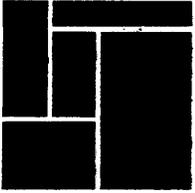


IBM



IBM Functional Wiring Principles

This publication provides general information for learning wiring methods used to obtain the various functions of IBM unit record machines. Major functions discussed are: printing, punching, emitting, comparing, storage, column splits, selection, addition, subtraction, programming, and zero-print control. Review questions at the end of each chapter enable the reader to test his understanding of the principles presented.

Sections on machine control and timing charts facilitate application of the principles described. No machine is completely described, but specific machine-wiring examples are given to illustrate the wiring principles.

Minor Revision, February 1966

This edition, A24-1007-1, does not obsolete the previous edition. The only change is in the format of the cover.

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This reference manual has been written to give you a background of general wiring methods and principles for IBM punched-card machines. We also have included many of the basic expressions and terms related to these functions.

The machines are used here to illustrate the principles listed in the table of contents. A list of page references for each machine is in the index.

No single machine has been covered in its entirety.

Concepts and backgrounds of individual machines are in the Machine General Information Manual series. Detailed discussions of individual machine components, functions, and control panels are in the Machine Reference Manual series.

This reference manual is intended as an introduction to IBM punched-card equipment. You will find the study of individual IBM machines much easier when you understand, and are able to apply, the methods discussed here.

The review questions are intended to test how well you understand and retain the information discussed in each section.

If you are unable to answer one or two of the questions, refer again to the preceding text. If you are unable to answer several of the questions, it would be best to re-read the entire chapter.

Controlling Functions in IBM Machines

Most IBM machines can accomplish more than a single function. The machine must know what function to perform and how to handle the information it receives. You must instruct the machine exactly what you want it to do. It is capable only of following your instructions and using the logic you give it. A machine has the ability to make decisions only after you have established the decisions to be made for each given set of conditions.

You must know what each hub is for and then, knowing what you want the machine to do, you can insert the wires into the proper hubs.

Controlling Functions with the IBM Control Panel

Of course, a machine does not understand oral instructions. A control panel has been provided so that you can give instructions.

A control panel is a panel or board which, in most cases, can be removed from, or inserted into, the machine when desired. The panel has many small holes, called *hubs*, into which you can insert wires with special tips. Various instructions are given to the machine, according to what wires go into which hubs. Each of the hubs in the panel has a specific purpose or function.

Controlling Functions with the IBM Card

We have discussed the control panel in general, and said that the machine is instructed to handle the desired information in a specific manner by control-panel wiring. However, many of the instructions and most of the information depend on the holes in an IBM card.

The IBM Card and Card Code

Standard IBM cards are composed of 80 vertical columns into which holes representing any digit (0-9), any alphabetic letter (A-Z), or a special character can be punched (Figure 1) as machine-readable code.

UNIT RECORDS AND UNIT RECORD MACHINES

Because IBM cards are actually units of information, they are often referred to as *unit records*. The machines that process IBM cards are often called *unit record machines*.

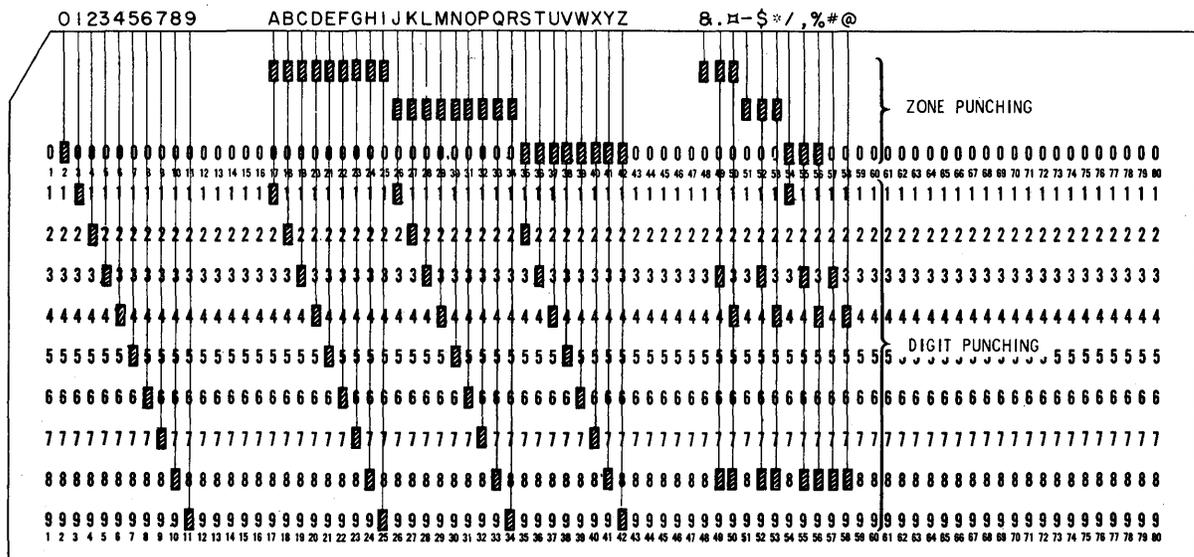


FIGURE 1. IBM PUNCHING CODES

NUMERICAL CODE

There are twelve vertical punching positions in a column, and the 0 through 9 positions are identified by printing on the card. These ten positions correspond to the numerical digits mentioned before. Numerical information is recorded in the card by punching a single hole, in a given column, in the position that represents that digit. For example, a single hole in a column punched in the "2" position always means the number "2" to IBM machines.

ALPHABETIC CODE

Alphabetic information is recorded by a two-hole code. Each alphabetic character consists of two punches: a numerical punch (1-9) and a zone punch. There are three zones:

- 12-zone — at the very top edge of the card.
- 11-zone — just below the 12-zone position.
- 0-zone — just below the 11-zone position.

The 0-zone is also the numerical zero that was mentioned, and is labeled on the card. The 12- and 11-zone positions are not labeled as this area is usually set aside for printing headings.

The codes for the alphabetic characters are:

A - 12 and 1	J - 11 and 1	S - 0 and 2
B - 12 and 2	K - 11 and 2	T - 0 and 3
C - 12 and 3	L - 11 and 3	U - 0 and 4
D - 12 and 4	M - 11 and 4	V - 0 and 5
E - 12 and 5	N - 11 and 5	W - 0 and 6
F - 12 and 6	O - 11 and 6	X - 0 and 7
G - 12 and 7	P - 11 and 7	Y - 0 and 8
H - 12 and 8	Q - 11 and 8	Z - 0 and 9
I - 12 and 9	R - 11 and 9	

You need not memorize the code, because it is punched automatically by pressing a letter key on the card-punch keyboard, and is usually read automatically

by IBM machines. In cases where the information is to be read by the human eye, it can be printed across the top of the card (Figure 2).

RECONSTRUCTING THE ALPHABETIC CODE

If it becomes necessary for you to read the punches, the table of codes can be reconstructed if you remember that the top or first punch on the card is combined with the digits 1 through 9 to make up the first nine alphabetic characters A through I. The 1 is a part of A, 2 a part of B, etc. The 11-zone is used for the next 9, J through R, and the 0-zone for S through Z. However, you should note and remember that the 0-zone starts with 2 and not 1. The combination 0-1 is not used in the alphabetic code because the alphabet uses only 26 of the 27 possible digit-zone combinations. The 0-1 combination can be used for (/), (*), or some other special character, on those machines equipped to handle special characters.

SPECIAL CHARACTER CODING

Most IBM unit-record machines can process special characters in varying combinations and quantities. These characters are represented by the following punches:

1. 11- and 12-zone punches, without accompanying digit punches
2. the 8-3 or 8-4 code punches
3. a combination of one of the zones, and the 8-3 or 8-4 code (Figure 1).

Card Identification

Certain types of cards have a distinguishing colored stripe printed across the top or have one of the cor-

CUSTOMER NO	INVOICE	ENTRY DATE	INVOICE AMOUNT	ACCOUNTS RECEIVABLE	NEW MEXICO COMPANY	ENTRY										
ENTRY DATE	CUSTOMER NUMBER	INVOICE DATE	INVOICE NUMBER	CUSTOMER NUMBER	LOCATION	TRADE CLASS	SALES MAN NO	DATE PAID	DISCOUNT ALLOWED	AMOUNT PAID	INVOICE AMOUNT					
MO	DAY	MO	DAY	MO	DAY	ST.	CITY	BRANCH	NO	MO	DAY	YR.	PERCENT	NO	NO	NO
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9

FIGURE 2. CARD FIELDS

ners cut so that you can recognize them easily. However, the machines cannot distinguish between card types by means of the color stripe or corner cut, so an 11- or 12-punch is often used to distinguish one type of card from another. For example, these control punches can tell the machine, through control-panel wiring, which cards are to be added and which are to be subtracted. The 11- and 12-punches can be used as control features in most unit-record machines. These functions are discussed in detail in other sections of this publication.

Card Layout

In normal usage, IBM cards are printed with field headings. A field is a column or group of columns, set aside by vertical lines, for a particular type of information.

For example, the accounts-receivable card (Figure 2) was printed so that columns 39-43 are set aside as the customer number field. The card-punch operator always punches the digits representing customer number in columns 39-43; the other IBM machines are then instructed to recognize columns 39-43 as customer number.

If the customer number is 59751, it is recorded by the card-punch operator as follows:

- Column 39 - 5
- Column 40 - 9
- Column 41 - 7
- Column 42 - 5
- Column 43 - 1

Each position of the card field has a name (Figure 3).

The unit amount of the figure must be punched in the units position (extreme right column) of the field set aside for that information. The tens position of the figure must be punched in the tens column in the field, etc.

Sometimes the field set aside is larger than the figure to be punched. When this happens in a numerical field, the units position of the figure still must be punched in the units position of the field. In order to correctly align the figure to be punched, the card-punch operator fills the unused left-hand positions of the field with zeros.

For example, if the invoice amount to be punched is \$414.40 (five columns), and the field set aside is seven columns, the operator punches 0041440. He mentally subtracts the actual number of digits to be punched from the total number of columns in the field. The difference represents the number of zeros he must fill in to the left of the figure to have the figure positioned correctly in the field. With practice, this mental calculation becomes entirely automatic.

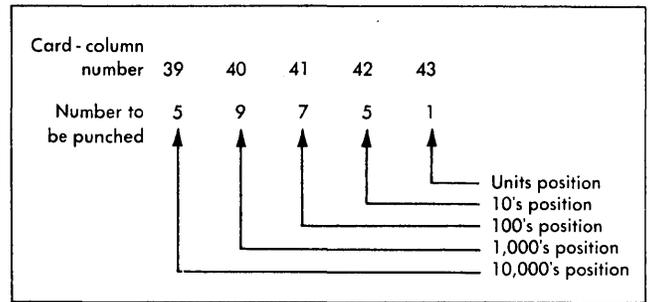


FIGURE 3. CARD-FIELD POSITIONS

Card Reading

We record alphabetic and numerical information in IBM cards by means of punched-hole coding so that it can be read electrically at a high rate of speed.

The IBM machines can add, subtract, multiply, divide, copy, file cards, and print reports automatically. However, these activities can take place only after the information in the card is read.

READING THE PUNCHED HOLE

Each IBM machine has a brush or brushes that read the holes in IBM cards as they pass through the machine.

Let's start the discussion of card reading with the sorter, for in this machine only one column of the card is read at a time, by one brush.

As the card passes through the machine, it passes over an electric-contact roller. While the card is passing over the contact roller (Figure 4), it passes under a brush. The brush is positioned by the operator to read one of the 80 vertical columns in the card. The illustration shows the contact roller, the card, and the brush.

As the card passes through the machine, bottom (9-edge) first, the brush is kept from touching the contact roller by the card, which acts as an insulator. However, when a punched hole reaches the brush (a 4-hole in the illustration), the brush drops into the hole and touches the contact roller.

This completes an electric circuit, just as you do when you switch on your electric lights at home. When

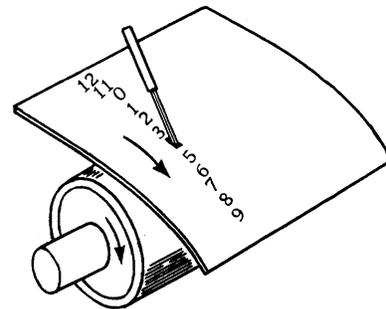


FIGURE 4. BRUSH MAKES CONTACT WITH ROLLER

the brush makes contact with the roller, electric current flows from the roller to the brush. This flow of current, or impulse, continues until the contact between the brush and the roller is broken by an unpunched portion of the card moving between the brush and the roller.

TIMING AS CHARACTER RECOGNITION

The timing of the brush impulse, or flow of current, is the means by which the machines recognize whether the punch is a 9, 8, 7, 6, 5, 4, 3, 2, 1, 0, 11, or 12. If the impulse is available just after the 9-edge of the card has passed between the contact roller and the brush, the machine recognizes that a hole is punched in the 9-position of the card. If the impulse is available a little later, the machine recognizes that a hole is punched in the 8-position of the card. This is true of all positions that can be punched. In fact, the machines recognize which digit has been punched by the amount of time that elapses from the moment the leading edge of the card passes under the brush to the moment when the brush drops into a punched hole and the impulse becomes available. Figure 5 shows a "1" being read by a brush.

MULTIPLE-COLUMN READING

In discussing the sorter, we have considered one brush, set to read one column at a time. In most IBM machines, however, we have a set of 80 brushes; each brush reads one of the 80 card columns. Therefore, the entire card is read as it passes between the set of 80 brushes and the contact roller.

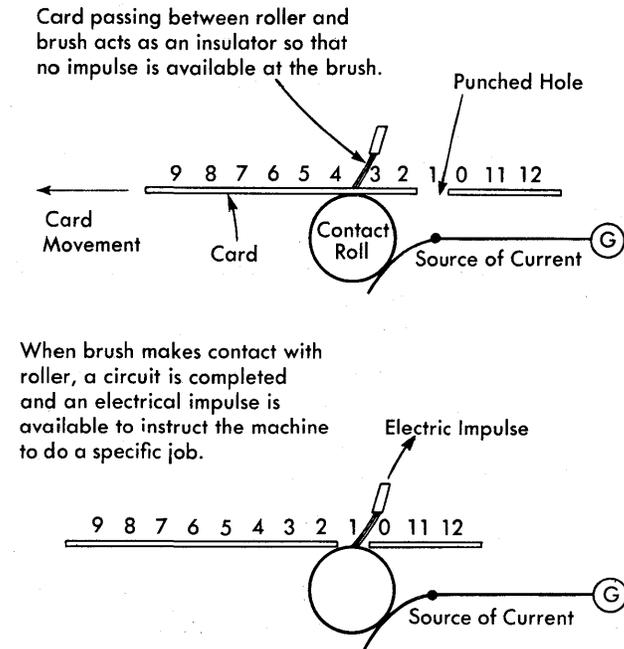


FIGURE 5. BRUSH READING NUMERAL 1

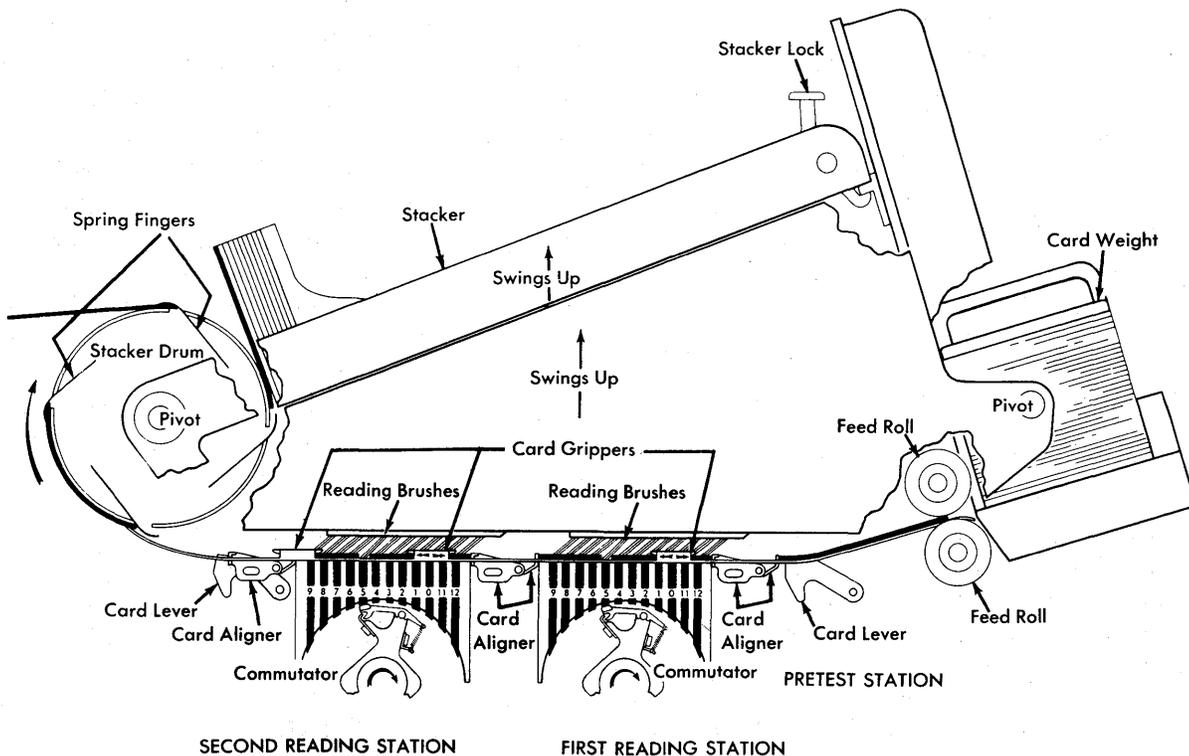


FIGURE 6. IBM 407-408-409 CARD FEED SCHEMATIC

Reading Stations

IBM 407, 408, and 409 Accounting Machines are equipped with two reading stations. Each reading station has 960 stationary reading brushes, and 960 metal segments instead of a contact roller. All possible punches in all card columns can be read (12 positions multiplied by 80 card columns). Each reading station also contains 80 commutators that rotate from the 9-position to the 12-position (Figure 6).

If a hole is punched in a card, a contact is made between the reading brush for that specific column and punch, and the metal segment for that specific column and row. Each column has one commutator. When the commutator has rotated to the specific position of the punched hole, an electric circuit is completed through the brush. An impulse is available in the control panel at the corresponding position in FIRST READING or SECOND READING hubs .

Depending on its type and function, an IBM machine may have one, two, or more sets of brushes.

In the 407, 408, and the 409, the card can be held at either the first or second reading station and read several times.

Control Panel

You have learned that machine operations are controlled by external wiring in a control panel. We have also seen how cards can be read by brushes in the machine. However, before we talk about what happens as

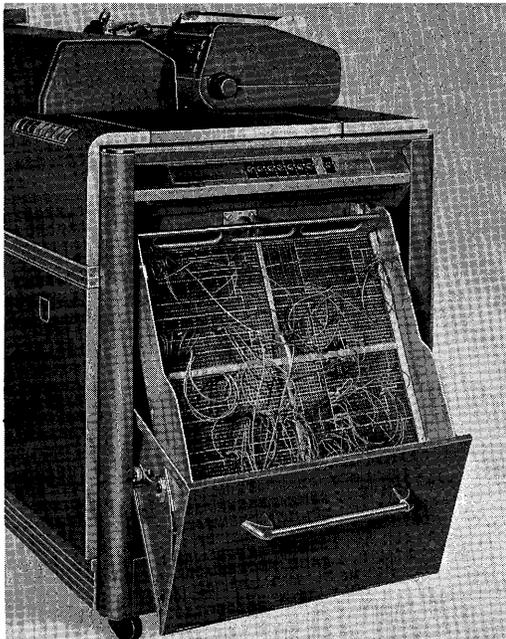


FIGURE 7. AN IBM CONTROL PANEL

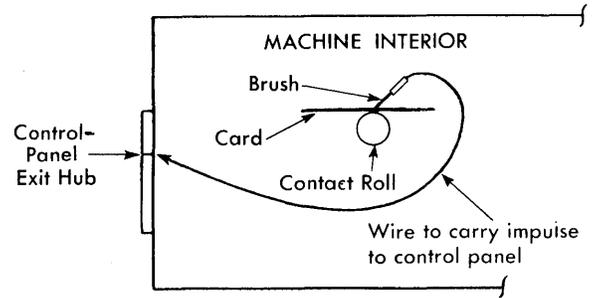


FIGURE 8. IMPULSING CONTROL PANEL FROM CARD

a result of reading a card, a few details of the control panel should be discussed (Figure 7).

In general, we can say that the size of a control panel and the number of hubs depend on the machine type. The larger the machine and the more varied the functions, the larger the control panel.

PURPOSE OF CONTROL PANEL

Basically, the control panel is similar, in principle, to a telephone switchboard. An incoming call on a switchboard lights a signal light that tells the operator which line the incoming call is on. After she answers the call, she plugs the cord into a hub on the board that is internally connected to the desired extension. Actually, the operator has completed an electric circuit to give the correct result.

A control panel does exactly the same thing; it completes electric circuits through wires you insert. The internal circuits (Figure 8) to be controlled by external wiring are connected to rows of metal prongs (*contacts*) that are the ends of these internal circuits.

When the control panel is fitted into place, a *jack* on the control panel touches each one of the machine's metal contacts. In this way the external wiring (control-panel wiring) completes the desired circuits (Figure 9).

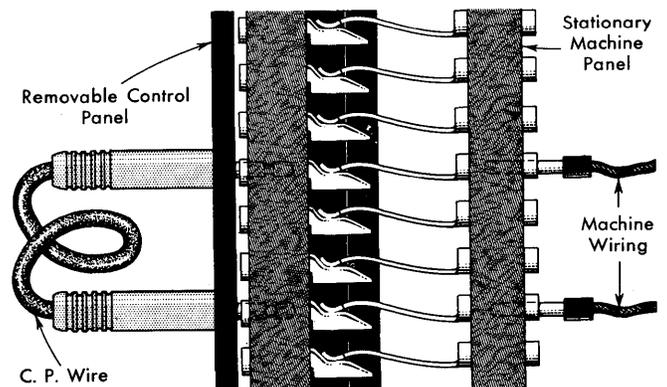


FIGURE 9. CIRCUITS COMPLETED BY EXTERNAL WIRING

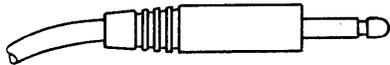


FIGURE 10. CONTROL-PANEL WIRE

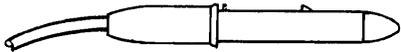


FIGURE 11. SELF-CONTACTING CONTROL-PANEL WIRE

TYPES OF CONTROL PANELS

There are two general types of control panels. Control-panel wires with special tips are used with each of the two types of panels.

One type of panel has metal prongs, or contacts, that press against the stationary internal contacts. The external wires (Figure 10) plug into these metal prongs to complete the internal circuits.

The second type of panel consists only of hubs into which the external wires are inserted. The wires themselves have longer and larger tips (Figure 11) that pass through the control panel and press directly against the stationary prongs. These wires are known as *self-contacting* control-panel wires. Each of the two general types of wires is available, color-coded in various lengths.

CONTROL-PANEL HUBS

The hubs which represent circuits that accept electric impulses are called **ENTRIES**; those which represent circuits that emit impulses are called **EXITS**.

Control-panel hubs may be single, or two or more may be internally connected to each other. If they are internally connected, they are called **COMMON**. Common hubs are identified on the face of the control panel by lines connecting them (Figure 12).

If these hubs are exit hubs, the exit impulse is available out of all the hubs connected by a line. If these common hubs are entry hubs, an impulse wired externally into any one of the connected hubs is directed into the machine and is available out of the other hubs common to each other.

Bus hubs (Figure 13) are several hubs internally connected to each other; they are neither exit nor entry hubs, for, although they are connected to each other, they are not connected to an internal machine circuit. If an impulse is wired from an exit hub on the control panel to a bus hub, this same impulse is available out of all the other bus hubs of that group.

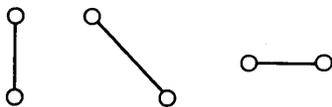


FIGURE 12. COMMON HUBS



FIGURE 13. BUS HUBS

COMMON CONNECTORS (SPLIT-WIRING)

Sometimes bus hubs are not available, and it may be necessary to connect one exit hub to more than one entry hub; this is done through the use of a *common connector* (Figure 14). An impulse brought into the connecting block is available from all the other terminals in the block. Connecting blocks for both types of control-panel wires are shown. This type of control-panel wiring is often referred to as *split-wiring*.

JACKPLUGS

Jackplugs (Figure 15) are wires designed to connect externally two adjacent hubs. A regular wire of the type discussed can be used, but a jackplug is more convenient and less bulky.

CONTROL-PANEL DIAGRAMS

Paper diagrams (drawings) of the hub layouts on each type of control panel are available. These are used to keep a permanent record of a control-panel setup. To make the diagram as legible as possible, we have a few simple rules to follow when drawing a diagram:

1. Use different colored pencils to diagram wiring that makes the machine perform different functions. For instance, wiring for printing might be a different color than wiring for addition.
2. Pencil-in the hubs of a field and connect these hubs with a horizontal line (Figure 16).
3. Connect the exit and entry fields by one line. Actually, this line may represent any number of individual wires in the control panel. However, in order to make the diagram easy to read, we use this abbreviation, understanding that, although only one line is shown on the diagram, a four-position field requires four wires in the actual control panel (Figure 17).

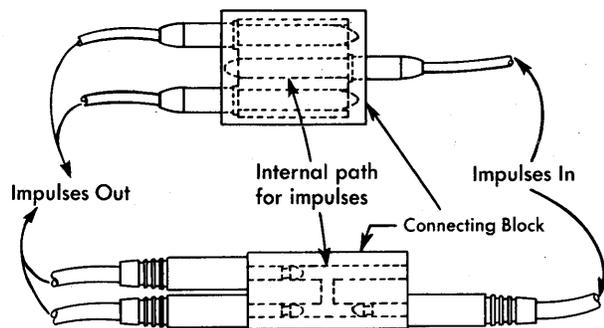


FIGURE 14. TYPES OF COMMON CONNECTORS

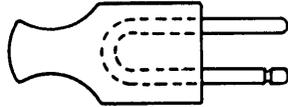


FIGURE 15. JACKPLUG



FIGURE 16. HORIZONTAL LINE CONNECTS HUBS IN A FIELD

4. Indicate exit and entry hubs by drawing an arrow pointing to the entry hubs (Figure 18).
5. When it is necessary to cross lines on a diagram, break one line (Figure 19). This prevents the possibility of following the wrong line to the entry hub.

READING-BRUSH HUBS

Now let's take a look at the control panel with respect to the reading brushes. We have already shown that when a brush senses a hole in the card, an electric impulse is available from the source.

Each brush in the machine that reads a column of the card is internally connected to one of the copper contacts in the stationary control panel. For each reading brush, we also have a hub in the removable control panel in a section labeled READING BRUSHES. These hubs are exit hubs, and emit an impulse when a hole in the card is sensed (Figure 20).

Timing

Timing is an important concept to understand. For example, as a result of timing, an 8-hole read causes an "8" to be printed, or causes an 8-hole to be punched. You hear people speaking of impulses being available and things happening in a machine at 9-time, 8-time, etc. All they mean is that the impulse is available, or things are happening, at the time the card is in position

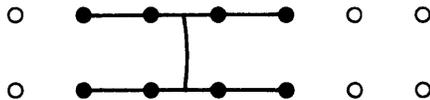


FIGURE 17. EXIT AND ENTRY FIELDS ARE CONNECTED BY ONE LINE

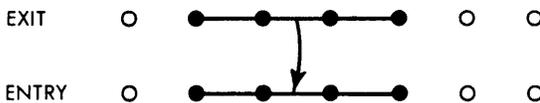


FIGURE 18. ARROW POINTS TO ENTRY HUBS

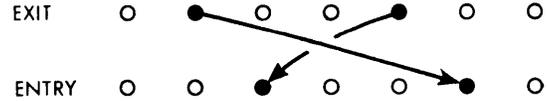


FIGURE 19. A LINE IS BROKEN WHEN IT CROSSES ANOTHER

				5	READING BRUSHES				15	20					
o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
			25				30				35				40
			45				50				55				60
			65				70				75				80

FIGURE 20. READING-BRUSH EXITS

for a 9, 8, etc., to be read. When the term 9-time is used, it really means at 9-time in the cycle.

The Cycle Concept

The term *cycle* is one we have not discussed yet, and there are others, such as cycle points, card cycle, print cycle, and degrees. The word cycle itself is a familiar term. A cycle is the period (or time interval) required to complete a round of events or operations that occur in sequence on a regular basis. We have weather cycles, economic cycles, business cycles, and many others. A cycle can, therefore, be thought of as a circle. One cycle is the time required for the circle to make one revolution. Think of it as a pointer making one revolution around the circle. You can think of a second hand on a clock as the pointer, and in one revolution it has completed a cycle (Figure 21).

Machine Cycles

Each IBM machine is made to perform its functions within a given time, called a *machine cycle*. A machine, when running, operates at so many machine cycles per minute.

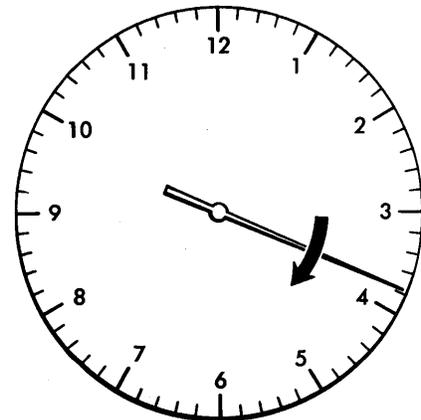


FIGURE 21. A SECOND HAND COMPLETES A CYCLE EVERY MINUTE

However, a machine may be capable of performing several functions such as feeding cards, printing, or punching. If card feeding is occurring during the cycle, then it is a *card-feed cycle*. A machine cycle can be qualified by any function occurring during the cycle, such as print cycle, total cycle, or punch cycle.

Cycle Points

During a cycle, there are various points in the cycle that are of particular interest. These are the points at which a hole in the card is read or punched, or at which a typebar is positioned to print a specific digit. Because they are specific points on the cycle, we call them *cycle points*.

In most machines a disk or gear is used as an *index* to indicate the cycle points, or *timing*, of a cycle. The index is geared to make one revolution per cycle and has the cycle points marked (Figure 22). In many instances, these divisions are not small enough for timing purposes. The disk is a circle so that it can be divided into degrees for timing purposes. We can now refer to the time that a 5-hole is read as *5-time* or it can be expressed in degrees (Figure 23).

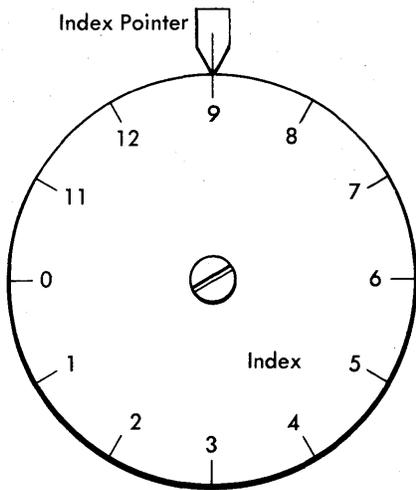


FIGURE 22. CYCLE-TIME-INDICATING DIAL

Timing Charts

Some manuals have a *timing chart* that shows when a control-panel hub emits or accepts impulses within the cycle, and a note to indicate the type of cycle during which it occurs, if it does not occur every cycle (Figure 24). Timing charts are discussed in detail in their section of this manual.

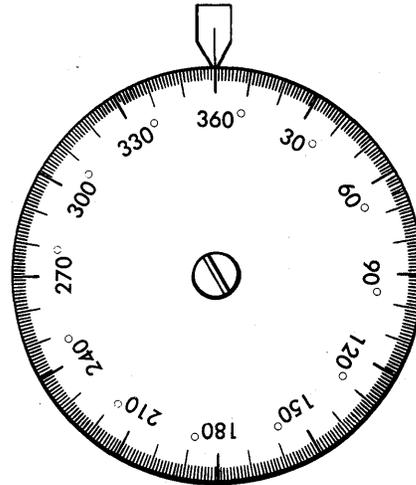


FIGURE 23. CYCLE, SHOWN IN DEGREES

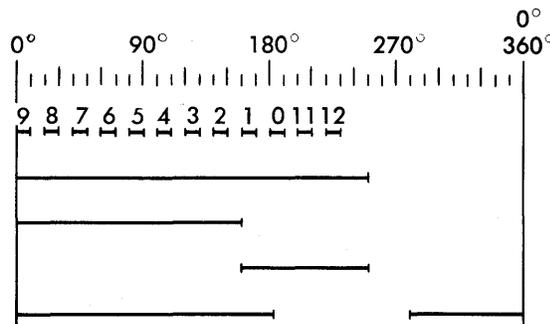


FIGURE 24. TIMING CHART

Review Questions

1. How many columns are there in a standard IBM card?
2. What does the word *field* mean?
3. How many columns are there in a field?
4. The amount \$450.00 is punched in a card. What is punched in the 1,000's position?
5. If the field contains eight columns, and the amount to be punched is only five digits, how many fill-in zeros are required?
6. How many punching positions are there in a column?
7. What are zone punches?
8. If a column is punched with an 11 and a 9, what character is represented?
9. What special uses are made of the 11- and 12-punches?
10. As a card feeds through an IBM machine it is read by
11. An electric circuit is completed and an impulse available when
12. What is meant by 9-time, 8-time, etc?
13. What is a machine cycle?
14. What is a card cycle?
15. What is a print cycle?
16. What is a total cycle?
17. Holes in a control panel are called
18. What is an exit hub?
19. What is an entry hub?
20. What is a bus hub?
21. What is the special use for split wires?
22. What is a timing chart?

Printing

The information read at the reading brushes can be used for many functions. One of these is printing information as it is read. In IBM machines equipped for printing, control-panel wiring (Figure 25) needed is essentially the same.

Don't be dismayed by the number of hubs in a control panel, because many of them perform identical functions. For instance, the control panel for any machine that has a set of 80 reading brushes has 80 reading-brush exit hubs, one for each column of the card. Each machine with 60 typebars or typewheels has 60 print entry hubs. Once you have learned the function of one of the reading-brush exit hubs, or one of the print entry hubs, it applies to all reading-brush hubs and all print entry hubs.

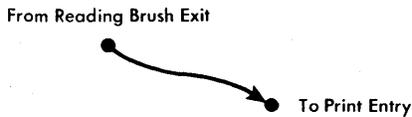


FIGURE 25. PRINTING FROM CARD

IBM 548 Interpreter

To make it easy to understand the principles of printing, we shall discuss a specific machine, the IBM 548 Interpreter (Figure 26). This machine prints the information punched in a card across the top of the same card. Thus, it can be easily read by the machine operator (Figure 26). The top of the card shown in Figure 2 was printed by the IBM 548 Interpreter.

Numerical Printing

As you know, a numerical punch is one hole (0 through 9) in a column. To print a number, we connect the reading brush exit hub to the print entry hub (Figure 27) by a wire in the control panel.

The actual printing is accomplished internally and automatically by the IBM machine after the hole punched in the card is read.

The wiring shown in the diagram causes information read in card columns 5-10 to be printed by typebars 15-20 (Figure 28).

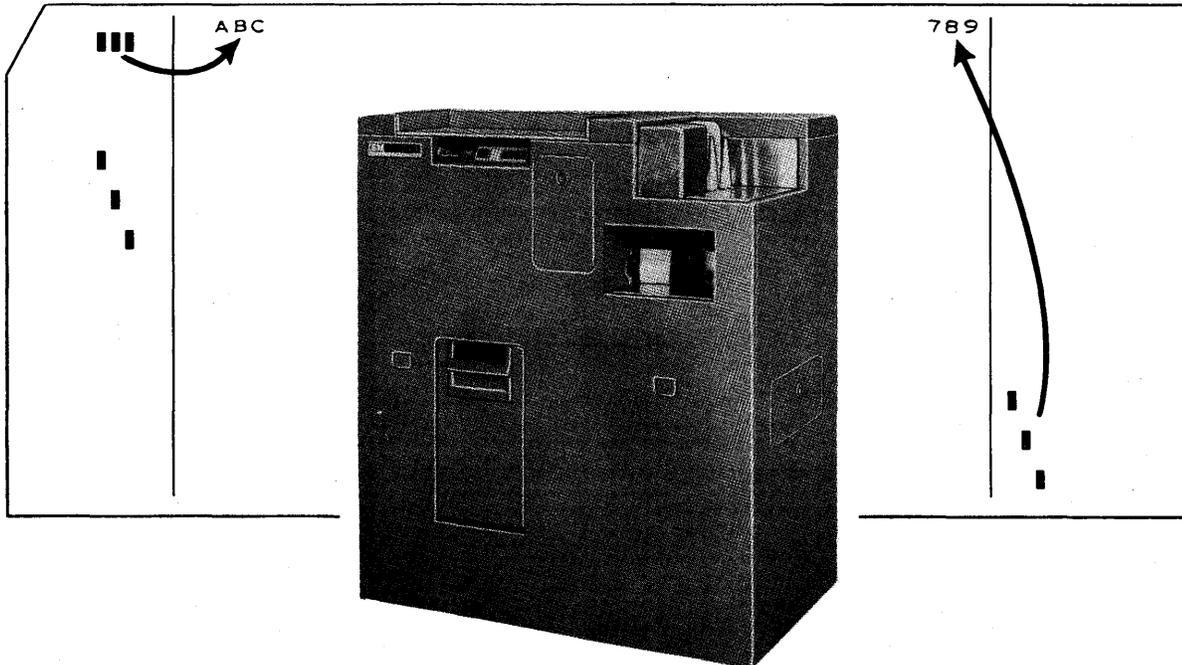


FIGURE 26. IBM 548 INTERPRETER AND INTERPRETED CARD

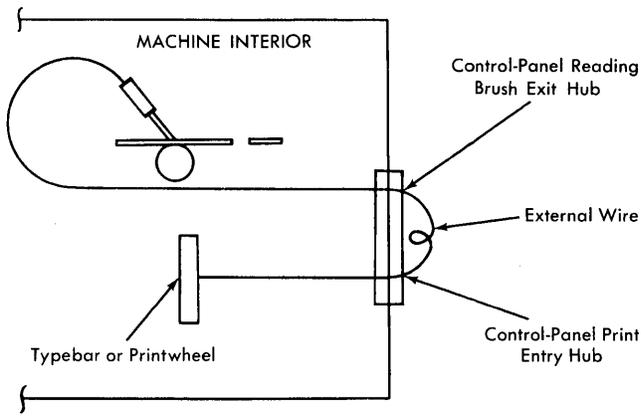


FIGURE 27. SCHEMATIC FOR PRINTING FROM CARD

If we wish the same information to be printed in two places, we can wire out of the common print entry hubs, 15-20, and take the impulses to any other print entry hubs (Figure 29). If we had only one entry hub for each print entry, we would have to use split wires.

Alphabetic Printing

A letter is composed of two holes in a single column: a zone punch and a digit. To print a letter with any machine, both the zone-punch impulse and the numerical-punch impulse must be received by the typebars or typewheels.

Each IBM 548 Interpreter typebar contains all letters (A-Z), all the numbers (0-9), and three positions for special characters, such as the asterisk (*) or ampersand (&). The letters are arranged in three groups, A-I (12-zone), J-R (11-zone), and S-Z (0-zone). Also, there is a fourth group, the numbers 1-9 (Figure 30).

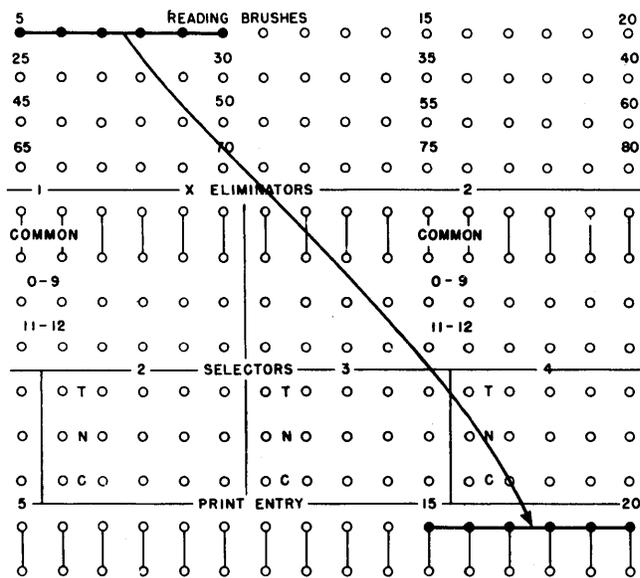


FIGURE 28. PRINTING A FIELD IN A SINGLE LOCATION

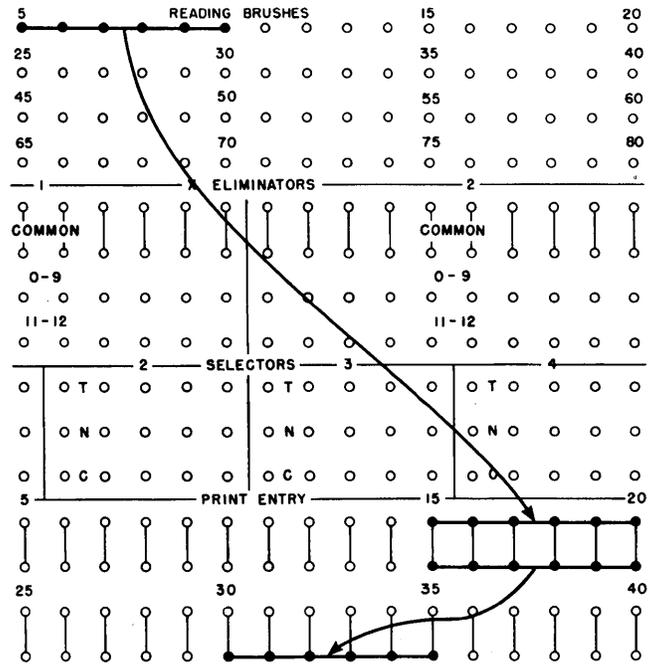


FIGURE 29. PRINTING A FIELD IN TWO LOCATIONS USING COMMON HUBS

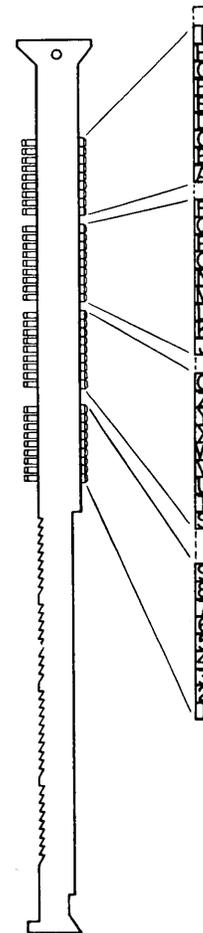


FIGURE 30. IBM 548 TYPEBAR

POSITIONING THE TYPEBAR

Because of the mechanical structure of the typebars, they must receive the zone-punch impulse before the numerical punch impulse. To make this possible, the cards are fed face up, 12-edge first.

The zone impulse is carried internally to the reading brush hubs, over the external wire to the typebar hubs, then by internal wiring to the typebar. This partially positions the typebar; that is, the 12- or 11- or 0-zone group of type is moved to the printing line. When the numerical punch is sensed, it is carried over the same circuit to the same typebar. This second impulse completes positioning of the typebar, and the letter that is made up of the specific combination of zone and numerical punches is printed when the typebars are fired (when the type is pressed against the platen).

Printing and Restoring

After the card has been read, it moves between the typebars and the platen. When the top edge of the card is between the typebar and the platen, the type is pressed against the ribbon, and the character prints on the card. All the characters to be printed are printed at the same time. If an impulse has not been received by the typebars, the typebars move to a blank position on the bar and nothing is printed.

Common Wires for Zone and Digit Impulses

The wiring for numerical or alphabetic printing for the IBM 548 Interpreter is exactly the same. One wire from the reading brushes to the typebars carries the numerical impulse alone, or both the numerical and zone impulses. Because the cards are fed 12-edge first, the zone impulse reaches the typebar first.

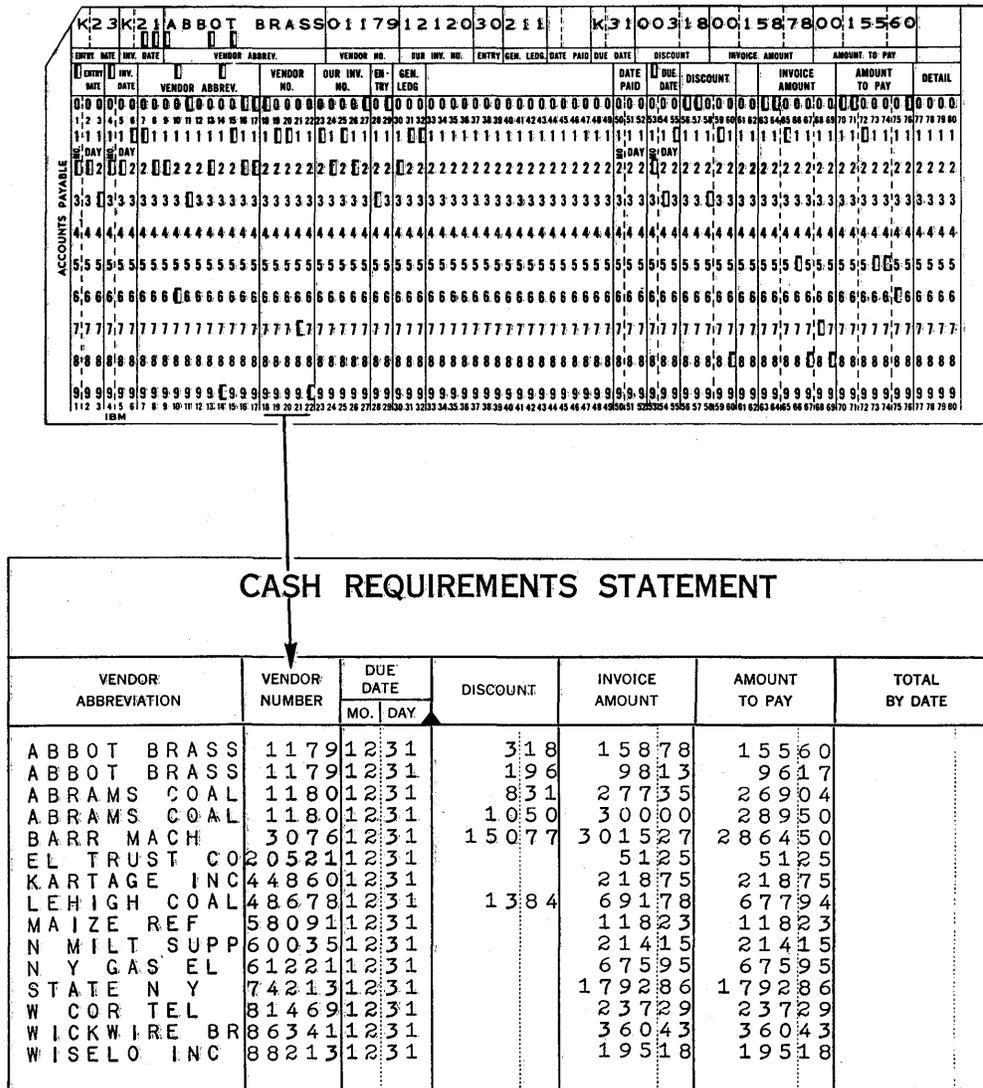


FIGURE 31. REPORT PRINTED FROM IBM CARDS

IBM 403 Accounting Machine

One of the functions of the IBM 403 Accounting Machine is printing reports. Numerical information punched in IBM cards can be printed in any sequence desired from any one of 88 typebars (Figure 31). The principle of printing in the IBM 548 Interpreter and the IBM 403 Accounting Machine is the same. Reading brushes read the holes in the card, and by external wiring in the control panel, the impulses are directed to the desired typebars.

The labels of the typebar entry hubs are different in the IBM 403 and the IBM 548, mainly because of the difference in the physical arrangement of the typebars.

In the IBM 548 Interpreter we have one set of 80 brushes, labeled **READING BRUSHES**.

In the IBM 403 Accounting Machine we have three sets of 80 brushes, labeled **FIRST READING**, **SECOND READING**, and **THIRD READING**. As each card passes through the 403, it can be read three times depending upon control panel wiring (Figure 32).

Typebar Arrangement

The 403 has 88 typebars. They are arranged in two banks across the top of the machine. At the left it has 43 alphamerical typebars, and at the right it has 45 numerical typebars (Figure 33).

The name *alphamerical* (a combination of the words alphabetic and numerical because either alphabetic or numerical information can be printed by them) is given the 43 typebars at the left.

The 45 numerical typebars at the right can print numerical information only. Therefore, numerical information can be printed by any one of the 88 typebars, and alphabetic information is limited to the left-hand bank (alphamerical) typebars.

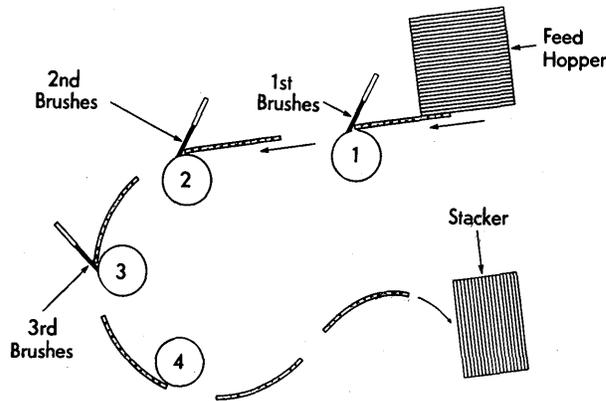


FIGURE 32. IBM 403 ACCOUNTING-MACHINE FEED SCHEMATIC

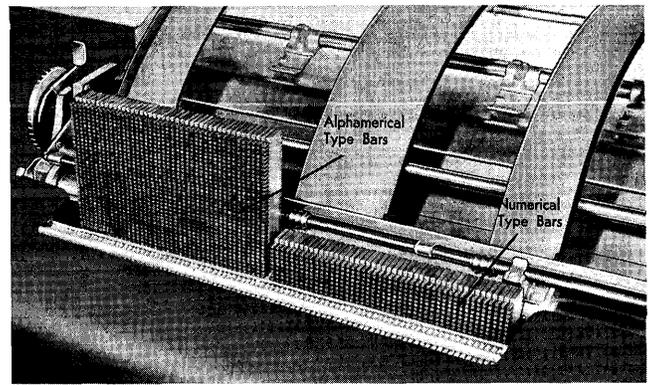


FIGURE 33. IBM 403 TYPEBARS

Numerical Printing

To print numerical information, we use the third-reading-brush impulses. They are the same as the reading-brush impulses in the IBM 548 Interpreter.

The numerical punch read by the third-reading brushes is externally wired to any one of the 43 alphamerical print entry hubs, or the 45 numerical print entry hubs.

Figure 34 shows the external wiring for printing two numerical fields. The third reading-brush positions represent the card columns being read, and the alphamerical and numerical print entry positions represent the typebars or printing positions.

Alphabetic Printing

Alphabetic punching in IBM cards consists of a zone and a digit punch for each letter. To print alphabetic information, both the digit and the zone punch must be read and signaled to the typebar.

The mechanism of the alphamerical typebar is such that the zone punch must be received by the typebar before the digit punch. Because the cards are fed into the IBM 403 Accounting Machine 9-edge first, it is apparent that the zone punch must be read and signaled to the typebar one card cycle earlier than the digit punch is.

This is accomplished by wiring both the second reading brushes and the third reading brushes to the typebar.

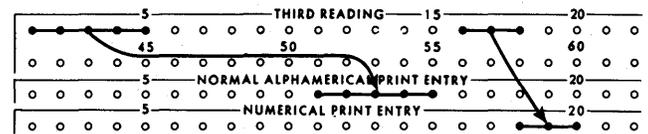


FIGURE 34. WIRING FOR NUMERICAL PRINTING, IBM 402-403

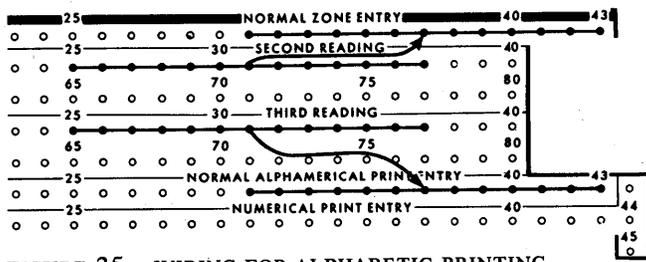


FIGURE 35. WIRING FOR ALPHABETIC PRINTING, IBM 402-403

The only difference between wiring for numerical and alphabetic printing is that a second wire is needed for each alphabetic printing position. This wire signals the zone punch to the typebar one cycle earlier than the digit punch. The second wire is taken from the second reading brush exit hub to the zone entry hub corresponding to the alphanumerical print entry hub already used for the digit wiring.

POSITIONING TYPEBAR FROM SECOND READING

If a zone impulse is available at the second reading brushes, it is taken by the external wire to the zone entry hub. (The zone entry hub accepts zone impulses only and ignores digit impulses.) The zone impulse partially positions the alphanumerical typebar for alphabetic printing.

POSITIONING TYPEBAR FROM THIRD READING

When the same card moves past the third reading brushes in the next card cycle, the digit punch is signaled to the typebar, and the typebar is then positioned completely for alphabetic printing. Figure 35 shows the wiring necessary to print an alphabetic field.

The important thing to remember is that the columns read from the card are represented by the second and third reading brushes and must always correspond to one another for each column. For instance, if we wish typebar number 5 to print alphabetic information, we must make sure that the wires from the second and third reading brushes are both coming from like-numbered reading brush exit hubs.

Also, we must make sure that the zone entry hubs and the alphanumerical print entry hubs used are the same. If we use alphanumerical print entry hub number 8, then we must use zone entry hub number 8.

Failure to use the like-numbered reading-brush hubs causes incorrect printing. Failure to use the like-numbered zone and alphanumerical print entry hubs also results in incorrect printing.

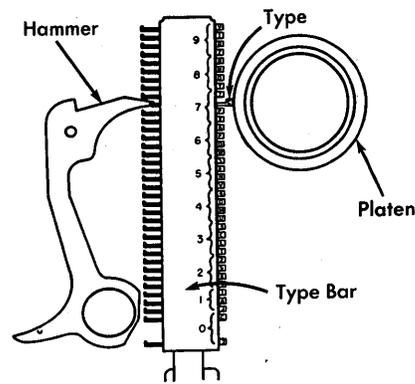


FIGURE 36. IBM 402-403 PRINT MECHANISM

Print Unit

To produce a printed character on a sheet of paper, four things are needed: (1) paper, (2) an inked ribbon, (3) a hard-rubber roller (platen) that supports the paper, and (4) type. In an accounting machine the paper, ribbon, and platen perform the same function that they perform in a typewriter. However, the type unit functions in an entirely different manner.

Figure 36 shows parts of one typebar in an IBM 403 Accounting Machine. There are 88 typebars in a complete print bank, one typebar for each possible printing position in a line of a report. Each typebar contains an individual piece of type for each character. A numerical typebar has 11 pieces of type, one for each digit (0-9) and one special character, usually an asterisk (*) or credit symbol (CR). Each alphanumerical typebar contains 38 pieces of type (26 alphabetic characters, 10 numerical characters, one special character (&), and one extra zero).

Printing and Restoring

While a card is being read, the typebars are moving. When the reading is finished, all typebars are in position with the selected piece of type opposite the line about to be printed on the report. At print time, 88 hammers (one for each typebar) strike the ends of the type pieces opposite the printing line. This produces one complete line of printing on the paper. The paper then moves up, another card is read, the typebars again are positioned, the hammers strike, and another line is printed.

IBM 557 Interpreter

The type unit for each printing position in some IBM machines (557, 407) is a wheel instead of a bar. The

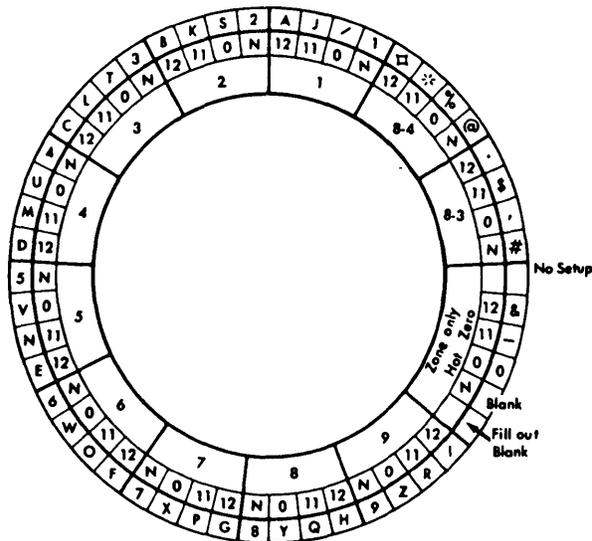


FIGURE 37. IBM 557 TYPEWHEEL SCHEMATIC

wheel rotates until the proper character is in position to print. Positioning of the characters is controlled by information punched in the card and control-panel wiring. Printing is accomplished by pressing raised characters on the circumference of the wheel against the paper.

Typewheel Format

As shown in Figure 37, the 557 typewheel is divided into 12 sectors: one sector for each digit 1 through 9; one sector each for 8-3 and 8-4 codes; and one sector for zone punches alone.

Each sector is divided into four sections: 12-zone, 11-zone, 0-zone, and no zone (N). The combination of any given sector and zone prints a digit, an alphabetic character, or a special character.

The *zone-only* sector is divided into six sections. Three sections are used to print the zone-only punches. The section labeled *No setup blank* is in the print position if the position is not wired in the control panel; the N-zone blank is in the print position if no punch is read but the print position has been wired in the control panel; the section labeled *fillout blank* is necessary for the structure of the typewheel but is never used in printing.

Positioning the Typewheel

The 557 has 60 typewheels (one for each printing position) and 80 reading brushes (one for each column in the card). Any one of the reading brushes can be wired to any one of the printing positions; any card column

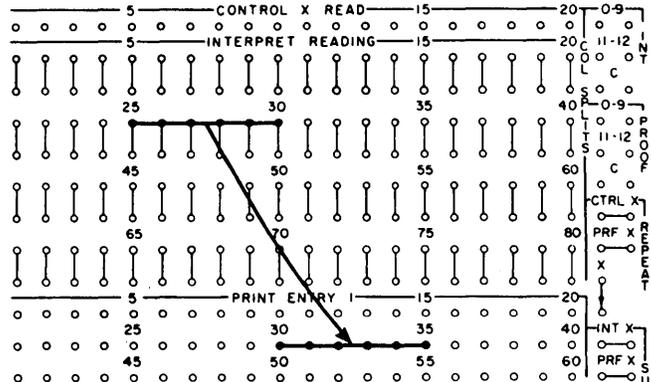


FIGURE 38. IBM 557 PRINTING

can be printed in any one of the 60 positions on the card (Figure 38).

Because cards are fed 12-edge first in the 557, the zones are read before the digits.

The typewheel rotates according to the zone (if any) and digits that are read. The construction of the typewheel and the internal circuitry of the machine make it possible to print all characters — alphabetic, numerical and special — by a single wire from the reading brush to the typewheel.

Printing and Restoring

Figure 39 illustrates the printing station. For each typewheel there is a hammer. At print time, all 60 hammers are fired, and the card is pressed against 60 typewheels. If there is no wire in a particular print position, the *no setup blank* section of the typewheel for that position presses against the card, and restores to the no-setup-blank position. Reading brushes in the 557 are labeled INTERPRET READING; entries to the typewheels are labeled PRINT ENTRY.

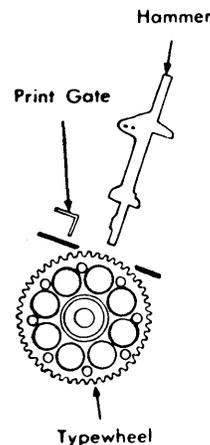


FIGURE 39. IBM 557 PRINT STATION

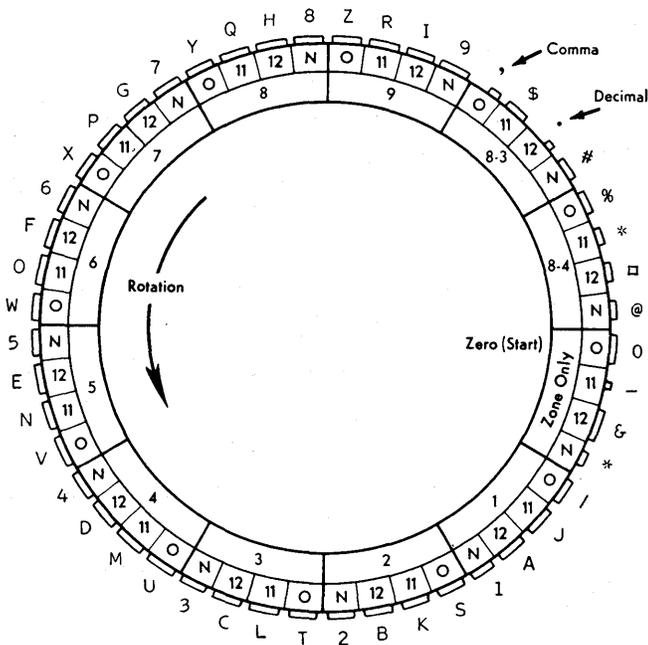


FIGURE 40. IBM 407-408-409 PRINT WHEEL SCHEMATIC

IBM 407, 408, and 409 Accounting Machines

Printing in the 407, 408, and 409 is accomplished by means of 120 printwheels that print either numerical or alphabetic information. As shown by Figure 40, the printwheel is similar to the typewheel used in the 557. It is divided into 12 sectors: 1 through 9, 8-3, 8-4, and Zone Only. Each sector is sub-divided into four sections: 0-zone, 12-zone, 11-zone, and no zone (N). Various combinations of zone and digit punches result in printing whatever digit, alphabetic character, or special character is shown outside the section in Figure 40.

The asterisk in the Zone Only sector is a special check-protecting asterisk that can be printed in blank positions of the amount field on a check.

Positioning the Printwheel

As shown by the feed schematic in Figure 41, the 407, 408, and 409 have two reading stations. Cards can be held at either reading station and read repeatedly. Because cards are fed into the machine 9-edge first, the digit punches are read first, then the zone punches. Both impulses are read, for printing, at the second reading station. If a printing position is impulsed to print, the printwheel for that position rotates and selects one of the 12 sectors; if a zone is then read, a section in that sector is selected (Figure 40). If a print position is not impulsed, the printwheel remains stationary.

Printing

At print time, rotation speed is reduced, and at the actual time of printing, the wheel is pressed against the platen. If a print position is not impulsed, the printwheel for that position is not pressed against the platen.

Reading Stations

Only two reading stations are necessary: FIRST READING for control impulses (X- or 12-punch for example); SECOND READING for print impulses (numerical and zone). There are two sets of exits from the second reading brushes; they are completely interchangeable, and are internally common to each other. A single wire from SECOND READING to any of 120 print entries is sufficient to position all characters — numerical, alphabetic, and special — for printing (Figure 42). The first

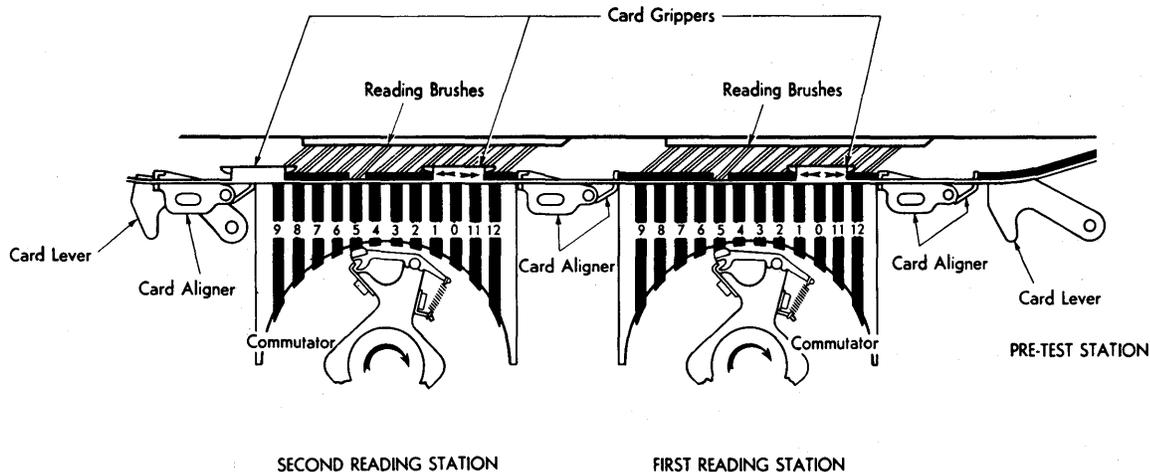


FIGURE 41. IBM 407-408-409 CARD-FEED SCHEMATIC

reading brushes are used for control impulses of various kinds: comparing, selecting, and storing. They are discussed in subsequent sections of this publication.

Printwheel Entries

Three sets of entries to the printwheels are provided in the IBM 407, 408, and 409. They are the NORMAL PRINT ENTRY, TRANSFER PRINT ENTRY, and COUNTER CONTROLLED PRINT.

NORMAL PRINT ENTRY

NORMAL PRINT ENTRY, as the name implies, is usually used for information read from cards, from an emitter, or from the storage units of the machines.

TRANSFER PRINT ENTRY

Data entered in TRANSFER PRINT ENTRY reaches the printwheels only when the TRANSFER PRINT PICKUP hub is activated by a control impulse. The unit remains transferred only for the duration of the impulse wired to the pickup hub.

COUNTER CONTROLLED PRINT

COUNTER CONTROLLED PRINT accepts only numerical information. COUNTER CONTROLLED PRINT is internally

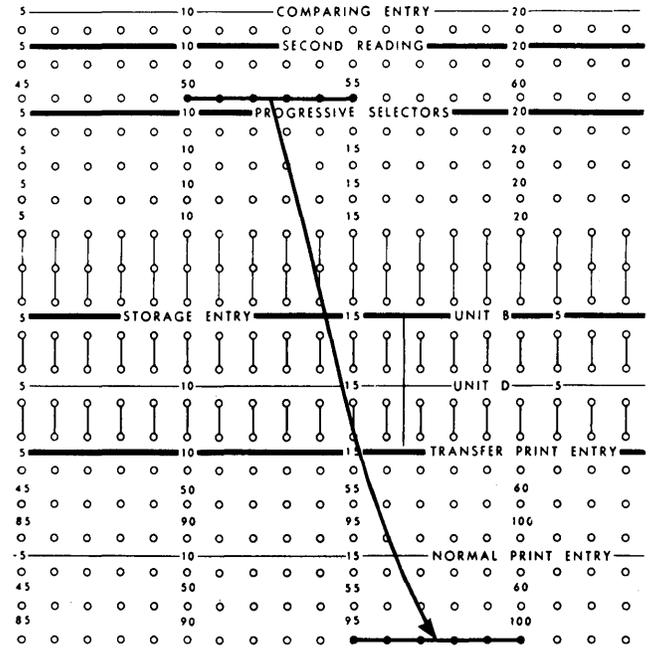


FIGURE 42. NORMAL PRINTING, IBM 407-408-409

common to either NORMAL PRINT ENTRY, or TRANSFER PRINT ENTRY, whichever one is active during a print cycle. It is usually wired from COUNTER EXIT to print data from a counter. COUNTER CONTROLLED PRINT is illustrated in this publication under the heading *Addition*.

Review Questions

1. To make a typebar print an alphabetic character, should the zone or the numerical impulse be received first?
2. The wiring required to make a typebar print a numerical character with the IBM 548 Interpreter is
3. The wiring required to make a typebar print an alphabetic character with the IBM 548 Interpreter is
4. To make a typebar in the IBM 403 Accounting Machine print an alphabetic character, should the zone or the numerical impulse be received first?
5. The wiring required to make a typebar on the IBM 403 Accounting Machine print a numerical character is
6. The wiring required to make a typebar on the IBM 403 Accounting Machine print an alphabetic character is
7. Why is there a difference between the wiring for alphabetic and numerical printing on the IBM 403 Accounting Machine?
8. What is a *hammer*, and what does it do?
9. How is the 407, 408, 409 printwheel different from the 557 typewheel?
10. How do you wire the 407, 408, 409 to print digits? Alphabetic characters? Special characters?
11. Name and explain the three sets of entries to the printwheels in the 407, 408, and 409.
12. What is a section of a typewheel?
13. What is a sector of a typewheel?
14. In the IBM 557 Interpreter, which are read first, zones or digits?
15. How do you wire the 557 to print digits? Alphabetic characters? Special characters?

Punching

When a machine prints information, it writes in language our eyes can read. When a machine must record information in a form that can be read by other machines, the machine must write in its own language, which is usually the language of punched holes.

Punch Components

The mechanism used by a machine to record information in the form of punched holes is a punch. The principal components of any punching mechanism are a punch, die, and stripper.

The punch (Figure 43) is the actual cutting element. It cuts the hole in the card. The die supports the card. The stripper supports the punch and holds the card when the punch is withdrawn.

Punching Methods

Serial Punching

In some machines (like the card punches and the IBM 602 Calculating Punch) the cards pass the punching mechanism column by column. Column 1 is punched first, followed by column 2, etc. (Figure 44). The punch mechanism covers one column at a time and is equipped with 12 punches to punch any of the 12 possible holes, or combinations (Figure 44). This is called *serial punching*.

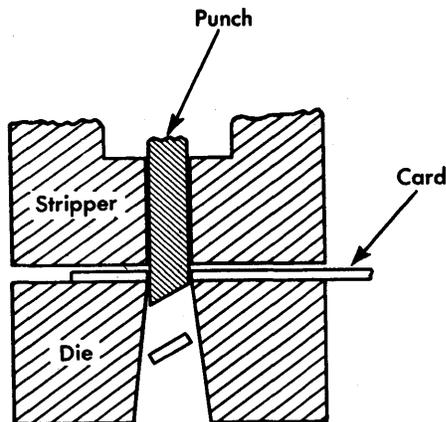


FIGURE 43. PUNCH MECHANISM

Parallel (Digit-by-Digit) Punching

In most of the machines (such as the IBM 514 Reproducing Punch) in which cards are fed 12-edge first, the cards are fed on a digit-by-digit basis, and all like digits are punched at the same time. This is *parallel punching*.

This type of punching mechanism is equipped with 80 punches, one for each card column. All 12's are punched at the same time, the card moves, all 11's are punched, the card moves, all 0's are punched, etc. (Figure 45).

Reproducing

Copying information from one card to another is called *reproducing*. Only two things are necessary:

1. The card from which we wish to take information must pass under a set of reading brushes at the same time that the card into which we wish to copy it passes under a punch.
2. The proper card columns to be read and punched, for the particular job, must be connected by control-panel wires (Figure 46).

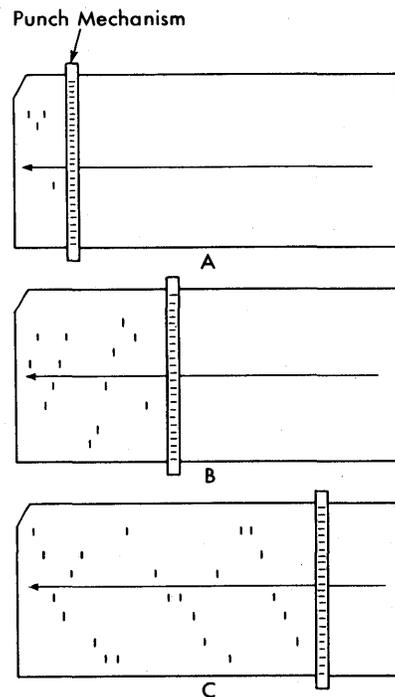


FIGURE 44. COLUMN-BY-COLUMN PUNCHING

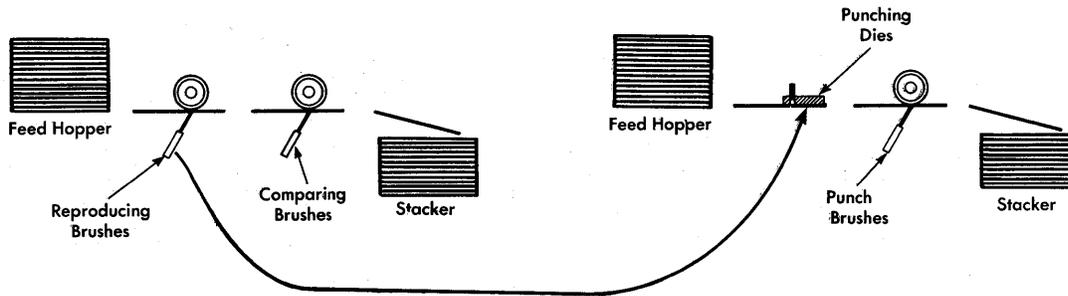


FIGURE 49. IBM 514 REPRODUCING-PUNCH SCHEMATIC

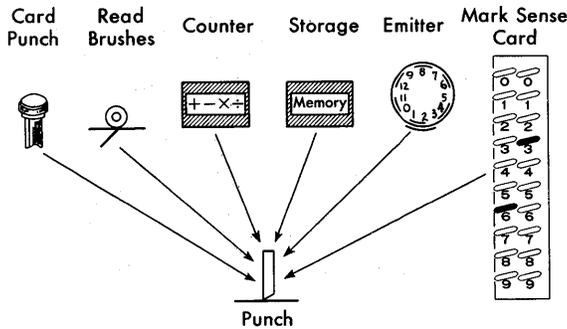


FIGURE 50. SOURCES OF IMPULSES TO A PUNCH

When information is punched into a different set of card columns than those from which it is read, the operation is called *offset reproducing*.

These operations can be represented by means of control-panel wiring diagrams, such as you have just seen. They can also be expressed in symbols that represent the elements of the machine that perform the

operations. These symbolic representations are called *schematics* or *schematic diagrams*.

The schematic shown (Figure 49) expresses in symbols the reproducing operation by an IBM 514 Reproducing Punch. This is the same operation that we just saw expressed as a control-panel diagram.

Punching Data from Other Sources

Punch entry hubs frequently receive information from reading-brush exit hubs, but this is not the only source from which information can be brought to the entry hubs. Some machine units that have not yet been discussed also serve as sources from which we draw information to take to a punch unit. For the moment, it is important only to realize that reading brushes are not the sole source of information that can be punched (Figure 50).

Review Questions

1. What is a punch? Die? What functions do they serve?
2. When cards are punched in a card punch, which edge of the card is first to pass the punches?
3. When cards are punched in a reproducing punch, which edge of the card is first to pass the punches?
4. Columns 1-10 in one deck of cards are to be reproduced into columns 41-50 of another deck. Which exit and entry hubs must be connected?
5. Is the punching described in Question 4 *offset* or *column-for-column*?
6. What is a *schematic*?

Frequently we want to print or punch repetitive information that does not originate from a brush reading a punched card. Therefore, we have to *manufacture* the impulses required. The IBM machines have a simple solution to this problem. By means of a device called an emitter, the machines can manufacture impulses just like those obtained from a punched card.

In general, two types of digit emitters are used in IBM machines. These are called *digit emitters* and *digit selectors*.

Digit Emitters

A digit emitter is simply a switch with twelve positions (Figure 51). Each position is accessible at the control panel and numbered to correspond to a punching position.

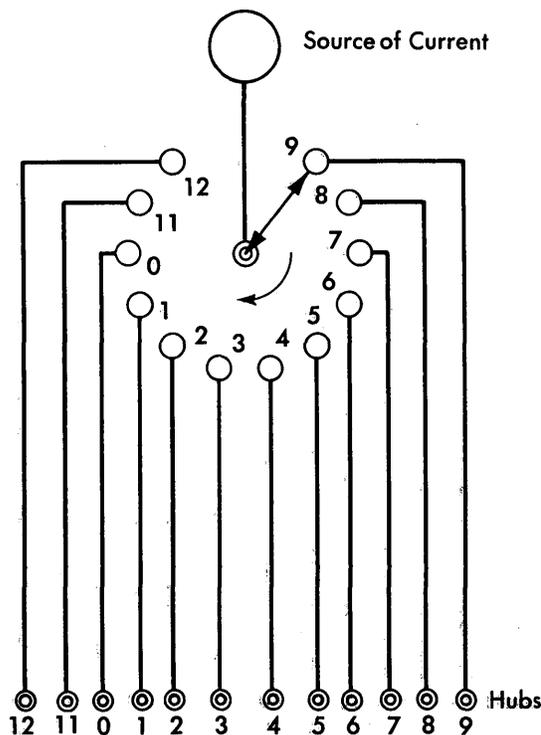


FIGURE 51. DIGIT-EMITTER SCHEMATIC

The switch is operated by the machine so that the 12 positions are connected to the source of electricity one at a time, in time with the machine. Thus, the 12-hub emits an impulse at the same time that a 12-hole would be read in the card. The 11-hub emits at the time when 11-hole would be read, etc.

When these impulses are wired to other machine functions, they have the same effect as the corresponding holes read from a card.

Emitter Exit Hubs

The arrangement of emitter exit hubs varies, depending on the type of machine, but the hubs are all used for the same basic functions (Figure 52).

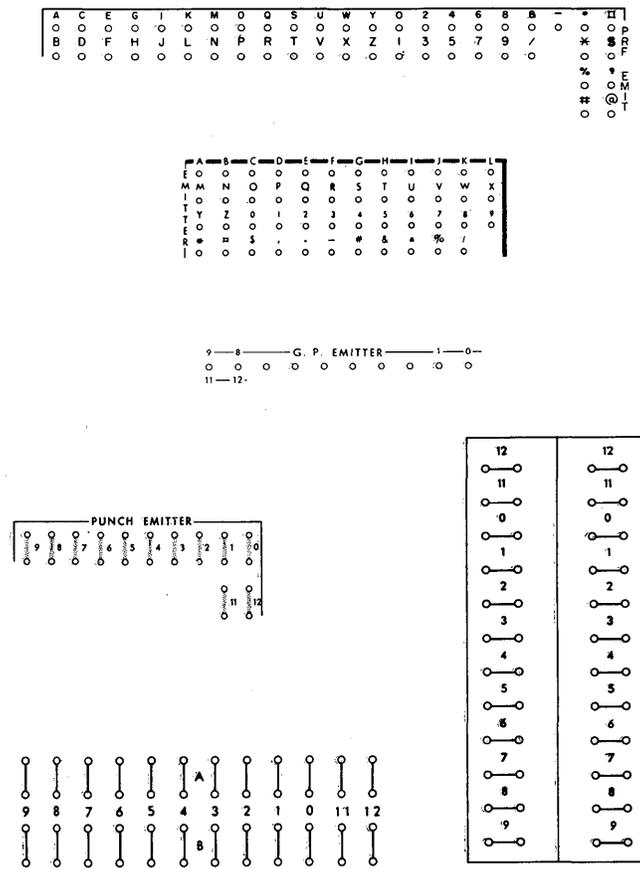


FIGURE 52. EMITTER EXIT HUBS

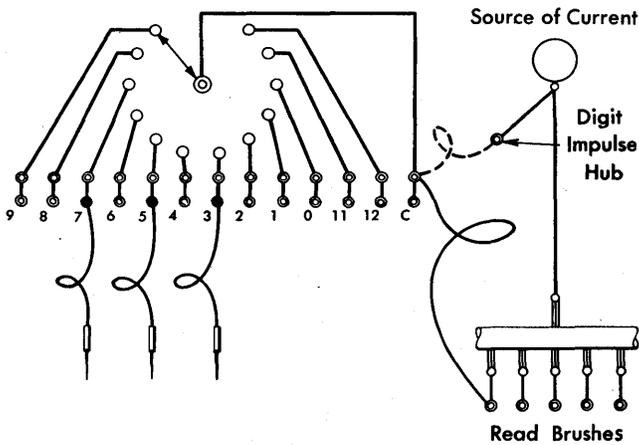


FIGURE 53. DIGIT-SELECTOR SCHEMATIC

An impulse is available from the emitter exit hub labeled 2 during 2-time of each card-feed cycle. This 2 can be used to perform any function a 2 punched in a card can perform.

If, for example, this emitted digit is connected by a control-panel wire to a punch-entry hub, each card passing the punches is punched with a 2.

Digit Selectors

The emitter just described is permanently connected to the source of electricity. Some emitters are arranged to allow the operator to wire the source of electricity into the emitter. These emitters are usually called *digit selectors*. A common (c) hub is internally connected to the rotating part of the emitter. Otherwise, this emitter operates in exactly the same manner.

Methods of Wiring Digit Selectors

We said earlier that digit selectors allow more flexibility than digit emitters (which have the source of electricity permanently wired). The illustration of the digit selector shows why (Figure 53). The broken line represents a control-panel wire that connects the digit impulse hub to the common hub of the digit selector. When this wiring is completed, the digit selector operates exactly like a digit emitter. However, impulses other than digit impulses created within the machine can be wired into the common hub. For example, a reading brush can be wired as shown in the solid line. Now impulses are available from the exit hubs only if the corresponding hole is punched in the wired card

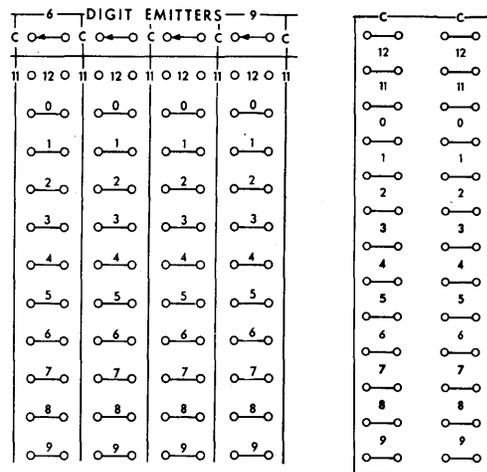


FIGURE 54. DIGIT-SELECTOR CONTROL-PANEL HUBS

column. An impulse is emitted from the 7-hub at 7-time if a 7 is punched in the column being read.

Figure 54 shows some examples of digit selectors in IBM machines. The first example is called a *digit emitter* because it can be used to emit digits when the two hubs at the top of each column (DI to C) are connected by jackplugs. However, because the impulses to the common hub can be wired from other exits, this device is better classified as a digit selector.

Wiring for Emitting

IBM 513-514 Reproducing Punch

An emitter is a special, or optional, device in reproducing punches. This type of emitter does not have an entry hub on the control panel. The source of current to the emitter brush is automatic and internal.

NEED FOR EMITTER

Let's review why we need an emitter in a reproducing punch. In the reproducing operation previously discussed, remember that we read information from one deck of IBM cards and punched it into another deck of cards. Frequently, however, the original deck of cards does not have some of the information we want

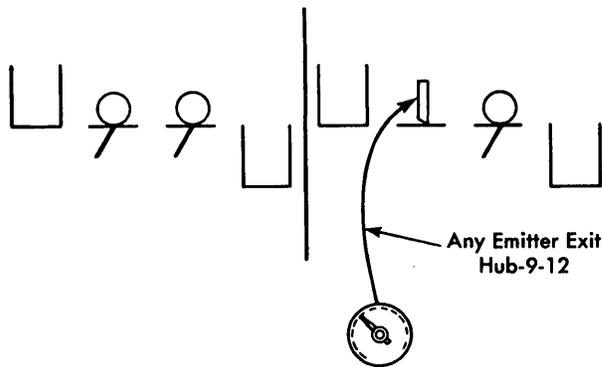


FIGURE 55. PUNCHING EMITTED INFORMATION

to punch in the new deck and, therefore, we have to *manufacture* the needed impulses by the use of an emitter.

This information is repetitive in nature; that is, the same punching is needed in each of the new cards. Information such as date, a special code, and alphabetic information is often required in all the cards of the new deck.

Let's see how this emitting is done by the IBM 514 Reproducing Punch.

EMITTING COMMON DATA

As you can see in the schematic diagram (Figure 55), instead of getting the information from the cards by means of the reproducing brushes, we can get this constant information from an emitter exit hub wired directly to a punch entry hub.

EMITTING NUMERICAL DATA. An example of control-panel wiring for numerical punching is shown in Figure 56. Wiring necessary to punch the date 9-17-60 into each card as it passes the punch station is illustrated.

EMITTING ALPHABETIC DATA. Alphabetic information also can be emitted and punched by wiring both a zone impulse and a digit impulse to the same punching position. Wiring to punch the word "art" is shown as an example of alphabetic punching from an emitter (Figure 57). Split wiring is used to accomplish this punching. The word "art" is selected in this case so that a specific zone or numerical impulse is used only once. Suppose we had chosen the word "dart." Then the 12-zone would have been used a second time in conjunction with a 4. If we split-wire to add the *d*, then it connects the 12-zone to both the 1 and 4 impulse. This causes a 12, 1, and 4 punch to occur in both columns 69 and 70. As a result, it should be clear that when alphabetic punching is to be

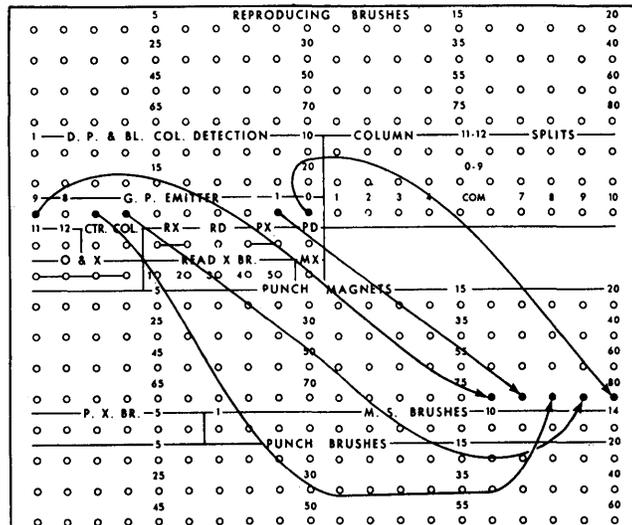


FIGURE 56. CONTROL-PANEL WIRING FOR EMITTING NUMERICAL INFORMATION

accomplished from emitted impulses, some precaution must be taken to prevent back circuits from causing incorrect punching.

One device that accomplishes this is a *column split*. This device is explained elsewhere in this manual.

Interpreters

NEED FOR EMITTER

In an interpreting operation, data punched in cards is printed on the same card or subsequent cards. Repetitive information — like a date or a decimal point in the amount field of a check — can be printed on each card under the control of the interpret emitter.

EMITTING COMMON DATA

The emitter in the IBM 552 and 548 Interpreters operates like the emitter for the reproducing punches, except that the emitted information is printed on, rather

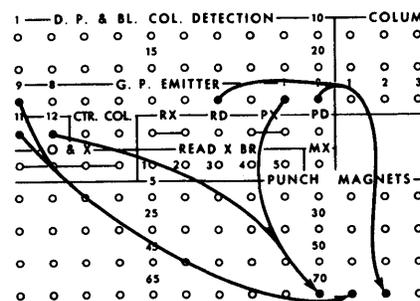


FIGURE 57. CONTROL-PANEL WIRING TO PUNCH "ART" IN IBM 514

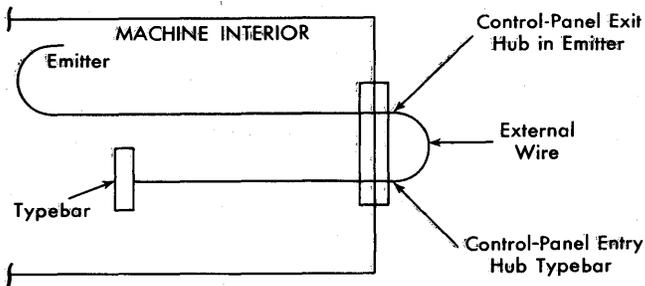


FIGURE 58. EMITTER-PRINTING SCHEMATIC

than punched in, the card. Figure 58 is a schematic of printing emitted information with the 548.

A single wire from the emitter to one of the print entry hubs is sufficient to print any one of the alphabetic, numerical, or eleven special characters in the IBM 557 Interpreter.

Figure 59 illustrates the wiring from the 557 emitter — which is labeled INT EMIT — to PRINT ENTRY to print “art” in the same position on each card.

IBM 402 and 403 Accounting Machines

NEED FOR EMITTER

When using the IBM 402-403 Accounting Machine, we often wish to print repetitive information that is not

punched in the cards. For instance a date, a customer number, or alphabetic information might be needed on a report, but must originate from something other than the cards passing through the machine.

METHODS OF WIRING

As in the reproducing punches and interpreters, we must manufacture the impulses needed for this repetitive printing by the use of an emitter. We can emit both numerical and alphabetic information.

There are two major differences between an emitter on a reproducing punch and an emitter on an IBM 402-403 Accounting Machine.

First, there is a difference in name. The 402-403 emitter has two uses. It can be used as an emitter, but it can also be used as a digit selector. The latter use is discussed in detail in a later section of this book, but for now, just remember that it is this second use that gives the 402-403 emitter its name. It is called a *digit selector*.

Second, there is a difference in the source of current to the emitter brush. In the reproducing punch and interpreters, the emitter brush receives its impulse internally and automatically. This is not so in the 402-403. An impulse must be wired to the emitter brush.

WIRING THE SOURCE IMPULSES. Which impulse do we use? On the 402-403 control panel there is a hub labeled DI. This stands for *digit impulse*. A digit impulse exit hub emits 12 electric impulses corresponding in time to the reading of the 12 punching positions of a card (9-12). These impulses are wired to an entry hub labeled c (common), which is the direct entry to the emitter brush.

The illustration shown (Figure 60) is a schematic drawing of the digit impulses being fed to the emitter common through control-panel wiring. The impulses are then available at the emitter exit hubs.

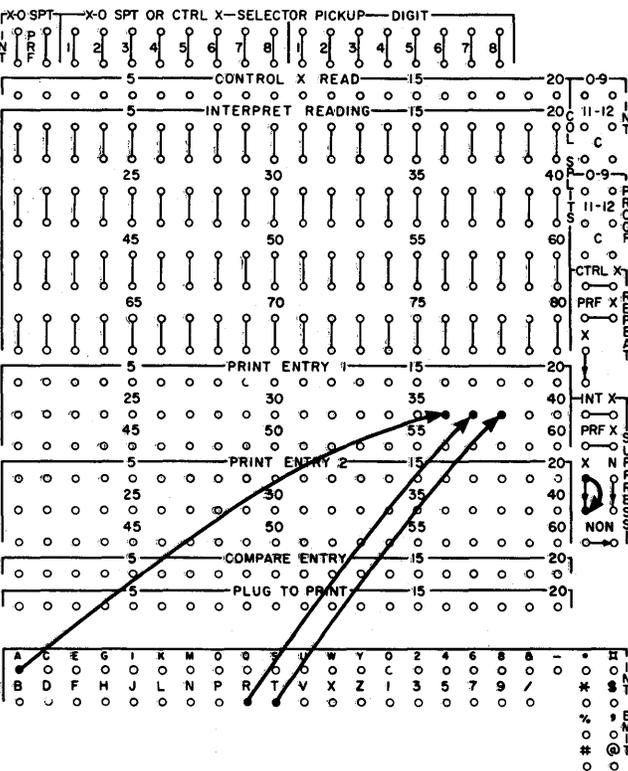


FIGURE 59. CONTROL-PANEL WIRING TO PRINT “ART” IN IBM 557

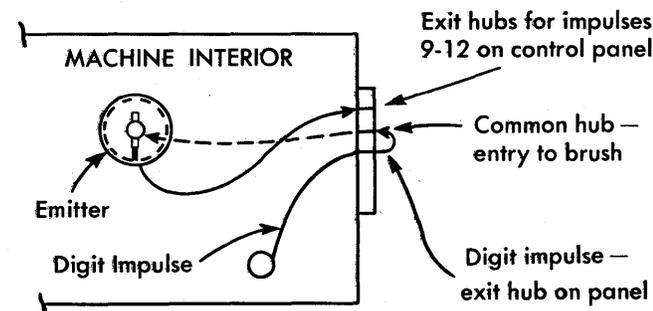


FIGURE 60. EMITTER SCHEMATIC, IBM 402-403

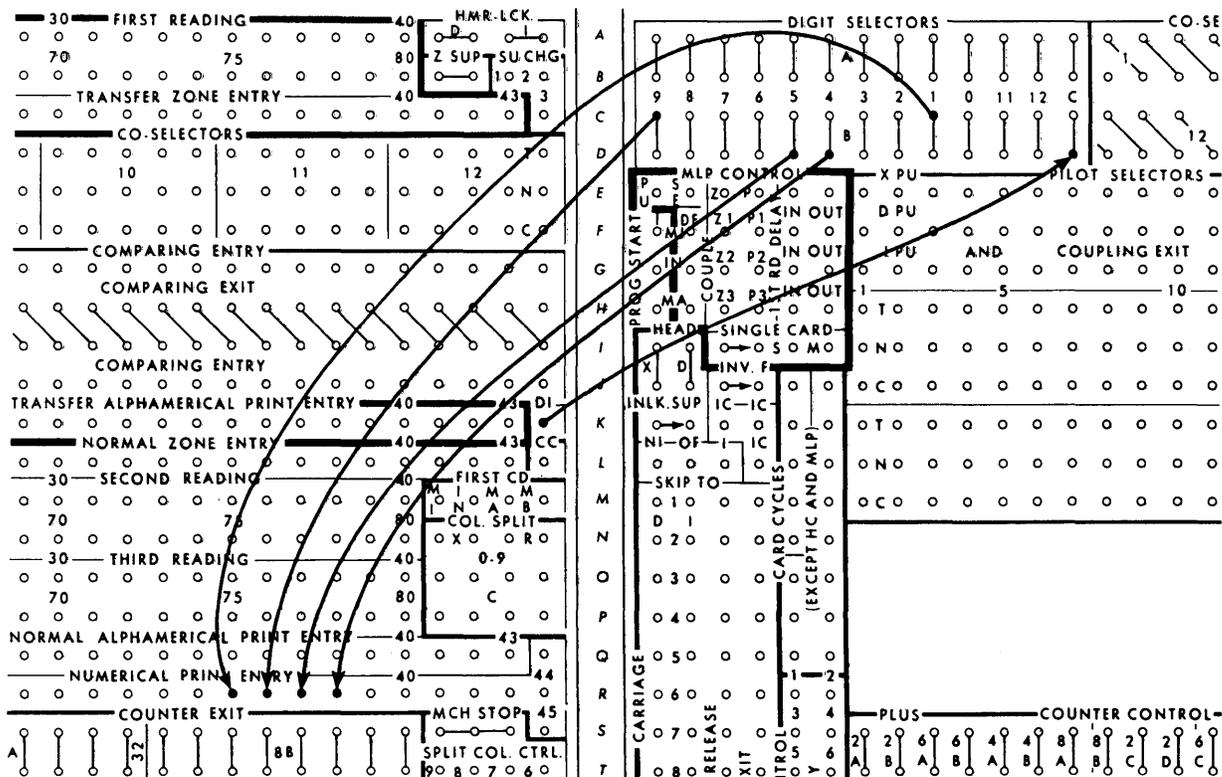


FIGURE 61. CONTROL-PANEL WIRING TO PRINT NUMERICAL INFORMATION, IBM 402-403

WIRING FOR PRINTING. The wiring for numerical printing is the same as it was for punching numerical information from an emitter (Figure 61) or printing on the 548 Interpreter.

The wiring for printing emitted alphabetic data in the 402-403 requires two wires for each letter.

In the section on printing, you will remember that to make the accounting machine print a letter, we transmitted both the zone impulse and the digit impulse to the typebar. However, it was entered through two different hubs rather than through one. The zone impulse was wired to the normal zone entry hub, and the digit impulse was wired to the normal alphanumerical print entry hub.

When emitting alphabetic information in the 402-403 we do the same, substituting the digit-selector exit hubs for the reading-brush exit hubs. The wiring to print the word "art" is again used in the illustration (Figure 62). However, it is not necessary in this case to use split wiring, because the zone is not connected to the numerical impulse but goes to its own entry. The word "dart" could have been used, and no difficulty experienced. The 12-impulse can be split-wired to several zone entries, and the corresponding numerical information wired to print entry without establishing back circuits.

IBM 407, 408, and 409 Accounting Machines

The 407, 408, and 409 Accounting Machines have both a character emitter and a digit selector. As with the 402-403, the digit selector can be used as an emitter.

WIRING THE CHARACTER EMITTER

The character emitter in the 407-408-409 is similar to the character emitter in the 557 Interpreter. Each

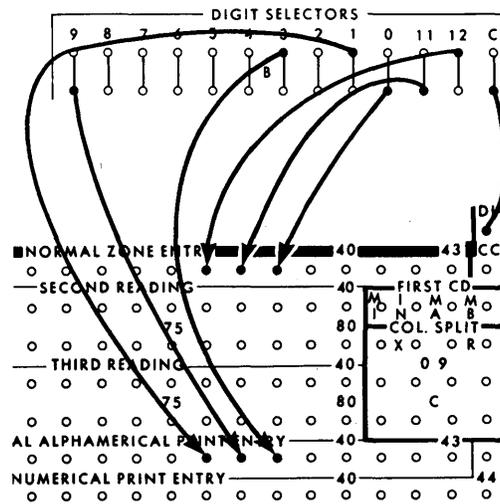


FIGURE 62. WIRING TO PRINT "ART," IBM 402-403

numerical, alphabetic, and special character has a separate hub in the 407-408-409 emitter. A single wire from the emitter position to print entry prints the desired character during every machine cycle.

Figure 63 illustrates wiring the emitter to print the word "art" during every machine cycle in the 407-408-409.

WIRING THE DIGIT SELECTOR

The digit impulse is usually used to impulse the digit selector on the 407, 408, and 409 for use as an emitter. If the selector is used as an emitter, two wires are needed for each alphabetic character because both the zone and the digit punch must be conveyed to the printwheel.

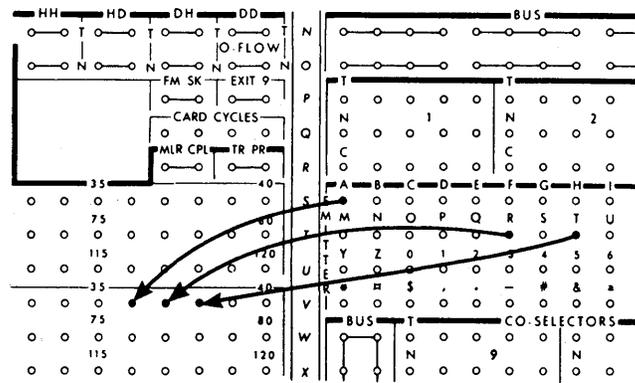


FIGURE 63. WIRING TO PRINT "ART" FROM THE CHARACTER EMITTER, IBM 407-408-409

The digit selector used as an emitter is shown (Figure 64) wired to NORMAL PRINT ENTRY to print the word "art" on every machine cycle.

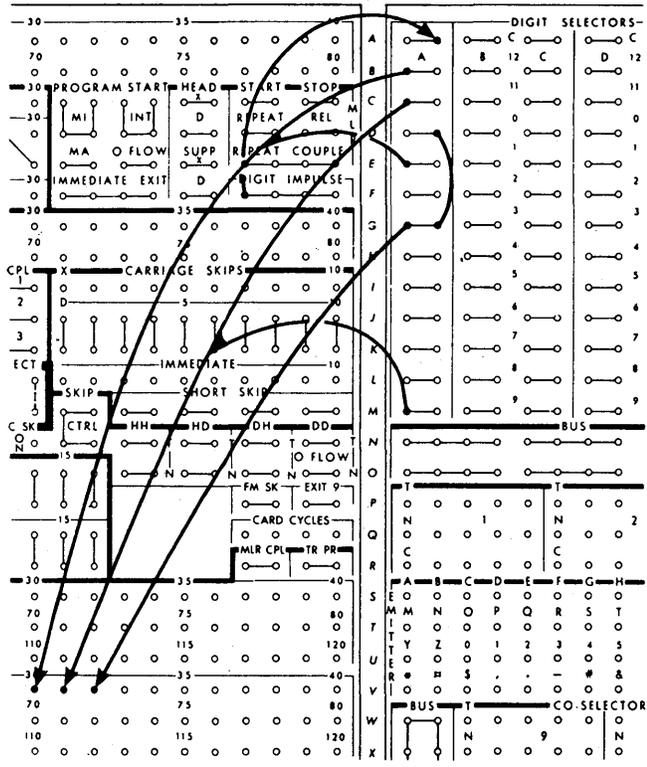


FIGURE 64. WIRING TO PRINT "ART," USING THE DIGIT SELECTOR AS AN EMITTER, IBM 407-408-409

Review Questions

1. When do you need to use an emitter?
2. What is a digit emitter?
3. What is a digit selector?
4. How are the impulses available at the exit hubs on the control panel?
5. When are the impulses available at the exit hubs on the control panel?
6. What are the two methods of impulsing the emitter brush?
7. What control-panel wiring is necessary to punch from an emitter?
8. Is it possible to punch alphabetic information using an emitter? If so, how?
9. What control-panel wiring is necessary to print emitted data in the Interpreter? The IBM 402-403 Accounting Machine? The IBM 407-408-409 Accounting Machine?
10. How do you print alphabetic information using an emitter in the IBM 557 Interpreter? In the 402-403? In the 407, 408, and 409?
11. What is a DI impulse? What is it used for?
12. What is a back circuit?

Uses of Comparing

Comparing, in the usual sense of the word, is the process of examining the character or qualities of two or more persons or objects for the purpose of discovering in what way they are alike or in what way they are different. Often items are set side by side to determine their relative value, size, weight, etc., or to establish proper relationship.

Comparing, when used as a term to describe a function of an IBM machine, means basically the same thing. However, the process of comparing is absolute, not relative. No means is available to ascertain how much the two or more items are different from each other. The IBM machine determines *only* whether two or more items of information *are* or *are not* identical. The operator by means of control-panel wiring, predetermines

the operation of the machine for either decision, depending on the purpose of the function: verification or control.

Verification

Verification is a process of testing for the correctness of punching. For example, after a machine has copied or reproduced the holes from one IBM card into another IBM card, you should compare the holes in the original card with the holes in the new card to verify the accuracy of the punching (Figure 65).

Control

Control is the process of directing a machine to perform specific operations. For example, you may need to check a file of IBM cards to make sure that they are in

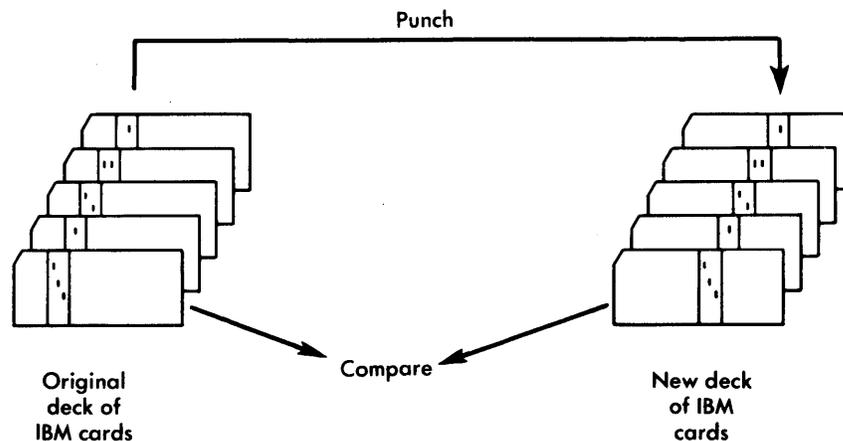


FIGURE 65. COMPARING REPRODUCED CARDS

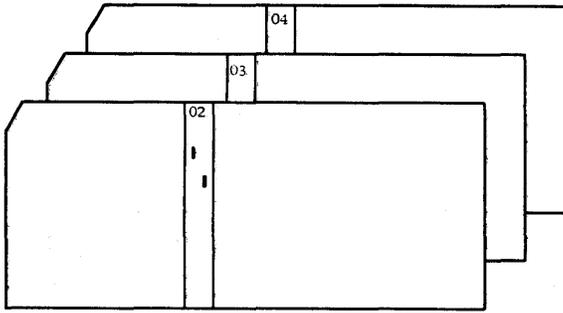


FIGURE 66. CARDS IN ASCENDING ORDER



FIGURE 69. MANUAL METHOD OF COMPARING

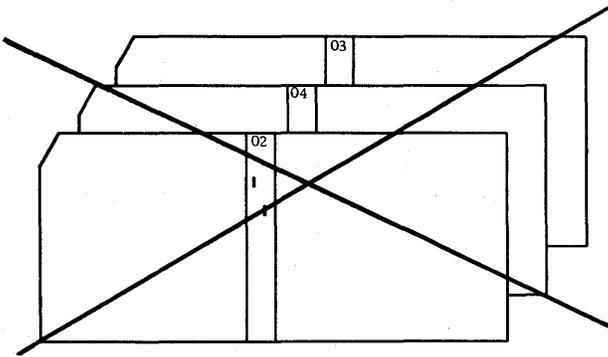


FIGURE 67. CARDS OUT OF SEQUENCE

correct ascending or descending order, or sequence. It is necessary to *compare* the first card with the second card, the second card with the third, the third card with the fourth, etc. If a card is out of order (sequence), you want to *control* the machine to stop so that you can locate the card that is out of sequence and refile it in its correct place.

The cards shown are in ascending numerical sequence (02, 03, 04) in Figure 66.

The cards in the next illustration (Figure 67) are not in ascending sequence. By comparing the first card with the second, the second with the third, etc., an IBM machine can recognize that the cards are out of sequence, and the machine can be controlled to stop.

Another example of the need for comparing in order to control machine operations is shown in Figure 68.

This is a report prepared by an IBM accounting machine. As cards are passed through the accounting machine, it prints commodity number, unit cost, quantity, and sales amount automatically from each card.

We also set up the machine to *compare* the commodity number of the first card with the commodity number punched in the second card, the commodity number of the second card with the commodity number of the third card, etc.

Whenever the machine recognizes, by means of its comparing feature, a difference in commodity number from one card to another, the machine stops feeding cards and prints a total for sales amount.

The total for the three cards for commodity number 11102 is \$17.94. The total for the six cards for commodity number 11202 is \$147.74.

So, you see, whether we wish to verify the correctness of punching, or control IBM machines to perform the desired operations, we must *compare*.

Now, let us see how comparing is done.

Commodity Number	Unit Cost	Quantity	Sales Amount
1 1 1 0 2	5 5 6	4	2 7 6
1 1 1 0 2	5 5 6	2	1 3 8
1 1 1 0 2	5 5 6	2 0	1 3 8 0
		2 6	1 7 9 4 *
1 1 2 0 2	6 6 4	4 0	3 3 2 0
1 1 2 0 2	6 6 4	1 5	1 2 4 5
1 1 2 0 2	6 6 4	4 0	3 3 2 0
1 1 2 0 2	6 6 4	4 0	3 3 2 0
1 1 2 0 2	6 6 4	3	2 4 9
1 1 2 0 2	6 6 4	4 0	3 3 2 0
		1 7 8	1 4 7 7 4 *
1 3 1 0 2	6 7 3	7 5	6 3 0 0
1 3 1 0 2	6 7 3	4 5	3 7 8 0
1 3 1 0 2	6 7 3	2 5	2 1 0 0
1 3 1 0 2	6 7 3	7 5	6 3 0 0
		2 2 0	1 8 4 8 0 *
1 4 2 0 2	7 0 9	1 5	1 3 2 0
1 4 2 0 2	7 0 9	4	3 5 2
1 4 2 0 2	7 0 9	1 5	1 3 2 0
1 4 2 0 2	7 0 9	1 5	1 3 2 0
1 4 2 0 2	7 0 9	3 0	2 6 4 0
1 4 2 0 2	7 0 9	2 0	1 7 6 0
		9 9	8 7 1 2 *

FIGURE 68. ACCOUNTING-MACHINE REPORT

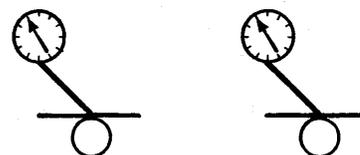


FIGURE 70. MACHINE METHOD OF COMPARING

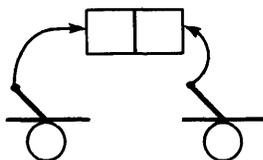


FIGURE 71. COMPARING MAGNETS

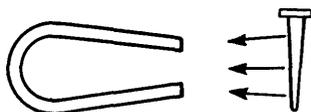


FIGURE 72. HORSESHOE MAGNET

Methods of Comparing

Manual Method

If you were comparing the numbers punched in two IBM cards, you would look at one card, remember the number, read the number punched in the other card, and mentally compare the two (Figure 69).

Machine Method

The IBM machines compare cards by substituting mechanical units for human intelligence.

An IBM machine reads cards by means of its reading brushes. To compare any two cards at the same time, we must have two sets of reading brushes. One set of brushes reads one card at the same time the other set of brushes reads the other card (Figure 70).

When two cards are read by two sets of brushes, the movement of the cards is synchronized, or *timed*, together. By this we mean that at 12-time the 12-position of one card is being read by one set of brushes, and at the same time, the 12-position of the other card is being read by the other set of brushes.

The comparing operation takes place in IBM machines in the *comparing magnets* (Figure 71). They are described in detail in the following pages, but for now remember that they are the place where the card

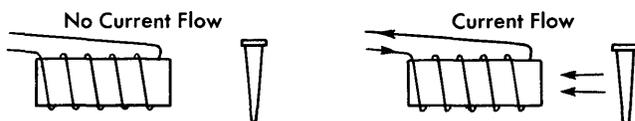


FIGURE 73. IBM ELECTROMAGNETS

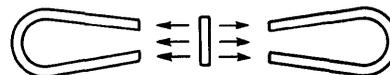


FIGURE 74. MAGNETIC FORCE EQUAL (HORSESHOE MAGNETS)

punches are analyzed. The result of this analysis directs the IBM machines to perform the desired operations.

Comparing Magnets

You should understand what a comparing magnet is before we get any further into a discussion of comparing. It will also be a help in wiring problems if you have a good idea of how a comparing unit works. Probably the best illustration of a *magnet* is the horseshoe magnet (Figure 72). The horseshoe magnet attracts a nail or a piece of iron, and this magnetism is permanent.

PRINCIPLE OF ELECTROMAGNETISM

The magnet in IBM machines is slightly different from the horseshoe type. It is a piece of iron (called a *core*) that becomes a strong magnet when an electric impulse goes through a length of wire (called a *coil*) wrapped around the core (Figure 73). When the electric impulse is *not* going through the coil, the core is not magnetized. When an electric impulse is going through the coil, the core becomes a magnet.

Therefore, you can see that the difference between the horseshoe magnet and the magnets used in IBM machines is that in the IBM type, the magnetism can be turned off and on by the presence or absence of an electric impulse.

The type of magnet used in IBM machines is called an *electromagnet*.

If we put a metal bar between two identical horseshoe magnets, the magnetic force is equal from both magnets, and the bar does not move toward either magnet (Figure 74).

If we put a metal bar between two identical electromagnets and take identically *timed* electric impulses to each of these magnets, then too, the metal bar stays in place and does not move toward either magnet (Figure 75). However, if at a given time, only one of the two electromagnets receives an impulse and is magnetized,

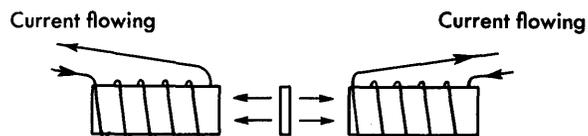


FIGURE 75. MAGNETIC FORCE EQUAL (ELECTROMAGNETS)

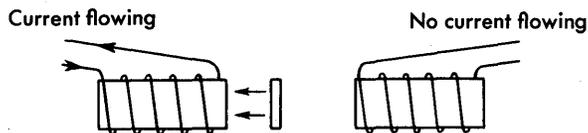


FIGURE 76. MAGNETIC FORCE UNEQUAL (ELECTROMAGNETS)

then the bar is attracted to the magnet that has received the electric impulse (Figure 76).

USING ELECTROMAGNETS FOR COMPARING

IBM machines use electromagnets in pairs to perform the comparing operation. Each pair of electromagnets is called a *comparing position* or a pair of *comparing magnets*. Therefore, there are two halves to each comparing position or magnet.

Whenever you are using a comparing position, remember that if you use one half (of comparing position 5, for instance) to record the reading of one card, then you must use the other half of the comparing position (position 5) to record the reading of the other card.

In the illustrations to follow, the magnets themselves are shown shaded if they are energized or impulsed, and plain if not impulsed (Figure 77).

In schematic diagrams, comparing magnets are shown as two squares side by side representing the two sides of a comparing unit (Figure 78).

HOW COMPARING MAGNETS WORK

Let's compare two cards that are punched identically in column 15. Both card A and card B have a 5-punch.

IBM machines must read both cards, so Figure 79 shows two sets of reading brushes.

The impulse resulting from a punch in card A energizes the left-hand magnet. An impulse resulting from a punch in card B energizes the right-hand magnet. This occurs because we have connected the reading-brush exit hubs with the comparing magnet entry hubs by means of external control-panel wires.

Because card A and card B are punched with the same number, *both* the left-hand and right-hand mag-

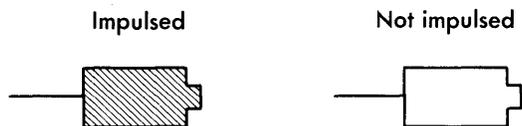


FIGURE 77. MAGNET SCHEMATIC



FIGURE 78. COMPARING MAGNETS

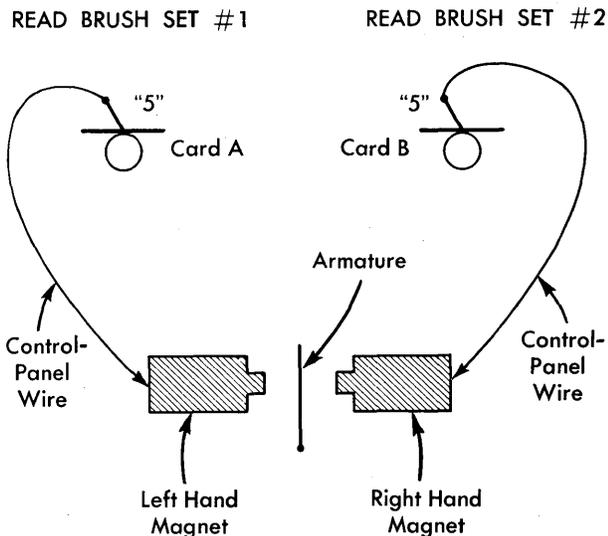


FIGURE 79. COMPARING (EQUAL CONDITION)

nets are energized at the same time, and the metal bar in the center (called an *armature*) remains in the position shown. This is called an *equal condition*.

Now assume that two pairs of cards are being fed through an IBM machine, 12-edge first. Card A of pair 1 is punched with a 5 in column 15, and card B of pair 1 is punched with a 9 in column 15.

At 5-time the hole in card A permits the brush and the contact roller to complete an electric circuit, and the resulting impulse is carried over the external wire on the control panel to the left-hand magnet. This impulse then energizes the magnet for the duration of 5-time (Figure 80).

Because there is no punch in card B in the 5-position, no impulse is available, and the right-hand magnet remains inactive. This creates an unequal condition of

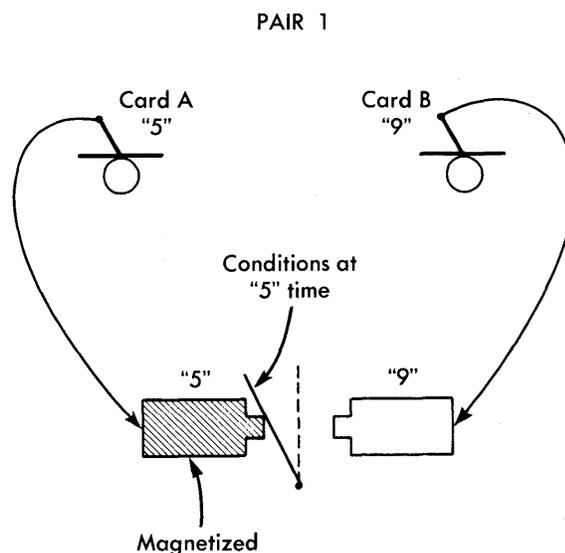


FIGURE 80. COMPARING (UNEQUAL CONDITION)

PAIR 2

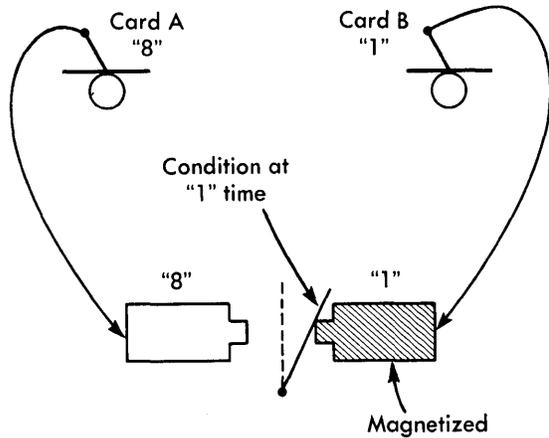


FIGURE 81. COMPARING (UNEQUAL CONDITION)

magnetism in the two magnets, and the armature is attracted to the left-hand magnet (Figure 80).

Now let's follow the second pair of cards through the machine. Card A is punched with an 8 in column 15; card B is punched with a 1 in column 15.

In this case the right-hand magnet is impulsed, and the left-hand magnet remains inactive. The unequal condition causes the armature to be attracted to the right-hand magnet (Figure 81).

The armature, when moved by unequal magnetic attraction, becomes a *switch*.

When the armature is in the central position, indicating that the punches in the two cards being compared are identical, then the switch is OFF. This central position of the armature is called *normal*.

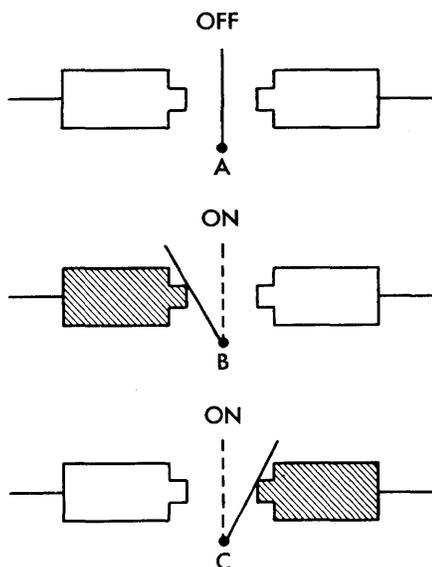


FIGURE 82. MAGNETS—NORMAL (A); UNEQUAL (B AND C)

When the armature is pulled to either the left- or right-hand magnet, indicating that the punches in the two cards are not the same, then the switch is ON. We call this movement of the armature from the normal position to the magnet a *transfer*. The armature is in the transferred position in Figure 82B and C. It is normal in Figure 82A.

We can demonstrate the usefulness of this switch by adding electric light bulbs and a few wires.

In Figure 83A, neither magnet has been energized, and the armature remains in the normal position. Although we have current flowing to the armature, it cannot be used to light the electric light bulb, for the current cannot jump the gap to the wires leading to the bulb.

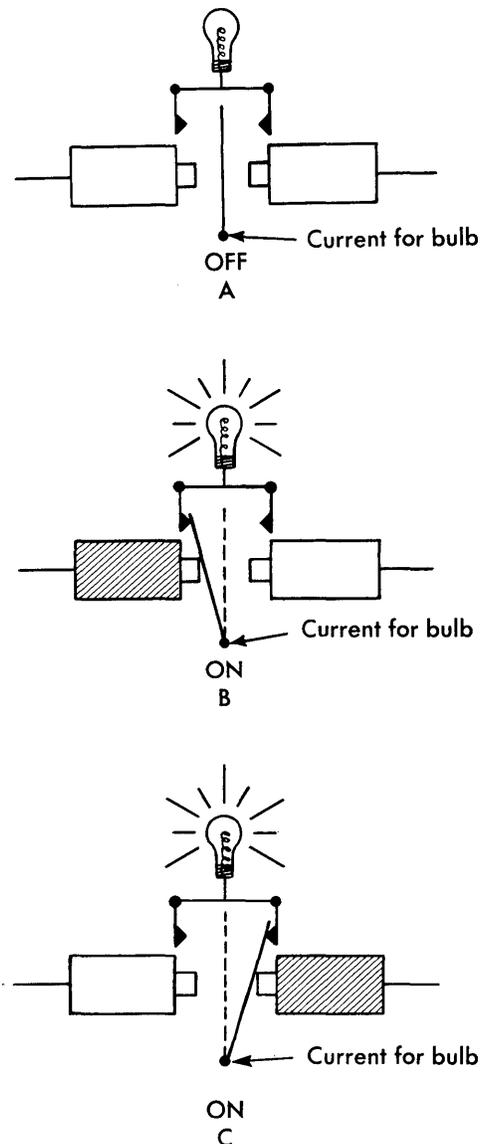


FIGURE 83. CURRENT REACHES LIGHT BULB ONLY WHEN SWITCH IS ON

Wiring for Comparing

Reproducing Punch

For a concrete example of how comparing magnets are wired, let's use the reproducing punch and assume that you are comparing the punching of card columns 15-20 in the original deck with card columns 15-20 in the new deck.

The only way to understand this operation is to understand the schematic diagram of the reproducing punch (Figure 84).

When you look at a schematic, you must realize that the cards shown at any station (that is, brush, punch, etc.) are really *going past* that station. They are *not* standing still but are in motion.

In the previous discussion of punching, we explained that you wired from READING BRUSHES to PUNCH. This control-panel wiring is shown in the schematic by the arrow labeled *punch*.

As the first original card is read by the reproducing brushes, the first new card is punched.

In the schematic (Figure 85) there are two extra stations.

The station immediately to the right of the reproducing brushes is called the *comparing brushes*, and the station to the right of punch is called the *punch brushes*. These are the two sets of brushes used for the comparing operation.

On the card cycle following the punching operation, the cards move past the next stations: the comparing, and punch brushes. As the cards move past these stations, the punch impulses are taken to the comparing magnets by the external control-panel wires.

If an unequal condition is set up in the comparing magnets, the resulting impulse *internally and automatically* directs the machine to:

1. stop feeding cards
2. light a signal light to tell the operator that the machine has stopped because of the comparing circuit
3. raise mechanical fingers that point out to the operator which pair of comparing magnets contains the unequal condition.

The reproducing (READ) brushes are wired to the punch magnets just as they are for punching. The punch brushes, which read the card that has just passed the punch station, are wired to one side of six comparing magnets (Figure 86). They are wired to comparing magnets 15-20 because it is easy to wire card columns to the corresponding comparing magnets, but it is not necessary. They can just as well be wired to any six comparing magnets.

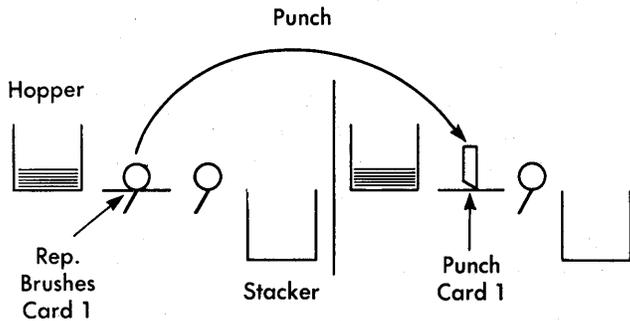


FIGURE 84. PUNCH SCHEMATIC, IBM 513-514

In Figure 83B, however, the electric light has been lighted. When the left-hand magnet is energized, it pulls the armature to the left where it makes contact with the wire leading to the bulb. The current that is connected to the armature has a completed path to the light bulb, and the bulb lights. This is accomplished by the transfer of the armature.

In Figure 83C the bulb also lights. This time, the right-hand magnet is energized and pulls the armature to the right where it makes contact with the right-hand wire leading to the bulb. Again, the bulb lights because a circuit is completed by the transfer of the armature.

In Figure 83A the electric circuit is not completed. In Figures 83B and C, the transfer of the armature completes the electric circuit, and the light bulb is turned on.

When these armatures transfer, they complete electric circuits. The completion of the circuit tells the machine that the two cards being compared have different punches . . . are *unequal*.

The collator can further analyze an unequal condition to tell which card has the lower number.

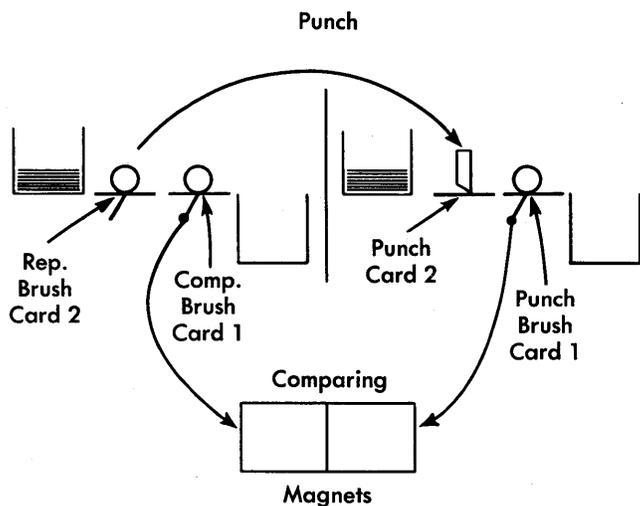


FIGURE 85. COMPARING SCHEMATIC, IBM 513-514

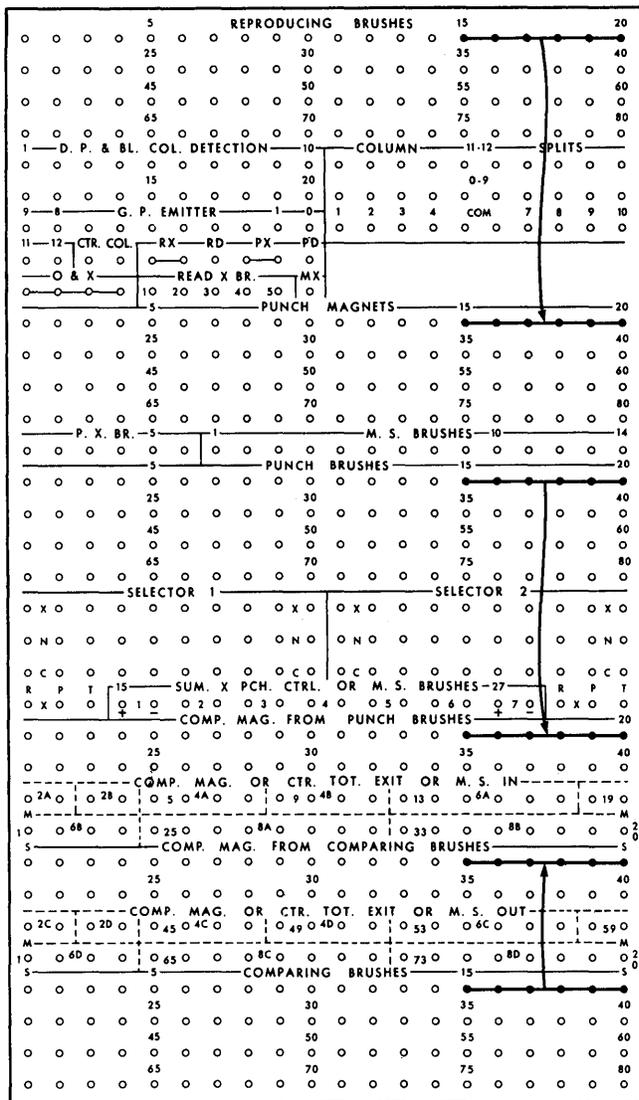


FIGURE 86. WIRING FOR COMPARING, IBM 513-514

The comparing brushes are wired to the other side of the comparing magnets to which the punch brushes are wired — in this instance comparing magnets 15-20. It is necessary to wire the same comparing magnets from punch brushes and comparing brushes. If we had decided to wire the punch brushes to comparing magnets 1-6, then the comparing brushes would also have to be wired to positions 1-6.

IBM 77 and 85 Collators

A reproducing punch is not the only IBM machine to use comparing magnets. Other machines, including the collators, also have comparing magnets.

Because collators have two separate feeds (the primary and secondary), which are individually controlled, they can perform a variety of operations. We shall discuss just one function — *sequence checking*.

Card #1

Card #2

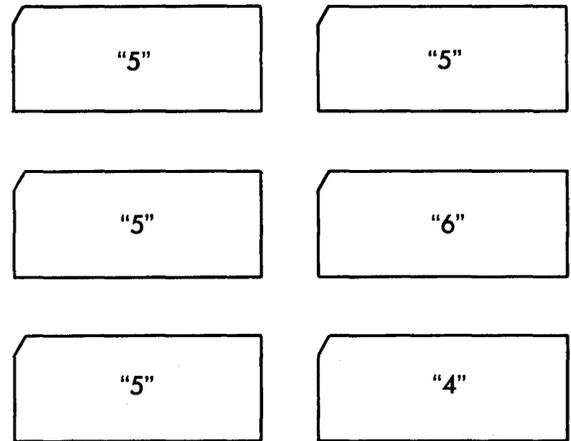


FIGURE 87. COMPARISON OF CARDS

SEQUENCE CHECKING

Sequence checking is determining whether or not a file of IBM cards is in proper ascending or descending order. To perform this operation, whether manually or by machine, we must *compare*.

In any sequence-checking operation, we compare one card with the *immediately preceding* card in order to determine which of the following conditions exists. There are only three possibilities:

1. The second card has the *same* punches as the immediately preceding card . . . EQUAL.
2. The second card has a *higher* number punched in it than the immediately preceding card . . . HIGH.
3. The second card has a *lower* number punched in it than the immediately preceding card . . . LOW.

If you look at a series of numbers to determine which condition exists between any two of them, you look at the number in which you are interested at the moment and then look at the other to make the comparison (Figure 87).

If the cards are in ascending order (Figure 88), the card out of order (or the one with the low condition) is card number 3. As long as the second number is equal to, or higher than, the first or preceding number, the numbers are in order. If the second number is low, we have a *low primary sequence* in the 77 and a *low sequence* condition in the 85.

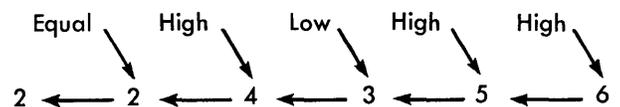


FIGURE 88. COMPARING—HIGH, LOW, AND EQUAL

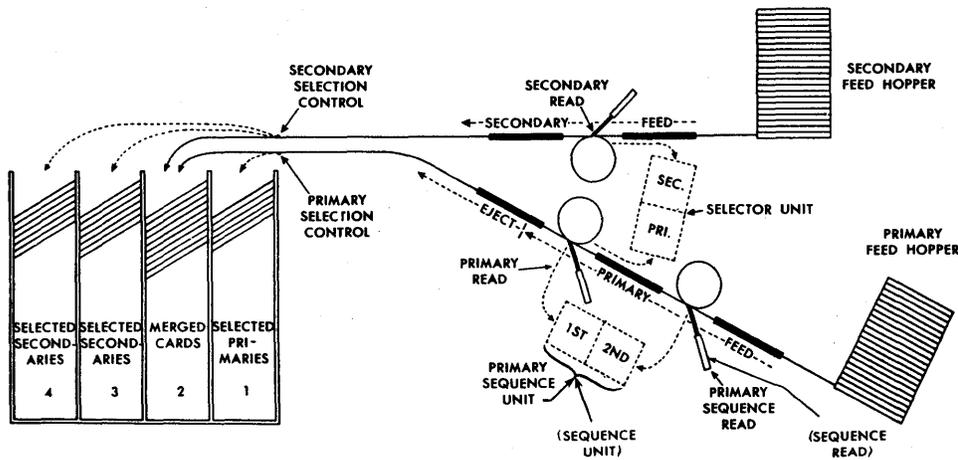


FIGURE 89. FEED SCHEMATIC, IBM 77-85 COLLATORS

The same terminology applies to the other two conditions. *Equal primary sequence* and *high primary sequence* are the correct names for the other two conditions in the 77. They are called *equal sequence* and *high sequence* in the 85.

HOW SEQUENCE CHECKING IS ACCOMPLISHED

Let's look at the schematic diagram of the collators (Figure 89) to see how the comparing operation takes place.

To compare cards, two sets of brushes and comparing magnets are needed. You can see by looking at the schematic that the collators have these units.

The collators have two feeds: the lower or primary feed, and the upper or secondary feed. The primary feed is used for this sequence-checking operation because it has two sets of reading brushes.

The reading brushes on the left are called *primary read* in both machines.

The brushes on the right are called the *primary sequence read* brushes in the 77, and *sequence read* in the 85, because they are located in the primary feed and make it possible to sequence-check (compare) the second card with the preceding card.

We also have pairs of comparing magnets. They are called the *primary sequence unit* in the 77, and *sequence unit* in the 85. To distinguish the left and right side of a pair of magnets, the entries are labeled *1st* and *2nd* in the 77, and *primary sequence* and *sequence* in the 85.

Control-panel wiring for comparing is simple and is much like that needed to check reproducing. We must wire both sets of reading brushes to the comparing entries because no comparison can take place until the punches in the cards have been received by the magnets.

In Figure 90, we have added the wires to the comparing magnets, and show that the 2's punched in each of the two cards have been taken to the comparing magnets. In this instance, we have an *equal primary*

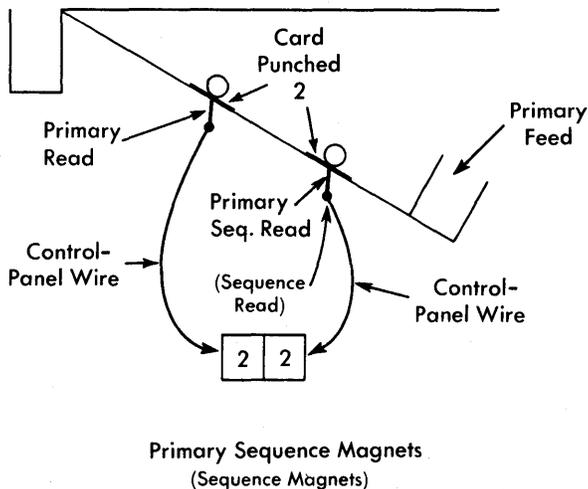


FIGURE 90. PRIMARY SEQUENCE UNIT (SEQUENCE UNIT)

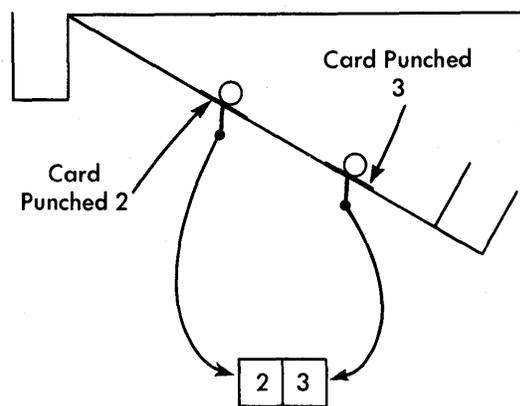


FIGURE 91. HIGH-SEQUENCE CONDITION

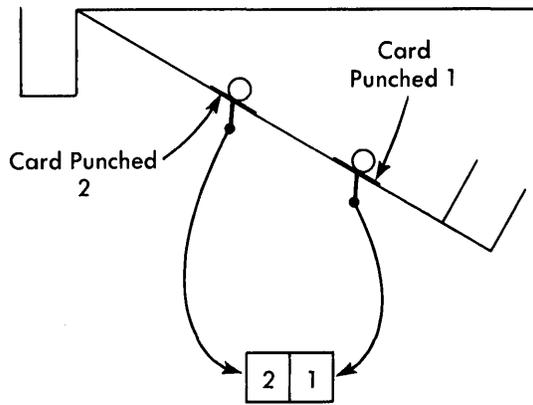


FIGURE 92. LOW-SEQUENCE CONDITION

sequence condition in the 77, and an *equal sequence condition* in the 85. (The second card in the primary feed is equal to the first card in the primary feed.)

In Figure 91, we have a *high primary sequence condition* in the 77, and a *high sequence condition* in the 85. (The second card in the primary feed is higher than the first card in the primary feed.)

In Figure 92, we have a *low primary sequence condition* in the 77, and a *low sequence condition* in the 85. (The second card in the primary feed is lower than the first card in the primary feed.)

HIGH-LOW-EQUAL COMPARING

The comparing unit analyzes the card punches, to establish which condition has occurred, in a way that is very much like the method used in the reproducing punch.

If neither magnet is impulsed, or if both are impulsed at the same time, we have an *equal primary sequence condition* in the 77, or an *equal sequence condition* in the 85. The armature stays in its normal position (Figure 93). The control input impulse going to the armature is available out of the control-panel exit marked

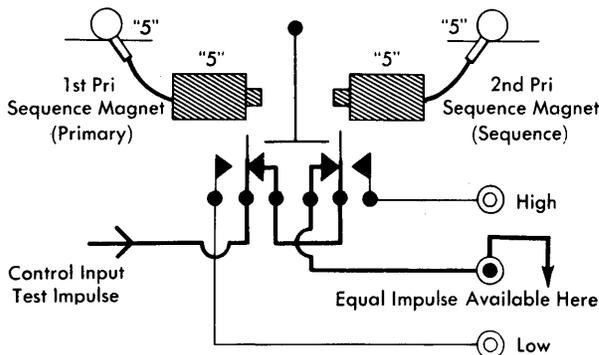


FIGURE 93. BOTH MAGNETS ENERGIZED

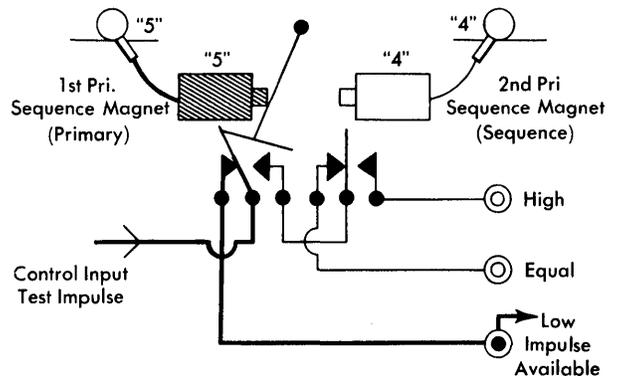


FIGURE 94. FIRST PRIMARY SEQUENCE MAGNET ENERGIZED

EQUAL PRIMARY SEQUENCE in the 77, and EQUAL SEQUENCE in the 85. In the schematics used to illustrate these comparing principles, the path for current is drawn as a heavy line for clarification.

If the 1st primary sequence magnet is impulsed (primary sequence magnet in the 85), and the 2nd primary sequence magnet (sequence magnet in the 85) is not impulsed, this would indicate a low primary sequence condition in the 77 (low sequence in the 85).

Let's look at the schematic diagram in Figure 94.

The cards are fed 9-edge first. Therefore, the highest number is read first. If the high number is under the primary brushes, then the 1st primary sequence magnet (primary sequence magnet in the 85) is impulsed.

The armature transfers to the left, and the impulse from the armature becomes available out of the low-primary-sequence exit hub in the control panel (low primary in the 85).

We get an indication of high primary sequence, or high sequence when the right-hand magnet (Figure 95) is energized first, attracting the armature and completing a circuit to the high primary sequence hub (high sequence hub in the 85).

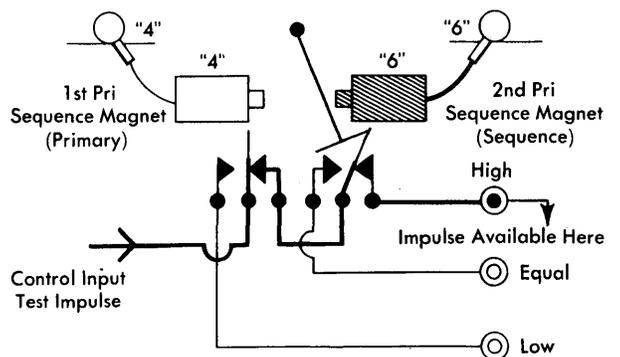


FIGURE 95. SECOND PRIMARY SEQUENCE MAGNET ENERGIZED

We have now discussed recognition by the machine of the three possible comparing conditions. In the reproducing punch, once a condition is recognized by the machine, it is internally and automatically controlled to stop, light a bulb, and indicate the comparing magnet causing the unequal condition.

This is not true of the collators. We must decide which condition requires us to stop the machine and then externally wire the selected condition to an entry hub. The impulse carried through this connection causes the machine to stop.

Let's look at the control-panel diagrams of the IBM 77 and 85 Collators (Figures 96 and 97).

In the lower sections, we show the wiring of column 15 from the primary-sequence read brushes to the comparing magnets (sequence read brushes in the 85). These wires are identified by the number 1.

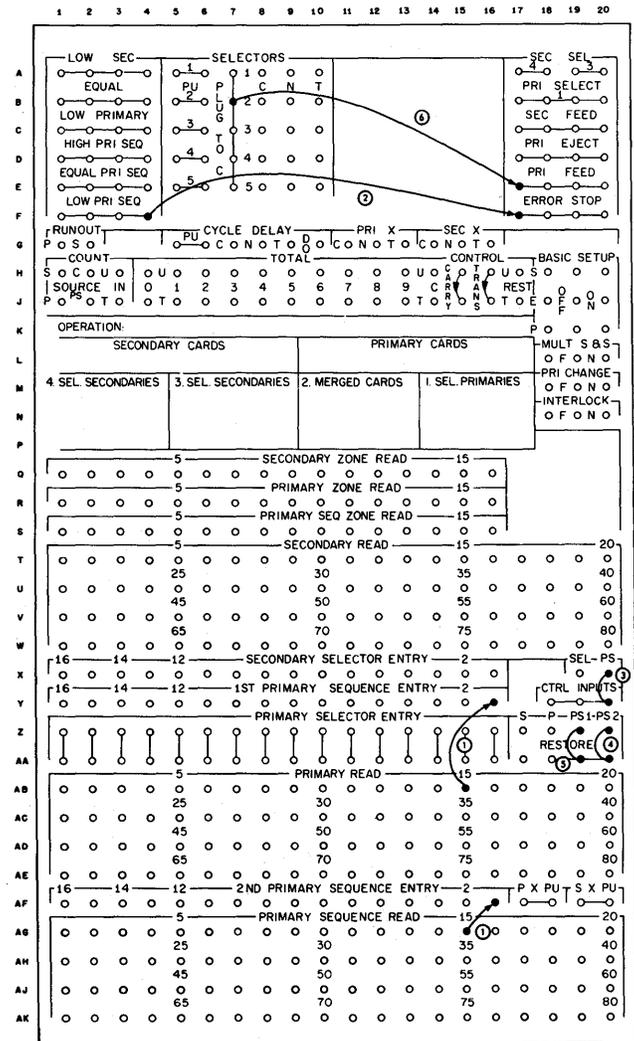


FIGURE 96. CONTROL PANEL, IBM 77 COLLATOR

In the upper sections, we show the wires that cause the machine to stop when a low primary sequence condition is recognized by the magnets (low sequence in the 85). This wire is indicated by the number 2.

If we want the machine to stop whenever duplicate cards pass through the machine, we can wire from the equal primary sequence exit hub to the error stop hub in the 77, and from the equal sequence hub to the error stop hub in the 85.

We have also added three jackplugs to the control panels. They are in the middle of the right-hand side in both the 77 and 85 panels.

The number 3 jackplug connects a hub labeled CONTROL INPUT with a hub labeled PS in the 77, and a hub labeled CTRL INP with a hub labeled SEQ in the 85.

In the reproducing punch, an impulse tests the position of the armature internally and automatically but in the collator we must wire this impulse to the armature. The jackplug numbered 3 accomplishes this. Because we are using the primary sequence unit (sequence unit in the 85), we jackplug any one of the common control input exit hubs to the PS (primary sequence) entry hub. In the 85, we wire from the control-input hub to the SEQ (Sequence) entry hub.

The control-panel hubs directly below the control-input section are for the purpose of restoring the magnets.

You notice that jackplug number 4 connects one of the common RESTORE exit hubs with the PS 2 entry hub on the 77. Jackplug number 5 connects another of the RESTORE hubs with the PS 1 entry hub. In the 85 Collator, these entry hubs are labeled PS and SEQ.

We are using both sides of the pairs of comparing magnets; therefore, we must restore both PS 1 and PS 2 (PS and SEQ in the 85) before entering new card readings.

The situation in the IBM 85-87 Collator is different, in that the comparing unit is also a storage unit. The actual comparing mechanism is mechanical and is not shown. However, it causes the comparing contacts to be transferred just as the previous illustrations show. So for all practical purposes, the comparison can be thought of as it was described for the reproducing punch. The information put into storage remains in storage until the unit restores or reads again. One half can be restored without the other, so that the reading from one card can be retained and compared to several others.

Another difference between the collators and most other machines (such as the reproducing punch) is that the collator feeds cards only under control of control-panel wiring. Other machines feed cards without in-

structions from the control panel. Wire number 6 performs this function. A constant impulse is available from the exit hubs labeled PLUG TO C. One of these common PLUG-TO-C hubs wired to the primary feed hub causes continuous feeding of cards in the primary feed, for both the 77 and the 85.

Comparing with Stored Information

Information from cards can be compared against information stored in the machine. Information is entered into storage from a card passing reading brushes. Once entered into storage, this information remains unaltered until the storage unit is restored (see *Storage*).

The storage exit is wired to one side, and the brushes are wired to the opposite side, of the comparing magnets. Storage is impulsed to read out during a card-read

cycle. Thus, information from one card can be compared against information in following cards.

IBM 557 Interpreter

This principle of comparing from storage is used for comparing in the IBM 557 Interpreter as a special feature. In this machine, an X or NX code, read at CONTROL X READ, identifies master cards. (CONTROL X READ reads X (11) punches only.)

As master cards are recognized at CONTROL X READ, the machine automatically instructs storage to read in new data from INTERPRET READ.

Storage exits in the 557 are permanently wired to one side of comparing. INTERPRET READING must be wired to the other side. Storage read-out is automatic as all detail cards pass INTERPRET READ brushes.

Thus, from one card reading station, information is read into storage from master cards, and is compared on all detail cards.

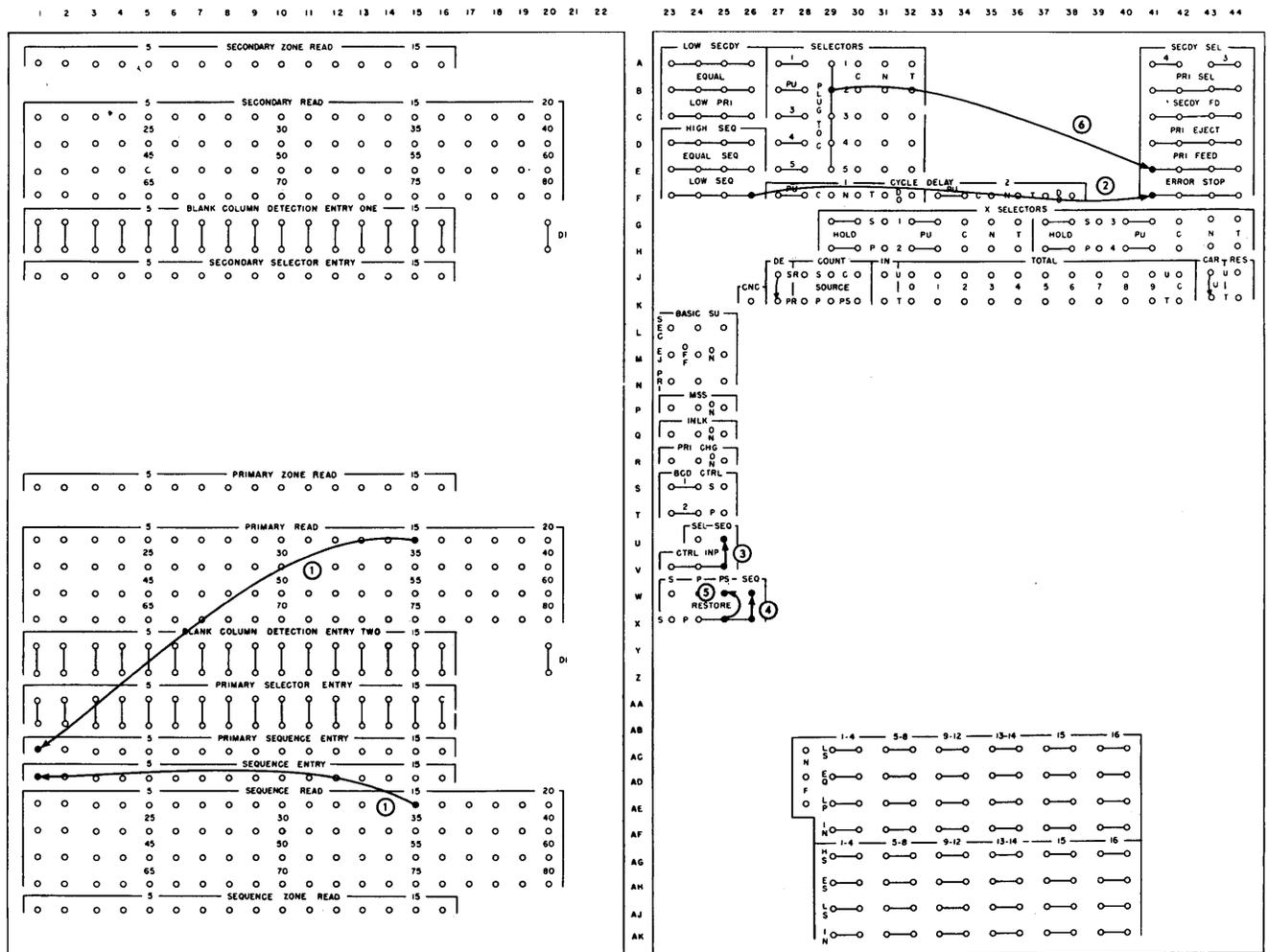


FIGURE 97. CONTROL PANEL, IBM 85 COLLATOR

Figure 98 illustrates the schematic of the comparing circuit. When master cards are recognized at the pre-sense station:

1. The magnet is impulsed.
2. The armature moves to the right.
3. Information read at the reading station moves to the right, following the path indicated, into the storage unit.

When detail cards are recognized at the pre-sense station:

1. The magnet is not impulsed.
2. The armature remains in the neutral position.
3. Information read at the reading station follows the path indicated into the comparing unit.
4. Stored information from the previous master card is also read into the comparing unit.

If control fields do not agree during the compare cycle, an impulse is available at the UNEQUAL hubs on the control panel.

detail card is followed by a detail card. This impulse is used to control machine functions, as is the impulse released by comparing exit when an unequal condition is recognized by the comparing magnets.

Comparing with Information in Counters

Another method of comparing is the use of counters as a substitute for storage. Information is read into a counter group, from a card, upon specific instructions. By wiring the counter exit and the reading brushes to opposite sides of the comparing magnets, and impulsing the counter group to read out on card cycles, comparing is achieved.

Wiring to Compare – The IBM Accounting Machines

Comparing magnets are used in IBM accounting machines to recognize the difference between groups of IBM cards.

To better understand this need for comparing, let's discuss a manual accounting operation, and then the same operation in an accounting machine.

ALTERNATE HUB

The 557 with comparing is equipped with a hub labeled ALTERNATE. The alternate hub emits an impulse whenever a master card is followed by a master card, or a

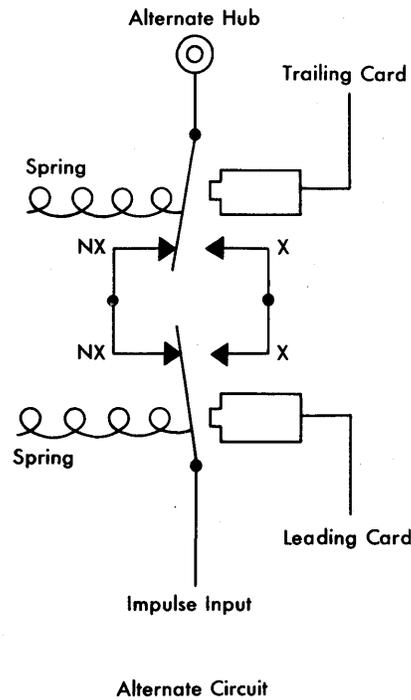
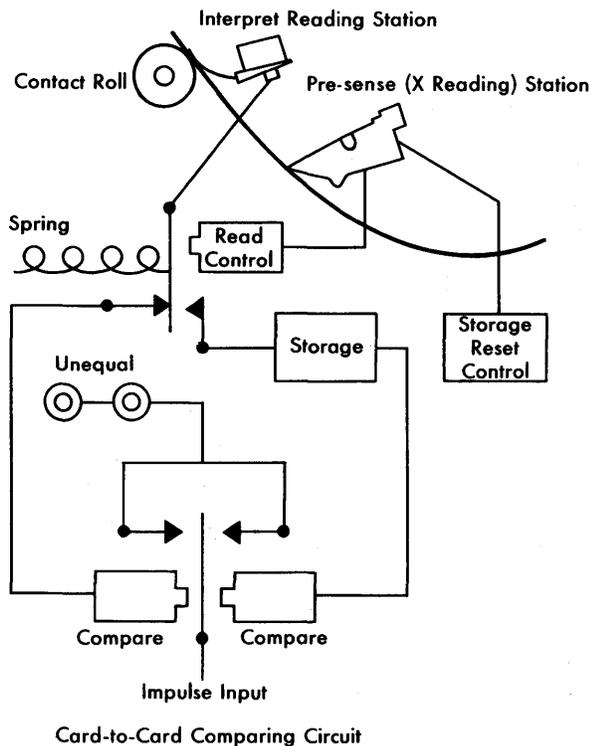


FIGURE 98. IBM 557 COMPARING CIRCUIT SCHEMATIC

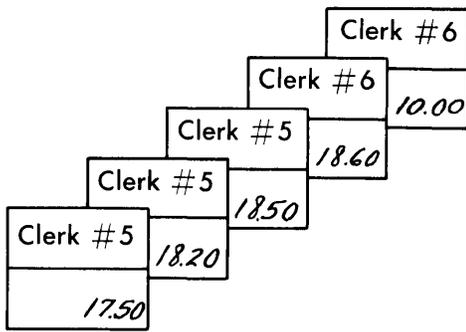


FIGURE 99. SALES CHECKS SORTED IN SALES-CLERK SEQUENCE

A Manual Method of Accounting

Assume you are the manager of a department store section. At the end of each day you are interested in the answers to these questions:

1. How many dollars worth of merchandise did each of the sales clerks in your section sell during the day?
2. What was the total amount of sales in your department during the day?

To obtain the answers you must collect all the sales checks written during the day.

The next step is to arrange, or sort them, so that all checks for one clerk are together; then arrange the groups of checks in sequence by sales clerk number (Figure 99).

Then you copy the information from the sales checks to a worksheet. At the end of the group of checks for each sales clerk, you stop, add the amounts, and write the total amount for that sales clerk (Figure 100).

By comparing the sales clerk number for one check with the sales clerk number on the following check, you recognize a change in the number as an indication that you have reached the last sales check for a particular sales clerk.

After you have copied all the amounts for each check and added these amounts to get sub-totals (minor totals) for each sales clerk, you add the entire list of amounts to arrive at a final total for a day's sales.

CLERK # 5	\$ 17.50				
CLERK # 5	18.20				
CLERK # 5	<u>18.50</u>				
	\$ 54.20		(SUB, OR MINOR TOTAL)		
CLERK # 6	18.60				
CLERK # 6	<u>10.00</u>				
	\$ 28.60		(SUB, OR MINOR TOTAL)		
	\$ 82.80		(FINAL TOTAL)		

FIGURE 100. SALES CHECKS LISTED AND TOTALED, MANUAL METHOD

SALES CLERK	AMOUNT
5	17 50
5	18 20
5	18 50
	<u>54 20*</u>
6	18 60
6	10 00
	<u>28 60*</u>
	82 80* *

FIGURE 101. SALES CHECKS LISTED AND TOTALED, MACHINE METHOD

The Machine Method of Accounting

We punch one IBM card for each item sold, check the punching to make sure it is accurate, and then arrange the cards (in the IBM Sorter) in sequence by sales clerk number.

Next we run the cards through an IBM accounting machine. The accounting machine can print, automatically, any or all of the punched information in each IBM card (see *Printing*).

Also, the accounting machine has the ability to accumulate numbers, because it is equipped with counters. Using its comparing magnets, the machine can (under the control of control-panel wiring) recognize a difference between a card for clerk number 5 and a card for clerk number 6. When this change in number is recognized, the result of the comparison can be used to tell the machine to stop feeding cards and print the totals accumulated in the counters (Figure 101).

The comparing magnets in the accounting machine recognize the difference between sales clerk number 5 and number 6 as an unequal condition. The impulse resulting from this unequal condition can be used to control the machine functions. This impulse is available from the comparing exit hub in the control panel.

IBM 402-403 Accounting Machine

The 402-3 has two sets of brushes that are used for comparing purposes. They are labeled SECOND READING and THIRD READING (Figure 102).

These brushes are connected to the comparing magnets by control-panel wiring. The comparing magnets are labeled COMPARING ENTRY on the control panel.

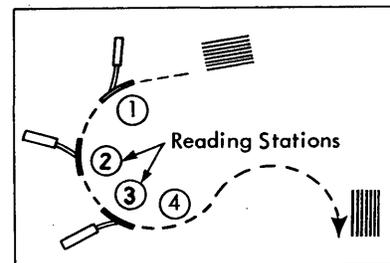


FIGURE 102. IBM 403 FEED SCHEMATIC

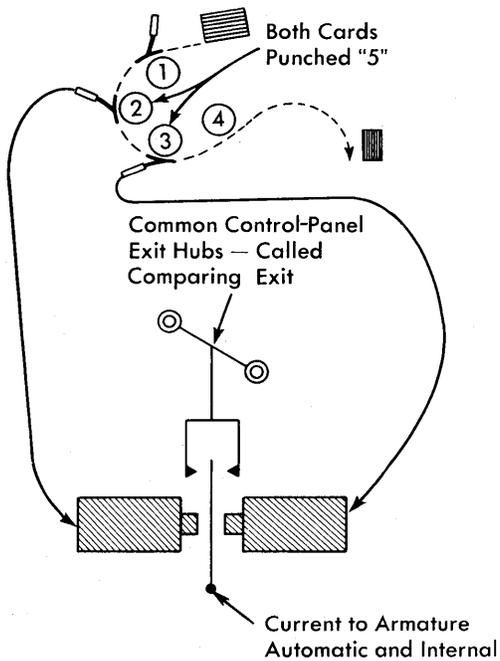


FIGURE 103. IBM 403 COMPARING, EQUAL CONDITION

In the first case, the card under the second-reading brushes and the card under the third-reading brushes are both punched with a 5. Both magnets are impulsed at the same time, and the two common exit hubs are inactive (Figure 103).

In the next instance, the left-hand magnet is impulsed, as the 6-punch is read first. The armature is transferred, and it makes contact with the relay point

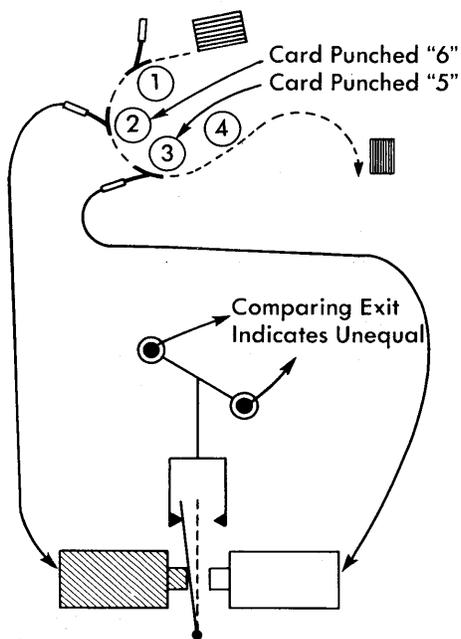


FIGURE 104. IBM 403 COMPARING, UNEQUAL CONDITION

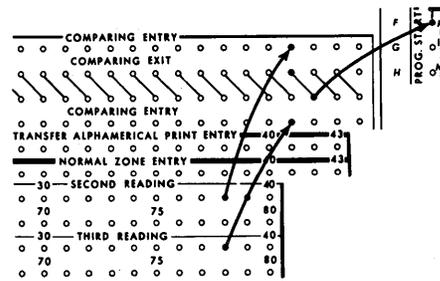


FIGURE 105. WIRING FOR COMPARING, IBM 403

connected to the common exit hubs on the control panel (Figure 104).

The same impulse would be available out of the comparing exit hubs if the right-hand magnet were impulsed.

An impulse is available out of the comparing exit hubs whenever an unequal condition exists in the magnets. One of the uses of the comparing-exit impulse is to control the machine by wiring either of the common exit hubs to an entry hub labeled MINOR PROGRAM START.

The control-panel wiring for comparing numerical information is shown in Figure 105.

This wiring causes the machine to stop feeding cards when an unequal condition is recognized, and the totals accumulated to print from the counters.

How information is read into the counters, and how the counters can be controlled to print their totals, are discussed later.

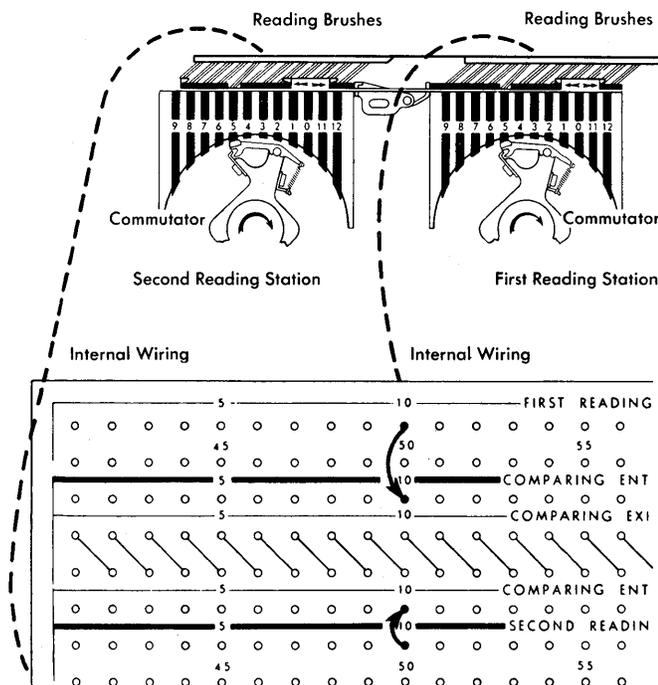


FIGURE 106. COMPARING SCHEMATIC, IBM 407-408-409

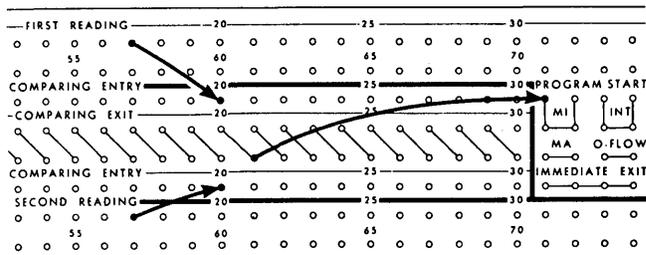


FIGURE 107. WIRING FOR COMPARING, IBM 407-408-409

IBM 407, 408, and 409 Accounting Machines

The IBM 407, 408, and 409 Accounting Machines have two sets of brushes that are used for comparing cards in the machine feed. They are labeled FIRST READING and SECOND READING, and are wired to opposite sides of COMPARING ENTRY on the control panel (Figure 106).

Comparing magnets in the 407-408-409 operate as they do in the 402-403, except that they are impulsed from the first and second reading stations (407-408-409 needs no third reading station). Consequently, control-panel wiring for comparing in the 407-408-409 is slightly different, even though the function of the unit is the same (Figure 107).

CARRIAGE COMPARING

An optional feature in the 408 and 409 makes it possible to compare cards passing through the machine with cards passing through the carriage.

Let's assume we are preparing a payroll to be printed on IBM card checks. These checks are passing through the carriage feed. They are printed from cur-

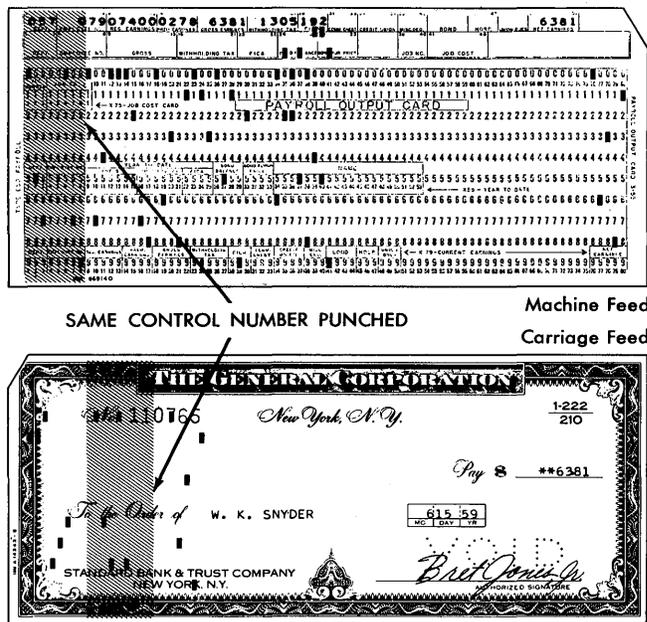


FIGURE 108. EARNINGS CARD AND CHECK

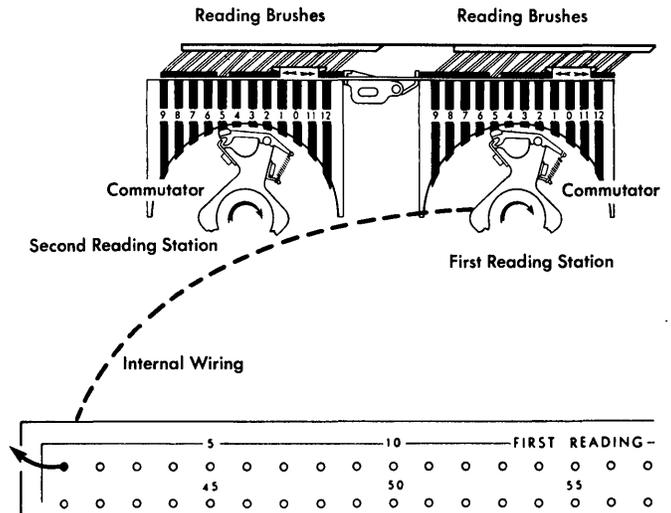


FIGURE 109. MACHINE CARD AT FIRST READING

rent earnings cards that are passing through the machine feed. In other words, for each man number there is a single earnings card and a single check (Figure 108).

The comparing occurs when the machine card is at the first reading station and the carriage card is at the aligner. The respective positions of the two cards are shown in Figures 109 and 110.

To allow the impulses from both feeds to reach the carriage comparing unit at the same time, the machine data is wired from FIRST READING, and the carriage data is wired from the carriage reading brushes. These exits from the carriage brushes are on the small control panels in the right side of the carriage and are labeled BRUSHES.

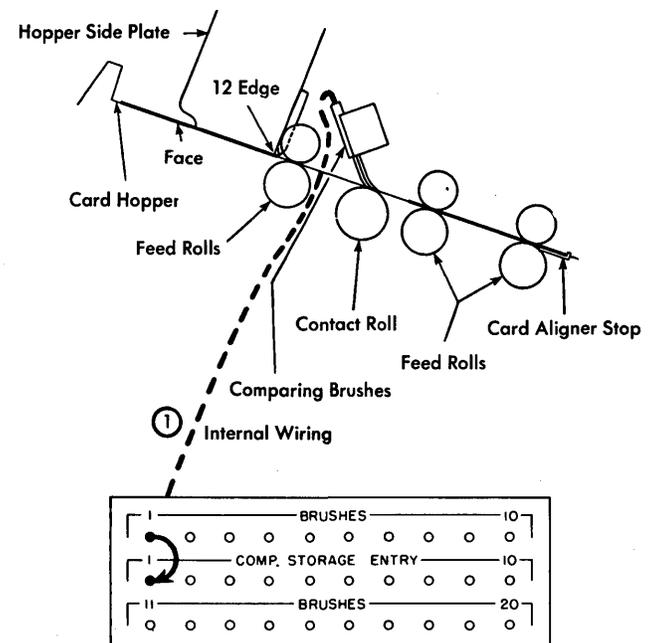
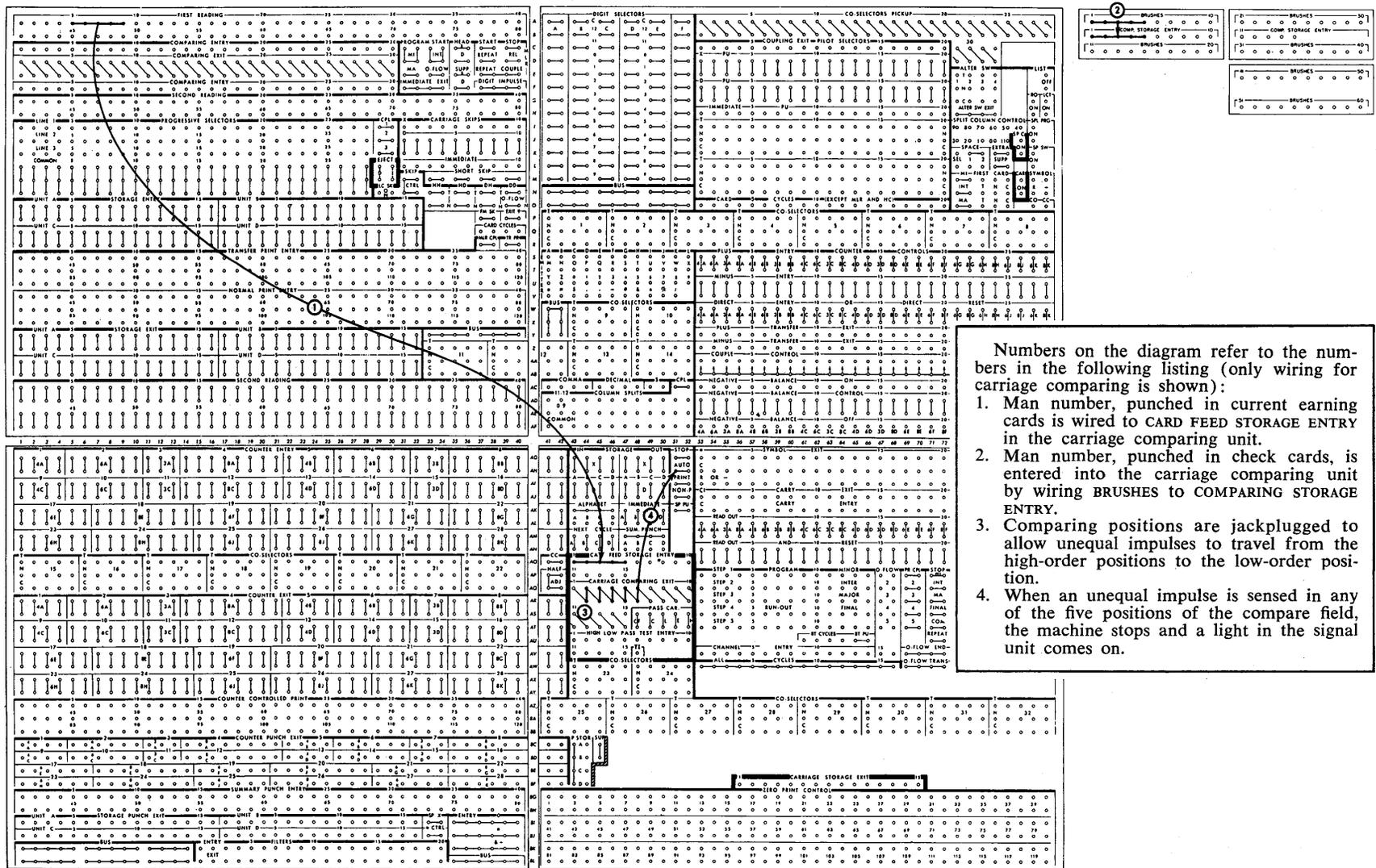


FIGURE 110. CARRIAGE CARD AT ALIGNER

FIGURE 111. WIRING DIAGRAM OF CARD-TO-CARD COMPARING, IBM 408-409



Numbers on the diagram refer to the numbers in the following listing (only wiring for carriage comparing is shown):

1. Man number, punched in current earning cards is wired to CARD FEED STORAGE ENTRY in the carriage comparing unit.
2. Man number, punched in check cards, is entered into the carriage comparing unit by wiring BRUSHES to COMPARING STORAGE ENTRY.
3. Comparing positions are jackplugged to allow unequal impulses to travel from the high-order positions to the low-order position.
4. When an unequal impulse is sensed in any of the five positions of the compare field, the machine stops and a light in the signal unit comes on.

(Although carriage cards feed 12-edge first, and machine cards feed 9-edge first, the machine automatically compensates for this and compares in a normal manner.)

The entry hubs for the machine data are called CARD FEED STORAGE ENTRY. The entry hubs for the carriage data (COMP STORAGE ENTRY) are located on the auxiliary control panel.

If the control fields in the two cards do not compare, an impulse is available out of CARRIAGE COMPARING EXIT.

The magnets and armatures for each position in the carriage comparing unit function like the positions in the machine comparing units in the 402-403, and 407-408-409.

One of the uses for the carriage comparing exit impulse is to prevent printing on unmatched cards and simultaneously stop the accounting machine. Figure 111 illustrates a comparing operation in the 408-409 to check agreement of control numbers punched in the current earning cards and checks (see Figure 108).

Review Questions

1. What do we mean by the word *comparing*?
2. Why do we compare in IBM machines? What are the two reasons given?
3. What do IBM machines need to accomplish comparing?
4. Describe an electromagnet. When is one magnetized?
5. What makes one *comparing position*?
6. What do we mean when we say an armature is *normal*?
7. What do we mean when we say an armature is *transferred*?
8. What exit and entry hubs on the control panel must be connected to compare the punching of one deck of IBM cards with the punching of another deck of IBM cards?
9. What do comparing magnets look like on schematic diagrams?
10. What is *sequence-checking*?
11. What is meant when we say a *low primary sequence* condition exists in the IBM 77?
12. What is meant when we say a *high primary sequence* condition exists in the IBM 77?
13. What is meant when we say an *equal primary sequence* condition exists in the IBM 77?
14. What are the conditions in questions 11 through 13 called in the 85 Collator?
15. How do you wire the IBM 403 Accounting Machine to compare groups of cards?
16. How is comparing done on the IBM 557 Interpreter?
17. Which reading brushes are used to compare cards in the IBM 407? To compare cards in the machine feed with cards in the carriage feed of the IBM 408?
18. What are the entry hubs for the comparing operation described in question 17 called?

Storage

You may find that some information, read by a machine in order to be printed, punched, or compared, is needed at some later time. You may also find that some information, not needed for any purpose at the time it is read, is needed later. As a result we have a situation in which we want the machine to store this information for later use.

The information to be stored must be sent to a storage unit where it will be accessible. Also, to be of use, the information must be sent at the time it is needed to the unit that is to use it.

We can say, then, that a storage unit must meet these three requirements:

1. accept information (read-in)
2. retain that information (store)
3. send out that information when needed (read-out).

The human brain is a familiar and complex type of storage unit. It is interesting to note how the brain fits the requirements of a storage unit. It can accept information in five different ways: sight, hearing, smell, taste, or touch. This information can be remembered (stored), and later this information can be sent out when it is needed. The sending out, or read-out, of this information can be done either by speaking or writing.

A machine storage unit is considerably simpler than the brain because there is only one way it can receive and send out information. It receives and sends out information in the form of electrical impulses. However, they both meet the requirements of a storage unit.

The IBM card (Figure 112), with which you are familiar, also meets these requirements. It accepts information in the form of punched holes, remembers that information, and later, when the card is read, it sends out that information. It is true that machines are needed to make the card fit these requirements, but a machine storage unit also requires a machine to operate it.

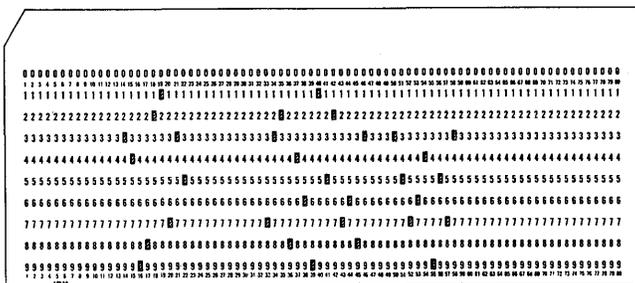


FIGURE 112. THE CARD IS USED FOR STORAGE

A storage unit does not function unless it is instructed to do so. It does not accept information unless you instruct it, by control-panel wiring, to read in. If it has been instructed to read in, it then accepts information and stores it. In some machines, read-out of storage is automatic; in others, the machine must be instructed (by wiring) to read out.

To illustrate the principles of storage and the details of the control-panel wiring needed to control the storage units, storage units on these machines are discussed: the IBM 602 Calculating Punch; 407, 408, and 409 Accounting Machines; 77 and 85 Collators, and the 557 Interpreter.

IBM 602 Calculating Punch

We have talked about the three requirements of a storage unit only in general terms up to this point. Now let's apply the general statements to the 602 type of storage unit and be a little more specific.

The storage unit in the 602 is a kind that accepts only digit information from 9 to 0. It also reads out the information in digit form. This means that if it stores a "5" it reads out a "5."

In the section on reading and timing, we said that a "5" is just an impulse that can be recognized as a "5" by the machine. The time in the cycle that the impulse is available is what makes it recognizable as a five. That is, the time in the cycle a 5-hole in the card would be read, or what we called *5-time*.

Now, let's repeat a statement that we made about 602 storage but think in terms of digits being timed impulses. This storage unit meets the general requirements of storage if, when it is instructed to read out, it sends

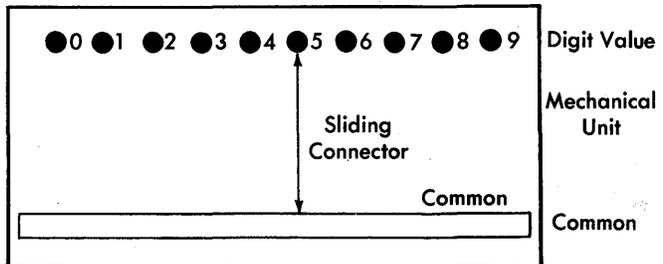


FIGURE 113. IBM 602-TYPE STORAGE POSITION

out a 5-timed impulse as a result of having read in a 5-timed impulse, or a 9-timed impulse for a 9-timed impulse, etc.

Figure 113 is a block representing a single position of the 602 type storage unit. The sliding connector, as shown, makes a connection between the 5-spot and the common. If you think of an emitter, you realize that this is similar to an emitter connection. The big difference is that the sliding connector on the storage unit does not move on every cycle.

The sliding connector is moved by impulsing the read-in hub of the unit. If only the read-in hub is impulsed, the sliding connector is moved, by mechanical means, to make a connection between the zero spot and common. This indicates that nothing (or zero) is stored

in this position. The movement of the sliding connector is always accomplished by mechanical means, but it is controlled electrically by two impulses. One is the impulse to the read-in hub, and the other is the impulse to tell the unit what should be stored. This can come from various sources, one of which is the reading brushes. The read impulse is wired to STORAGE ENTRY to tell the sliding connector where it should stop. If the sliding connector receives a 5-impulse, it stops on the 5-spot; if it receives a 9-impulse it stops on the 9-spot, etc. It is worth repeating, at this point, that if this unit is instructed to read in and there is no impulse to the entry hubs, the sliding connector stops on the zero spot.

Figure 114 shows the control-panel wiring necessary to cause a storage unit to accept and store information.

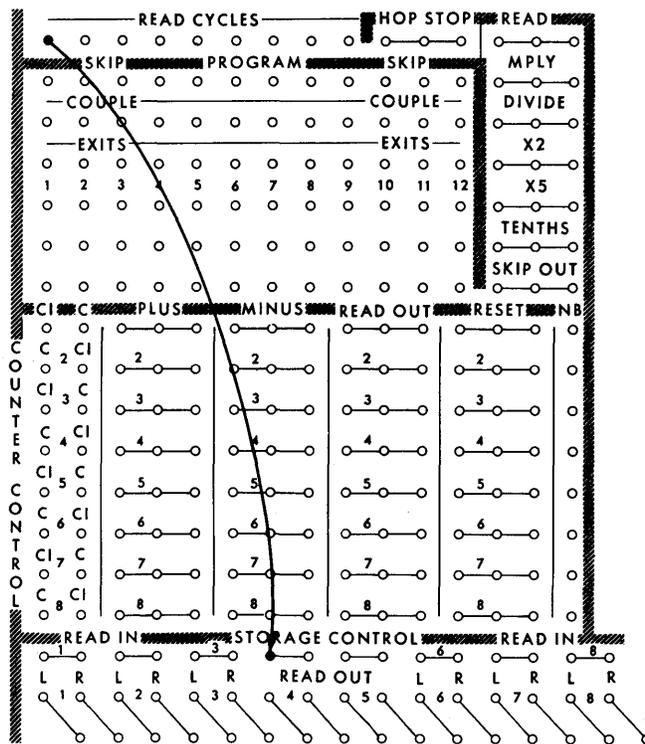
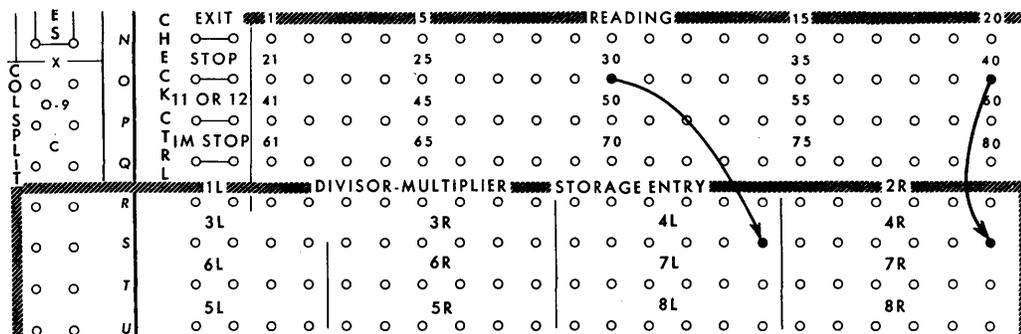


FIGURE 114. WIRING FOR STORAGE READ-IN, IBM 602

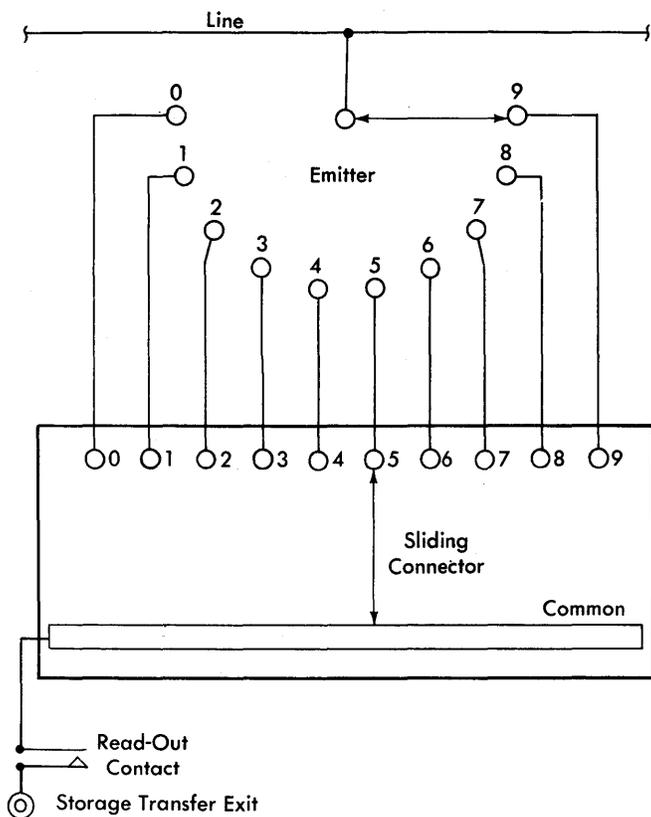


FIGURE 115. STORAGE READ-OUT SCHEMATIC

You can see that storage unit 4 is wired to read in from a READ-CYCLES hub. The READ-CYCLES hubs emit an impulse every card-read cycle, and as a result of this impulse, the storage unit is told to store information on every card-read cycle.

Each storage unit has twelve storage positions, each of which is like the one shown in Figure 113. Each unit, then, can store up to twelve digits of information, and is divided into two sides, a right and a left. All storage units, except storage unit 1, have six positions on each side; storage unit 1 has four on the left and eight positions on the right. In either case, an impulse to READ IN causes all twelve positions to be operative.

Figure 114 also shows that information in column 30 of the card is stored in the first position of 4L, which is actually the seventh position of storage unit 4. You can also see that information punched in column 40 is stored in the first position of 4R, which is also the first position of storage unit 4.

The sliding connector remains in any given position until the unit again receives an impulse to read in. This means that information can be read out as many times as desired without destroying the information in storage.

We have seen how a storage unit reads in and stores. This covers two of the three requirements of a storage unit. Let's take a look at the third requirement—read out.

Figure 115 explains this principle. The spots representing digit values are connected to emitter impulses

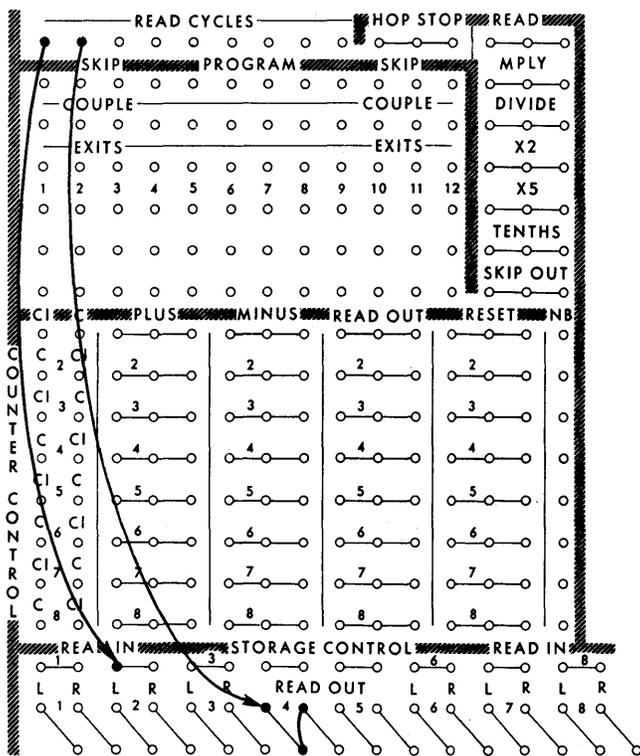
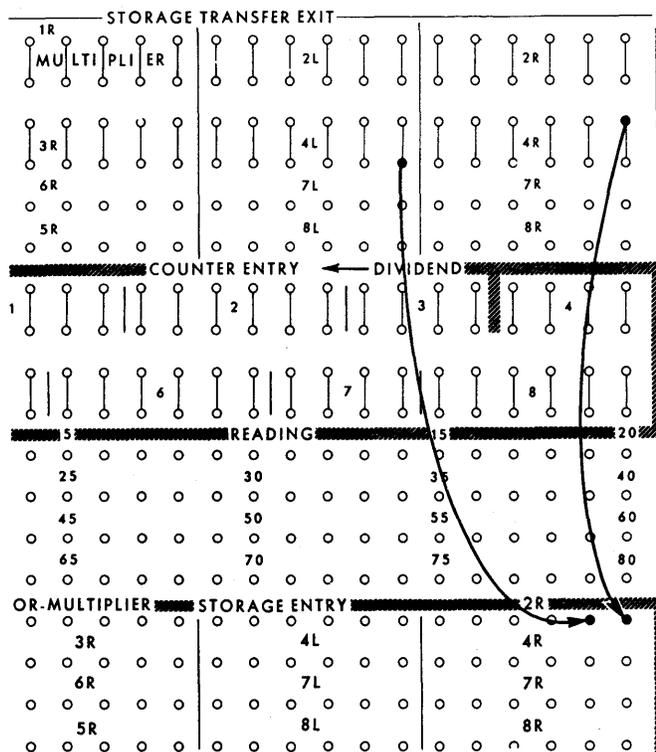


FIGURE 116. WIRING FOR STORAGE READ-IN AND READ-OUT, IBM 602



that have the same digit value. The emitter sends out digit impulses every cycle, and the impulse corresponding to the digit in the storage unit is available at the common. Therefore, the storage unit tries to read out every cycle but the open read-out contact prevents it from reaching the exit hub. You can see that if the read-out contact is closed, the impulse is available at the exit hub and is read out of storage.

The read-out contact is closed by impulsing the READ-OUT hubs. Remember that the units are divided into two parts. Each half of a unit has its own READ-OUT hubs. This makes it possible to read out of either side without the other. However, both sides *can* be wired to read out at the same time.

Figure 116 shows the control-panel wiring to cause storage unit 4 to read out, and storage unit 2 to accept and store the information from unit 4.

A practical application of a storage unit is not discussed at this time, because it would involve units you have not yet studied. Therefore, we are again using card cycles to impulse READ-OUT and READ-IN to illustrate the principles of reading out.

During a read cycle, the READ-OUT hubs for both the left and the right side of storage unit 4 are impulsed.

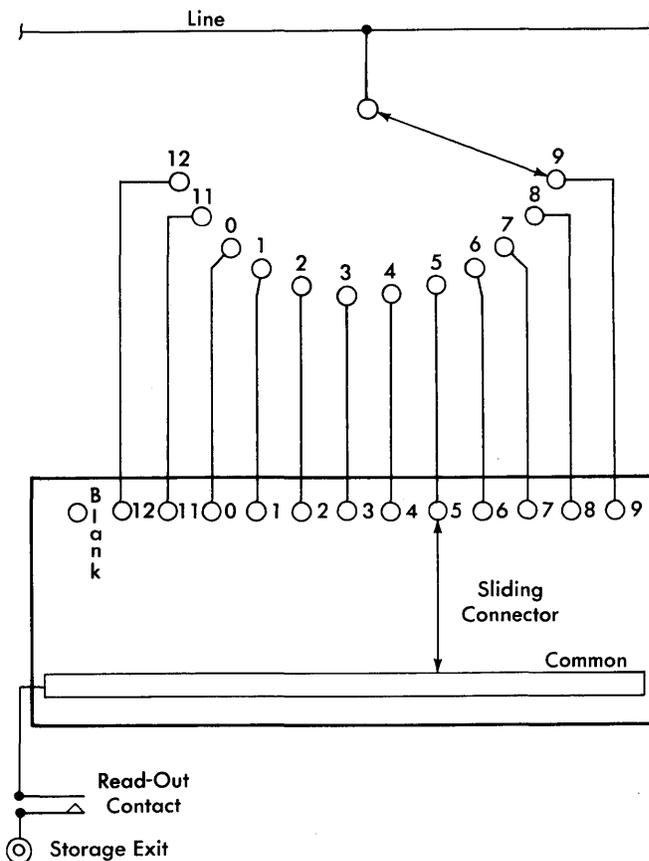


FIGURE 117. IBM 407 STORAGE UNIT SCHEMATIC

As a result, impulses are available from the first positions of 4L and 4R corresponding to the digits stored in these positions. By control-panel wiring, these impulses are directed to the ENTRY hubs of 2R. Storage unit 2 accepts and stores this information because the read-in hub for this unit is also impulsed from READ CYCLES.

IBM 407-408-409 Accounting Machines

The 407-408-409 storage units are of the same general type as the 602 units, and meet the same three requirements of storage: read-in, store, and read-out. One difference between the two is capacity. The 407 type of storage unit has 16 storage positions instead of 12. The 407, 408, and 409 have four of these units, which are lettered A, B, C, and D. The basic difference in the two units is the ability of the accounting machines to store zones. As it may be desirable to store alphabetic information in a 407, 408, or 409 storage unit, it has a position for 11- and 12-impulses, and a blank position, in addition to the digits 9 through 0 (Figure 117).

In this unit, as in the 602, when storage is instructed to read in, the sliding connector is operative. It stops in the position corresponding to the impulse (9-12) it receives. However, if the 407 type unit receives no impulse, the sliding connector moves to the blank position.

To read out of this unit, READ-OUT must be impulsed. The impulse corresponding to the digit stored is then available at the STORAGE-EXIT hubs for that position.

There is also an important difference between the accounting machine storage units and the 602 units where control is concerned. On the 602 type, when you impulsed READ-IN or READ-OUT, the unit always acted immediately and either read in or read out on the same cycle. On the 407, 408, and 409, this is not true. Figure 118 shows the control-panel hubs to control both

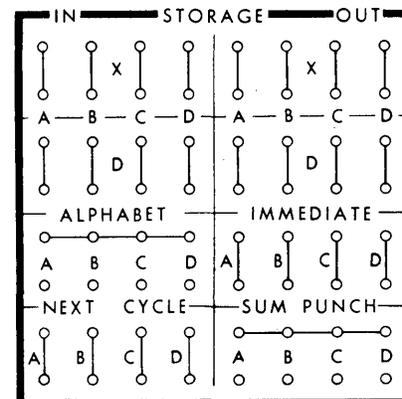


FIGURE 118. STORAGE HUBS, IBM 407-408 CONTROL PANEL

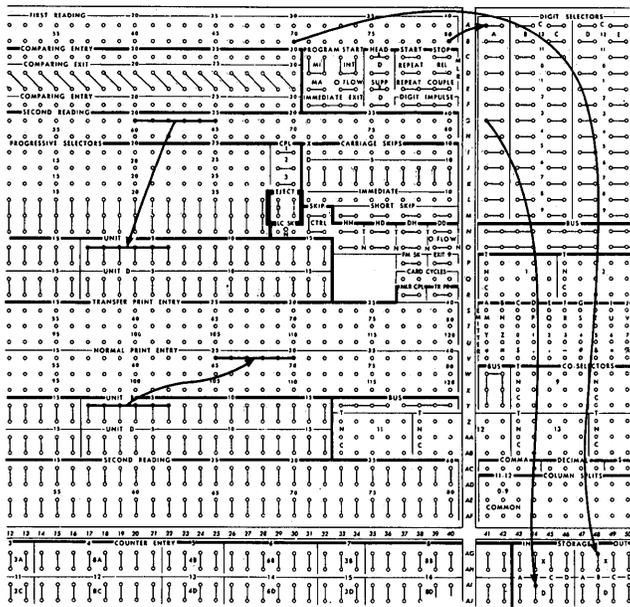


FIGURE 119. WIRING FOR STORAGE READ-IN, READ-OUT

read-in and read-out. There are several hubs to control each of the four units to read in, and several more to control them to read out. In each case the action is the same. The difference between them is in the type of impulses they accept to cause the unit to operate, and the time that the unit operates.

Let's first investigate the *storage in* hubs. Each of the four units has an x, d, and next cycle read-in hub. The x-hub accepts only 11- or 12-impulses, and the d-hub accepts all digit impulses (9-12) and cycle impulses such as card cycles, all-cycles, program exits. However, if either of these two hubs receives an acceptable impulse, the action is the same. In either case, the unit reads in on the next card-feed cycle. You realize that we can have print cycles without card-feed cycles. If a cycle of this type follows the cycle in which the x- or d-hub is impulsed, the unit will wait for a card-feed cycle before it reads in. This is true even though it may be several machine cycles later. However, if you impulse NEXT CYCLE, the unit reads in on the next cycle regardless of what type of cycle it is.

Now let's look at STORAGE OUT. Again we find an x and a d read-out hub, and also there is an IMMEDIATE read-out hub. The x accepts only 11- and 12-impulses while the d-hub accepts all digits, 11-, 12- and cycle-impulses. The read-out action is exactly the same, regardless of which hub receives the impulse. The read-out occurs on the next *card-feed* cycle in either case. Again, if a cycle other than a card-feed cycle follows the cycle in which they were impulsed, the read-out waits for a card-feed cycle.

There is no next-cycle read-out hub. If you want to read out during a specific cycle, or type of cycle, wire a corresponding cycle impulse to IMMEDIATE OUT. The

unit reads out immediately. This, then, is exactly the same as the READ-OUT hubs on the 602. The hubs selected to control the read-in and read-out are chosen to meet the requirements of the specific problem.

Let's now take a look at the control-panel wiring for a specific situation. Assume that we want to store information from a card only if it has a 3 punched in column 80. Also, we want the information to print when information prints from an X-70 card.

The solution for this is shown in Figure 119. Notice that column 80 is wired to the D-read-in hub through a digit selector to select a 3 only. It is also significant that column 80 is wired from the FIRST READING brushes. Because the unit reads in on the next card-feed cycle, the card passes second reading when the read-in occurs. This is the reason for wiring SECOND READING to STORAGE ENTRY. The delay in operation is also the reason the impulse to READ-OUT is wired from FIRST READING instead of SECOND READING. Note that column 70 did not go through the digit selector, because the X-hub accepts only 11- or 12-impulses.

There is a set of hubs in both the read-in and read-out sections that we have not yet discussed. These are the *alphabet* hubs in the read-in section and the *summary punch* hubs in the read-out section. The summary-punch hubs are not discussed in detail in this book, but in general, these hubs are jackplugged to cause a storage unit to read out during a summary-punch operation.

The alphabet hubs in the read-in section are used to permit storing alphabetic information. We have stated that the 11, 12, and blank positions are provided on this unit to store alphabetic information. Actually, a single position can store only one digit or zone. We know an alphabetic character code consists of a digit and a zone. This requires two positions of storage, one for the digit and one for the zone. To make wiring easier, the alphabet hubs are placed on the machine to separate automatically the digits from the zones.

This zone requirement places a new limitation on the storage-unit capacity. Instead of 16 positions, the storage unit has only eight positions that can be wired when the alphabet hubs are jackplugged. The eight that can be wired are the first eight.

The control-panel wiring for an eight-position alphabetic field is shown in Figure 120. The digit information (9-1) from columns 25-32 is stored in positions 1-8 of storage unit B. However, because we have jackplugged the alphabet hubs for storage unit B, the impulses are internally switched, between 1- and 0-time, to the last eight positions. As a result, the zones 0-12 (in columns 25-32) will be placed in positions 9-16 of storage unit B. The positions are combined so that 1 and 9 work together to store a letter; and 2 and 10, 3 and 11 through 8 and 16 provide an eight-position alphabetic storage unit.

Because alphabet control is jackplugged, the first and ninth positions are recombined on the read-out to cause the letter to be printed by printwheel 25. The other positions are also recombined automatically so that it is necessary only to wire from STORAGE EXIT to PRINT ENTRY. However, when the machine is wired for alphabetic storage, none of the entries or exits from 9 to 16 are operative.

Carriage Storage — IBM 408-409 Accounting Machines

In addition to the accounting-machine storage that we have discussed, the 408-409 can store numerical data from cards passing through the carriage feed.

Data is read from carriage-feed cards as they move to the aligner (see Figures 109 and 110) when the corresponding card in the accounting-machine feed is at first reading.

Only numerical data can be stored in the 408-409 carriage storage unit. The maximum number of carriage storage positions available is fifteen.

When the carriage storage special feature is added, the machine can:

1. interpret numerical fields punched in carriage cards
2. read carriage-card data into accounting-machine counters
3. compare prepunched carriage-card totals with computed totals from machine cards.

The entry hubs for the carriage storage units are located on a small control panel on the carriage. They are labeled COMP STORAGE ENTRY and are wired from the carriage brushes (BRUSHES), which are exit hubs on the same carriage control panel. These hubs and brushes are also used to read and record data into the carriage comparing unit. To reach the 408-409 carriage storage unit, information must first pass through the carriage comparing unit. For each position of storage installed, a comparing position must also be installed (see *Comparing*).

As the carriage card moves from the aligner station to the platen (first to second read for the corresponding card in the accounting machine), the information read from the carriage comparing brushes is transferred into the carriage storage unit, and another reading is set up in the comparing unit (see Figure 110).

The numerical data read from the carriage card is available from CARRIAGE STORAGE EXIT when the carriage card is at the platen and the corresponding machine card is at second reading.

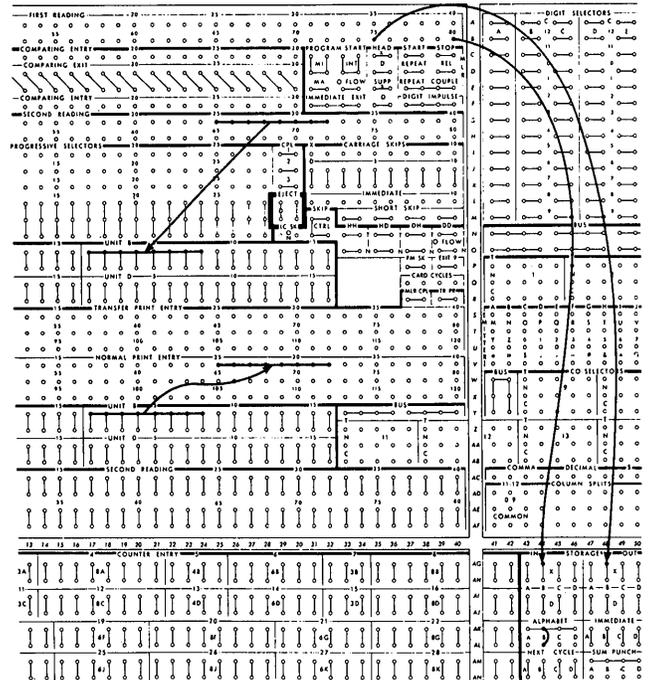


FIGURE 120. STORING ALPHABETIC DATA, IBM 407

Because both units have the same entry hubs, separate COMP STORAGE ENTRY hubs must be used for fields entering the comparing unit and fields entering the storage unit if one set of data is to be used for comparing and another set is to be stored for interpreting. Remember that while the comparing and storage units have a single set of entry hubs, each unit has a separate set of exit hubs. If compared fields do not match, an *unequal impulse* is available at CARRIAGE COMPARING EXIT and numerical data is available from the storage unit at CARRIAGE STORAGE EXIT (control-panel hubs are illustrated in Figure 111).

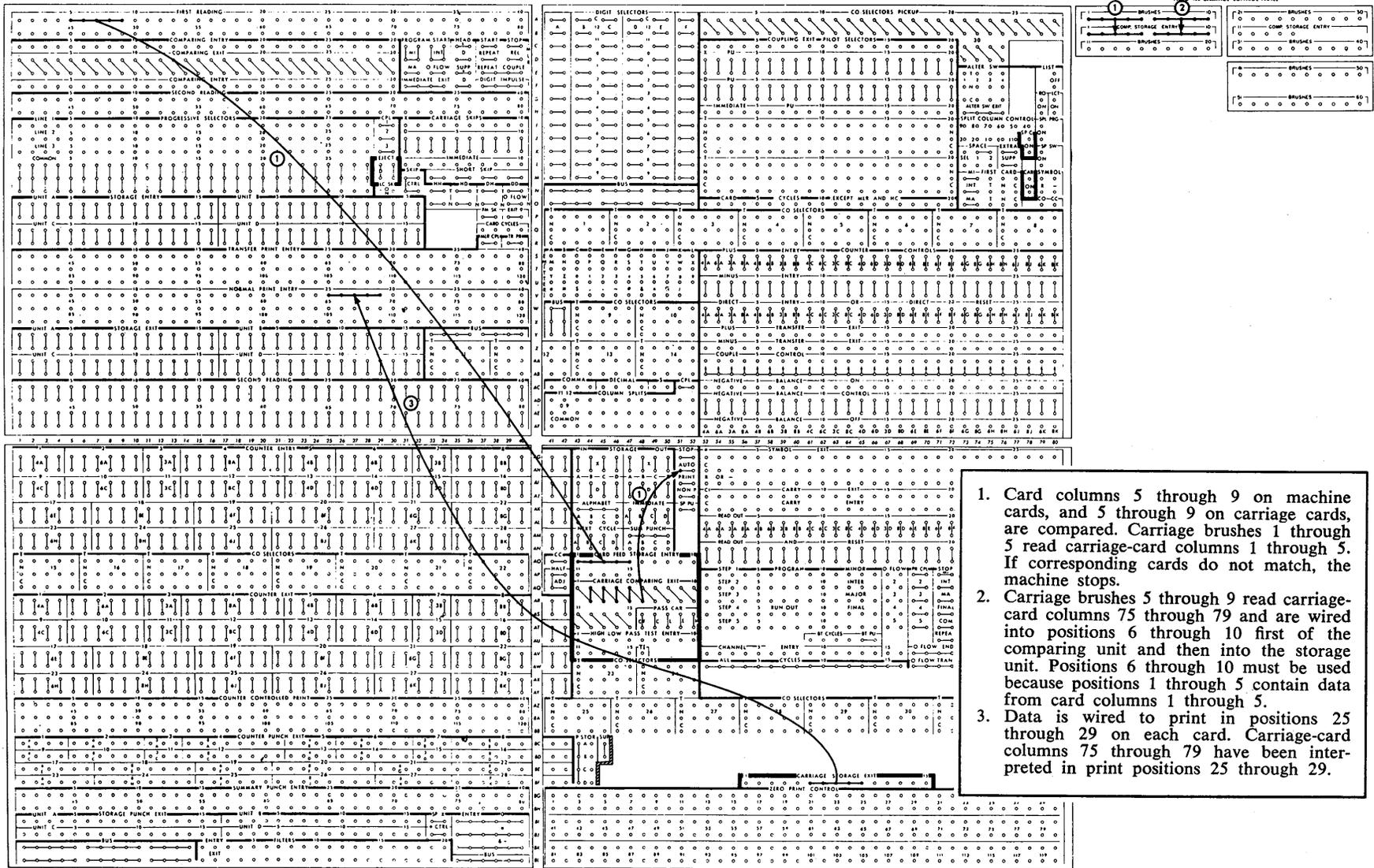
Unlike the 407-408-409 machine storage units, the 408-409 carriage storage unit has no individual control. Read-in and read-out of the storage unit is automatic and occurs during each carriage feed cycle.

If the CARRIAGE STORAGE EXIT hubs are wired, the data is read out of the storage unit on each carriage feed cycle; they can be wired to several entry hubs — NORMAL PRINT ENTRY to interpret carriage cards, for instance. Before reaching the entry hubs, the data from carriage storage can be wired through a device that allows them to reach the entry hubs under certain conditions and not to reach the entry hubs under other conditions (see *Selection*).

Remember, the exits from the carriage storage positions cannot be internally controlled. They emit on each carriage-feed cycle if:

1. data is read in on the previous carriage-card-feed cycle
2. the exit position is wired on the control panel.

FIGURE 121. INTERPRETING CARRIAGE CARDS



Control-panel wiring for two operations: (1) comparing carriage cards and machine cards and (2) interpreting carriage cards (using carriage storage) is shown in Figure 121.

IBM 77 and 85 Collators

Collators have an unusual type of storage unit that is actually a combination comparing and storage unit. The comparing principles are described in the section on *comparing*.

The storage portion of the unit is the same as the 602 and 407-408-409 machine units for read-in and storage. However, collator storage does not read out the information that it stores.

The 77-85 storage unit has the ability to store only the digits (0-9) as does the 602 storage unit. As in the 407 and 602, this unit must be instructed to accept information before the unit becomes operative; the name of the controlling hub on the control panel is RESTORING MAGNETS.

Look at the control panels shown in Figures 122 and 123. The names of the hubs for the two storage units are different from the names of other storage units because this unit is used as a comparing unit. The RE-

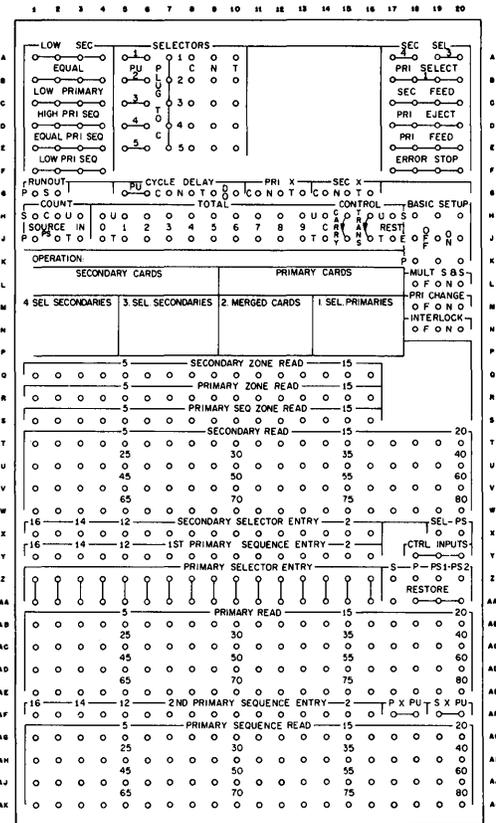


FIGURE 122. IBM 77 CONTROL PANEL

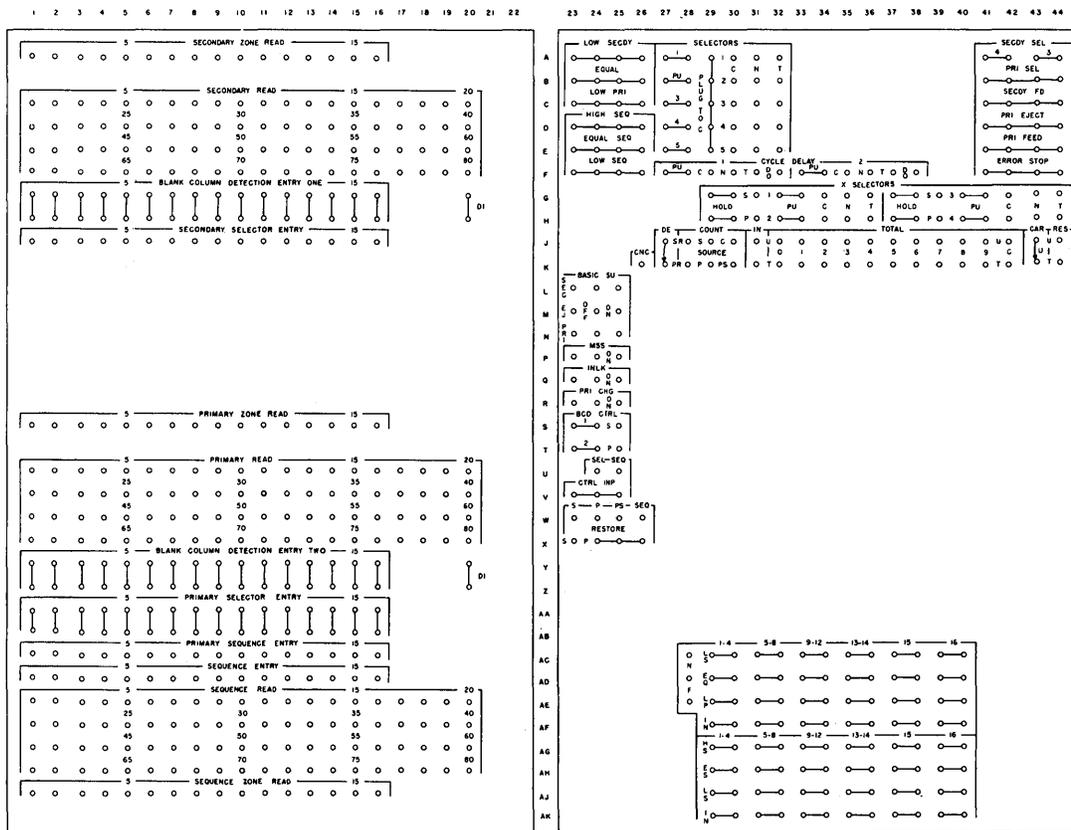


FIGURE 123. IBM 85 CONTROL PANEL

STORE hubs are the same as *read-in* hubs, and the SEQUENCE ENTRY and SELECTOR ENTRY hubs are the same as *storage entry* hubs. There are no *storage exit* hubs.

Sixteen positions of information can be compared in either the SEQUENCE or the SELECTOR unit. Because each position has the ability to store the two digits to be compared, each unit has 32 positions of storage, which is shown on the control panel as 32 entry hubs.

As stated in the *Comparing* section, the actual comparison is made mechanically, but an electrical test of the unit gives the result of the comparison as an impulse emitted from one of three hubs; these hubs are labeled HIGH, EQUAL, and LOW.

Even though this unit is a storage unit and is treated as such in this section, the control panel is not shown

here. The control-panel wiring is described in the section on comparing, where it logically belongs.

IBM 557 Interpreter

The IBM 557 Interpreter storage unit operates with the card-to-card comparing special device. This device is discussed functionally in the section on *Comparing*. The storage unit in the 557 is similar in operation to the storage unit in the 602.

Storage in the 557 meets the three requirements (read-in, store, and read-out) that are components of a true storage unit.



FIGURE 124. IBM 557 CONTROL PANEL WIRED FOR CARD-TO-CARD COMPARING

However, the three functions just mentioned are possible only under limited conditions.

Read-in occurs only when a master card is at the reading station (see Figure 98). Read-out is automatic, always into the comparing unit, and occurs only when a detail card is at the reading station.

The read-out is repeated, each time a detail card passes the reading station, until a new master card is recognized at the *pre-sense station*. The pre-sense station is just ahead of the reading station, and reads 11

punches only. Cards are identified here by an X-punch in a predetermined column.

Figure 124 shows the 557 control-panel diagram. A *control X-Read device* reads the prepunched X that identifies a master or detail card. Comparing is controlled, with this unit, to accept data. The storage unit then accepts data from master cards. This data is read from the master card into the storage unit of the card-to-card comparing device by wiring from INTERPRET READING to COMPARE ENTRY.

Review Questions

1. What are the three requirements of a storage unit?
2. The 602 storage unit will accept what type of information?
3. Information in the 602 storage unit remains in storage until when?
4. When a 602 storage unit is instructed to read in, will all positions of the unit accept information?
5. Do all positions of the 602 storage unit necessarily operate as a result of an instruction to read out?
6. What is the basic difference between the 602 and the 407 types of storage?
7. In the 407 type storage unit, what kind of impulses will X and D READ-IN and READ-OUT accept, and when is the unit operative?
8. Can a digit and a zone for an alphabetic character be stored in a single position of the 407 storage?
9. The 77 and 85 storage units serve what other function besides storing?
10. What, on the 77 and 85 control panels, corresponds to the read-in hubs on the 407 and 602?
11. What type of information can the IBM 77 Collator storage unit store?
12. What will be stored, in each of the three types of storage units, if the entry hubs receive no impulse during a read-in cycle?
13. What kind of information can be stored in the 408 carriage storage unit?
14. Name three things that can be done when carriage storage is installed in the 408.
15. What are entry hubs to the 408 carriage storage called?
16. With what device does the storage unit on the 557 Interpreter operate?

Column Splits

In the report in Figure 101, we compared sales-clerk numbers to determine when the accounting machine had reached the end of a particular group of cards.

Some of the cards run through the accounting machine to prepare this report might have had an X punched over the sales-clerk field. Quite often it is

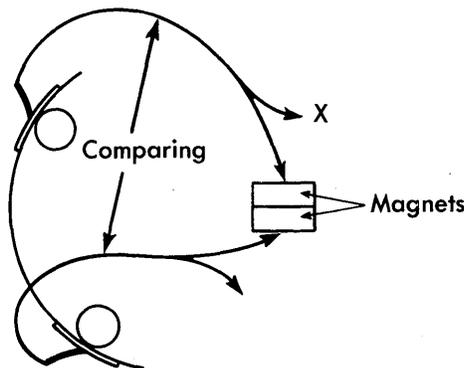
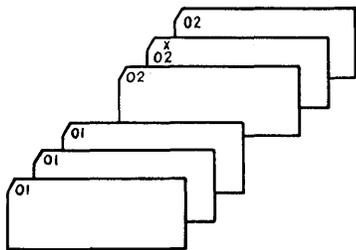


FIGURE 125. COMPARING CARD AGAINST NO-X CARD

necessary to tell the machine that a different type of card is approaching the reading brushes, and an X-punch is one way the machine can be signalled. An X-punch over a field on which we are comparing gives us an unequal condition in the comparing magnets, for not all cards have an X. By the use of a column split we can eliminate these occasional X-punches from a field on which we wish to compare (Figure 125).

It is recommended that an identifying X-punch *not* be placed over a field we are comparing. However, in this case it is done to illustrate one possible need for a column split.

Suppose we want to reproduce the punches in an original deck of IBM cards into a new deck of IBM cards. The original, or master deck, has an X punched in column 80. Also, part of the amount field is punched in column 80. The X in column 80 is not needed in the new deck. We can prevent the X from being reproduced when we reproduce the digit in column 80 by the use of a column split (Figure 126).

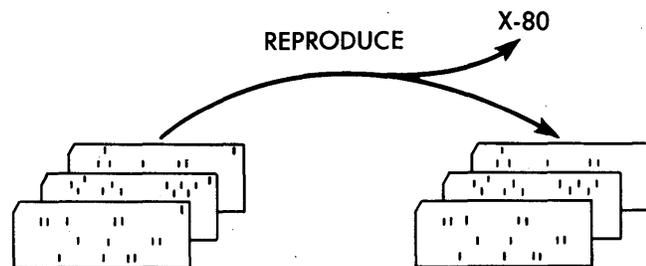


FIGURE 126. REPRODUCING — ELIMINATING X IN COLUMN 80

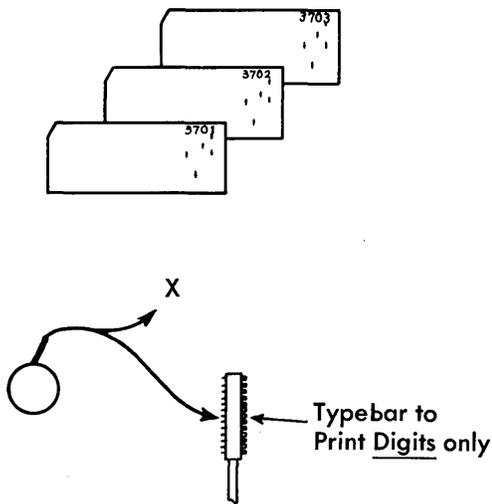


FIGURE 127. X-ELIMINATION IN PRINTING

If we interpret a deck of IBM cards that has an X punched over one of the amount fields we wish to print, we will print alphabetic information instead of the desired numerical information. This happens because an X and a digit form a letter. We can prevent the X-punch from reaching the typebars, and print just the digit, by the use of a column split (Figure 127).

In the chapter on *Emitting* we discussed the need for a column split when punching alphabetic information, such as the word DART. Without the use of a column split, back circuits would punch a 12, 1, and 4 in both columns of the card in which we want to punch a D and an A.

Splitting the Column

Splitting a column means separating the digit punches (0-9) from the 11- and 12-punches. When a brush in an IBM machine reads a card column, it reads *all* the holes punched in that column. If a column is punched 12 through 9, all twelve punches are available out of the reading-brush exit hub. We already know that it is often necessary to divide the punches of a column into two separate groups, 0-9, and 11 and 12 (Figure 128).

Let's see what a column split looks like, and how it operates. The column split is nothing more than a magnet. The magnet shown is like the comparing magnet we've already discussed.

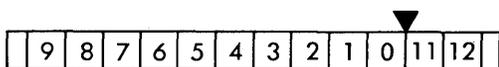


FIGURE 128. COLUMN SPLIT BETWEEN 0 AND 11

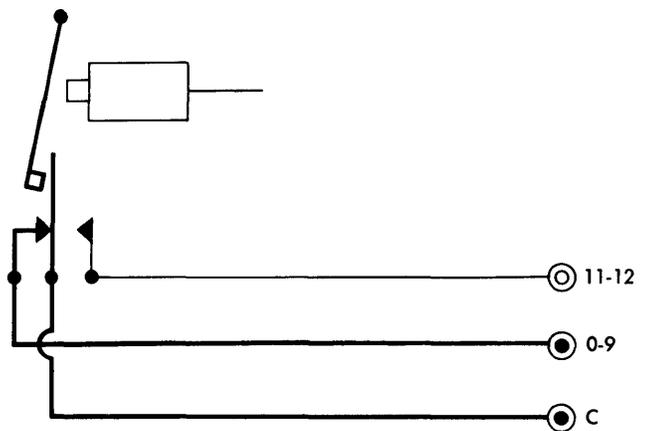


FIGURE 129. COLUMN SPLIT SCHEMATIC

There are a magnet, an armature, and control-panel hubs (Figure 129). Notice that the hub leading to the armature is shown between the 0-9 and 11-12 hubs, and labeled COMMON because it is at all times in contact with either the 0-9, or the 11 and 12 hub.

Remember, comparing magnets are impulsed by punches in the cards. In the case of a column split, the magnet is internally and automatically impulsed each time a card passes the brushes, between the 0- and 11-position. The magnet remains energized during 11- and 12-time of each card-feed cycle, and is de-energized, or drops out, just after 12-time.

When the magnet is *not* impulsed (during 0-9 time) the armature remains in its normal position. There is an internal connection between COMMON and the 0-9 hub because the armature is in contact with the contact point leading to the 0-9 hub. Any 0-9 impulse put into COMMON is available out of the 0-9 hub (Figure 130).

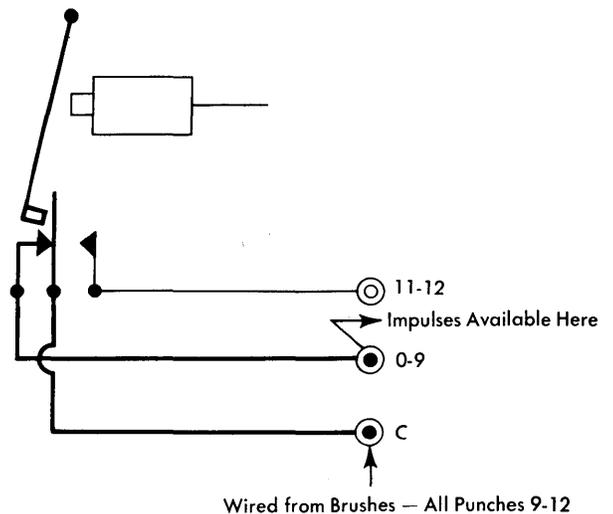


FIGURE 130. COLUMN SPLIT AT 0-9 TIME

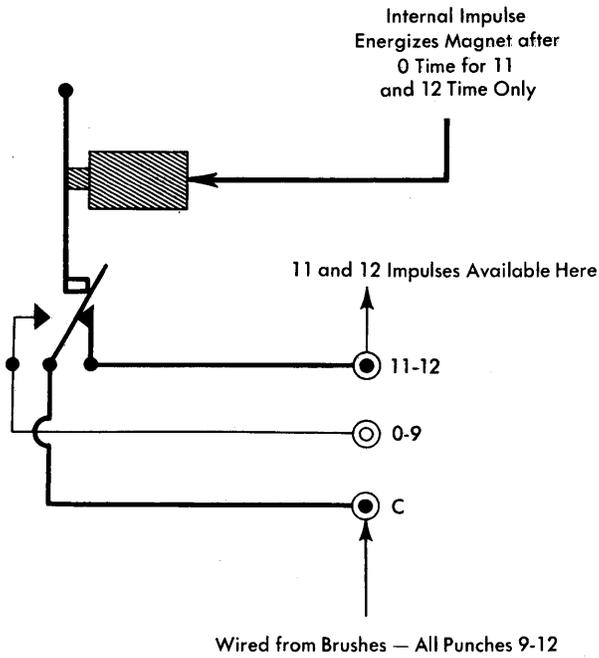


FIGURE 131. COLUMN SPLIT AT 11-12 TIME

When the magnet is impulsed (during 11-12 time) the armature is transferred, and makes contact with the path leading to the 11-12 hub. An 11- or 12-impulse put into COMMON is available out of the 11-12 hub (Figure 131).

After the 11- and 12-positions of the card pass the

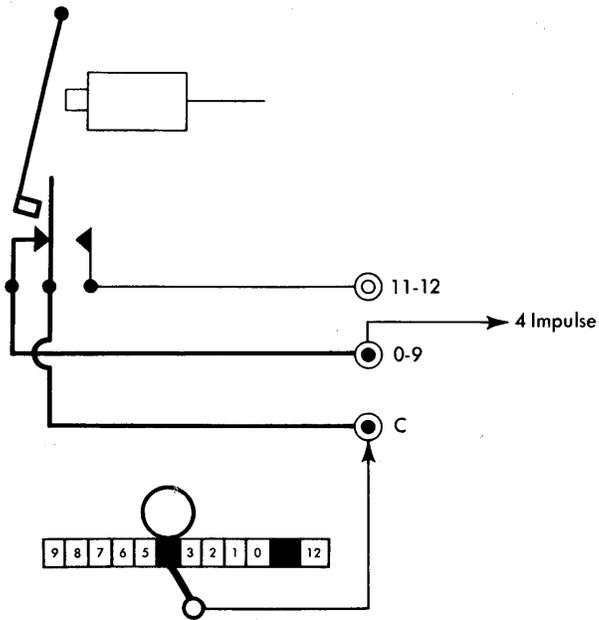


FIGURE 132. IMPULSE 4 AVAILABLE FROM 0-9 SIDE OF COLUMN SPLIT

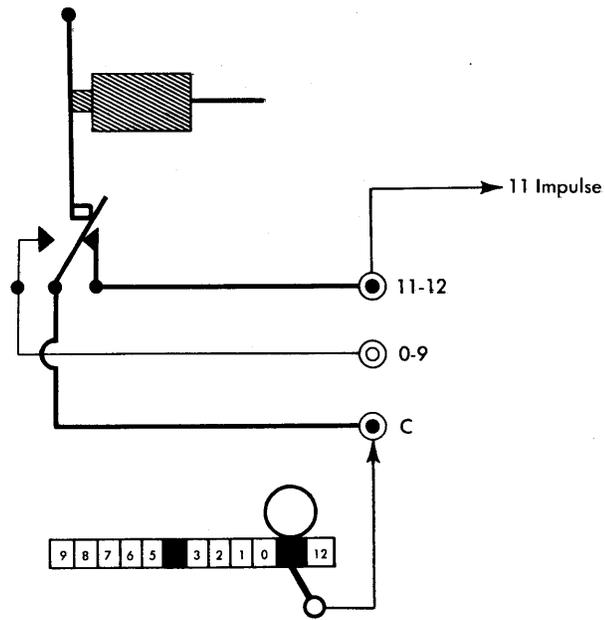


FIGURE 133. IMPULSE 11 AVAILABLE FROM 11-12 SIDE OF COLUMN SPLIT

reading brushes, the impulse to the magnet is stopped, and the armature returns to its normal position.

In Figure 132 the card, which has been fed into the machine 9-edge first, has the 4-position under the reading brush. At this time, the armature is still in its normal position, and the connection is between COMMON and 0-9.

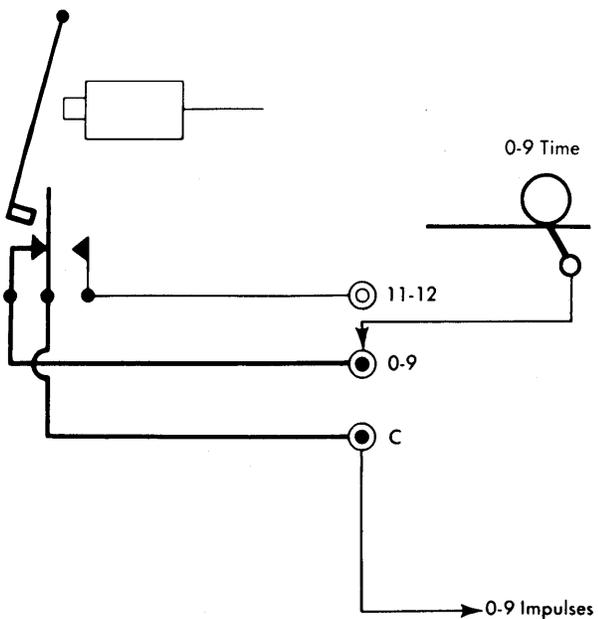


FIGURE 134. IMPULSE 4 AVAILABLE AT COMMON

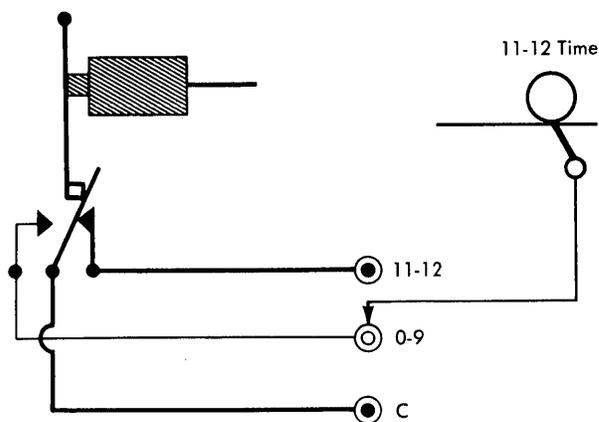


FIGURE 135. AN IMPULSE AT 11-12 TIME HAS NO EXIT WHEN WIRED TO THE 0-9 HUB

If we wire a card column to COMMON, any digit punched in that card column is available out of the 0-9 hub. The path for the impulses is shown by the heavy black line connecting COMMON and 0-9.

In Figure 133, the 11-position of the card is under the reading brush. As the armature transfers automatically between 0- and 11-time, the connection is shown between COMMON and 11-12. If a card is wired to COMMON, any 11- or 12-punch is available out of the 11-12-hub.

We have shown the impulse coming from a reading brush to the common hub of a relay, and out of either 0-9 (NORMAL) or out of 11-12 (TRANSFERRED). Actually, we can wire a card column at the 0-9 hub and have an impulse come out of COMMON. In other words, COMMON can be either an EXIT or ENTRY hub. The path we set up for impulses to travel can be considered a two-way street.

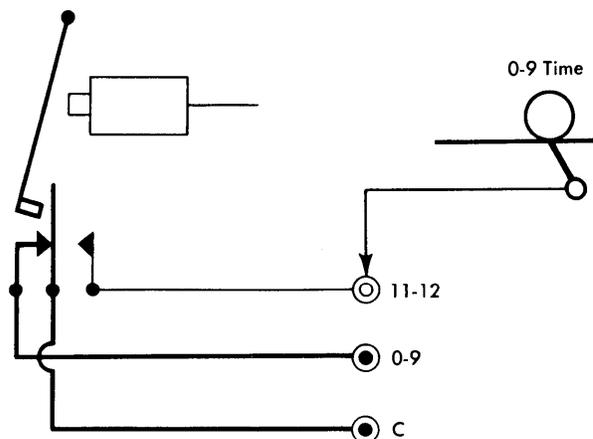


FIGURE 136. AN 0-9 IMPULSE WIRED TO 11-12 HUB HAS NO EXIT FROM COLUMN SPLIT

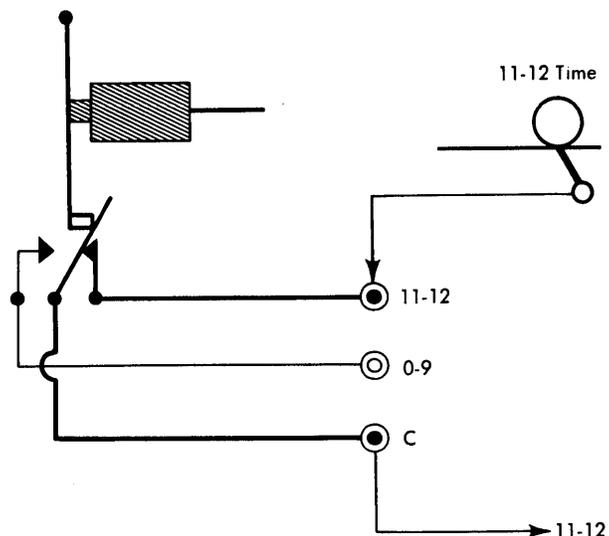


FIGURE 137. IMPULSES 11-12 ARE AVAILABLE FROM COMMON AT 11-12 TIME ONLY

In the examples previously shown, we wired the card column to the common side of the relay, took the 11- and 12-punches from the 11-12 hub, and the 0-9 punches from the 0-9 hub. Now let's reverse this wiring. We have wired the card column to the 0-9 hub (Figure 134). Assume that the card column has been completely punched.

Only the 0-9 impulses will be available out of COMMON. At 11- and 12-time the armature is connected to the 11-12 hub. Any impulses wired to the 0-9 hub have no path to COMMON (Figure 135).

In Figure 136 we have wired a fully punched card column to the 11-12 hub of the column-split relay. Only the 11- and 12-impulses are available out of COMMON. During 11- and 12-time of the card-feed cycle, the 11-12 hub and COMMON are connected to each other (Figure 137). At no other time during the card cycle are they connected.

You can see, therefore, the COMMON can be used as either an EXIT or an ENTRY hub. Also, the 0-9 and 11-12 hubs can be either EXIT or ENTRY hubs.

When we wire the card column to COMMON, we divide the card column in two. The 0-9 impulses are available out of one hub on the control panel, and the 11-12 impulses are available out of another hub on the control panel.

When we wire the card column to the 11-12 hub, we are eliminating any 0-9 punches from COMMON. When we wire the card column to the 0-9 hub, we are eliminating any 11-12 punches from COMMON. Therefore, the hubs of a column split are either entries or exits, depending on the results we wish to obtain from their use.

Some examples of how the column-split hubs look on the control panels of various IBM machines are shown in Figure 138. In each case we have a row of common hubs, a row of 0-9 hubs, and a row of 11-12 hubs. However, the number of column split relays varies with the type of machine.

If you count the number of hubs across the common row of each of the groups of column splits shown, you find that there is a group of 2, a group of 4, a group of 8, a group of 10, and a group of 12.

When using a column split, you must make sure that you use the common, 0-9, and 11-12 hubs belonging to the same column split. The three hubs go together to make a vertical column-split unit. Make sure that if you use the extreme left-hand common hub, you also use the 0-9 or 11-12 hubs directly above or below the COMMON used.

Uses for Column Splits

Early in the section we stated that we need a column split when we wish to interpret an amount field that is overpunched with an X (11). Normally, the combination of an X, which is a zone punch, with a digit gives us an alphabetic character. We wish the number, not the letter, to print; so, we must eliminate the X-punch.

In the example shown (Figure 139), we have an amount field punched in card columns 73-80. In column 80 there is an X-punch, as well as the digit belonging to the amount. We must eliminate the X.

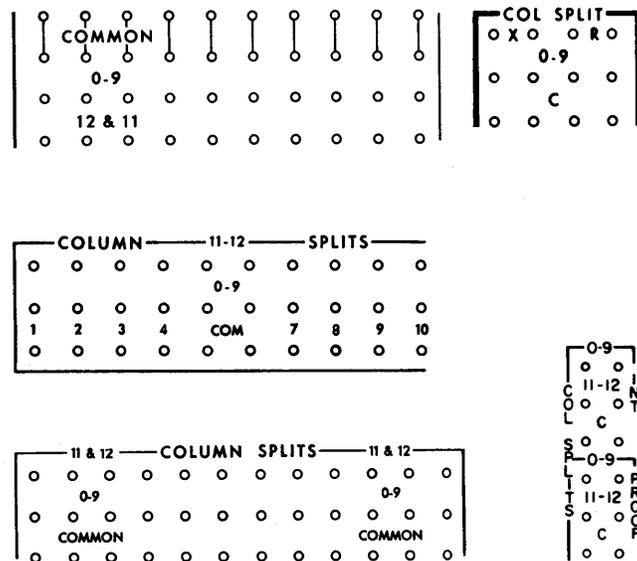


FIGURE 138. CONTROL-PANEL HUBS, COLUMN SPLITS

Card columns 73-79 are wired normally, that is, from the reading brush exit hubs to the typebar entry hubs. However, the wiring of card column 80 is different. The reading-brush exit hub for column 80 is wired to COMMON of one of the X-eliminators (another name for a column split); the 0-9 hub is wired to the typebar. This wiring keeps the X-punch from reaching the typebar.

During 11- and 12-time of the card cycle, the internal connection in the column split is between COMMON and the 11-12 hub. As we have not wired from the 11-12 hub to the typebar, the impulses that are available are not used. At 0-9 time, COMMON and the 0-9 hub are connected. The digits in the amount field can get to the typebar.

If we had wired the card column to the 0-9 hub, and then from COMMON to PRINT ENTRY, we would still have printed the numbers and eliminated the X-punches.

IBM 548 Interpreter

There is one difference in the IBM 548 Interpreter column split that must be mentioned.

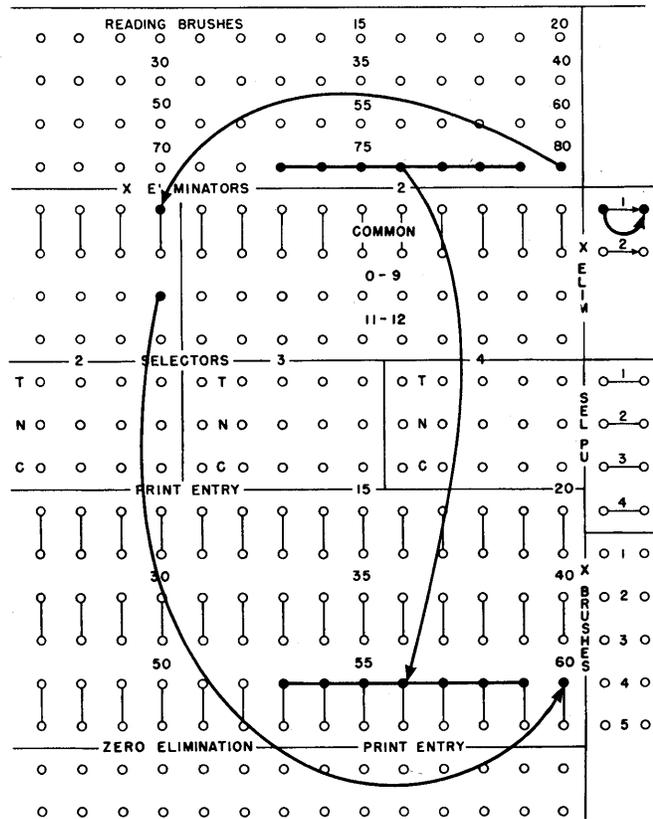


FIGURE 139. IBM 548 ALPHABETIC INTERPRETER CONTROL PANEL

In the 548, the column splits are operative only if their respective switches (labeled 1 and 2) are wired. The magnet is not impulsed for card-feed cycles unless this connection is made. When the connection is made on the control panel, the armature transfers between 0- and 11-time of each card-feed cycle.

IBM 557 Interpreter

Figure 140 illustrates wiring for the same problem in the IBM 557 Interpreter. Card columns 74-79 are wired normally from INTERPRET READING to PRINT ENTRY. PRINT ENTRY are the entry hubs to the typewheels in the 557.

Column 80 is wired through COMMON and 0-9 of the INTERPRET COLUMN SPLIT and then to PRINT ENTRY 80. The column splits labeled INT must be used. The PROOF COLUMN SPLITS are part of a device that checks the accuracy of printing in the 557.

If this device is installed, the PROOF COLUMN SPLITS are wired from PROOF READING to PROOF ENTRY; a duplication of the wiring on the INTERPRET side of the control panel is necessary if the proof device is to function correctly. The wiring for PROOF is shown as dotted lines in Figure 140.

The column splits are automatically operative on all card-feed cycles in the IBM 557 Interpreter. It is not necessary to wire a switch to impuls the relay magnets.

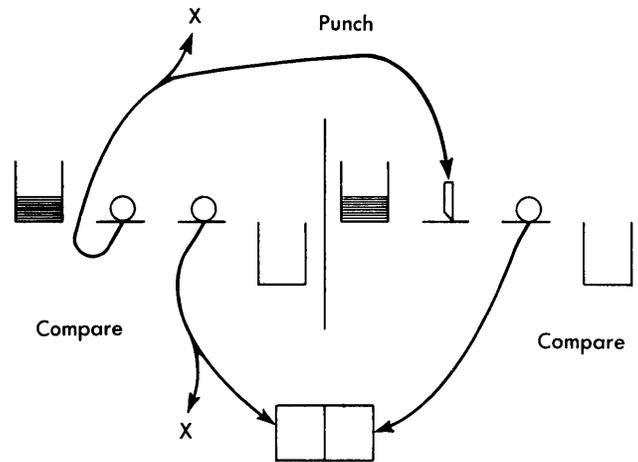


FIGURE 141. REPRODUCING, COMPARING, AND ELIMINATING X-PUNCH IN COLUMN 80

IBM Reproducing Punch

Now let's set up the reproducing punch to reproduce and compare a deck of cards punched in card columns 73-80, withholding the X punched in card column 80 from the new deck of cards.

The schematic diagram of the operation is shown in Figure 141, and the wiring required is shown in Figure 142. We wish to punch the digits, but must eliminate the X-punches. We wish to compare the digits punched, but again must withhold the X-punch impulses or we will have unwanted unequal conditions in the comparing magnets.

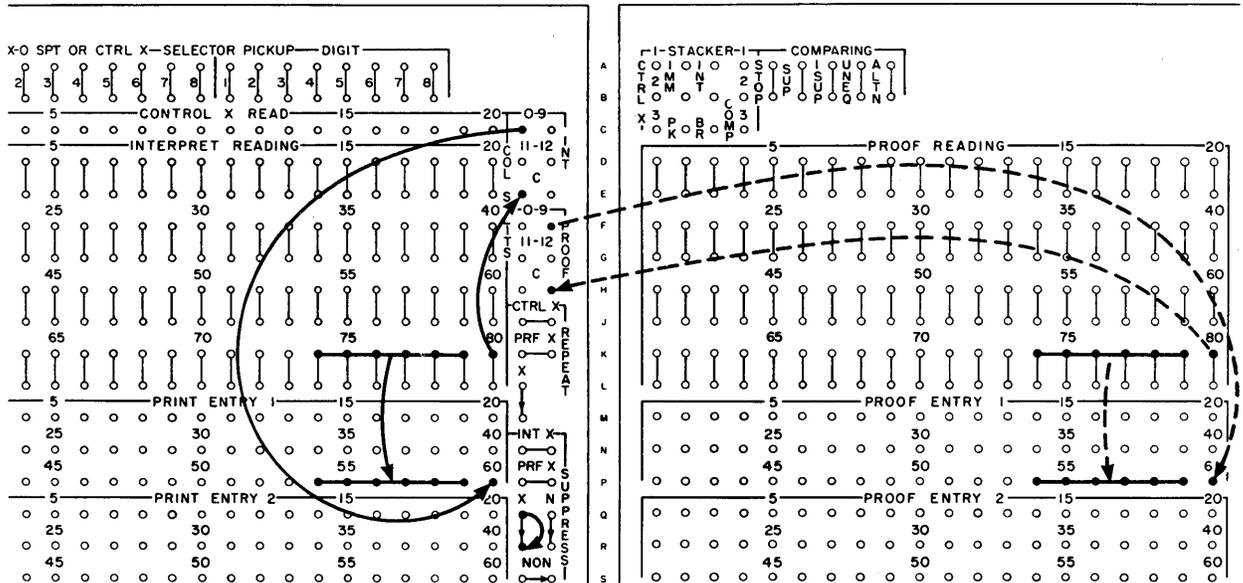


FIGURE 140. PROOF COLUMN SPLITS

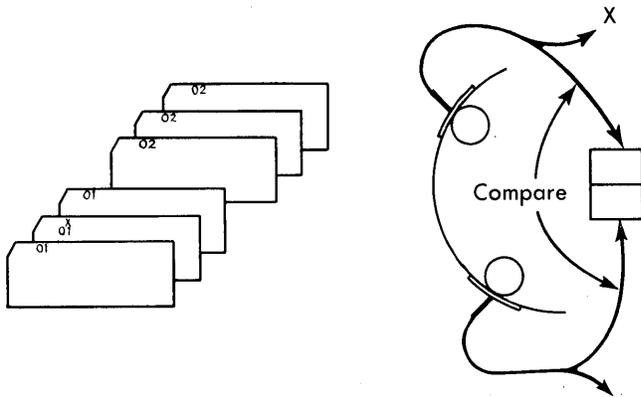


FIGURE 143. ELIMINATING OCCASIONAL X-PUNCHES FOR COMPARING

IBM 407, 408 and 409 Accounting Machines

We have an occasional X-punch over a field on which we wish to compare in the 407-408-409 (Figure 143). It is obvious that we must arrange to remove the X-punches from both the first and the second reading-brush exit impulses.

Figure 144 shows how the column split on a 407-408-409 Accounting Machine is used to prevent the possibility of unwanted unequal impulses while comparing on card columns 32-33.

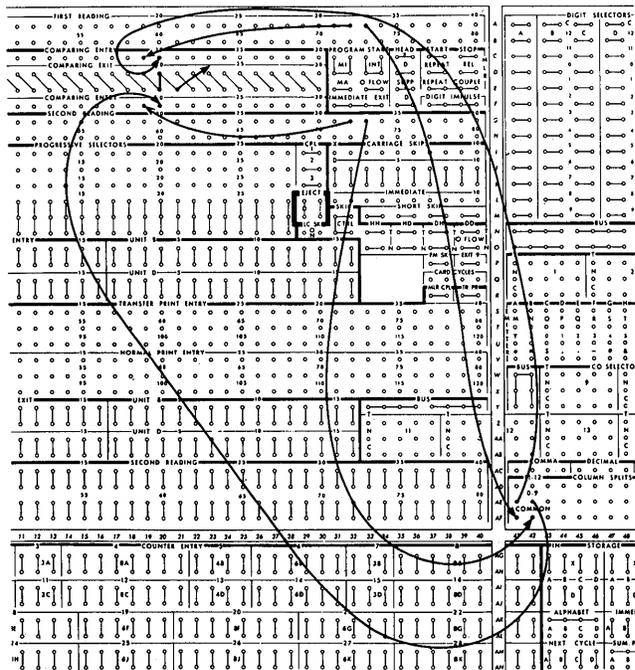


FIGURE 144. COMPARING WITH ELIMINATION OF X-PUNCHING

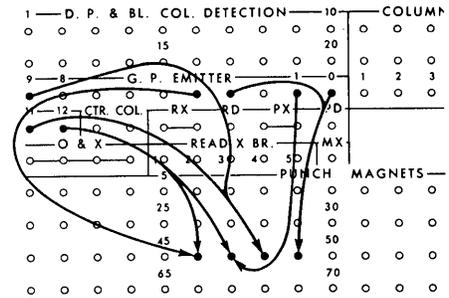


FIGURE 145. PUNCHING *Dart* WITHOUT USING A COLUMN SPLIT

Earlier in this chapter we showed the need of a column split when punching certain alphabetic information such as DART from a digit emitter. First let's look at the control-panel wiring necessary to punch DART from the digit emitter *without* the use of a column split (Figure 145). The letters D and A both have the same zone punch (12); so, we wire a split plugwire from the 12-emitter hub to punch magnet hubs 46 and 47.

Along with this we have PUNCH MAGNET 46 wired from the 4-emitter hub, and PUNCH MAGNET 47 wired from the 1-emitter hub. This wiring should punch a D (12-4) in column 46 and an A (12-1) in column 47. However, we have a back circuit that punches 12-1-4 in columns 46 and 47. Let's trace this back circuit. The 12-impulse is the first to be emitted and punches a 12 in columns 46 and 47.

The next impulse we are using is a 1-impulse that is wired to column 47, punching a 1 in column 47. This 1-impulse can also flow from PUNCH MAGNET 47 through the split wire to the 12-emitter hub, back through another split wire to PUNCH MAGNET 46, and cause the punching of a 1 in column 46. We don't want this to happen. The same back circuit exists at 4-time. The impulse emits from the 4-emitter hub to PUNCH MAGNET 46 to the 12-emitter hub and then to PUNCH MAGNET 47, causing a 4 to be punched in both columns. A column split can prevent this back circuit.

Now look at the same control-panel wiring *using* a column split (Figure 146). At 1-time, the impulse

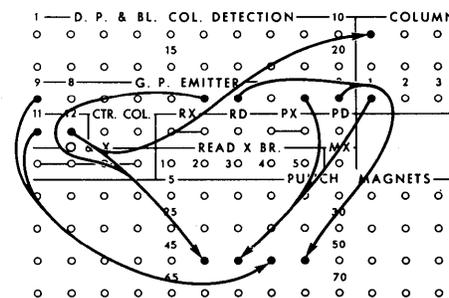


FIGURE 146. PUNCHING *Dart* USING A COLUMN SPLIT

reaches PUNCH MAGNET 47, punching a 1 in that column; but when it goes up through the split plugwire to COMMON of column split 1, it is lost and cannot get through to PUNCH MAGNET 46. This is so because at 1-time COMMON and 11-12 of the column split are not connected. The same holds true at 4-time. The 4-impulse reaches PUNCH MAGNET 46 but cannot get

through the column split and have a path to PUNCH MAGNET 47. At 12-time, however, COMMON and 11-12 of the column split are connected, and the 12-impulse *can* reach PUNCH MAGNET 47. This is what we want. Once again a column split proves to be a valuable device for stopping unwanted impulses.

Review Questions

1. What does a column split do? Why do we use one when printing, comparing, or punching?
2. Which of the column-split hubs is always internally connected to one of the other control-panel hubs?
3. Which two column-split hubs are never internally connected to each other?
4. What are the common, 0-9, and 11-12 hubs? Exits, entries, or both?
5. At what time during the card cycle does the magnet become energized? When does the armature transfer?
6. Is the magnet energized automatically, or must it be externally wired?
7. Is the column split operative on every card-feed cycle? If so, why?
8. What column-split control-panel hubs are used to eliminate an X-punch and retain the digit punches?

Selection, in the usual sense of the word, means *making a choice or decision*.

In IBM terminology we mean exactly the same thing, but it is a choice limited to electric impulses. If a choice is to be made by an IBM machine, it must be set up by means of the control panel, using a device called a *selector*.

The use of selection is basic in most IBM machines. Although the operation of the selectors can be slightly different in various machines, their basic operations are the same.

An understanding of the principle and uses of selection is essential.

Need for Selectors

Assume that you are employed by the IBM department of the local gas and electric company. Each month you send each of your customers a bill. To prepare the bill, you punch one or more IBM cards for each customer — one card showing the amount due for gas used during the month, and another card showing the amount due for the electricity used during the month.

The amount of money due is punched in the same card field in both the gas and the electric cards (Figure 147).

Corner cuts or colored stripes across the face of the card provide a method of visual identification to distinguish between the two types of cards, but IBM unit record machines cannot use this means of identification.

The eyes of IBM unit record machines are their brushes, and they read punched holes only. Therefore, each type of card must have in a specified column a

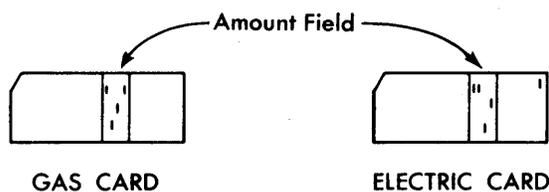


FIGURE 147. AMOUNT PUNCHED IN SAME FIELD



FIGURE 148. ELECTRIC CARDS ARE IDENTIFIED BY AN X IN COLUMN 80

distinguishing punch, or lack a distinguishing punch, to identify it.

This distinguishing punch is sometimes a specified digit (0-9), or it can be a 12-punch. Most often, however, it is an X- (or 11) punch.

So that IBM machines can recognize the difference between a gas card and an electric card, you punch an X in card-column 80 of each electric card. The gas cards do not have an X in card-column 80 (Figure 148). Cards identified by an X-punch are called X-cards; cards identified by having no X-punch are called NX- (no-X) cards; cards identified by a 12- or digit-punch take the name of the position punched.

The cards for all customers, with gas and electric accounts intermixed, are sorted on customer number. Without disturbing the sequence of the card file, you prepare a report on the IBM Accounting Machine showing the value of the gas sold and the value of the electricity sold.

1. By use of a selector (because a choice or decision must be made), you tell the IBM machine to add the gas amount in one counter and the electricity amount in another counter.
2. If you need to run the entire file of gas and electric cards through an IBM Interpreter and print the gas amounts only, you will again use a selector, because again a choice or decision must be made (Figure 149).

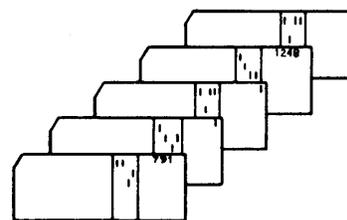


FIGURE 149. PRINT OR INTERPRET GAS CARDS ONLY

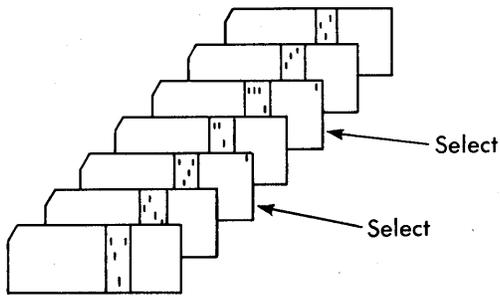


FIGURE 150. ELECTRIC CARDS ARE SELECTED

3. A selector is needed if you decide to use the IBM Collator to separate the gas and electric cards into two files, because again a choice or decision must be made (Figure 150).

Nature and Operation of Selectors

Consider the column split. Fundamentally, it is a selector (Figure 151).

The column split consists of the C (COMMON) hub, 0-9 and 11-12 hubs, an armature, and a magnet that is energized automatically between 0- and 11-time. A selector consists of the same parts: a magnet, an armature, and three control-panel hubs.

A selector differs from a column split in these ways:

1. The labeling on the control panel is different. Both the selector and the column split have a c (COMMON) hub. The function of these hubs is the same in both cases, for the c hub is internally connected by means of the armature to one of the other hubs at any one time.

The other hubs on a column split are called 0-9 and 11-12. On a selector they are called NORMAL and TRANSFERRED (Figure 152).

The NORMAL hub gets its name from the fact that, when the magnet is *not* energized, the armature is in its usual (normal) position, and the internal connection is between the COMMON and the NORMAL control-panel hubs.

The TRANSFERRED hub gets its name from the fact, that when the magnet is energized, the armature is transferred, and the internal connection is between the COMMON and TRANSFERRED (Figure 153).

2. The transfer of the selector armature is *not* automatic. The column split armature transfers from the 0-9 to the 11-12 connection during each card-feed cycle, and this transfer is automatic. No special

control-panel wiring is required to energize the magnet and cause the transfer of the armature. The selector differs in that the armature *never* transfers without special external control-panel wiring.

Each selector has one or more *pickup* hubs, which are entries to the magnet. The magnet is not energized, and the armature does not transfer, unless a pickup hub has been impulsed.

Because it is necessary to impulse the magnet of a selector through its pickup hub, you will hear IBM people say, "the selector has been picked up" or, "the selector has been picked." All we mean is that the pickup hub was wired, and an impulse to the magnet caused the armature to transfer.

Selector Pickup Hubs

Selectors can be used in a variety of ways. Accordingly, the selector pickup hubs vary as to the type of impulses

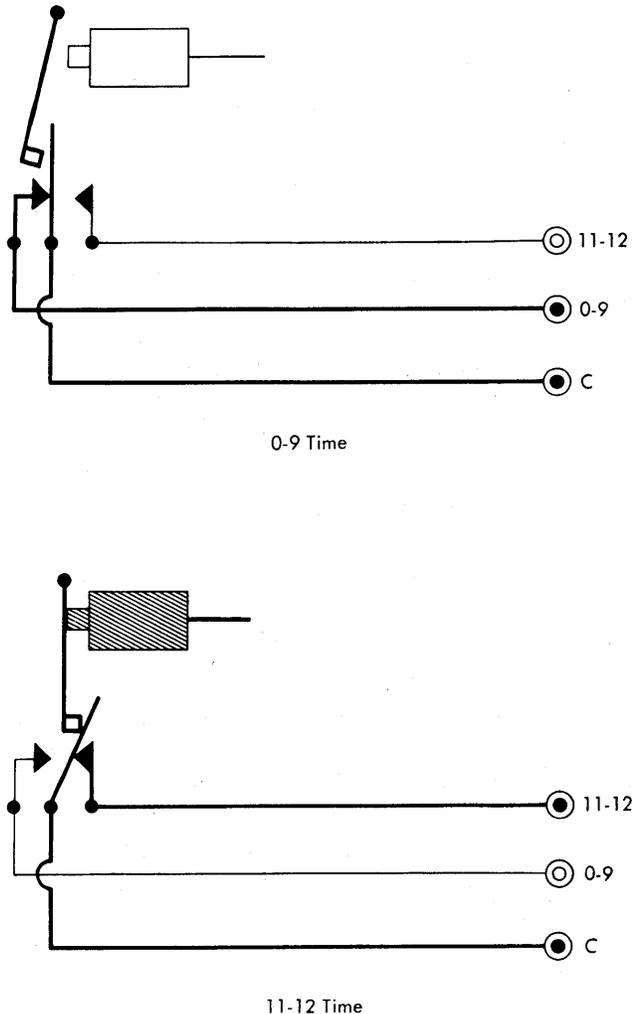


FIGURE 151. COLUMN SPLIT SCHEMATICS

they accept to cause the transfer of the selector. Illustrations of different types of hubs are shown in Figure 154. Although the labeling of pickup hubs differs, the basic function of the hubs is the same, for in each case the pickup hub is the entry hub to the selector magnet. When an acceptable impulse is brought to the pickup hub, the selector is conditioned to transfer at an appropriate time.

The X-PICKUP hubs are so labeled because they often accept X-impulses only. The name of these hubs is not always precise, for the hubs sometimes accept 12-impulses as well as X-impulses, depending on the type of IBM machine.

The D-PICKUP hubs are designed to accept all the digits 0-9, and the 11 and 12 impulses. Any card impulse wired to the D-PICKUP reaches the magnet and causes the transfer of the selector. Frequently the selector is designed so that any machine impulse can be wired to the D-PICKUP to cause the selector to transfer.

The I-PICKUP is impulsed when you want a selector to transfer *immediately*. This hub also accepts most impulses to cause transfer of the selector.

DIGIT PICKUP in the 557 operates like D-PICKUP on other machines. It allows any digit (0-9) or the 11- or 12-punch to reach the magnet and cause the transfer of the selector.

X-O SPLIT or CONTROL X PICKUPS in the IBM 557 Interpreter accept impulses from two different sources:

1. An X-punch read at the pre-sense or CONTROL-X READ station;
2. Impulses from X-O SPLIT exit hubs in the 557 control panel.

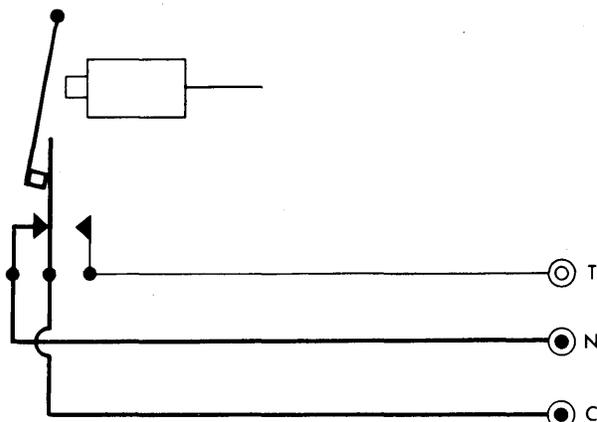


FIGURE 152. COMMON AND NORMAL ARE CONNECTED INTERNALLY WHEN A SELECTOR IS *Normal*

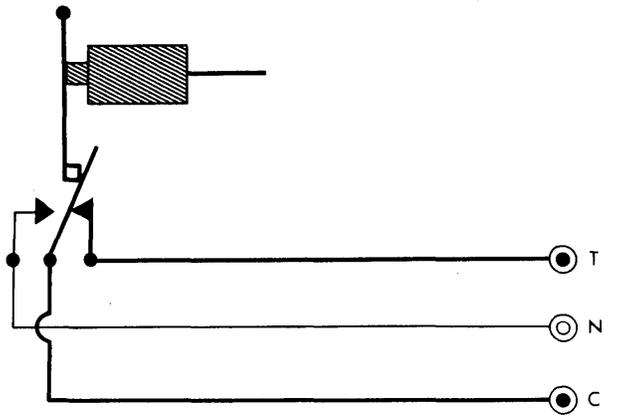


FIGURE 153. COMMON AND TRANSFERRED ARE CONNECTED INTERNALLY WHEN A SELECTOR IS *Transferred*

On the IBM 101 Electronic Statistical Machine, the RECODE PICKUPS can receive all digit impulses (0-9) and zone impulses (11 and 12) punched in the card or emitted from the digit emitters. These hubs also accept *edit* impulses, which are emitted from EDIT hubs on the control panel.

Examples of Selectors

Although all selectors are basically the same, there are differences in their arrangement and, in some cases, in their operation.

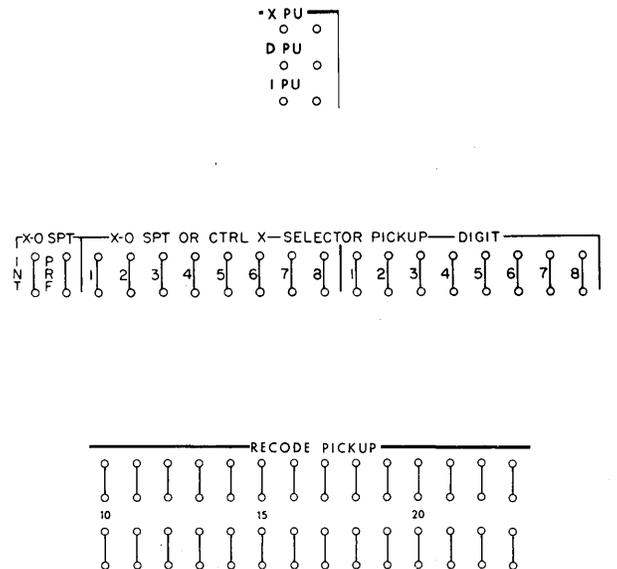
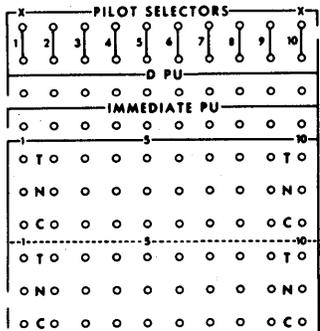
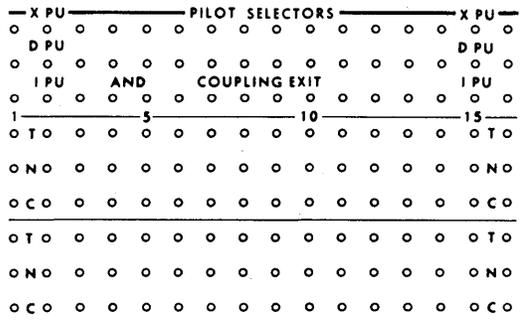


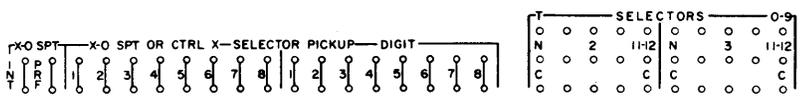
FIGURE 154. SELECTOR PICKUP HUBS



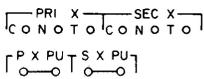
407 ACCOUNTING MACHINE



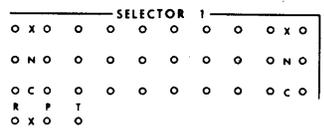
402- 403 ACCOUNTING MACHINE



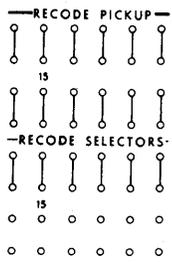
557 ALPHABETIC INTERPRETER



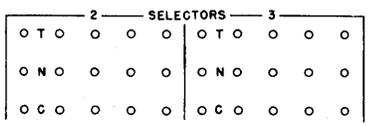
77 COLLATOR



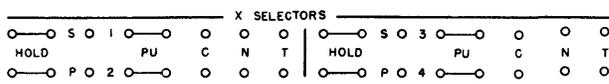
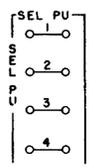
514 REPRODUCING PUNCH



101 ELECTRONIC STATISTICAL MACHINE



548 INTERPRETER



85 COLLATOR

FIGURE 155. SELECTORS

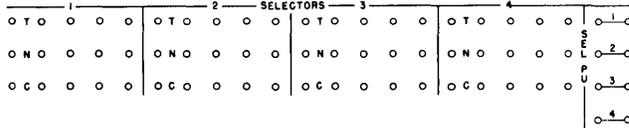


FIGURE 156. IBM 548 SELECTOR

Figure 155 illustrates some examples of control-panel hubs for various selectors and how they differ in appearance and arrangement.

Notice that in many cases, as in the column split, we have more than one set of common, normal, and transferred hubs working together as a group. Groups of 1, 2, 4, 5, or 10 or more work together from the same pickup hub.

You will also notice that the hubs themselves are labeled differently. Some selectors are labeled C, N, and T. Others are called C, NORMAL, and CONTROLLED. Still others are called C, N, and X.

In each case the hubs are identical in purpose. The C is the common hub. The N hub is the normal hub. The X, T, or CONTROLLED is the transferred hub.

Use of Selectors

IBM 548 Interpreter

Going back to the problem we discussed earlier, let's see how we can print the amount on the gas cards and prevent printing the amount on the electric cards.

A selector must be used, and interpreters can be equipped with selectors (Figure 156). Notice, however, that the IBM 548 Interpreter selector has only one pickup hub. This is the SEL PU hub on the right side of the control panel. The 548 selector is normal (Figure 157) when the pickup hub has not been impulsed.

When an impulse reaches the magnet, the selector transfers, and it remains transferred for the rest of that same card cycle and for printing time (Figure 158).

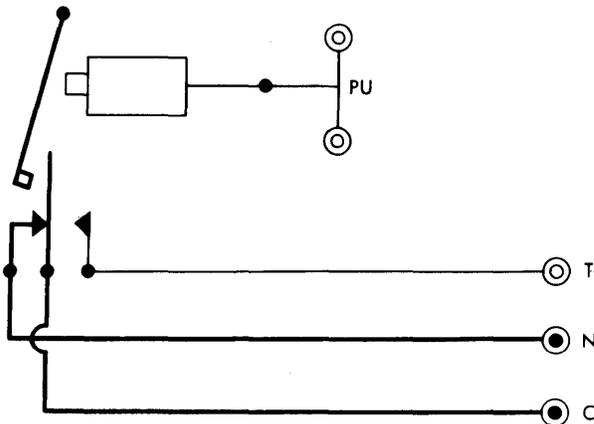


FIGURE 157. IBM 548 SELECTOR, NORMAL

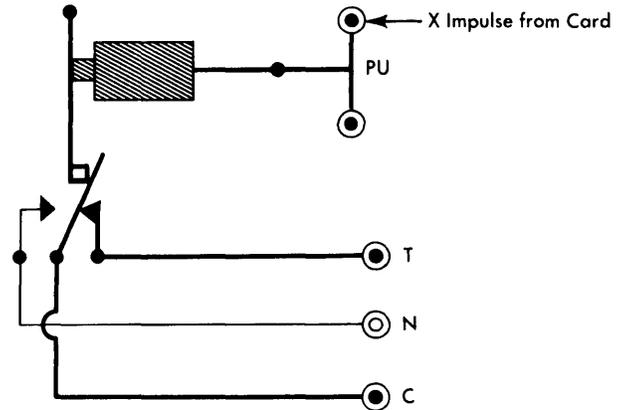


FIGURE 158. IBM 548 SELECTOR, TRANSFERRED

Notice that each 548 selector has five sets of vertical hubs. When the selector transfers, all five COMMON are disconnected from NORMAL and are connected to CONTROLLED. As you see, CONTROLLED is another name for the *transferred or X-side* of a selector.

In the 548 diagram illustrated in Figure 159, we show the wiring necessary to print the gas amount on the gas cards, and ignore the electric amount punched in the electric cards.

The gas and the electric amounts are punched in the same card columns — let's say columns 51-55. A file, with two types of cards combined, is sorted on customer number. Type of card can be identified because of the presence of an X-punch in card-column 80 of each electric card.

The amount field (51-55) is wired to COMMON of the selector from the reading brushes. Therefore, as a gas card goes through the machine and is read by the brushes, the gas amount goes into the common side of the selector. When an electric card goes under the brushes, the electric amount also goes into the common side of the selector.

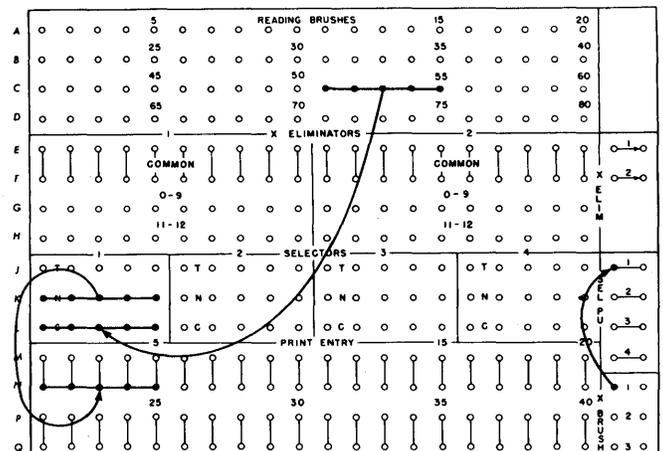


FIGURE 159. GAS CARDS ONLY ARE PRINTED

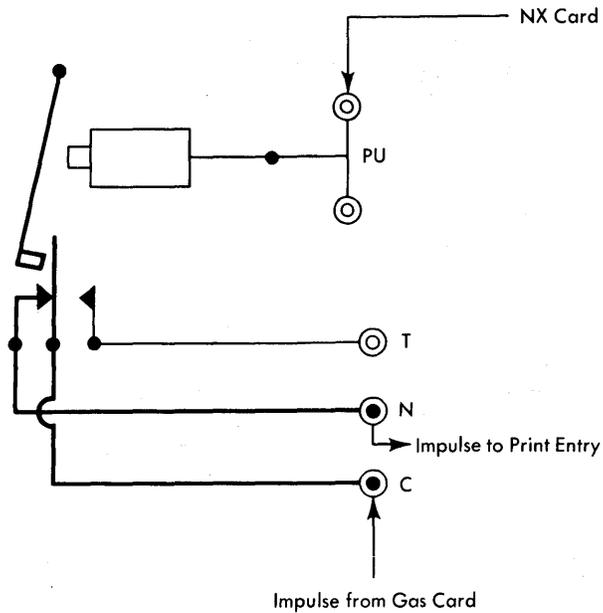


FIGURE 160. SELECTOR NORMAL FOR GAS CARDS

The X-punch is in column 80 of the electric cards. X-brush number one is set to read column 80 in all cards. The X-brushes are a set of five brushes that can read any five non-adjacent columns before the card reaches the reading brushes.

We know, then, that out of the controlled side of selector I we can get the information from punched-card-columns 51-55 of the X (electric) cards. Out of the normal side of the selector, we can get the information punched in columns 51-55 of the no-X (gas) cards.

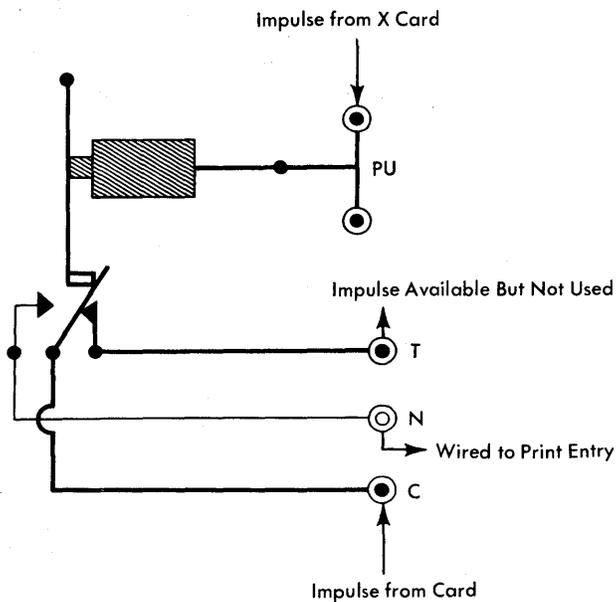


FIGURE 161. SELECTOR TRANSFERRED FOR ELECTRIC CARDS

We said we want to print the gas cards only. Therefore, we wire NORMAL of the selector to the print entry.

If we wire CONTROLLED of the selector to the print entry, we will print the amounts for the electric cards.

Figure 160 shows the position of the armature in a 548 selector when an NX (gas) card is being read by the brushes.

Figure 161 shows the position of the armature in a 548 selector when an X (electric) card is being read by the brushes.

IBM 557 Interpreter

Selectors in the IBM 557 Interpreter work on the same principle as those in the 548; Figures 160 and 161 are applicable to both machines for numerical selection.

The wiring for the 557 is different from that for the 548. As illustrated in Figure 162, columns 51-55 are wired to the common hubs (C) of selector 1, from the normal hubs (N) to PRINT ENTRY positions 1-5. The X from INTERPRET READING causes selector 1 to transfer for electric cards.

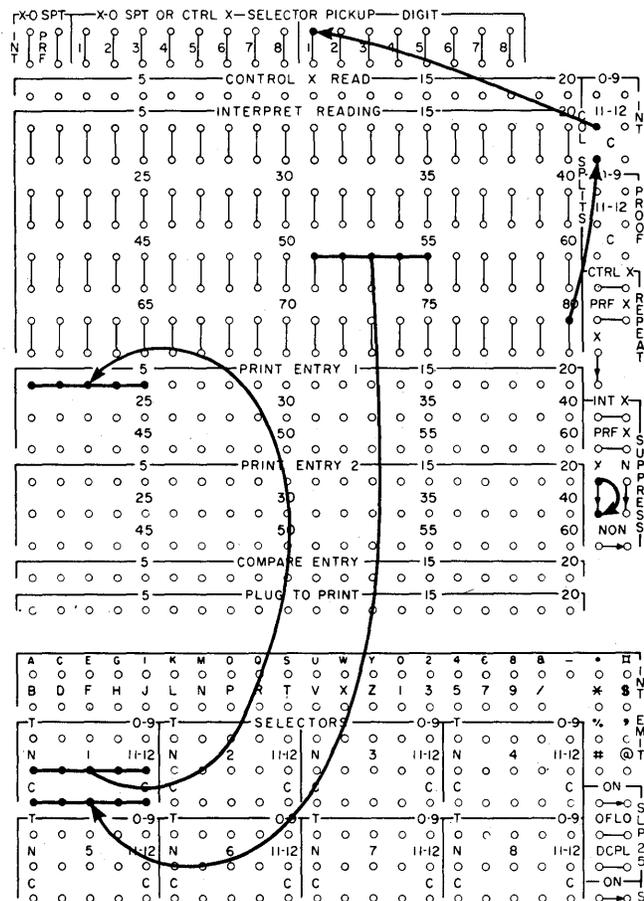


FIGURE 162. GAS CARDS ONLY ARE PRINTED, IBM 557 INTERPRETER

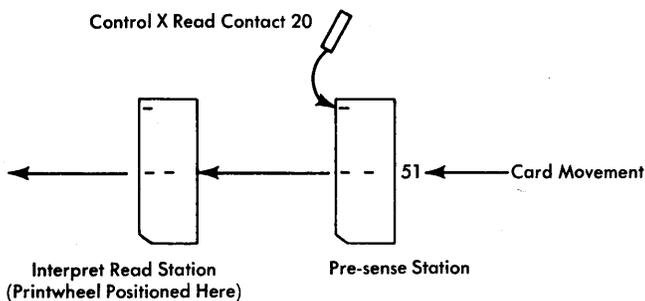


FIGURE 166. CONTROL X CONTACT 20 READS COLUMN 80

Before the card reaches the interpret reading station in the 557, it passes a pre-sense station of 20 contacts that can be set over any 20 columns of the card. These contacts recognize X- (11-) punches only; their exit hubs on the control panel are called CONTROL X READ (Figure 166). CONTROL X READ contact 20 has been set over card-column 80.

The X-punch impulses the control-X pickup hub for selector 1. The selector transfers and remains transferred through interpret-reading time. As the card passes the interpret reading station, brush 51 reads the 12 and 3; because the selector transfers before it reaches the reading station and remains transferred for the complete read time, both impulses pass through COMMON and TRANSFERRED of selector 1 (Figure 167). Printwheel 45 is positioned and a C is printed on the X-punched (electric) card.

Alphabetic printing through the NX side of a selector is the same as numerical printing through the NX side of a selector; this function has been described in the discussion of the IBM 548 Interpreter.

We said earlier that the selectors in the 557 can be impulsed from hubs called X-0 SPT on the control panel.

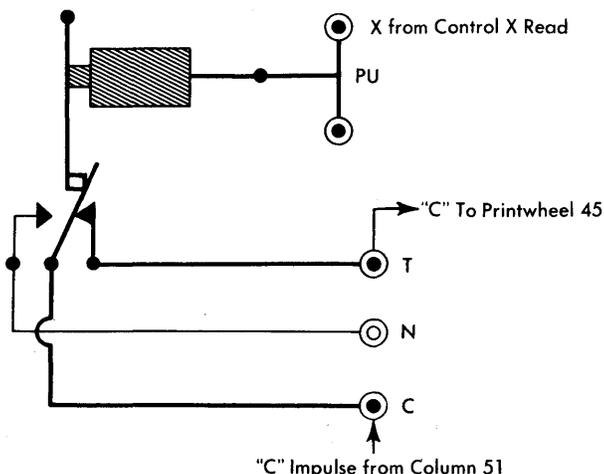


FIGURE 167. SELECTOR TRANSFERRED THROUGHOUT INTERPRET READ TIME

These X-0 SPLIT hubs, when wired to the X-0 SPT SELECTOR PICKUP, turn the selector involved into five separate column-splits.

Recall the section in this manual that explained the function and wiring for column splits. When the magnet controlling each selector is impulsed, the digit punches are separated from the 11- and 12-punches and are available at one set of exit hubs, while 11- and 12-punches are available at a different set of exit hubs.

Wiring from X-0 SPT to X-0 SPT SELECTOR PICKUP transfers the selector between 0-time and 11-time so that the 0-9 impulses are available from the T (transferred) hubs of the selector, and the 11- and 12-impulses are available from the N (normal) hubs.

There are two sets of column splits on the IBM 557 Interpreter: one for *interpret read* impulses — the impulse that actually causes the printing on the card, and one for *proof read* impulses — the impulses that check the accuracy of the printing and the functioning of the machine.

There are also two sets of X-0 SPT hubs: one that times the selector to operate with *interpret reading* impulses, and one that times the selector to operate with *proof reading* impulses. They must *never* be connected to the same X-0 SPLIT selector pickup hub. Interpret reading impulses must *never* be wired through a selector that has been impulsed from X-0 SPLIT PROOF; proof reading impulses must *never* be wired through a selector that has been impulsed from X-0 SPLIT INTERPRET.

In Figure 168, Selector 1 is used as a column split for INTERPRET READING column 45 that is wired to PRINT ENTRY 15; and selector 2 is used as a column split for PROOF READING column 45 that is wired to PROOF ENTRY position 15.

IBM 77 and 85 Collators

We must use a selector to check the sequence of a file of cards, and at the same time *select*, or pull out, the X-punched cards from the file.

In the problem illustrated, we are planning to pull the electric cards from the file, and to leave the no-X (gas cards) in the file.

The IBM 77 Collator selector looks different from the selector on the interpreter. Yet, basically, they are much alike.

The IBM 77 Collator has two selectors (Figure 169): PRI X (PRIMARY X) and SEC X (SECONDARY X).

The words *primary* and *secondary* are used because the 77 has two feeds: the primary feed and the secondary feed. The primary-X-selector is used normally to control the cards in the primary feed. The secondary-X-selector is used normally to control the cards in the secondary feed.

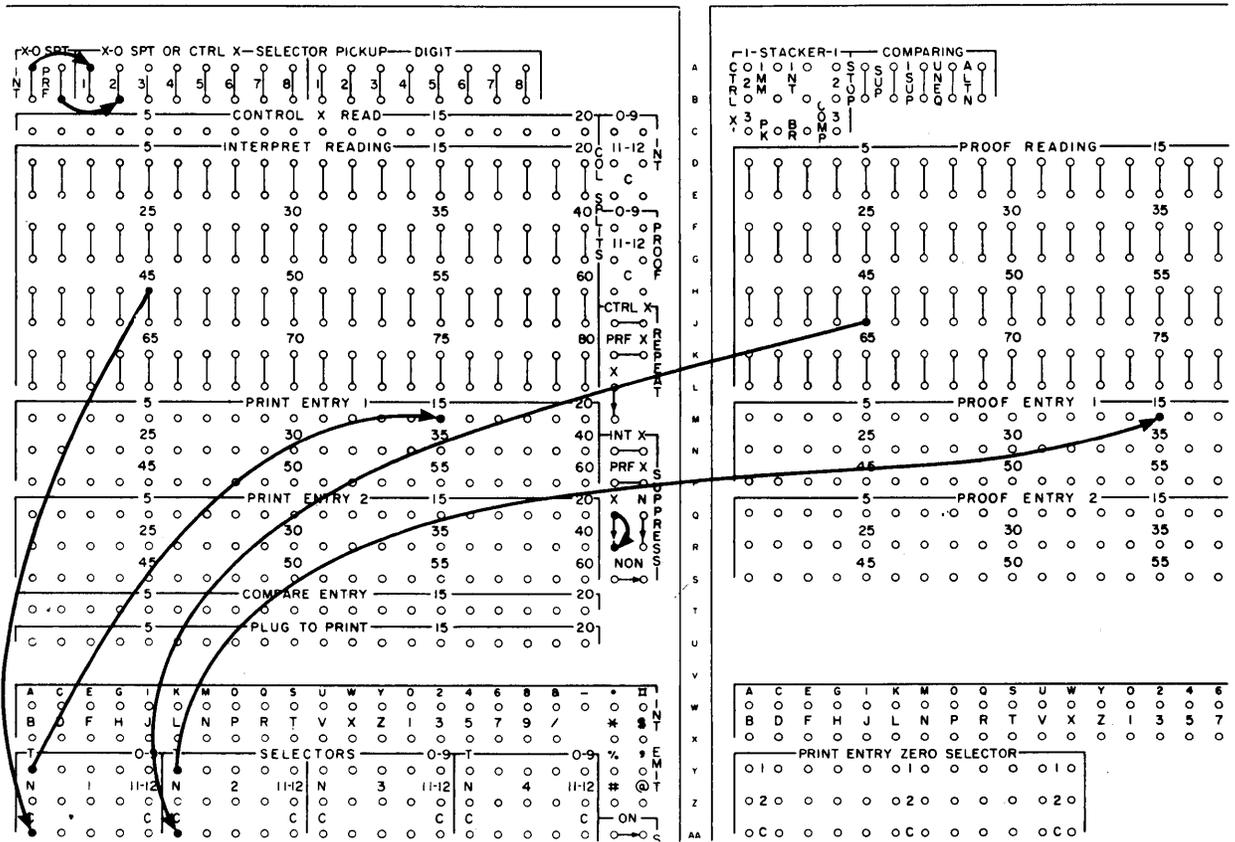


FIGURE 168. SELECTOR 1 USED AS A COLUMN SPLIT

The hubs in both selectors are labeled C, N, and T.

The pickup hubs of IBM 77 selectors are not located next to the selector hubs, but are in the lower right corner of the control panel. These hubs are labeled PX PU and SX PU; PX PU means PRIMARY X-PICKUP and SX PU means SECONDARY X-PICKUP (Figure 170).

The primary-X-pickup hub is normally wired from the primary brushes and accepts X-punches only.

The secondary-X-pickup hub is normally wired from the secondary brushes and also accepts only X-punches.

As in the interpreter, there is a contact between the pickup hub and the selector magnet (Figure 171). Yet, the contact on the collator is different from that on the

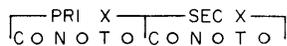


FIGURE 169. IBM 77 COLLATOR SELECTORS

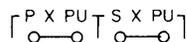


FIGURE 170. IBM 77 COLLATOR SELECTOR PICKUP HUBS

interpreter. The collator contact is open during 0-9 time and 12-time. It is closed only for X- (or 11-) time. Therefore, the only time there is a completed circuit to the magnet from the brushes is at X-time.

X-selectors in the standard IBM 77 can be picked up by an X-punch in the card only.

The wiring diagram (Figure 172) illustrates the wiring necessary to select X-80 cards from the primary-feed file.

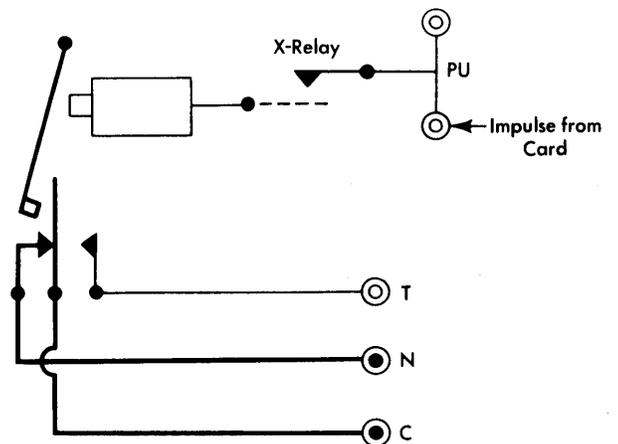


FIGURE 171. IBM 77 COLLATOR X-RELAY

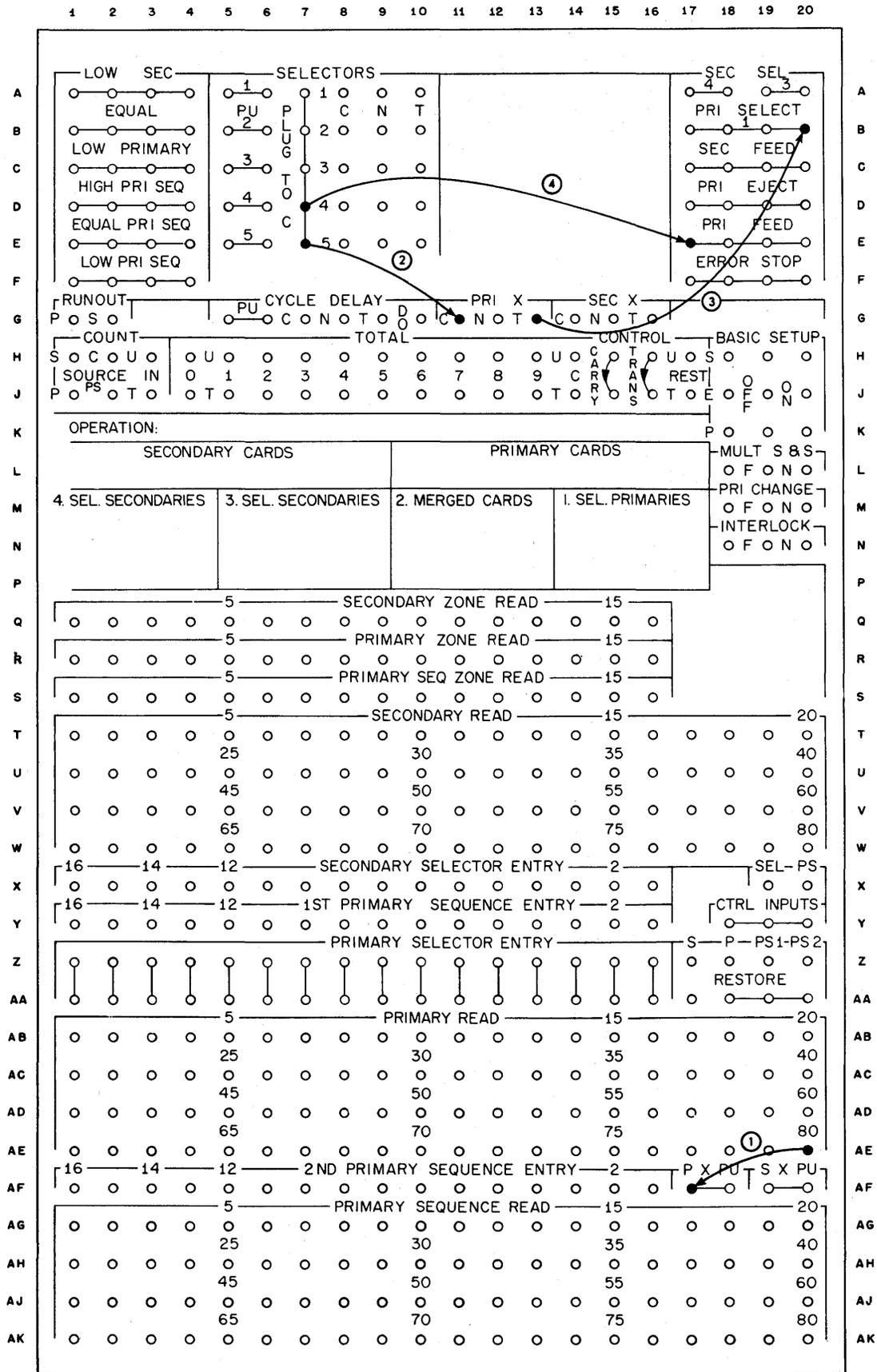


FIGURE 172. WIRING TO SELECT X-80 CARDS, IBM 77 COLLATOR

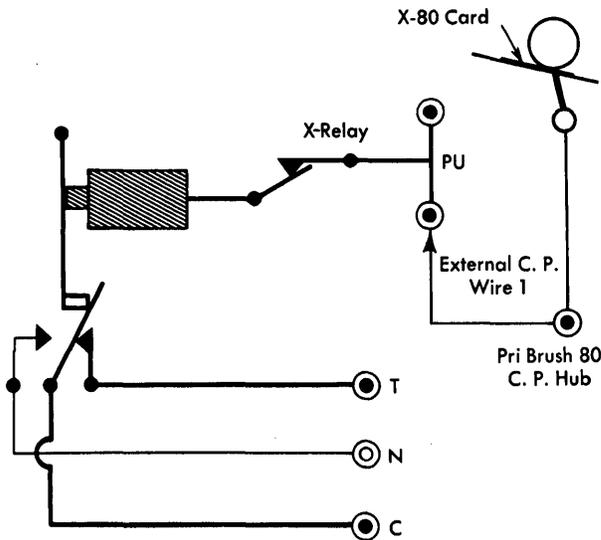


FIGURE 173. X-80 IMPULSE PICKS UP SELECTOR

1. Wire 1 is used to pick up (or energize) the selector when an X-80 card passes the primary brushes (Figure 173).
2. Wire 2 is a PLUG-TO-C impulse, which is nothing more than a constant impulse available every card cycle. When PLUG TO C is wired to the common side of a selector, it is available out of the normal or N-side of the same selector (Figure 174).

Whenever an X-80 card, for instance, passes the primary brushes, the selector is picked up. The PLUG-TO-C impulse that we wired to common is now available out of the T-side of the selector (Figure 175).

3. Wire 3 is the selected PLUG-TO-C impulse. This impulse travels to the primary-select hub *only* if the selector has been transferred by the sensing of an

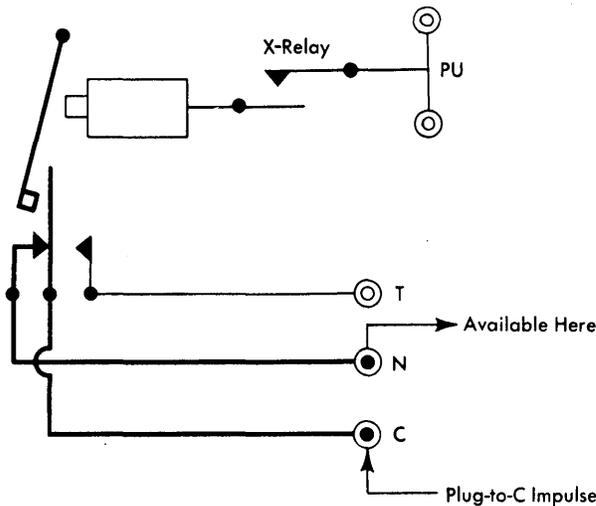


FIGURE 174. PLUG-TO-C IMPULSE AVAILABLE FROM NORMAL SIDE OF SELECTOR

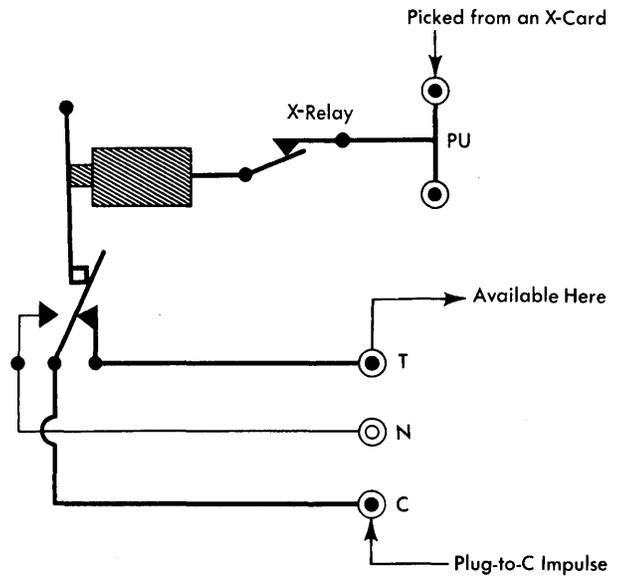


FIGURE 175. PLUG-TO-C IMPULSE AVAILABLE FROM TRANSFERRED SIDE OF SELECTOR

X-punch in column 80. In every other case, it is available at the N-hub; and, as it is not wired anywhere, causes no action.

When PRIMARY-SELECT receives the PLUG-TO-C impulse, it directs a card into the first pocket of the collator. Therefore, all X-cards are directed to pocket 1; all no-X cards continue on to pocket 2 (Figure 176).

4. Wire 4 is used to instruct the primary feed to feed cards. Without this wire, cards could not move through the primary feed.

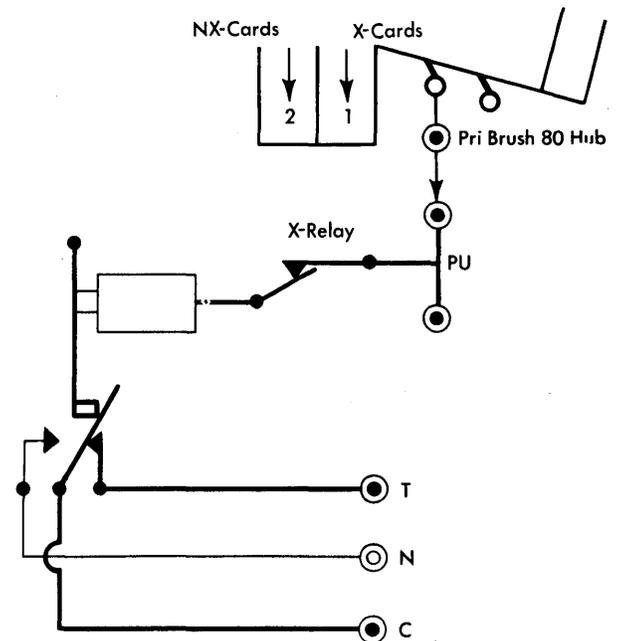
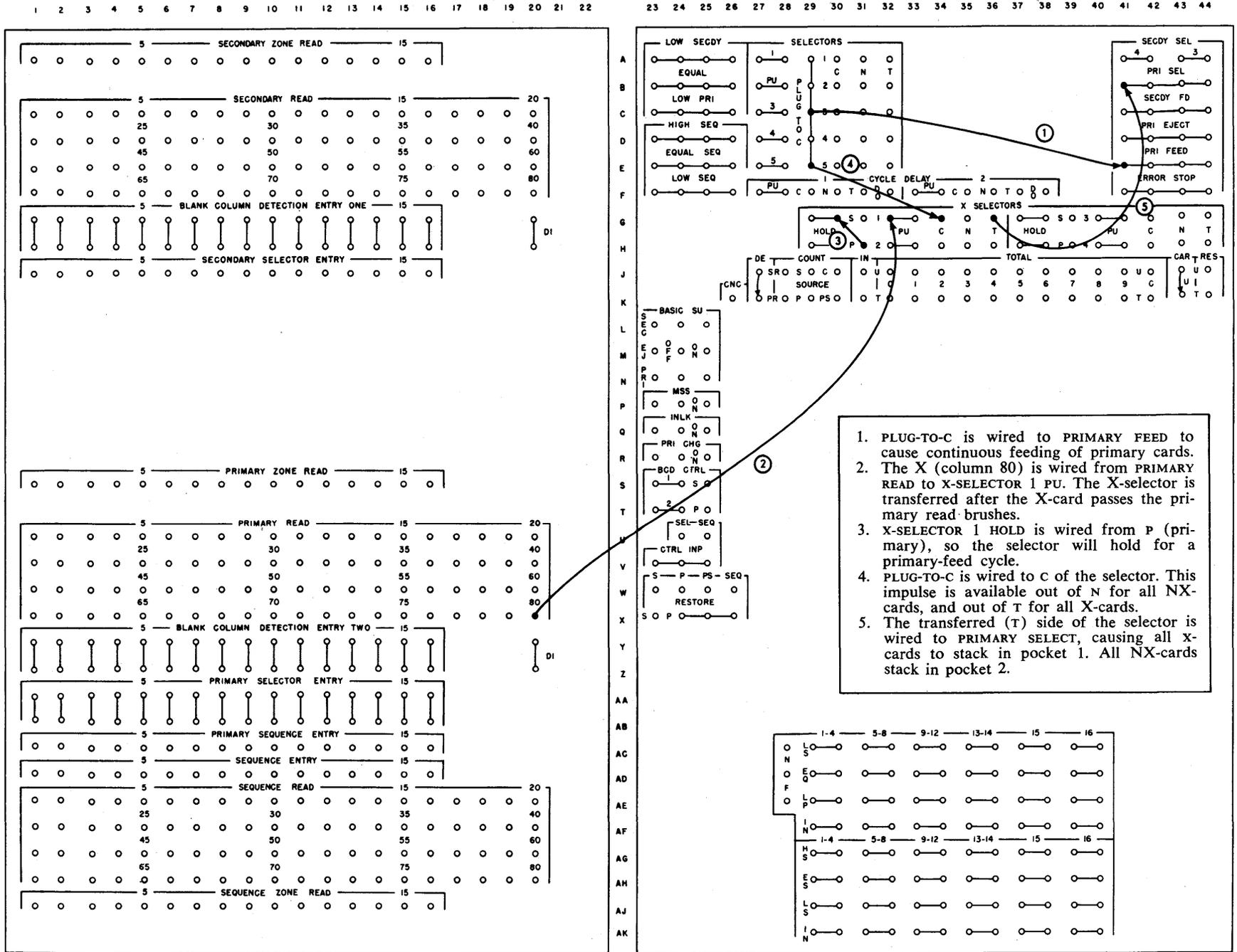


FIGURE 176. X-CARDS ARE SELECTED INTO POCKET 1

FIGURE 177. WIRING TO SELECT X-80 CARDS, IBM 85 COLLATOR



The IBM 85 Collator also has two selectors that are the same as the selectors in the IBM 77 with these exceptions:

1. Either selector can be used to control cards in either feed — they are completely interchangeable.
2. The pickup hubs for the selector are labeled PU and are located in the selector unit. (The pickup hubs function exactly like the pickup hubs on the IBM 77 Collator.)
3. Additional hubs have been added. They are labeled HOLD, S, and P. When S is wired to HOLD, and PU is impulsed with an X, the selector is timed to operate with cards in the secondary feed. When P is wired to HOLD, and PU is impulsed with an X, the selector is timed to operate with cards in the primary feed.

Figure 177 illustrates the wiring necessary to select X-80 cards from the primary feed file on the 85 Collator.

IBM Accounting Machines

The card-cycles impulse is used to add from gas cards in one counter, and add from electric cards in another counter (Figure 178), because this impulse can control the movement of the counter wheels and the addition of amounts into the counters.

A card-cycles impulse is an internally manufactured impulse available in an accounting machine only on a

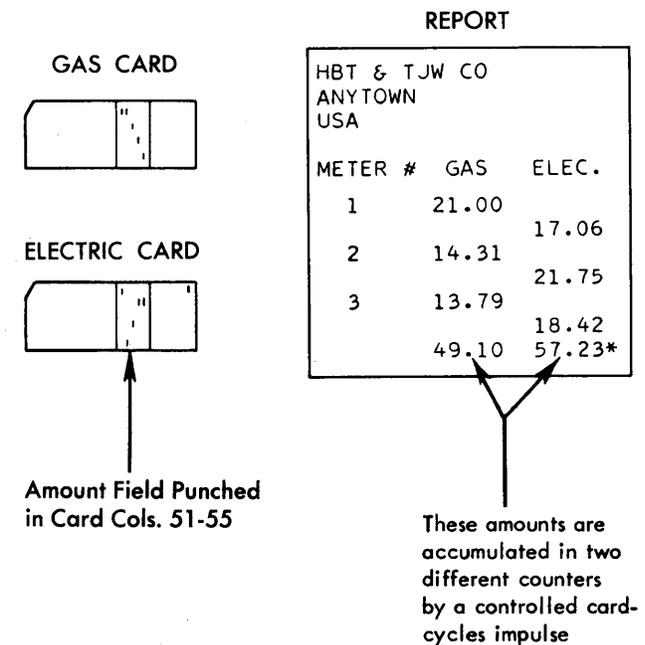


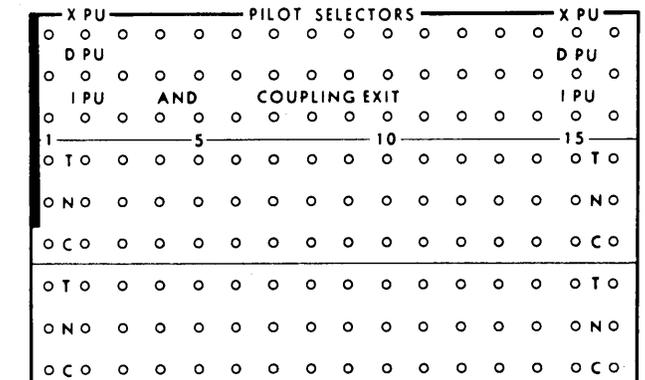
FIGURE 178. SELECTION, IBM 402-403

card-read cycle. This impulse can be used to pick up the counter-controlled plus relay, if the amount is to be added; or the counter-controlled minus relay, if the amount is to be subtracted in the counter. This topic is discussed more thoroughly in the sections on *Addition* and *Subtraction*.

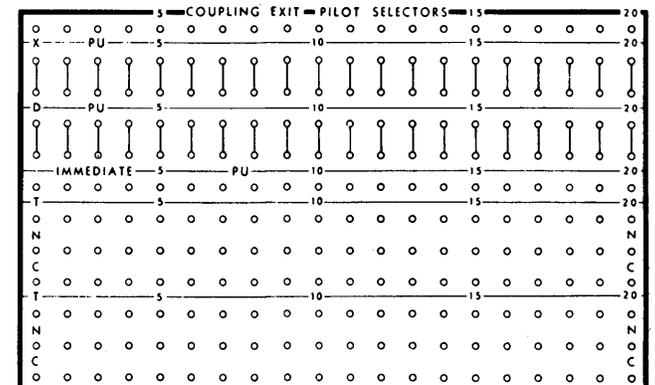
Somehow we must wire the control panel so the card-cycles impulse goes to one counter when X-cards are read, and to another counter when NX-cards are read. Cards are read as they pass third reading in the 402-403, and second reading in the 407-408-409.

A full-capacity 402-403 has 16 pilot selectors (11 standard and 5 optional), as shown in Figure 179. They are called *pilot selectors* because, through their operations, other selectors can be controlled. In other words, the pilot selectors take the lead.

Each selector has two sets of hubs, labeled C, N, and T, which are arranged vertically. The operation of these selectors is similar to other selectors we've discussed so



A



B

FIGURE 179. IBM 402-403 SELECTORS (A) AND IBM 407-408-409 SELECTORS (B)

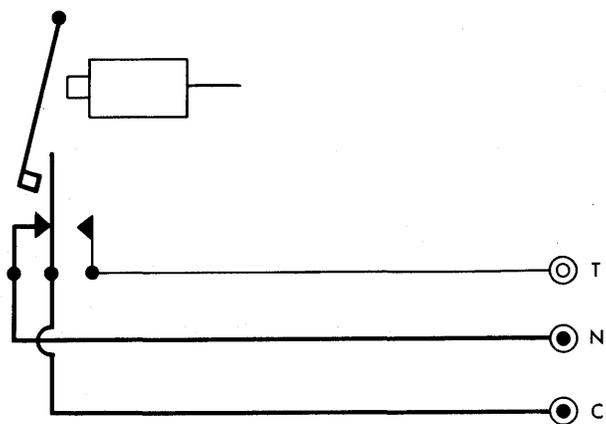


FIGURE 180. ACCOUNTING MACHINE SELECTOR,
NORMAL

far. The schematics (Figures 180 and 181) show that their operations must be basically the same, for the schematics are practically identical with those we've already studied. As shown by Figure 179, a standard 407-408-409 Accounting Machine has 15 pilot selectors.

In general, the selectors in both types of accounting machines function and operate alike. You will notice, however, that the 407-408-409 selectors have a separate set of hubs labeled COUPLING EXIT. The 402-403 I-PICKUP functions also as a coupling exit. This function is discussed in the section about pilot selector pickup hubs.

We discuss the 402-403 and the 407-408-409 selectors in detail in the following pages to illustrate some basic principles that apply to control-panel wiring in many other IBM machines.

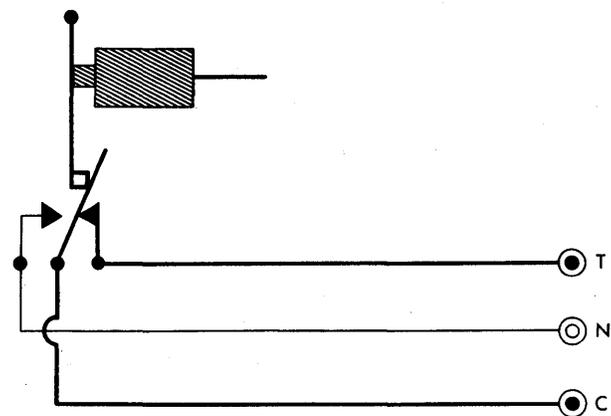


FIGURE 181. ACCOUNTING MACHINE SELECTOR,
TRANSFERRED

Until now, the selectors we've discussed had only an X-pickup hub. The 402-403 and 407-408-409 are examples of machines that have more than one pickup hub.

Until now we've assumed that the selector armature transfers as soon as the impulse is received by the pickup hub. You will see in the following explanations that the armature in accounting machine selectors can transfer at a later time.

Look at the schematic for the 402-403 shown in Figure 182, and for the 407-408-409 in Figure 183, as we discuss the pickup hubs. See whether you can trace a path to the magnet for the impulse.

X-PICKUP HUB

The X-pickup hub accepts only an 11- or 12-impulse from the card because the 11-12 relay is closed during 11- and 12-time, and is open at all other times.

After the 11- or 12-impulse passes the 11-12 relay, it reaches the *delay* relay. This relay is internally operated to delay the 11- or 12-impulse so that the impulse gets to the magnet only at the end of the cycle. This causes the selector to be transferred for the next cycle. Furthermore, the selector remains transferred through the next card-feed cycle.

Remember that the 403 has three reading stations, and the 402 and 407-408-409 have only two reading stations. Therefore, if we wire from the second-reading brushes in the 402-403 or from the first-reading brushes on the 407-408-409 to the X-pickup hub, and an X-punch is sensed, the selector does not transfer until late in the cycle. In this case, the selector transfers for the cycle in which the card with the X-punch passes the third reading station in the 402-403, or the second reading station in the 407-408-409. The selector remains transferred during any program cycles occurring between the readings of the card at the two stations.

As an additional example, if the X-punch is wired from the first-reading brushes on the 403 or the 407-408-409 to the X-pickup hub, the selector is transferred through the cycle in which the X-punched card passes the second reading station.

D-PICKUP HUB

The D-pickup hub accepts 9-12 timed impulses. As there is no 11-12 relay for the D-pickup hub, all impulses get to the delay relay.

Because we are using the same delay relay we used when we wired the X-pickup hub, the effect is exactly the same.

Therefore, if we wire from the second-reading brushes on the 402-403 or from the first-reading brushes on the 407-408-409 to the *D*-pickup hub, and any 9-12 punch is sensed, the selector does not transfer immediately. Instead, the selector is transferred at the end of the cycle during which the selector pickup hub is impulsed, and remains transferred until the end of the next card feed cycle. This is the cycle in which the card with the digit punch passes third reading on the 402-403, and second reading on the 407-408-409.

I-PICKUP HUB

As you can tell by looking at the schematics (Figures 182 and 183), the *I* (IMMEDIATE) PICKUP accepts any impulse from the card, causing the selector to transfer immediately. This is because there is neither an 11-12 relay nor a delay relay between the pickup hub and the selector magnet. Program exit impulses and some other impulses can also be used to impulsed the *I Pickup* (see *Timing Charts*).

COUPLING EXIT HUB — IBM 407-408-409 ACCOUNTING MACHINES

The *COUPLING EXIT*, which is part of the selector, emits impulses whenever the selector transfers. As the name implies, the impulse from this hub expands the positions of the selector by coupling it with another selector.

It can be wired to the *IMMEDIATE PICKUP* of another pilot selector, in which case the two selectors transfer at the same time. A *COUPLING EXIT* can also be wired to *CO-SELECTOR PICK-UP*; in this case, the co-selector concerned also transfers at the same time as the pilot selector.

Figure 183 illustrates the operation of the 407-408-409 pilot selector. When the pickup magnet is impulsed from either the *I*-, *D*- or *X*-hubs, the *hold* magnet is also impulsed. An impulse from the constant internal emitter is then available from *COUPLING EXIT*.

COUPLING EXIT emits an impulse once each cycle after it is initially transferred for as long as the pilot selector remains transferred.

IBM 101 Electronic Statistical Machine

RECODE SELECTOR

A schematic representation of a recode selector indicates how its pickup differs from the pickup of the conventional selector we have studied up to this point.

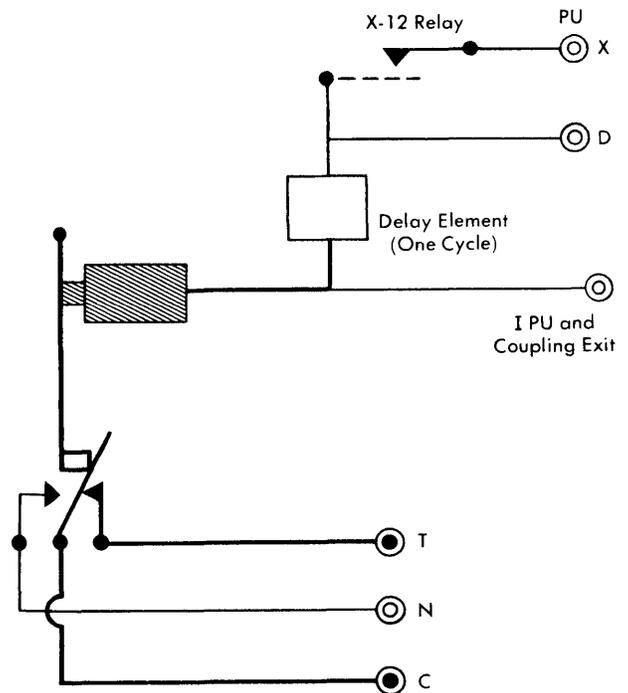


FIGURE 182. IBM 402-403 SELECTOR, TRANSFERRED

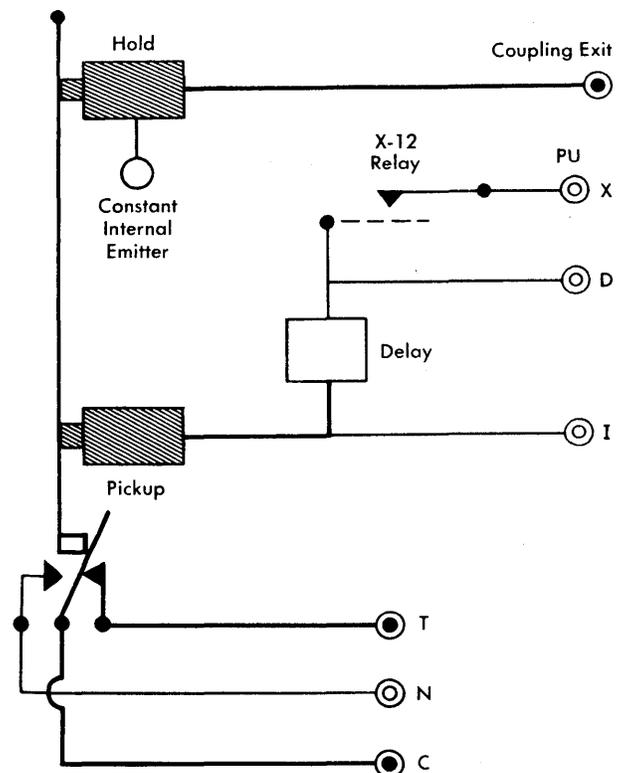


FIGURE 183. IBM 407-408-409 SELECTOR, TRANSFERRED

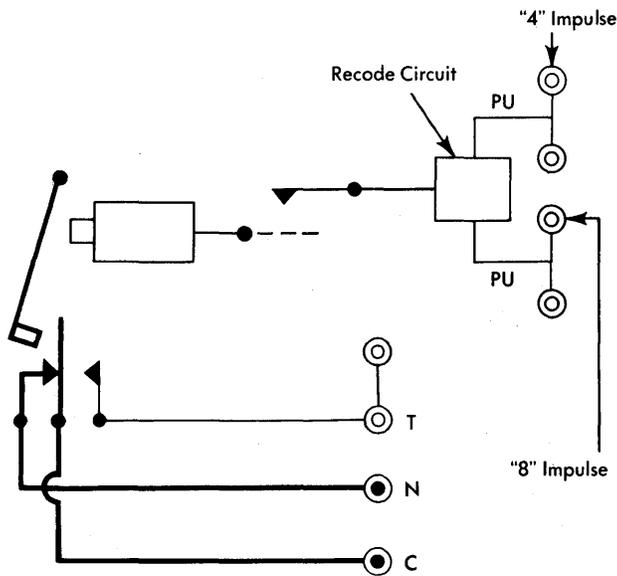


FIGURE 184. RECODE SELECTOR, NORMAL

Figure 184 shows the recode selector in the normal position. Notice that each selector has two separate pickups, each of which has two common hubs.

Both pickups must be impulsed simultaneously before the magnet is impulsed to transfer the selector. This can be done by:

1. wiring the same impulse from two different sources
2. wiring an impulse from a single source and jack-plugging the pickup hubs.

The selector in Figure 184 is not transferred, because one RECODE PICKUP has been impulsed with a 4

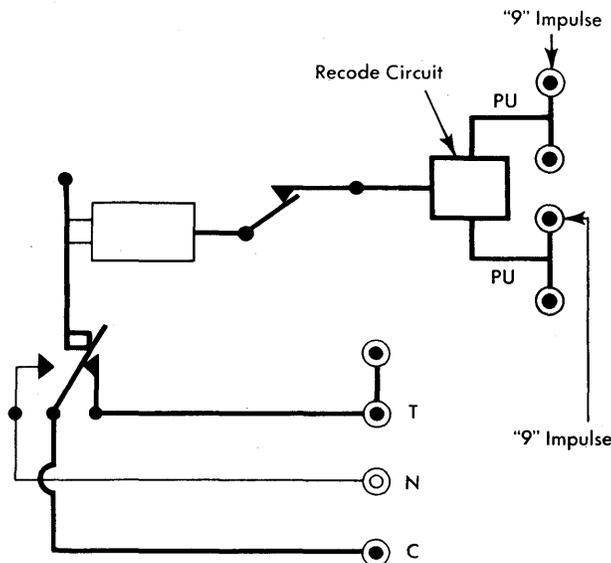


FIGURE 185. RECODE SELECTOR TRANSFERRED BY A 9 IMPULSE FROM TWO DIFFERENT SOURCES

and the other with an 8. Because cards are fed 9-edge first, the 8-impulse reaches one pickup; then the 4-impulse reaches the other pickup. The impulses do not arrive simultaneously, so the selector does *not* transfer.

In Figure 185 the 9-impulse has been wired to both of the pickup hubs from two different sources. The selector transfers whenever both impulses are received simultaneously; if only one is received, the selector remains normal.

Figure 186 illustrates the method of transferring the selector with a single impulse from a single source. A 9-impulse is wired from a single source into one of the pickups. The common hub of that same pickup is wired to one hub of the other pickup. In this case, because the 9 is wired into both pickups at the same time, the single impulse transfers the selector.

Timing of Selectors

The punch in a card (commonly an X) that is used to distinguish between card types and to transfer a selector, is a short impulse. Furthermore, this impulse is often used to transfer the selector for the *next* card read cycle. It becomes obvious, then, that this impulse alone cannot control the transfer of the selector.

IBM machines are engineered to delay the impulses received by some pickup hubs, as described under the heading *X Pickup*. The selector is held in a transferred position by one of two methods — the hold circuit, or by mechanical latches.

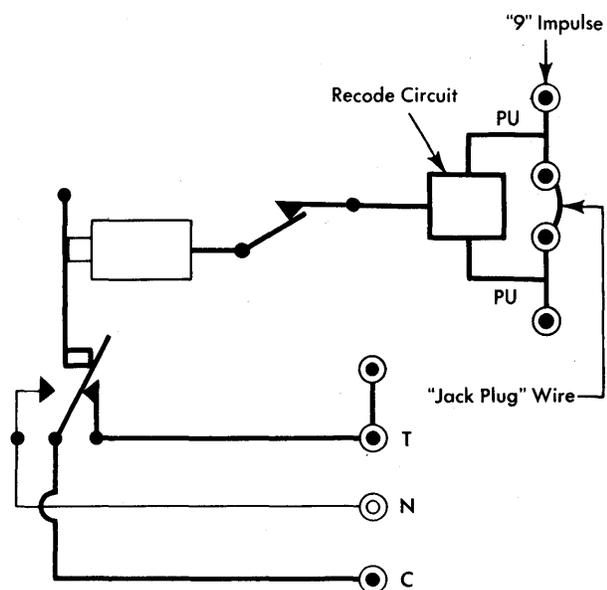


FIGURE 186. RECODE SELECTOR, TRANSFERRED BY A 9 IMPULSE FROM A SINGLE SOURCE

Latch-Type Pilot Selectors

In some machines, such as the IBM 602 Calculating Punch and the IBM 528 Accumulating Reproducer, the armature stays in its transferred position indefinitely once a selector is transferred.

This type of selector is called a *latch-type* selector, because the armature actually is latched, or locked, into the transferred position.

The latch-type selector returns to normal only when a hub called DROP-OUT is impulsed. Even turning off the main source of power does not cause the selector to return to NORMAL.

The pilot selectors shown in Figure 187 are used in the IBM 528 Accumulating Reproducer. They look like the pilot selectors on the accounting machines. The points of difference are:

1. There is no I-PICKUP hub.
2. Just below the second row of selector hubs there is a row of hubs called *drop out*. There are two common drop-out positions for each selector.

Once a pickup hub of a 528 pilot selector has been impulsed and the armature has been transferred, it remains transferred until the drop-out hub has been impulsed. Only then can the armature return to its normal position.

Non-Latch-Type Pilot Selectors

The selectors in the interpreters, collators, the accounting machines, and the electronic statistical machine are different from the latch-type selectors, because non-latch selectors remain transferred only as long as the magnets are energized.

We've already stated that if we wire the X- or D-pickup of a 402-403 accounting-machine pilot selector

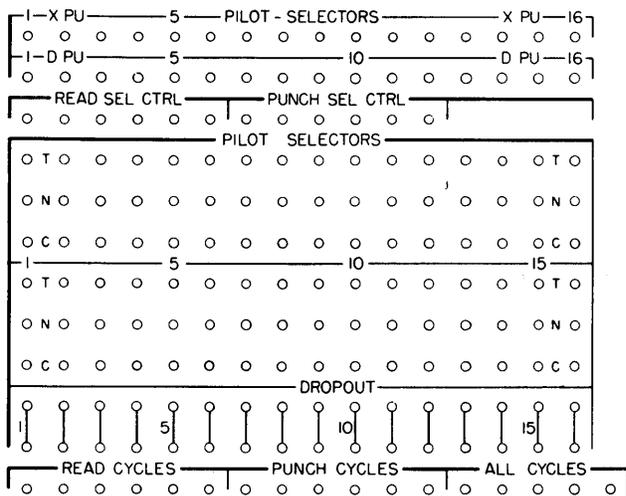


FIGURE 187. IBM 528 LATCH-TYPE SELECTORS

from SECOND READING, the selector magnet is energized and the armature is transferred as the X- or D-card passes the third reading station. The 402-403 Accounting Machine pilot selector remains transferred until the end of the cycle in which the X- or D-card passes third reading.

An impulse, available only during a small portion of the card cycle, causes the magnet to be energized for an *entire* cycle because, in effect, the machine stretches the short X- or digit-impulse, which was used to energize the magnet, to a longer one. The accounting machines have an internal electric circuit that operates whenever a selector magnet has been energized. This circuit is called a *hold* circuit, and, in effect, is a chain reaction started by the original impulse reaching the magnet (Figure 188).

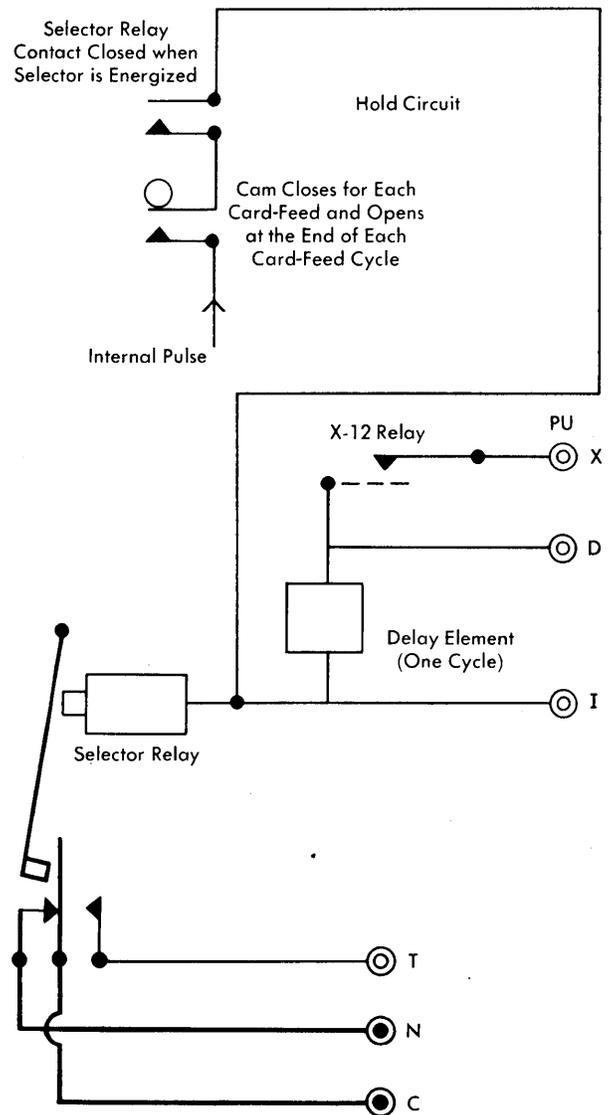


FIGURE 188. HOLD CIRCUIT

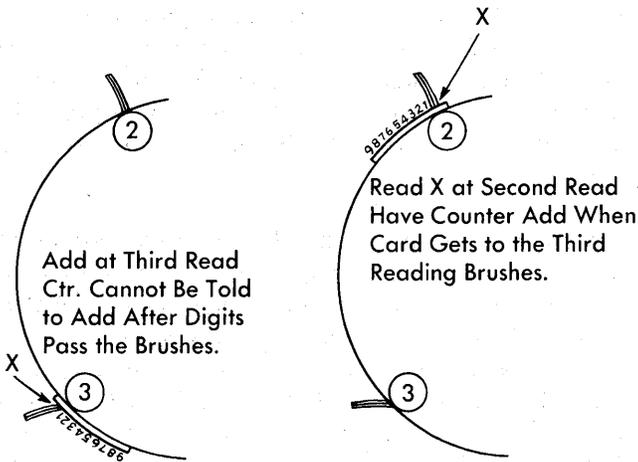


FIGURE 189. IBM 403 READ SCHEMATIC

The longer impulse, which travels through the *hold* circuit, is always available; it is used to keep the selector magnet energized only after the selector pickup hub has been impulsed.

Actually, the X- or D-pickup hub starts energizing the selector magnet, and then the *hold* impulse takes over and keeps the selector magnet energized for the rest of the cycle.

Figure 188 shows the operation of the *hold* circuit.

Now that we've discussed the pilot selectors of the accounting machines in detail, let's see what wiring is necessary on the 402-403 control panel to add the gas cards in one counter, and add the electric cards in another counter (Figure 190). The schematic (Figure

189) illustrates why we must wire the X-punch from the second-reading brushes. Remember that the electric cards have an X punched in column 80. Wires 2, 3, and 4 tell the counters to add. In this case, you see that we have not wired CARD CYCLES directly to each counter that is to add. Instead, we have selected the card-cycles impulse. Wire 1 is used to pick up selector 2. We have wired card-column 80 from SECOND READING. We must use SECOND READING rather than THIRD READING. Cards are fed into the IBM 402-403 Accounting Machine 9-edge first. Therefore, as we are adding from third reading brushes, the reading of the X would have been too late. All of the digits to be added would have passed third reading before the X-punch had been sensed. Wire 2 is connected to the card-cycles impulse, which is the impulse being selected. Wire 3 adds the amount into counter A if we have an NX- (gas) card passing through the machine. The card-cycles impulse comes out of the normal side of the selector to the counter-control-plus hub of counter A, and causes counter 8A to add *only* when NX-cards are passing the third-reading brushes. Wire 4 adds the amount into Counter B if we have an X- (electric) card passing through the machine. The card-cycles impulse comes out of the transferred side of the selector to the counter-control-plus hub of counter B, and causes counter 8B to add *only* when X-cards are passing the third-reading brushes.

Figure 191 shows the wiring necessary to accomplish the same thing (adding X-punched electric cards in counter 8B and NX-cards in counter 8A) in the 407-408-409.

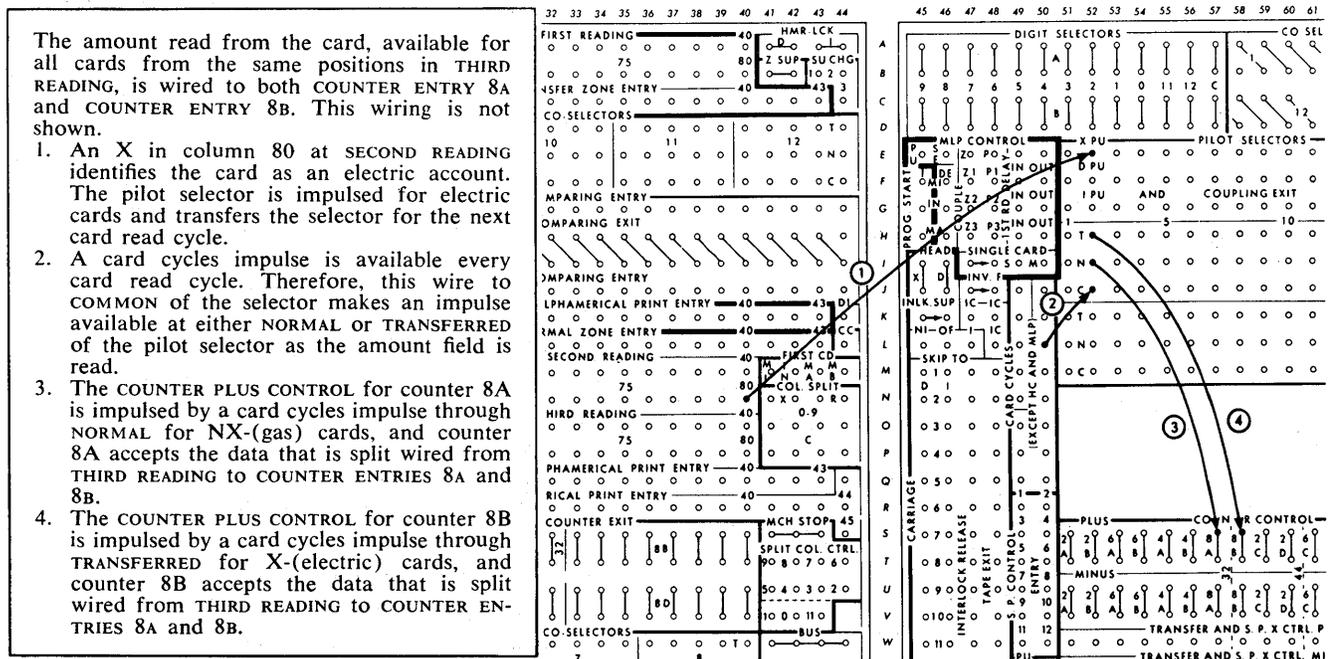


FIGURE 190. WIRING FOR COUNTER-CONTROL SELECTION, IBM 403

2. Co-selectors have no delay relays and can never be latched. To expand pilot selector positions and make a co-selector transfer at the same time as a pilot selector, the co-selector PICK-UP is wired from the COUPLING EXIT in the 407-408-409 and from the I PU AND COUPLING EXIT in the 403 (Figures 193 and 194).

As illustrated, co-selector 1 is picked up to operate like pilot-selector 1 in both the 403 and the 407-408-409 control panels.

The pilot selector in Figure 193 is picked up from SECOND READING by an X-punch in column 80. Because the pilot selector is impulsed at X-PU, it transfers for the following cycle — when the card is at third reading. As you remember, the 403 has three reading stations, and cards are fed in the machine 9-edge first. Therefore, both pilot selector 1 and co-selector 1 are transferred in time to read the card completely before it has passed third reading.

Figure 194 is the same problem wired in the 407-408-409. Because the 407-408-409 has only two reading stations, the X must be read from column 80 at the first reading station, and the pilot selector is impulsed at the X-PU. Co-selector 1 is wired from the COUPLING EXIT of pilot selector 1. Both selectors are transferred in time to read the cards completely at the second reading station.

Wiring for Selection

IBM Accounting Machines

NUMERICAL SELECTION

In the section on selection in the IBM 557 Interpreter, we instructed the machine to interpret column 51 in one place on the X- (electric) cards and in another place on the NX- (gas) cards.

Now let's assume, in a report being printed on the accounting machine, that we want to print columns 51-55 in print-positions 20-24 on X- (electric) cards, and in position 39-43 in NX- (gas) cards.

Figure 195 illustrates wiring for numerical selection in the IBM 402-403. Figure 196 illustrates wiring for selection in the IBM 407-408-409.

In these examples we have used co-selectors to illustrate their use when working in conjunction with pilot selectors.

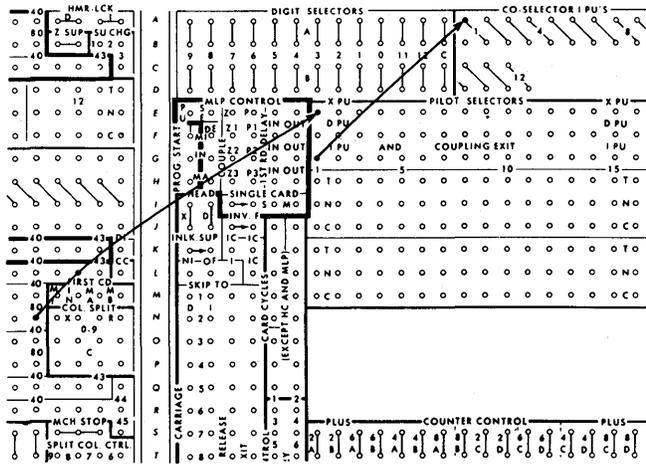


FIGURE 193. CO-SELECTOR PICKUP IMPULSED FROM PILOT SELECTOR COUPLING EXIT IN IBM 402-403

ALPHABETIC SELECTION

Using the same selection problem we have talked about thus far, except that the data in columns 51-55 is alphabetic, let's examine the wiring necessary to select alphabetic data on the 402-403 and the 407-408-409.

Electric cards are identified by a digit punch in column 80; gas cards have no punching in column 80. A digit punch (9-1) is used to control alphabetic selection in the 402-403 because the selector must be transferred before 0 zone time in the cycle.

Figure 197 shows alphabetic selection in the 402-403.

The alphabetic characters punched in columns 51-55 print from typebars 20-24 for electric cards, and from typebars 39-43 for gas cards.

Figure 196 serves for alphabetic as well as numerical selection on the 407-408-409. This is so because the printing device on these machines is a printwheel rather than a typebar. If you remember the discussion of printing on the 407-408-409, you recall that the

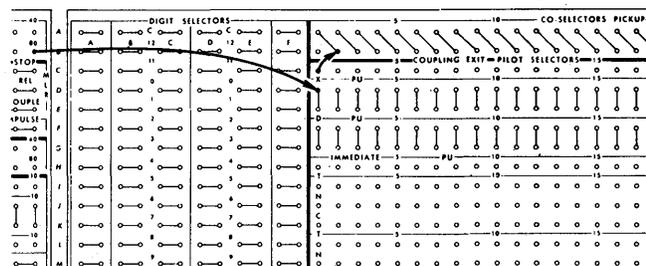


FIGURE 194. CO-SELECTOR PICKUP IMPULSED FROM PILOT SELECTOR COUPLING EXIT, IBM 407-408

FIGURE 195. CO-SELECTOR OPERATION, IBM 402-403

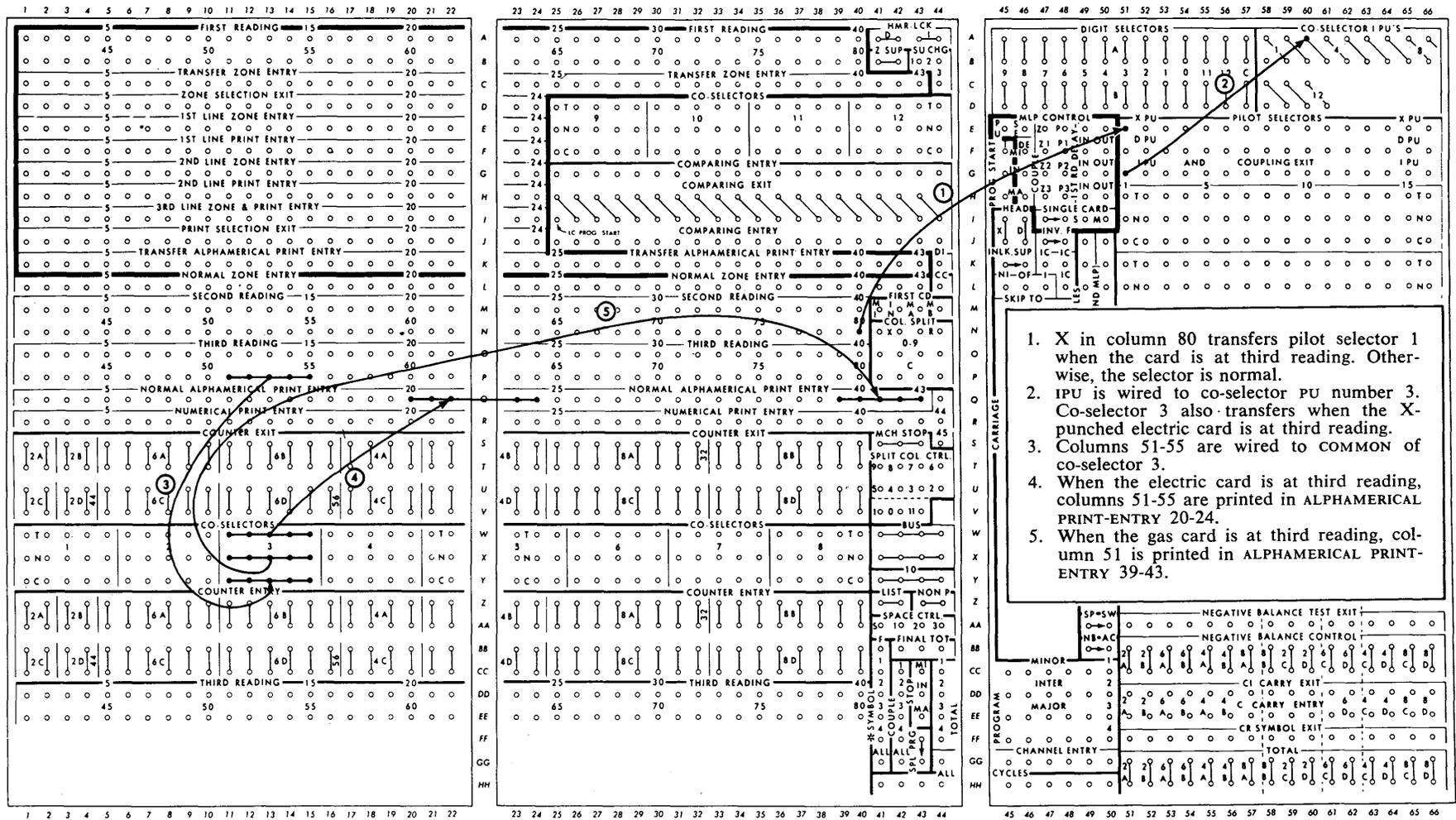
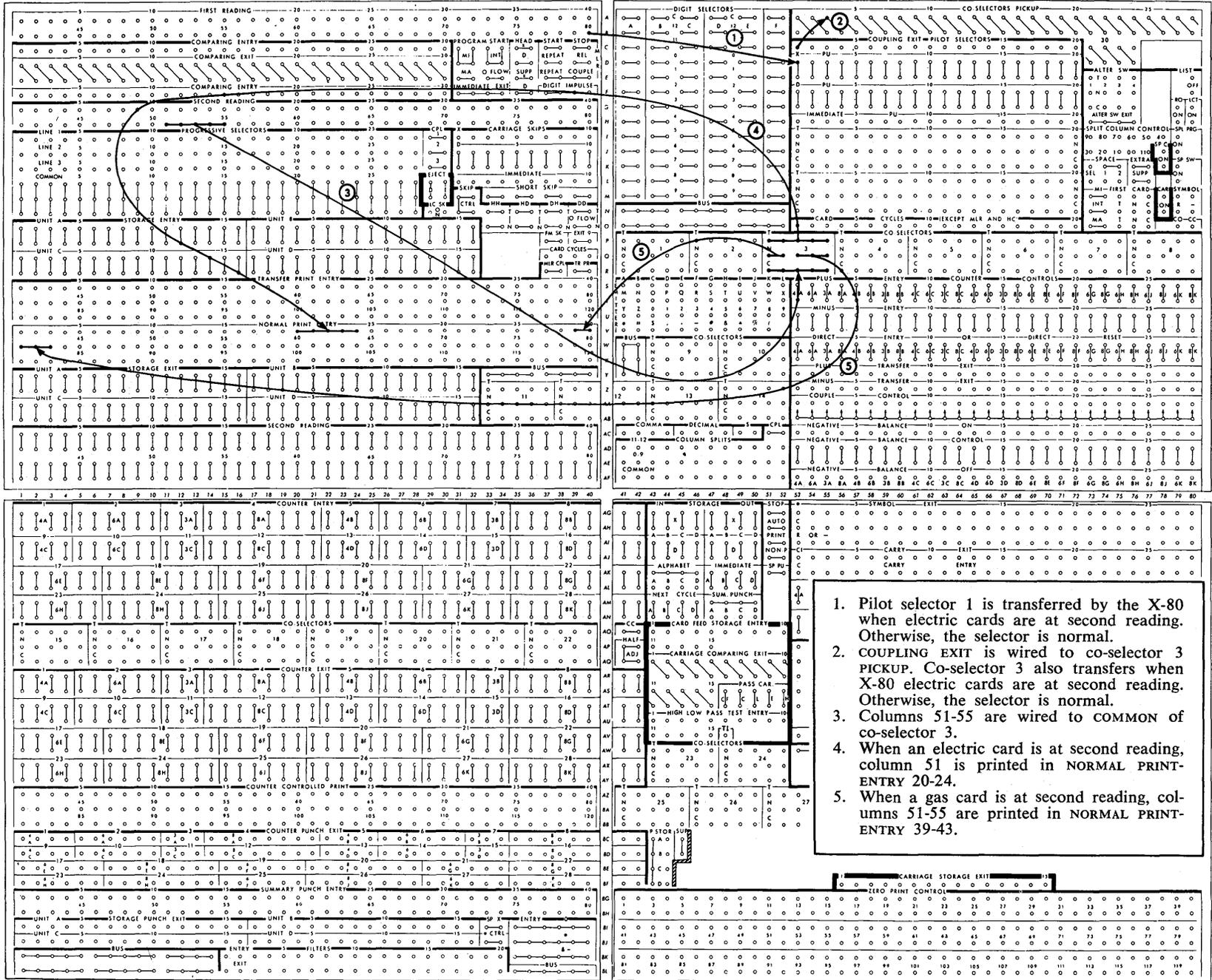
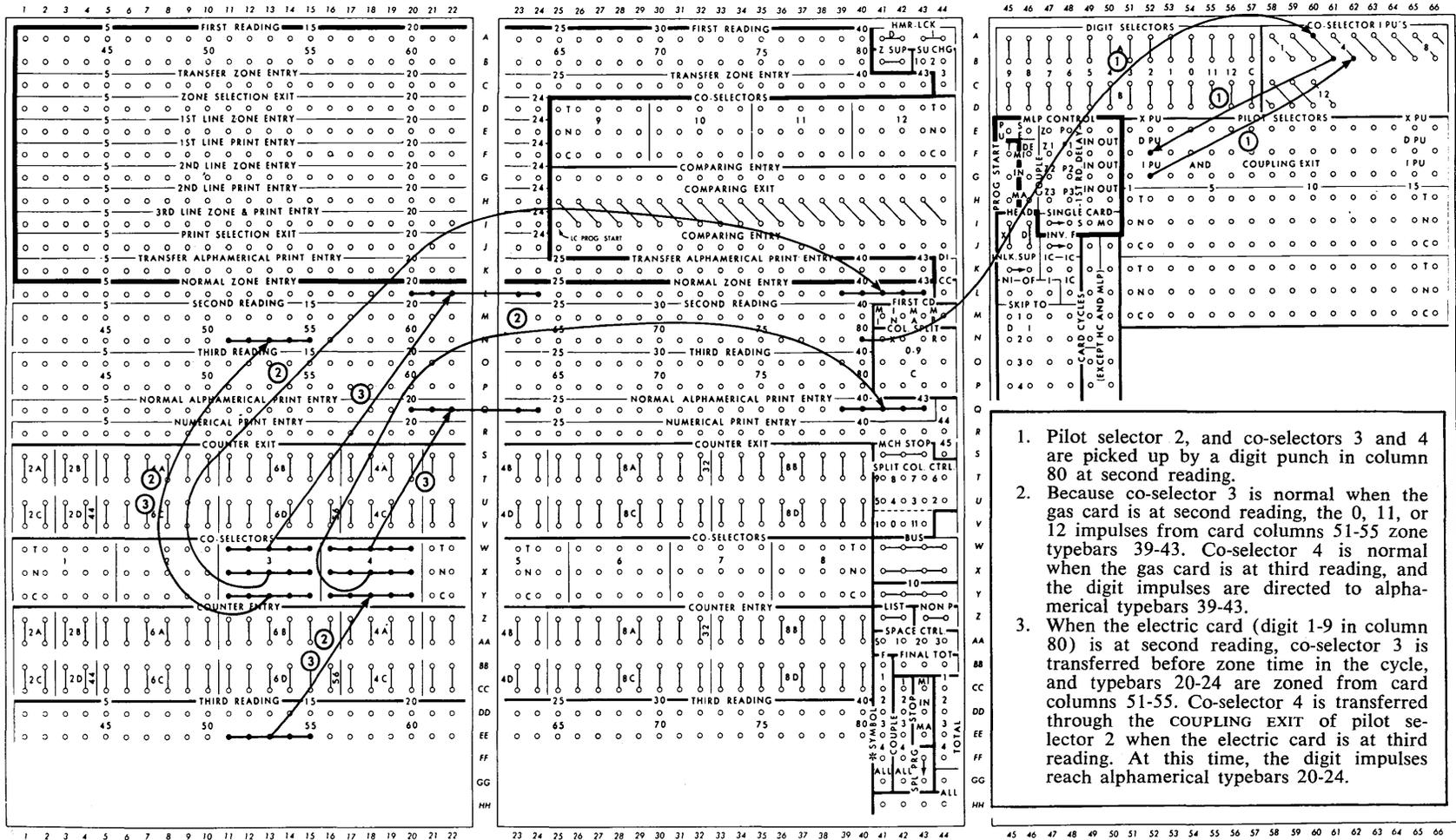


FIGURE 196. NUMERICAL AND ALPHABETIC SELECTION, IBM 407 AND 408



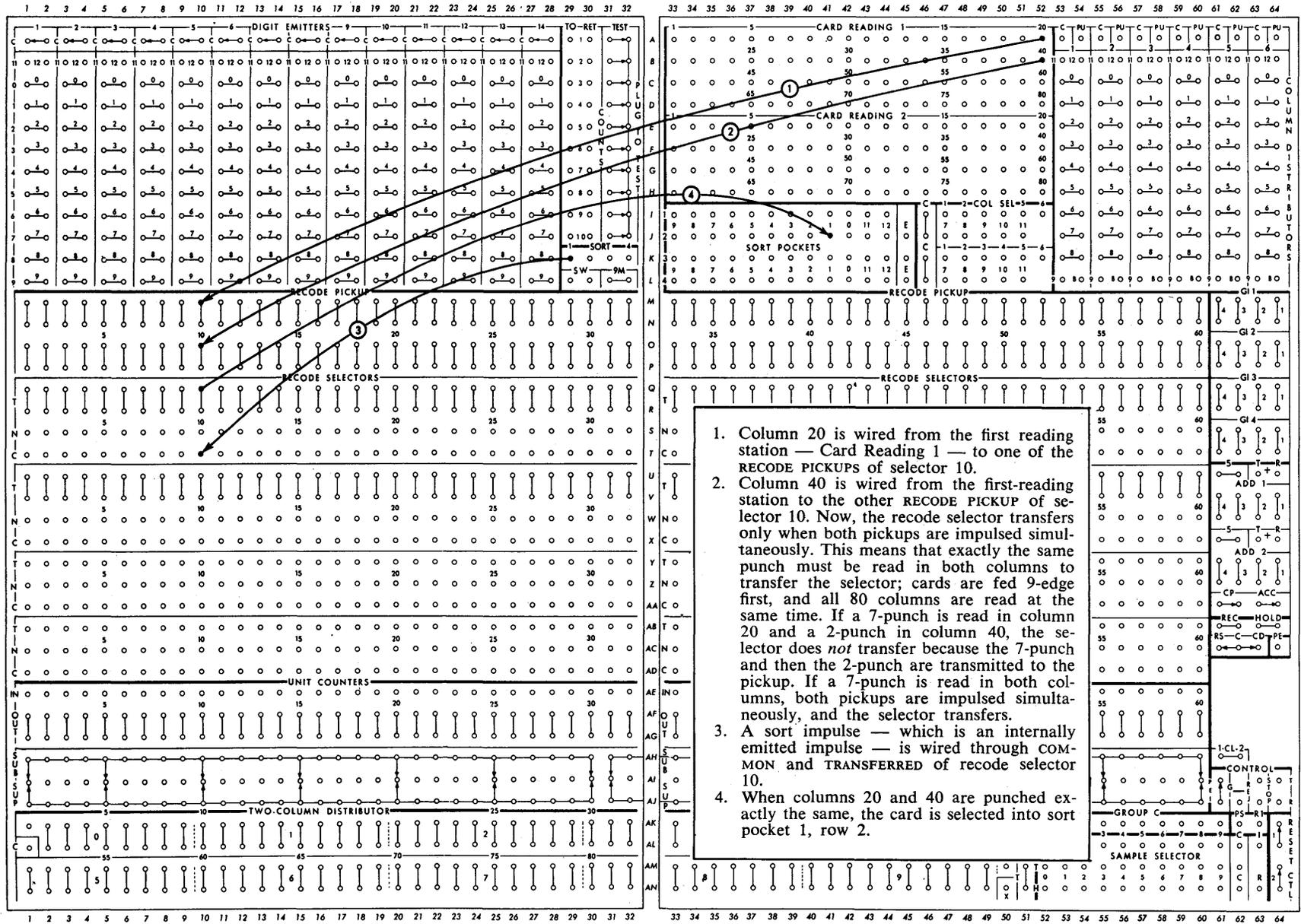
1. Pilot selector 1 is transferred by the X-80 when electric cards are at second reading. Otherwise, the selector is normal.
2. COUPLING EXIT is wired to co-selector 3 PICKUP. Co-selector 3 also transfers when X-80 electric cards are at second reading. Otherwise, the selector is normal.
3. Columns 51-55 are wired to COMMON of co-selector 3.
4. When an electric card is at second reading, column 51 is printed in NORMAL PRINT-ENTRY 20-24.
5. When a gas card is at second reading, columns 51-55 are printed in NORMAL PRINT-ENTRY 39-43.

FIGURE 197. ALPHABETIC SELECTION, IBM 402-403



1. Pilot selector 2, and co-selectors 3 and 4 are picked up by a digit punch in column 80 at second reading.
2. Because co-selector 3 is normal when the gas card is at second reading, the 0, 11, or 12 impulses from card columns 51-55 zone typebars 39-43. Co-selector 4 is normal when the gas card is at third reading, and the digit impulses are directed to alphabetical typebars 39-43.
3. When the electric card (digit 1-9 in column 80) is at second reading, co-selector 3 is transferred before zone time in the cycle, and typebars 20-24 are zoned from card columns 51-55. Co-selector 4 is transferred through the COUPLING EXIT of pilot selector 2 when the electric card is at third reading. At this time, the digit impulses reach alphabetical typebars 20-24.

FIGURE 198. RECODE SELECTOR OPERATION



1. Column 20 is wired from the first reading station — Card Reading 1 — to one of the RECODE PICKUPS of selector 10.

2. Column 40 is wired from the first-reading station to the other RECODE PICKUP of selector 10. Now, the recode selector transfers only when both pickups are impulsed simultaneously. This means that exactly the same punch must be read in both columns to transfer the selector; cards are fed 9-edge first, and all 80 columns are read at the same time. If a 7-punch is read in column 20 and a 2-punch in column 40, the selector does *not* transfer because the 7-punch and then the 2-punch are transmitted to the pickup. If a 7-punch is read in both columns, both pickups are impulsed simultaneously, and the selector transfers.

3. A sort impulse — which is an internally emitted impulse — is wired through COMMON and TRANSFERRED of recode selector 10.

4. When columns 20 and 40 are punched exactly the same, the card is selected into sort pocket 1, row 2.

wheel first receives digit impulses and positions itself; if a zone impulse is then received, the wheel re-positions itself to print an alphabetic character.

Because the zone impulses do *not* have to be received first on the 407-408-409, both digits and zones can be read and selected at second reading. Control impulses (in this case, the X in column 80 of electric cards) are read at first reading to impulse the selector.

IBM 101 Electronic Statistical Machine

Selectors on the 101 have many uses related to sorting various cards and combinations of cards into various pockets in the machine.

Figure 198 illustrates the wiring necessary to select all cards that have the same punch in columns 20 and 40 into pocket 1, row 2.

Review Questions

1. When must a selector be used?
2. How can an IBM machine tell the difference between two types of cards?
3. Name the different parts of a selector.
4. How does a selector differ from a column split?
5. The X-pickup hub of a selector normally accepts
6. The D-pickup hub of a selector normally accepts
7. The I-pickup hub of a selector normally accepts
8. What is the effect of the X-12 relay?
9. Selector X-pickup hubs and their effect may vary. What is the reason for the difference between the X-pickup hub of a collator and X-pickup hub of an IBM 403 Accounting Machine?
10. What is the effect of the delay relay in the 403 selector?
11. How long does a latch-type selector remain transferred?
12. What controls how long a non-latch-type selector remains transferred?
13. Can you wire into the transferred side of a selector and out of the common hub?
14. The X-O SPT PICKUP of a 557 selector accepts
15. The DIGIT PICKUP of a 557 selector accepts
16. The RECODE PICKUP of a 101 selector accepts
17. How does alphabetic selection differ from numerical selection on the 557?
18. What are the differences between the selectors on the 77 collator and the selectors on the 85 collator?
19. How does a co-selector differ?

Addition

Addition is accumulation of individual amounts to obtain totals.

Manual totals for single-digit numbers can be obtained with comparative ease. However, when larger numbers must be added, time is needed to secure accurate totals (Figure 199).

When simple numbers are being added, it isn't necessary to provide the human mind with help. However, as the numbers become larger, and their use more frequent, it is necessary to relieve the individual of this work. Machines have been developed to enable the individual to spend his time more productively.

Primitive man counted on his fingers to arrive at totals. Modern man has been given help in the form of counters. Counters can be mechanical, like a mileage indicator in an automobile, or they can be electronic, employing tubes, magnetic cores, etc. (Figure 200).

Basic Steps in Addition

You are familiar with desk adding-machines. Let's review the basic steps needed to make this kind of machine add, and then see how the same four basic steps are used in the IBM machine method.

There are four basic steps needed to make any machine add. Whether a machine has wheels or electronic circuitry for counters, or is manually or automatically operated, does not affect the four basic steps.

The Adding-Machine Method

1. The operator must *read* the number to be added and take it to a counter by pressing the proper keys on the keyboard (Figure 201).

$$\begin{array}{r}
 2 \\
 2 \\
 \hline
 4
 \end{array}
 \qquad
 \begin{array}{r}
 65849370 \\
 13582968 \\
 \hline
 54839201 \\
 \hline
 134271539
 \end{array}$$

FIGURE 199. TOTALING LARGE NUMBERS

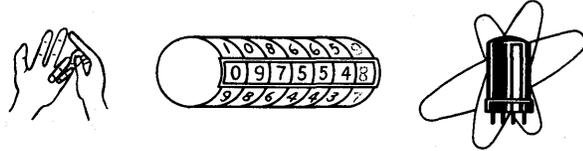


FIGURE 200. TYPES OF COUNTERS

2. The operator must tell the machine to *add* the number in the counter by pulling a handle (Figure 202).
3. The operator must make the machine *print* the individual amounts and the total by pulling the handle. Type and paper are provided in the machine (Figure 203).
4. The operator must tell the machine to print the *total* by pressing a total key on the keyboard and pulling the handle (Figure 204).

Therefore, the four basic steps are:

- | | |
|---------|----------|
| 1. Read | 3. Print |
| 2. Add | 4. Total |

The only difference between the desk adding-machine method and the IBM method is that in the IBM machines, control-panel wiring is substituted for the manual operations.

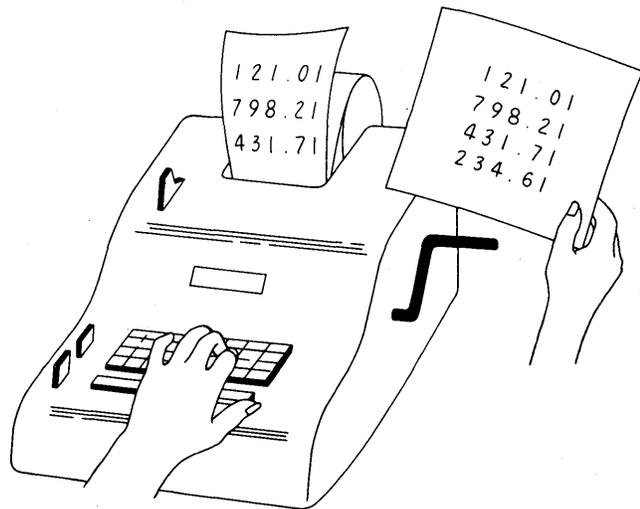


FIGURE 201. READ

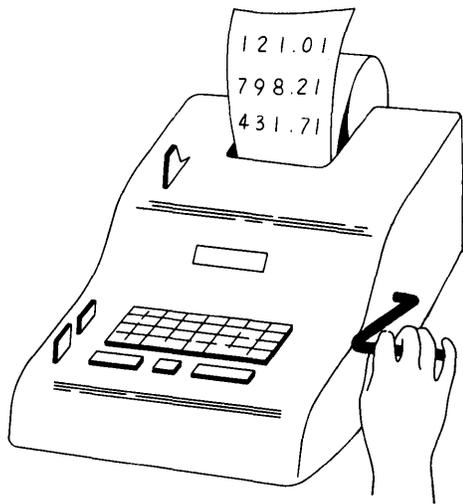


FIGURE 202. ADD

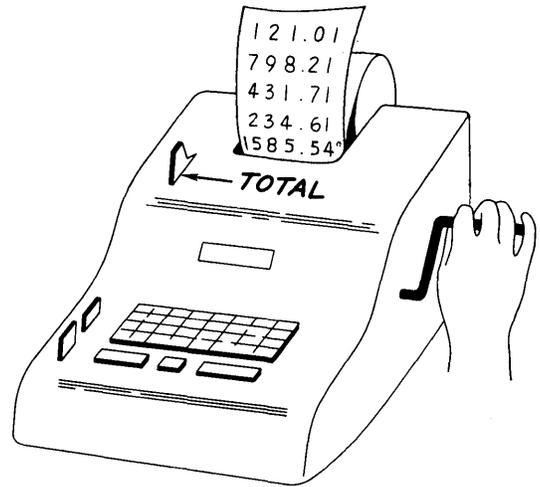


FIGURE 204. TOTAL

The IBM Method

1. The machine can *read* the information to be added from an IBM card by a set of brushes and, by means of control-panel wires, take it to the counter (Figure 205).
2. The counter can *add* the information when told to do so. On the adding machine we pull a handle; on IBM machines we must wire a special impulse to the counter to tell the machine to add (Figure 206).
3. IBM machines equipped with paper and type can *print* the information being added in the counters. On the adding machine we pull a handle to force the printing; on the IBM machine we connect the counter and the typebars or typewheels by control-panel wires (Figure 207) and force the machine to print by impulsing the print unit with controlled impulses.

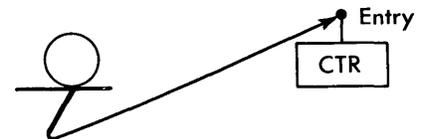


FIGURE 205. READ

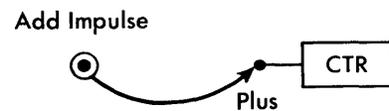


FIGURE 206. ADD

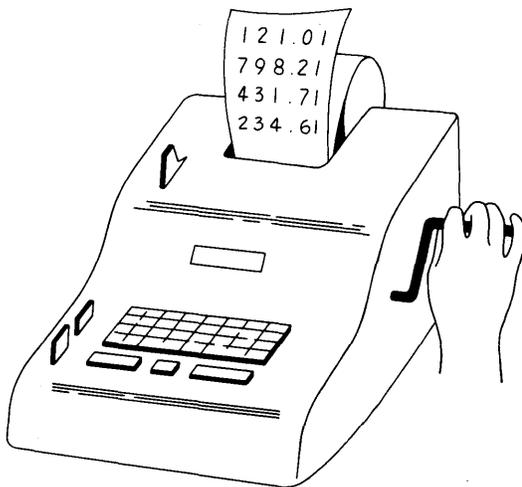


FIGURE 203. PRINT

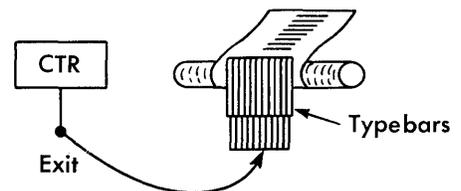


FIGURE 207. PRINT

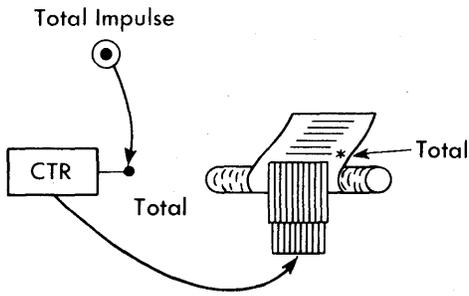


FIGURE 208. TOTAL

- IBM counters must be told to print the *total*. On the adding machine, when the operator recognized the end of a group, he pressed the total key, and pulled a handle. On IBM machines, the comparing magnets recognize the end of a particular group of cards, and a resulting impulse is wired to the counter controls to tell the machine to print the total (Figure 208).

COUNTER WHEELS

The general arrangement of a counter wheel from an IBM machine is shown in Figure 209. Each counter wheel has the digits 0-9.

Two or more counter wheels placed next to each other in an IBM machine are called a counter, or counter group. Some IBM machines have as many as 168 counter wheels (counter positions). These are arranged in counter groups, or counters, of two, three, four, six, or eight counter wheels (Figure 210).

All the wheels in one counter group are entirely separate from the wheels of another counter group. To avoid any possibility of confusion on the control panel, the counter groups have been given separate designations.

For example, in an IBM machine with 80 counter wheels, there are 16 separate counters, each with a digit and letter combination. The *digit* indicates the number of counter wheels (positions) in that particular counter group. The *letter* identifies the particular counter group, as there are four of each size: A, B, C, and D. There are four 2-position, 4-position, 6-position, and 8-position counters (Figure 211).

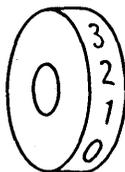


FIGURE 209. COUNTER WHEEL

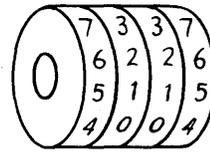


FIGURE 210. COUNTER WHEELS ARRANGED IN A GROUP

2A	4A	6A	8A
2B	4B	6B	8B
2C	4C	6C	8C
2D	4D	6D	8D

FIGURE 211. COUNTER GROUPING

If you think about the speedometer in an automobile you will remember what happened when your mileage changed from 9,999 to 10,000 miles.

The addition of a 1 in the units wheel changed the wheel from 9 to 10. As the wheel does not have a 10 character, it turned back to 0 and the 1 was internally carried over to the counter wheel to its left.

In the example given, the addition of the 1 to the units position of the counter changed the units, 10's, 100's, and 1,000's wheel to 0. The 1 appeared in the 10,000's wheel.

Within a counter group, each wheel is internally connected to the wheel immediately to its left. Each time a counter wheel moves from the 9-position to the 0-position, the wheel to its left (within the same counter group) automatically advances one position (Figure 212).

The right-hand wheel and the left-hand wheel in each counter group have been given special names (Figure 213). The right-hand wheel is called the *low-order position*; the left-hand wheel is called the *high-order position*.

An understanding of counter capacity is necessary before we discuss wiring a specific machine. A 2-position counter can add to a total of 99. A 6-position counter can accumulate a total of 999,999. An 8-position counter can accumulate a total of 99,999,999. Therefore, to determine which size counter to use, we must know the size of the largest total we shall ever accumulate.

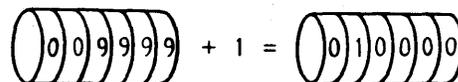


FIGURE 212. COUNTER WHEEL CHANGES FROM 009999 TO 010000

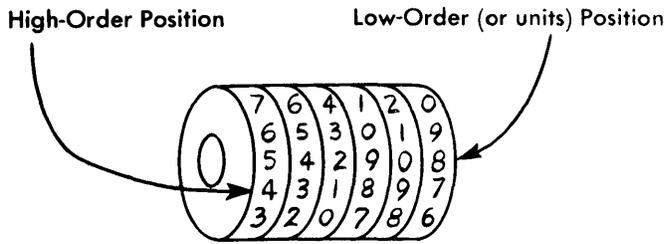


FIGURE 213. COUNTER POSITIONS

Wiring for Addition

The IBM 402-403 Accounting Machines

To fix in your mind the basic steps necessary for addition, let's see how you would make the 402-403 Accounting Machine prepare the report shown in Figure 214.

STEP 1: READ. We must read the information from the card columns in which it is punched and take it to the counter (Figure 215). Therefore, we must wire from THIRD READING to a counter entry.

We wish to add the amount that is punched in card columns 75-78. Therefore, we must use third-reading-brush exit hubs 75-78. As the field contains four columns, we must use at least a 4-position counter.

We need a counter larger than four positions because we know from past experience that a clerk in this department can sell more than \$99.99 worth of goods in one day. We also know that no one has ever sold more than \$999.99. Therefore, since our total may run as high as five positions, but no higher, we must use a 6- or 8-position counter.

When wiring information into a counter group from a set of brushes reading a card field, we wire the units position of the card field to the units position of the counter group, the 10's position of the card field to the 10's position of the counter group, etc. (Figure 216).

SALES CLERK	AMOUNT
5	17 50
5	18 20
5	18 50
	54 20 *
6	18 60
6	10 00
	28 60 *

FIGURE 214. ACCOUNTING-MACHINE REPORT



FIGURE 215. READ

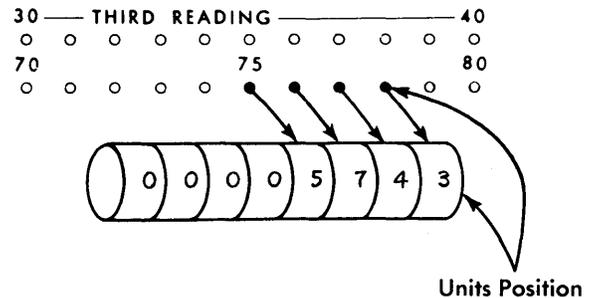


FIGURE 216. A CARD FIELD IS READ BY BRUSHES

Because of this rule, the columns at the edges of a card field are called *high order* and *low order*. These names have the same meaning as used in reference to a counter group. The left-hand column is the high-order position, and the right-hand column is the low-order position (Figure 217).

We read the information into a counter by using COUNTER ENTRY. Counter-entry hubs for counters 2A, 2B, etc. are shown in Figure 218. The wiring

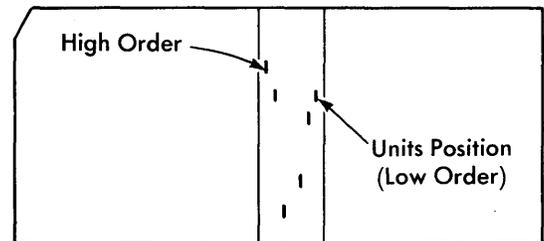


FIGURE 217. CARD FIELDS HAVE HIGH-ORDER AND LOW-ORDER POSITIONS

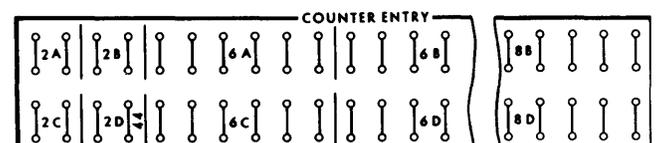


FIGURE 218. COUNTER ENTRY HUBS

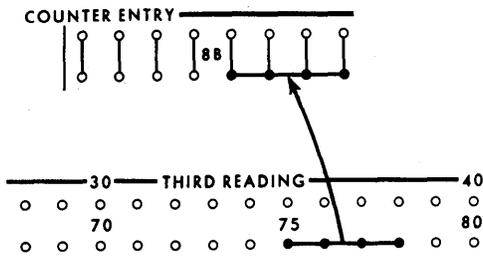


FIGURE 219. WIRING FOR COUNTER ENTRY

required to take the information from card columns 75-78 to counter 8B is shown in Figure 219.

In addition to wiring the information from the third-reading-brush exit hubs to the counter-entry hubs, we must tell the counter to add. The schematic diagram (Figure 220) shows us why we must give the machine special instructions to make it add.

To get the impulses that are wired to the counter-entry hubs into the counter itself, we must transfer the relay shown to complete a circuit.

The relay (called *counter control plus*) closes only when its magnet is energized. The schematic shows that two common control-panel hubs, labeled COUNTER CONTROL PLUS, lead to the magnet. If an impulse is wired to either of the common hubs for this relay, the magnet is energized, and the relay transfers.

This transfer of the armature completes a circuit and sends an impulse from the counter-entry hubs to the counter.

Each counter group has its own counter-control-plus hubs (Figure 221).

We wish to add the amount from each card as it passes the third-reading brushes. Therefore, the

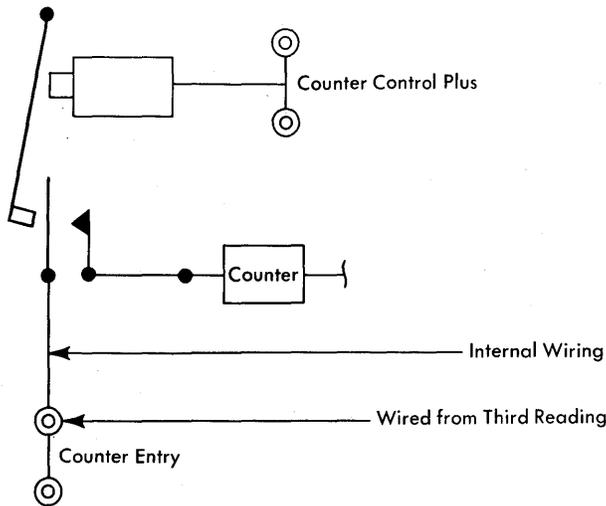


FIGURE 220. COUNTER-ENTRY SCHEMATIC

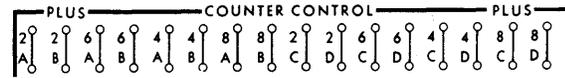


FIGURE 221. COUNTER CONTROL PLUS HUBS

counter-control-plus relay must be transferred while the card passes third reading.

On the 402-403 control panel there are 16 hubs labeled CARD CYCLES. Each of these independent hubs (Figure 222) emits a manufactured impulse while a card is passing third reading, and *at no other time*. This, then, is the impulse we can use to transfer the counter-plus relay and complete the circuit to the counter.

If we wire a card-cycles impulse to the counter-control-plus hub for the particular counter used, we close the counter-control-plus relay whenever a card is passing third reading (Figure 223). Any information read by the third-reading brushes and wired to the counter-entry hub now adds in the counter. Digit impulses read into COUNTER-ENTRY can now get to the counter.

Figure 224 illustrates this control-panel wiring.

STEP 2: ADD. When we impulse the counter-control-plus hub, we allow the digits punched in the card to reach the counter wheels. When the first card starts through the 402-403 Accounting Machine, 9-edge first, the wheels of all the counters stand at 0. When impulses from the card reach the counter, the counter wheels start turning.

In Figure 225, the counter is standing at 0, and the impulse from the hole in the card has just reached the counter wheel.

The wheel now starts to move in time with the movement of the card past the reading brushes. From the time the wheel starts to move, until it stops at 0-time, four positions of the card move past the third-reading brushes. As the four punching positions of the card pass the reading brushes, the counter wheel advances four numbers and stops at 0-time.

The digit 4 has been added into the counter wheel as shown.

When adding in a counter it is necessary only to *start* electrically the adding wheel in motion. The wheel is stopped mechanically and automatically at 0-time of the machine cycle. Figure 225

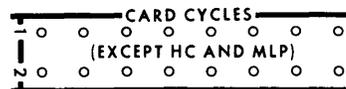


FIGURE 222. CARD-CYCLE HUBS

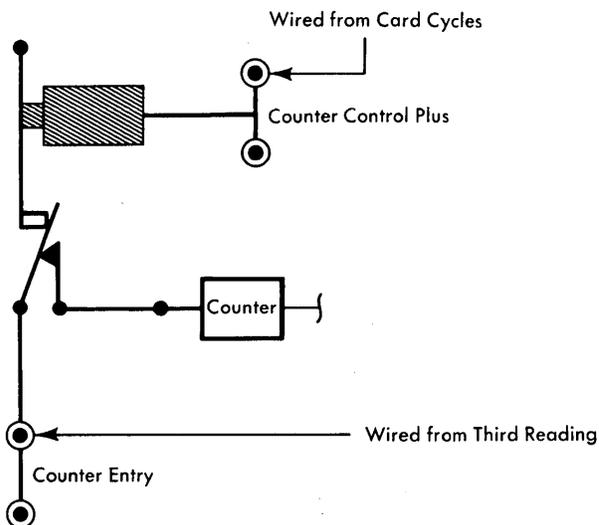


FIGURE 223. PATH FROM THIRD READING TO COUNTER WHEN COUNTER CONTROL PLUS IS IMPULSED

showed a 4 being added into a counter wheel. Fig. 226 shows this on a counter chart. Assume we have zeros in the counter wheels, and that we are using a two-position counter. The units-position wheel does not move until the 4-hole in the card is read by the brush. At that time the impulse to the start magnet starts the wheel moving. The adding wheel continues to turn until it is stopped mechanically at 0-time of the machine cycle.

The tens-position adding wheel did not turn because the card was not punched in the tens column. At the completion of the card-feed cycle we have 04 standing in the counter wheels.

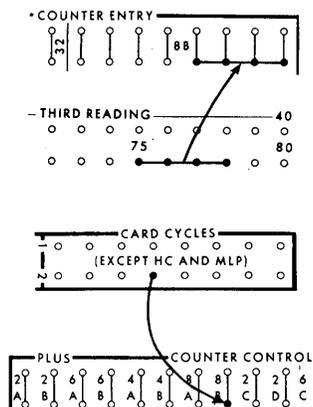


FIGURE 224. WIRING FOR ADDITION

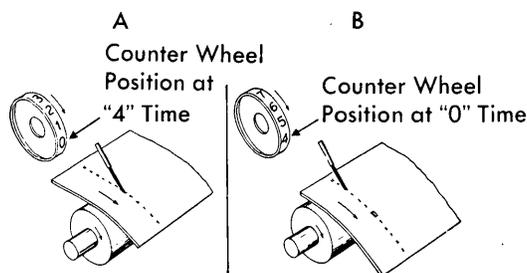
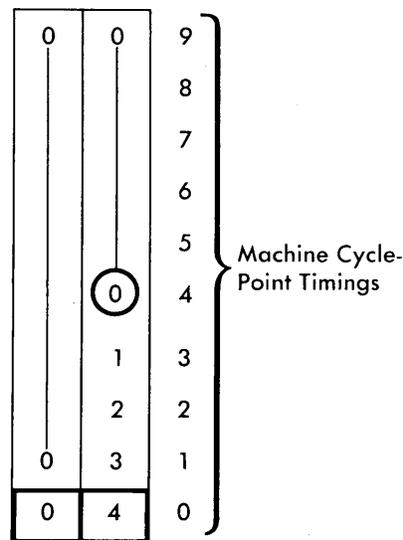


FIGURE 225. MOVEMENT OF COUNTER WHEEL IN ADDITION

STEP 3: PRINT. In the preceding steps we took the information from each card into a counter and caused the counter to add.

By using the counter exits provided for each counter (Figure 227) we can print the numbers from each card as it passes the brushes.



Adding "4" in Counter



FIGURE 226. MACHINE CYCLE-POINT TIMINGS IN ADDITION

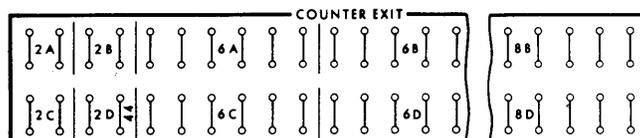


FIGURE 227. COUNTER-EXIT HUBS

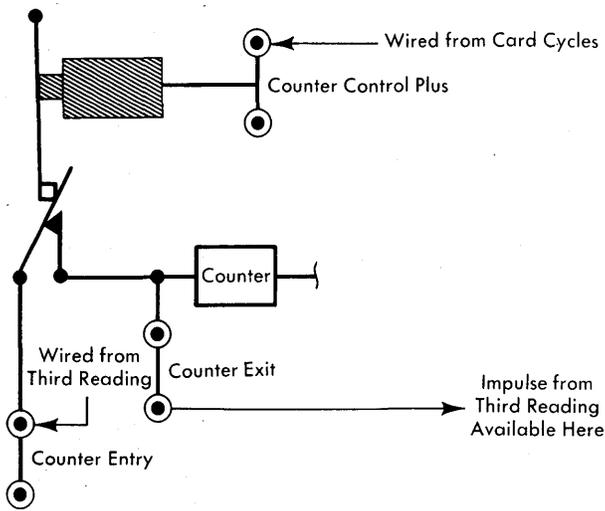


FIGURE 228. PATH FROM COUNTER ENTRY TO COUNTER EXIT WHEN COUNTER CONTROL PLUS IS IMPULSED

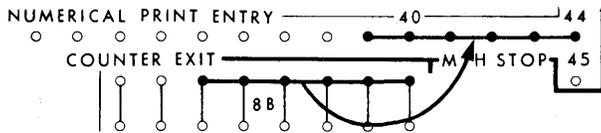


FIGURE 229. COUNTER EXITS ARE WIRED TO PRINT ENTRY HUBS

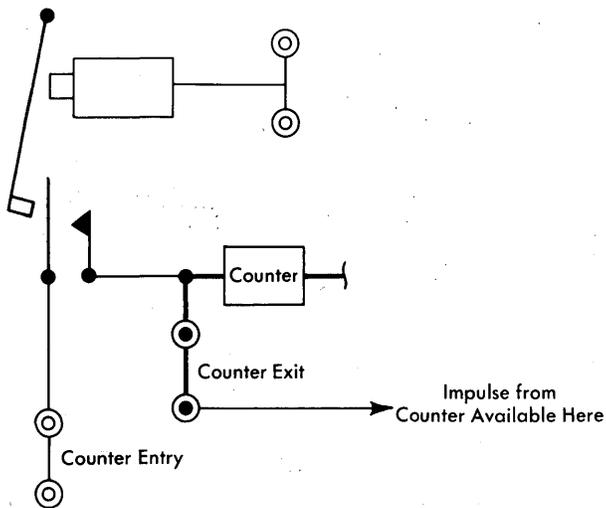


FIGURE 230. WHEN IMPULSED TO TOTAL, COUNTER EMITS THROUGH COUNTER EXITS TO PRINT ENTRY

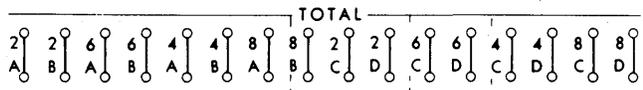


FIGURE 231. COUNTER TOTAL HUBS

The schematic diagram (Figure 228) shows that whenever COUNTER-CONTROL-PLUS of a counter is impulsed, anything put into COUNTER-ENTRY goes to two places:

1. to counter wheels to be added, and
2. to COUNTER-EXIT.

If, on the control panel, we wire the counter-exit hubs to the typebar entry hubs, we can set up the typebars to print information from each card as it passes the third-reading brushes. Looking at the schematic you will also see that *only information added* into the counter is available at the counter-exit hubs.

Figure 229 shows the wiring added to the control panel to provide this path to the typebars.

STEP 4: TOTAL. In the preceding steps we have taken the information from the card, printed it, and accumulated the numbers in a counter.

But we still have to tell the counter to print the total. The counter schematic (Figure 230), shows a path from the counter to the counter-exit hubs.

For each counter on the control panel, there are two common hubs labeled TOTAL (see Figure 231).

Impulsing a total hub for a particular counter causes the counter wheels to reset to 0. When this reset occurs, the digits that stand in the counter wheels are emitted (or read out) at COUNTER-EXIT.

Therefore, we can tell the counter to print the total by impulsing the total hub.

But we want the total hub impulsed only when the end of a particular group of cards is reached.

In the section of this manual on *comparing* we wired the unequal impulse, which indicated the end of one group of cards and the beginning of another, to a hub on the control panel called MINOR PROGRAM START (Figure 232).

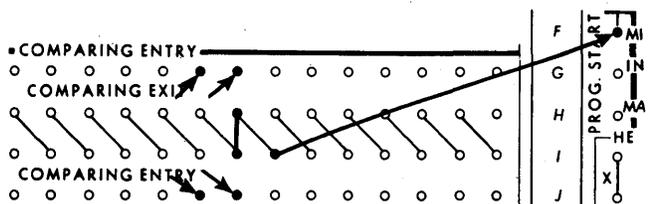


FIGURE 232. COMPARING FOR GROUP CONTROL

At the end of the card-feed cycle during which the minor-program-start hub receives an unequal impulse (due to the recognition of the end of a particular group of cards), two things happen:

1. The feeding of cards stops.
2. The hubs on the control panel labeled MINOR PROGRAM (Figure 233) emit impulses that you can use to tell the counters to read out and reset.

These two things happen only because the unequal impulse wired to the MINOR PROGRAM start hub tells the machine to take a total, or program cycle.

A *total cycle* is a machine cycle during which the counters can be reset and the amounts standing in the counters can be printed.

Because we impulse minor program start when the end of a group of cards is recognized, we have an impulse available out of the minor-program hubs. This we wire to the *total* hub of the counter we wish to read out and reset (Figure 234).

The schematic diagram (Figure 235) shows how the minor-total-program impulse becomes available when MINOR-PROGRAM-START is impulsed.

Figure 236 shows one wire that has not yet been discussed. This is the wire connecting one of the hubs labeled ALL CYCLES with one of the two common hubs labeled LIST.

Impulsing one of the LIST hubs causes the typebars to rise, and advances the paper roller (or platen) one space to allow for printing the next line of information.

In the problem for which we drew the wiring diagram, we wish to print from each card as it passes the third-reading brushes, and we also wish to print the total for each group of cards. To do this, we must make the typebars operate for each card-feed cycle and each total cycle.

The list hub must, therefore, be impulsed by an impulse available on all card-feed and all total cycles. As its name implies, the *all-cycles* impulse is the answer. It is available on all machine cycles, which include the card-feed and total cycles.

This wiring completes the steps required to make the 402-403 accumulate and print a total.

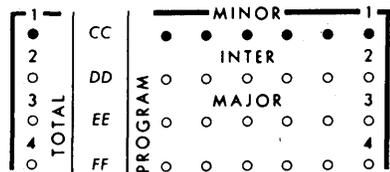


FIGURE 233. PROGRAM TOTAL HUBS

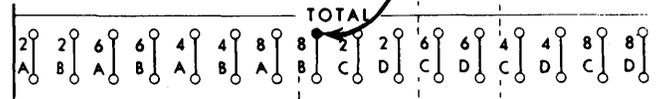
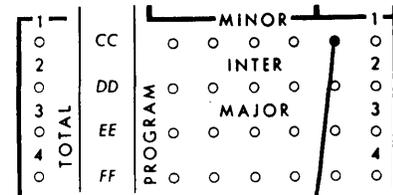


FIGURE 234. COUNTER IMPULSED TO TOTAL FROM PROGRAM HUB

Again, the four basic steps that apply to a desk adding-machine or an IBM accounting machine are:

1. Read
2. Add
3. Print
4. Total

IBM machines, in addition to the accounting machines, are capable of adding. In some the mechanical principles are slightly different, but the four basic steps must always be taken. In some IBM machines, such as the IBM Calculating Punches, the results are punched, instead of printed. If you substitute PUNCH for PRINT in step 3, you still have the same four basic steps.

Wiring the IBM 407-408-409 Accounting Machines to Add

We shall now discuss the wiring and circuitry necessary to print the report shown in Figure 214 using the 407-408-409.

Many of the concepts we discussed concerning the 402-403 are applicable to the 407-408-409; some are not. Both types of concepts are covered in this section.

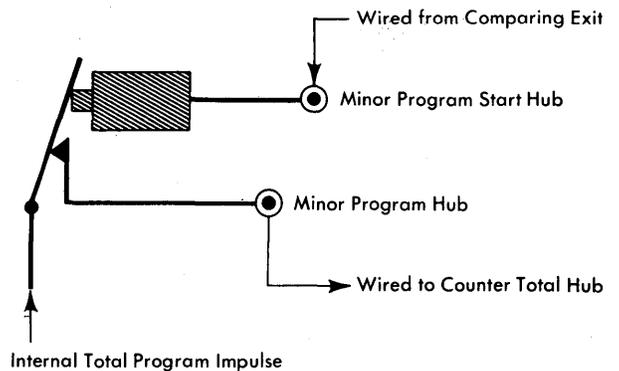
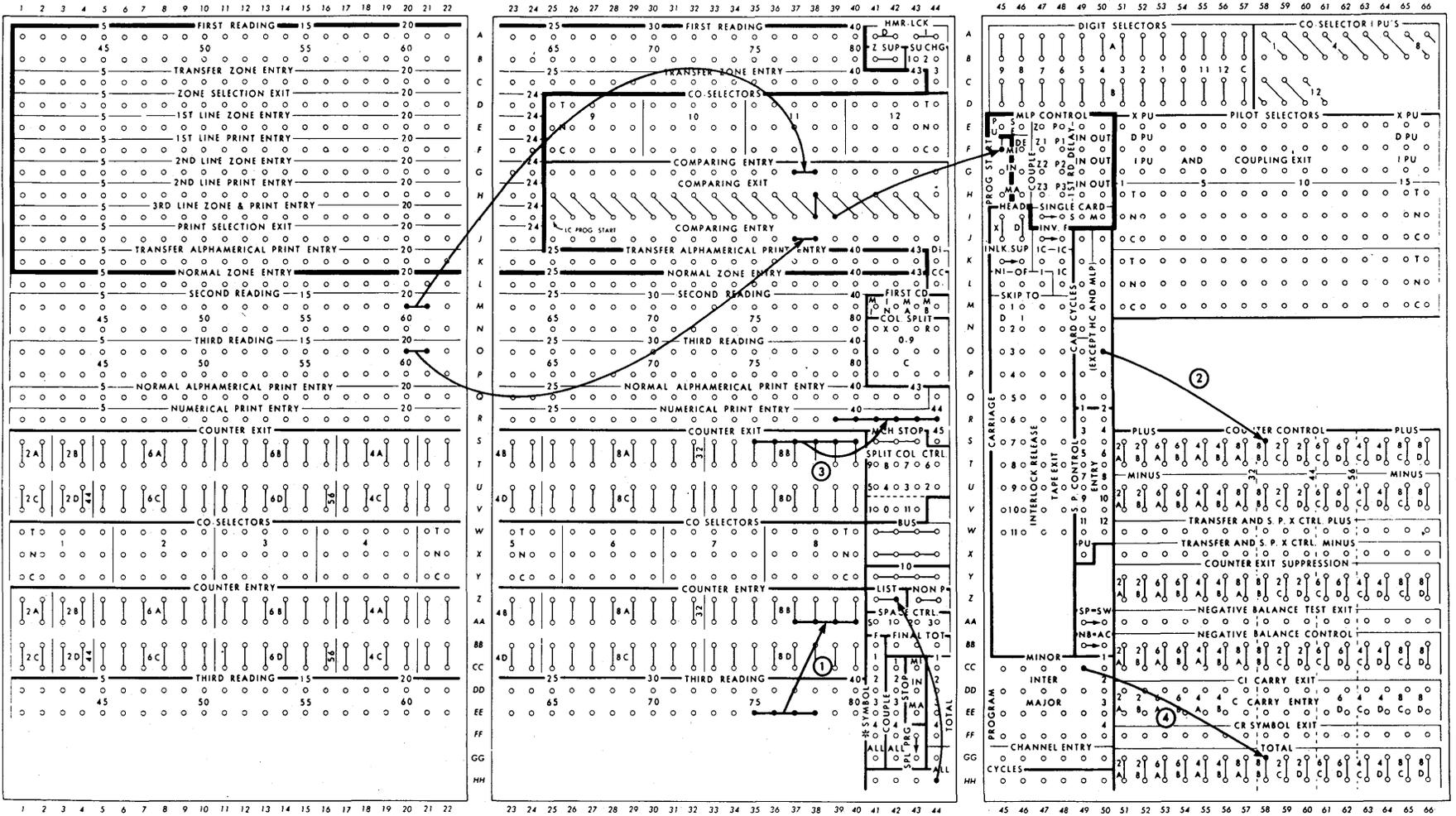


FIGURE 235. TOTAL CYCLE IMPULSED FROM COMPARING EXIT

FIGURE 236. ADDITION WITH GROUP TOTALS



As you know, the printing mechanism on the 407-408-409 is the printwheel instead of the typebar. The function of this wheel is included in the section *Printing*.

Both the 402-403 and the 407-408-409 have counter wheels and groups. The 407-408-409 have a minimum of 112 individual accumulators arranged in 20 counter groups that vary in size from three-position (3-wheel) groups to eight-position groups. The counter groups can be coupled together in any desired arrangement.

Counter wheels in the 407-408-409 are reset to 9 rather than to 0. This is done because of a special checking feature that is discussed later in this section. At this time you should understand that each counter wheel revolves starting with 9, it goes to 0, then to 1, then to 2, etc. In other words, each 407-408-409 counter wheel is one digit step behind a comparable wheel on the 402-403.

The capacities of counters on the 407-408-409 are the same as comparable capacities on the 402-403: for instance, in a six-position counter in the 407-408-409, the largest positive number that can be accumulated is 999,999; in an eight-position counter, 99,999,-999; and so on.

READ AND PRINT

Wiring into the counter in the 407-408-409 involves exactly the same principles as it did in the 402-403:

1. Low-order position of the field in the card should be wired to the low-order position of the counter.
2. The counter must be instructed to add by control-panel wiring.
3. Card cycles hubs in the 407-408-409 perform the same function as they did in the 402-403.

The first obvious difference, between the two machines is that the data must be wired from SECOND READING to COUNTER ENTRY in the 407-408-409. Because the maximum size of the amount field we are computing is 5 positions (a maximum sales of \$999.99), we must use a *six-position* counter (Figure 237).

The process of printing, in conjunction with counters, is different in the 407-408-409. Figure 238 shows the division of a machine cycle in the 407-408-409 in relationship to what is occurring in the counter circuitry. Exit hubs from the counter are called COUNTER EXIT, and the entry hubs to print information from the counters are called COUNTER CONTROLLED PRINT. The external wiring concerning these hubs is shown in Figure 239. The internal circuitry for adding on the *first*

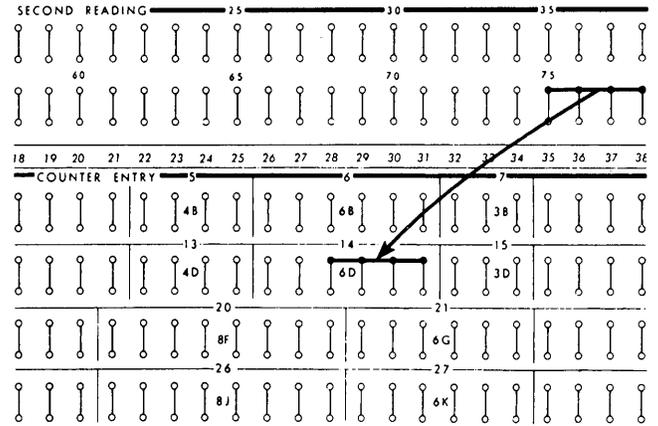


FIGURE 237. ADDITION REQUIRES SIX-POSITION COUNTER FOR MAXIMUM TOTAL

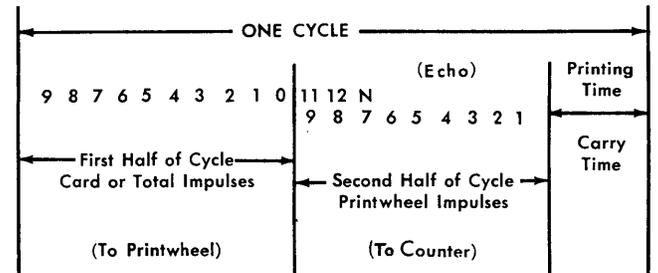


FIGURE 238. IBM 407-408-409 MACHINE-CYCLE SCHEMATIC

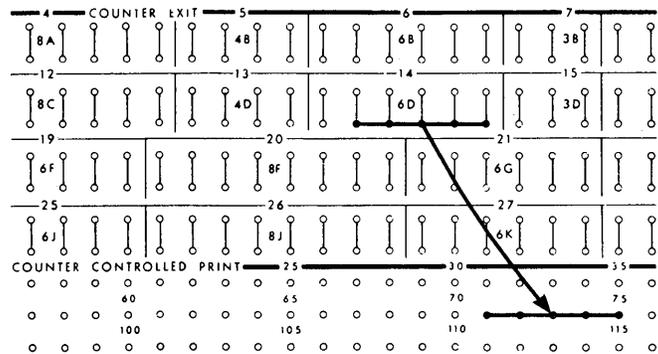


FIGURE 239. COUNTER EXITS MUST BE WIRED TO PRINT THROUGH THE COUNTER-CONTROLLED-PRINT HUBS

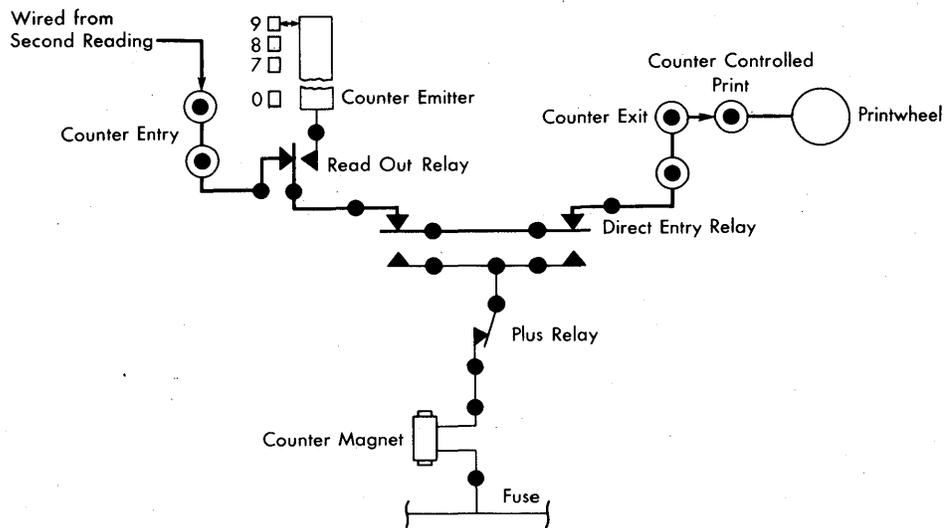


FIGURE 240. IBM 407-408 COUNTER OPERATION — FIRST HALF OF MACHINE CYCLE

half of the machine cycle is shown in Figure 240. You will need to refer to these four figures (237-240) during the following discussion.

During the first half of the machine cycle, the information read from second reading enters the COUNTER ENTRY (external wire in Figures 237 and 240) and travels through the counter circuitry to the COUNTER EXIT. Here another external wire (Figures 239 and 240) carries the data from COUNTER EXIT to COUNTER CONTROLLED PRINT, and the print wheel is positioned to print during the first half of the machine cycle.

During the second half of the cycle, the information is read back from the print wheel through COUNTER-CONTROLLED PRINT and COUNTER EXIT. This return impulse during the second half of the machine cycle is

called the *echo impulse*. The impulse must reach the counter start magnet.

Now, Figure 240 shows the path for the echo impulse. Relays are in the position indicated in Figure 240 during the first half of the cycle.

The path of the *echo* impulse to the counter on the second half of the machine cycle is indicated in Figure 241.

ADDING

You will notice another relay that is transferred called the *Plus, Minus, or Reset*. Whenever the counter is impulsed to add, subtract, or reset, this relay transfers.

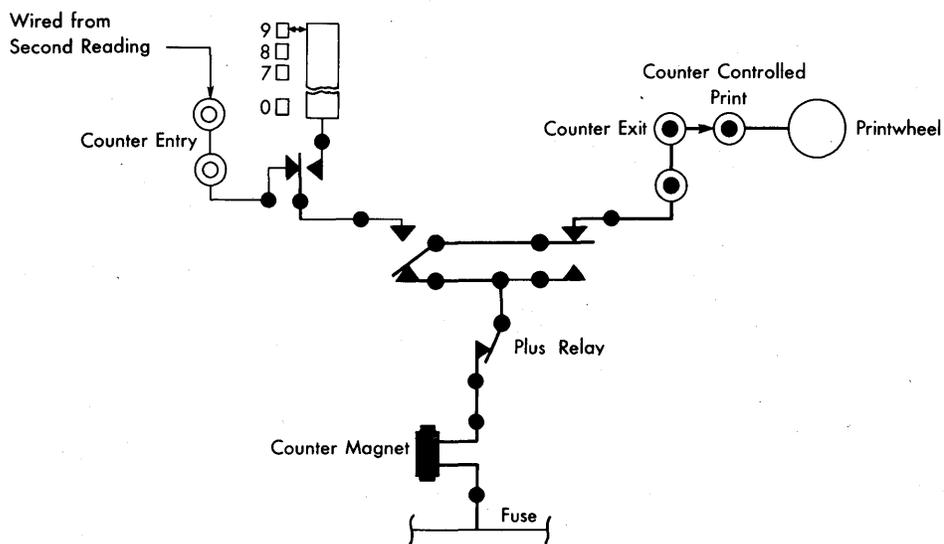


FIGURE 241. IBM 407-408 COUNTER OPERATION — SECOND HALF OF MACHINE CYCLE (ECHO CYCLE)

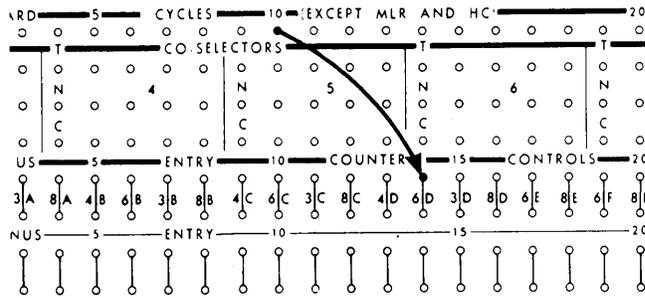


FIGURE 242. COUNTER CONTROL PLUS IMPULSED FROM CARD CYCLES

As depicted in Figure 242, wiring to make the counter add for the 407-408-409 is exactly the same as the wiring required for the 402-403.

CARD CYCLES (EXCEPT MLR AND HC) is wired to COUNTER CONTROL PLUS ENTRY of counter 6D. The counter adds from each card as it passes second reading, and at no other time.

Earlier, we said that the counters in the 407-408-409 reset to 9 instead of 0. Let's see how they move when instructed to add.

When positive numbers in the 407-408-409 are being added, it is necessary only to start the counter wheel; it stops automatically at 0 time. The counter wheels on the 407-408-409 begin revolving when the echo impulse reaches the counter start magnet. For instance: if a 5 is transmitted to a counter start magnet, the counter wheel begins turning from 9 to 0 when the cycle point changes from 6 to 5.

Figure 243 illustrates the plus operation of a 407-408-409 counter wheel. In this instance, assume we are adding the quantity 053446 into a six-position counter. There are no other figures in the counter; therefore, all positions stand at 9 when the card is at second reading.

The punches in the card are read as 053446 during the first half of the cycle. During the second half of the cycle, the information is read back from the print wheels to the counter start magnet. The counter wheels revolve until they are stopped at 0 time.

READ BACK FROM PRINTWHEELS — 053446

COUNTER POSITIONS MACHINE CYCLES PRINT TIMING

9	9	9	9	9	9	9	Read back on second half of cycle
9	9	9	9	9	9	8	(Echo Impulses)
9	9	9	9	9	9	7	
9	9	9	9	9	9	6	
9	9	9	9	9	0	5	
9	0	9	9	9	1	4	
9	1	9	0	0	2	3	
9	2	0	1	1	3	2	
9	3	1	2	2	4	1	
9	4	2	3	3	5	0	

FIGURE 243. MACHINE-CYCLES PRINT TIMING

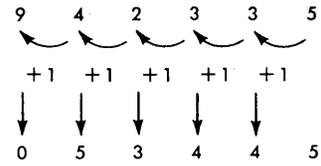


FIGURE 244. COUNTER AFTER CARRY

Notice that the counter stands at 942335.

Obviously, if this amount were added to the counter it would be inaccurate. Now, look at Figure 238. At the end of the cycle is a division called *Carry Time* and *Print Time*.

During *Carry Time* a quantity of 1 is automatically added in each counter wheel to the left.

When each counter wheel turns from 9 to 0, the quantity 1 is available to be added in the next position to the left. The only counter wheel that does not have the automatic addition is the units position — the extreme right position in Figure 243.

In Figure 243, the high-order position (the extreme left position) is not occupied by a significant digit, because only five numbers were read into a six-position counter. The position remains at 9.

However, the position immediately to the right does have a significant digit, and so a carry impulse of 1 is transmitted to the high-order 9. This causes the high-order position to move one position to 0. Now, because the high-order position counter wheel has turned from 9 to 0, another impulse of 1 is manufactured. There are no more positions to the left in the counter; so, this impulse cannot be transmitted internally.

Figure 244 illustrates the standing of the counter after this *internal carry* addition has been completed. All positions of the amount field *except* the units position are now correct.

If the additional impulse of 1 that is available when the high-order position turns from 9 to 0 were transferred to the units position, the number standing in the counter would be correct.

This 1 is carried back to the units position of the counter by external control-panel wiring (Figure 245). The hubs that accomplish this are called CARRY EXIT (CI) and CARRY ENTRY (C). When the CI hub is wired

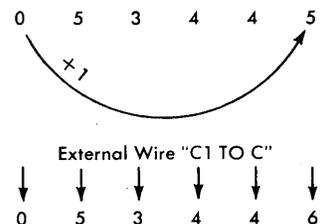


FIGURE 245. INTERNAL CARRY CONTROL

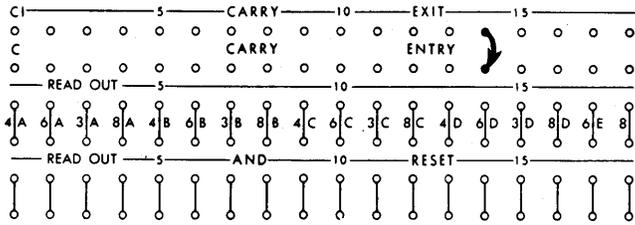


FIGURE 246. WIRING FOR CARRY CONTROL

to the C hub of a counter (Figure 246), the quantity *I* is carried from the high-order position of the counter to the units position of the counter. The CI to C connection must always be made or every amount added into a counter will be short by the quantity *I*.

Before we examine the operation of the circuitry during read-out and reset, let's consider another method of printing and computing the report. Look back to Figure 214. Instead of listing each sale, suppose we want to print the sales check number only once and then print the amount of total sales.

In other words, instead of printing amounts from each card as it is read, we print only the total amount for each sales clerk. The report would then appear like the illustration in Figure 247. This is called *group printing* and *direct entry* addition.

We want to do the following:

1. Print the sales-clerk number from the first card as an identification of each group (No. 5; No. 6; etc.). This *group indication* occurs during a *group-indicate cycle*.
2. Add in the counter the amounts for all sales within the group but print only the total.
3. Print nothing else from any of the cards. To prevent printing from each card as it passes the second-reading brushes, we wire the hubs labeled LIST OFF (Figure 248). The LIST OFF wire accomplishes the following:
 - a. causes a group-indicate cycle for the first card of each group
 - b. allows counter exit hubs to emit only during program cycles (that is, minor, intermediate, and major program, etc.) and group-indication cycle
 - c. suppresses printing and normal spacing on all cycles except the group-indicate and program cycles.

SALES CLERK	AMOUNT
5	54 20*
6	28 60*

FIGURE 247. TOTAL AMOUNTS PRINTED

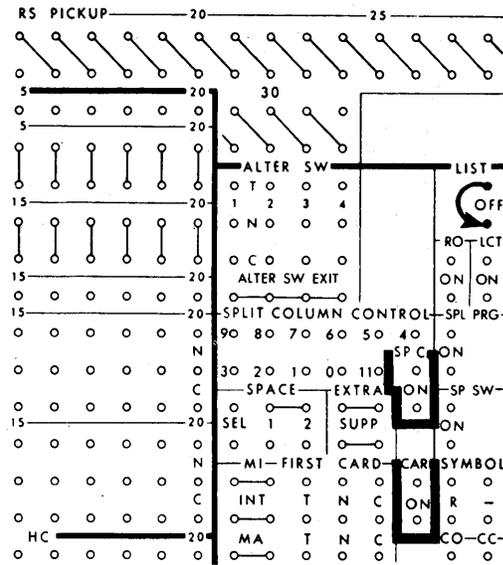


FIGURE 248. LIST OFF IS WIRED FOR GROUP PRINTING

In other words when we print the sales clerk number 5 in Figure 214 from the first card of that group, we also print the amount 1750 at the same time. (Printing clerk number and amounts from subsequent cards in the No. 5 group is prevented by the LIST OFF wiring.)

We must do two things:

1. prevent printing the amount from the first card of the group
2. add amounts from all cards *directly* into the counter without using the *echo* impulse.

This is accomplished by allowing the digit impulse from second reading to find a path directly to the counter start magnet. At the same time, the connection between the counter exit and counter entry hubs must be broken.

Figure 249 illustrates the external wiring that accomplishes this; Figure 250 depicts the internal circuitry that results from it.

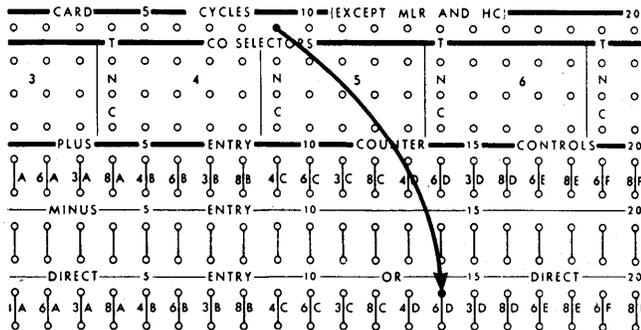


FIGURE 249. DIRECT ENTRY WIRED

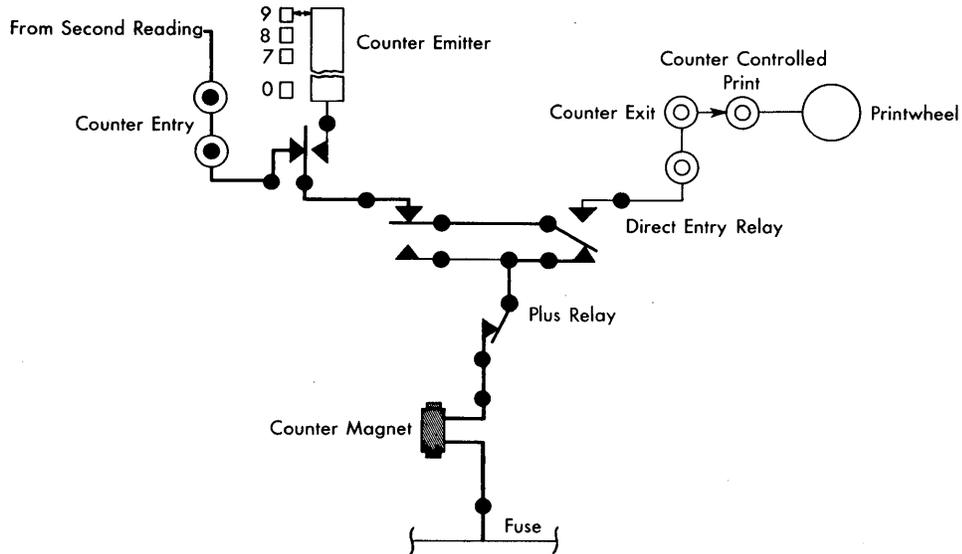


FIGURE 250. DIRECT ENTRY DISCONNECTS COUNTER EXITS AND ENTRIES

If the direct entry hubs from the counter — in this case 4D — are impulsed from CARD CYCLES, the connection between COUNTER ENTRY and COUNTER EXIT is broken and the counter is impulsed directly with whatever figures are read from second reading.

Follow the path of data from COUNTER ENTRY to the counter start magnet in Figure 250. Notice how the direct entry relay, impulsed from CARD CYCLES, accomplishes the break between counter entry and counter exit hubs.

the counter resets, the following events occur in the machine circuitry:

1. The true number in the counter reaches the printwheels through the action of an internal *total* emitter.
2. At the same time, the counter wheels begin revolving from another internal impulse called the *hot 9*.
3. The *echo* impulse returning from the printwheels resets the counter to 9's.

TOTAL, PRINT, AND RESET — POSITIVE NUMBER

Counters in the 407-408-409 compute totals on the same principle as they did in the 402-403. The control-panel hubs that cause the counter to read out to the printwheels and reset to 9 are called READ OUT AND RESET. They perform the same function for the 407-408-409 as TOTAL do for counters on the 402-403; and like the total hubs, they are impulsed from PROGRAM.

The program hubs on the 407-408-409 emit under the same conditions as they did in the 402-403 Accounting Machine. Wiring to cause the counter to read-out and reset is similar in both machines.

Figure 251 illustrates the wiring to cause counter 6D to both read-out and reset. Notice that the hubs labeled READ OUT AND RESET are impulsed. Another set of hubs for each counter is labeled READ OUT. These hubs cause the counter to read out without resetting.

When a position number is read out of a counter and

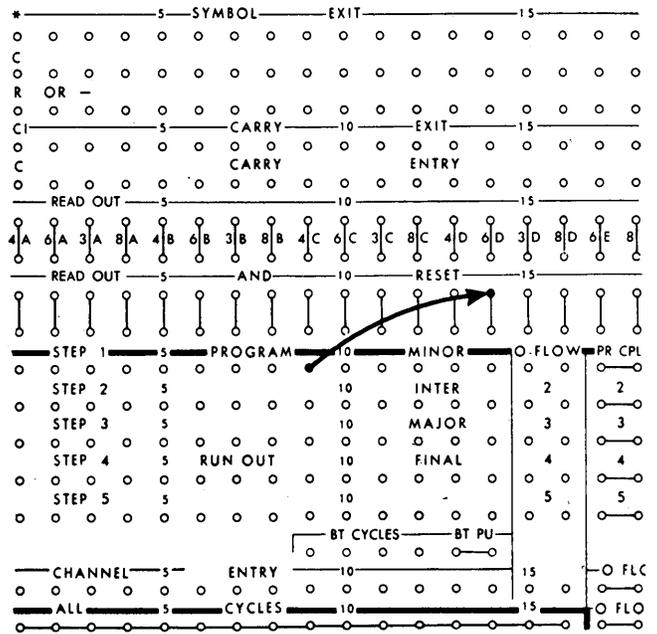


FIGURE 251. WIRING FOR READ OUT AND RESET

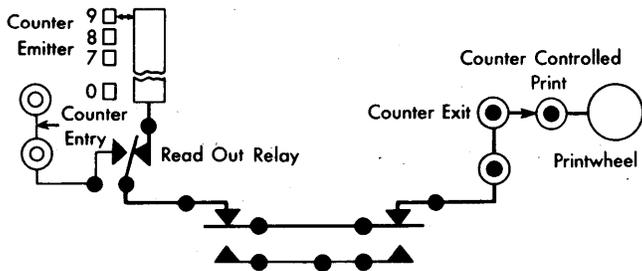


FIGURE 252. ON FIRST HALF OF READ-OUT-AND-RESET CYCLE, COUNTER EMITS THROUGH COUNTER EXIT TO PRINTWHEELS

Figure 252 illustrates the path of the data from the counter to the print wheels.

The external wiring necessary to impulse the counter is shown in Figure 251. Of course, if the figures in the counter are to reach the print wheels, the counter exits must be externally wired (in the control panel) to the printwheels (COUNTER CONTROLLED PRINT).

During the second half of the read-out-and-reset cycle, the figures from the printwheels are returned to the counter. The counter stop magnet is impulsed by the echo impulse, and the counter is reset to 9's. Figure 253 shows the path of the echo impulse to the counter stop magnet.

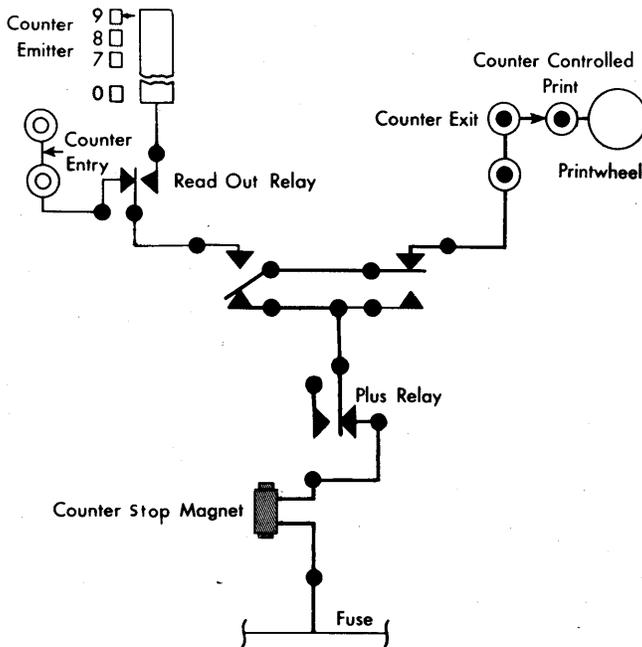


FIGURE 253. ON SECOND HALF OF READ-OUT-AND-RESET CYCLE, PRINTWHEELS ECHO BACK IMPULSES TO COUNTER FOR RESET

Assume that we have read the quantity 03 out of a two-position counter. The counter must be reset to 99 by the echo impulse returning from the printwheels to the counter stop magnet. Figure 254 shows the revolution of the counter wheels in relation to the cycle-point time of the echo impulse.

The echo impulse returns from the printwheels in the same sequence as the cards are read; that is, nines followed by eights followed by sevens, etc. Remember, the quantity 03 is still in the counter. When the cycle time of the echo impulse reaches 3, the units position of the counter stopped; when the cycle time of the echo impulse reaches 0, the tens position of the counter stopped. Both positions have reset to 9.

The same process of reading out and resetting occurs for each counter position that we have wired (from program hubs to read out and reset hubs).

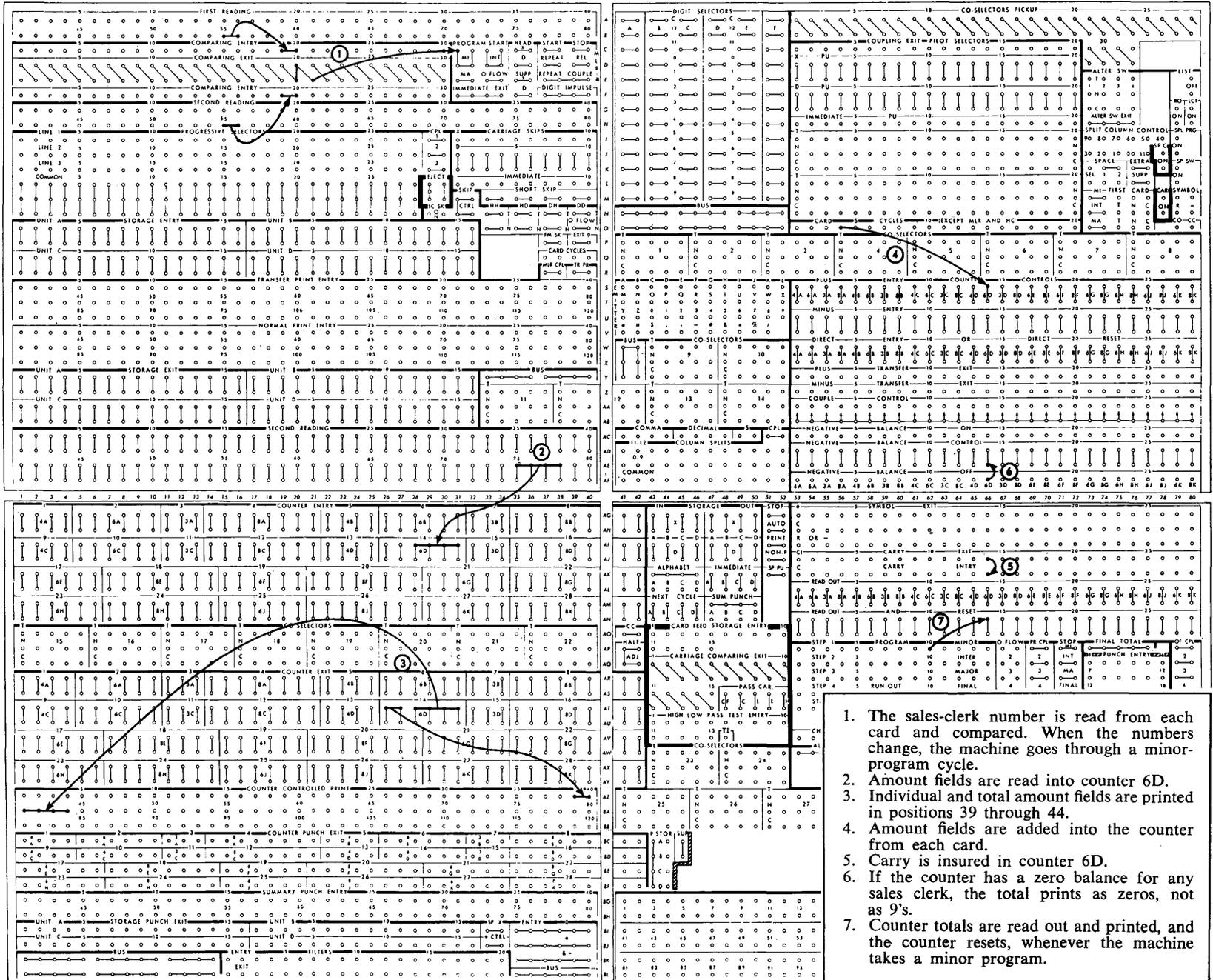
Two more sets of hubs must also be wired when quantities are added in 407-408-409 counters. They are labeled NEGATIVE BALANCE OFF and NEGATIVE BALANCE CONTROL. NEGATIVE BALANCE OFF wired to NEGATIVE BALANCE CONTROL insures that a zero balance in a counter prints as a zero balance, not as 9's.

Figure 255 illustrates the wiring necessary in the 407-408-409 to print the report in Figure 214. The counter wheels revolve as depicted in Figure 243, except they are impulsed directly from the card during the first half of the cycle, instead of from the printwheels during the second half of cycle.

CYCLE POINT TIMES ON ECHO IMPULSE	TENS	UNITS	
9	0	3	Wheels Turn From "Hot 9"
8	1	4	
7	2	5	
6	3	6	
5	4	7	
4	5	8	
3	6	9	Wheels Stopped at "3" Time
2	7		
1	8		
0	9		Wheels Stopped at "0" Time
COUNTER RESET			
			9 9

FIGURE 254. CYCLE-POINT TIMING ON ECHO IMPULSE

FIGURE 255. WIRING FOR REPORT IN FIGURE 214, IBM 407-408-409



1. The sales-clerk number is read from each card and compared. When the numbers change, the machine goes through a minor-program cycle.
2. Amount fields are read into counter 6D.
3. Individual and total amount fields are printed in positions 39 through 44.
4. Amount fields are added into the counter from each card.
5. Carry is insured in counter 8D.
6. If the counter has a zero balance for any sales clerk, the total prints as zeros, not as 9's.
7. Counter totals are read out and printed, and the counter resets, whenever the machine takes a minor program.

Review Questions

1. What are the four steps required to make an adding machine add?
2. What are the four steps required to make an IBM machine add?
3. What does the high-order position of a counter mean?
4. What does the low-order position of a counter mean?
5. Which exit and entry hubs must be connected in the 403 control panel to take the information from the card to the counter wheels?
6. Which entry hub must be impulsed before a counter can add?
7. Which exit hub is usually wired to the hub that allows a counter to add?
8. Explain how the movement of a counter wheel causes adding in a 403. in a 407.
9. What exit and entry hubs must be connected to take the total from the counter to the typebars in the 403?
10. What happens when you impulse a counter total hub?
11. What impulse is used to impulse a counter total hub?
12. What is a total cycle? How does it differ from a card-feed cycle?
13. What relationship do both the total and card-feed cycles have to a machine cycle?
14. What hub must be wired on the 403 to make the typebars operate and the platen move? What impulse is wired to this hub? Why?
15. How does the 407 counter wheel differ from the 403 counter wheel?
16. What does the expression *9's complement* of a number mean?
17. What is an *echo* impulse?
18. What is *carry time*?
19. What is the purpose of wiring NEGATIVE BALANCE CONTROL on the IBM 407-408-409?

Subtraction

Subtraction in the IBM 402-403 Accounting Machines

We often find it necessary to subtract as well as add amounts in a counter. An example of this is subtracting income tax deductions when preparing payroll checks. It is possible to both add and subtract in a counter of an accounting machine. Each operation must be handled separately; it is impossible to add and subtract in one counter group during the same machine cycle.

Because of its construction, a counter wheel cannot turn backwards when subtracting. Therefore, it is necessary to turn the counter wheel forward to the same

number that it would be turned to if it were possible to turn the wheel backwards. For example, if we subtract 3 from 6 the wheel should be standing at 3 at the end of the cycle. The wheel cannot be reversed; so, we *add* 6 to the 6 already standing in the wheel. This 6 is the 9's complement of 3. The 9's complement of a figure is that figure subtracted from 9. Assume we have the amount 06 accumulated in a two-position counter group. The next card to be accumulated is a subtract card with 03 punched in the amount column.

- 06 Standing in counter
- 96 Complement of 03 punched in card
- 92 Standing in counter before carry time
- 11 Carry
- 03 Standing in counter wheels at completion of cycle

Subtract cards are usually identified by an X- or 11-punch in some specified column of the card. The cards to be added into the counter group will not have the X- or 11-punch. The machine is now able to read this column of the card and decide whether to add or subtract the amount punched in the card; in other words, add all NX-cards and subtract all X-cards.

To make this possible, we must use a decision-making device, a *selector*. Any pilot selector may be used for this purpose. To operate this selector, we must wire the X-PICKUP from SECOND READING for the column of the card containing the X-punch. The selector then transfers on the next cycle, just before the card to be subtracted is read at the third-reading brushes. We can now use this selector to decide whether to add or subtract; that is, to pick up either the counter-controlled-plus or counter-controlled-minus relays. When the plus relays are picked up, the counter adds as previously explained. When the minus relays are picked up, the counter subtracts. Let's see how this looks on the 402-403 control panel (Figure 256).

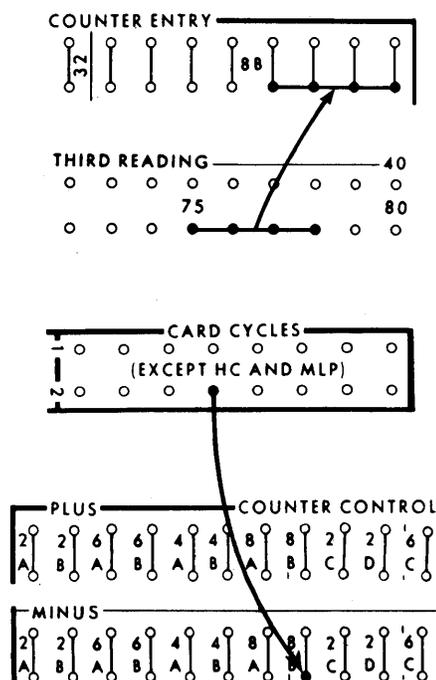


FIGURE 256. WIRING FOR SUBTRACTION, IBM 402-403

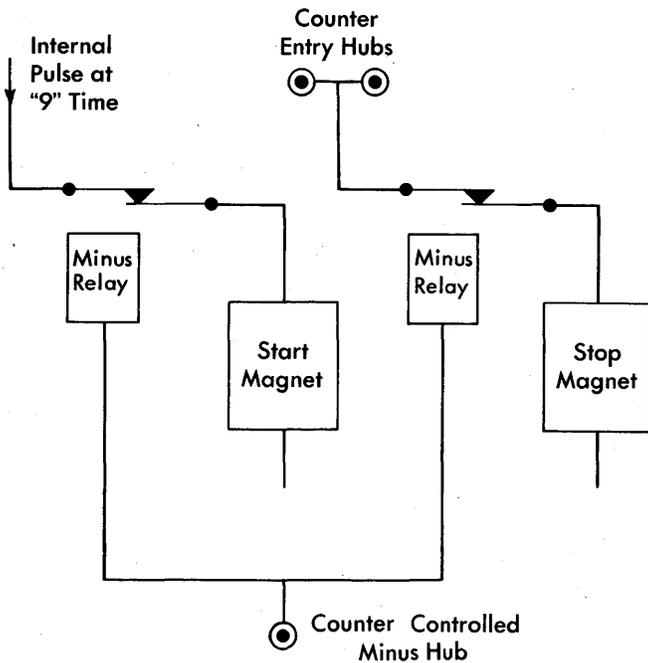


FIGURE 257. INTERNAL SCHEMATIC, SUBTRACTION

When adding into a counter, it was necessary only to electrically *start* the adding wheel in motion. It was *stopped* mechanically at 0-time. This was done by picking up the counter-controlled-plus relays. However, when subtracting, it is necessary to electrically *start* and *stop* the movement of the adding wheel. This is done by picking up the counter-controlled *minus* relays. Hereafter, then, the counter is shown with a start magnet and a stop magnet. When the start magnet is energized, the wheel starts moving; and when the stop magnet is energized, the wheel stops moving.

When the minus relays are picked up, we complete an internal electrical circuit to start advancing all the wheels in the counter group at 9-time (Figure 257). The wheels continue to advance until stopped by an impulse to the stop magnets. These impulses are received from the third-reading brushes reading the holes punched in the card. Let us assume that we already have 06 accumulated in counter group 2A (Figure 258). The next card to pass the third-reading brushes is a subtract card with 03 punched in the amount field. Because the minus relays are picked up, we start advancing both counter wheels at 9-time. The units position wheel does not stop until the 3-hole in the card is read by the brush. Don't overlook the fact that we are starting out with a 6 already in the counter wheel.

Looking at the illustration, we find that 6 cycle points have passed before the 3-hole was read by the brush (9 to 3); this means that the adding wheel was advanced 6 cycle points before being stopped. That is,

the wheel advanced from 6 to 7 to 8 to 9 to 0 to 1 to 2 (Figure 259).

The tens-position counter wheel was treated in the same manner, only in this position we have a 0 punched in the card and we started with a 0 standing in the counter wheel.

You notice that the wheel was advanced 9 cycle points before being stopped. The counter wheels are now standing at 92 (Figure 260).

As previously explained, each time a counter wheel moves from 9 to 0, the wheel to its left within the same counter group automatically rotates one position more at carry time.

As the high-order counter wheel moves from 9 to 0, we complete a circuit through control-panel wiring to cause the units-position counter wheel to advance one position. This is done by wiring the carry impulse exit

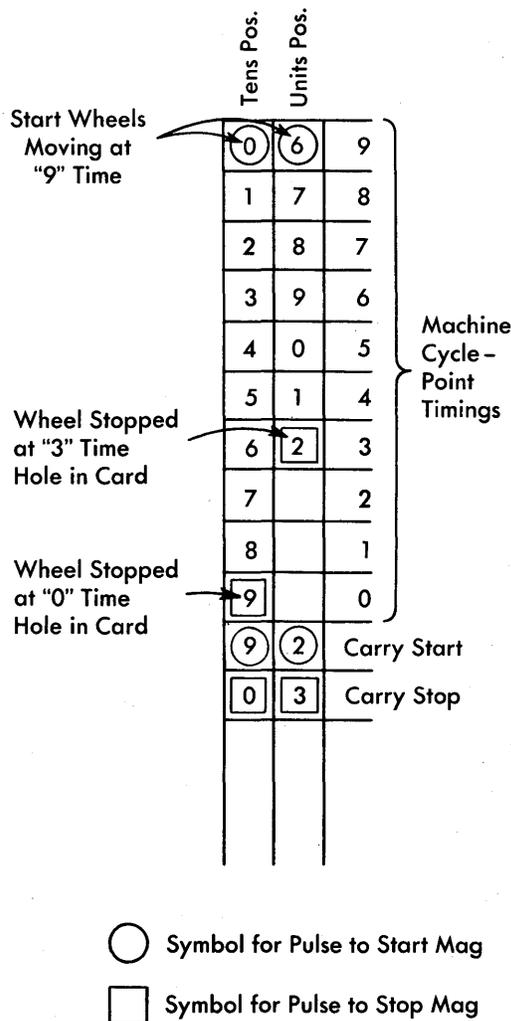


FIGURE 258. MACHINE-CYCLE TIME — SUBTRACTION, IBM 402-403

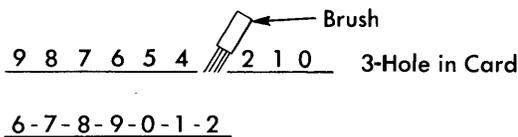


FIGURE 259. COUNTER WHEEL ADVANCED 6 CYCLE-POINTS

hub to the carry entry hub (Figure 261). The ci hub emits an impulse when the high-order position goes from 9 to 0. The carry-entry hub accepts this impulse, which causes the units position to add 1 for the carry operation.

You remember this ci to c connection must be wired in the 407-408-409 when we are adding as well as subtracting.

This is so because during *carry time* the quantity *one* is added from each counter wheel to the counter wheel to the left. To carry this quantity of *one* from the high-order to the low-order counter wheel, the external ci to c must be wired (see *Wiring the 407-408 to Add*).

We now have 92 standing in the counter wheels. However, the units-position wheel did move from 9 to 0, causing the tens position to advance 1. The tens-position wheel then moved from 9 to 0, causing a carry through the control-panel wire back to the units-position wheel advancing it one position.

- 06 In counter
- 96 Nines complement of 03 added in counter
- 92 In counter before CARRY time
- 1 Carry impulse held until CARRY time
- (1) 02 In counter due to carry in tens position as during CARRY time (Internal circuits)
- 1 Carry impulse transferred from high to units position during CARRY time by ci to c wiring
- 03 Standing in counter at end of card cycle

So we complete this card cycle with 03 standing in the counter wheels. This is the correct total for our problem of 06 minus 03.

There is probably a question in your mind about now. "Suppose the amount being subtracted in a counter group is larger than the positive amount we already have accumulated in the counter?" The counter then

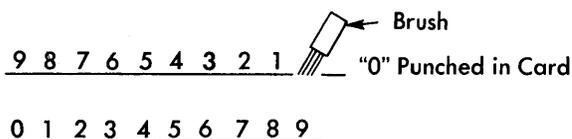


FIGURE 260. COUNTER WHEEL ADVANCED 9 CYCLE-POINTS



FIGURE 261. WIRING FOR CARRY CONTROL

turns negative. For example, let's use a four-position counter group and assume we already have 0745 accumulated in the counter. From this amount we subtract 0856:

Manual	-0856	
Computation:	+0745	
	-0111	
Machine	0745	Standing in Counter
Computation:	9143	Add 9's complement of 0856
	9888	Total

We now have 9888 accumulated in the counter at the end of our computation. The 9 standing in the high-order position of the counter indicates to the machine that this is a *negative* or *credit* amount. When subtracting into a counter in both the 402-403 and 407-408-409, it is imperative that the high-order position always be left available for this purpose. Or, in other words, never accumulate directly from the card or carry into the high-order position of a counter group when subtracting in the counter. At the completion of a card-feed cycle, the high-order counter wheel always stands at 9 or 0; a 9 if the amount is negative, or a 0 if the amount is positive.

Our counter is now standing at 9888 or 0111 *negative*. If the next card to be accumulated is a positive or an add card and the amount is greater than 0111, the counter will then turn positive again and a 0 should appear in the high-order position. Assume the next card is positive and the amount is 0245:

Manual	Machine	
Computation	Computation	
+0245	9888	Amount in Wheels
-0111	+0245	+ Amount in Card
+0134	9023	
"0" Indicates	1111	Carry
Positive Amount	0134	Total

While running a report and accumulating in a counter, it is quite possible to have the counter turn negative and positive back and forth many times before a total is printed.

Conversion — 402-403

When subtracting, we found that a counter may turn negative, such as the 9888 we had previously. If the machine at this particular time had sensed a control

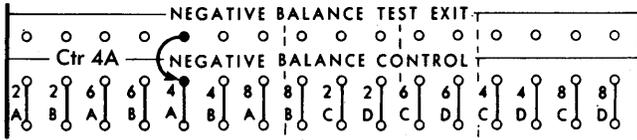


FIGURE 262. WIRING FOR NEGATIVE BALANCE CONVERSION

change and signaled for this counter to print a total, the total printed would have been 9888. The operator might believe this to be a positive total of \$98.88, which is not so. Actually, the total is \$1.11 negative or credit. So, a conversion of the complement to a true negative figure should take place prior to printing the total.

To have conversion take place, we must wire the control panel as shown in Figure 262. Assume we are using counter group 4A.

The fact that we have the negative-balance-test exit hub wired to the negative-balance control hub allows the machine to test the high-order position of the counter group. If there is a 9 present, the machine knows that the amount is negative and should be converted before printing takes place. The total cycle is then held up, and the machine takes a conversion cycle. During a conversion cycle, the machine adds 1, 3, 5, 7, or 9 to the amount already standing in the wheels. All carry operations are suspended during a conversion cycle. Let us see how we convert 9888 to 0111 before printing:

9888	
1333	Added during conversion cycle
0111	

The 1333 added came from internal circuits established when the machine decided conversion was necessary for this counter. The high-order position of a

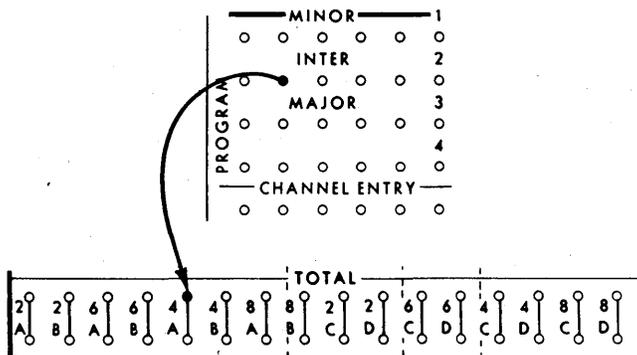


FIGURE 263. WIRING FOR COUNTER TOTAL, IBM 402-403

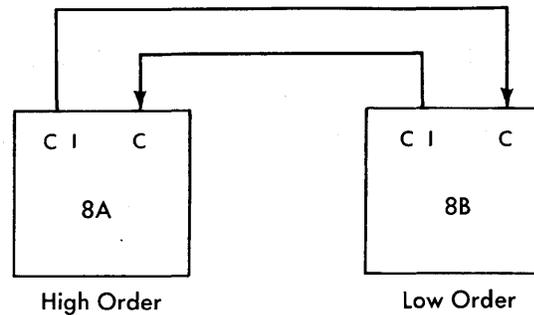


FIGURE 264. PATH OF CARRY FROM ONE COUNTER TO ANOTHER

counter group is tested for the presence of a 9 only when the counter is impulsed to total.

If counter group 4A is wired to total-print on an intermediate total cycle, the counter will not be tested when a minor control change is sensed (Figure 263). However, it will be tested before the intermediate total cycle if an intermediate or major control change is sensed.

COUNTER COUPLING

How do we wire the 402-403 control panel if two counter groups are coupled together to form a larger counter group? Assume we are coupling counter groups 8A and 8B together to form one 16-position counter group (Figure 264).

First of all we must consider carrying from one group to the other. We must wire the CI hub of counter group 8B to the C hub of counter group 8A. This will enable us to carry from the eighth-position counter wheel into the ninth-position counter wheel. If the 16th-position counter wheel advances from 9 to 0, we must also be able to carry back into the units-position wheel in counter group 8B. This is accomplished by wiring the CI of counter 8A to the C of counter 8B (Figure 265).

What control-panel wiring is necessary to convert counters 8A and 8B? With the two counter groups coupled together, the high-order position of counter 8B has now lost its identity. The high-order position of the two combined counter groups is the high-order position of counter 8A. Now this is the position the machine must test for a 9 indicating a negative amount. Therefore, the negative balance test exit for counter group 8A must be wired to 8A NEGATIVE BALANCE CONTROL (Figure 266). We must also wire the negative balance control hub of counter 8A to the negative balance control hub of counter 8B, otherwise only 8A is converted.

We have already found that when conversion takes place, a true figure is printed such as \$1.11 instead of

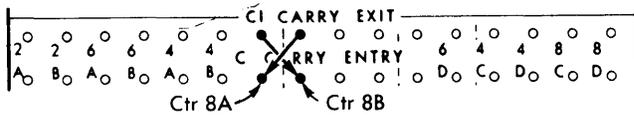


FIGURE 265. WIRING FOR CARRY CONTROL — COUNTER COUPLING

\$98.88. However, we need some way to identify the \$1.11 as a credit amount. To do this, wire the CR SYMBOL EXIT hub of the counter being used to some *even-numbered* numerical typebar (Figure 267). Only the even-numbered typebars in the 402-403 are equipped with CR symbols.

If two counter groups are coupled together, such as 8A and 8B, the credit-symbol exit hub of either counter can be wired to the typebar. The total then would appear on the report as \$1.11 CR.

Subtraction in the IBM 407-408-409 Accounting Machines

The following functions and wiring are the same for both the 407-408-409 and the 402-403:

1. Counter MINUS ENTRY, CARD CYCLES and pilot selectors are wired the same way for both machines when subtracting.
2. High-order positions of counters that contain negative amounts must not contain significant digits.

When a 407-408-409 counter is wired to subtract, the following events occur in the machine circuitry:

1. The data moves directly from MINUS ENTRY to the print magnet exactly the same way it did when adding in the counter (see Figure 240).
2. The counter wheel begins to revolve automatically from the hot 9 impulse.
3. The *echo* impulse returns to the counter stop magnet and stops the counter wheel.
4. The 9's *complement* of the number, not the true number, is in the counter. The 9's complement of a

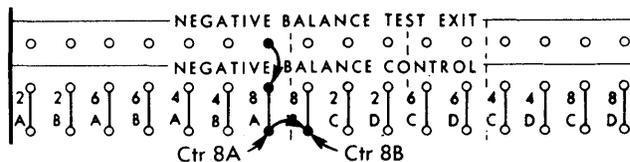


FIGURE 266. WIRING FOR NEGATIVE BALANCE CONTROL — COUNTER COUPLING

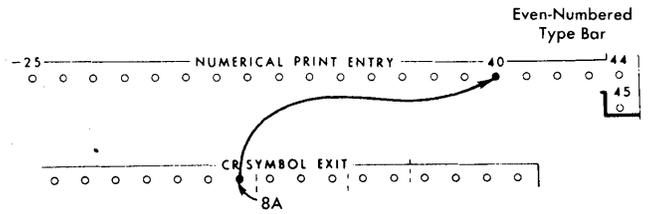


FIGURE 267. PRINTING CREDIT SYMBOL, IBM 402-403

number is the quantity that must be added to that number to equal 9. The 9's complement of 3 is 6; the 9's complement of 9 is 0; the 9's complement of 25 is 74.

Now, the *hot 9* impulse reaches the counter automatically and directly when the minus entry hubs are impulsed (see Figure 252), just as it was when we read out and reset the counter for a positive number. However, the internal total emitter that was transferred in Figure 252 is *not* transferred during subtraction. The echo impulse returns to the counter stop magnet exactly as illustrated in Figure 253.

Figure 268 illustrates the movement of the counter wheels when a number is subtracted in a 407-408-409 counter.

Assume that a three-position counter has no data in it; that is, all positions are standing at 9. The counter wheels begin turning from the internal *hot 9* impulse. The number subtracted is 062. The echo impulse stops the three counter wheels at 826.

During carry time, a one is added in the tens and hundreds positions because the units and tens counter wheels, respectively, each turned from 9 to 0. The hundreds counter wheel also turned from 9 to 0, and the one is carried to the units position by the external *CI-to-C* wire.

Number Subtracted
062

Echo Impulse Cycle Time

9	9	9	Counter Wheels begin Moving from "Hot 9"
8	0	0	
7	1	1	
6	2	2	
5	3	3	
4	4	4	
3	5	5	
2	6	6	
1	7	7	
0	8	8	
	9	9	

Carry Time and External C1 to C Wire
9 3 7 9's Complement of 062

FIGURE 268. MOVEMENT OF IBM 407-408-409 COUNTER WHEELS — SUBTRACTION

The 9's complement of the number subtracted is standing in the counter wheels. The 9 in the high-order or hundreds position of the counter indicates that this is a negative quantity.

Read Out and Reset — Negative Number

When a counter in the 407-408-409 is impulsed to read out and reset a negative number, the following events occur in the machine circuitry:

Note: The 9's complement of the number must be in the counter because the quantity is negative.

1. The internal total emitter is transferred, as it was when we read out and reset a positive number.
2. The quantity in the counter passes through another element before it reaches the counter exit and print magnet. This element inverts the number from the 9's complement to the true number. The echo impulse reaches the counter start magnet through the transferred *echo* and *counter plus* relays. This true number that has been read back from the print magnets adds to the 9's complement of the number still in the counter.
3. The counter is reset to 9's.

Let's read out and print the quantity 063— and reset the counter. The 9's complement of the number (936) is read out of the counter. The number enters the inversion element (Figure 269) as 936 but exits from

the read out and reset relay to the counter exit and the print wheels as 063. In other words, the number is inverted from the 9's complement to the true number by this inversion element. The true number is printed; the 9's complement remains in the counter.

On the second half of the cycle, the echo impulse returns from the print wheels to the counter start magnet through the transferred relay points shown in Figure 270.

Now, the counter contains the quantity 936 (Figure 271), and the quantity 063 is read back from the print wheels.

The high-order position does not move because it contains a 9, and the 9 is the first cycle point time that is recorded. The tens position revolves until cycle point time 3; the units position revolves until cycle point time 6.

The counter has been reset to 9's in all three positions.

Testing for Negative Number

A negative number in the counter, as you have seen, has a 9 in the high-order position. A positive number can also have a 9 in the high-order position. But the machine recognizes the difference in these ways:

1. During subtracting, the high-order counter position must always be left blank; it must never contain a significant digit.

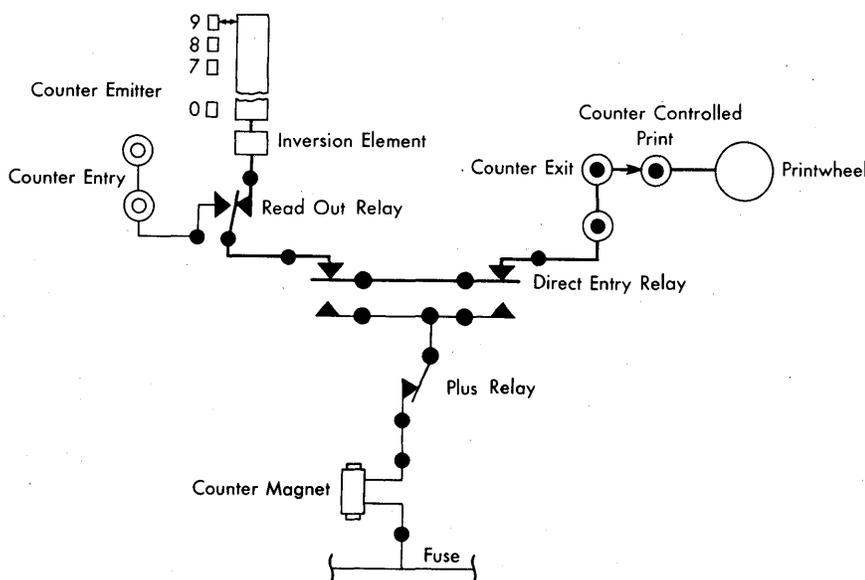


FIGURE 269. INVERTING THE 9'S COMPLEMENT — FIRST HALF OF READ-OUT-AND-RESET CYCLE

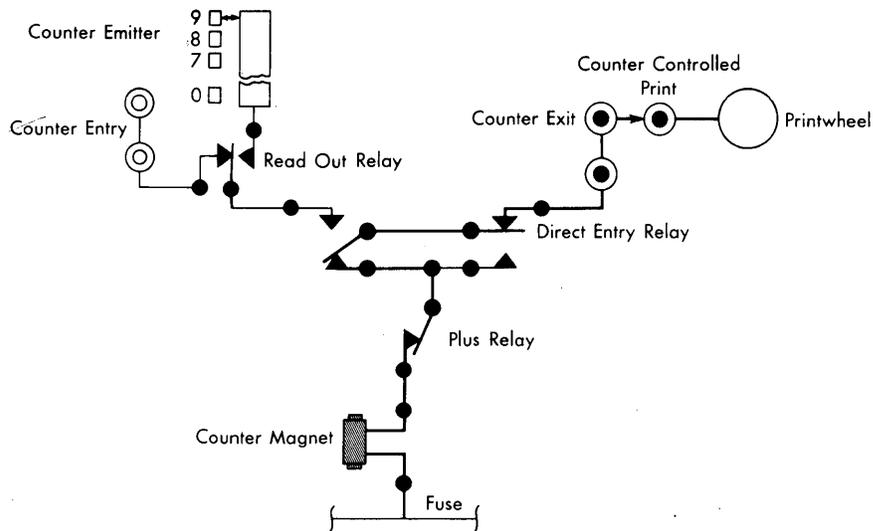


FIGURE 270. RESETTING THE COUNTER — SECOND HALF OF READ-OUT-AND-RESET CYCLE

2. NEGATIVE BALANCE CONTROL on the control panel must be wired from NEGATIVE BALANCE ON. This wire:

- a. insures that negative balances are printed as true numbers, not as 9's complements, by controlling the inversion relay.
- b. insures that a zero balance prints as zeros, not as 9's.

Identifying negative balances is accomplished by the SYMBOL SWITCH and the symbol exit hubs (Figure 272). The minus side of the switch is inoperative.

If the R side of the switch is wired, the c and R hubs emit:

1. when the minus hub of this counter is impulsed, or
2. when this counter receives an impulse to read out and reset a negative amount.

If the R side of the switch is *not* wired:

1. The c hubs operate the same way.
2. The R hubs operate the same way but they emit a minus (-) character.

c and R hubs must be wired to individual printwheels. They must *not* be wired to COUNTER CONTROLLED PRINT because that print entry will not accept 11 or 12 impulses. (A C consists of 12-3 impulses; an R consists of 11-9 impulses.) Figure 273 illustrates the wiring required to instruct the 407-408-409 to add, subtract, total, and print from the counter 6D.

Figure 274 — Section A shows wiring to couple two counters for adding only. In Section B, counters 3C and 8C add and subtract.

Read Out and Reset — Negative Number

Cycle Point Time — 9	9	3	6	In Counter 9's Complement of -063
8		4	7	Wheel Remains At "9"
7		5	8	
6		6	9	Wheel Stopped At "6" Time
5		7		
4		8		
3		9		Wheel Stopped At "3" Time
2				
1				
0				
	9	9	9	Counter Reset

FIGURE 271. COUNTER MOVEMENT — READ OUT AND RESET, NEGATIVE NUMBER

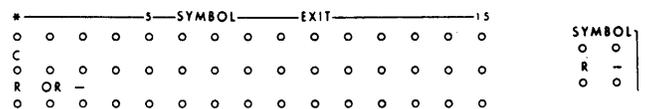
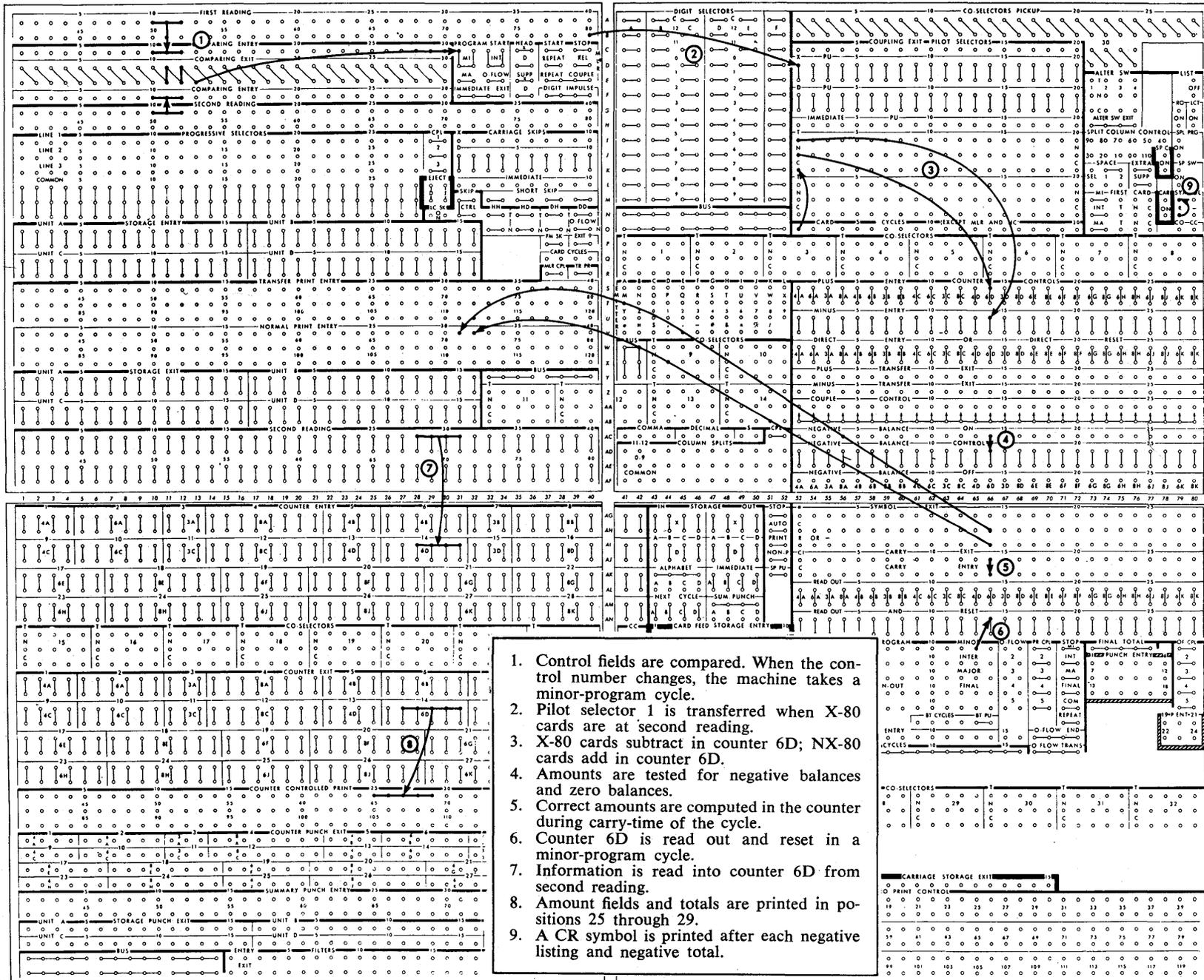


FIGURE 272. SYMBOL CONTROL HUBS AND SWITCH

FIGURE 273. WIRING FOR ADDITION, SUBTRACTION, AND TOTAL PRINTING, IBM 407-408-409



Review Questions

1. Why is it necessary to add the 9's complement of a figure when subtracting?
2. What relays must be picked up to add into a counter group in the 403? in the 407?
3. What relays must be picked up to subtract into a counter group in the 403? in the 407?
4. When subtracting in a counter, what starts the adding wheel in motion in the 403? in the 407?
5. When subtracting in a counter, what stops the movement of the adding wheel in the 403? in the 407?
6. What initiates a carry operation?
7. What control-panel wiring is necessary to carry from the high-order position to the units position of a counter group?
8. Why is it necessary to use a selector when subtracting?
9. Explain briefly what is meant by conversion.
10. What control-panel wiring is necessary to have a counter convert?
11. Does the machine go through a conversion cycle before or after the total cycle? Why?
12. What counter position is tested for the presence of a 9 when wired for conversion?
13. What control-panel wiring is necessary to couple two counter groups together?
14. What control-panel wiring is necessary to print a CR symbol in the 403? in the 407?
15. Can a CR symbol be printed from any typebar in a 403? any typewheel in a 407?
16. What is the inversion relay?
17. Describe the function of the inversion relay in adding in the 407. Subtracting.
18. Describe the function of the inversion relay when reading out and resetting a positive amount in the 407 counter. When reading out and resetting a negative amount.

You are familiar with the term *programming* as applied in everyday activities. For example, the program for a play, or perhaps for the planned activities of a holiday celebration, are often printed in program form. In this sense a program is a schedule (or sequence) of activities, listed in the order in which they are to happen (Figure 275).

We have basically the same type of programs in IBM machines, with the exception that these programs are wired, rather than printed. Programming in a machine is a sequence of activities or, to use machine terms, operations. The operations to be performed, and their sequence, are determined by control-panel wiring. Actually, a series of machine cycles is set aside for this purpose. These machine cycles are generally called *program cycles* or *program steps*. In some machines they are also referred to as *total cycles*.

These program steps can be thought of as a series of cycles that begins after a card-read operation, but not necessarily after *every* card-read operation. After the program steps have been completed, another card-read operation occurs. In other words, the program steps occur *between* card-read operations and *not during* a card-read operation.

The number of program steps to be taken is in some cases determined by the type of machine used. In other instances it is determined by control-panel wiring to give no more than the number required to perform the operations wanted. Each machine has a maximum number of steps.

Some machines do not have a program unit, and, as a result, do not have program steps available.

The program steps that we have spoken of are associated with a series of hubs on the control panel (Figure 276). These impulses can then be used to control

FIELD DAY	
SATURDAY MORNING	
8:00	Three-Legged Race
8:30	Potato Race
9:00	Softball Game
	Champions vs. All Stars
11:00	Tug-O-War
11:30	Picnic

FIGURE 275. PROGRAM

other machine features in performing specific operations. For instance, on any given program step, a storage unit can be instructed to read in or read out, a counter can be instructed to add, subtract, read out, or reset, or perhaps to read out and reset on the same cycle.

Programming in Calculators

The program steps just described are also used in a calculate operation. In many machines, programming cannot be separated from calculating because program steps *only* are used for calculations. This is true of the IBM 602 Calculating Punch and the IBM 604 Electronic Calculating Punch.

Before we go any further, let's see what is meant by calculating. Actually, calculating is familiar to all of us. Each of us comes into daily contact with some form of calculating. We may be only adding and subtracting to

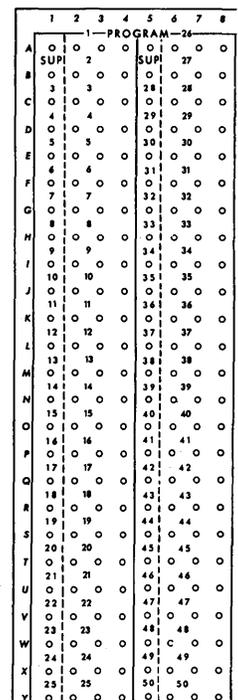
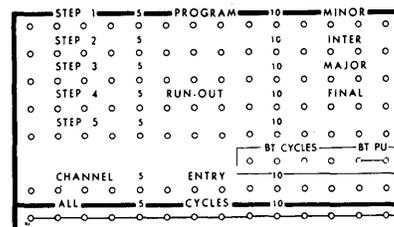
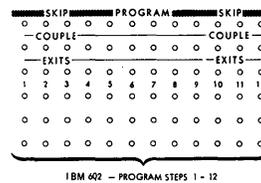


FIGURE 276. PROGRAM HUBS

check our bank balance, but this is calculating. We may also do some multiplying or dividing to see whether our pay envelope or check is correct or not. Whatever the situation, any time that we use any of the four operations we learned long ago — adding, subtracting, multiplying, or dividing — we are calculating.

We make calculations because we want to solve a problem or answer a question. To solve a problem, the calculations are usually done in a definite order. One step in the calculation logically follows the one before it. The actual order of these steps is determined by the problem.

As stated previously, many of our machines have a program unit that provides us with a series of steps, or cycles, occurring in sequence. We can use these program steps to control counters and storage units to operate the machines in the order needed to solve our problems.

To explain best how programming is used, and also how calculations are performed and controlled by control-panel wiring, let's work a problem. It should be stated that the operations which can be performed during a program step depend upon the type of machine used. Some machines can only add and subtract. Others can also multiply and divide. For our first example let's solve a problem that requires a multiplication that the 602 and 604 calculating punches can do. We first use this problem to explain programming and wiring on the 602 and then on the 604.

IBM 602 Calculating Punch

Before the problem is stated, you should know how the program unit on the 602 operates. Although all programming involves a series of program steps, the details of each machine differ slightly.

The program unit on the 602 Calculating Punch does not require an instruction to start working. Immediately following a read cycle, the program cycles begin. Program step one, or exit-one hub, emits a cycle impulse on the cycle following the read cycle; then the program-exit-two hubs emit on the next cycle. This advancement

continues through the twelve program steps available unless you stop it.

You can stop the advance from one program step to another by instructing the machine to read another card. To do this you wire from the last program step used to the hubs labeled READ. For example, if you need only four program steps in your calculating program, you wire from PROGRAM EXIT FOUR to READ (Figure 277). This causes the program to stop, and the next cycle is a read cycle.

One of the read hubs must be wired to get another read cycle. Programming advances to program step 12 and then goes back to program step 1, and continues to repeat programming if none of the program steps is wired to READ.

Now let's take a look at the problem we are going to solve using this machine. Assume you are an hourly employee. Your pay can be determined by knowing two facts: how many hours you worked, and your hourly pay rate for these hours. We also assume that none of these hours is overtime. They are all computed at the same hourly rate.

The first step is to calculate the total number of hours worked in the week by adding the hours worked each day. This weekly total is then multiplied by your hourly rate to get the amount of your total, or gross, pay. If this were a difficult problem, you might want to work out the problem by hand to determine exactly what the machine must do, step by step. This would help you to wire the control panel. A planning chart for the 602 is provided for a step-by-step breakdown of a problem to make the control-panel wiring easier. Again, if the problem were a difficult one, we would plan the entire problem and then wire the control panel. However, for purposes of explanation to closely tie the wiring into the planning chart, let's wire each step on the control panel as we develop it on the planning chart.

We know that there are several factors involved in this problem; to work better with these factors, letters can be assigned to each.

Hours worked Monday	A
Hours worked Tuesday	B
Hours worked Wednesday	C
Hours worked Thursday	D
Hours worked Friday	E
Hourly Rate	R
Gross Pay	P

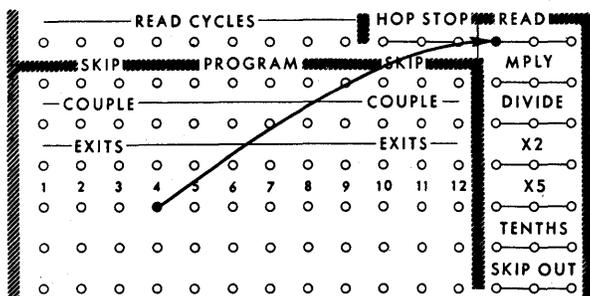


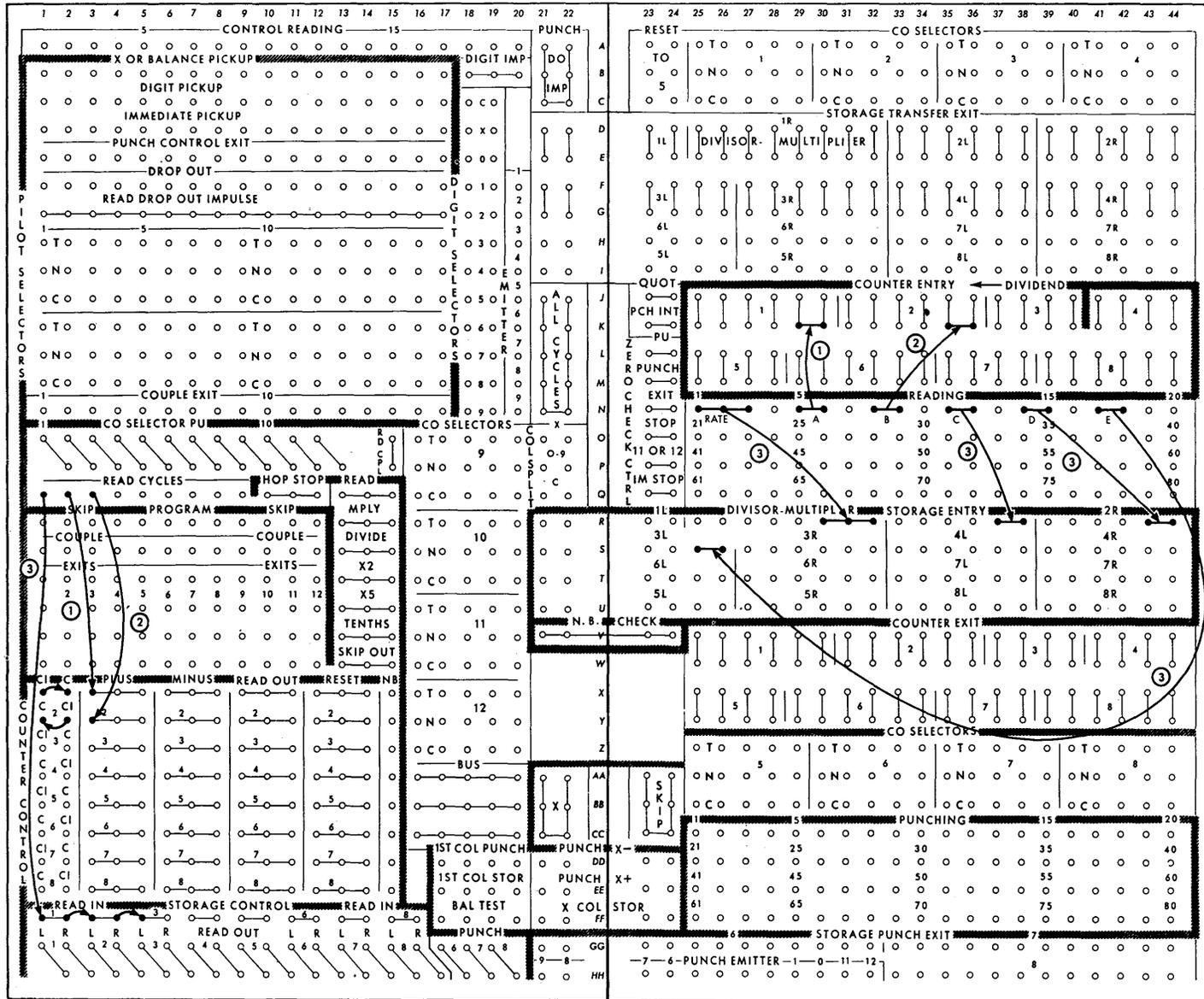
FIGURE 277. PROGRAM EXIT 4 WIRED TO READ

The problem can now be stated as the formula $(A + B + C + D + E)R = P$. If you were going to work this problem by hand, you would first put down, or record, all of the known factors in the formula. Assuming some arbitrary values, and substituting in the formula, we have $(8 + 6 + 8 + 8 + 5)1.25 = P$. The next thing

FIGURE 278.

RECORDING KNOWN FACTORS IN STORAGE UNITS AND COUNTERS

PROGRAM STEP	OPERATION	STORAGE UNIT		COUNTER						STORAGE UNITS					
		DIVR-MULT	1R	DIVIDND	1	2	3	4	5	6	2L	2R	3L	3R	4L
READ CYCLE	READ IN	R		ADD	ADD						READ IN	READ IN	READ IN		
	X00			XX	XX						XX	XX	XX		



PROGRAM STEP	OPERATION	STORAGE UNIT		COUNTER						STORAGE UNITS									
		1L	1R	1	2	3	4	5	6	2L	2R	3L	3R	4L	4R				
1	ADD C %A ADD D %B			ADD	ADD									READ OUT	READ OUT				

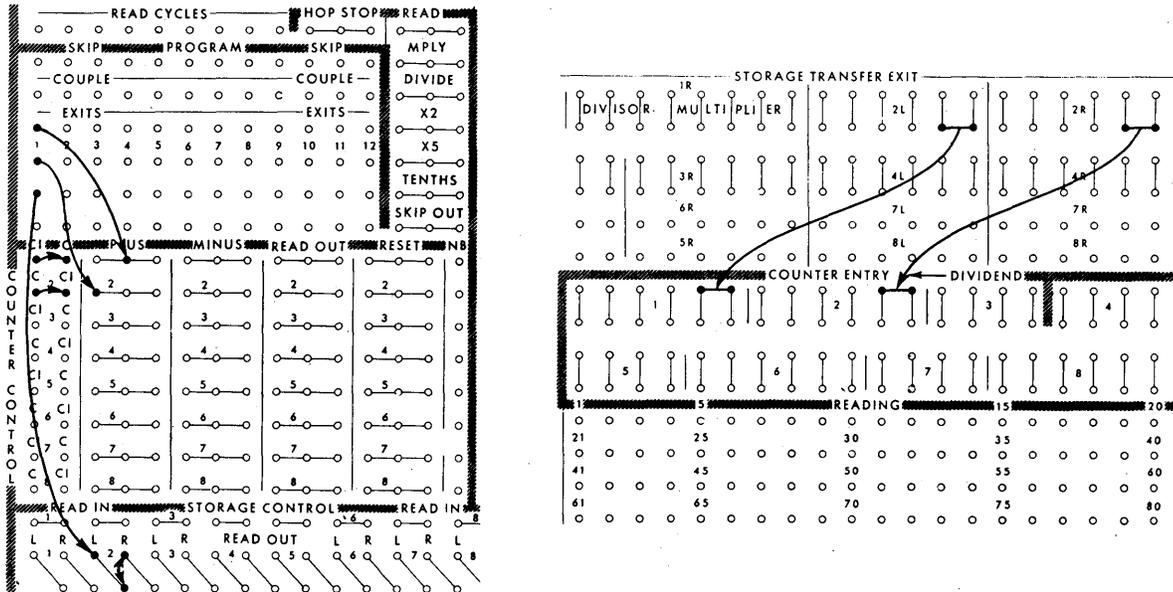


FIGURE 279. FACTORS ARE READ OUT OF STORAGE AND ADDED

you do is add 8 to 6, then 8 to 14, 8 to 22, and 5 to 30 to obtain the total of 35 hours worked. At this point, you have $(35)1.25 = P$. You then multiply 35 by 1.25, or perhaps you multiply 1.25 by 35. In either case, of course, the result is the same. If you multiply 35 by 1.25, then 1.25 is the multiplier, and the amount multiplied (in this case 35) is the multiplicand. The result, or product is 43.75 gross pay.

The machine approach to this problem is similar to this manual method. One basic difference, however, is that when using manual methods you are able to use at will either quantity as multiplier or multiplicand, depending upon which is smaller, whereas the machine must always use the same multiplier. In other words, the machine either multiplies by the rate in each case or by the total hours worked in each case. It does not change from problem to problem. For our wiring solution, we wire with the rate (R) as the multiplier.

Now to get back to the similarities between the machine and manual method. The first thing we did in the manual method was to record all of the known factors in the formula. In the machine method also, the first thing to do is to record those known factors. In the machine they are recorded in counters or storage units. This is done on a read cycle when these factors can be read from the card. Figure 278 shows the planning for this and also the control-panel wiring to cause it. Notice

that factors A and B are put into counters 1 and 2 respectively, and factors C, D, and E into storage units 2L, 2R, and 3L. The rate goes into storage unit 1R. Remember, we said the rate is always to be the multiplier. It is necessary to choose one or the other because storage unit 1R must always contain the multiplier in a problem involving multiplication. Because the rate comes directly from the card and can be placed in the multiplier storage at the time it is read, this is probably the simplest solution.

On the read cycle, when we want to enter these factors from the card, it is necessary to instruct counters 1 and 2 to add, and storage units 1, 2, and 3 to read in. You can see that the controls for counters 1 and 2, and storage units 1, 2, and 3 are wired from a READ CYCLES hub to do this. The wiring on the right shows the wiring to ENTRY of the units so the information in the card is available to the various units. This is referred to as *position wiring*, as opposed to *control wiring*.

The next thing we did manually was to add the hours worked daily to obtain the total hours worked for the week. Therefore, the next thing we do in the machine is to begin accumulating to obtain the total hours worked for the week.

Because counters can be operated separately, two counters can be instructed to accumulate on the same program step. For example, both counters 1 and 2,

which already contain A and B, respectively, can be instructed to add. If storage unit 2 is instructed to read out, counter 1 can add C to A, and counter 2 can add D to B. The planning and control-panel wiring to do this are shown in Figure 279. At the end of program step 1, counter 1 contains the sum of $A + C$, and counter 2 contains the sum of $B + D$. By similar wiring, on program step 2 we add E in counter 2, so that at the end of the cycle counter 2 contains the sum $B + D + E$.

On program step 3 we cause counter 2 to read out and reset, and counter 1 to add. As a result, counter 1 contains $A + B + C + D + E$, which is our multiplicand. The planning and control-panel wiring for both steps 2 and 3 are shown in Figure 280.

The multiplier is in storage unit 1 where it was stored on the read cycle, and the multiplicand is in counter 1 as a result of the calculations up to this point. The multiplication step is next. When we multiply manually, we start by multiplying the multiplicand by the units position of the multiplier and writing that product down. We then multiply by the tens position of the multiplier and write that down under the tens. We continue in this way until we use all of the positions of the multiplier. We then add all of the individual products to get the final answer, which in this case is the gross pay:

Total Hours	35
Rate	$\times 1.25$
	1 75
	7 00
	<u>35 00</u>
Gross Pay	43.75

The following, then, are requirements of multiplication:

1. The multiplier must be so stored that the machine can analyze each position and use it individually.
2. The multiplicand must be stored, or remembered, to be used many times, because it is used each time we multiply by a different digit.
3. A means must be provided to accumulate the individual products to get the total or final product.

We said earlier that the multiplier goes into storage unit 1. This is necessary to satisfy requirement 1 of multiplication. Internal circuitry for storage unit 1 tests each position individually for a multiplier factor when the multiply hub on the control panel is impulsed.

Requirement 2 is satisfied by having the multiplicand in counter 1 where it can be read out as often as needed. The multiplicand can be in a counter or a storage unit but must be wired to read out on the same

PROGRAM STEP	OPERATION	STORAGE UNIT	COUNTER						STORAGE UNITS								
			DIVR	MULT	DIVIDEND	1	2	3	4	5	6	2L	2R	3L	3R	4L	4R
2	ADD E to (B+D)				ADD E										READOUT		
3	ADD (B+D+E) to (A+C)				ADD (B+D+E) to RESULT												

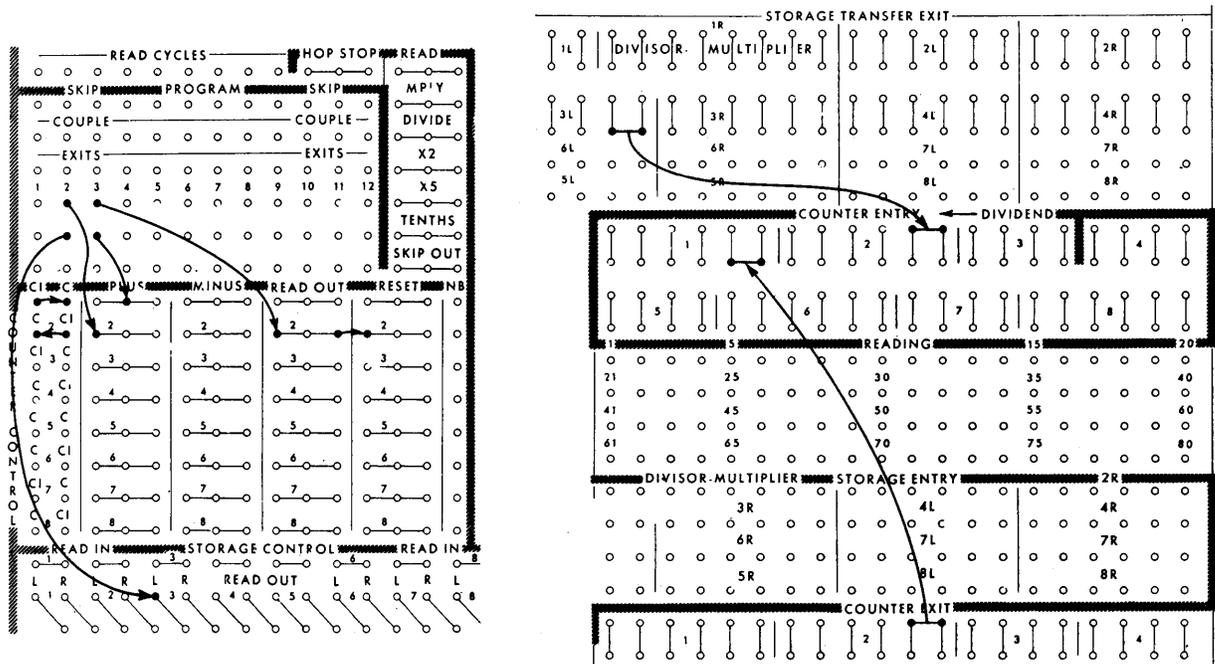


FIGURE 280. COUNTER 1 CONTAINS $A + B + C + D + E$

PROGRAM STEP	OPERATION	STORAGE UNIT		COUNTER						STORAGE UNITS				
		1L	1R	DIVIDEND		4	5	6	2L	2R	3L	3R	4L	4R
4	MULTIPLY			READY				ADD						
				X1				XXIX						

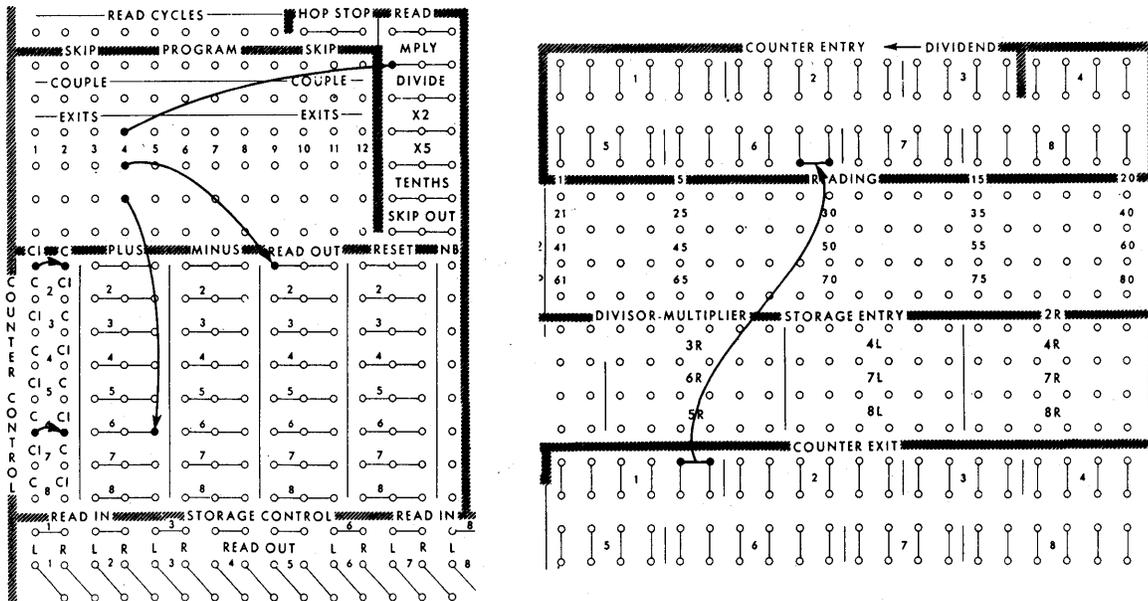


FIGURE 281. WIRING FOR MULTIPLICATION, IBM 602

program step in which the multiply hubs are impulsed.

The last requirement is satisfied by a counter. Any counter group of large enough capacity to contain the product can be used. The maximum size of a product is determined by the sum of the number of digits in the multiplier and the multiplicand. The counter selected (counter 6, in this case) is wired to add on the same program step from which the multiply hubs are wired.

Figure 281 shows the planning chart and control-panel wiring for program step 4, which is the program step on which multiplication occurs. The impulses going to COUNTER 6 ENTRY from COUNTER 1 EXIT are the impulses, corresponding to the product of the multiplier and multiplicand, which are developed internally.

Logically, multiplication of this type cannot be completed in one cycle. Internal circuits are set up in the machine to repeat the multiply program step (step 4 in this problem) until multiplication is complete. The machine recognizes this when it reaches the last digit of the multiplier. Programming then advances to the next step, or reads another card, depending upon the control-panel wiring.

Figure 282 shows the planning chart and control-panel diagram for the problem we have just worked out to illustrate programming and calculating in the 602.

IBM 604 Electronic Calculating Punch

The 604 actually consists of two machines — the electronic calculator (604) and a punch (521). In addition to punching, the feed unit in the 521 also reads the card and enters information into the 604. The 521 operates at the rate of 100 cycles per minute. The 521 feeds and punches cards continuously under normal operating conditions. The 604 is an electronic machine, and all calculations are performed at a high speed, compared with the 521. As a matter of fact, the 604 must perform all of its calculations between the time the factors are read in the 521 at the read station and the time the card is at the punch station ready to be punched. This amounts to the time between the reading of a 9 (cards feed 12-edge first) and the time a 12 is read on the next cycle. This is considerably less than a 521 cycle. The 604 operates on a cycles basis also, but they are much faster electronic cycles. Actually, during the interval of time allowed for calculating, there is time for two hundred and thirty-one electronic cycles.

The program cycles are automatically started again following the reading of a card in the 521. The standard machine has 20 program steps, but it can have 40, or 60, program steps if desired. The program steps, as in the 602, progress from program step 1 through the

PROGRAM NUMBER	OPERATION - NOTES	READ UNITS	PROGRAM SUPPRESS	FACTOR STORAGE ASSIGNMENT				MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT				PROGRAM NUMBER	
				6-4 8-6	1	2	3			4	1	2	3		4
R	READ	INTO OUT OF		RI-A X X	RI-B X X	RI-C X X	RI-D X X	RI-RATE X 0 0					RI-E X X		R

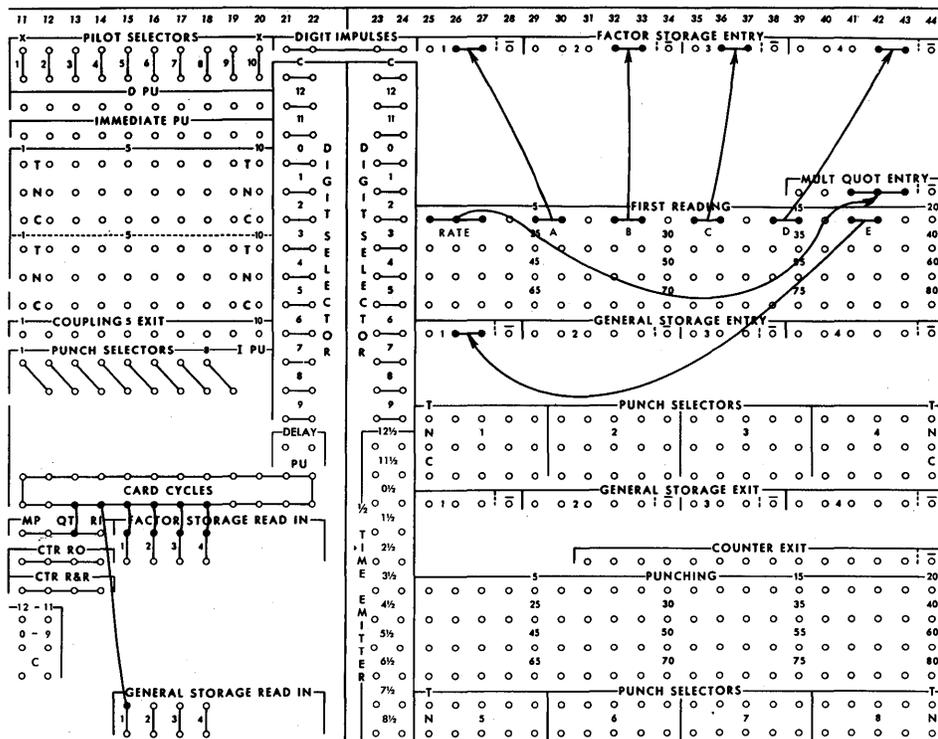


FIGURE 283. STORAGE READ IN, IBM 604 CALCULATING PUNCH

last step provided in the machine — 20 in a standard machine. There is no way to stop programming in this machine except to finish the last program. However, in most cases, there is ample time to complete programming before the next card is read or the results are punched.

Now let's use the 604 to work the same problem we did with the 602. We must first read and store all of the factors concerning the problem, just as we did in the 602 and the manual method. This is done on a card cycle when the card is being read at first reading in the 521. Figure 283 shows that A is entered into FACTOR

PROGRAM NUMBER	OPERATION - NOTES	READ UNITS	PROGRAM SUPPRESS	FACTOR STORAGE ASSIGNMENT				MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT				PROGRAM NUMBER	
				6-4 8-6	1	2	3			4	1	2	3		4
R	READ	INTO OUT OF		RI-A X X	RI-B X X	RI-C X X	RI-D X X	RI-RATE X 0 0					RI-E X X		R
1	ADD MONDAY TIME - A								ADD - A						1
2	ADD TUESDAY TIME - A+B								ADD - B						2
3	ADD WEDNESDAY TIME A+B+C								ADD - C						3
4	ADD THURSDAY TIME A+B+C+D								ADD - D						4
5	ADD FRIDAY TIME A+B+C+D+E								ADD - E						5

FIGURE 284. PLANNING CHART — STEPS 1-5

PROGRAM NUMBER	OPERATION NOTES	READ UNITS	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT				MULT QUOT	COUNTER	GENERAL STORAGE ASSIGNMENT				PROGRAM NUMBER
					1	2	3	4			1	2	3	4	
R	READ	INTO			RI-A	RI-B	RI-C	RI-D	RI-RATE		RI-E				R
1	ADD MONDAY TIME -A			1	RO					ADD-A					1
2	ADD TUESDAY TIME -A+B			2		RO				ADD-B					2
3	ADD WEDNESDAY TIME A+B+C			3			RO			ADD-C					3
4	ADD THURSDAY TIME A+B+C+D			4				RO		ADD-D					4
5	ADD FRIDAY TIME A+B+C+D+E			5						ADD-E	RO				5
6	STORE WEEKLY TIME TOTAL			6	RI					RO					6
7	MULTIPLY + WEEKLY TOTAL BY RATE			7	RO					GROSS PAY					7

FIGURE 285. SAME PLANNING CHART WITH STEPS 6-7

STORAGE UNIT 1 (FS1), B into FACTOR STORAGE 2 (FS2), C into FS3, D into FS4; E is put into GENERAL STORAGE UNIT 1 (GS1) because we have only four factor-storage units. The rate is entered into the MULT QUOT ENTRY (Multiplier-quotient, or MQ, unit). The rate must go into this unit because it is to be the multiplier. All of the factors have now been entered into the 604, and the calculations can begin.

The planning chart and control wiring for the 602 were built together step by step. However, in the 604 we plan it first and then wire the control panel.

As the planning chart (Figure 284) indicates, there are four factor storage units and four general storage units. There is, however, only one MQ unit and one counter. As a result, the multiplicand is developed by adding one factor at a time into the counter in a manner similar to the way we did it manually. Therefore, five program steps are required to accumulate the multiplicand, or weekly total.

Before going further, let's review the three requirements for multiplication, and how the 604 satisfies them:

1. Store the multiplier so the machine can analyze and use each position individually.
2. Store the multiplicand so it can be used as many times as needed.
3. Accumulate the product.

The first requirement is satisfied on the read cycle when the rate, or multiplier, is placed in the MQ unit. This unit is similar to 602 storage unit 1. It has the built-in ability to analyze the multiplier when the machine is instructed to multiply.

The second requirement for multiplication could be satisfied by having the weekly total in a counter or storage unit. However, as we indicated earlier, there is only one counter. We know this is needed for the third requirement also. Therefore, to satisfy both the second and third requirements, the multiplicand is placed in a

storage unit so the counter can be used to develop the product.

We can now see by our planning chart that we are not yet ready for a multiplication operation because our multiplicand is in the counter. We therefore must take the sixth program step to transfer this information to a storage unit.

The requirements all satisfied, the seventh program step is a multiplication operation. The completed planning chart is shown in Figure 285.

The control-panel wiring necessary on the 604 to do this problem is shown in Figure 286. On the first five program steps, the counter is impulsed to READ IN; the

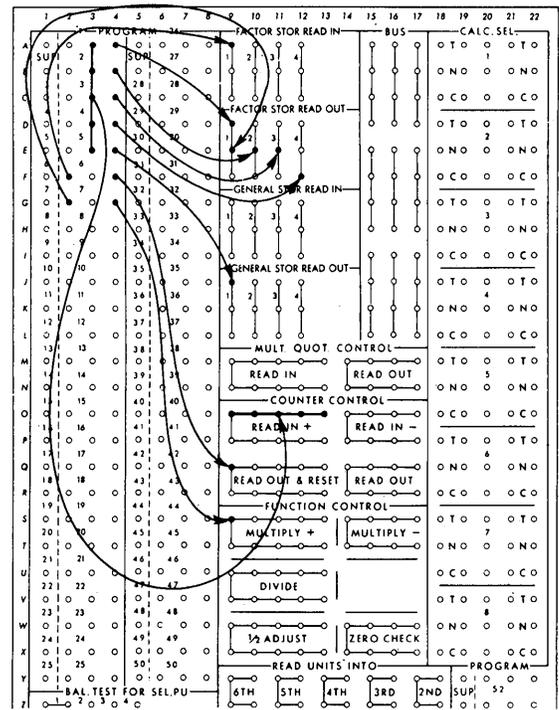


FIGURE 286. IBM 604 WIRING FOR ARITHMETIC CONTROL

storage units are wired to READ OUT on the program step indicated by the planning chart.

It should be apparent at this point from Figure 286 that there is no position wiring on the 604 as on the 602. All units in the 604 are wired together internally. Information read out of any unit can be accepted by any others impulsed to read in. Of course, if a unit has not been impulsed to read in, information has no effect on a unit.

Wiring the counter to READ OUT and RESET on program step 6 empties the counter so the product can be accumulated during the multiply operation.

Then, on step 7, it is necessary to instruct the machine to multiply. However, there are two multiply hubs: MULTIPLY+ and MULTIPLY-. The plus and minus refer to how the product goes into the counter. Because we want a positive rather than a negative number in the counter, we need to multiply +. Now go back to the planning chart (Figure 286) and notice that we indicate a multiply plus operation. There is no need for extra counter-control wiring, because there is only one counter; it is impulsed internally as a result of the multiply + impulse. It is necessary, then, only to impulse the storage unit containing the multiplicand to READ OUT.

As you know, programming continues to advance through all steps on the machine, regardless of whether they are wired to control anything or not. However, it should again be pointed out that multiplication of this type cannot be completed in one cycle. The number of cycles required depends upon the multiplier, just as it

did in the 602. Again, as in the 602, the 604 programming remains in program step 7 and takes as many cycles as necessary to complete multiplication before it advances.

The program steps following step 7 can be wired to perform any other calculations necessary. The results are normally punched in the card from which the factors were read.

Programming in Accounting Machines

The program units discussed up to this point are normally used for some type of calculation, and their progression is automatically started as a result of a card-read operation. We do have program units, however, about which neither of these two statements is true. These are the program units on the accounting machines. There are some differences between the program units used on the 402-403 and those used on the 407-408-409, but they are the same in principle and application. Therefore, only programming on the 407-408-409 is discussed.

IBM 407-408-409 Accounting Machines

All of the general statements about programming made in the beginning of this section apply to the 407-408-409 program unit. However, this unit is not normally used to program calculations involving multiplication or division. A simple multiplication operation can be done, but there is no multiply hub to achieve it automatically. The usual type of calculation done on this machine is addition and subtraction, for example: $A + B - C = T$.

This is similar to the calculation of the weekly total of man hours worked in the problem we did on the 602 and 604. This type of calculation is generally referred to as *crossfooting*.

The normal use for the 407-408-409 program unit is printing various types of totals accumulated (Figure 287). For example, when accumulating sales amounts, we may want to print a total of the sales made by each salesman. We may also want to print the total of each local office. If we want to carry this a little further, we can get a total sales amount for each state. As the cards pass through the machine, certain information, such as product and sales amount, can be printed from each card. This happens at the same time that the counters are accumulating the amounts from the amount field.

STATE	OFFICE	SALESMAN	PRODUCT	AMOUNT AND TOTAL BY S'MAN	TOTAL BY OFFICE	TOTAL BY STATE		
1	1	1	A	12.40				
			B	6.28				
			C	14.82				
			D	12.45				
							61.95*	
							28.64	137.48*
							4.26	
							42.63	
							75.53*	
							10.16	
							4.22	
							14.38*	
				42.50				
				53.72				
				10.81				
				107.03*				
				121.41*	258.89*			
2	1	1	A	48.21				
			B	33.33				

FIGURE 287. ITEMIZED REPORT SHOWING GROUP TOTALS BY SALESMAN, OFFICE, AND STATE

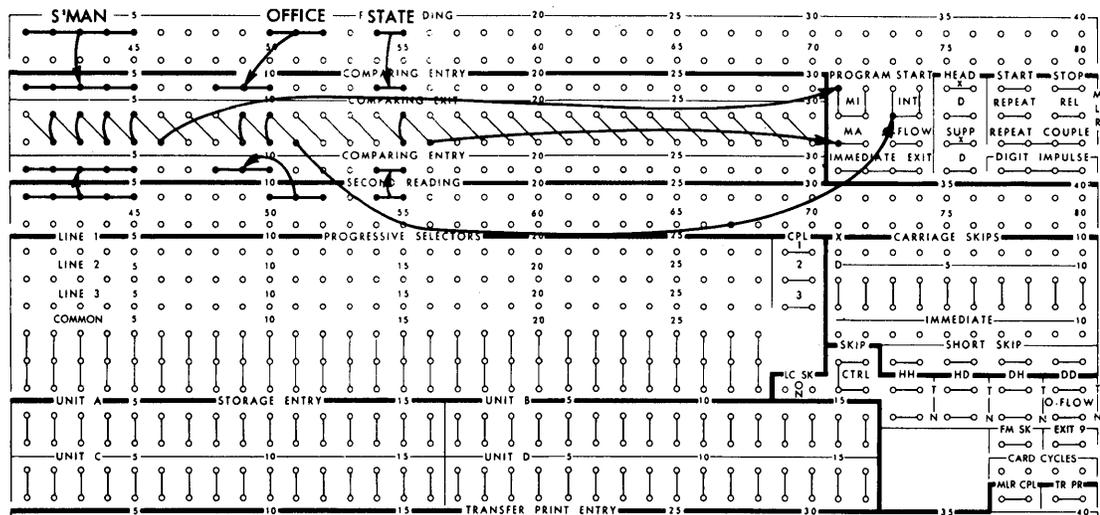


FIGURE 288. COMPARING FOR PROGRAM CONTROL, IBM 407-408-409

The total sales for each salesman are printed as soon as all of his transactions have been accumulated. Similarly, the total sales for each office and each state are printed as soon as all of the transactions for a given office or state have been accumulated. The totals by salesman are printed on program step 1, the totals by office on program step 2, and the totals by state on program step 3.

The office total includes the sales made by *all* salesmen in the office; in other words, it is the sum of all of the individual salesman totals. The state totals would be the sum of the totals from all of the offices in the state. The salesman totals would be minor in relation to the office totals. The relationship is usually true of any totals printed on program step 1 related to those printed on program step 2. As a result, program step 1 is referred to as a minor total cycle, and the total printed on that cycle, in this case salesman total, as a minor total.

If there were only two program steps, then program step two could logically be called the major total cycle. However, this type of program unit has three program steps, the third step being the most major. For example, the total sales by state would be the major total. The total printed on program step 2 being neither minor nor major but somewhere in between, is referred to as an intermediate total, in this case total by office. The second program step is referred to as intermediate, even when only two classes of totals are used.

It is logical then that we do not want all three program steps to occur every time programming is started, and also that we do not want programming to occur every time a card is read.

Actually, we want programming to begin as a result of a change in salesman, office, or state. This means that we must be able to recognize a change in group. This is done by means of the comparing unit, which was described in the section on *Comparing*.

Another requirement is that we take one, two, or three program steps, depending upon the type of control change — salesman, office, or state — or more generally stated, depending upon whether we have a minor, intermediate, or major control change. This is general enough to be used in any situation and is the terminology usually used. In the 602 the number of program steps taken can be determined by wiring the last program step needed to the read hubs. However, in the 602 the same number of program steps are used for each card. In the 407-408-409 we want to vary the number of program steps taken, depending upon the type of change in group. We use the impulses from the comparing unit to start programming. The number of program steps taken is dependent upon how the programming is started. Three different entries, labeled MI, INT, and MA, start programming. If MINOR START is impulsed, programming stops automatically after program step 1. Programming stops after program step two if INTERMEDIATE START is impulsed, and after the third program step if MAJOR START is impulsed. This wiring is illustrated in Figure 288.

Because we have already studied accumulation, we are not concerned at this point with how counters are wired to add and subtract. Now let's take a look at the wiring needed to cause totals to print, according to the pattern we have established.

Assume the total for salesmen is being accumulated in counter 4B, for office in counter 6B, and for state in

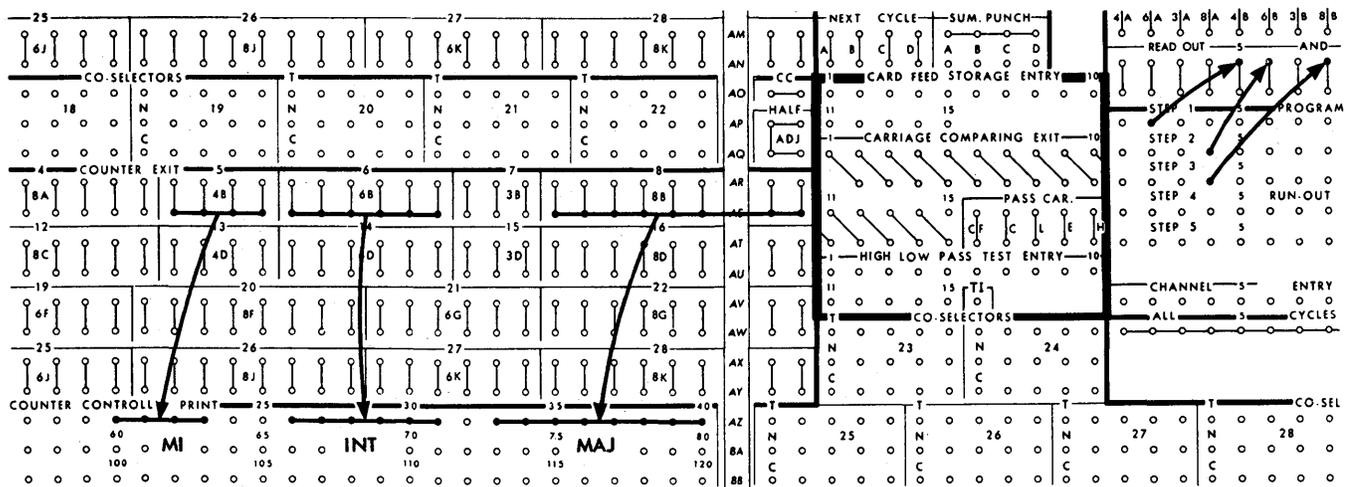


FIGURE 289. NORMAL PROGRAMS, IBM 407-408-409

counter 8B. It becomes a simple matter, then, to wire these counters to read out and reset on their respective program steps, and to wire the COUNTER EXITS to PRINT ENTRY. This is done as shown in Figure 289 to give the type of report shown in Figure 287.

The diagram in Figure 289 indicates more than three program steps. However, only the first three are normal program levels in this machine. The remaining steps can be obtained by special programming. This feature is explained in the IBM 407 Reference Manual.

Review Questions

1. In general terms, what is *programming*?
2. What is meant by *calculating*?
3. What causes programming to begin on the 602?
4. Can the number of program steps taken by the 602 be determined by control-panel wiring? If yes, what do you wire to control it?
5. On the 602 the multiplier must always be placed in what unit?
6. How do you instruct the 602 to multiply? Is multiplication completed in one cycle?
7. What causes programming to begin on the 604?
8. Can the number of program steps taken by the 604 be determined by control-panel wiring? If yes, what do you wire to control it?
9. How do you instruct the 604 to multiply? Is multiplication completed in one cycle?
10. What is the 407 programming unit normally used for?
11. What causes programming to begin on the 407?
12. Can the number of program steps taken by the 407 be determined by control-panel wiring? If yes, what do you wire to control it?
13. The program steps in the 407 have special names; what are they?

Zero printing in punched-card machines is controlled in one of two ways:

1. Externally by the operator, as in the IBM 402-403 Accounting Machine
2. Internally by control-panel wiring, as in the IBM 548, 552, and 557 Interpreters and 407-408-409 Accounting Machines

In this manual, we are concerned with machines that have internally controlled zero-print control.

To illustrate the zero-print control devices that are a part of the accounting machines and the interpreters, let's take two fields punched in a payroll card. The first field is the amount of the net pay that an employee receives during each pay period. The amount is \$76.04.

The largest check ever written by this company amounts to \$1351.21. So, in the field punched in the card, we must make allowances for a six-digit number.

The second field is the date (April 3, 1959) on which the pay check is issued. Now, if we punch the full alphabetic date in the card, we need nine columns for the longest month, two columns for the day, and four columns for the year — a total of 14 columns. If we punch the date numerically, we can use two columns for the month, two for the day, and two for the year — a total of 6 columns.

Both fields must have *all* positions punched in the card. If there is no significant digit for a position, that position must be punched with a zero. [A significant digit is any digit (0-9) that contributes to the real value of a number.] So, the field containing the amount for the first pay check must be punched 007604 and the field for that date, 040359. (If the largest check paid by the company were being paid on December 24, 1959, the payroll card would be punched 135121 and 122459.)

When the data is interpreted, only zeros to the right of significant digits are printed, zeros to the left of significant digits are suppressed:

	As Punched	As Interpreted
Field 1	007004	7004
Field 2	040359	40359

This is often done when a large amount of data is being interpreted, to prevent confusing adjacent printed fields.

The top card in Figure 290 shows the amount and date fields interpreted exactly as punched. The lower card shows the fields interpreted with significant zeros suppressed. As you can see, the lower card is much easier to read.

Figure 291A represents the payroll register discussed earlier. Notice that, if we do not wire zero-print control in the 407-408-409 Accounting Machine, none of the zeros is printed in any of the amount fields.

Figure 291B shows the two fields interpreted in the 557 Interpreter. Here too, without zero-print control wired, none of the zeros is printed. As you can see from these examples, control of zero printing is important for clarity, legibility, and accuracy of printed numerical fields.

Let's find out how and why this control works.

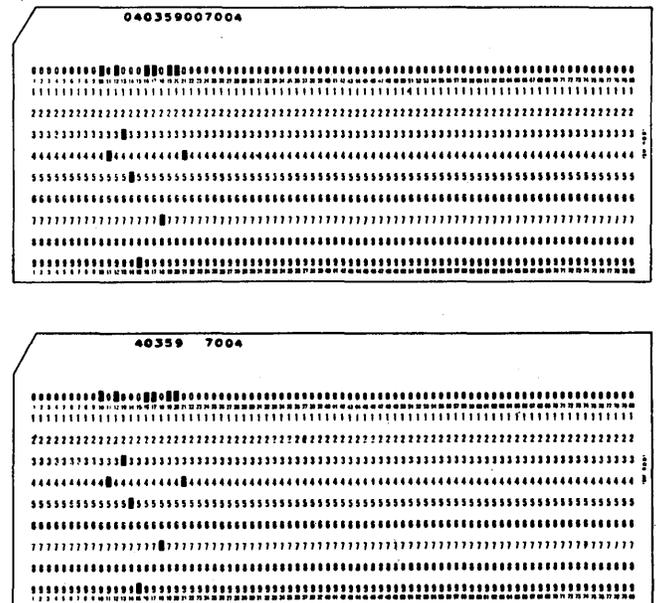


FIGURE 290. INTERPRETED CARDS

PAYROLL REGISTER

Year-to-Date		Employee		Employee Name		Hours			Earnings			Deductions			Net Pay	
Earnings	Withholding Tax	Dept	No	1st	2nd	Regular	O. T.	Total	Rate	Regular	Overtime	Gross	Withholding Tax	F. I. C. A.		Other
101250	17313	57	079	W	K	SNYDER	400	15	415	185	7400	278	7678	1305	192	6381
Zero - Print Control Wired																
1 125	17313	57	79	W	K	SNYDER	4	15	415	185	74	278	7678	13 5	192	6381
Zero - Print Control Not Wired																

A

Zero-Print Control Wired

Zero-Print Control Not Wired

B

FIGURE 291. PAYROLL REGISTER AND CARDS

Zero Elimination in the IBM 552 and 548 Interpreters

Recall from the discussion on printing in the 552 and 548, that these machines have typebars, and that the card is read 12-edge first so the zones are received by the typebars before the digits.

When an alphabetic code is read, the typebar is positioned first by the zone; then repositioned by the digit. Pressing the type against the platen prints the alphabetic character.

Now, with the zero-elimination device installed and wired in the 552 and 548, the 0-1 section of the typebar is pressed against the platen whenever zeros are read in high-order positions. This special-character position on the typebar must be blank to eliminate printing zeros.

How is the typebar positioned to the 0-1 section only when zeros are read in the high-order position of a field?

Recall the discussion of emitters and of subtraction on the accounting machines. We subtracted by adding the 9's complement of a number. This involved starting

and stopping the counter wheel. Whenever a *minus* hub was impulsed, an *internal emitter* started the counter wheel revolving.

In zero elimination in the 548 and 552, an *internal emitter* emits a 1 impulse if a 0 impulse has been received from the reading brushes. The typebars are positioned, first by the zone (0), then by the digit (1). This *internal emitter* is activated by the zero punch *only* if:

1. The high order (left position) of each field is wired in a special way in the control panel (Figure 292).

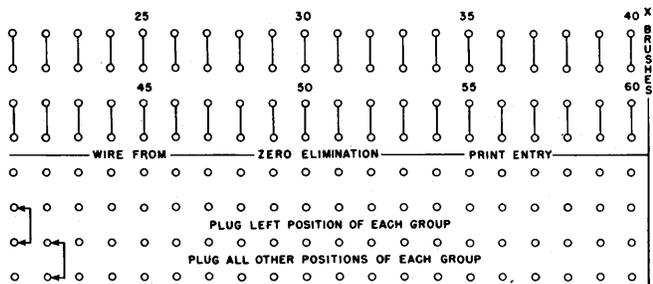


FIGURE 292. ZERO-ELIMINATION HUBS, IBM 548 INTERPRETER

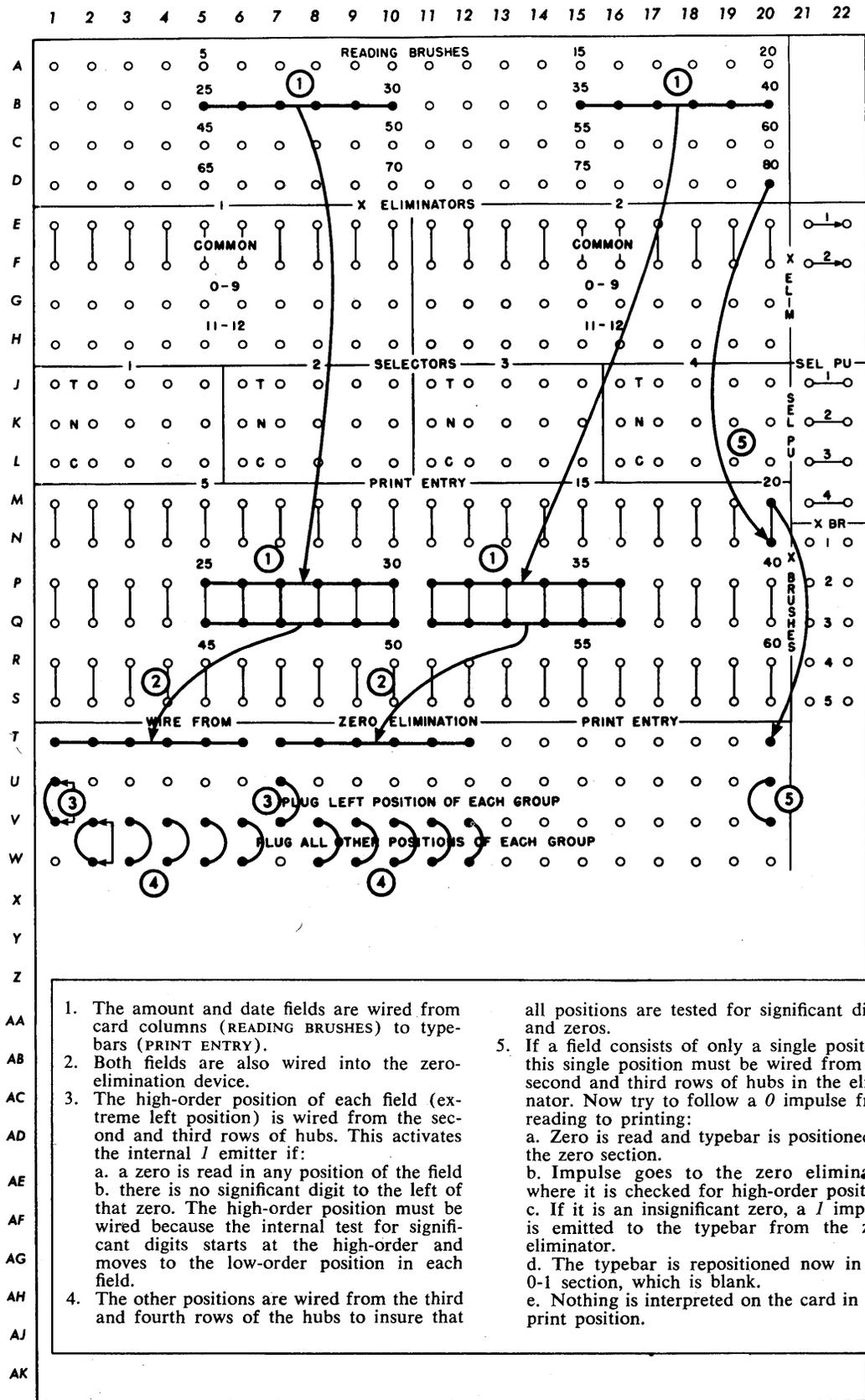


FIGURE 293. WIRING FOR ZERO ELIMINATION

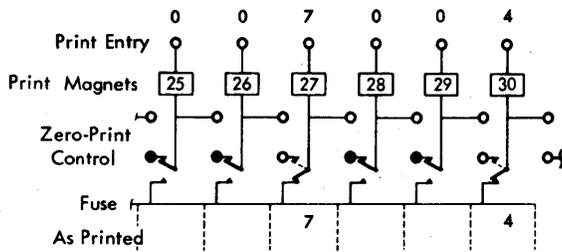


FIGURE 294. ZERO-PRINT-CONTROL SCHEMATIC

2. There is no significant digit read in the field to the left of the zero.

The zero elimination hubs in the 548 and 552 are in four rows. The top row is always wired from PRINT ENTRY.

The third and second rows are wired together for the high-order position, and the third and fourth rows are wired together for all other positions in the field.

Figure 293 shows the wiring necessary to interpret the fields without high-order zeros shown in Figure 290.

Zero-Print Control in the IBM 557 Interpreter

Interpreting zeros in the 557 is influenced by the fact that the printing device is a typewheel instead of a type-bar and that the zeros do not print by themselves. An *internal* machine impulse must be supplied by *external* control-panel wiring to make zeros print.

Let's explain this a bit more. The zero-print contacts provide a path from the print entry to the print magnet. If the print contact for a given position does not transfer, the data for that position cannot reach the fuse and consequently does not print.

Figure 294 shows a schematic of the internal circuitry for zero-print control. Figure 295 shows ZERO PRINT CONTROL on the 557. Notice that the upper and lower zero-print-control hubs for each position are diagonally connected to facilitate wiring. This is *not* marked on the control panel, but you must understand the positioning to wire the board correctly. The upper hub in the first position is really the upper hub for print position (entry) 60; the lower hub in the first position

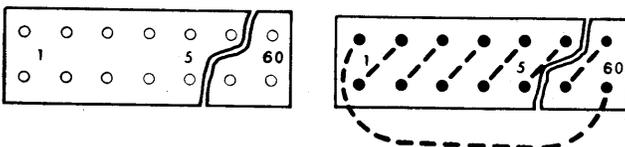


FIGURE 295. ZERO-PRINT-CONTROL HUBS, IBM 557

is the lower hub of print position (entry) 1; the upper hub in the second position is the upper hub of print position (entry) 1, and so on.

Now look back at Figure 290. The amount position is punched 007004. We want to interpret the field as shown in the second card: 7004.

Figure 294 illustrates how the field prints if we do not wire zero-print control. Remember the three points stated earlier:

1. If the zero-print contacts do not transfer, data cannot reach the fuses and therefore can not print.
2. Digit punches 1-9 transfer the contacts automatically.
3. Zero punches by themselves do not transfer the contacts.

We are interpreting the amount field in print positions 25 through 30. Only zero-print contacts for positions containing significant digits (1-9) are transferred. Thus, only positions 27 and 30 interpret on the card.

Figure 296 shows the wiring and circuitry for zero-print control to print the field as 7004 and eliminate zeros to the left of the first significant digit.

The significant zeros — those between the 7 and 4 — still do not have a direct path to the fuse. The zero-print contacts for positions 28 and 29 are still not transferred. But because of the external zero-print-control wiring, the zeros have an indirect path to the fuse through the transferred print contacts of position 27. Follow the path of the zero impulse from position 29 through the external zero-print-control wire to position 28; through the external zero-print-control wire to position 27; through the transferred zero-print contact of position 27 to the fuse.

The external wiring on the control panel of the 557 required to interpret the amount field (as pictured on the lower card in Figure 290) is illustrated in Figure 297.

Suppose you want to interpret *all* zeros in the amount field. In other words, if the field is to be interpreted exactly as it is punched, how do we wire zero-print control?

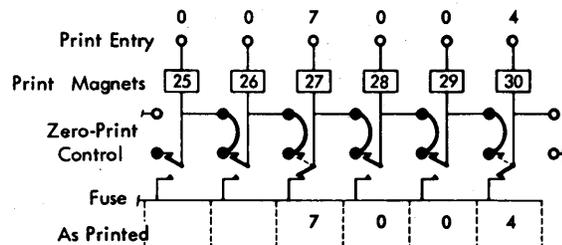
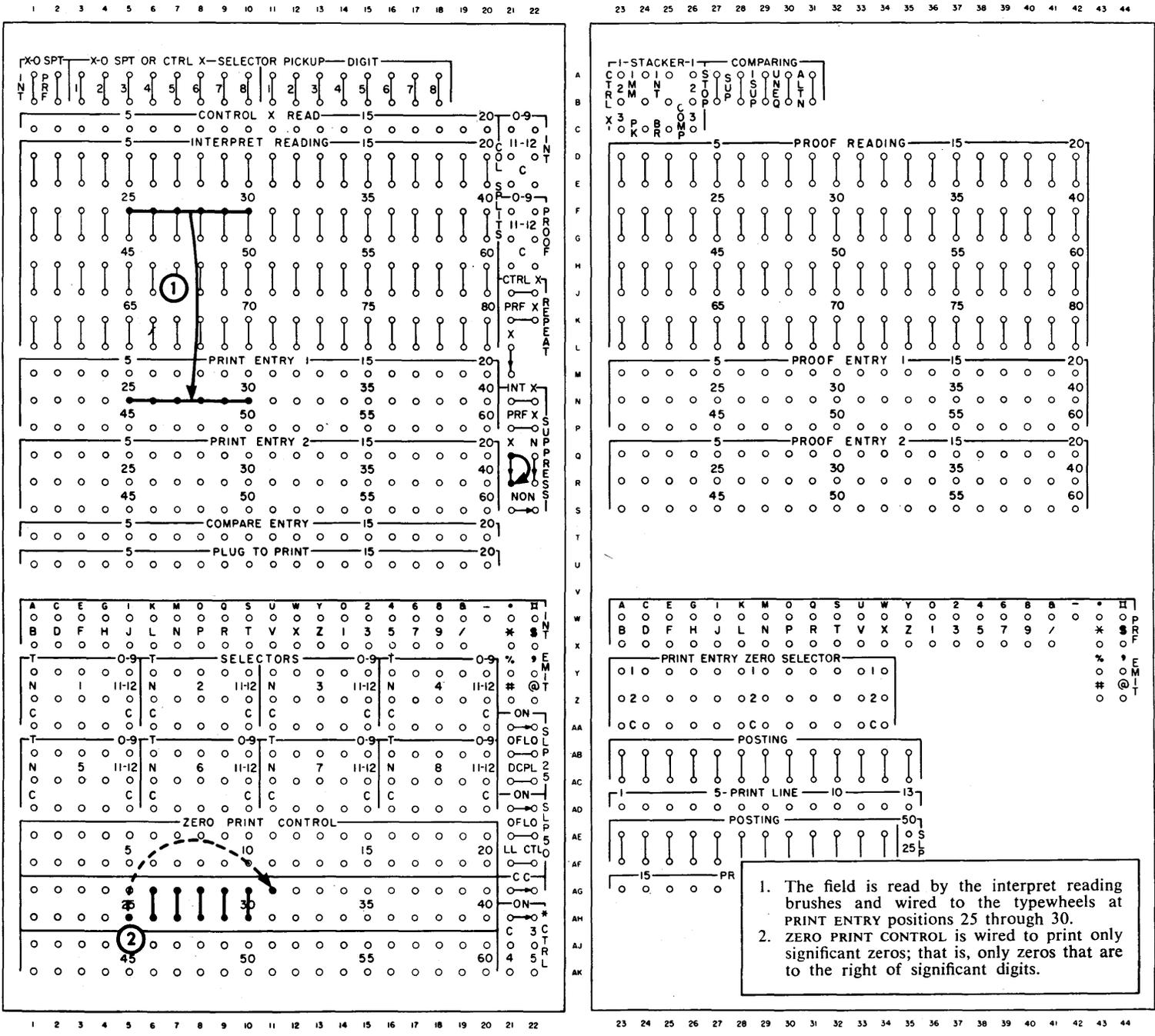


FIGURE 296. STANDARD ZERO-PRINT CONTROL WIRING, PRINTING ZEROS TO RIGHT OF SIGNIFICANT DIGITS

FIGURE 297. WIRING FOR PRINTING ALL ZEROS IN A FIELD, IBM 557



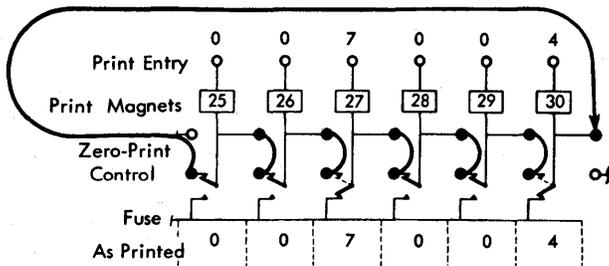


FIGURE 298. ZERO-PRINT-CONTROL SCHEMATIC FOR PRINTING ALL ZEROS

We must provide a path to the fuse for all zeros: those to the left of the first significant digit as well as those to the right. The path is provided by an external wire from the lower hub of the high-order position (zero-print control 25) to the upper hub of the low-order position (zero-print control 30) (Figure 298).

We saw in Figure 296 how the zeros in positions 28 and 29 found a path to the fuse. They use the same path in Figure 298.

Now let's follow the path of the zero in print position 26. It cannot reach the fuse through position 27 because the contact for that position is transferred by the digit 7.

The zero moves through external wiring to position 25, through the external wire to position 30, then through the transferred zero-print contact of position 30 to the fuse.

The additional external wire (from position 25 to position 30) is illustrated as a dotted line in Figure 297. Through this wire, zeros to the left of significant digits reach the fuse and are printed.

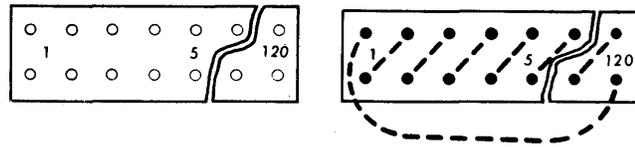


FIGURE 299. ZERO-PRINT-CONTROL HUBS, IBM 407-408-409

Because letters are composed of a digit punch as well as a zone punch, the magnets are automatically transferred for all alphabetic characters. It is not necessary to wire ZERO PRINT CONTROL for alphabetic fields.

Zero-Print Control in the IBM 407-408-409 Accounting Machines

The control of zeros in the 407-408-409 is the same as that in the IBM 557 Interpreter. In neither machine can zeros print by themselves. An additional internal impulse must be provided through external control-panel wiring.

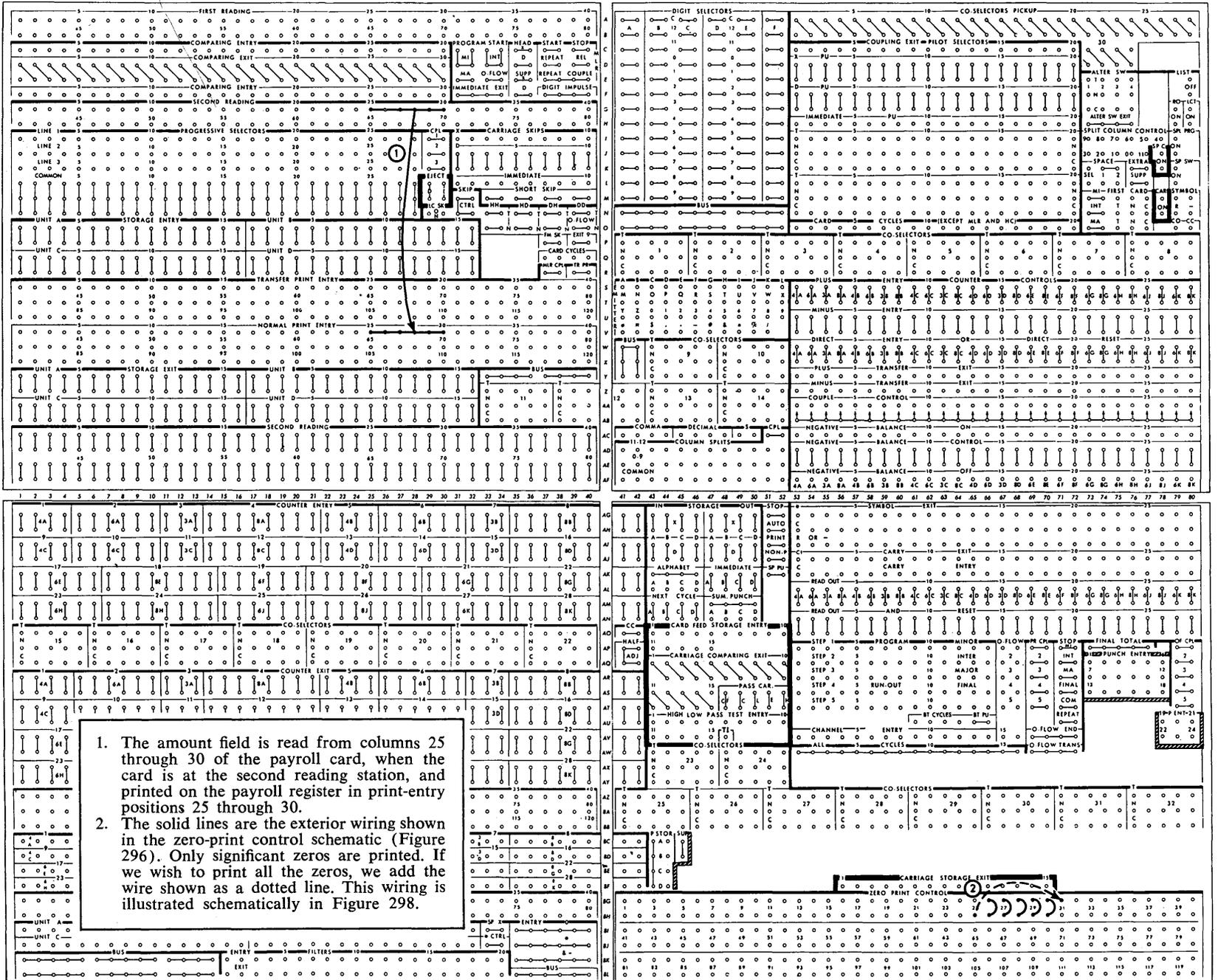
As indicated in Figure 299, the zero-print-control hubs in the 407-408-409 are similar to the same hubs on the IBM 557 Interpreter. Each of the 120 zero-print positions in the 407-408-409 has two hubs that are connected internally. As shown by the dotted lines, the lower hub of position 120 is internally connected with the upper hub of position 1.

Figure 300 illustrates the wiring for zero-print control in the 407-408-409 Accounting Machines.

Review Questions

1. How is zero-printing controlled in IBM punched-card machines?
2. How are zeros *eliminated* in the 548 Interpreter?
3. How are zeros *printed* in the 557 Interpreter? The 407?
4. Why is zero-print control unnecessary for alphabetic characters?
5. What is the difference between a significant zero and an insignificant zero?
6. Explain the difference between an indirect and a direct path from the print magnets to the fuse in the 407.
7. What is the purpose of the zero-elimination device for the IBM 548, 552 Interpreters?

FIGURE 300. ZERO-PRINT-CONTROL WIRING, IBM 407-408-409



1. The amount field is read from columns 25 through 30 of the payroll card, when the card is at the second reading station, and printed on the payroll register in print-entry positions 25 through 30.
2. The solid lines are the exterior wiring shown in the zero-print control schematic (Figure 296). Only significant zeros are printed. If we wish to print all the zeros, we add the wire shown as a dotted line. This wiring is illustrated schematically in Figure 298.

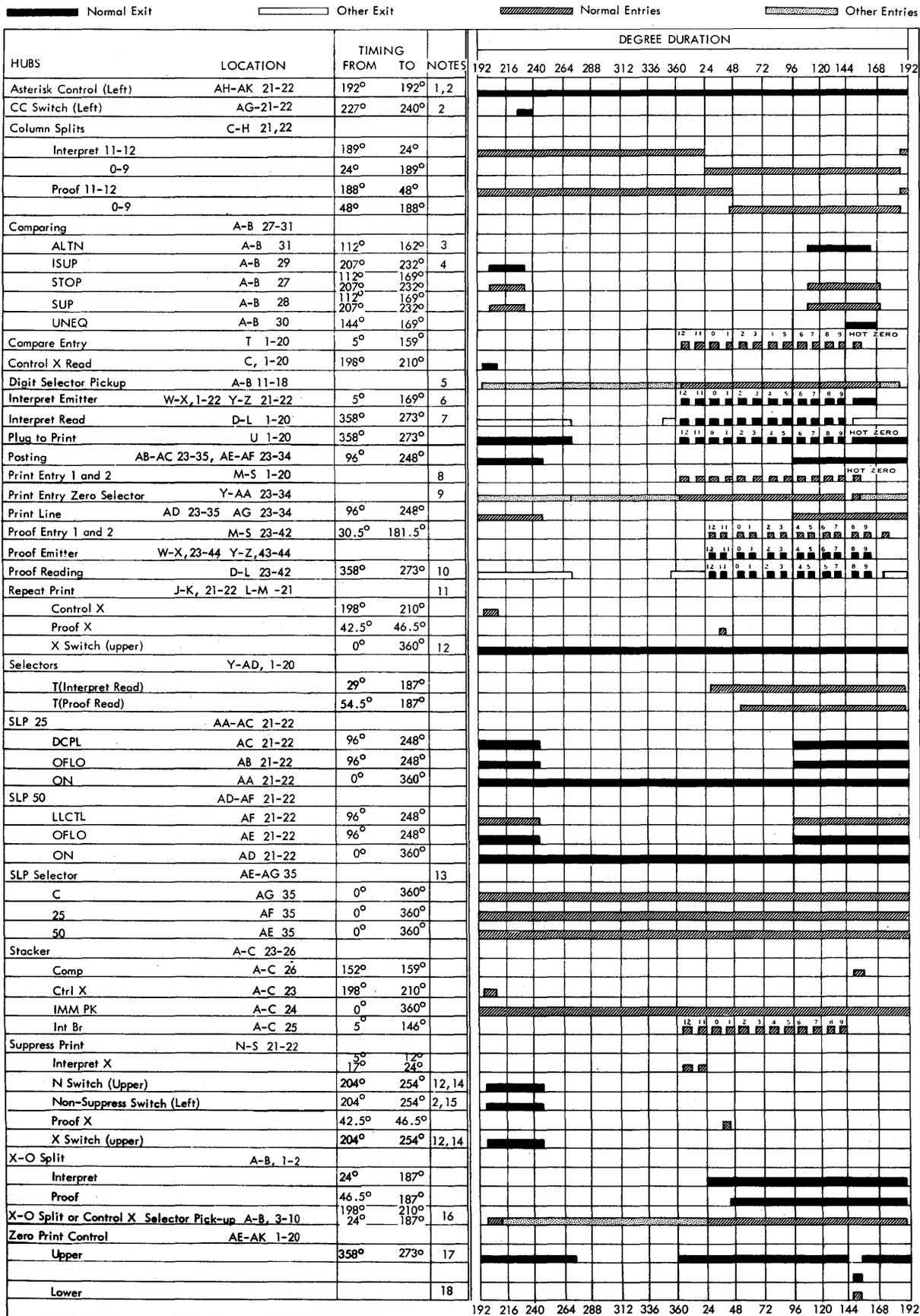


FIGURE 301. TIMING CHART, IBM 557 ALPHABETIC INTERPRETER

Timing Charts

Now that you have learned how basic wiring causes certain functions to take place, you are ready to learn how to read a timing chart. A knowledge of timing is perhaps the most important key to the application of functional wiring principles.

Timing charts help you determine whether or not wiring can control machine functions without damaging the machine internally. Once you have learned the basic wiring for a specific machine, you can use the control-panel summary and the timing chart advantageously.

Timing charts for IBM machines are usually composed of the following elements, as illustrated in the timing chart for the IBM 557 Alphabetic Interpreter (Figure 301).

1. **Key:** this shows which bars on the chart represent exit impulse times, normal entry times, and times when entry hubs can receive impulses not normally directed to them.
2. **Hubs and Locations:** this section lists all the hubs and their location on the control panel.
3. **Notes:** these are additional explanations, exceptions, etc., listed by note number. Some hubs have more than one note significant to their operation.
4. **Degree Duration:** this indicates the range of degree-time in the cycle during which a hub emits or accepts an impulse.

Let's look again at Figure 301. You have learned that a cycle is always represented as 360 degrees (from 0° to 360°). The timing chart for the 557 shows the functional cycle beginning at 192° and ending at 191°,

because the first significant control function operative for any single card, or group of cards, is the *Control-X-impulse* that emits just after 192° cycle-time.

We know that the selectors in the 557 can be impulsive from CONTROL-X-READ. We can verify this from the timing chart. CONTROL-X-READ emits an exit impulse from 198 to 210 degrees in the cycle. X-SPLIT or CONTROL X SELECTOR PICKUP is an entry that accepts impulses from 200° to 187°. Because the pickup accepts when CONTROL X emits, a control-panel wire connecting these two hubs completes a circuit (Figure 302).

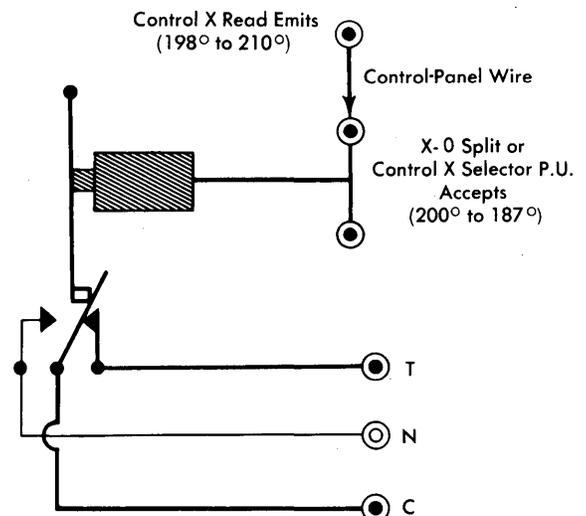
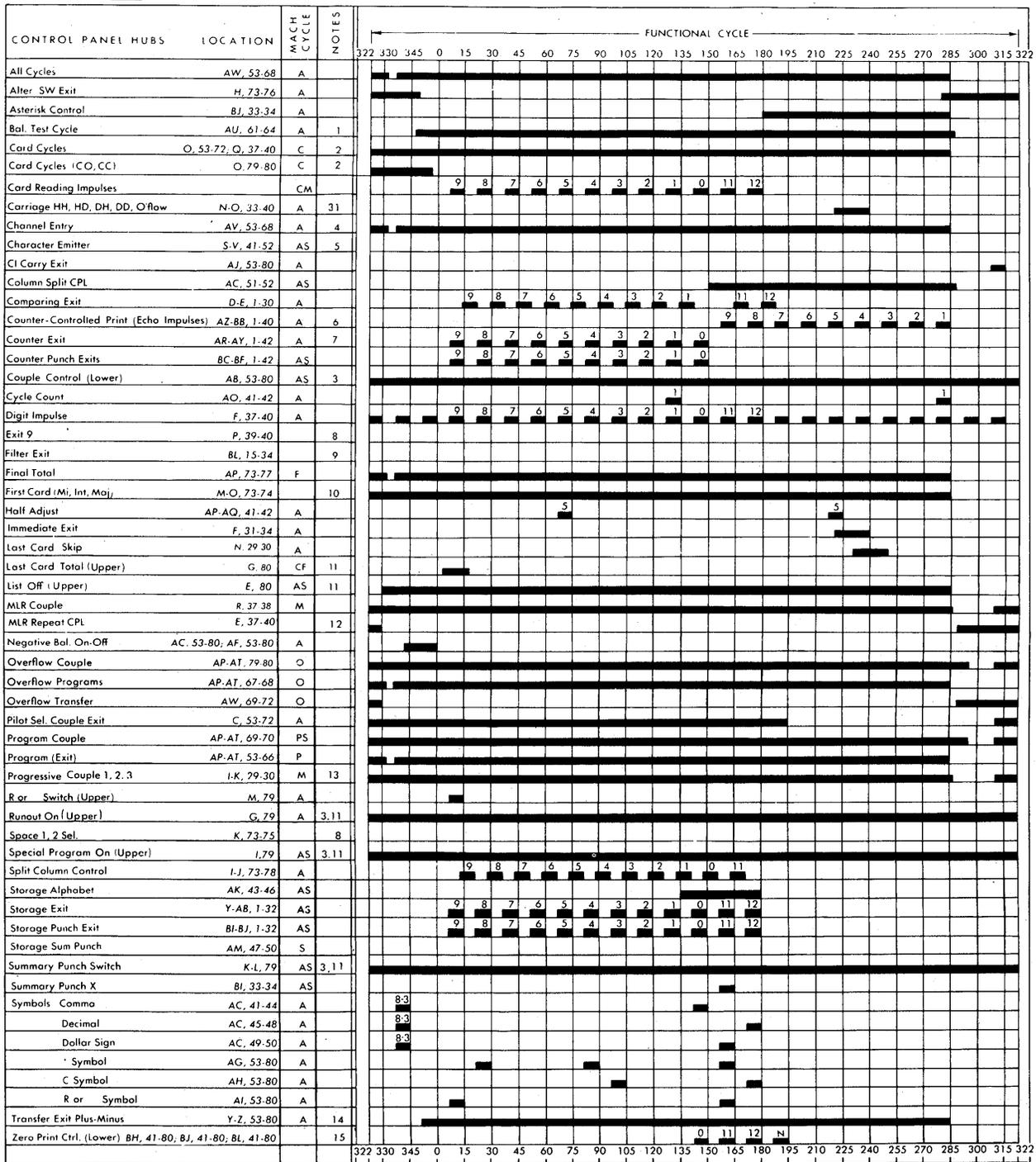


FIGURE 302. X-0 SPLIT OR CONTROL X SELECTOR PICKUP ACCEPTS CONTROL X READ IMPULSE



MACHINE CYCLES CODE

- | | | |
|---|---|---|
| <p>A All machine cycles, except summary punch and long carriage skip cycles</p> <p>C Card cycles</p> <p>F Final total cycle</p> <p>M MLR cycles</p> <p>O Overflow programs</p> <p>P Program cycles</p> <p>S Summary punch cycle; timing under control of summary punch</p> <p>NOTES</p> <p>1. Should not be used for counter crossfloating</p> <p>2. Q, 37-40 active on all card cycles; O, 53-72 and O-79-80 except HC and MLR cycles</p> <p>3. Line impulse</p> <p>4. Except special program</p> <p>5. Emits impulses as designated on control panel</p> <p>6. All cycles if impused</p> <p>7. Except on direct entry or direct reset</p> | <p>8. Under control of carriage</p> <p>9. Emits whatever is entered</p> <p>10. Minor also active on first body card</p> <p>11. Wire only to lower hub</p> <p>12. All MLR cycles after repeat is impused. First repeat cycle good only from 310-350°</p> <p>13. Timing shown for MLR only. When used as entries, timing depends on pickup impulse</p> <p>14. Only when counter is impused to read out and reset</p> <p>15. Print cycles only; N internal no-zone impulse</p> <p>16. Immediate transfer at time impused</p> <p>17. Minus must be impused not later than 351°</p> <p>18. Counter-controlled print internally common with either normal or transfer print entry on first half of cycle</p> <p>19. Must be impused not later than 336°</p> <p>20. Except when release is impused on the same cycle</p> <p>21. Including last MLR cycle</p> | <p>22. Accepts 3 on line 3, 2 on line 2, 1 on line 1</p> <p>23. Accepts only after overflow program start has been impused</p> <p>24. Except overflow programs</p> <p>25. Transfer time on X or D pickup</p> <p>26. Com. accepts any program; Mi, Int, Maj accept when corresponding program start is impused; Final accepts when runout final is active</p> <p>27. Except cycle preceding summary punch cycle</p> <p>28. Read in effective on next card feed cycle or next MLR cycle; Read out effective on same card feed cycle if impused between 322 and 335°</p> <p>29. Read in effective on next card feed cycle or next MLR cycle</p> <p>30. Any impulse from 5 to 110 degrees including digits 9 through 3; will suppress spacing before and after printing. Any impulse on a program cycle from 135 to 260 degrees will suppress any automatic spacing that may occur after total printing</p> <p>31. In MLR, emits only on the last cycle</p> |
|---|---|---|

FIGURE 303A. IBM 407 TIMING CHART — EXITS

ENTRIES  Normal
 Available but not normally used

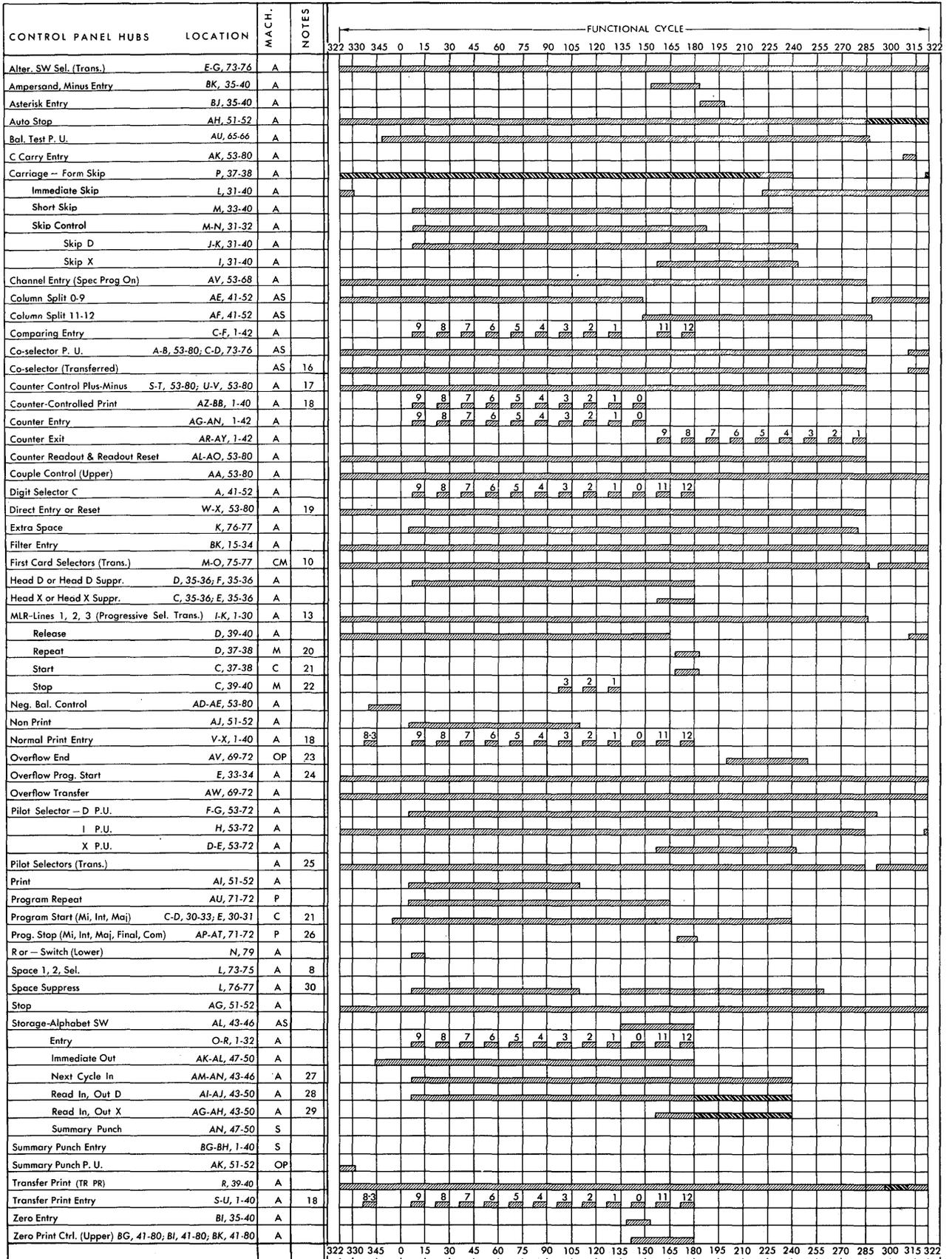


FIGURE 303B. IBM 407 TIMING CHART — ENTRIES

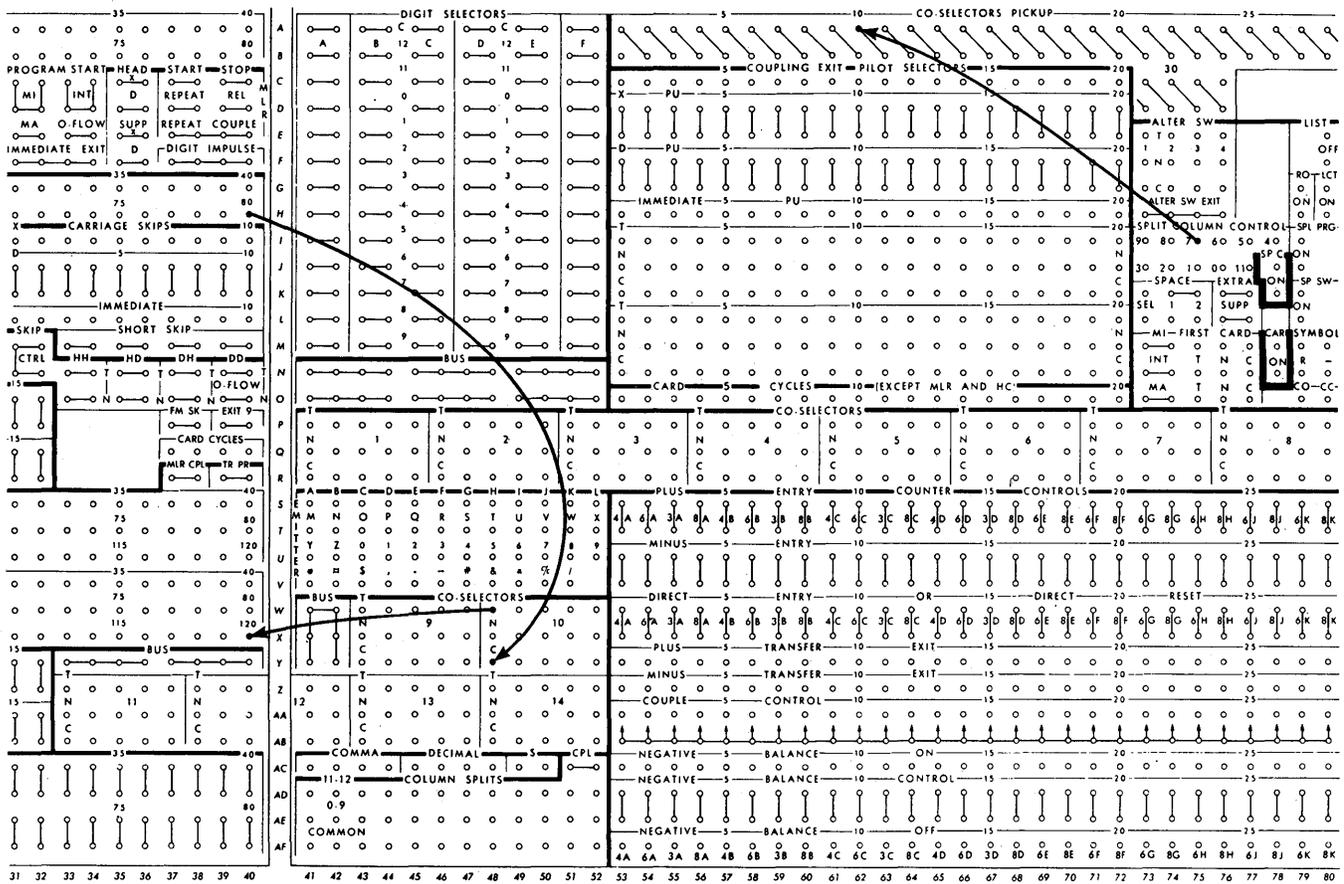


FIGURE 304. WIRING FOR SPLIT-COLUMN CONTROL

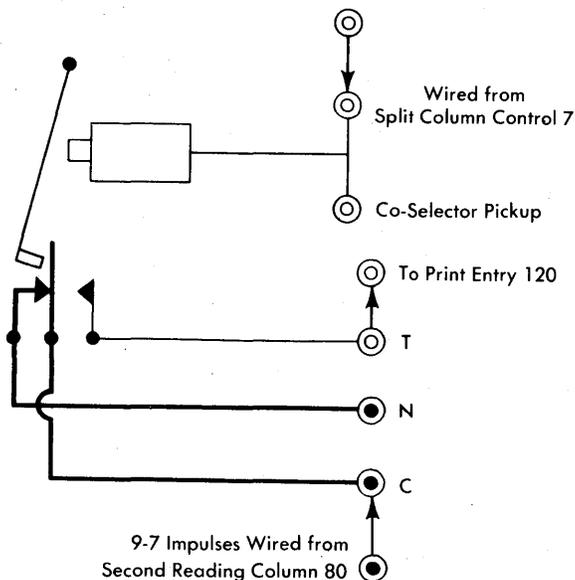


FIGURE 305. CO-SELECTOR NORMAL DURING 9-7 CARD-READING TIME (8° TO 45°)

The timing chart shows that normal entry times for impulses directed to the x-0 SPLIT or CONTROL X SELECTOR PICKUP is from 200° to 210° and from 25° to 187°. This entry can also accept an impulse from 211° to 24°. However, *Note 16* tells us that this is to be used as an entry *only* for x-0 split impulses or control-X-read impulses. This means that even though x-0 SPLIT or CONTROL X SELECTOR PICKUP can accept an impulse emitted from 211° to 24°, such impulses should not be wired to this hub.

Some timing charts (such as the 407 illustrated by Figure 303) show exit and entry hubs separately. The 407 timing chart has a special column indicating during which machine cycle, or cycles, an impulse is active.

Because there is a variable lag in the actual transfer of selectors, an allowance of 7° should be made between the selector pickup time and the impulse to be selected. We must be sure to follow this rule, or we may damage the selector. This damage is called *arcing* or *burning the points*.

Now let's examine the 407 timing chart to see whether the wiring in Figure 304 will be effective.

In this example we wire the split column control 7 *hub* to the pickup of co-Selector 10. We want to use the co-selector to permit only 6-12 impulses from card column 80 to print in position 120 when the selector is transferred.

SPLIT COLUMN CONTROL 7 emits on all machine cycles from 40° to 52° .

Co-selector pickup hubs can receive impulses from 307° to 285° . If we allow 7° for the co-selector to transfer, we can assume that the selector will be transferred before 52° in the cycle.

Digit 6-12 impulses emit intermittently from 52° to 180° . The co-selector is transferred from 51° to 285° . Therefore, only impulses 6-12 from the card can get through the transferred side of co-selector 10.

NORMAL PRINT ENTRY can receive impulses intermittently from 337° to 180° to complete the circuit from the reading brushes through the selector to print entry (Figures 305 and 306).

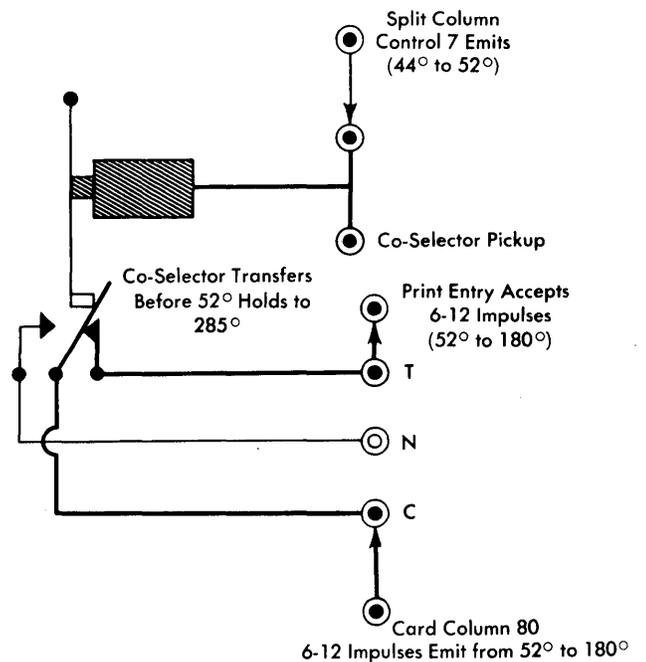


FIGURE 306. CO-SELECTOR TRANSFERRED DURING 6-12 CARD-READING TIME (52° TO 180°)

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