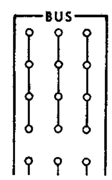


Sup (Cal A-Y, 1; A-Y, 5; Y-HH, 19). A program step may be suppressed by impulsing the SUP hub for that step, from either suppress on plus balance, or suppress on minus balance, providing balance test for step suppression had been previously impulsed. SUP hubs may be wired from suppress without balance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

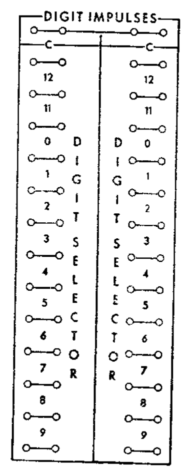


Emitter Control (Cal EE-FF, 1-9). The emitter can be used to enter a single digit into the counter, any storage unit, or the MQ unit on a program step. Multiple digits can be entered into the counter only. They are entered one at a time on as many program steps as there are digits. Multiple digits cannot 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 exit 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.

A number read from the emitter can be multiplied by a factor in the MQ unit on the program on which it is emitted. For example, if EMITTER CONTROL 5 and MULTIPLY + are impulsed on the same program, 5 will be multiplied by the factor in the multiplier unit. Similarly, in a division problem a constant divisor can be emitted on the program on which DIVIDE is impulsed.



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 calculator control panel and 3 sets on the punch control panel. They are used to expand entries or exits. The primary purpose of bus hubs is to eliminate split wires.



Digit Selectors — Digit Impulse (Pch A-N, 21-24). There are two digit selectors standard on

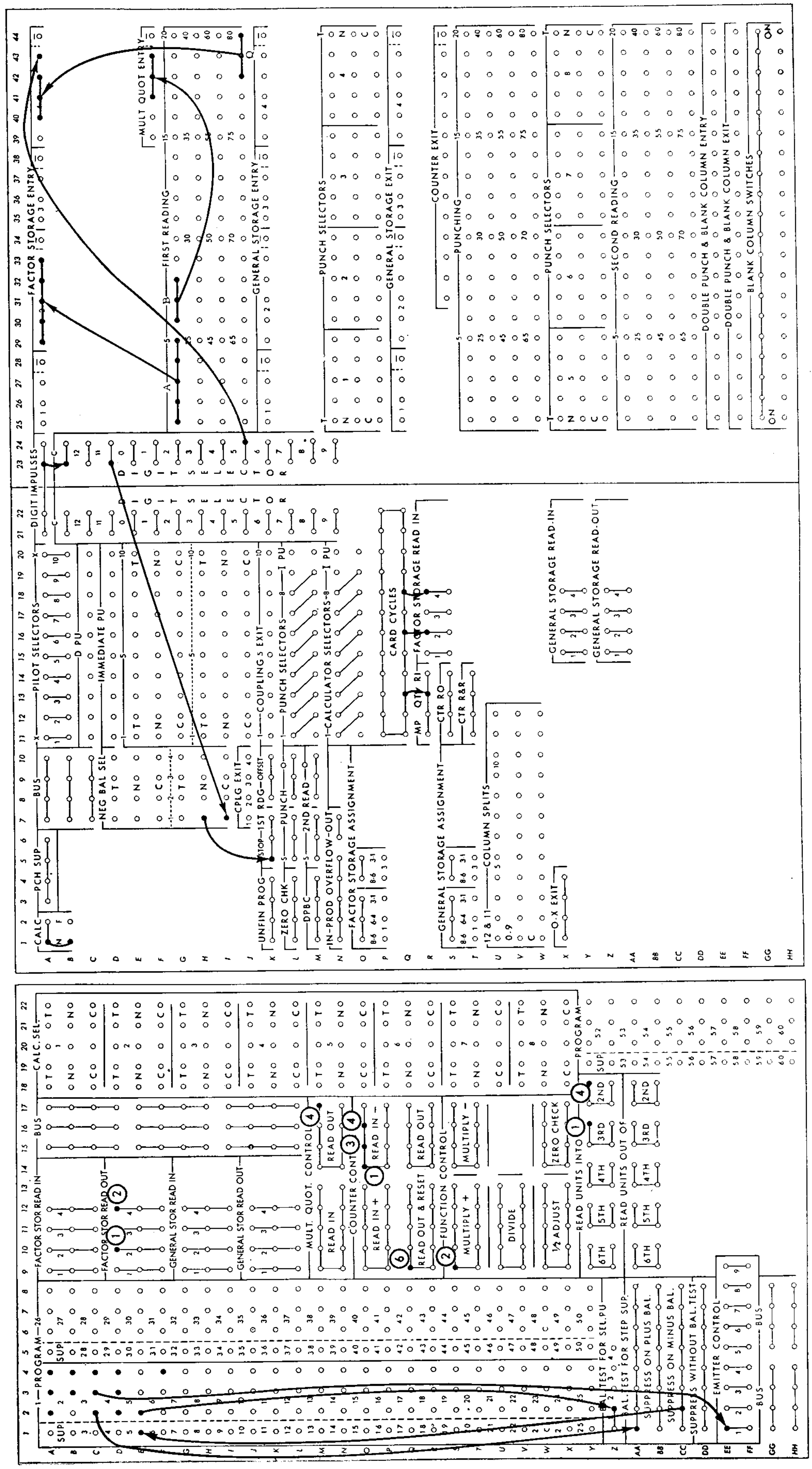


FIGURE 14A. CHECKING DIVISION

APPLICATION *Division Checking* PROBLEM *−A+ (QxB)+.5B −.1−B = 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 (6-6)	4
Emit 5 to units position of FS 4		R		A 095.75		Q 234⑤	B 4.09					
R.I. 3rd Subtract A		1		RO				−95.75				
Multiply		2				RO		+95.9105 / 1605				
1 from Emitter Test for Step Suppression		3						− .1 / 1604				
R.I 2nd		4					RO	− 409 / −2486				
Test For Sel. PU	NB	5										
		6						R & R				

FIGURE 14B

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.

PLANNING CHART AND WIRING DIAGRAM

(Figures 14A and 14B)

READ. The dividend (A) is read into FS2 and the divisor (B) into the M-Q unit. The quotient (Q) is read into FS4, starting with the second position. A 5 is emitted into the units position of FS4 by wiring the digit impulse hub to the C of a digit selector and the 5 hub of the selector to storage entry. The purpose of placing a 5 immediately to the right of Q is to allow .5B (disregarding the decimal position in B) to be automatically added to the product of Q × B.

1. The dividend is read out of FS2 and subtracted in the counter. It is entered into the counter starting with the third position so that the decimal will line up with the decimals in the product to be developed on the next program.

2. The quotient and .5 are multiplied by the divisor by reading out FS4 and impulsing multiply plus. The result standing in the counter satisfies the following part of the equation: −A + (Q × B) + .5B.

3. On this program .1 is subtracted, and the counter is tested to determine its positive or negative condition by impulsing BALANCE TEST FOR STEP SUPPRESSION. If the counter is positive, another test must be made to determine whether the quotient is correct; this test will be made on program 5. If the counter is negative, the quotient punched in the card is incorrect (too small), and program 5 will be suppressed.

4. The divisor (offset one position) is subtracted from the balance in the counter.

5. This program is suppressed if the counter was negative on program 3. If the counter was positive, the program is taken and the counter is tested again, this time by impulsing BALANCE TEST FOR SELECTOR PICKUP. If the counter is positive, the quotient punched in the card is incorrect (too large); if it is negative, the quotient is correct. On the punch panel, an 11 impulse is wired through the normal side of the NEGATIVE BALANCE SELECTOR to FIRST READING STOP. Thus, the machine stops for incorrect cards (either negative on the first test and the second test suppressed, or positive on both the first and second tests), since the selector is not transferred. It continues to run for correct cards (positive on the first test and negative on the second), since the selector is transferred.

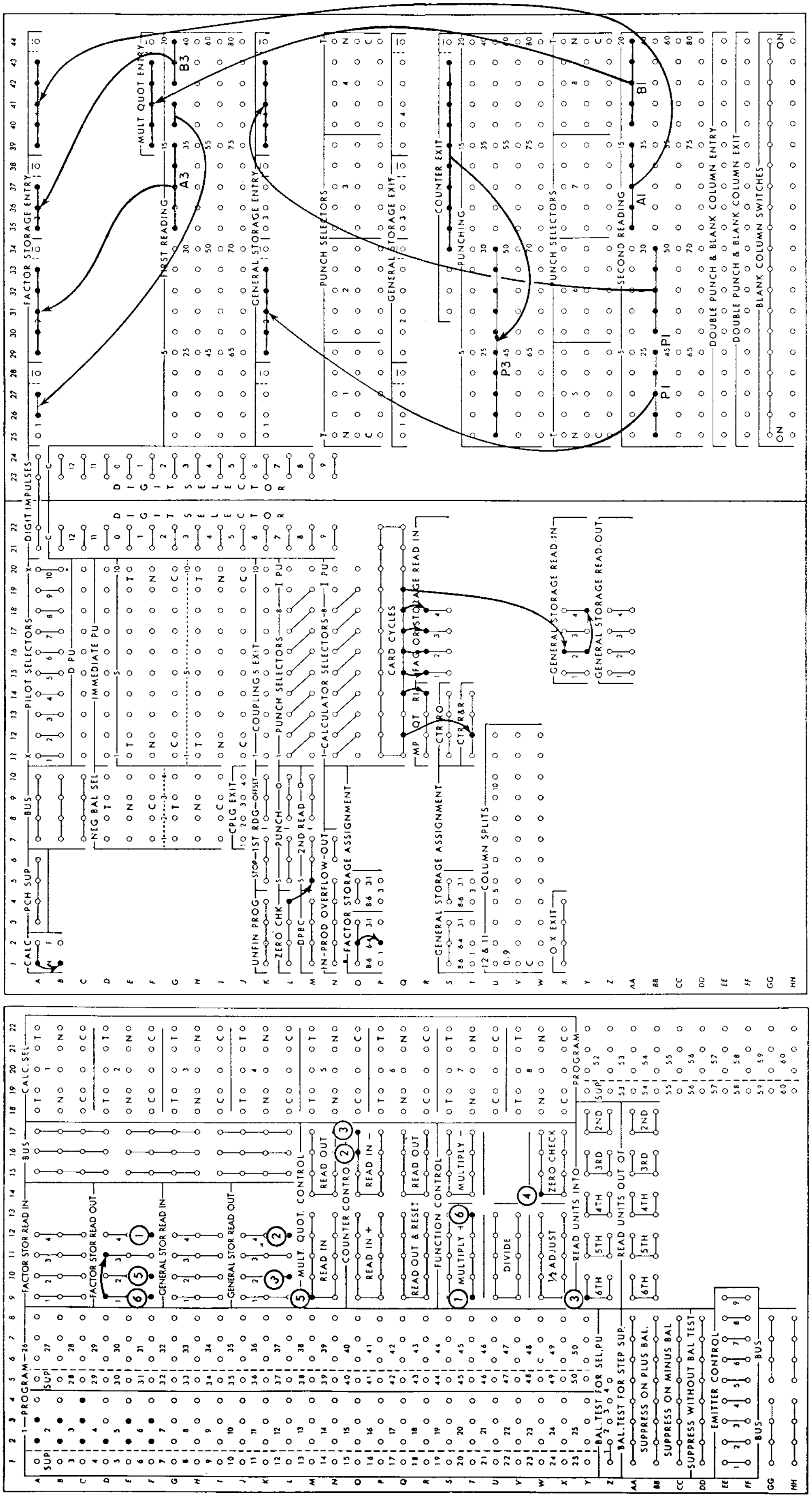


FIGURE 15A. SIMULTANEOUS MULTIPLICATION AND CHECKING

There is no light for this type of error, but the machine stops when the error card is in the stacker. The reset key must be depressed before re-starting.

On the run-in, the start and reset keys must be depressed alternately. After the fifth depression of the start key, automatic feeding will start unless the first card is an error card.

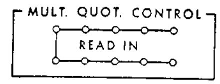
6. The counter is reset.

SIMULTANEOUS MULTIPLICATION AND CHECKING

Two 5-digit factors may be multiplied and the result punched and checked by reverse calculation in the same operation. Reference to the schematic diagram in Figure 15B will show that as card number 3 is at the first reading station, card number 2 is being punched and card number 1 is at the second reading station. Thus, during the third card cycle, while the product of card number 2 is being punched, factors may be read from card number 3 as well as factors and the product from card number 1.

Two separate calculations can then be performed during the same card cycle. The first will be B1 × A1 = P1 - P1 = Check; the second will be A3 × B3 = P3. Four program steps are required for the first calculation and two program steps are required for the second. The two calculations are performed on the same cycle from two different cards — card 1 is recalculated and checked against a punched result; card 3 is calculated for the first time and punched on the following card cycle. The sequence of operation for each card would be — first calculated, second punched, third re-calculated and checked.

Although the planning would be normally shown on one chart, a better understanding of the problem may be gained by treating each phase of the operation separately.



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

PLANNING CHART 1 AND WIRING DIAGRAM (Figures 15A and 15B)

Read (Second Reading). Factors A1 and B1, and product P1 are read from card 1 as follows: A1 into FS4; B1 into MQ; P1 (10 digits) into GS 2 and GS 4.

1. A1 is read out of FS 4 and multiplied by B1 to recalculate P1.

2. P1 in GS 2 and GS 4 is subtracted from P1 in the counter. Since there are only 8 channels available for transfer and P1 has 10 digits, the transfer must be accomplished on two program steps. The low order digits of P1 are read out and subtracted from P1 in the counter.

3. The high order digits of P1 are read out (units into 6th) and subtracted from P1 in the counter.

4. Zero check can now be made. It is accomplished by wiring program number 4 to ZERO CHECK on the calculator control panel, and ZERO CHECK to 2ND READ STOP on the punch control panel. The counter is reset automatically when zero check is impulsed.

PLANNING CHART 2 AND WIRING DIAGRAM

Read (First Reading). A3 is read into FS 2; B3 is read into FS 1 and FS 3. This requires a 6-4-1 factor storage assignment.

5. A3 is read out of FS 2 and transferred into MQ.

6. B3 is read out of FS 1 and FS 3 and multiplied by A3. The product P3 is developed in the counter.

Punch. The counter is cleared by wiring card cycles to Ctr R & R on the punch control panel and the result is punched in the card from counter exit.

CHART 1

APPLICATION ______ PROBLEM B1 x A1 = P1 − P1 = 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
R	READ Card 1 from 2nd Reading		R				A1 99999	B1 66666			P1 66665		P1 33334
1	Multiply (Recalculation)		1				RO		(P1) 0006666533334				
2	Subtract low order digits (P1)		2						− 33334 0006666500000				RO
3	Read units into 6th Subtract high order digits (P1)		3						−66665 0000000000000		RO		
4	Zero Check		4						←Zero Check→				
5			5										

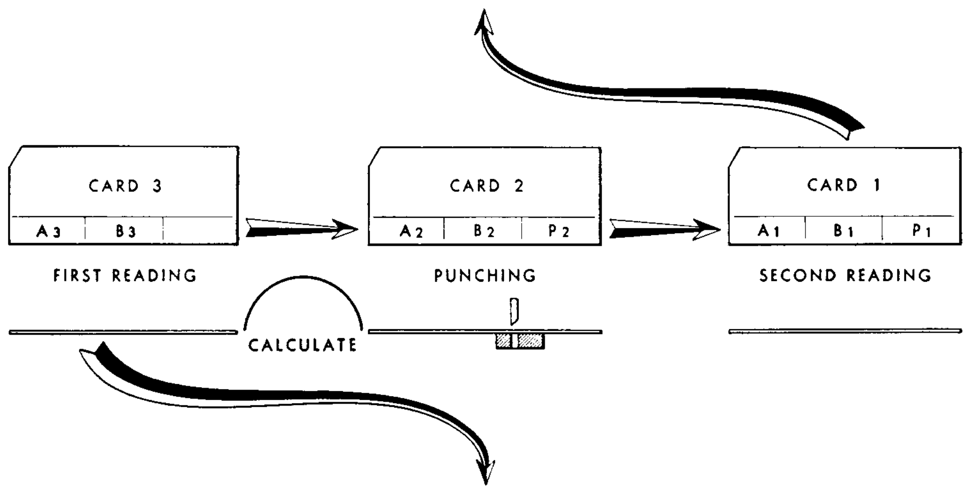


CHART 2

APPLICATION ______ PROBLEM A3 x B3 = P3

	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
R	READ Card 3 from 1st Reading		R	B3 77	A3 88888	B3 777							
1			1										
2			2										
3			3										
4			4										
5	Transfer Multiplier from FS2		5		RO			A3 88888					
6	Multiply		6	RO		RO			(P3) 6913441976				
P	PUNCH		P						R&R P3 6913441976				

FIGURE 15B

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 split into parts and multiplied to obtain part-products which are 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
666659925926
```

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

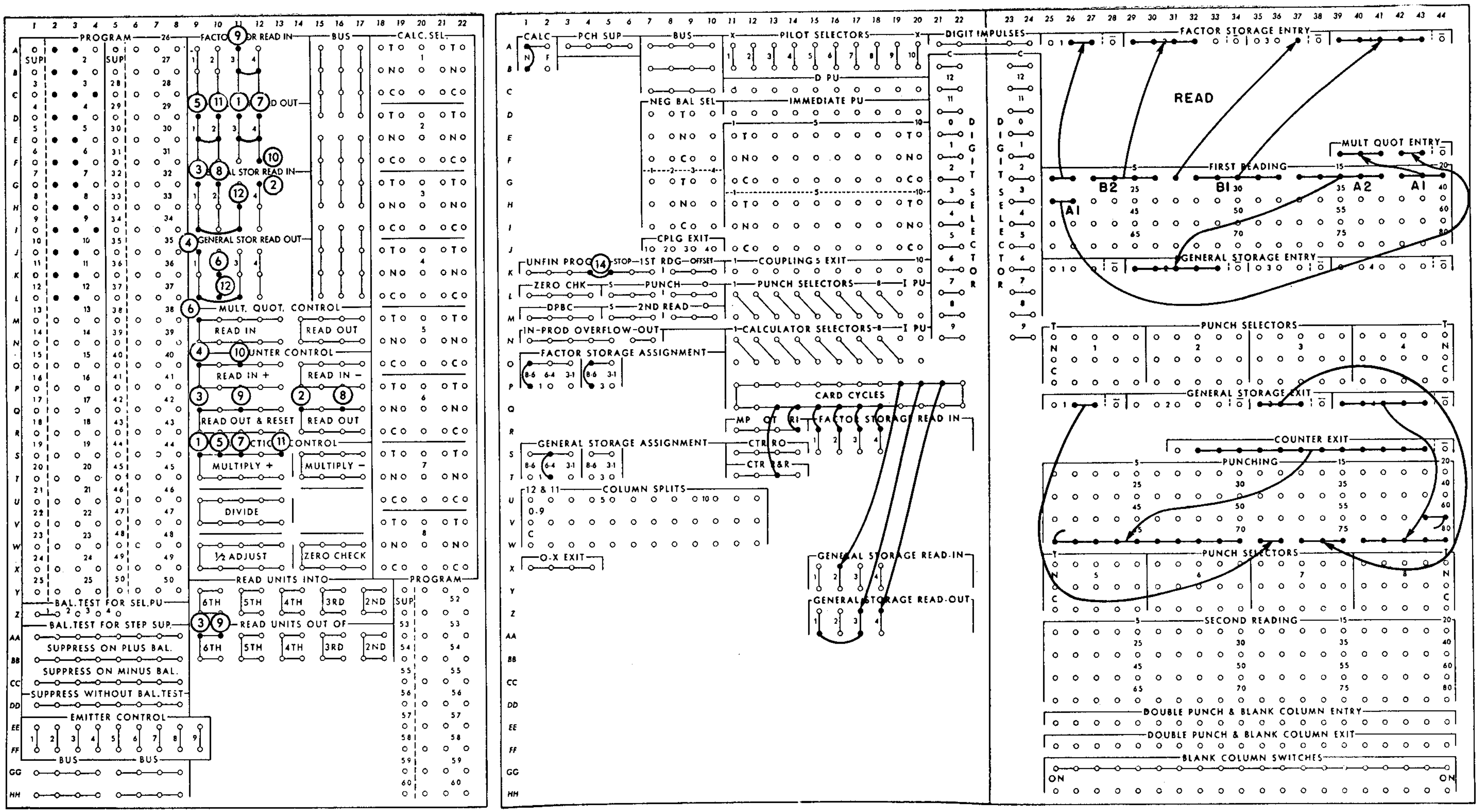


FIGURE 16A. MULTIPLICATION FACTOR EXPANSION

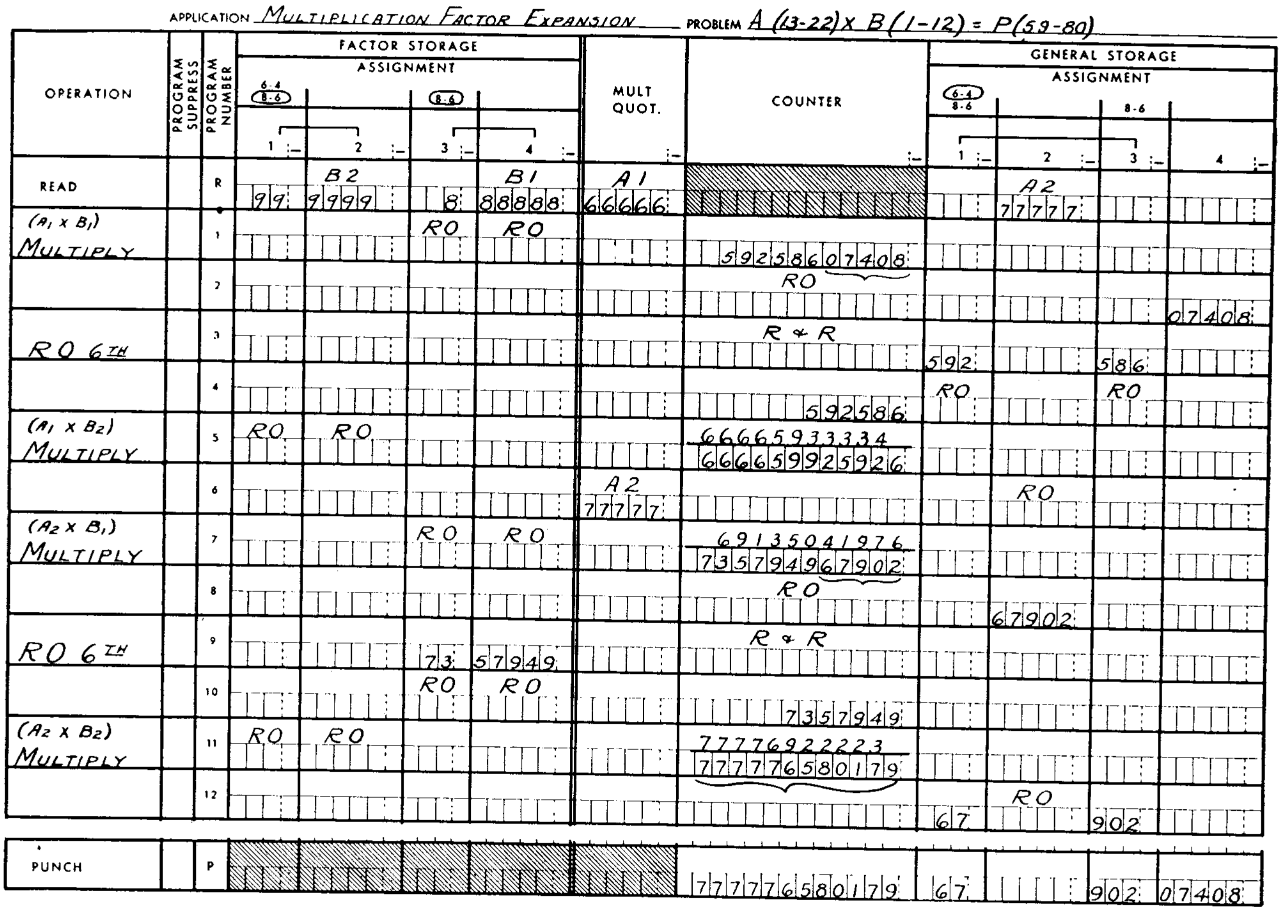
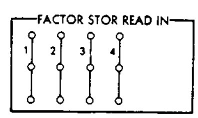


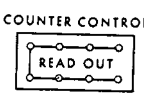
FIGURE 16B

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 hubs accept impulses to stop the machine, or offset the card in the stacker (special device). When the stop hubs are impulsed, the machine completes that cycle, takes two more cycles, and then stops. These hubs are normally wired to stop the machine for a condition recognized at the first reading station, such as Unfinished Program. This stops the machine when the card causing the condition reaches the stacker.



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 with a program exit.



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

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

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 MULTIPLY +.

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 +.

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 +. 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 17A and 17B)

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.

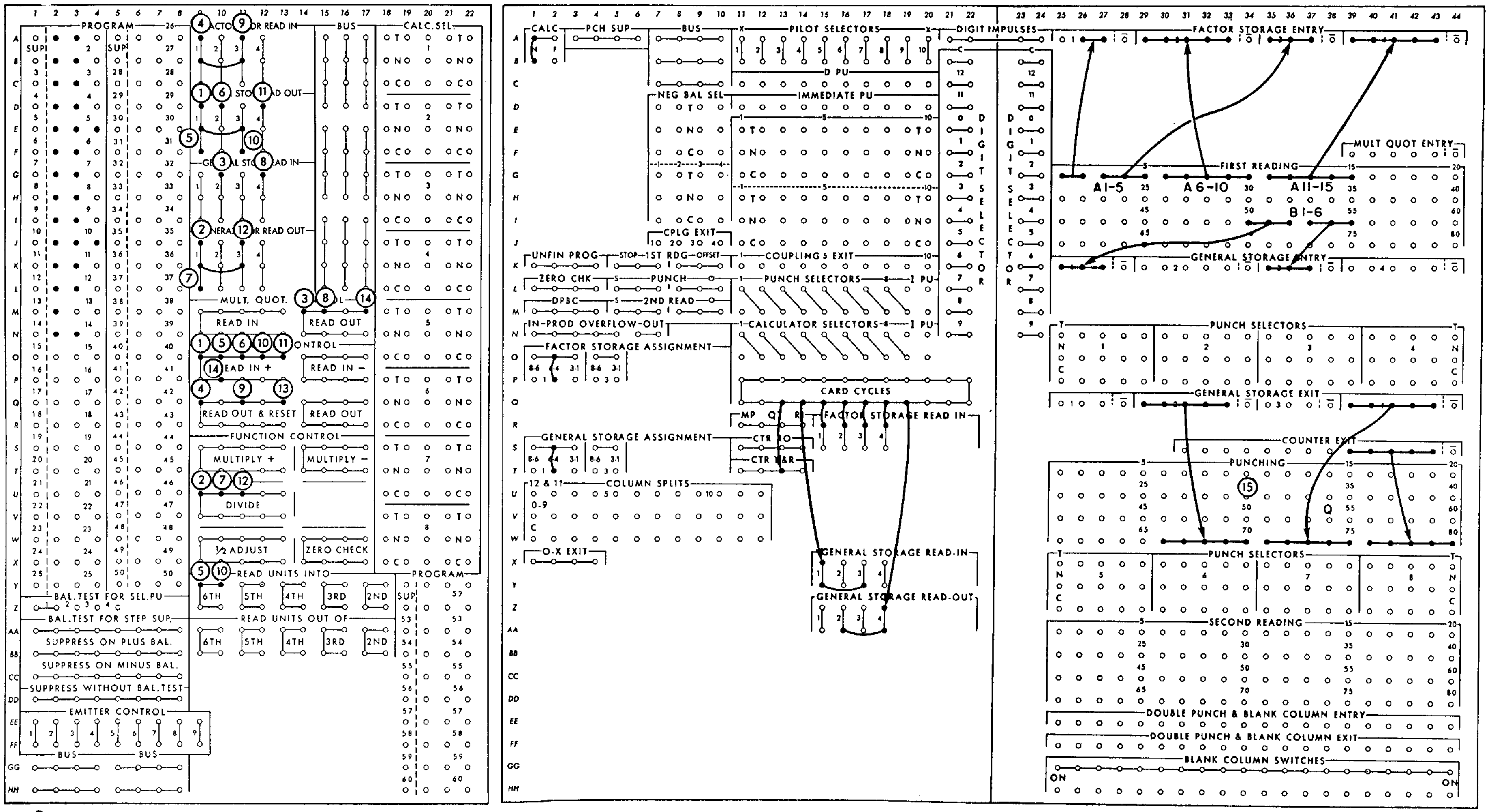


FIGURE 17A. QUOTIENT EXPANSION

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

Operation	Program Suppress	Program Number	Factor Storage Assignment 1 (6-4 / 8-6)	Factor Storage Assignment 2	Factor Storage Assignment 3 (8-6)	Factor Storage Assignment 4	Mult. Quot.	Counter	General Storage Assignment 1 (6-4 / 8-6)	General Storage Assignment 2	General Storage Assignment 3 (8-6)	General Storage Assignment 4
READ		R	(A1-2) 99	(A6-10) 88888	(A3-5) 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 999999				
		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 17B

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.

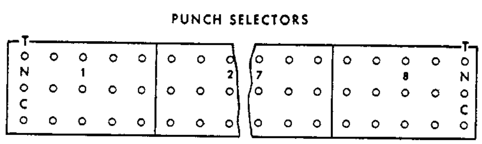
14. The part of the quotient standing in MQ is moved to the counter so that it may be punched.

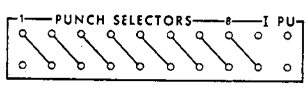
15. The whole quotient is punched from GS 2, GS 4 and the counter in that order.

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.

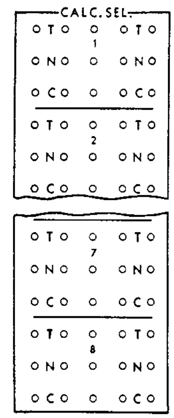


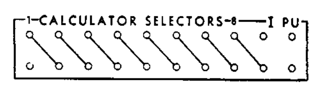


Punch Selectors (Pch N-P, 25-44; X-Z, 25-44). There are eight 5-position punch selectors standard on the Type 604. Each has a row of C (common), N (normal) and T (transferred) hubs. When a selector is transferred, there is a common connection between the C and the T hubs. When a selector is not transferred(normal), there is a common connection between the C and N hubs. The pickup hubs *(L-M, 11-18)* accept any impulse to transfer the selectors; they are normally impulsed by an X, a 12, or the coupling exit of a pilot or negative balance selector. 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.

When a card cycles impulse is wired through the normal side of a punch selector, the pickup impulse must be a coupling exit or a 12 punch. This is necessary because a card cycles impulse originates between 12 and 11 time.





Calculator Selectors (Cal A-X, 18-22). There are eight 5-position calculator 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 calculator control panel. 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 calculator 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 must be impulsed from the card cycle impulses, to read out without resetting.

PLANNING CHART AND WIRING DIAGRAM (Figures 18A and 18B, C, D)

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 calculator selector 1 which is picked up by 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.

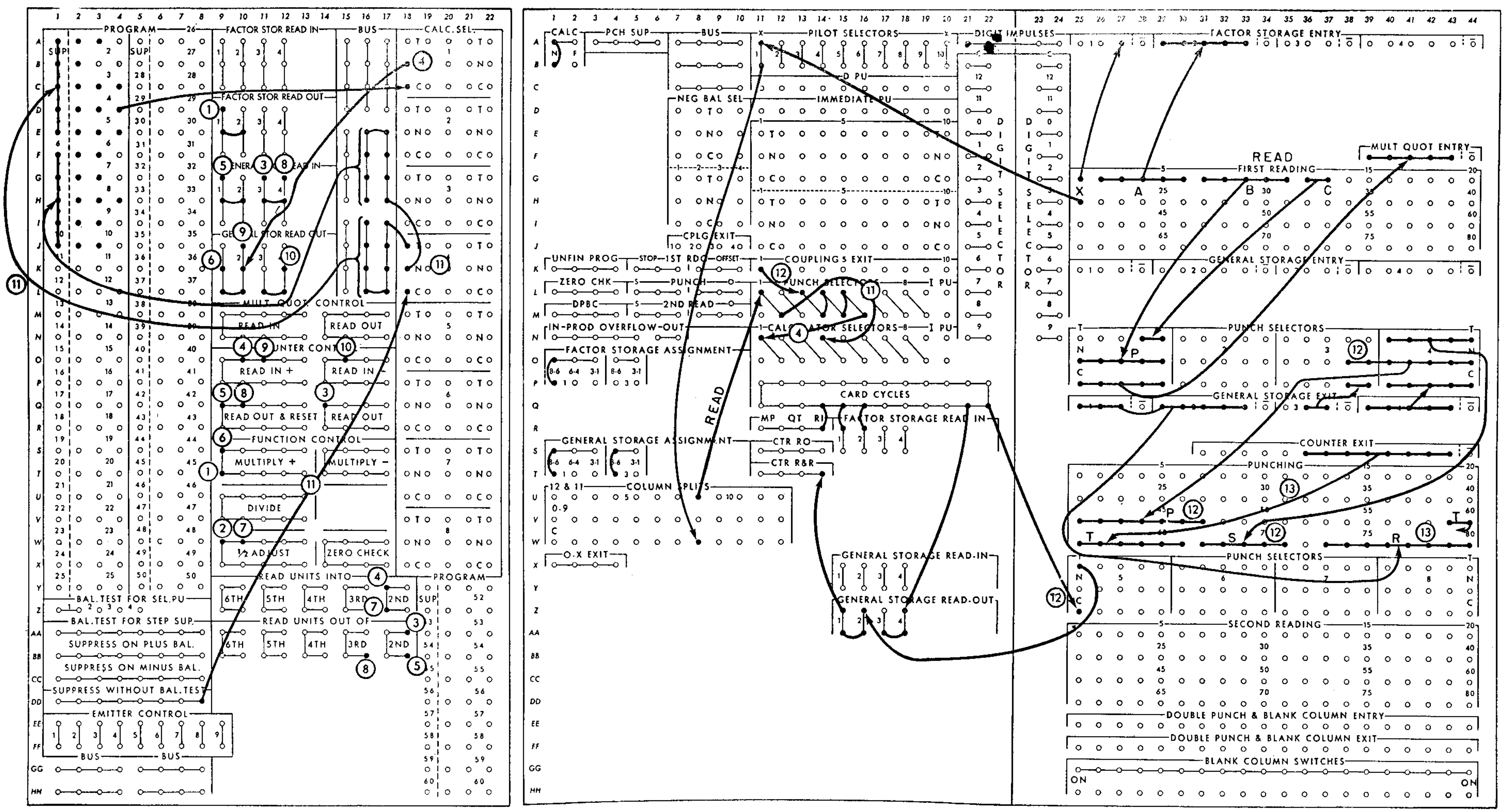


FIGURE 18A. SUMMARY PUNCHING

BILLING EXTENSIONS AND DISCOUNT AMT.

APPLICATION: SUMMARY PUNCHING: 1ST NX CARD — PROBLEM: QTY (A) X PRICE (B) = EXTENSION P

OPERATION	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT 1 (6-4 / 8-6)	FACTOR STORAGE 2	FACTOR STORAGE 3 (8-6)	FACTOR STORAGE 4	MULT QUOT	COUNTER	GENERAL STORAGE ASSIGNMENT 1 (6-4 / 8-6)	GENERAL STORAGE 2	GENERAL STORAGE 3 (8-6)	GENERAL STORAGE 4
FIRST NX CARD		R	(QTY) A 0	01000			(PRICE) B 00252					
MULT	X	1	RO	RO				P 00252000				
½ ADJ	X	2						5 00252005				
RO 2ND	X	3						RO			00	P 25200
	X	4										
RO 2ND	X	5						R & R	SUM 000	OF PS 25200		
	NX	6										
	NX	7										
	NX	8										
	NX	9										
	NX	10										
PUNCH		P									00	P 25200

FIGURE 18B

11. Program steps 1-5 are suppressed on X cards by wiring SUPPRESS WITHOUT BALANCE TEST through the transferred side of calculator selector 4 to the suppress hubs of the first 5 programs. The calculator 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 calculator 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 by 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 by the coupling exit of pilot selector 1.

The run should be preceded by a blank X card.

APPLICATION: Billing Extensions and Discount Amt — Summary Punching; 2nd Following NX Cards

PROBLEM: Qty (A) X Price (B) = Extension (P); 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	A 0	02000			B 00175		R (Sum of Ps) 000	25200		
Mult	X	1	RO	RO				00350000				
½ Adj	X	2						5 00350005				
RO 2nd	X	3						RO			00	P 35000
RI 2nd	X	4						00025200 000602005		Sel RO		
RO 2nd	X	5						R & R	R (Sum of Ps) 000	60200		
	NX	6										
	NX	7										
	NX	8										
	NX	9										
	NX	10										
PUNCH		P									00	P 35000

FIGURE 18C

APPLICATION: Billing Extensions and Discount Amt — Summary Punching; X Card

PROBLEM: Invoice Total (R) X Discount % (C) = Discount Amt. (S); 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) 000	60200		
	X	1										
	X	2										
	X	3										
	X	4										
	X	5										
Mult	NX	6						(S) 09030000	RO	RO		
½ Adj RI 2nd	NX	7						5 09030050				
RO 3rd	NX	8						R & R				(S) 09030
	NX	9						(R) 00060200	RO	RO		
	NX	10						− 9030 (T) 00051170			RO	RO
PUNCH		P						R & R (T) 00051170	000	(R) 60200		(S) 09030

FIGURE 18D

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. An X punched over the units position of a factor for reasons other than sign control must be eliminated through a column split.

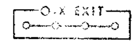
The extreme right-hand position of each unit is a sign control position. It will accept any digit or an X to identify the positive or negative value of a factor. By an internal column split, an X punch over the units position of a factor is automatically entered in the sign control position of the unit, 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.

When multiplying, the product will be positive or negative, depending upon the combination of signs for the multiplier and multiplicand factors, and what type of multiplication is used ($+\times$ or $-\times$). The following combinations are possible:

$$(+A)\ +\times\ (+B) = +P$$
$$(-A)\ +\times\ (-B) = +P$$
$$(+A)\ +\times\ (-B) = -P$$
$$(-A)\ +\times\ (+B) = -P$$
$$(+A)\ -\times\ (+B) = -P$$
$$(-A)\ -\times\ (-B) = -P$$
$$(+A)\ -\times\ (-B) = +P$$
$$(-A)\ -\times\ (+B) = +P$$

The problem illustrated in Figure 19A shows different methods for introducing the signs of factors and for punching the signs of results.



0-X Exit (Pch 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 being wired to punch.

PLANNING CHART AND WIRING DIAGRAM

(Figures 19A and 19B)

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 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).

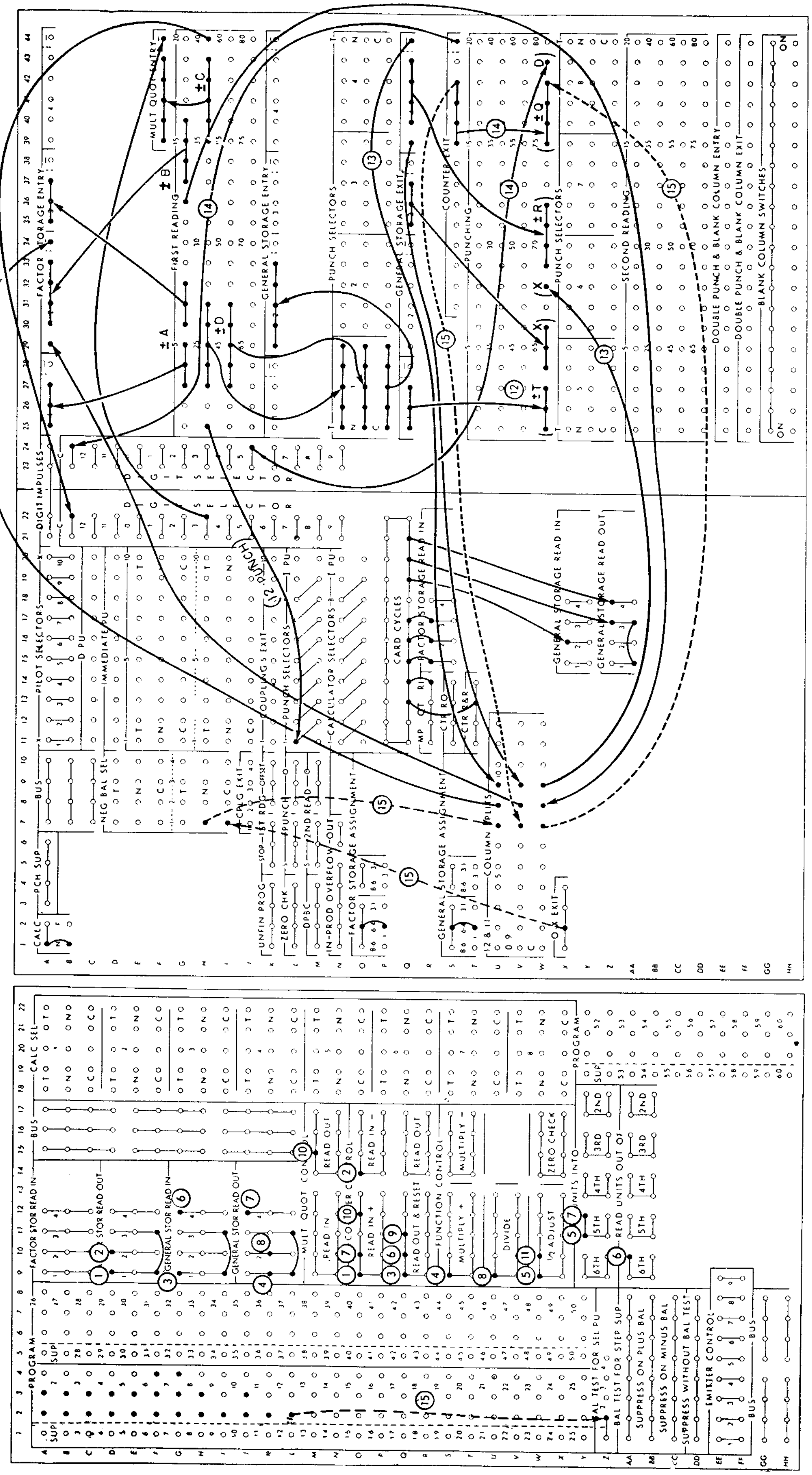


FIGURE 19A. SIGN CONTROL

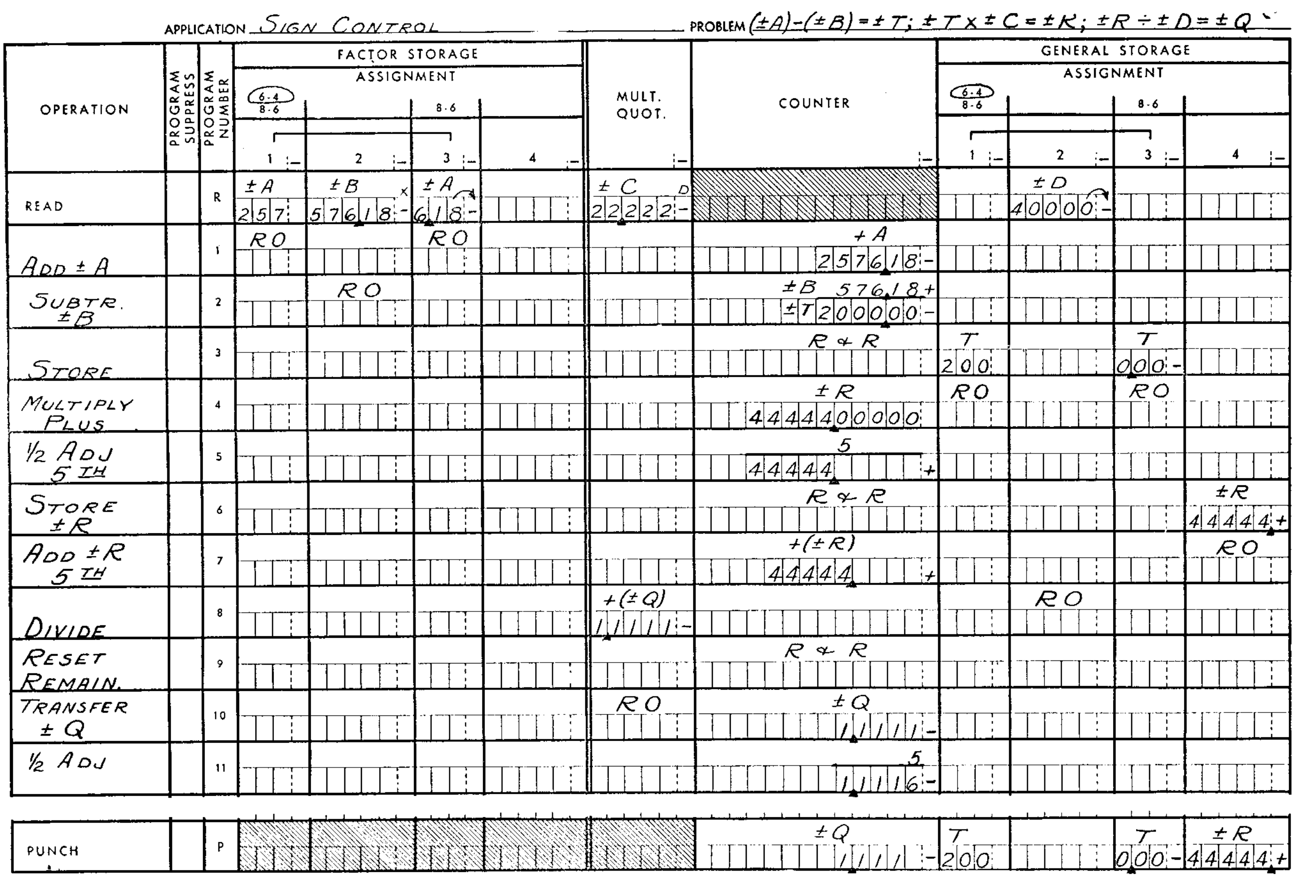


FIGURE 19B

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, 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 READ IN +. 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.

PAYROLL: 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 20A and 20B)

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 placed in the counter, according to the decimal rule: one decimal in the divisor, plus three decimals in the quotient, plus one position for half adjustment 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 transferred 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.

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.

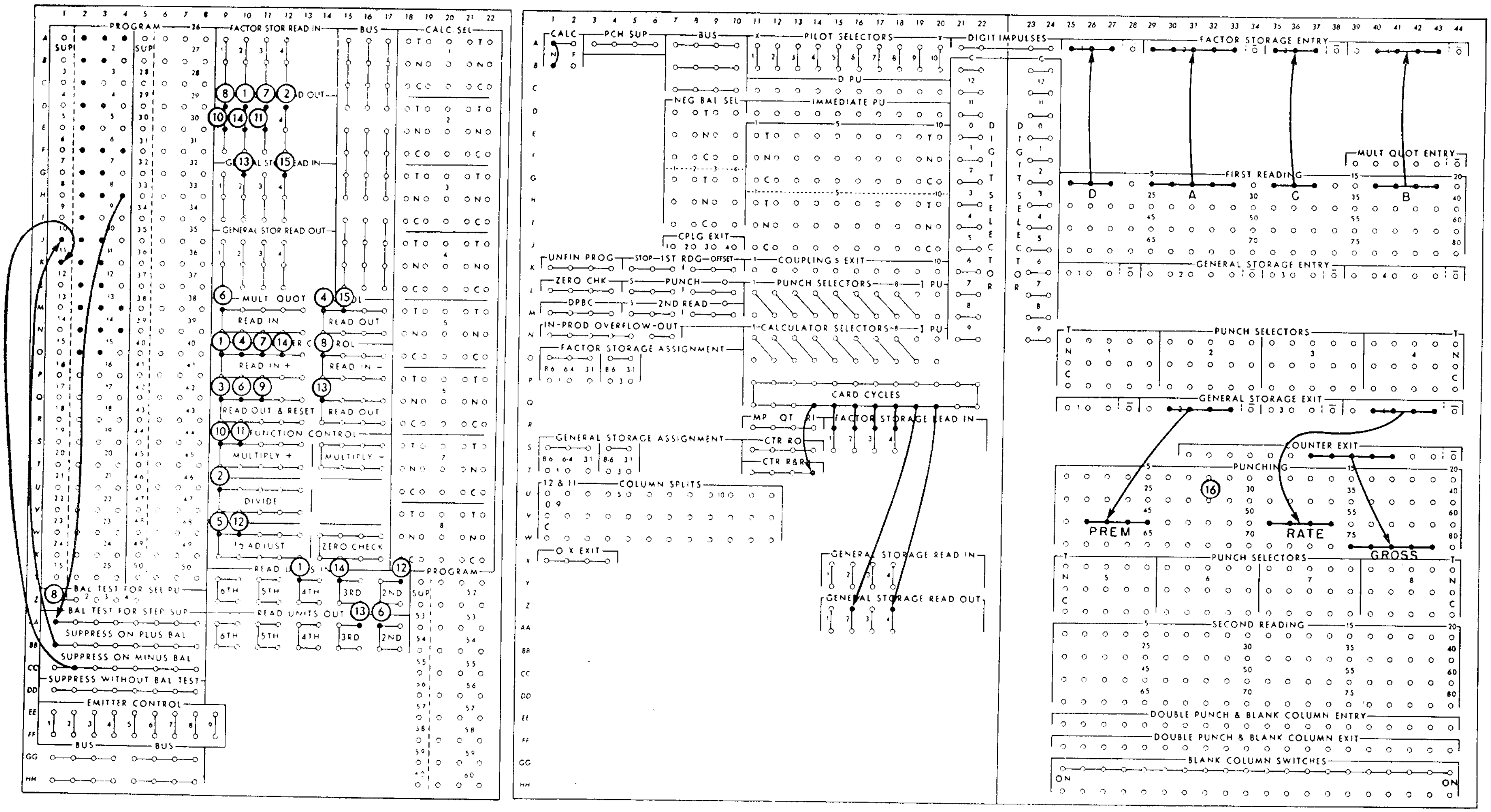


FIGURE 20A. PAYROLL: AVERAGE HOURLY RATE AND GROSS EARNINGS

$A \div B = Q$ (AVER. RATE)
$C - D = \pm T$ (BAL. TEST) } $D \times Q = P$ (PREM EARN) IF T IS +
} $C \times Q = P$ (" ") IF T IS −

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

OPERATION	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT 6-4 8-6 D 1	A 2	8-6 C 3	B 4	MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT 6-4 8-6 1	2	8-6 3	4
READ		R	WKLY PREM. 060	BASE PAY 11700	DLY. PREM. 040	TOT. HRS. 0520						
R.I. 4TH		1		RO				BASE PAY 11700				
DIVIDE		2				RO	Q(AVE RATE) 22500					
REMAINDER		3						R & R				
		4					RO	22500				
½ 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							
½ 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 20B

PAYROLL: GROSS TO FIRST NET, INCLUDING OASI AND SUI LIMITS

PAYROLL applications on the Type 604 vary considerably, depending on the industry, location and tax rates in effect. (The rates used in this problem are not necessarily those currently in effect.) This problem shows one method of computing:

- Withholding tax (18% of taxable earnings)
- State Unemployment Insurance tax (2% of gross earnings up to $3,000)
- Old Age and Survivors Insurance Tax (1½% of gross earnings up to $3,600)
- Net pay (gross earnings minus three taxes)

The following factors are prepunched:

- Gross earnings (current period)
- Earnings-to-date (end of previous period)
- Tax allowance

The tax allowance punched in the card is 18% of the exemption amount. The exemption amount and the tax allowance for each dependent are:

Pay Period	*Exemption*	*Allowance*
Weekly	$13.00	$ 2.34
Biweekly	26.00	4.68
Semimonthly	28.00	5.04
Monthly	56.00	10.08

In cases where the tax allowance exceeds the tax computation, the withholding tax is not deducted.

The payroll cards are punched X78 when earnings are $3,000 or over, and X76 when earnings are $3,600 or over. SUI tax is not calculated for cards punched X78; OASI tax is not calculated for cards punched X76. Provision is also made to punch either X when the corresponding limit is exceeded during the current period.

The method illustrated requires 33 program steps and can be adapted to varying tax rates with very little change in control panel wiring. On machines with only 20 program steps, two separate runs would be required. The withholding tax and the OASI tax would be computed and punched during the first run in a manner similar to that shown on the planning chart (read through Step 17). The SUI tax and net pay would be computed and punched during the second run.

The figures for a typical case (gross earnings $175.85, earnings-to-date $2,900, and tax allowance $5.04) are used to develop the planning chart and assist in understanding the problem.

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

READ. Earnings-to-date are entered in FS1 and 3 with FS1 assigned to the 4th, 5th, and 6th channels. Gross earnings and tax allowance are entered in FS2 and 4, respectively. Constant factors are entered from digit selector 2, wired as an emitter, as follows:

- 18 in the MQ unit for W. tax rate (18%)
- 36 in GS1 for the OASI limit ($3,600)
- 15 in GS3 for the OASI rate (1.5%)

1. Gross is read out of FS2 and multiplied by the withholding tax rate.
2. The withholding tax computation is ½ adjusted in the 2nd position.
3. The withholding tax allowance is read out of FS4 and subtracted from the withholding tax computation. READ UNITS INTO 3RD is impulsed to line up the decimals.
4. If the counter is minus on step 3, withholding tax is not to be punched or deducted from gross; if the counter is plus, the amount is the withholding tax deduction. To determine the plus or minus condition of the counter, BALANCE TEST FOR STEP SUPPRESSION normally would be impulsed on step 3. Since the three exits on step 3 are needed for the three functions described in step 3, balance testing is accomplished on step 4.
5. The withholding tax amount is read out of the counter (units out of 3rd) and entered in GS4. The counter is reset.
6. If the counter was plus on program 4, this step is suppressed. If the counter was minus, however, this step is used to impulse GS4 to read in. This would clear the storage unit and a withholding tax of zero will be deducted from gross, on a later program, and punched in the card.
7. Programs 7-16 are used to calculate the OASI tax amount on NX76 cards. The programs

are suppressed for cards punched X76, which indicates that the $3,600 OASI limit has been exceeded in a previous pay period. They are suppressed by wiring SUPPRESS WITHOUT BALANCE TEST through the transferred side of calculator selectors 1 and 2, which are picked up on X76 from first reading.

On this step, the $3,600 limit is added in the counter which will be used for two purposes:

a. To determine the OASI taxable balance when earnings-to-date are subtracted.

b. To determine whether the current gross earnings are greater than the taxable balance. If the gross is greater, the OASI tax amount is computed on the taxable balance for the year; if it is not, the OASI tax is computed on the current gross. To enter the $3,600, GS1 is read out, the counter is impulsed to add, and read units into 5th is impulsed.

8. Earnings-to-date are read out of FS1 and 3 and subtracted in the counter. The resulting amount in the counter is the OASI taxable balance for the year. This amount will be used for the OASI computation if it is less than gross.

9. The OASI taxable balance for the year is read out of the counter and stored in FS4.

10. Gross is read out of FS2 and subtracted in the counter.

11. The counter is tested at this time to determine whether it is plus or minus. If it is plus, the OASI limit is not exceeded and the tax is to be computed on the current gross; if it is minus, the limit is exceeded during the current period and the tax is to be computed on the OASI taxable balance for the year. Also, if the counter is minus, an X is to be punched in column 76. BALANCE TEST FOR STEP SUPPRESSION and BALANCE TEST FOR SELECTOR (1) PICKUP are impulsed.

The X (obtained from the 0-X EXIT which is wired through a column split to eliminate the 0) is wired through the transferred side of negative balance selector 1 and through the transferred side of pilot selector 1, which is picked up by X78 from first reading. When an X is to be punched in 76, the card already has an X in column 78.

The pilot selector controls the punching of the X as follows:

a. If the card already has an X in 78 and the OASI limit is exceeded during the current period, the X is punched in column 76.

b. If the card is not X punched in 78 and the SUI limit is exceeded during the current period (steps 18-28), the X is punched in column 78.

This selector wiring is required on machines having only one negative balance selector which must be used to test two negative balance conditions — once for the OASI limit and later for the SUI limit. On machines having two negatives balance selectors, the pilot selector would not be needed if each negative balance condition were tested by a separate negative balance selector.

12. The counter is reset.

13. The OASI tax rate (1.5%) is read out of GS3 and entered in the MQ unit.

14. A 5 is entered in the 3rd position of the counter to ½ adjust the OASI tax, which will be computed on the following steps.

15. The OASI taxable balance is read out of FS4 and multiplied by the tax rate. This step is taken if the counter was minus on program 11, but is suppressed if the counter was plus.

16. Gross is read out of FS2 and multiplied by the tax rate. This step is taken if the counter was plus on program 11, but is suppressed if the counter was minus.

17. The OASI tax amount is read out of the counter (units out of 4th) and stored in GS2. The counter is reset.

18. Programs 18-27 are used to calculate the SUI tax amount on NX78 cards. The programs are suppressed for cards punched X78, which indicates that the $3,000 SUI limit has been exceeded in a previous pay period. They are suppressed by wiring SUPPRESS WITHOUT BALANCE TEST through the transferred side of calculator selectors 4 and 5, picked up on an X78 from first reading.

On this step, the $3,000 limit is added in the counter which will be used for two purposes:

a. To determine the SUI taxable balance when earnings-to-date are subtracted.

b. To determine whether the current gross earnings are greater than the taxable balance.

If the gross is greater, the SUI tax amount is computed on the SUI taxable balance for the year;

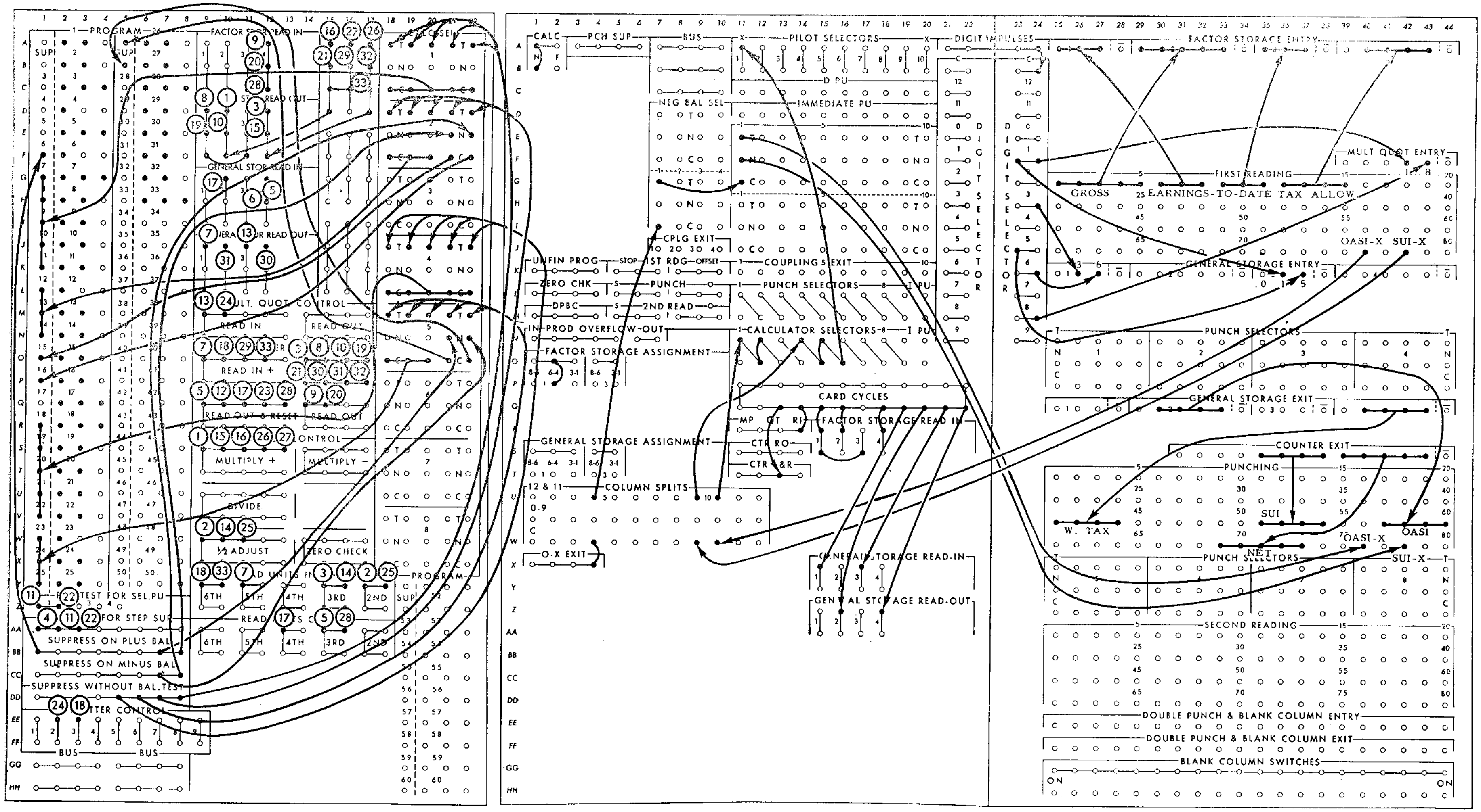


FIGURE 21A. PAYROLL: GROSS TO FIRST NET

APPLICATION: Calculating W. Tax, OASI Tax, SUI Tax and Net

	Operation-Notes	Program Suppress	Program Number	Factor Storage Assignment 1 (6-4 / 8-6)	Factor Storage Assignment 2	Factor Storage Assignment 3 (8-4)	Factor Storage Assignment 4	Mult Quot.	Counter	General Storage Assignment 1 (6-4 / 8-6)	General Storage Assignment 2	General Storage Assignment 3 (8-6)	General Storage Assignment 4
R	READ W Tax Rate (18), OASI Limit (36), and OASI Rate (15) From Digit Selector		R	Earn To Date 290	Gross 17585	Earn To Date 000	Tax Allow 0504	W Tax Rate 18		OASI Limit 36		OASI Rate 015	
1	Multiply W Tax		1		RO				316530				
2	½ Adjust RI 2nd		2						5 / 316580				
3	Subtract W Tax Allow RI 3rd		3				RO		- 504 / 266180				
4	Bal Test For Step Sup		4										
5	Transfer W Tax RO 3rd		5						R + R				W Tax 2661
6	Clear GS 4	+	6										(RI)
7	Add OASI Limit RI 5th	X76	7						OASI Limit 360000	RO			
8	Subtract Earn-To-Date	X76	8	RO		RO			- 290000 / 70000				
9	Transfer OASI Tax Bal	X76	9				OASI Tax Bal 70000		RO				
10	Subtract Gross	X76	10		RO				- 17585 / 52415				
11	Bal Test For Step Sup and Sel PU	X76	11										
12	Reset Counter	X76	12						R + R				
13	Transfer OASI Rate	X76	13					OASI Rate 015				RO	
14	½ Adjust RI 3rd	X76	14						5				
15	Mult OASI Using Tax Bal	X76 +	15				(RO)						
16	Mult OASI Using Gross	X76 −	16		RO				263775 / 264275				
17	Transfer OASI RO 4th		17						R + R		OASI 264		
18	Add SUI Limit RI 6th (3 From Emitter Control)	X78	18						SUI Limit 300000				
19	Subtract Earn-To-Date	X78	19	RO		RO			- 290000 / 10000				
20	Transfer SUI Tax Bal	X78	20				SUI Tax Bal 10000		RO				
21	Subtract Gross	X78	21		RO				- 17585 / - 7585				
22	Bal Test For Step Sup and Sel PU	X78	22										
23	Reset Counter	X78	23						R + R				
24	Enter SUI Rate (2 From Emitter Control)	X78	24					SUI Rate 02					
25	½ Adjust RI 2nd	X78	25						5				
26	Mult SUI Using Tax Bal	X78 +	26				RO		20000 / 20050				
27	Mult SUI Using Gross	X78 −	27		(RO)								
28	Transfer SUI Tax RO 3rd		28				SUI 200		R + R				
29	Add Gross		29		RO				Gross 17585				
30	Subtract W Tax		30						- 2661 / 14924				RO
31	Subtract OASI		31						- 264 / 14660		RO		
32	Subtract SUI		32				RO		- 200 / Net 14460				
33	Transfer SUI RI 6th		33				RO		SUI 200				
P	PUNCH		P						SUI 0200 Net 14460		OASI 0264		W Tax 2661

NOTE: Steps 6, 15 and 27 are Suppressed in The Problem Illustrated

Figure 21B

if it is not, the SUI tax is computed on the current gross. To enter the $3,000, EMITTER CONTROL 3, COUNTER READ IN +, and READ UNITS INTO 6TH are impulsed.

19. Earnings-to-date are read out of FS1 and 3 and subtracted in the counter. The resulting amount in the counter is the SUI taxable balance for the year. This amount will be used for the SUI computation if it is less than gross.

20. The SUI taxable balance for the year is read out of the counter and stored in FS4.

21. Gross is read out of FS2 and subtracted in the counter.

22. The counter is tested at this time to determine whether it is plus or minus. If it is plus, the SUI limit is not exceeded and the tax is to be computed on the current gross; if it is minus, the limit is exceeded during the current period and the tax is to be computed on the taxable balance for the year. Also, if the counter is minus, an X is to be punched in column 78. BALANCE TEST FOR STEP SUPPRESSION and BALANCE TEST FOR SELECTOR (1) PICKUP are impulsed.

An X from the 0-X EXIT is wired through the transferred side of negative balance selector 1 and the normal side of pilot selector 1 to punch in column 78, as explained in program 11.

23. The counter is reset.

24. The SUI rate (2%) is entered in the MQ unit by impulsing EMITTER CONTROL 2 and MQ READ IN.

25. A 5 is entered in the 2nd position of the counter to ½ ADJUST the SUI tax, which will be computed on the following steps.

26. The SUI taxable balance is read out of FS4 and multiplied by the tax rate. This step is taken if the counter was minus on program 22, but is suppressed if the counter was plus.

27. Gross is read out of FS2 and multiplied by the tax rate. This step is taken if the counter was plus on program 22, but is suppressed if the counter was minus.

28. The SUI tax amount is read out of the counter (units out of 3rd) and stored in FS4. The counter is reset.

29. Gross is read out of FS2 and added in the counter to develop net.

30. Withholding tax is read out of GS4 and subtracted in the counter.

31. OASI is read out of GS2 and subtracted in the counter.

32. SUI is read out of FS4 and subtracted in the counter. The counter now contains the net amount to be punched.

33. SUI is read out of FS4 and added in the counter to the left of net for punching. It is offset by impulsing READ UNITS INTO 6TH.

PUNCH. SUI and net are punched from the counter, OASI from GS2, and W. tax from GS4.

APPROXIMATE SQUARE ROOT

The square root of a base number containing eight digits or less may be obtained on the Type 604 at 6000 numbers per hour by four iterations of the following formula.

$$\left(\frac{B}{A1} + A1\right) \times .5 = A2$$

B — Base number for which the square root is to be found.

A1 — First approximate square root.

A2 — Second approximate square root.

A1 is the first approximate square root number and is set up in the machine from the EMITTER CONTROL. It may be 3, 30, 300 or 3000 depending upon the number of significant digits in the base number. For a 1- or 2-digit base number, 3 is used. For a 3- or 4- digit base number, 30 is used. For a 5- or 6-digit base number, 300 is used, and for a 7- or 8-digit base number, 3000 is used. Theoretically, any number could be used as a first approximate. The number 3 is chosen because greater accuracy is obtained when the square root is carried beyond the decimal point.

As indicated on the planning chart, A2 and A3 are the successive approximates developed by the machine on each iteration. A4 is the approximate square root.

Some base numbers will not require four iterations, but a maximum of four will be required for any base number from 1 to 8 digits; for example, the square root of 16 would be developed in one iteration as follows:

$$\left(\frac{16}{3} + 3\right) \times .5 = 4 \text{ (square root of 16),}$$

but the square root of 5625 would be developed in three iterations as follows:

$$\left(\frac{5625}{30} + 30\right) \times .5 = 108 \text{ (second approximate)}$$

$$\left(\frac{5625}{108} + 108\right) \times .5 = 80 \text{ (third approximate)}$$

$$\left(\frac{5625}{80} + 80\right) \times .5 = 75 \text{ (square root of 5625)}$$

It may be seen from the formula that each iteration is a repetition of the previous step, the only difference being the introduction of a new approximate as a divisor. Regardless of the number of iterations a base number may require, the machine will always take four.

The problem requires only 32 program steps, 8 program steps to each iteration. The size of the base number is determined on the read cycle so that on program 1 the digit 3, 30, 300 or 3000 (first approximate) may be entered into FS4.

The square root of any uneven number of digits requires the addition of a zero to the right for accurate development.

PLANNING CHART

(Figure 22B)

READ. The base number is entered into GS1-2. At this time the size of the number is determined, as described under *Wiring*.

1. The first approximate is entered into FS4 as 3, 30, 300 or 3000 depending upon the size of the base number.
2. The base number is read out of GS1-2 into the counter in preparation for a dividing operation.
3. The base number is divided by the first approximate and the quotient developed in MQ.
4. The first approximate must be added to the result of $\frac{B}{A1}$. The quotient developed on program 3 is read out of MQ into the counter starting with the sixth position. The right side of the counter may contain a remainder and normally would require a reset. This step is saved by using the left side of the counter for accumulating the result of $\frac{B}{A1}$ and A1.
5. A1 is read out of FS4 and added to the result of $\frac{B}{A1}$. A1 is read into the counter starting with the sixth position.
6. The counter now contains the result of $\frac{B}{A1} + A1$. This amount is read out of the counter and stored in GS4. The counter is cleared.
7. A 5 is emitted into the MQ unit in preparation for multiplication by .5.
8. The amount standing in GS4 $\left(\frac{B}{A1} + A1\right)$ is multiplied by .5. The result is A2 (second approximate). This finishes the first iteration.

The remaining program steps are repetitions of the first eight steps and are self-explanatory. The square root of 99,999,999 is obtained on program step 32.

WIRING

(Figure 22A)

1. Punch selectors 1 and 2 are picked up from a digit-emitted 1. The selectors pick up immediately and, since the cards feed into the machine 12's first, punch selectors 1 and 2 will be transferred for digits 1 to 9 and normal for zeros.
2. The high order six digits of the base number are wired through the transferred side of punch selectors 1 and 2 to the pickup hubs of the first six calculator selectors. Calculator selectors, once picked up, remain transferred during calculation.
3. For a 1- or 2-digit base number, all six calculator selectors are normal. Therefore, program 1 cannot reach any of the read units into hubs, and the digit 3 from the emitter goes into the units position of FS4.

For a 3-digit base number, the first 5 calculator selectors are normal and selector 6 is transferred. Program 1 reaches READ UNITS INTO 2ND, and 30 is entered into FS4.

For a 4-digit base number, the first 4 calculator selectors are normal and selector 5 is transferred. Program 1 reaches READ UNITS INTO 2ND, and 30 is entered into FS4.

For a 5-digit base number, calculator selectors 1, 2 and 3 are normal, and selector 4 is transferred. For a 6-digit base number, calculator selectors 1 and 2 are normal, and selector 3 is transferred. In either case program 1 reaches READ UNITS INTO 3RD, and 300 enters FS4.

For a 7-digit base number, calculator selector 1 is normal and selector 2 is transferred. For an 8-digit base number, calculator selector 1 is transferred. In either case program 1 reaches READ UNITS INTO 4TH, and 3000 enters FS4.

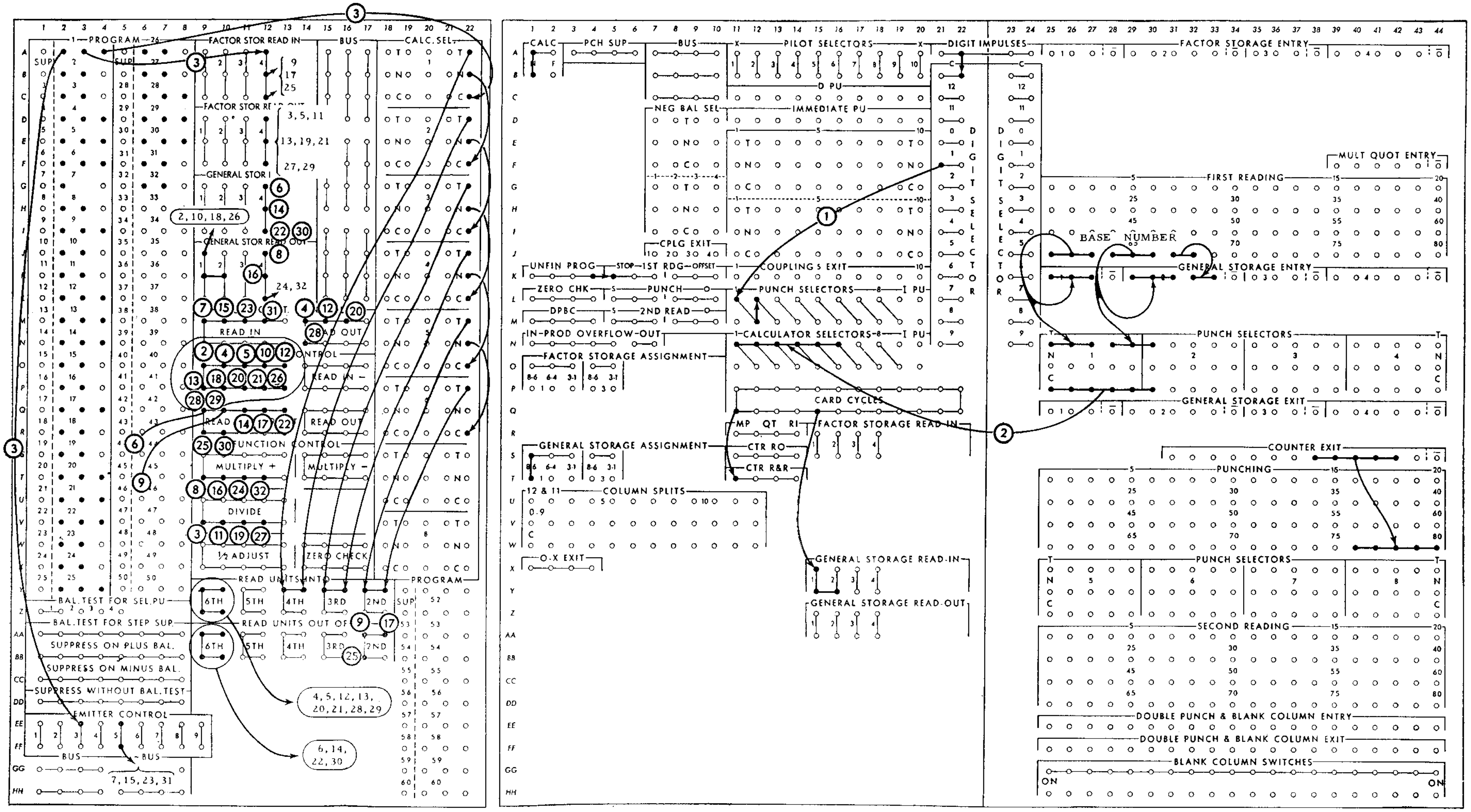


FIGURE 22A. APPROXIMATE SQUARE ROOT

APPLICATION $\left(\frac{B}{A_1}+A_1\right)\times .5 = A_2$ PROBLEM *Square Root 1-8 Digits*

Program Number	Operation Notes	Read Units Into	Read Units Out Of	Program Suppress	Factor Storage 1	Factor Storage 2	Factor Storage 3	Factor Storage 4	Mult. Quot.	Counter	General Storage 1	General Storage 2	General Storage 3	General Storage 4	Program Number
R	READ *Size of Base Number Determined on Read Cycle.*										*Base* 999	*Number* 99999			R
1	*First Approximate Emitted* (First Iteration)	4						A_1 3---							1
2										B 99999999	RO	RO			2
3	*Divide*							RO	Q 33333	(Possible Remainder)					3
4		6							RO	33333					4
5		6						RO		3000 36333					5
6			6							R&R				36333	6
7	*Emit*								5						7
8	*Multiply*									A_2 181665				RO	8
9	(Second Iteration)		2					A_2 18166		R&R					9
10										B 99999999	RO	RO			10
11	*Divide*							RO	Q 5504	(Possible Remainder)					11
12		6							RO	5504					12
13		6						RO		18166 23670					13
14			6							R&R				23670	14
15	*Emit*								5						15
16	*Multiply*									A_3 118350				RO	16
17	(Third Iteration)		2					A_3 11835		R&R					17
18										B 99999999	RO	RO			18
19	*Divide*							RO	(Q) 8449	(Possible Remainder)					19
20		6							RO	8449					20
21		6						RO		11835 20284					21
22			6							R&R				20284	22
23	*Emit*								5						23
24	*Multiply*									A_4 101420				RO	24
25	(Fourth Iteration)		2					A_4 10142		R&R					25
26										B 99999999	RO	RO			26
27	*Divide*							RO	Q 9859	(Possible Remainder)					27
28		6							RO	9859					28
29		6						RO		10142 20001					29
30			6							R&R				20001	30
31	*Emit*								5						31
32	*Multiply*									*Square Root* 100005				RO	32
P	PUNCH									*Square Root* 10000-					P

FIGURE 22B

This planning chart includes a special column *Read Units Into, Out Of* for making shift notations.

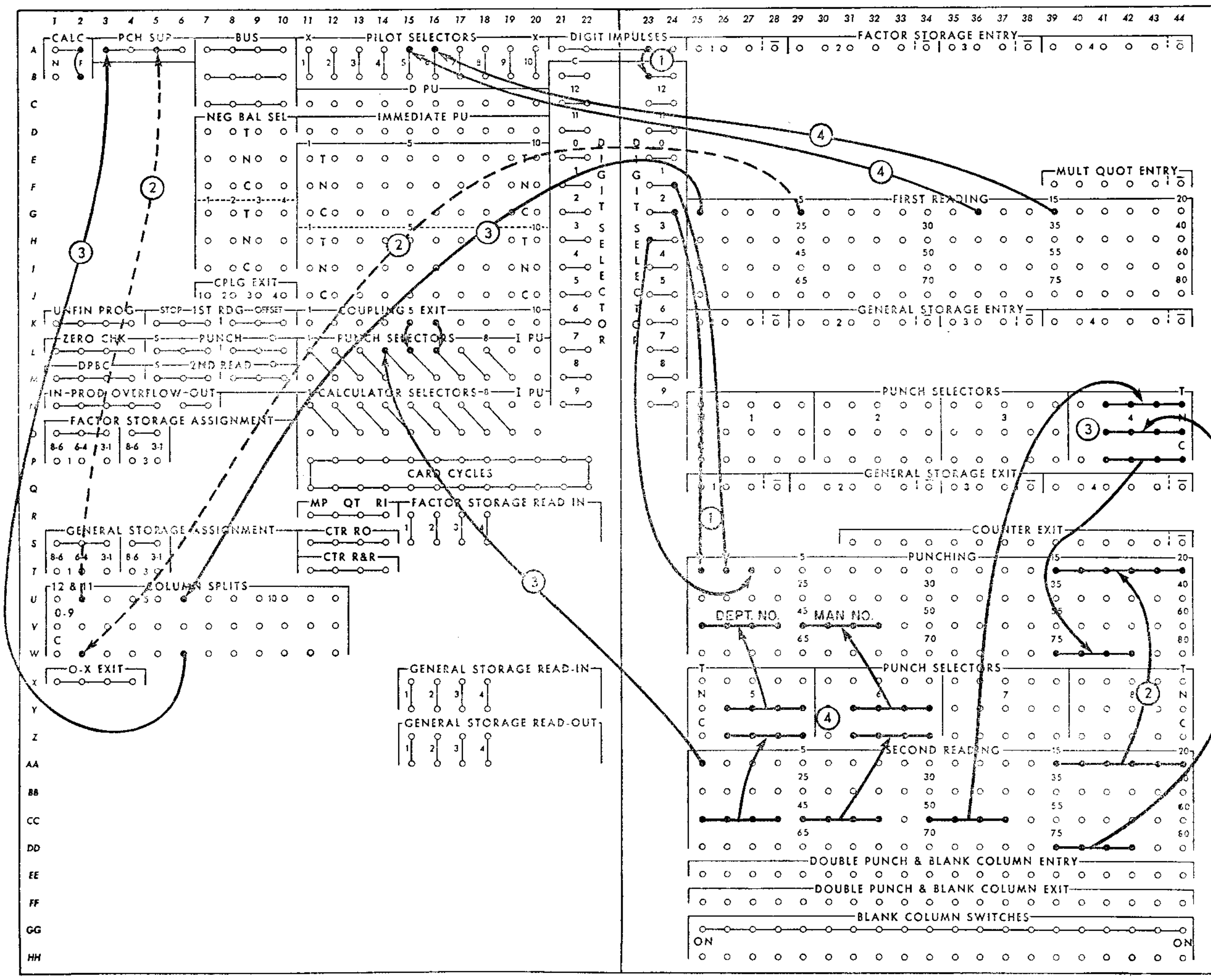


FIGURE 23. GANG PUNCHING

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 SECOND READING to PUNCH, column for column. Each card becomes a master card for the card following, as it reaches second reading.

When interspersed master card gang punching is done, punching of the master cards is prevented by impulsing PUNCH SUPPRESS, as shown by the dotted wiring. As the master card passes first reading, punch suppression is impulsed and one cycle later, as the master card passes the punch station, punching will be suspended.

3. *Offset Numerical 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 second reading station. The punch selector is transferred by wiring

the X impulse to the pickup from SECOND READING. Punching is suppressed for all master cards by wiring the master card X from FIRST READING 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.

Forward Punching

The punching station in the Type 521 is located between the first and second reading stations. Therefore, it is possible not only to gang punch normally from the second reading station but also to punch from the first reading station and thus accomplish what may be termed Forward Punching.

A specific application in which this operation may be desirable occurs when interspersed X master cards containing invoice numbers are followed by billing cards containing customer numbers. The invoice number in the X master card is to be gang punched into all billing cards in the same group (SECOND READING to PUNCH), but the customer number from the first billing card in the group

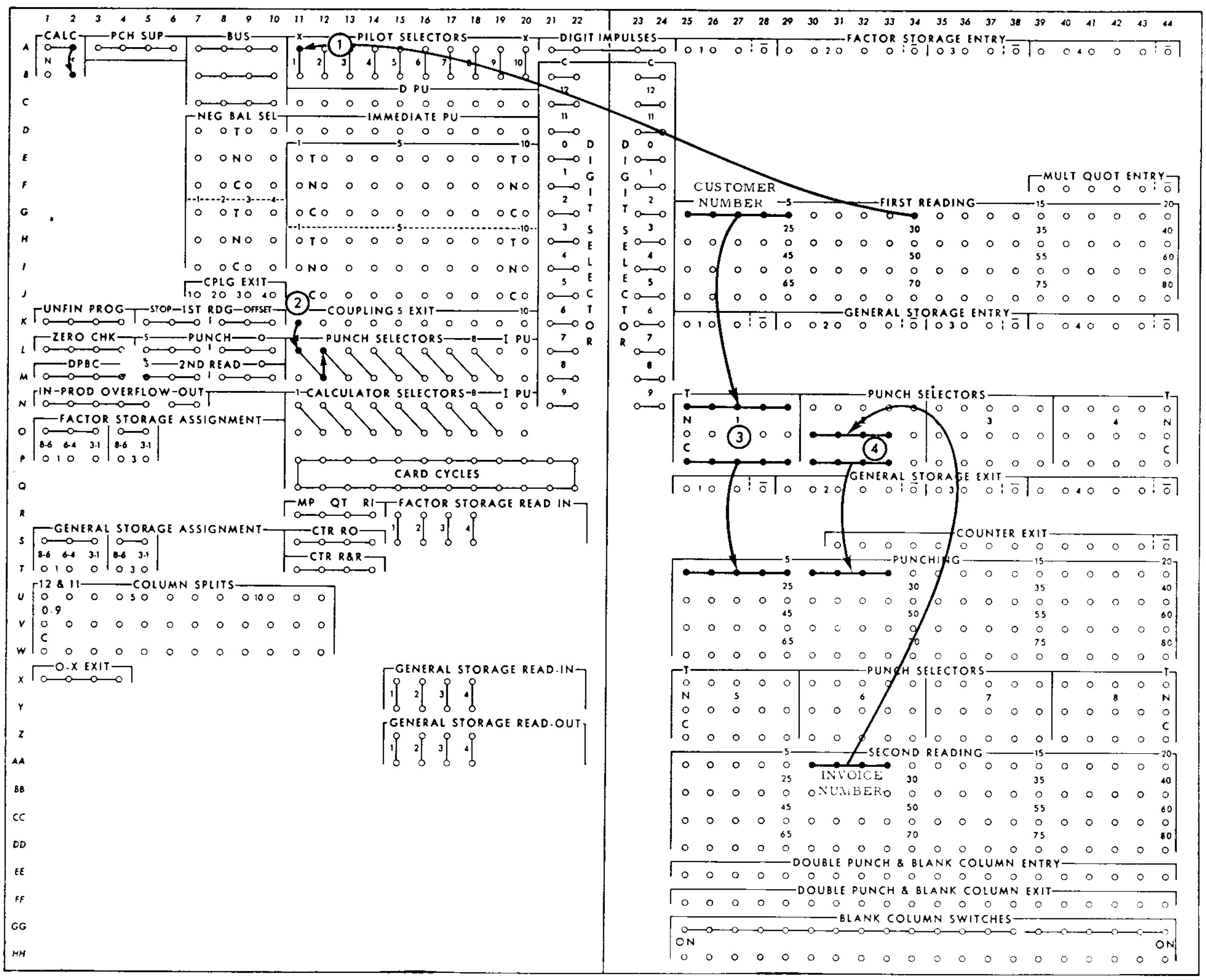


FIGURE 24. FORWARD PUNCHING

is to be forward-punched into the X master card (FIRST READING to PUNCH).

WIRING

(Figure 24)

1. An X in column 10 of the invoice number master card picks up pilot selector 1 from FIRST READING. The selector transfers on the next cycle.

2. Punch selectors 1 and 2 transfer on the same cycle from COUPLING EXIT of pilot selector 1.

3. Customer number from the first billing card forward-punches to the X master card through the transferred side of punch selector 1.

4. Since punch selector 2 also transfers on this cycle, the invoice number, read from the last card of the previous group (second reading station) does not gang punch into the X master card. On the next cycle when the X master card is read at the second reading station, punch selectors 1 and 2 drop back to normal. Thus, punch selector 1 suspends forward punching of customer number, and punch selector 2 allows normal gang punching of invoice number.

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 231 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 after 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 by 25, twelve electronic cycles are needed even though only one program step is used. When dividing 72 by 6, fourteen 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 method 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 method 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, plus one end-of-division cycle (5 × 2 + 1 = 11)	=11	electronic cycles
Sum of the digits in the quotient (1 + 2 =3)	= 3	" "
One program step	14	" "

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 231 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*, 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.

The indicator lamp panel (Figure 25) consists of a group of small neon lamps that light up to indicate the factors stored and the functions performed on any given program step.

Its purpose is to make it easy to locate errors in planning or control panel wiring. When control panels are tested, the usual procedure is to pass a test card through the 521 punch unit and check the punched result against the result arrived at on the planning chart for the same given factors. If the results do not agree, the wiring is checked against the planning chart. If no errors are found by this method, it is then necessary to check each program step as follows:

1. Depress the PROGRAM TEST key. This causes the PROGRAM TEST light to turn on and will allow the programs to be advanced one at a time.
2. Place the test card in the hopper of the 521.
3. Feed the test card for two cycles.
4. Depress the PROGRAM ADVANCE key once. All calculations or transfers of factors from one unit to another that occur on program 1 will be recorded on the indicator lamp panel. A comparison can be made between the results shown by the lighted lamps and those arrived at on program 1 of the planning chart. If the two do not agree, proper adjustments can be made in the control panel wiring. If they do agree, the PROGRAM ADVANCE key is depressed again (program 2), and the procedure is repeated. This is continued one program step at a time until all errors on either the planning chart or the control panels are corrected.
5. The machine is returned to normal operation by depressing the PROGRAM TEST key at which time the PROGRAM TEST light turns off.

How to Read the Indicator Lamp Panel

Each position of factor storage, general storage, multiplier-quotient storage, and the counter is represented by four lamps, vertically arranged. The upper or first row of lamps has a value of 1 as indicated on the left, the second row a value of 2, the third row a value of 4, and the fourth row a value of 8. The value of a digit standing in any one position may be determined by adding the values of the lighted lamps in that position. For example, if the number 791 were stored in FS1, the lamps would be lighted as shown in Figure 26.

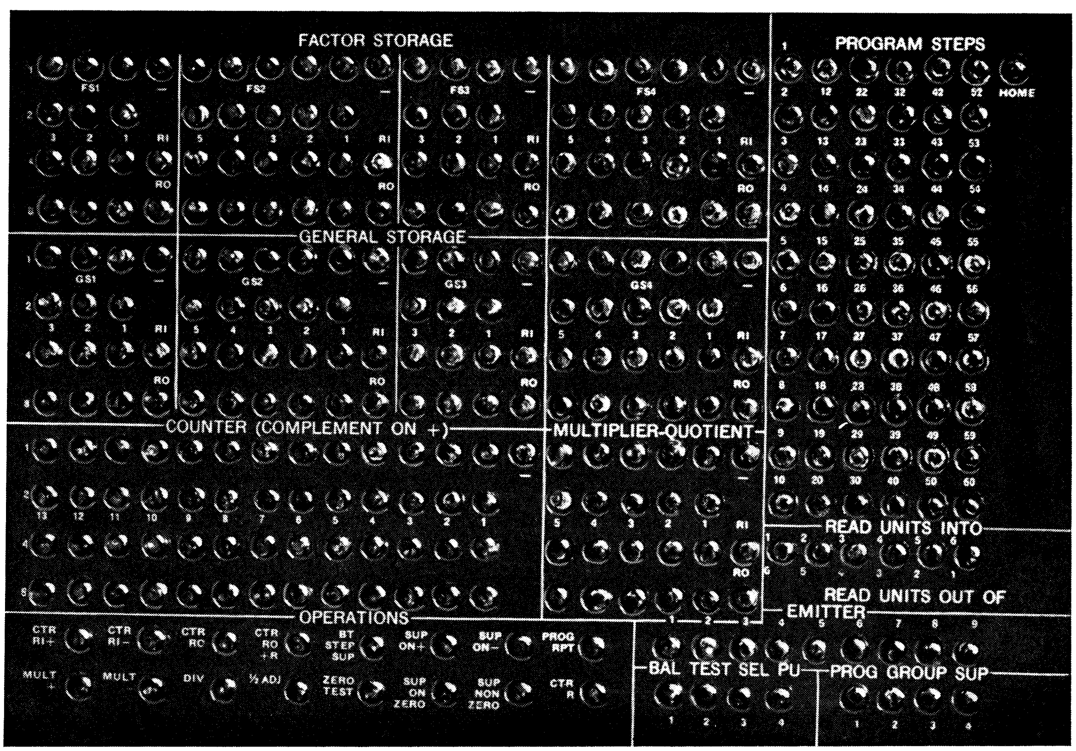


FIGURE 25. INDICATOR LAMP PANEL

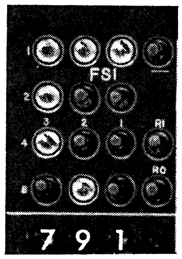


FIGURE 26. AMOUNT +791 IN FS1

Storage Units

In addition to the four lamps for each position, the storage units (including MQ) have three other lamps labelled – (minus), RI (read in), and RO (read out). Factors, whether plus or minus, always appear in storage units as true figures. The – (minus) lamp turns on when the factor in storage is negative. The RI lamp turns on when a factor enters storage, and the RO lamp turns on when a factor is read out of storage.

Counter

A positive amount in the counter will read as a 9's complement. For example, plus 791 would appear as shown in Figure 27. A negative amount will appear as a true figure with (–) MINUS lamp turned on.

Program Steps

There is a HOME lamp and one lamp for each of the possible 60 program steps. The HOME lamp turns on when a card is fed in the Type 521 and signifies that programming can be started. The PROGRAM STEP lamps turn on one at a time each time the PROGRAM ADVANCE key is depressed.

Read Units Into — Out Of

These lamps indicate the position of shift when a factor is transferred from one unit to another. Starting from the left the lights are labelled 1 through 6 for READ UNITS INTO and 6 through 1 for READ UNITS OUT OF. Although one light serves both for READ UNITS INTO and READ UNITS OUT OF for each position of shift, a distinction between the two is possible by reference to the COUNTER RI or RO lamps. For example, if the RI lamp for the counter is on, any shift lamp that is on at the same time would be interpreted as READ UNITS INTO. If the RO lamp for the counter is on, any shift lamp that is on at the same time would be interpreted as READ UNITS OUT OF. When a factor is transferred without shifting, lamp 1 (either read units into or read units out of) turns on.

Operations

Most of the operation lights are self-explanatory. They turn on when the corresponding control panel hubs are impulsed. It is necessary only to explain the abbreviations.

Ctr RI +	Counter read in plus
Ctr RI –	Counter read in minus
Ctr RO	Counter read out
Ctr RO & R	Counter read out and reset (counter resets at the beginning of the next program)
BT Step Sup	Balance test for step suppression
Sup on +	Suppress on plus
Sup on –	Suppress on minus
Mult +	Multiply plus
Mult –	Multiply minus
Div.	Divide
½ Adj.	Half Adjust
Zero Test	Zero Check

The indicator lamp panel is used for both the Type 604 and the Type 605 (CPC). The remaining lamps (Prog. Rpt., Sup. on Zero, Sup. Non-Zero, and Ctr. R) represent standard features of the 605, not standard on the 604.

Emitter

One of these lamps turns on when the corresponding emitter hub on the calculator control panel is impulsed.

Bal. Test Sel. PU

These lamps represent the balance test for selector pickup hubs on the calculator control panel. They turn on when the respective hubs are impulsed.

Prog. Group Supp. (Program Group Suppression)

These lamps operate on CPC machines only.

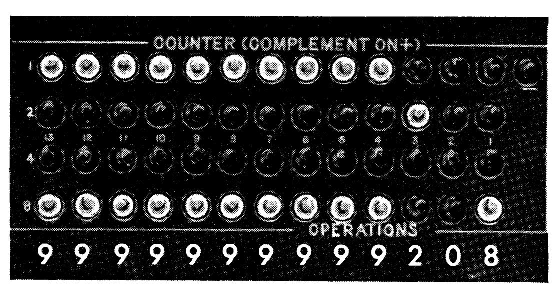


FIGURE 27. AMOUNT +791 IN THE COUNTER

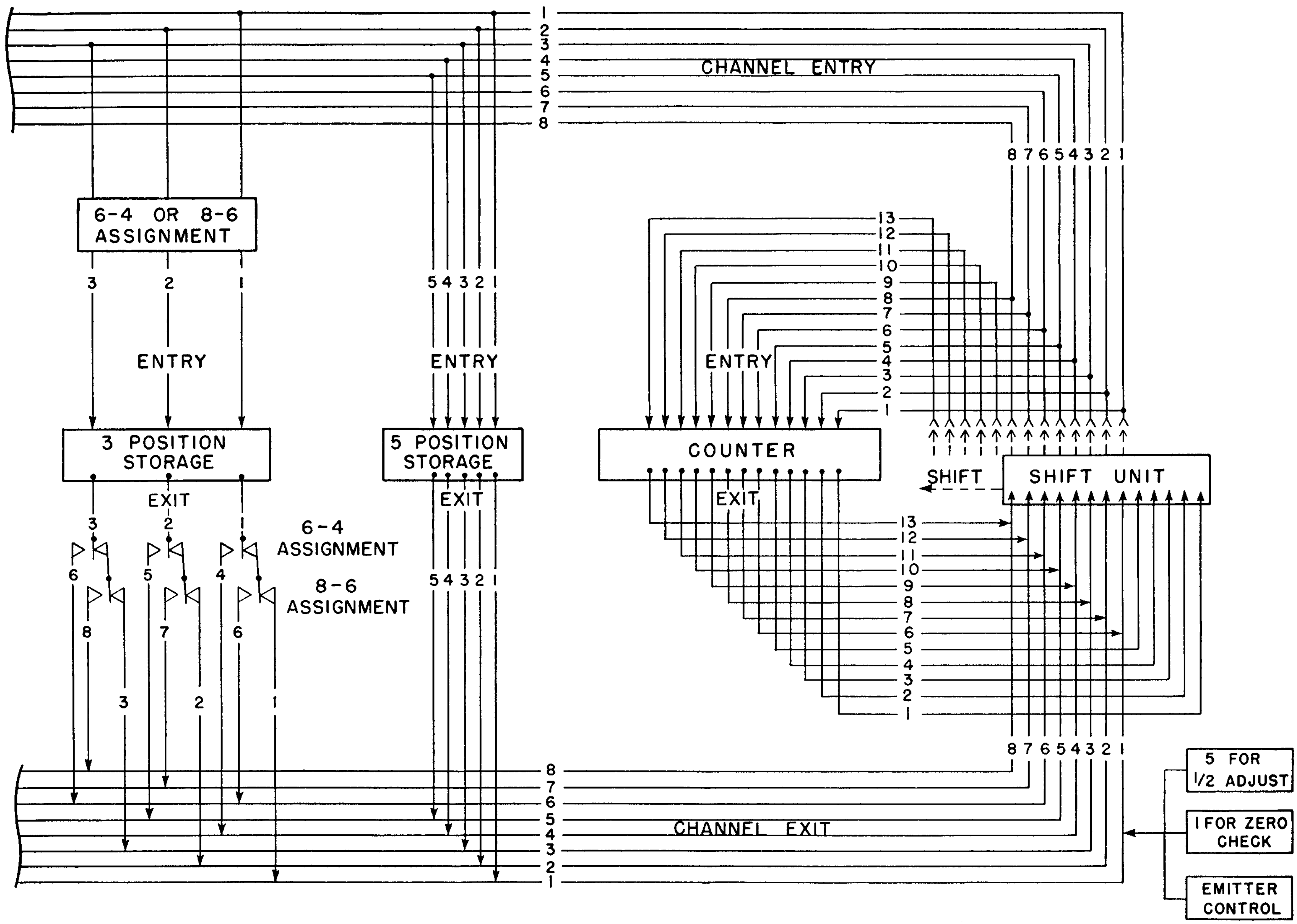


FIGURE 28. TYPE 604 CHANNEL SCHEMATIC

CHANNEL SCHEMATIC

THE channel schematic (Figure 28) is intended to clarify both STORAGE ASSIGNMENTS and READ UNITS INTO and READ UNITS OUT OF (shifting). It shows one 3-position and one 5-position storage unit to demonstrate channel assignments, and the counter and shift unit to demonstrate READ UNITS INTO and OUT OF.

Storage Assignment

The 3-position storage units can be assigned so that the units position is connected (assigned) to channel 1 (normal), channel 4 (6-4 assignment), or channel 6 (8-6 assignment). The second position will then be connected to channel 2, 5, or 7 and the third position to channel 3, 6, or 8. The assignment is controlled by internal selectors, the points of which are shown on the schematic; the selectors are transferred by the STORAGE ASSIGNMENT wiring on the punch control panel.

The 5-position storage units are always connected to channels 1 through 5.

Read Units Into

READ UNITS INTO concerns both the counter and the storage units. The first position of counter entry or a storage entry is connected to channel entry 1, the second to channel entry 2, etc. The first position of a storage exit is connected to channel exit 1, the second to channel exit 2, etc. Normally channel exits are aligned with corresponding channel entries, through a shift unit; this connects the units position of any storage unit with the units position of the counter or any other storage unit. If READ UNITS INTO 2ND is wired on the control panel, the shift unit moves one position to the left, thus lining up channel exit 1 with channel entry 2 (the second entry position of the counter or a storage unit); if READ UNITS INTO 6TH is wired, the shift unit moves all the way to the left and channel exit 1 will line up with channel entry 6. When any one of the READ UNITS INTO hubs is wired, the shift unit moves for one program step and then returns to normal.

Read Units Out Of

READ UNITS OUT OF concerns the counter only, since it is not possible to drop positions when reading out of a storage unit. The 6th position of the counter exit is connected to channel exit 1. Normally, when the counter is impulsed to read out, the shift unit moves all the way to the left (5 positions) so that the units position of the counter exit lines up with channel entry 1, the 2nd position with channel entry 2, etc.

If READ UNITS OUT OF 2ND is wired on the control panel, the shift unit is stopped after it has moved 4 positions to the left, thus lining up the 2nd position of counter exit with channel entry 1. Similarly, if READ UNITS OUT OF 5TH is wired, the unit stops after it shifts one position, thus aligning the 5th position of counter exit with channel entry 1.

It will be seen that READ UNITS OUT OF 5TH actually causes the same shift operation as READ UNITS INTO 2ND. These control panel hubs are common internally. Similarly, READ UNITS OUT OF 4, 3, and 2 cause the same shift as (and are common with) READ UNITS INTO 3, 4, and 5, respectively.

Other Functions

HALF ADJUST, ZERO CHECK, and EMITTER CONTROL are connected to channel exit 1, and may be shifted as many as five positions to the left by impulsing READ UNITS INTO.

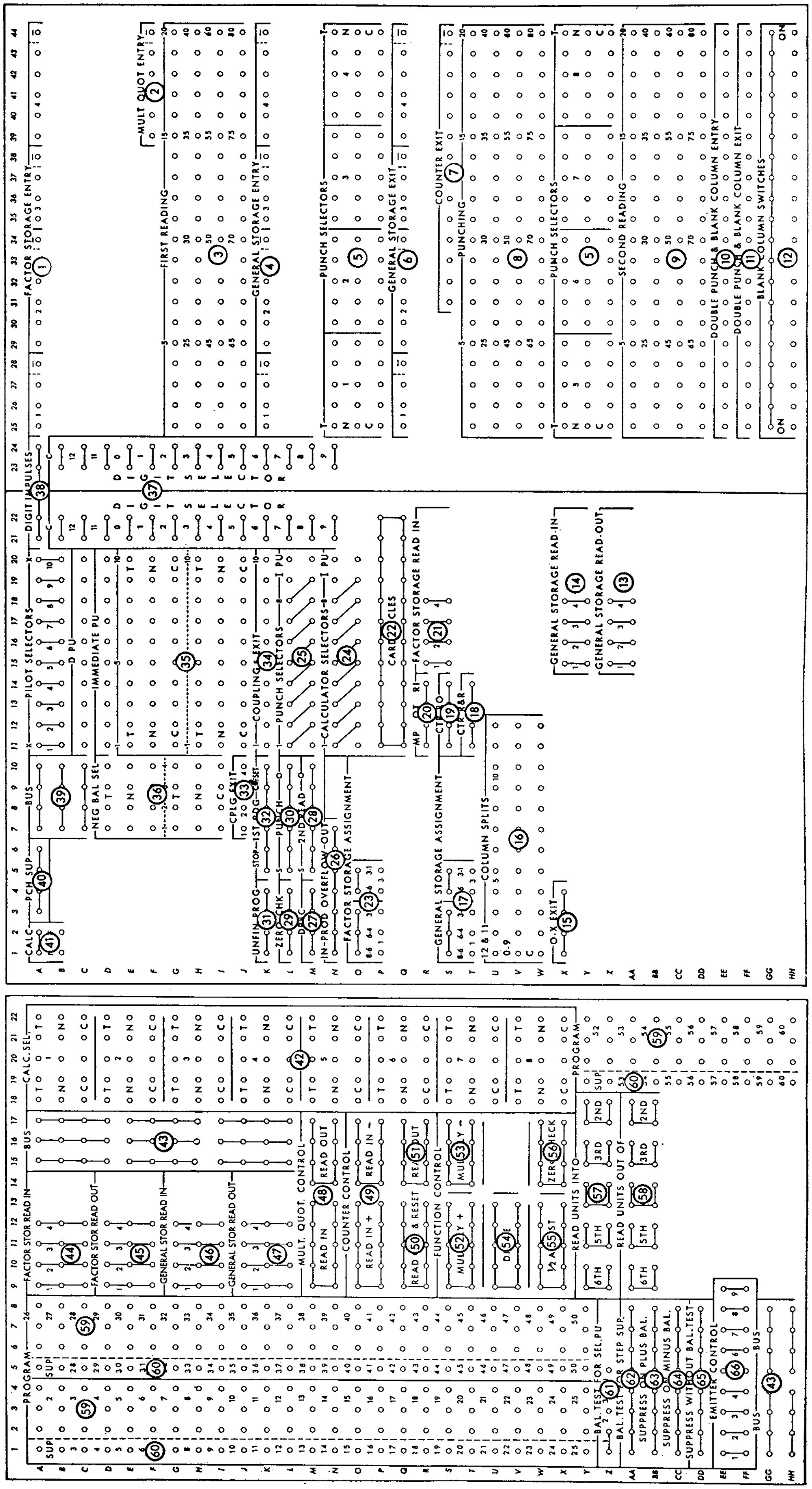


FIGURE 29. CONTROL PANEL SUMMARY

CONTROL PANEL SUMMARY

EACH SECTION of the control panel (Figure 29) is assigned a number under which the hubs are described.

Type 521 Control Panel

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. An X punch over any column, or over the units position for reasons other than sign control, must be eliminated by a column split. Without elimination in other than units position, an incorrect zero may be entered. More than a single digit in a column causes the sum of the digits to enter storage without a carry. Factor storage entry or exit during calculation is controlled by the calculator control panel. 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. An X punch over any column, or over the units position for reasons other than sign control, must be eliminated by a column split. Without elimination in other than units positions, an incorrect zero may be entered. More than a single digit in a column causes the sum of the digits to enter storage without a carry. General storage entry or exit during calculation is controlled by the calculator control panel. 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 521. Their pickup hubs are located on the left-hand 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 the counter, which receives impulses only during calculation, 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 DPBC 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. For a double-punched column, only the lowest digit punched will be available, i. e., if 9 and 6 were punched, only the 6 would be available.

These hubs can be used as entries, in which case only blank columns can be checked.

12. *Blank Column Switches.* Ten blank column switches are standard. When they are wired ON, columns wired to the corresponding double punch and blank column entry or exit hubs are checked for blanks (unpunched).

13. *General Storage Read Out.* These hubs accept only card cycle impulses to read factors out of the general storage units for punching.

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.

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 channels by connecting the 8-6 to the common hubs above. The 3-1 hubs are inactive.

24. *Calculator Selectors I PU.* These are the pickup hubs for the calculator selectors located on the calculator control panel. When impulsed, they transfer the selector for the following calculate cycle. They are normally wired from first reading, and can also be wired from second reading or the coupling exit of a pilot selector.

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

26. *Product Overflow In-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. Overflow OUT hubs are normally wired to punch stop.

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 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. They are normally wired from DPBC when detecting double punch-blank columns, or from zero check for simultaneous multiplication and checking operations. (See Figure 30.)

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 2nd read stop for simultaneous multiplying and checking operations, or to 1st reading stop when multiplication is checked in a separate run.

30. *Punch Stop-Offset.* The hubs labelled S (stop) are entry hubs that accept impulses to stop the machine for a product overflow condition that is recognized at the punch station. They are normally wired from product overflow OUT. 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. (See Figure 30.)

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. *1st Rdg Stop-Offset.* The hubs labelled S (stop) are entry hubs that accept an 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. (See Figure 30.)

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

34. *Coupling Exit (Pilot Selectors).* The coupling exit hub emits an impulse when the corresponding pilot selector is transferred through its X or D pickup, and is normally used to pick up punch or calculator selectors. The coupling exit and the Immediate pickup of a pilot selector are common.

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 calculator 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 calculating and punch units are used together. It must be wired OFF when the punch unit is used independently of the calculating unit for gang punching operations.

Type 604 Control Panel

42. *Calculator Selectors.* There are eight 5-position calculator selectors standard. Their pickup hubs are located on the punch control panel. When impulsed from first reading a calculator 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 calculator 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 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. The counter is reset automatically at the beginning of the next program step.

57. *Read Units Into.* Shifting from one to five positions may be done on any program step except those used for multiplication and division, 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 by wiring a program exit directly to the read units into hubs. Positioning of the ½ adjustment or zero check impulses is also controlled by impulsing read units into with a program exit. Read units into cannot be used when transferring factors from counter to storage.

58. *Read Units Out Of.* Shifting from one to five positions may be done on any program step except those used for multiplication or division, 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 with a program exit. 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. Read units out of cannot be used when transferring from storage.

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 exits.

60. *Sup (Program Suppression).* A program step may be suppressed by wiring 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 selectors located on the punch control panel. Only the first selector 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 on the next program, if the counter is plus, and the suppress on minus balance hubs will be active on the next program, if the counter is minus. These hubs will continue to be active until another program impulse reaches the balance test for step suppression or until the end of calculate time.

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 for that card.

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 for that card.

65. *Suppress Without Bal Test.* These hubs emit impulses on every program step and are normally wired through calculator 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.

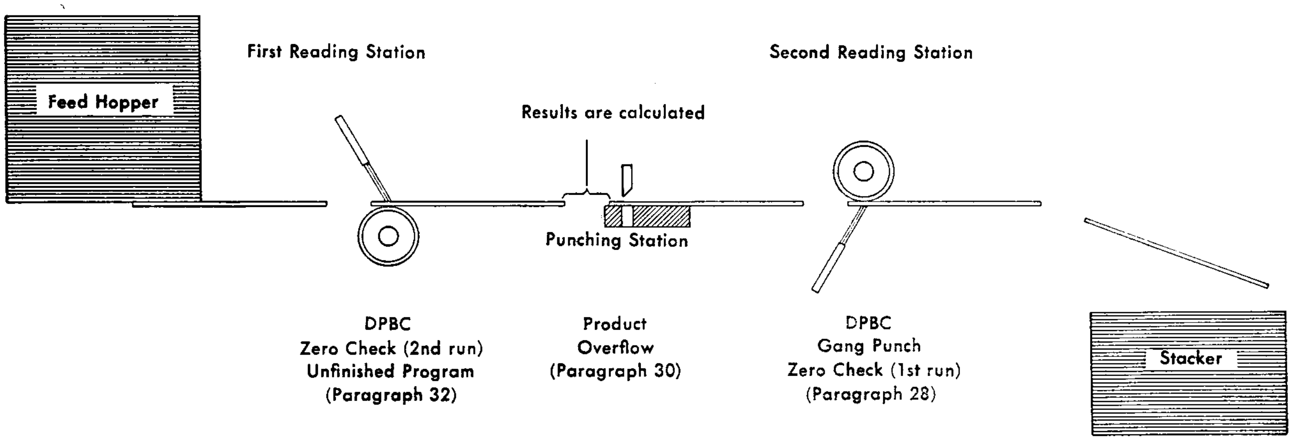


FIGURE 30. SCHEMATIC, STOP WITH CARD IN STACKER

Figure 30 shows which stacker stop hubs (paragraphs 28, 30, and 32) should be used to stop the machine when a stop is signalled at any of the three stations (first read, punch, or second read).

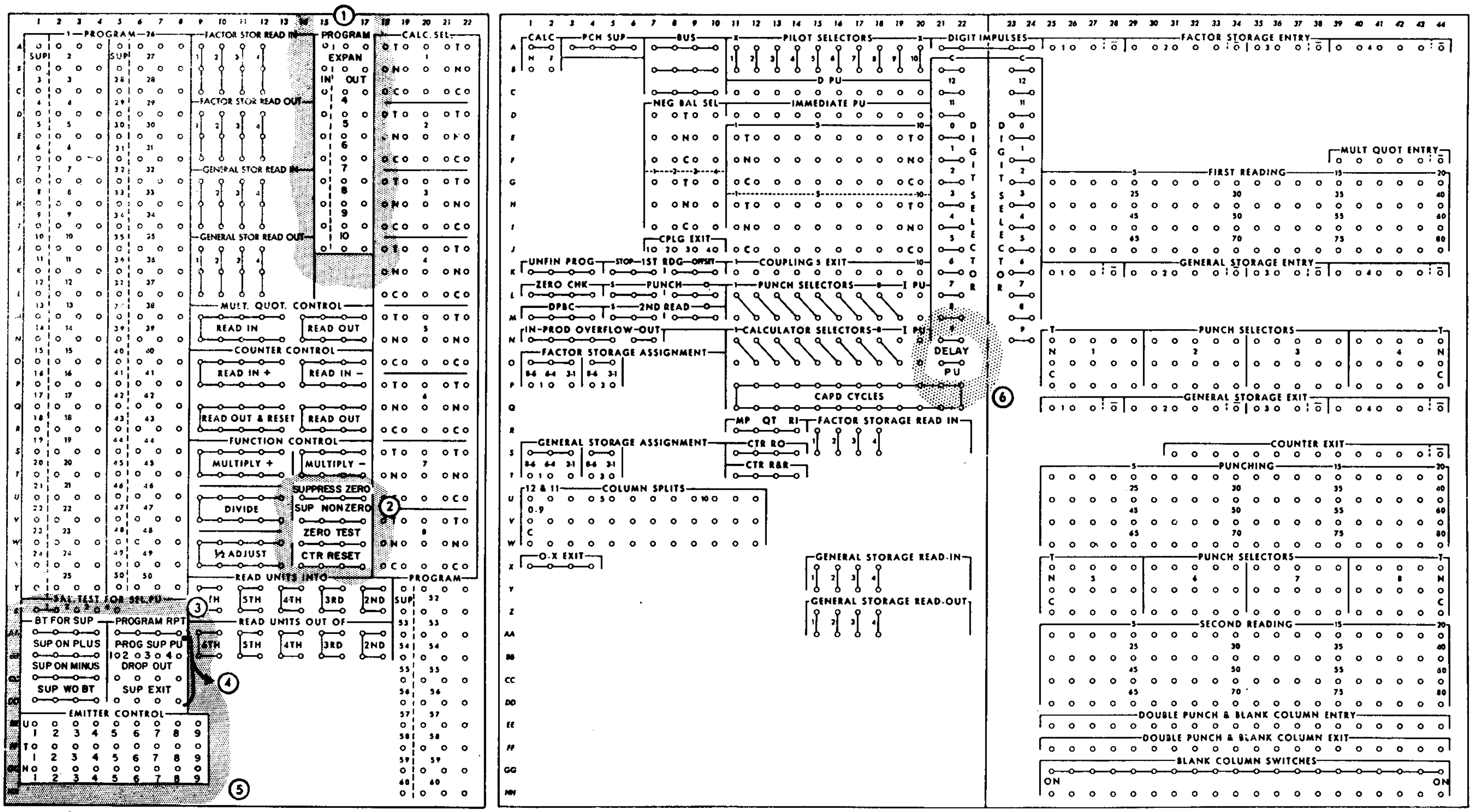


FIGURE 31. CONTROL PANEL SUMMARY FOR SPECIAL DEVICES

CONTROL PANEL SUMMARY, SPECIAL DEVICES

FIGURE 31 shows the control panel for a machine equipped with the special devices described below.

1. *Program Expanders.* Program expanders permit the wiring of more than one function from a program exit. Expanders contain an IN and two OUT hubs. When a program exit is wired to the IN hub, the OUT hubs can be used to provide program impulses to two separate functions, permitting the independent wiring of up to six functions on one program step. Two or more expanders may not be coupled to provide for additional outlets.

2. *Zero Test.* This device replaces the standard zero-check feature. When the zero-test hubs are impulsed, the 604 will test the counter for either a plus zero (counter has all 9's from the position being checked to counter position 13) or a minus zero (counter has all 0's from the position being checked to position 13).

The test will activate either the suppress zero or suppress non-zero hubs, depending upon the condition of the counter. These hubs may be used to suppress one or more succeeding program steps. The zero or non-zero will remain active until the next zero test is made. The program test on which a zero test is made cannot be suppressed because of the result of a previous zero test.

Zero test does not automatically reset the counter. However, the value in the counter is changed. If a reset is required, counter reset should be impulsed on the same program step as zero test.

When the counter reset hubs are impulsed by a program step, the counter will reset, without reading out, at the next program step. If counter reset is impulsed on the same program step as divide, the remainder will be reset at the beginning of the next program step. Counter reset does not affect the normal operation of the next program step.

3. *Program Repeat.* When these hubs are impulsed by a program step, the 604 will receive a signal after the last program step is completed. The signal will instruct it to return to program step one rather than to punch the card. The 604 will continue to repeat all program steps until the step on which program repeat is impulsed is suppressed. The signal to punch the card will then be given after the last program step is completed. Program repeat cannot be impulsed on the last program step.

In calculations with program repeat, the punch delay device is used, if calculation time exceeds the 521 operation rate of 100 cards per minute.

4. *Group Suppress.* There are four independent group suppress hubs, each with a pickup, a drop-out, and a suppress hub. Once the pickup hub is impulsed, the suppress hub of a unit is active until the unit is dropped out. The suppression operates on the step during which drop-out is impulsed, but not on the following step. The pickup hub is impulsed by an unsuppressed program exit, usually following a program on which a test (such as zero, or negative balance) is made and before another similar test is made. The unit is dropped out either automatically on the next card feed cycle, or by impulsing the drop-out hub from a later program exit. When the suppress hub is active, any program-suppress hub wired to it causes that program step to be suppressed.

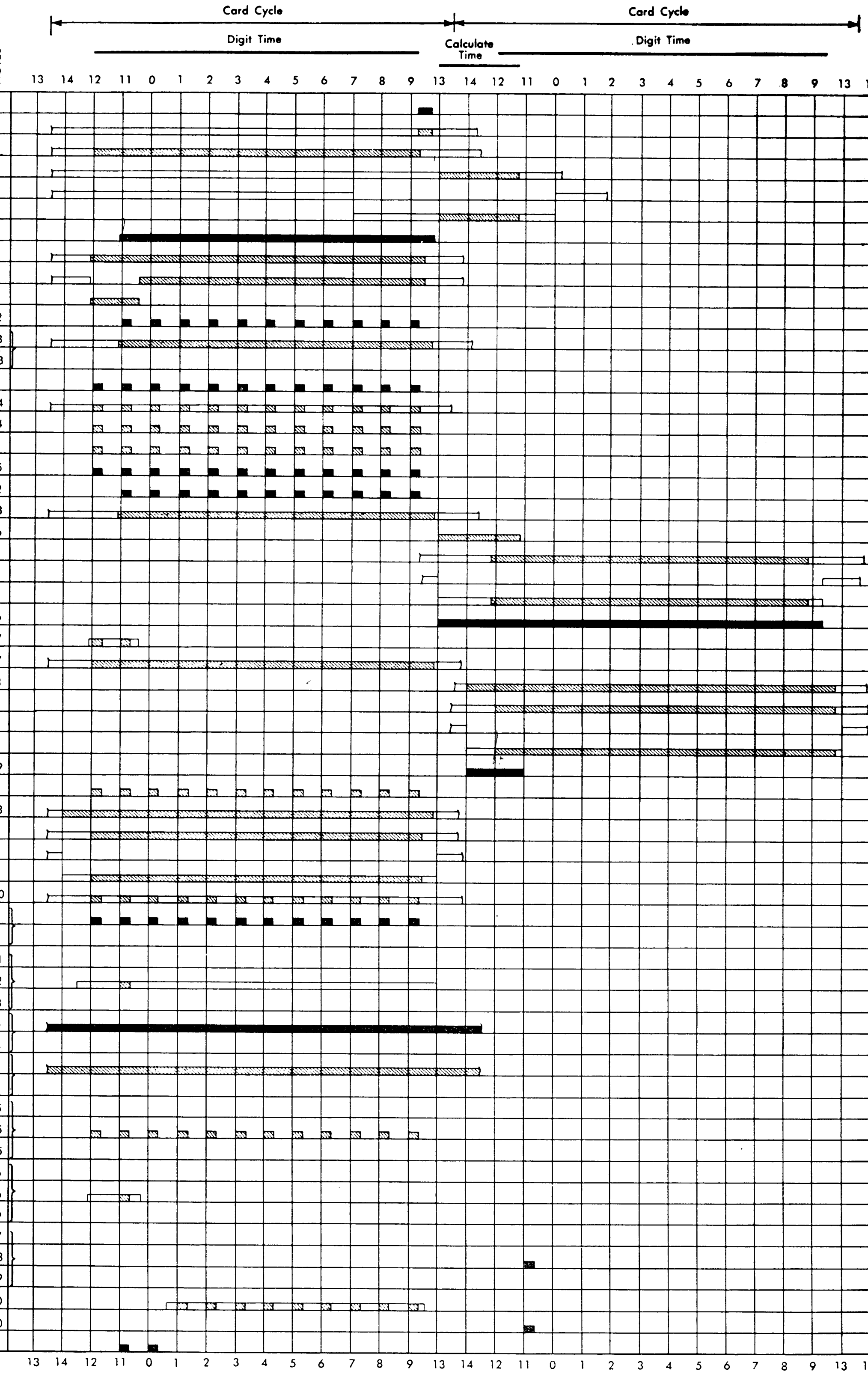
Because, once it is picked up, the unit remains active until dropped out, later programs can be suppressed on the basis of an earlier test, even though intervening tests have been made. This does not apply to the other suppress units (e.g., suppress-on-minus balance) which might be changed by each succeeding test and, therefore, lose the result of any previous test.

5. *Electronic Emitters—Tens, Hundreds.* These emitters are like the standard units emitter except that the digits are normally directed to the tens and hundreds channels. By the three emitters, and with program expanders, a three-digit constant can be emitted on one program step.

6. *Punch Delay — 521.* These hubs will accept any impulse available on the 521 control panel. When they are impulsed from a control punch in the card which is being read at the first read station, punching will be delayed a minimum of one 521 cycle until calculation is completed for that card.

Exit
Normal Entry
Other Entry

CONTROL PANEL HUB	LOCATION	NOTES
Blank Column Switches Common	GG, 25-44	
On	HH, 25-44	
Calculator Selector Pickup	N-O, 11-19	1
Common		
Normal		
Transferred		
Card Cycles	P-Q, 11-22	
Column Split Common	W, 1-12	
0-9	V, 1-12	
11-12	U, 1-12	
Counter Exit	S, 31-44	2
Counter Read Out	S, 11-14	3
Counter Read Out and Reset	T, 11-14	3
Digit Impulses	A, 21-24	
Digit Selector Common	B, 21-24	4
12-9	C-N, 21-24	4
Double Punch Blank Column Entry	EE, 25-44	
Double Punch Blank Column Exit	FF, 25-44	5
General Storage Exit	Q, 25-44	2
General Storage Readout	Z-AA, 15-18	3
Negative Balance Selector Pickup		6
Common	F, 7-10; I, 7-10	
Normal	E, 7-10; H, 7-10	
Trans	D, 7-10; G, 7-10	
Cplg Exit	J, 7-10	6
Pilot Selector X Pickup	A-B, 11-20	7
D Pickup	C, 11-20	7
I Pickup	D, 11-20	8
Common	G, 11-20; J, 11-20	
Normal	F, 11-20; I, 11-20	
Transferred	E, 11-20; H, 11-20	
Coupling Exit	K, 11-20	9
Punching	T-W, 25-44	
Punch Selector I Pickup	L-M, 11-20	8
Common	P, 25-44; Z, 25-44	
Normal	O, 25-44; Y, 25-44	
Transferred	N, 25-44; X, 25-44	
Punch Suppression	A, 3-6	10
Reading First	G-J, 25-44	
Second	AA-DD, 25-44	
Stop-Offset 1st Reading	K, 5-7, 8-10	11
Punch	L, 5-7, 8-10	12
2nd Reading	M, 5-7, 8-10	13
Storage Assignment General	S, 1-5	14
Factor	O, 1-5	14
(General) 8-6 6-4	T, 1-5	
(Factor) 8-6 6-4	P, 1-5	
Storage Entry General	K, 25-44	15
Factor	A, 25-44	15
MQ	F, 39-44	15
Storage Read In General	X-Y, 15-18	16
Factor	R-S, 15-18	16
MQ	R, 11-14	16
Stop Controls DPBC	M, 1-4	17
Zero Check	L, 1-4	18
Unfin. Prog.	K, 1-4	19
Prod. Oflow In	N, 1-5	20
Out	N, 6-7	20
O-X Exit	X, 1-4	



WIRING DIAGRAM NO 222301 G

FIGURE 32. TIMING CHART, TYPE 521

TIMING CHART, TYPE 521

A CYCLE is a period of time required to complete a given series of events at the end of which the series is repeated. On the Type 521, each cycle is divided into 14 equal parts called points. The points are numbered on the timing chart in the following sequence: 13, 14, 12, 11, 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. Points 13 and 14 represent the space between cards, and points 12 to 9 correspond to the 12 reading and punching positions of the card.

A card cycle starts at 13.5 (midway between 13 and 14) and ends fourteen points later at 13.5. Digit time is that time during which digits 12-9 are read or punched. Calculating time is that time required for calculation and is shown on the timing chart as occurring from 13 of one cycle to 12.7 of the next cycle.

Two card cycles are shown on the timing chart (Figure 32) in order to illustrate functions occurring on any cycle that were brought about by conditions recognized during the previous cycle. For example, pilot selectors picked up from X or D on one cycle transfer on the following cycle.

Notes

The timing of the calculate switch is not shown. This switch is wired either ON or OFF depending on the operation.

1. Impulsed during digit time (12-9) to transfer the selector for calculating time of that card.
2. Impulse emitted by each exit position is dependent upon the digit stored when impulsed to read out. In addition, the units position also emits an 11 (X) impulse if the total read out is negative. The sign hub emits impulses 11 through 9 when the total read out is negative. When a general storage unit is wired to read in for some cards and punch (read out) for others, a selector is required not only to control storage read in and storage read out, but also to select general storage exits to the punch magnets. If general storage exits are wired directly to the punch magnets, X's will punch whenever storage read in is impulsed.
3. Only card cycles impulses should be wired to these hubs.
4. Only digit-timed impulses (12-9) should be wired to C of a digit selector. C and 12 are common at 12 time; C and 11 are common at 11 time, etc.
5. Only the first impulse read into the DPBC entry hub is emitted from the corresponding exit hub.
6. The selector is picked up on the calculator control panel from a program exit to transfer the selector on the next cycle if the counter is negative. Coupling exit emits when the selector transfers.
7. When the X or D pickup hubs are impulsed, the selector transfers for the next cycle.
8. When the I pickup is impulsed, the selector transfers immediately and remains transferred for the rest of that cycle.
9. If X or D pickup is impulsed, coupling exit emits when the selector transfers. Coupling exit and I pickup are common.
10. When impulsed, all punching is suppressed for the following cycle.
11. When stop is impulsed, the machine will complete that cycle and two more before stopping. When offset is impulsed, the machine will not stop but the card will offset in the stacker.
12. When stop is impulsed, the machine will complete that cycle and one more before stopping. When offset is impulsed, the machine will not stop but the card will offset in the stacker.
13. When stop is impulsed, the machine will complete that cycle and stop. When offset is impulsed, the machine will not stop but the card will offset in the stacker.
14. These are line impulses and are not to be selected.
15. The units position will accept an 11 (or 12) impulse to cause a negative sign to be stored. The sign hub will accept any impulse from 12 through 9 to cause a negative sign to be stored.

16. The Timing Chart shows that storage read in will accept a 12, 11, or the 11 portion of a card cycles impulse. A 12 cannot be used, however, since it would reset the storage unit during calculating time of the preceding card and could cause an erroneous result. An X impulse read from a card should not be used to impulse read in when overpunched X's can reach the storage entry hubs. If an X impulse is used to impulse storage read in, overpunched X's must be eliminated through column splits.
17. This emits an X impulse during the cycle following the one in which an error is detected.
18. The X impulse is emitted immediately following the calculation in which the counter was non-zero.
19. The X impulse is emitted when calculating time available is not sufficient to complete the problem.
20. Wired from a counter or general storage exit position which should be zero. If a digit 1 through 9 is present, the out hub will emit an X impulse on the following cycle.

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