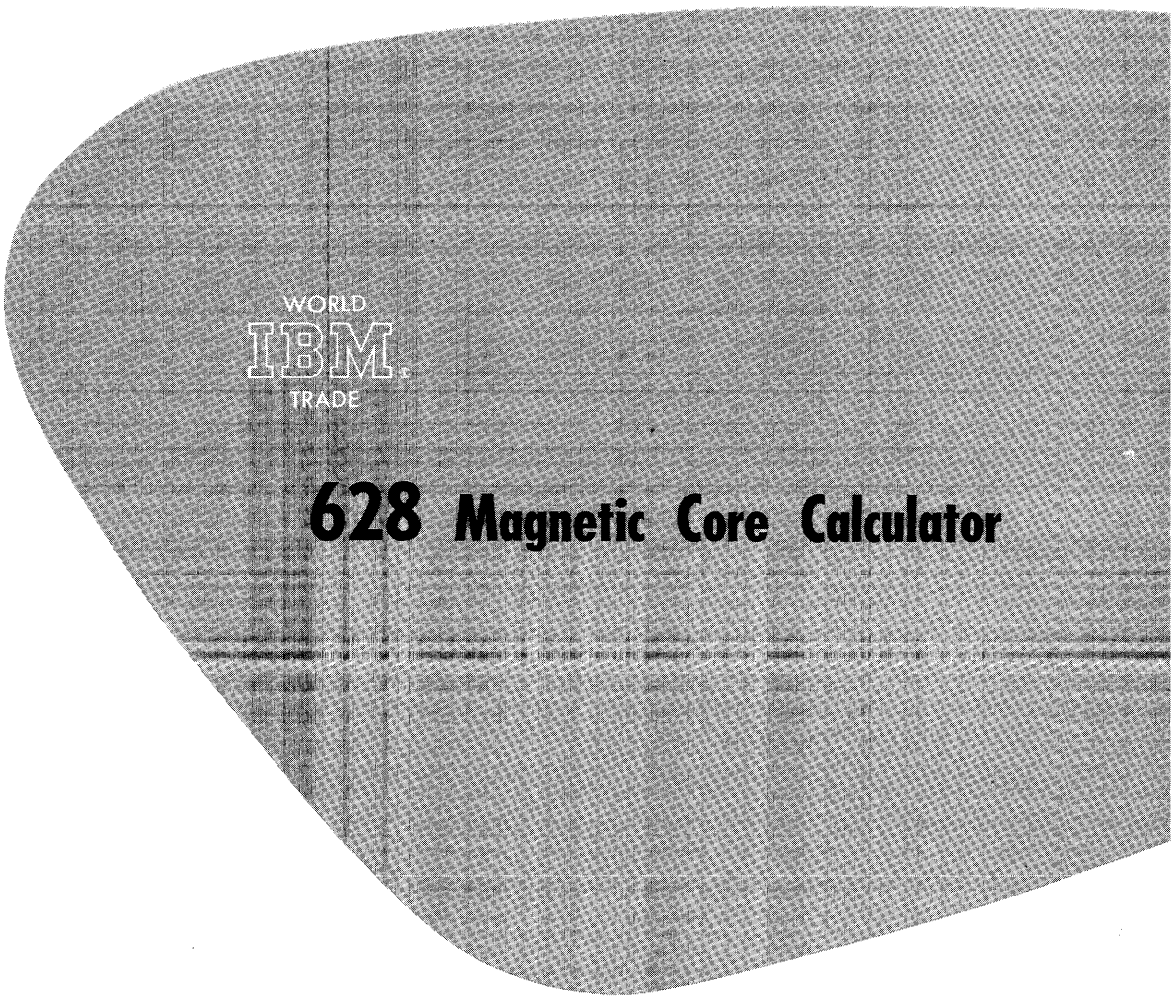


628 Magnetic Core Calculator

MANUAL OF OPERATION: PRELIMINARY EDITION

Printed in U. S. A.
Form 212-9924-0

MAGNETIC CORE CALCULATOR

628 - 565

or

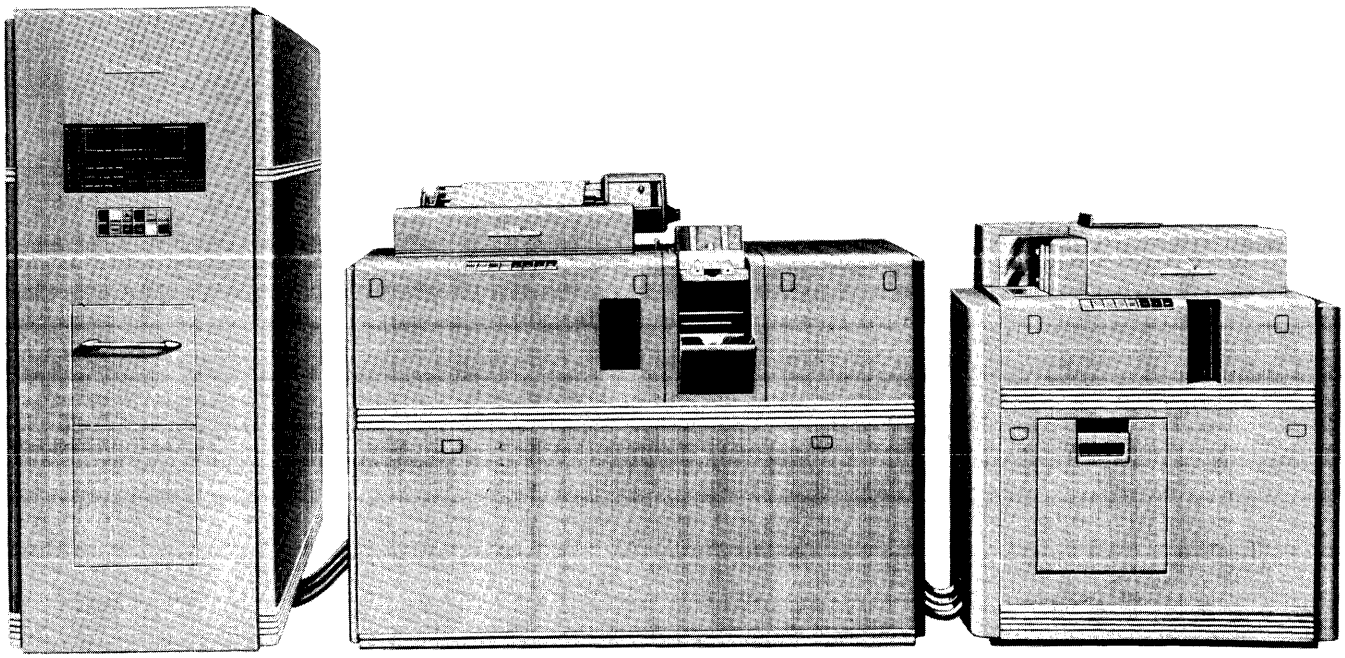
628 - 565 - 421

PRINCIPLES OF OPERATION

PRELIMINARY EDITION

IBM WORLD TRADE CORPORATION
821 United Nations Plaza
New York 17, New York

C O N T E N T S



Type 628 Magnetic Core Calculator

IBM 628 MAGNETIC CORE CALCULATOR

Introduction

The IBM 628 Magnetic Core Calculator is composed of an Electronic Calculator Type 628, and a Type 565 Punching Unit, and an optional Alphanumeric Accounting Machine 421 (150 lpm). These three machines operate as a system via interconnecting cables.

This group analyses input data entered in punched form on IBM cards; it adds, subtracts, multiplies, divides, selects and transfers data automatically, separates card groups and prints the results of these operations. It can register accounting data, rates used to calculate totals, commissions, quantities, etc; it controls calculations of these operations performed at electronic speed for each card or each group of cards, uses the results obtained to print and/or punch them, add them, subtract them, compare them to results already previously obtained or to partially totalized results. It controls recapitulative summary punching of selected data from totals and progressive balances from the counters of the accounting machine or of results calculated by the 628.

The standard 628 calculator is furnished with a 565 Punching Unit at 100 cards per minute. This unit contains one card feed with two read stations and a punching station. The 565 performs the following functions:

Card Feed - Input data at 100 cards per minute to the 628.

Calculate Control - Calculates with selected information from each card or group of cards and punches results into the input card or a trailer card.

Punching - Results are punched at the rate of 100 cards per minute into selected punching positions and cards.

When the 421 accounting machine is also attached to the 628 it performs the following functions:

Card Feed - Input data at 150 cards per minute to the 421, 628 or 565.

Listing - To print selected information at 150 lines per minute from one or more cards or groups of cards during detail printing.

To print selected information from the first card of each group (Group Indication) during group printing.

Calculate Control - Calculates with selected information from each card or group of cards and prints results from the 628. Calculated information can also be stored or accumulated in the 421 for further control and results.

Comparing - The standard control panel comparing feature of the 421 can be used to compare data from the card, accounting machine or calculator for input-output and intermediate control.

Punching - The 565 Punching Unit is used with the 421 to punch at the rate of 100 cards per minute selected information from calculated results in the 628 and/or the 421. An optional, Simultaneous Punch While Print Device, stores punch output data in a special 421 buffer so that the 421 will not be interrupted while the 565 is punching results.

CHARACTERISTICS OF THE 628

The following description of 628 characteristics and operating principles applies to the machine with a 421 accounting machine attached, in addition to the standard 565. Although in this section the 628 operation is not described in detail when the 421 is not attached, the 565, which then becomes the only source of input and output, operates in an equivalent fashion to the 421 from a standpoint of control.

The entry of factors and the exit of calculated results are made by the 421 Accounting Machine at the speed of 150 cards or 150 Program Cycles per minute. The 421 Accounting Machine is equipped with three reading stations which makes it possible to calculate, check and print during the course of one passage of cards in the Calculator Group.

Input data is stored in magnetic cores in words of 8 digits each. These magnetic cores have the following properties: high speed, immediate access, small space requirements and reliability.

One of the major advantages of this machine is its ability to split any storage word through program instructions. Each storage word of 8 digits, with its sign, can be split into words of 3 and 5 digits, each with sign.

Calculations in the IBM 628 are made at the basic frequency of 100 KC in an Accumulator equipped with magnetic cores of 16 digits, using a one digit adder. Information is transmitted in series by digits, and in parallel by bits, with a code of 4 bits for each digit and a digit interval of 10 microseconds. All the operations are controlled by wired program steps; each program step requires 180 microseconds. All data is processed in "true" form with algebraic signs.

Calculate time allotted between the reading of two cards on the 421 or two Program cycles is 152 milliseconds (i.e. 844 Electronic Cycles) in normal calculate, and 172 milliseconds (i.e. 955 Electronic Cycles) in Early Calculate Start.

Operating Speeds		Milliseconds
Adding	(with or without Reset to Zero)	.18
Subtracting	(with or without Reset to Zero)	.18
Add or Subtract	(with changing of sign)	.36
Multiplication	(8 x 8 = 16, multiplier all 9's)	14.58
Dividing	(16 ÷ 8 = 8, quotient all 9's)	17.46
Transfer	Accumulator to Storage	.18
Program Skip		.18

For all operations (except multiplication, division or an addition or subtraction with change of sign) a Program step corresponds to an Electronic Cycle, i.e.: 180 microseconds. In multiplication or division, a Program step can comprise several Electronic Cycles, their number depending on the number and value of the digits being calculated. For example, the multiplication of 796 by 25 requires 16 Electronic Cycles, although one Program step is used. In the division of 72 by 6, 28 Electronic Cycles are necessary, in spite of the fact that only one step is used.

Multiplication is accomplished by successive additions, and the number of Electronic Cycles needed can be determined by the method of the following example:

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

There must be one shift Cycle for each position of the multiplier capacity or (8 positions)	= 8 Electronic Cycles
One cycle per unit contained in each one of the numbers of the multiplier (2 plus 5 equal 7) (the maximum could be 8 x 9 = 72)	= 7 Electronic Cycles
One cycle for end of multiplication	= 1 Electronic Cycle
One Program Step	= 16 Electronic Cycles

The number of Electronic Cycles in the operations of division can be determined in the following manner:

$$\frac{76}{6} = 12$$

One Shift Cycle, one overflow cycle, and one correcting cycle are necessary for each position of the quotient capacity. (8 positions)

$$8 \times 3 = 24 \text{ Electronic Cycles}$$

Total of the units contained in each number of the quotient

1 plus 2 equal 3	=	3 Electronic Cycles
One Cycle for end of division	=	1 Electronic Cycle
One Program Step	=	28 Electronic Cycles

The calculations accomplished by the Electronic Calculator can be simultaneously checked because of the speed and capacity of the machine.

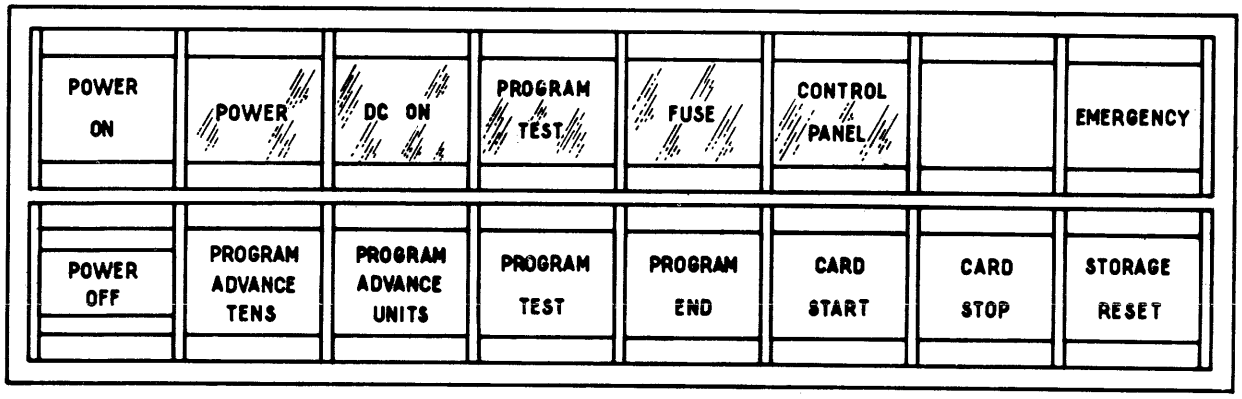


Figure 1. Operating Switches and Signal Lights on the IBM 628

Operating key "Power On"

When operating key "Power On" is depressed, the signal light "Power On" immediately lights up, the electronic tubes and ventilators are energized. After approximately 60 seconds the signal light "D.C. ON" lights up.

Note: The main line switch on the 565 Punching Unit (and the 421 Accounting Machine) must also be turned on to start the 628.

Signal Light "Power On"

The signal "Power On" lights up as soon as operating key "Power On" is depressed and remains lit until operating key "Power Off" is depressed.

Signal Light "DC On"

This signal lights up approximately 60 seconds after operating key "Power On" has been depressed.

Operating key "Power Off"

This key can be used at any time to turn off the machine. When this key is depressed the current is cut off sequentially in the machine, with the ventilators continuing to operate for approximately five minutes. In order to start the machine again it is necessary to once more depress the key "Power On".

Note: Although this operating key is depressed, a special circuit feeds the ventilators for about 5 minutes in order to avoid overheating which could harm the proper functioning of the machine.

It is therefore recommended to wait approximately 5 (five) minutes before shutting off the main power feeder.

Operating key "Emergency Stop"

This operating key can be used in case of an emergency in order to shut off all power to the calculator. An IBM Customer Engineer should be called to again connect the electric current to the machine and re-set the internal circuit breakers.

Signal light "Control Panel"

This safety signal lights up when the control panel is not placed in its cradle or is not locked properly.

Operating key and signal light "Program Test"

When operating key "Program Test" is depressed, the signal "Program Test" lights up. As long as this signal is lit, calculate does not start automatically after the reading of the card, but may be operated manually step by step. To shut off the signal light "Program Test" and restore the machine to automatic normal operation, it is necessary to again depress the operating key "Program Test".

Operating key "Program Advance Units"

When the signal light "Program Test" is on, this operating key governs a Program step by step operation.

Operating key "Program Advance Tens"

When the signal light "Program Test" is on, this operating key governs the Program steps ten by ten.

Operating key "Program End"

This key controls manually the end of a Program at any step when it is desired to only test a section of the program under Manual Program Control.

Operating key "Card Start"

This operating key can only be operated when signal light "Program Test" is on and through this key the 421 can be controlled to feed one card at a time.

Operating key "Card Stop"

This key can stop the feeding of cards at any given moment without affecting the calculate process.

Operating key "Storage Reset"

This key makes it possible to reset to zero all the storage units of the 628 machine. (This key will not reset the Accumulator.)

Signal light "Fuse"

The signal light "Fuse" goes on immediately when a fuse blows in the 628.

DISPLAY PANEL

The display panel is located above the console of operating keys and signal lights. It is composed of neon bulbs which light up at each stage to signal the controlled functions. (See Figure 2.) The panel is composed of the following sections:

Accumulator

Each position of the Accumulator is represented by four bulbs placed vertically, to which the following values have been assigned.

The top bulb "1" = "1"
The second "2_1" = "2"
The third "2_2" = 2 or 0
The lower bulb "5" = 5

The panel hereunder represents the bulbs lighted for the numbers 0 to 9:

Numbers / Bulbs	0	1	2	3	4	5	6	7	8	9
1		x		x			x		x	
2_1			x	x	x			x	x	x
2_2	x				x	x				x
5						x	x	x	x	x

The bulb labelled -(minus) lights up if the data contained in the Accumulator is negative.

Note that bulb 2_2 only represents a "value" when on with bulb 2_1 - otherwise it represents "zero" or no value.

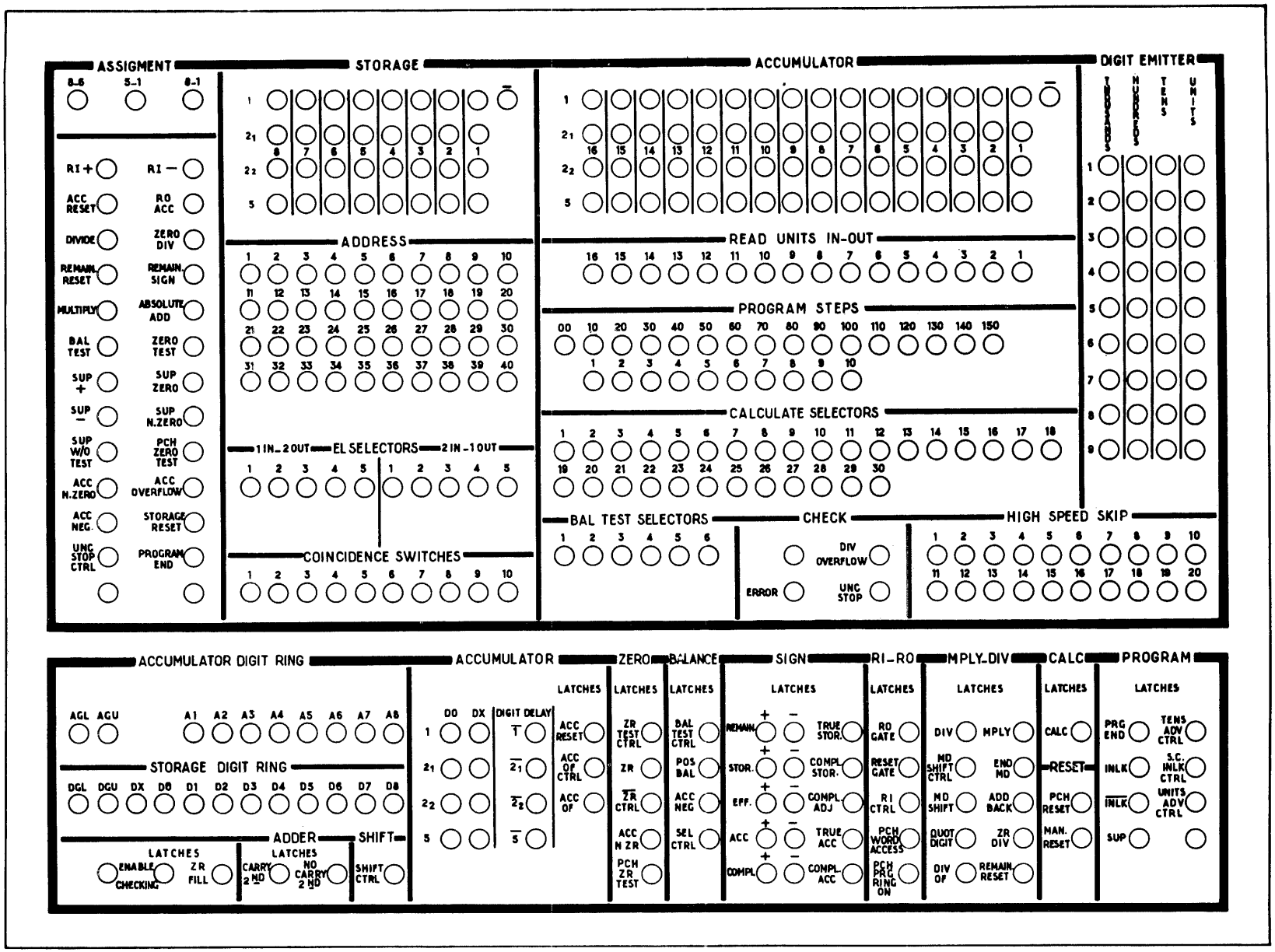


Figure 2. Display Panel on IBM 628

Storage Display

Each position in the addressed storage is represented by four bulbs having the same coding system as those of the Accumulator.

The bulb labelled -(minus) lights up if the data contained in the Storage addressed, is negative.

Assignment

Each of the bulbs represents one of the three possible assignments of the storage used at each Program step and lights up when the corresponding control (1-8, 1-5, or 6-8) is made. (i.e. 8 positions, 5 positions or 3 positions)

Addressed Storages

Each time a Storage is controlled in "Entry" or in "Exit" the corresponding bulb lights up.

Read Units In-Out

The sixteen bulbs represent either "Unit Entry in Position" or "Unit Exit from Position" of the Accumulator.

Program Steps

The upper row represents the number in "tens" of the Program Steps.

The lower row represents the number in "units" of the Program Steps.

The step which is about to be executed corresponds to the total of the values of the two bulbs which are "On"; one bulb "tens" and one bulb "units".

High Speed Skip

Each one of the bulbs represents one of the controls "High Speed Skip" and lights up when the corresponding control is made.

Emitters

Units

These nine bulbs represent the numbers 1 to 9 of the "Units" Emitter. Each bulb lights up when the corresponding number is controlled.

Tens

These nine bulbs represent the numbers 1 to 9 of the Emitter "Tens". Each one of them lights up when the corresponding number is controlled.

Hundreds

These nine bulbs represent the numbers 1 to 9 of the Emitter "Hundreds". Each one of them lights up when the corresponding number is controlled.

Thousands

These nine bulbs represent the numbers 1 to 9 of the Emitter "Thousands". Each one of them lights up when the corresponding number is controlled.

Calculate Selectors

Each one of these bulbs represent the Calculate Selectors, and lights up when the corresponding selector is controlled.

Balance Test Selectors

Each one of these bulbs represent one of the Balance Test Selectors of the Accumulator and lights up when the corresponding selector is controlled.

Electronic Selectors

Each one of these bulbs represent an Electronic Selector and lights up when the corresponding selector is controlled.

Coincidence Switches

Each one of these bulbs represent a Coincidence Switch and lights up when the corresponding coincidence is controlled.

FUNCTIONS

RI + Accumulator (Read in Plus Accumulator)

This bulb lights up when the function "Add" of the Accumulator is controlled.

RI - Accumulator (Read in Minus Accumulator)

This bulb lights up when the function "Subtract" of the Accumulator is controlled.

Accumulator Reset to Zero

This bulb lights up when the function "Reset to Zero" of the Accumulator is controlled.

RO Accumulator (Read Out Accumulator)

This bulb lights up when the function of "Read-Out" of the Accumulator is controlled.

Divide

This bulb lights up when the function "Divide" is controlled.

Zero Divide

This bulb lights up when the function "Detection Zero Divide" is controlled.

Remainder Reset

This bulb lights up when the function "Remainder Reset to Zero" is controlled in division.

Remainder Sign

This bulb lights up when the function "Read-Out Remainder Sign" is controlled.

Multiply

This bulb lights up when the function "Multiply" is controlled.

Absolute Add

This bulb lights up when the function "Add in Absolute Value" is controlled.

Balance Test

This bulb lights up when the function "Balance Test" is controlled.

Suppress On +

This bulb lights up when the function "Suppress Balance Plus" is controlled.

Suppress On -

This bulb lights up when the function "Suppress Balance Minus" is controlled.

Zero Test

This bulb lights up when the function "Zero Test" is controlled.

Suppress On Zero

This bulb lights up when the function "Suppress On Zero" is controlled.

Suppress Non Zero

This bulb lights up when the function "Suppress Non Zero" is controlled.

Punch Zero Test

This bulb lights up when the function "Punch Zero Test" is controlled.

Suppress Without Test

This bulb lights up when the function "Suppress Without Test" is controlled.

Accumulator Non Zero

This bulb lights up if the Accumulator is not at zero at the preceding step. If a shift has been made at the preceding step, the "Non Zero" condition is only valid from the shift position up to and including the 16th position.

Accumulator Overflow

This bulb lights up if the machine detects a capacity overflow on the preceding step.

Accumulator Negative

The bulb lights up when the machine detects a negative balance in the Accumulator at the preceding step.

Storage Reset to Zero

This bulb lights up when the function "Reset to Zero" of a storage word is controlled.

Stop Control

This bulb lights up when the function "Conditional Stop" is controlled.

Program End

This bulb lights up when the function "Program End" is controlled.

CHECK

Overflow Capacity Divide

This bulb lights up when the machine detects an overflow capacity during division.

Functions and Hub Assignments of the IBM 628

General

Exit hubs may be chain wired.

Split wiring is not permissible - only one exit hub may be connected to a particular entry hub.

All test outputs can be used to make logical decisions when used with Coincidence Switches and Electronic Selectors to alter routines.

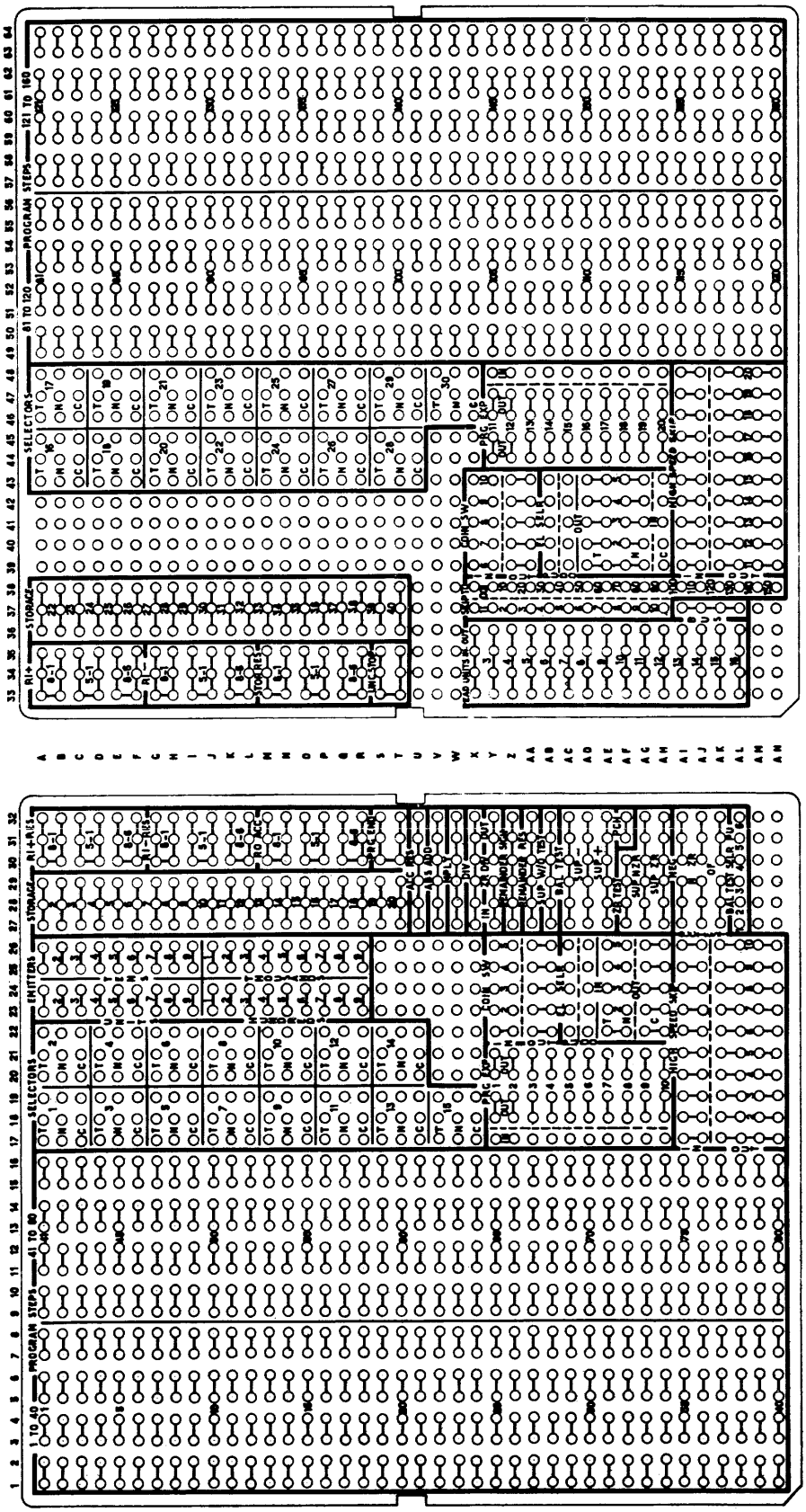


Figure 3. IBM 628 Control Panel

Program Exits

After the data from a card has been loaded into the 628, calculations are started and controlled by a series of program steps. These program steps occur successively and on each step the calculator can be controlled to perform a specific part of a required calculation. Each program step has four independent 2-position exits. A program exit must not be wired to more than one function.

Program Expanders

This feature is used to increase the number of isolated program exit hubs for any program step.

When the "IN" hub is wired to Program Exit, two 2-position "OUT" hubs produce the same signal as the program step wired to the "IN" hub.

Expanders cannot be wired in series.

RI + Reset, RI - Reset, RI + No Reset, RI - No Reset
(With assignments of 1-8, 1-5, 6-8)

When wired from the Program Exit hubs, they initiate read-in to the Accumulator from storage with the following controls active depending on the hub plugged. Only one of these hubs is plugged on any Program Step.

RI + or - : The operation is addition or subtraction.

RI + (or -) : This refers to the Accumulator and causes resetting of the Accumulator prior to read-in.

No reset is plugged when factors are to be added to or subtracted from the Accumulator value.

Assignment 1-8 or 1-5 or 6-8: This selects one of the three word sizes that can be obtained from each storage word. These sizes are 8, 5 or 3 digit words each, with signs.

Accumulator Read Out

When wired from "Program Exits" they cause the transfer of the Accumulator content with its sign into the assigned Storage.

These hubs are divided into three groups in order to determine the positions of the Storage to be used:

Positions 1-8, or,
Positions 1-5, or,
Positions 6-8

During any Program Step, only the above assigned positions can be made.

Storage Reset

When wired from Program Exits, it causes reset of storage value to zero according to the assignment plugged. The storage location must also be wired on the same Program Step.

Shift In (Out)

When plugged from a Program Exit, it causes an alignment of the units position of the storage value with any one of the second through 16th positions of the Accumulator. If not plugged, the units position of the Accumulator and storage will line up. This in effect controls shifting during transfer.

Storage

In the course of an Electronic Program all Storage is available to read-out or read-in data.

During the course of each Program Step it is possible to wire any one Storage word for "Exit" or "Entry".

Any Storage to Storage transfer must pass through the Accumulator.

Each Storage word has 8 positions plus 2 signs (1 sign for positions 1 to 5 and 1 sign for the positions 6 to 8), which may be assigned in one of three alternatives:

1 word of 8 positions with its sign, or,
1 word of 5 positions with its sign, or,
1 word of 3 positions with its sign.

Each new Read-In to Storage erases automatically the preceding information in the assigned positions.

Read-Out from Storage does not reset its contents to zero, unless it is so controlled, the "Read-Out and Reset to Zero" can be made simultaneously.

Accumulator Reset

When wired from Program Exits, these hubs cause a reset of the Accumulator to zero.

Add in Absolute Value

When wired from Program Exits, these hubs initiate an addition of the absolute value of the Accumulator with the absolute value of the Storage. The sign of the Accumulator remains the same.

The hubs RI + (No Reset) (assignments 1-8, or 1-5, or 6-8) and the Storage address must be picked up on the same Program Step.

Data from the Digit Emitter can be used in place of a Storage word.

Divide

When wired from Program Exits, these hubs cause internal programming to divide the dividend, which has been previously read into the Accumulator, by a value in Storage (divisor), and automatically develops the quotient into positions 1 through 8 and the remainder into positions 9 through 16, of the Accumulator. Shift cannot be plugged on the same step as divide.

Remainder Sign

This hub is plugged from Program Exits to transfer the sign of the remainder to Storage following division.

On all other transfers of data, including the quotient, from the Accumulator to Storage, the sign is automatically transferred.

Multiply

When plugged from Program Exits, these hubs cause internal programming to multiply. The multiplier must be previously read into positions 9-16 of the Accumulator, the multiplicand will be in Storage and the product will be automatically developed starting in units position of the Accumulator. At the end of multiplication the multiplier will be reduced to zero and the product will be contained in the entire Accumulator. Shift cannot be plugged on the same step as Multiply.

Negative Balance Test Pick Up

These hubs are wired to Program Exits to test the Accumulator for a negative balance. If a negative balance exists when tested, a Negative Balance Selector in the punch (and printer) will be picked-up. Six Negative Balance Selectors are provided.

Suppress Without Test

These hubs are normally used to suppress Program Steps under control of selected cards by means of Calculate Selectors. They are normally wired through selector points from the Program Step(s) to be suppressed.

Balance Test

These hubs, when wired from Program Exits, make a test on the Accumulator for a positive or negative balance. The result of this test is stored and used in conjunction with the Suppress + and Suppress - hubs to suppress program steps. The result of one balance test is available for succeeding steps until the next balance test is made, or until Program End.

Suppress (-)

These hubs are wired from Program Exits and will cause suppression of the calculation to be performed on that program step, when the result of the last balance test of the Accumulator was negative.

Suppress (+)

These hubs are wired from Program Exits and will cause suppression of the calculation to be performed on that program step when the result of the last balance test of the Accumulator was positive.

Zero Test

These hubs, when wired from Program Exits, make a test on the Accumulator for a zero or non-zero balance. The result of this test is stored and used in conjunction with the Suppress Zero and Suppress Non-Zero hubs to suppress program steps. The result of one zero test is effective until the next zero test is made.

Suppress Non-Zero

These hubs are wired from Program Exits and will cause suppression of the calculation to be performed on that program step when the result of the last zero test of the Accumulator indicated a non-zero balance.

Suppress Zero

These hubs are wired from Program Exits and will cause a suppression of the calculation to be performed on that program step when the result of the last zero test of the Accumulator indicated zero balance.

Punch (Zero Test)

These hubs, when wired from Program Exits, and the result of the last zero test gave a non-zero indication, will cause the "Check" hubs in the punch or printer to emit an impulse for control.

Remainder Reset

These hubs, when wired from Program Exits on the same program step as divide, will automatically reset to zero the "remainder" portion of the Accumulator following the divide operation.

Digit Emitter Units

This emitter can be used to enter a single digit into the Accumulator. The emitter can be controlled the same as any storage unit except that the Accumulator must be wired with a 1-8 assignment. The digit normally enters the units position of the Accumulator but may be shifted to any position under shift control.

Digit Emitter-Tens

This feature is the same as the Units Emitter except that the digit normally reads into the tens position of the Accumulator.

Digit Emitter-Hundreds

This feature is the same as the Units Emitter except that the digit normally reads into the hundreds position of the Accumulator.

Digit Emitter-Thousands

This feature is the same as the Units Emitter except that the digit normally reads into the thousands position of the Accumulator.

Calculate Selectors

Thirty 3-position selectors are standard which are picked under control of the card reading machine. They are used in the calculator to alter programming, storage controls, etc.

Program End

This hub is wired on the program step following the last program step used. This hub is used to save time by making the end of calculate signal pluggable instead of having to wait for the Automatic Program End Signal which comes after the last program step in the machine. This is always recommended when using punch delay for the attached input-output machine(s).

High Speed Skip

This feature is provided to allow skipping from any program step in one electronic cycle. This skipping to program steps can be either forward or backwards.

The IN hubs are plugged from program exits to initiate a skip. The OUT hubs then provide two separate signals that must be wired to the "Skip To" hubs. One of the OUT hubs is wired to one of the ten "Units Skip To" hubs and the other to one of the sixteen "Tens Skip To" hubs. The combination of the units and tens "Skip To" hubs allows skipping to any of the 160 program steps. The OUT hubs may be wired through selectors or chain wired.

Electronic Selectors: 2 IN - 1 OUT (Five)

This device provides a selection of either of two inputs and allows alteration of this selection through its P.U. (Pick Up) and D.O. (Drop Out) hubs.

These Electronic Selectors act similar to a selector in that, when the P.U. hub is pulsed, the signal wired to the "T" (Transfer) hub will be available at the "C" (Common) hub and when the D.O. hub is pulsed a signal wired to the N (Normal) hub will be available at the C hub. The selector will stay in the P.U. state until wired to D.O. and vice-versa.

These selectors can be picked on any program step for use in or selection of the next program step.

Electronic Selectors: 1 IN - 2 OUT (Five)

This device provides a selection of one input to one of the two outputs and allows alteration of this selection through its P.U. and D.O. hubs. These Electronic Selectors act similar to a selector in that, when the P.U. hub is pulsed, the input signal at the C hub will be available at the T hub and when the D.O. hub is pulsed the signal will be available at the N hub. The selectors will stay in the P.U. state until wired to D.O. and vice versa.

Because of a timing restriction, the Electronic Selectors cannot be picked up and used on the same program step.

Accumulator Negative Test Exits

These hubs provide a signal on a cycle by cycle basis every time the Accumulator value goes negative. This signal occurs on the cycle following the one on which the Accumulator went negative. These hubs are normally wired to coincidence switches.

Accumulator Non Zero Test Exits

These hubs provide a signal on a cycle by cycle basis every time the Accumulator has a non zero balance. This signal occurs on the cycle following the one on which the Accumulator has a non zero balance. If a shift was made at the preceding step this Non Zero condition is only valid from the "shift to" position up to and including the 16th position.

Accumulator Overflow Test Exits

These hubs provide a signal on a cycle by cycle basis every time the Accumulator overflows (carry from the high order position). This signal occurs on the cycle following the one on which the Accumulator overflowed. (Negative, Non-Zero, Overflow Capacity) can be used directly or through the intermediary of coincidence switches to control; an Electronic Selector, a Skip Program step, or a Suppress step.

Coincidence Switches (Ten):

These are logical decision switches with two inputs and one double hub output for each switch. One of the inputs is normally wired to one of the three "Accumulator Test Exits" and the other input to a Program Exit signal. When both signals are present at the Inputs, an Output Signal will be available for program alteration.

Zero Divide

When it is desired to check for the presence of a zero devisor, the IN hub would be wired on the same program step as division. If a zero devisor is detected, the calculator will automatically advance program without a divide overflow error signal. The Accumulator will be reset to zero.

On the first program step following a detected zero divisor, a signal is available at the OUT hub for use in altering the programming.

Also a signal will be available on the punch or printer panel following a detected zero divisor for control of the punch or printer. The OUT impulse is reset by the next card cycle.

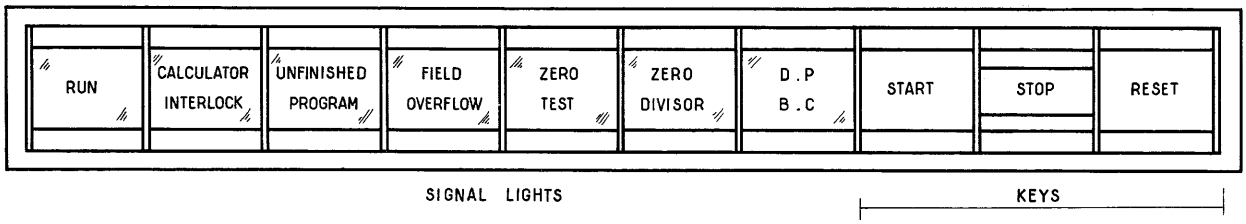


Figure 4. Operating Switches and Signal Lights on the IBM 565

When the Main Line Switch of the Punch Unit is turned "ON" and the "Power ON" key of the Calculator is depressed, the two units are power fed. Operation can be started after one minute in order to allow the necessary time for the heating of the electronic tubes.

The signal light "D. C. ON" of the Calculator and the signal light "Calculate" of the Punch Unit are on when the machine is ready to operate.

Operating Key "Start"

When the two signal lights mentioned above are on, the depressing of operating key "START" initiates a card feed which in turn will cause calculation to start.

Operating Key "Stop"

By depressing operating key "STOP" operations in both the Punch Unit and the Calculation Unit are controlled for stop at the end of the card or calculate cycle.

Operating Key "Reset

When an error is detected by one of the 5 signal lights of the Punch Unit, the machine can only be started again by depressing the operating key "RESET".

Signal Light "Run"

This signal lights up as soon as the Main Line Switch is turned "ON". It goes out during the card run and lights up again as soon as the machine stops. It also goes out when the control panel is taken out of one of the two units or when a fuse is blown in the Punch Unit.

Signal "Calculator Interlock"

This signal lights up at the same time as the signal "D.C. ON" of the Calculator and indicates that the machine is ready to operate.

Signal "Unfinished Program"

In the case when a calculation cannot be terminated in the time necessary for the card to go from the first reading station to the Punch station or an Accumulator Capacity Overflow in division is detected, the signal "unfinished program" lights up, the machine stops and punching does not take place. This light is controlled by 565 control panel wiring.

Signal "Field Overflow"

This signal lights up and the machine stops if the result is greater in a storage word than the columns wired for punching. This signal is controlled by 565 control panel wiring.

Signal "Zero Test"

This signal lights up and the machine stops when, in the course of check operation for instance, the subtraction of the punched result from the calculated result a second time does not yield a zero balance. This signal is controlled by the 565 control panel wiring.

Signal "Zero Divisor"

This signal lights up and the machine stops, if, in the course of an operation (division), a Zero Divisor is detected. This signal is controlled by the 565 control panel wiring.

Signal "Double Punch and Blank Column"

The signal "DPBC" lights up and the machine stops when a double punch or a blank column is detected. This signal is controlled by the 565 control panel wiring.

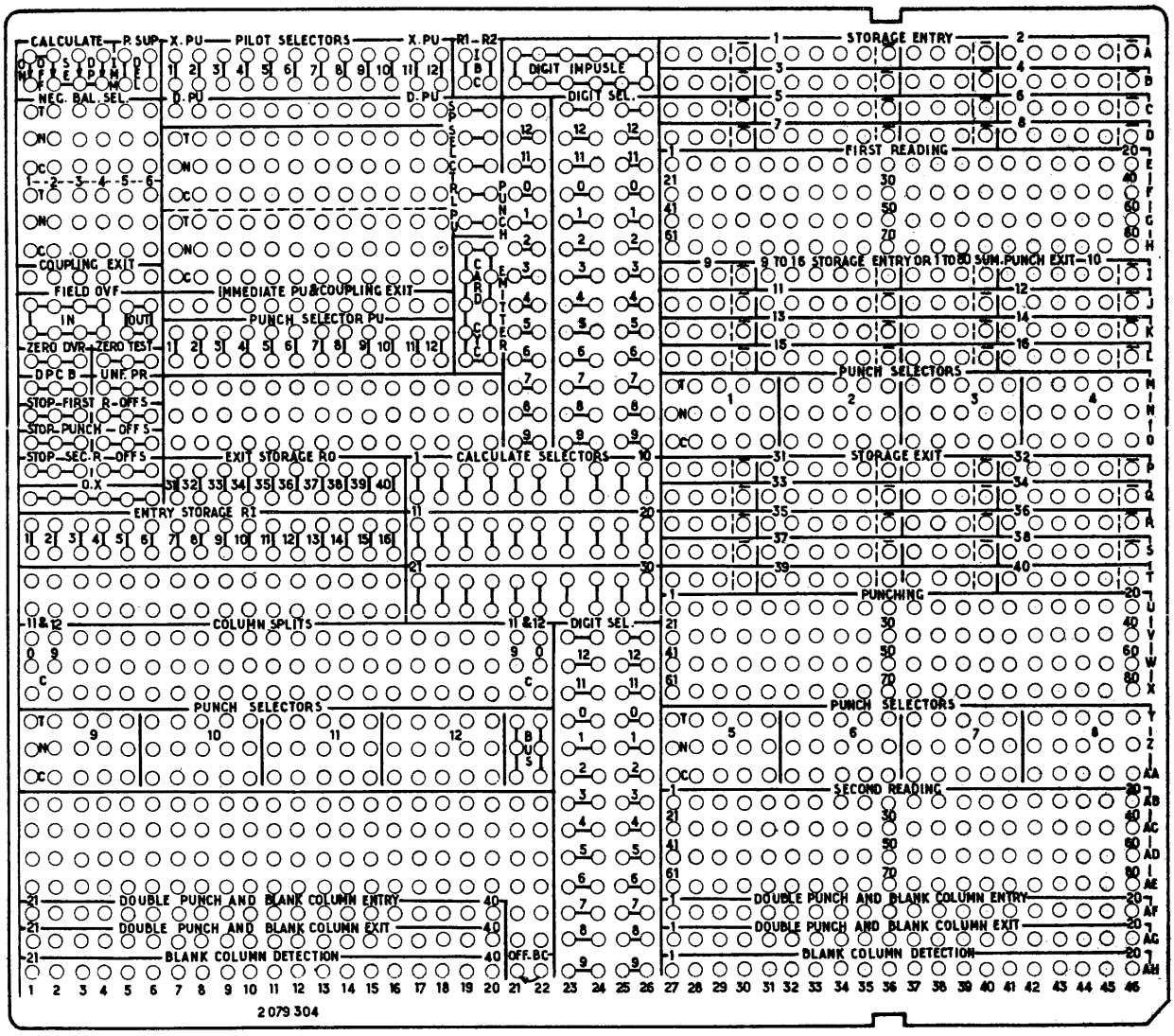


Figure 5. IBM 565 Control Panel

Functions and Hub Assignments of the 565 in the 628-565 Basic System

First Reading

These exit hubs correspond to the 80 reading brushes in the First Reading Station (before Punching Station).

They are normally connected, directly or through selectors to the 628 entry storages.

Second Reading

These exit hubs correspond to the 80 reading brushes in the Second Reading Station (after Punching Station).

They are normally used for gang punching, for reading punched results, for recalculating and checking or for double punch and blank column detection.

Punching

These are the hubs used for punching the results in predetermined columns of the card.

They are normally connected, directly or selected, either from the 628 Exit Storage words for punching the results of the calculation, or from the Second Reading for gang punching.

Punch Selectors

The machine is provided with eight 5-position Punch Selectors standard and four additional 5-position Punch Selectors optional.

These selectors are transferred immediately on receiving an impulse, and remain so until the end of the reading cycle.

Punch Selector I-PU

These are the punch selector pick up hubs.

When impulsed, the selector is immediately transferred. They are normally connected to the First or Second Reading or to a Pilot Selector coupling exit.

Pilot Selectors

The machine is provided with five 2-position Pilot Selectors standard and five additional 2-position Pilot Selectors optional.

Each selector has three PU hubs: X, Digit, Immediate.

When the X or D PU hubs receive an impulse, the selector is transferred on the following reading cycle and remains transferred until the end of that cycle.

When the Immediate PU hub receives an impulse, the selector is immediately transferred and remains transferred until the end of the cycle.

Coupling Exit (Pilot Selectors)

The Immediate PU of Pilot Selectors may be used as a coupling exit and emits an impulse when the corresponding Pilot Selector is transferred.

They are normally used to pick up a Punch or Calculate Selector.

Emitter

These hubs emit 12 through 9 impulses during each card feed cycle.

Digit Selectors

The machine is provided with 2 Digit Selectors standard and 2 additional Digit Selectors optional.

When the C hubs are connected to the First or Second Reading, the impulses corresponding to the digital value of the hole punched in the card is available at the Digit Selector hubs 12 to 9.

Digit Impulse

When the C hub of a Digit Selector is connected to an impulse digit hub, the Digit Selector becomes an Emitter.

Double Punch and Blank Column - 10 position Entry (Standard)

These are entry hubs to check the presence of blank columns and detect double punching. (Thirty additional positions optional.)

Double Punch and Blank Column - 10 position Exit (Standard)

These are the exits of the preceding hubs. They are normally connected to the punch hubs. (Thirty additional positions optional.)

Blank Column Detection Control - 10 positions

These hubs are active only when the "BC OFF" jumper is not connected.

They serve to select the presence of blank columns by wiring a shunt around each group of D.P. and BC hubs which are not to be checked for blank columns. For example, wiring from Blank Column Detection Control 4 to Blank Column Detection Control 9, would eliminate blank column checking in positions 5 through 9.

Blank Columns Off-2 hubs (BC-OFF)

When jack plugged (which can be selected) the detection of the presence of blank columns does not function. "BC" is an exit hub and "OFF" an entry hub.

Double Punch-Blank Columns

These hubs emit an X and 0 impulse when the double punch and blank column hubs are connected, and when a double punch or a blank column is detected.

They are normally connected to STOP and/or OFFSET. (Offset-optional feature).

Calculate-On

A jack plug must be wired between (CALC) and (ON) when the 565 is used as 628 input-output. (421 not in use).

Calculate-Off

A jack plug must be wired between (CALC) and (OFF) each time that the punch unit is used independently of the calculating unit for a gang punching operation, or as an output punch when used with the Calculator and Accounting Machine.

Sign Elimination

The Sign Elimination hub when jack plugged from (CALC) extends the calculation time through X. All controls, sign, etc. under these circumstances extend from "0 through 9", instead of "11 through 9" - and "11" only exits emit "0" such as "checking" etc.

Punch Delay

A jack plug must be wired in Punch Delay when the calculation time exceeds the 100 card-per-minute rate.

The object of this control is to extend the calculation time by preventing a card cycle until the calculation is completed. Card feeding is resumed automatically when the calculation is finished.

Impulse Before Calculation First Reading (IBC-L. 1)

This "9" impulse occurs each card cycle permitting the control of a Calculate Selector in order to alter the Electronic Program.

Impulse Before Calculating Second Reading (IBC-L. 2)

This "9" impulse occurs each card cycle permitting the control of a Calculate Selector in order to modify the Electronic Program.

Common

These hubs emit during points X to 9 of every card cycle including run-in and run-out and can be used for common control.

0-X Exits

These hubs emit an X impulse and a 0 impulse at each reading cycle.

Column Splits (X-Eliminators)

The machine is provided with 22 Column Splits used to separate the 0 to 9 punches from 11 and 12 punches.

Punch Suppress (Delay)

The suppression of all punching for the following card cycle can be accomplished by entry of any digit 9 through X into "Punch Suppress Delay".

Punch Suppress (Immediate)

The suppression of any punching on the same cycle can be accomplished by wiring the Punch Suppress (Immediate) hub with any impulse.

Zero Test

The Zero Test hubs emit an X or 0 impulse when, at a zero test step, the Accumulator balance is not zero.

They are normally connected to Stop and/or OFFSET. (Offset, optional feature).

First Reading Stop

Hubs marked (STOP) are the entry hubs which receive an X or 0 impulse to cause the machine to stop when an error is detected in the First Reading position. The machine stops as soon as the card arrives in the stacker.

First Reading Offset (Optional)

The hubs marked (OFFSET) are the entry hubs which receive an X or 0 impulse. When they receive this impulse, the card from First Read Station is offset in the stacker.

Punch Station Stop (Standard) - Punch Station Offset (Optional)

Same functions as First Reading (STOP), but valid for the punch station.

Second Reading Stop (Standard) - Second Reading Offset (Optional)

Same functions as First Reading (STOP), but valid for the Second Reading Station.

Unfinished Program

This hub is an emitter and permits controlling STOP of the punch when the program is unfinished or when, during division, the Accumulator overflows.

Overflow-Entry and Exit

The overflow entry "In" hubs are normally connected to one or several Storage Exit Hubs outside of the area of the hubs connected to "Punch". If a number other than zero is detected, the Overflow Exit Hub will emit an X and 0 impulse which can be connected to Machine Stop, or other controls.

Zero Divisor

This hub emits an "X" and "0" impulse when a Zero Divisor has been detected during a computing operation, providing that the Zero divide hub on the 628 control panel has been plugged in the same step as "Divide".

Negative Balance Selectors - Selectors 1 to 6

These hubs represent the common, normal and transfer points of the balance selector relays controlled from the 628.

All digits, reading or, transfer impulses can be filtered by means of these contacts during the cycle following a calculation.

These contacts are transferred during the calculation when the 628 Accumulator is negative at a program step, at which time a Negative Balance Selector can be picked up.

Coupling Exit-Balance Selectors

The coupling exit hubs emit an impulse when the corresponding Balance Selector is transferred.

They are normally used to pick up Punch or Calculate Selectors.

Calculate Selector PU-By digit

This machine is provided with 30 Calculate Selectors

These are the pick up hubs for the Calculator Selectors located on the 628 Calculator control panel.

They can receive any 12 to 9 impulse, and their contacts are immediately transferred.

Calculate Storage Entry - Words 1 to 16

Depending on the number of storage words installed on the 628, from 10 to 16 of these words are available with 8 positions each on the 565 panel for entry of digits 0 through 9 to the calculator.

These positions are normally connected to the First Reading and Second Reading Brushes or to the Calculate Storage Exits.

Each Storage Entry word has two hubs for sign read in capable of receiving 11 to 9 impulses - one hub for positions 6 to 8 and one hub for positions 1 to 5.

Only the 1 to 5 sign position hub need to be connected if the factor to be read in is 4 or more digits.

Entry Storage PU

One control hub for each entry word is impulsed normally by the "Common" impulse to control and select 628 Storage Entry.

Calculate Storage Exit - Words 31 to 40

Depending on the number of storage words installed on the 628, from 6 to 10 of these words are available with 8 positions each on the 565 panel for exit of digits 0 through 9 from the calculator. These words are normally connected to Punch.

Each exit word has 2 sign exit hubs: one for positions 6 to 8 and one for positions 1 to 5. These sign hubs emit X to 9 impulses when the storage is negative.

Exit Storage PU

One control hub for each exit word is impulsed normally by the "Common" impulse to control and select for punching from 628 Storage Exit.

Features of Type 421
When Used as Optional Feature with 628-565 System

GENERAL DESCRIPTION

The 421 Accounting Machine used in combination with the 628, is a machine which has the same characteristics as the standard 150 line per minute machine (model A-54, A-55, A-56 or B-54, B-55, B-56), but modified in the Plant with the 421-628 synchronizer for attachment (including a 3-brush Station Card Feed Unit).

- The first station may be used, for example, for the control of calculate selection;

- The 2nd station is used for read-in of the calculate elements in Storages 1 through 28 of the 628, in this example.

- The 3rd station allows printing of the card data simultaneously with the calculate results from Storages 31 through 40 of the 628 in this example.

The attachment to the 628 is brought about by means of up to three 180-position interconnecting cable receptacles.

The output punch is a 565. The attachment between the 421 and this punch is made by means of:

1. One 160-position summary punching standard cable,
2. One additional 180-position cable.

Functions and Hub Assignments of the IBM 421

Besides its standard features, the 421 presents the following characteristics when attached to the 628-565. (See Figure 6.)

Calculate Storage Entry - Words 1 to 28

Depending on the number of storage words installed on the 628, from 10 to 28 of these words are available with 8 positions each on the 421 panel for entry of digits 0 through 9 to the calculator.

These positions can be plugged from the Second and Third Reading Brushes, from 628 Storage Exit, from 421 mechanical storage operating on Read-Out (optional) from 421 Counter Exits or from 421 Digit Emitters.

Each entry word has two hubs for sign read-in capable of receiving 9 through 11 impulses, one hub for positions "6 to 8" and one hub for positions "1 to 5". The sign position "1 to 5" hub is wired if the factor to be read in is 4 or more digits.

Entry Storage PU

This control of entry to 628 storage can be impulsed by 421 card feed cycles or 421 program cycles, and one hub for each word permits individual and group selection of entry words to read in.

Calculate Storage Exit: Words 31 to 40

Depending on the number of storage words installed in the 628, from 6 to 10 of these words are available with 8 positions each on the 421 panel for exit of digits 0 through 9 from the calculator.

These exits are normally connected to the print bars, to 421 Counter Entry, or to the optional Mechanical Storage Units of the 421 Accounting Machine.

The Storage Exits 31 to 34 have two sign output hubs + and - each of which are effective for any word size. The output hubs emit code (0-1) for sign printing and/or control.

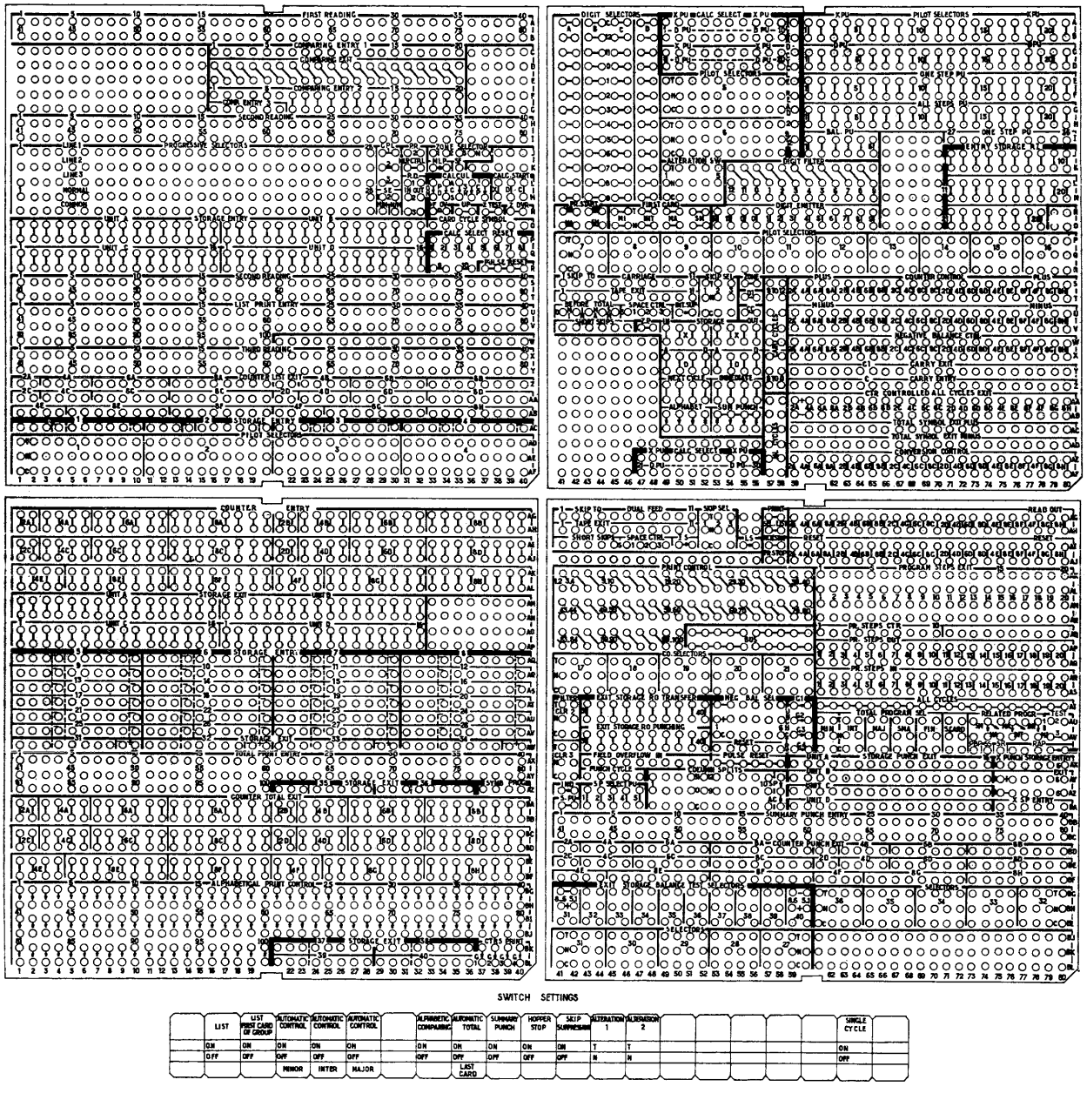


Figure 6. IBM 421/628 Control Panel

Exit Storage PU: Storages 31 to 40

This control of exit from 628 Storage can be impulsed by 421 feed cycles or 421 program cycles. One hub for each word controls selection of words.

Exit Storage PU Punch: Storages 31 to 40

This control of exit from 628 storage is impulsed during a punching cycle to control selection of words to be punched on the 565.

The above two functions can be performed simultaneously or individually as required through selectors.

Balance Selectors (Calculate Storage Exits)

The exit storages have no sign hubs, except storages 31 to 34, therefore a Balance Selector is provided for sign out-put control for all exit storages 31 to 40.

Each Storage has two Balance Selectors: one for positions "6 to 8" and one for positions "1 to 5".

The selector is dropped out when the storage balance is positive; it is transferred when the balance is negative.

It is possible to filter any impulse by means of this selector. For example, when a transfer from an Exit Storage to a Counter (in the Accounting Machine) occurs, the plus or minus read-in control of this counter can be controlled by this selector.

"X" Control of Calculate Selectors: 1 to 30

These hubs are entries and will only accept X impulses.

They control pick-up of the Calculate Selectors whose points are located on the 628 control panel.

They are normally connected to the reading brushes or to a digit emitter.

Digit Control of Calculate Selectors: 1 to 30

These hubs are entries and will accept any digit (11 or 0-9) or 421 program cycle impulse.

As with control by X, these hubs control pick-up of the Calculate Selectors on the 628 control panel.

They are normally connected to the Reading Brushes, to Digit Emitters or to the program cycles.

Calculate Selector Reset: Selectors 1 to 10

Normally, Calculate Selectors are reset automatically at the end of each calculation but selectors 1 to 10 have individual reset control.

These hubs are entries and can receive selected "Calculate Reset" impulses which drop out the previously picked selector(s).

Calculate Selector Reset Impulse

These hubs emit an impulse at the end of each calculation (including unfinished program) to drop out any Calculate Selector in the 1-10 group.

Negative Balance Selectors: Selectors 1 to 6

These hubs represent the common, normal and transfer points of the balance selector relays controlled from the 628.

All digits, reading, or, transfer impulses can be selected by means of these contacts during the cycle following a calculation.

These contacts are transferred during the calculation when the 628 Accumulator is negative at a program step, at which time a Negative Balance Selector can be picked up.

Reset of Balance Selectors: Selectors 1 to 6

These hubs are entries and permit balance selector reset.

Balance Selector Reset Impulse

These hubs are emitters at the end of the cycle following a calculation to permit balance selector reset.

Digit Control of Calculate Start

This hub is an entry for any digit impulse.

This hub controls the start of the program of an electronic calculation. The calculation begins at the feed cycle following the cycle during which the impulse is given.

X Control of Calculate Start

This hub only accepts "X" pulses.

It controls the start of the program of an electronic calculation. The calculation begins at the feed cycle following the cycle during which the impulse is given.

Cycle Control of Calculate Start

This hub is an entry for any digit impulse and can be connected either to card feed cycles or to program cycles.

It controls the start of an Electronic Calculation Program. The calculation begins at the feed or 421 program cycle during which the control has been picked up.

Note: When the 421 is listing, and both Calculate Start and Punch are picked up, Calculate Control is automatically delayed and start suppressed until the punching operation is completed.

Punching Results of Calculation

This hub is necessary for punching the results of a calculation from the 628. Results from the 421 are summary punched in the normal manner.

Calculate Control

In group calculating, this hub must be jack plugged. The calculating unit is then under the control of the 421 machine.

Early Calculate Start

When a jackplug is placed in these hubs, it increases the calculation time by starting it sooner than normal; this wiring can be selected.

The lower hub can receive either a 9 to 0 feed cycle impulse or a Program cycle impulse.

However, when this hub is impulsed, the entry storage signs must be a 9 to 0 digit impulse because the calculation starts before X - time.

Print Delay

A jackplug must be placed in these hubs when a calculation is exceptionally long. This will provide an idle cycle on the 421 Accounting Machine in order to avoid an unfinished program. Print Delay wiring can be selected.

The lower hub can receive either a digit impulse, a feed cycle or program cycle impulse.

Third Reading Station

These hubs must be jack-plugged for reading and printing from the Third Reading Station.

Unfinished Program

This hub is an emitter and permits controlling the Stop of the Accounting Machine when the program is unfinished or when Accumulator Overflow (in division) occurs during an electronic program.

Overflow-Entry and Exit

The overflow entry hubs are normally connected to one or several Storage Exit hubs outside of the area of the hubs connected for printing or transfer of results. If a figure other than zero is detected, the Overflow Exit hub will emit an impulse which can be connected to Machine Stop, or other controls.

Zero Test-Check

This hub emits an impulse when the Zero Test control has been activated during a calculation program and the Accumulator was not at zero.

This impulse can be connected to Machine Stop or other controls, for the cycle following the calculation.

Zero Divisor

This hub emits an impulse when a Zero Divisor has been detected during a calculation, on condition that the "Zero Divisor" hub is plugged on the same program step as "Divide".

Feed Cycle Second Reading

These hubs are emitters during the reading of points 9 to 12 through Second Reading Brushes.

They are normally connected to the entry or exit control of the storage words of the calculating unit. They can also control a Counter plus or minus, a selector by cycle, etc.

Feed Cycle Third Reading

a) Feed Cycle Impulses 9 to 0
b) Feed Cycle Impulses 9 to 12

In group Calculating, these hubs are emitters at feed cycle time from 9 to 0 and 9 to 12, starting from the reading of the first card by the Third Reading Brushes.

Note: During the run of the program cycles, hubs Feed Cycle Second Reading and Feed Cycle Third Reading are inoperative and isolated.

Card Lever Second Reading Filter

These hubs represent the two contacts of the automatic selector of the Second Read Card Lever. When there is no card at the Second Reading Brushes, the filter contacts are in the normal position.

The contacts are transferred when a card is read by the Second Reading Brushes.

All 9 to 12 impulses can be filtered by these contacts.

Card Lever Third Reading Filter

Same function as Card Lever Second Reading Filter, but under the control of the Third Reading.

Punch Cycle Impulse

These hubs are emitters during the whole punching cycle and can be used either to control the selectors or to control summary punching from 421 counters.

Simultaneous Punch While Print Device (Optional)

The 421 can be equipped, upon request, with a "Buffer Storage Unit" to provide output punching without loss of time.

The maximum punching frequency, without Accounting Machine idle cycle is one output card for two Accounting Machine cycles (feed cycle or program cycle).

This device is composed of Storage Units divided into ten 8-digit words corresponding position by position, to "Exit Storage Words"; moreover 20 sign positions are provided. Each 8-digit word can be loaded at any Accounting Machine cycle in order to be punched subsequently in an output card.

All storage units of the buffer are automatically cleared after completion of each "Punching results of calculation" operation.

During any punching operation, no impulse is emitted from the buffer blank positions.

It is possible to initiate a storage transfer and punching operation simultaneously.

Functions and Hub Assignments of the IBM 565 in the 628-565-421 System

All controls and functions related to calculator input from the 565 are inoperative and substituted in the 421. Therefore, the 565 features are as follows:

Second Reading

-For gang punching

-For Double Punch and Blank Columns Detection of punch output from the 628 or 421

Punching

-For punching results, both from 628 Storage Exits and the 80 connecting positions for summary punching from 421 Counters and/or optional 421 Storage.

Punch Selectors

These selectors can be controlled from the 421 and are transferred during punching time.

Pilot Selectors

The same function as the punch selectors but they must be picked up by "Immediate" P.U. hubs.

Pilot Selector Coupling Exit

These hubs emit when the corresponding Pilot Selector is transferred.

Emitter

These hubs emit 12 to 9 impulses during each punch cycle.

Double Punch and Blank Columns: Entry 10 positions

Same function as in operation as an Input-Output Unit.

Double Punch and Blank Columns: Exit 10 positions

Same function as in operation as an Input-Output Unit.

Blank Column Switches - 10 positions

Same function as in operation as an Input-Output Unit.

Blank Column Off

Same function as in operation as an Input-Output Unit.

Double Punch and Blank Columns: DPBC

Emits when a double punch or blank column is detected and can serve either to stop the machine or to offset the faulty card.

Calculate On

Should not be plugged.

Common

These hubs emit during points X to 9 of each punch cycle.

O-X Emitter

Same function as in operation as an Input-Output Unit.

Column Split (X-Eliminator)

Same function as in operation as an Input-Output Unit.

First Reading Stop Offset (Optional)

In group operation, this function can only be controlled by the DPBC out hub.

Second Reading Stop Offset (Optional)

The same as Stop First Reading but for the second reading.

Punch Station Stop Offset (Optional)

The same as First Reading Stop but for Punch Station.

Entry Storages

In group calculation operation, it is not possible to read in to entry storages of the Calculating Unit from the 565.

80 of these hubs are therefore used for 421 summary punch connection.

These hubs provide exits for counter read out and mechanical Storage Read Out (optional) from the 421 for summary punching.

Control Entry Storages

In the group calculating unit, this control is not used.

Exit Storages

In the group calculating unit, it is possible to punch calculation results from the calculating unit wired to punch entry in the same manner as when used as an Input-Output Unit.

Control Exit Storages

In the group calculating unit, it is not possible to control the exit storages on the 565 control panel. This control is available on the 421 control panel.

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