Functional Wiring Principles

IBM

punched card data processing equipment

Form 22-6275-0

preface

You can learn and understand a given subject more easily and completely, if you have the proper background. This book is intended to provide you with a background of general wiring methods used in IBM to accomplish the various functions of IBM machines, such as punching, printing, comparing, etc., and the terminology common in machine accounting.

We are making no attempt, in this book, to cover any one machine in its entirety. However, specific machines will be used to illustrate the principles, and these principles can be applied to the machines as you study them later.

contents

FUNCTIONAL WIRING PRINCIPLES

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. Therefore, the machine must be told what to do and you must tell it what 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 told it what decisions it should make for a given set of conditions.

Of course, a machine does not understand spoken instructions so a control panel has been placed on the machines so that you may give it instructions.

A control panel is a panel or board which, in most cases, can be removed from a machine or inserted into the machine when desired. The panel consists of a lot of holes, called hubs, into which you can insert wires with special tips, to vary the instructions. Each of the hubs in the panel has a specific purpose or function. You must know what each hub is for and then, knowing what is to be done by the machine, you can insert the wires into the proper hubs to cause it.

THE IBM CARD

WE HAVE discussed the control panel in general and it has been stated that the machine will be instructed to handle the desired information in a specific manner by means of control panel wiring. However, many of the instructions and most of the information will depend on the holes in an IBM card.

Standard IBM cards are composed of 80 vertical columns into which holes representing all digits (0-9), all alphabetic letters (A-Z), or special signal codes may be punched (Figure 1).

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 which 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 information is recorded by code. Each alphabetic character consists of two punches, a nu-

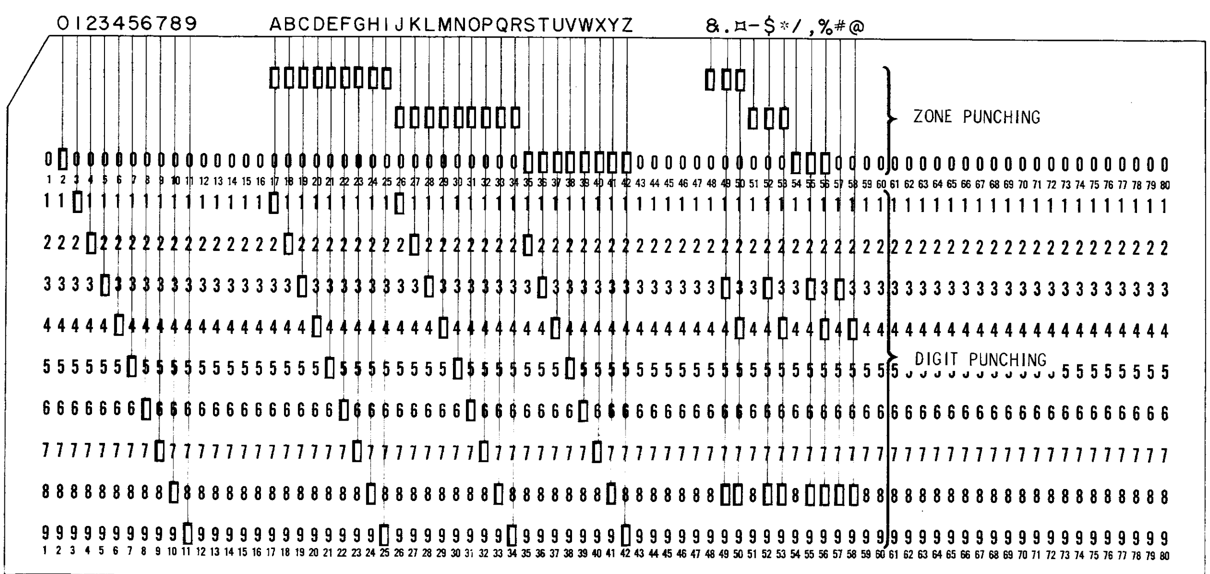


FIGURE 1. IBM PUNCHING CODES

merical punch (1-9) and a zone punch. There are three zone punches:

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 (labeled).

The 0-zone is also the numerical zero which 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 the printing of headings.

The codes for the alphabetic characters are:

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

You need not memorize the code, because it is punched automatically by the depression of a letter key on the card punch keyboard, and is normally read automatically by IBM machines. In cases where the information is to be read by the human eye, it may be printed across the top of the card as shown by the card illustrating the code punching.

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 has been left out because the alphabet uses only 26 of the 27 possible combinations.

Certain types of cards will have a distinguishing colored stripe printed across the top or may have one of the corners cut so that you may recognize them easily. However, the machines cannot distinguish between card types by means of the color stripe or corner cut and often an 11- or 12-punch will be 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 use of these special 11- and 12-punches will be explained in more detail later on.

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 will always punch the digits representing cus-

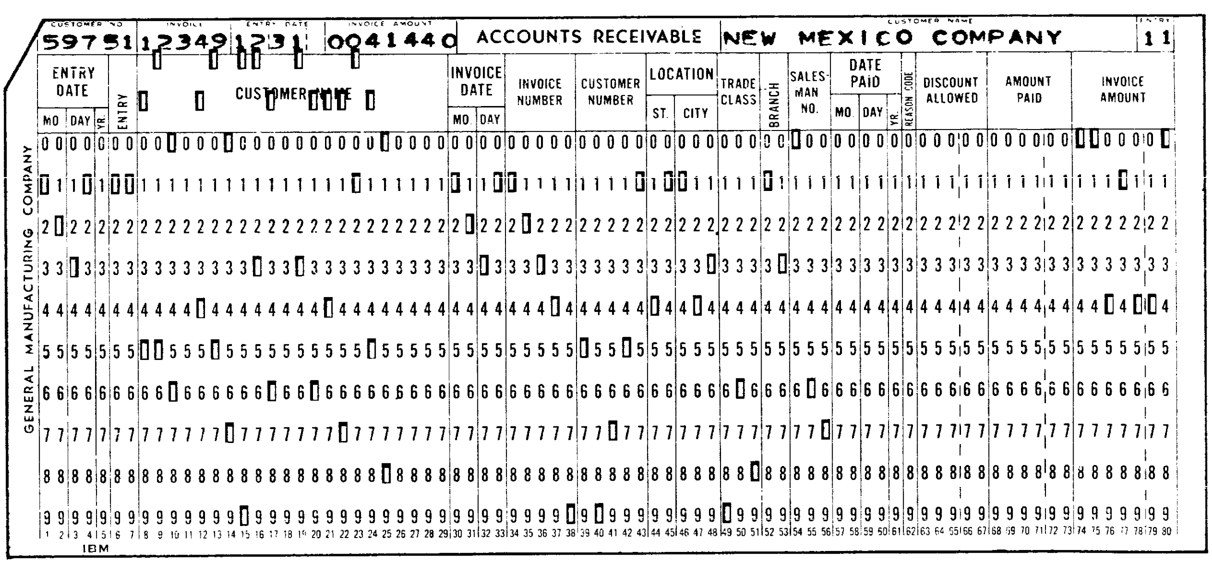


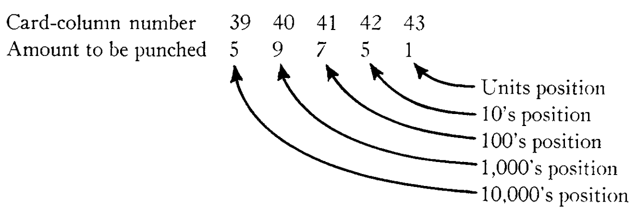
FIGURE 2. CARD FIELDS

tomer number in columns 39-43, and the other IBM machines will be instructed to recognize columns 39-43 as customer number whenever these accounts receivable cards are fed through.

If the customer number were 59751, it would be 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:



The unit amount of the figure must be punched in the units position, or column of the field set aside for that information. The 10's position of the figure must be punched in the 10's column in the field, etc.

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

For example, if the invoice amount to be punched were $414.40 (five columns), and the field set aside were seven columns, the operator would punch 0041440. She 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 she 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.

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 8 columns, and the amount to be punched is only 5 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 use is made of the 11- and 12-punches?

CARD READING

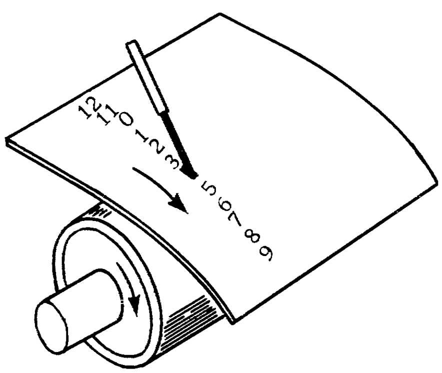
WE RECORD alphabetic and numerical information in IBM cards in punched-hole form so that it may be read electrically at a very high rate of speed.

The IBM machines can do such things as add, subtract, multiply, divide, copy, file cards, and print reports automatically. However, all of these activities can take place only after the information in the card has been read.

Each IBM machine has a brush or brushes which 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 electrically charged *contact* roller. While the card is passing over the contact roller, it passes under a *brush*. The brush may be set by the operator to read any one of the 80 vertical columns in the card. The illustration below shows the contact roller, the card, and the brush.



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

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

The brush impulse, or flow of current, is the means by which the machines recognize whether the punch was a 9, 8, 7, 6, 5, 4, 3, 2, 1, 0, 11, or 12. If the impulse were available just after the 9-edge of the card had passed between the contact roller and the brush, the machine would recognize that a hole had been punched in the 9-position of the card. If the impulse were available a little later, the machine would recognize that a hole had been punched in the 8-position of the card. This is true of all positions which may be punched. In fact, the machines recognize which digit has been punched by the amount of time which 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 3 shows a 1 being read by a brush.

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 reading 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.

In IBM machines there may be one, two, or more sets of 80 brushes, depending on the type and function of the particular machine. This means that as cards pass through these machines they may be read completely once, twice, or even more times.

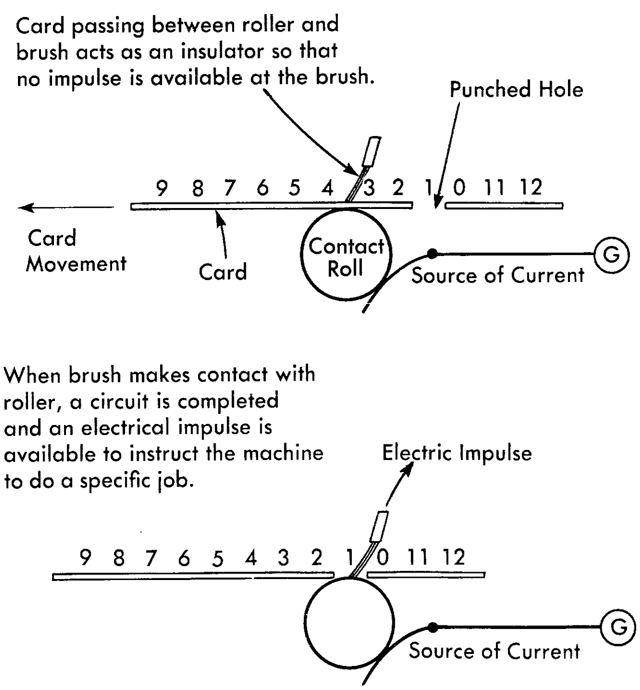


FIGURE 3. BRUSH READING A 1

Control Panel

You have learned that machine operations are to be 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 is to happen as a result of reading a card, a few details of the control panel should be known (Figure 4).

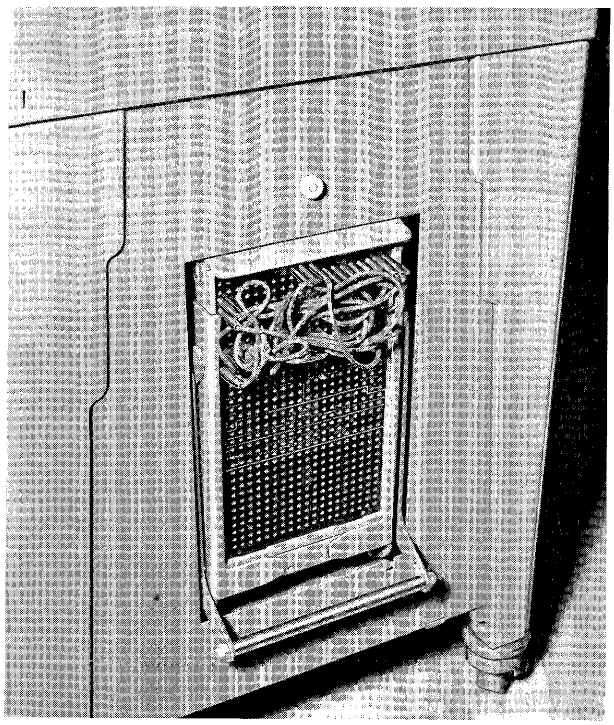
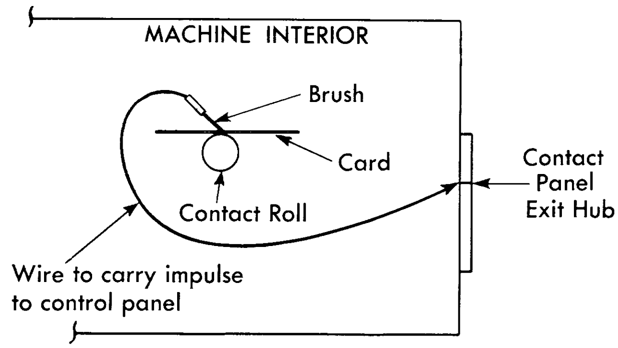


FIGURE 4. AN IBM CONTROL PANEL

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

Basically, the control panel is very similar, in principle, to a telephone switchboard. An incoming call on a switchboard lights a signal light which 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 which 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; that is, it completes electrical circuits by means of the wires you put in. The internal circuits, to be controlled by external wiring, are connected to rows of copper prongs or contacts that are the ends of these internal circuits.



When the control panel is fitted into place, a hub on the control panel fits under each one of the machine's copper contacts. In this way the external wiring (control panel wiring) will complete the desired circuits (Figure 5).

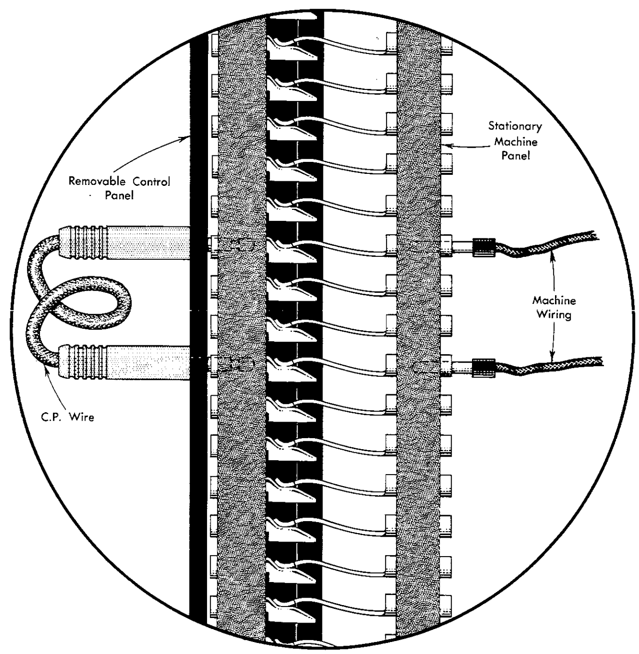
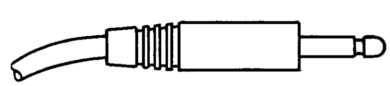


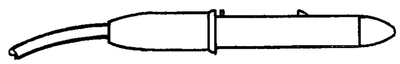
FIGURE 5. CIRCUITS COMPLETED BY EXTERNAL WIRING

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

One of the panels has copper prongs or contacts which press against the stationary contacts. The external wires plug into the copper 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 which pass through the control panel and press directly against the stationary prongs, and are known as self-contacting control panel wires.

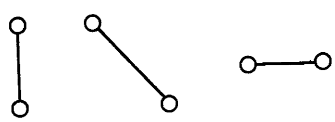


Each of the two general types of wires is available in various lengths and colors to facilitate wiring the control panel as neatly as possible.

The hubs which represent circuits that will 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 connected by a diagonal, vertical, or horizontal line. If two or more hubs are connected by a line it means that they are common; that is, they are internally connected to each other.

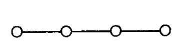
COMMON HUBS



If these hubs are exit hubs, the exit impulse will be 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 will be directed into the machine and will be available out of the other hubs common to each other.

Bus hubs are several hubs internally connected to each other, which 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 will be available out of all the other bus hubs of that group.

BUS HUBS



It may be necessary at times to connect one exit hub to more than one entry hub, and bus hubs are not available. This is done through the use of a common connector, as shown in Figure 6. An impulse

TYPES OF SPLIT WIRES

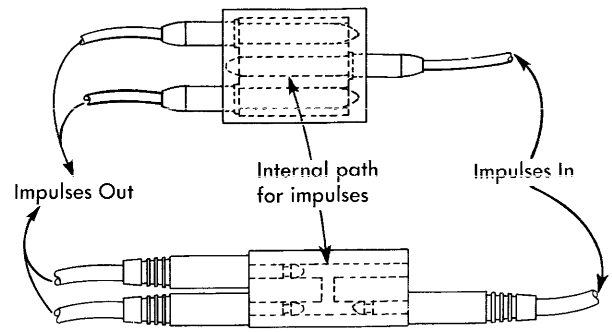
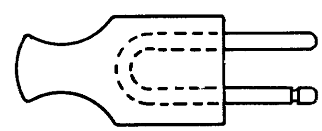


FIGURE 6. TYPE OF SPLIT WIRES

brought into the connecting block will be 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* (Figure 6).

Jack plugs are wires designed to externally connect two adjacent hubs. A regular wire of the type discussed above could be used, but a jack plug is more convenient and less bulky.



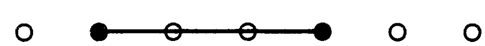
Control Panel Diagrams

Paper diagrams (drawings) of the hub layouts on each type control panel are available. These are used to keep a permanent record of a control panel setup.

In order to make the diagram as legible as possible, there are a few simple rules to be followed when drawing a diagram:

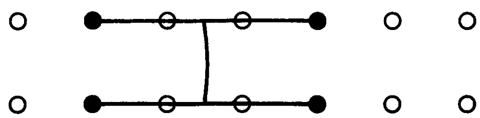
1. Use different colored pencils to diagram wiring which makes the machine perform different functions. For instance, wiring to print might be a different color than the wiring for addition.

2. Pencil in the left- and right-hand hubs of a field, and connect these hubs with a horizontal line.

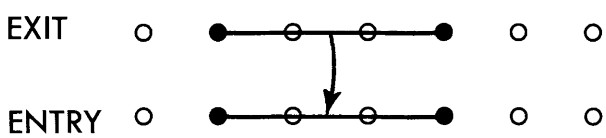


3. Connect the exit and entry fields by *one* line. Actually, this line may represent any number of individual wires in the control panel. However, in order to make the diagram easy to read, we use this ab-

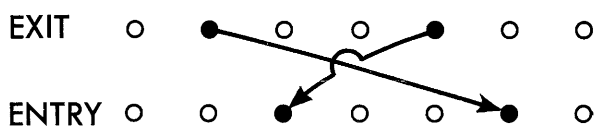
breviation. Anyone familiar with IBM diagrams will understand that although only one line is shown on the diagram, if it is a four-position field, four wires will be required on the actual control panel.



4. Indicate which are the exit and which are the entry hubs by drawing an arrow pointing to the entry hubs.



5. If it ever becomes necessary to cross lines on a diagram, loop one line over the other. This makes it possible to read the diagram correctly, for it prevents the possibility of following the wrong line to the wrong entry hub.



Reading-Brush Hubs

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

Each brush in the machine which reads a column of the card is internally connected to one of the copper contacts in the stationary control panel. When we have 80 brushes reading a card we have 80 hubs on the control panel labeled *reading brushes*. These hubs are exit hubs which emit an impulse when the hole in the card is sensed (Figure 7).

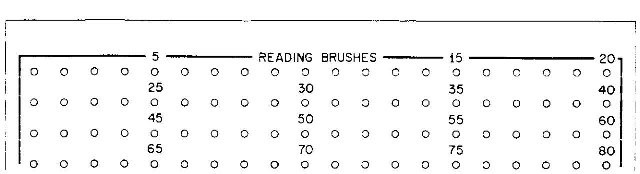


FIGURE 7. READING BRUSH EXITS

Timing

Timing is a very important concept to understanding machine operation. For example, it is a result of timing that an 8 read will print as an 8, or cause an 8-hole to be punched. You will often hear people speaking of impulses being available and things happening in a machine at 9-time, 8-time, etc. All that they mean is that the impulse is available or things are happening at the time the card is in position 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 term cycle is one we have not discussed yet, and there are others, such as cycle points, card cycle, print cycle, degrees, etc. The word cycle itself is a familiar term except when applied to IBM machines. A cycle is the period or time interval required to complete a round of events or operations which occur in sequence on a regular basis. We have weather cycles, economic cycles, business cycles, and many others which you can probably think of offhand. A cycle can, therefore, be thought of as a circle. One cycle would be the time required for the circle to make one revolution; or, 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 8).

Each IBM machine is made to perform its functions within a given time, which is a machine cycle. A machine, when running, will be operating at so many machine cycles per minute because all cycles are machine cycles.

However, as stated earlier, a machine may be capable of performing several functions such as feeding

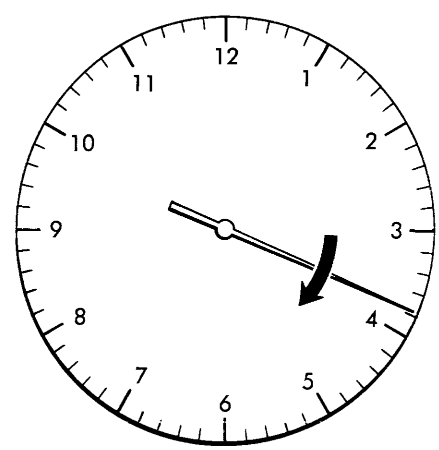


FIGURE 8

cards, printing, or punching. If card feeding is occurring during the cycle then it is a card-feed cycle as well as a machine cycle. A machine cycle can be qualified by any function occurring during the cycle, such as print cycle, total cycle, or punch cycle. More than one function could occur during the same cycle, in which case any of the functions could be used to describe the cycle.

During a cycle there are various points in the cycle which are of particular interest. These are the points at which a hole in the card is read or punched, or a typebar would be set up to print a specific digit. Since these are points of interest, we call these cycle points.

On most machines a disc 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 9). In many instances these divisions are not small enough for timing purposes. The disc, and essentially the cycle, is a circle so it can be divided into degrees for timing purposes. We can now refer to the time that a 5-hole would be read as 5-time or it may be expressed in degrees (Figure 10).

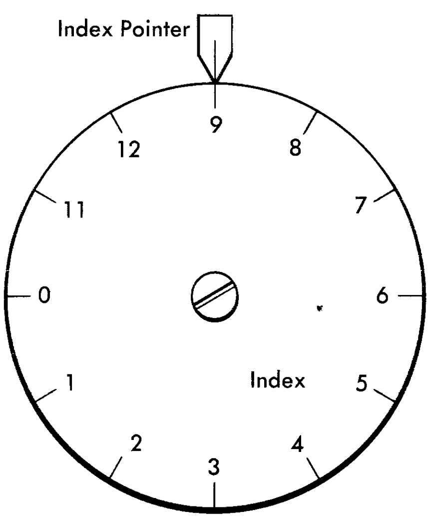


Figure 9

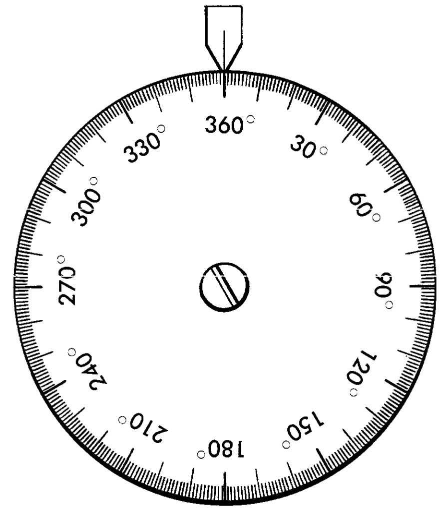


Figure 10

Most manuals of operation have a timing chart which shows when a control panel hub emits or accepts impulses within the cycle, and a note to indicate the type of cycle it will occur on if it does not occur every cycle (Figure 11).

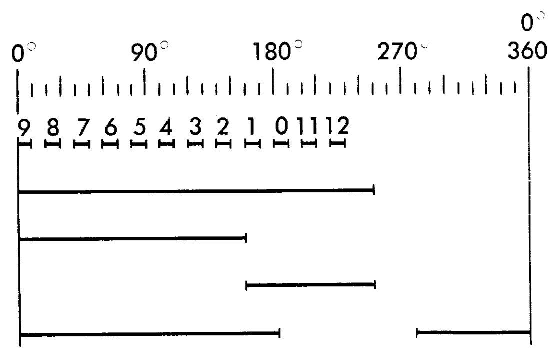


Figure 11

REVIEW QUESTIONS

1. As a card feeds through an IBM machine it is read by ....?
2. An electric circuit is completed and an impulse available when ....?
3. What is meant by 9-time, 8-time, etc.?
4. What is a machine cycle?
5. What is a card cycle?
6. What is a print cycle?
7. What is a total cycle?
8. Holes on a control panel are called ....?
9. What is an exit hub?
10. What is an entry hub?
11. What is a bus hub?
12. What is the special use for split wires?

PRINTING

THE INFORMATION read at the reading brushes can be used to cause many functions. One of these is the printing of information as read. The control panel wiring needed to make any IBM machine print is essentially the same:

From Reading Brush Exit
↓
To Type Bar Entry

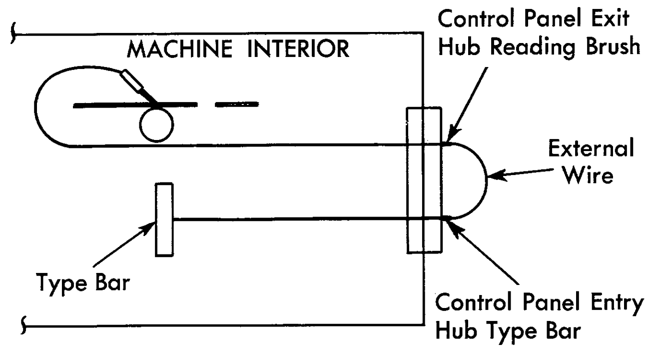


FIGURE 12

Numerical Printing

As you know, numerical punching is one hole in a column. In order to make a number print, we must wire the control panel from the READING BRUSH exit hub to the TYPEBAR entry hub (Figure 12).

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

Do not be dismayed by the number of hubs on a control panel, for many of them perform identical functions. For instance, the control panel for any machine which has a set of 80 reading brushes, will have 80 reading-brush exit hubs, one for each column of the card. Each machine with 60 typebars will have 60 typebar entry hubs. Therefore, once you have learned the function of one of the reading-brush exit hubs, or one of the typebar entry hubs, this same function applies to all reading-brush hubs and all typebar hubs.

In order to make it easy to understand the principle of printing, we will discuss a specific machine, the 552 Alphabetic Interpreter (Figure 13). This machine has as its only function the ability to print the information punched in a card across the top of the same card so that it may be read easily by the machine operator (Figure 13). The top of the card shown in Figure 2 was printed by the 552 Interpreter.

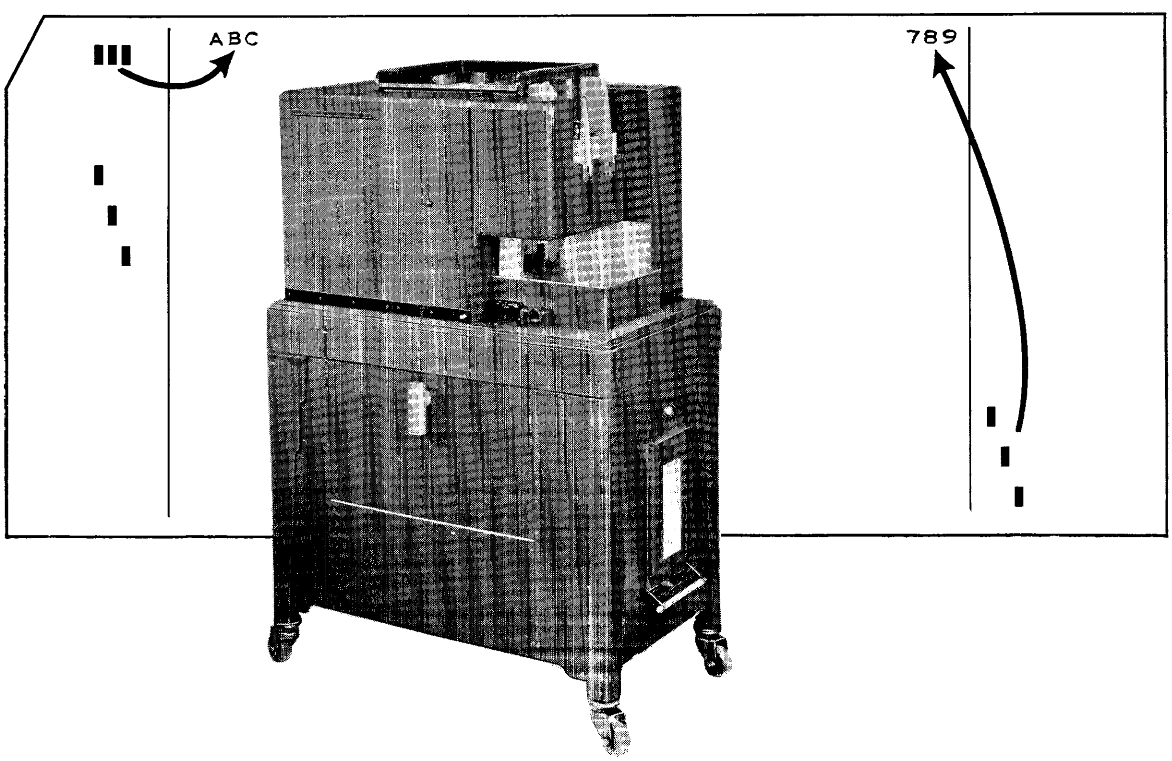


FIGURE 13. TYPE 552 INTERPRETER AND INTERPRETED CARD

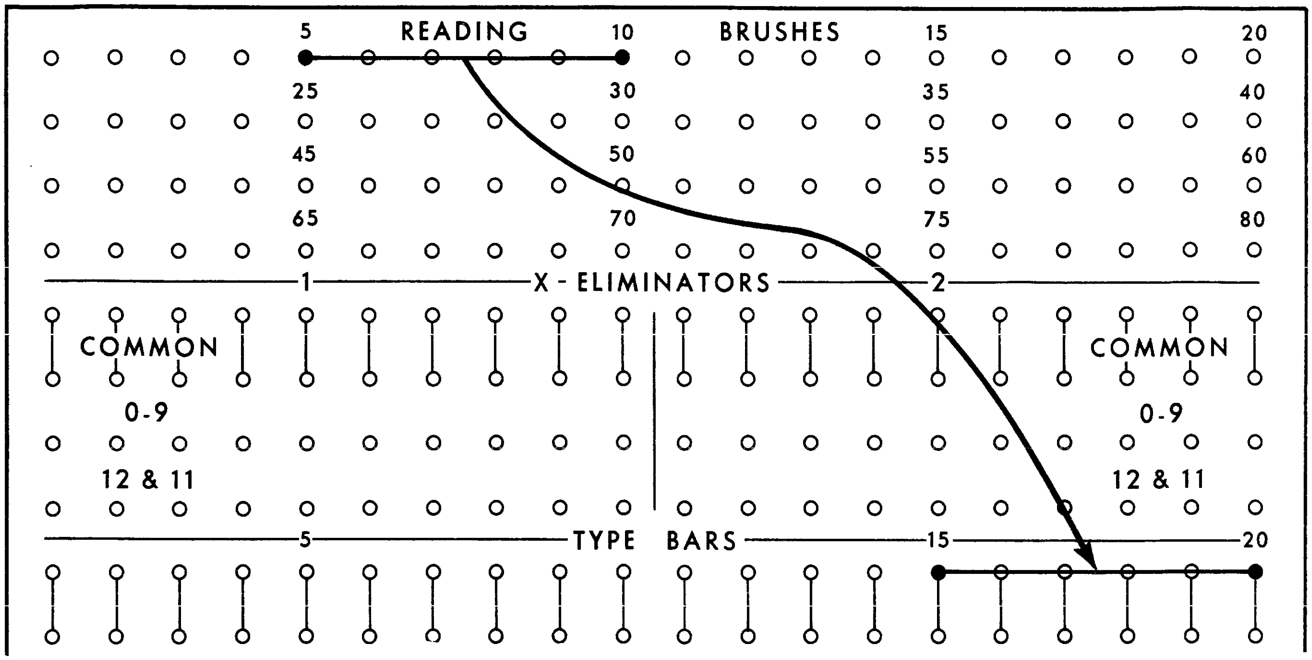


FIGURE 14

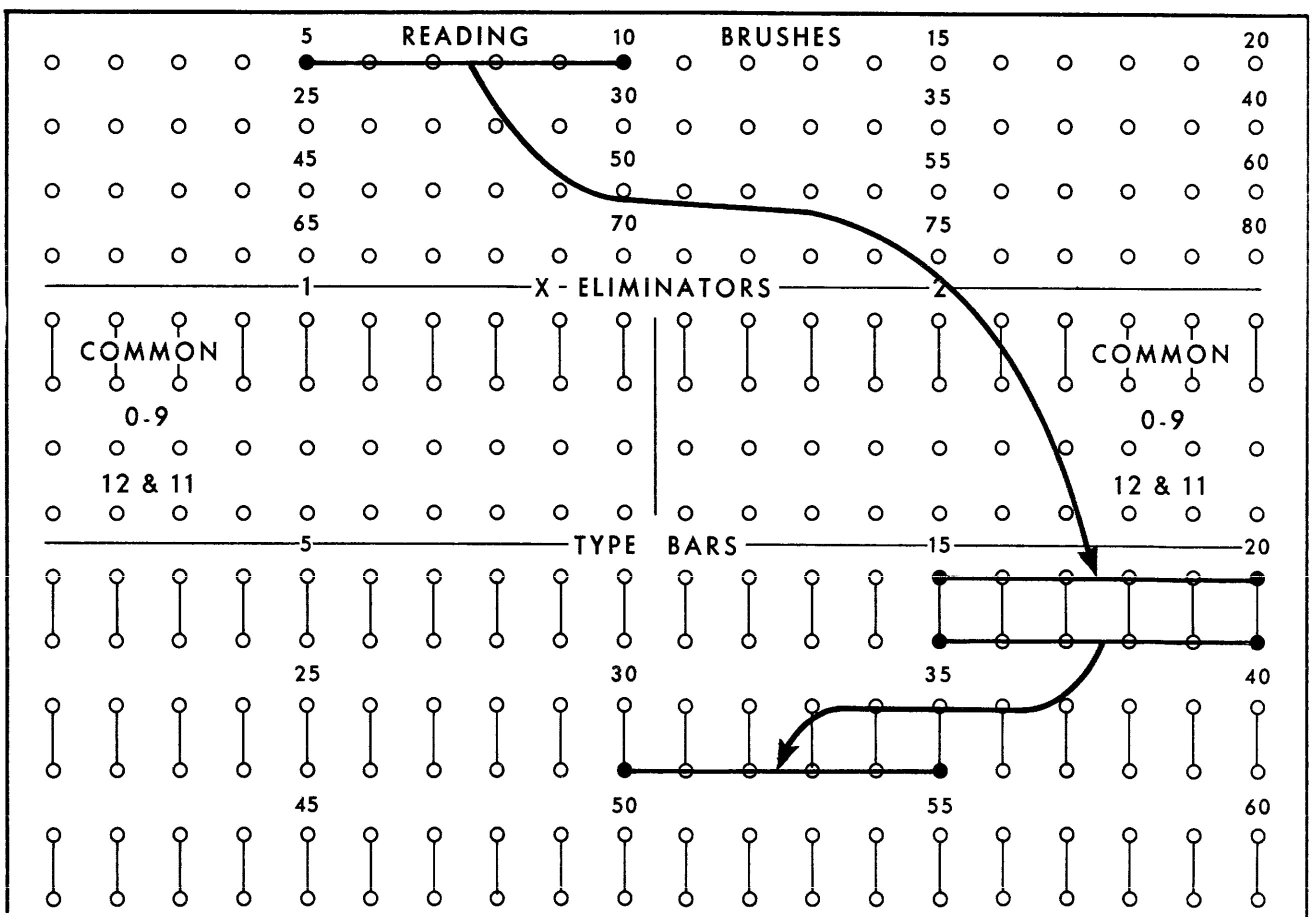


FIGURE 15

The wiring shown in the diagram will cause information read in card columns 5-10 to be printed by typebars 15-20 (Figure 14).

If we wished the same information to be printed in *two* places we may wire out of the *common* typebar entry hubs, 15-20, and take the impulses to any other typebars (Figure 15). If we had only one entry hub for each typebar, we would have had to use split wires. It is good practice to avoid the use of split wires whenever possible.

Alphabetic Printing—552 Interpreter

A letter is composed of two holes in a single column, a zone punch and a number. In order to print a letter on any machine, *both* the zone-punch impulse and the numerical-punch impulse must be received by the typebars.

Each 552 Interpreter typebar contains all letters, A-Z, all the numbers, 0-9, and three positions for any special characters desired, 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). In addition, there is a fourth group, the numbers 1-9 (Figure 16).

Because of the mechanical structure of the typebars, they *must* receive the zone-punch impulse before the numeric punch. In order to make this possible, the cards are fed face up, 12-edge *first*.

The zone impulse is carried over the external wire 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* external wire to the same typebar. This second impulse completes the positioning of the typebar, and the letter which 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).

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 was not received by the typebars, then the typebars would move to a blank position on the bar and nothing would be printed.

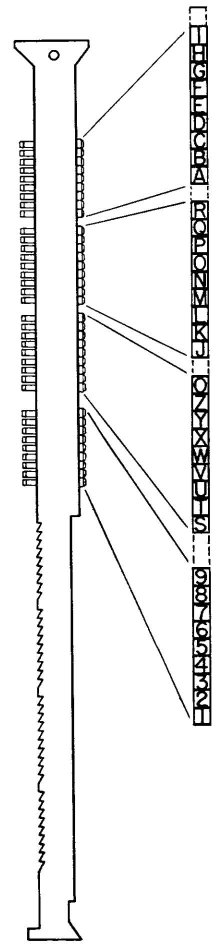


FIGURE 16. TYPE 552 TYPE BAR

The wiring for numerical or alphabetic printing on the 552 Interpreter is exactly the same. One wire from the READING BRUSHES to the TYPEBARS will carry the numerical impulse *alone*, or *both* the numerical and zone impulses. As the cards are fed 12-edge first, the zone impulse reaches the typebar first.

REVIEW QUESTIONS

1. In order 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 on the 552 Interpreter is ....?
3. The wiring required to make a typebar print an alphabetic character on the 552 Interpreter is ....?

Numerical Printing—403 Accounting Machine

One of the functions of the 403 Accounting Machine is the printing of reports. Information punched in IBM cards can be printed in any sequence desired from any one of 88 typebars (Figure 17). The principle of printing in the 552 Interpreter and the 403 Accounting Machine is the same. Reading brushes read the holes in the card, and by external wiring of the control panel, the impulses are carried to the typebars.

However, the labelling of the hubs on the two control panels is different.

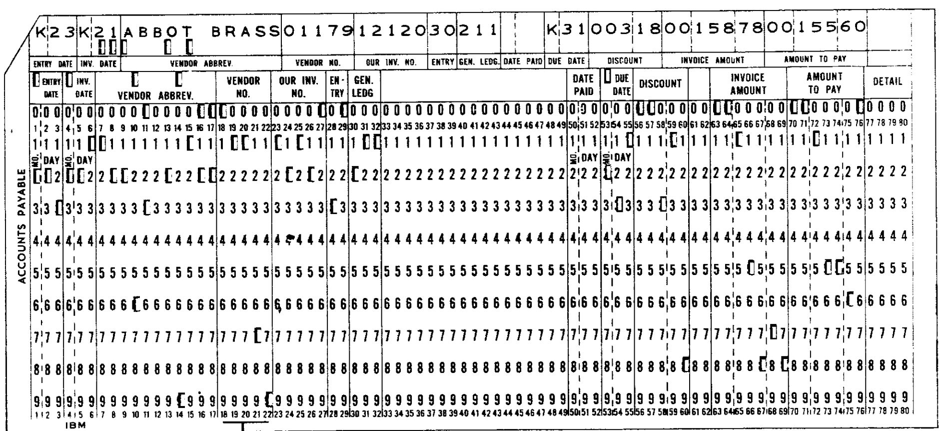
On the 552 Interpreter we have one set of 80 brushes, labelled READING BRUSHES.

On the 403 Accounting Machine we have *three* sets of 80 brushes, labelled FIRST READING, SECOND READING, and THIRD READING. As each card passes through the 403 Accounting Machine, it is read three times (Figure 18).

To print numeric information, we use the third-reading-brush impulses. They are the same as the reading-brush impulses in the 552 Interpreter.

The labelling of the typebar entry hubs is different on the 403 Accounting Machine from the 552 Interpreter, mainly because of the difference in the physical arrangement of the typebars.

In the 403 Accounting Machine we have 88 typebars. They are arranged in two banks across the top



CASH REQUIREMENTS STATEMENT

VENDOR ABBREVIATION	VENDOR NUMBER	DUE DATE MO.	DUE DATE DAY	DISCOUNT	INVOICE AMOUNT	AMOUNT TO PAY	TOTAL BY DATE
ABBOT BRASS	1179	12	31	318	15878	15560	
ABBOT BRASS	1179	12	31	196	9813	9617	
ABRAMS COAL	1180	12	31	831	27735	26904	
ABRAMS COAL	1180	12	31	1050	30000	28950	
BARR MACH	3076	12	31	15077	301527	286450	
EL TRUST CO	09521	12	31		5125	5125	
KARTAGE INC	44860	12	31		21875	21875	
LEHIGH COAL	48673	12	31	1384	69178	67794	
MAIZE REF	58091	12	31		11823	11823	
N MILT SUPP	60035	12	31		21415	21415	
N Y GAS EL	61221	12	31		67595	67595	
STATE N Y	74213	12	31		179286	179286	
W COR TEL	81469	12	31		23729	23729	
WICKWIRE BR	86341	12	31		36043	36043	
WISELO INC	88213	12	31		19518	19518	

FIGURE 17. REPORT PRINTED FROM IBM CARDS

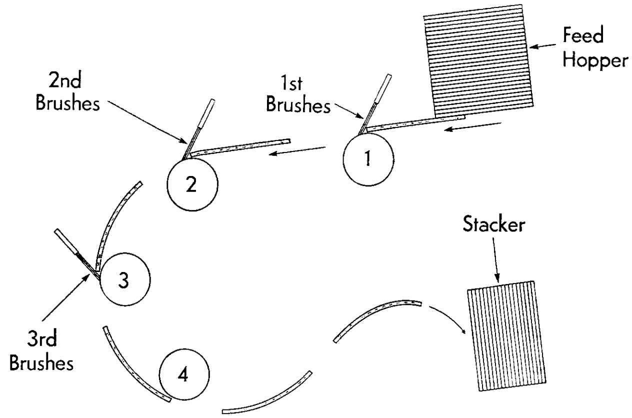


FIGURE 18. TYPE 403 ACCOUNTING MACHINE FEED SCHEMATIC

of the machine. On the left we have 43 alphamerical typebars, and on the right we have 45 numerical typebars (Figure 19).

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

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

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

The control panel diagram (Figure 20) 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.

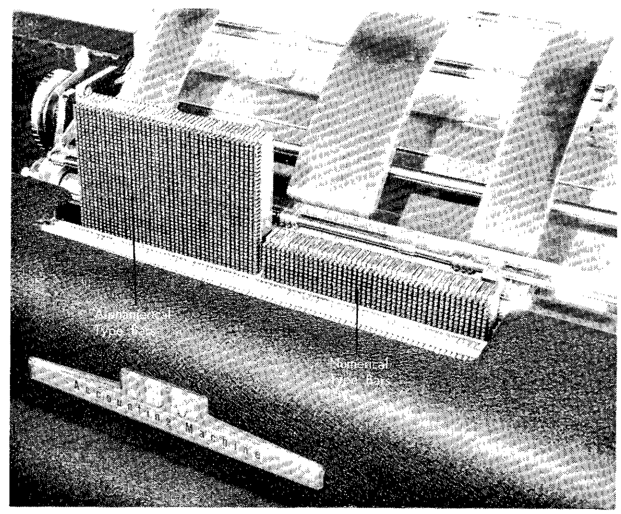


FIGURE 19. TYPE 403 ALPHAMERICAL AND NUMERICAL TYPE BARS

Alphabetic Printing—403 Accounting Machine

Alphabetic punching in IBM cards consists of a zone and a digit punch for each letter. In order to print alphabetic information both the digit and the zone punch must be read and taken 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. Since the cards are fed into the 403 Accounting Machine 9-edge first, it is apparent that the zone punch will have to be read and taken to the typebar one card cycle earlier than the digit punch.

This is accomplished by wiring both the SECOND READING BRUSHES and the THIRD READING BRUSHES to the typebar.

The only difference between wiring for numerical and alphabetic printing is that a second wire is needed for any one printing position. This wire takes the zone punch to the typebar one cycle earlier than the

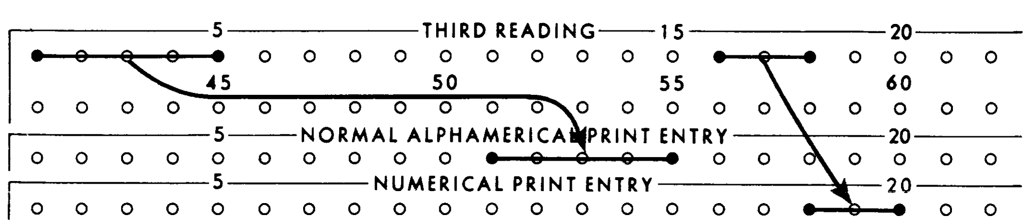


FIGURE 20. NUMERICAL PRINTING

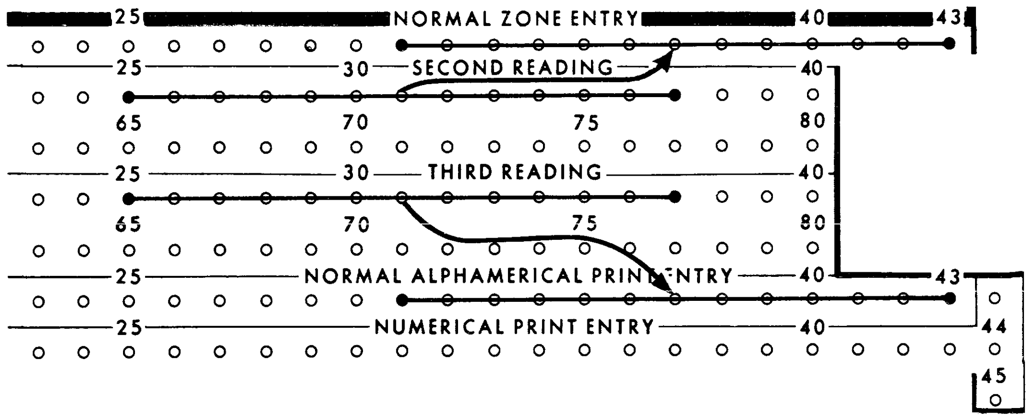


FIGURE 21. ALPHABETIC PRINTING

digit punch. This second wire is taken from the second-reading-brush exit hub to the zone entry hub corresponding to the alphamerical-print entry hub already used for the digit wiring.

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 will accept zone impulses only, and will ignore digit impulses.) The zone impulse will partially position the alphamerical typebar for alphabetic printing.

When the same card moves past the third reading brushes on the next card cycle, the digit punch is taken to the typebar, and the typebar is then positioned completely for alphabetic printing. Figure 21 shows the wiring necessary to print an alphabetic field.

The important thing to remember is that the columns we 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 alphamerical-print entry hubs used are the same. If we use alphamerical-print entry hub number 8, then we must use zone entry hub number 8.

Failure to use the like-numbered reading-brush hubs will cause incorrect printing. Failure to use the like-numbered zone and alphamerical-print entry hubs will also result in incorrect printing.

Print Unit—403 Accounting Machine

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) which supports the paper, and (4) type. On an accounting machine the paper, ribbon, and platen perform the same function that they perform on a typewriter. However, the type unit functions in an entirely different manner.

Figure 22 shows parts of one typebar in a 403 Accounting Machine. There are 88 typebars in a complete print bank, one typebar for each possible printing position on 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 alphamerical typebar contains 38 pieces of type (26 alpha-

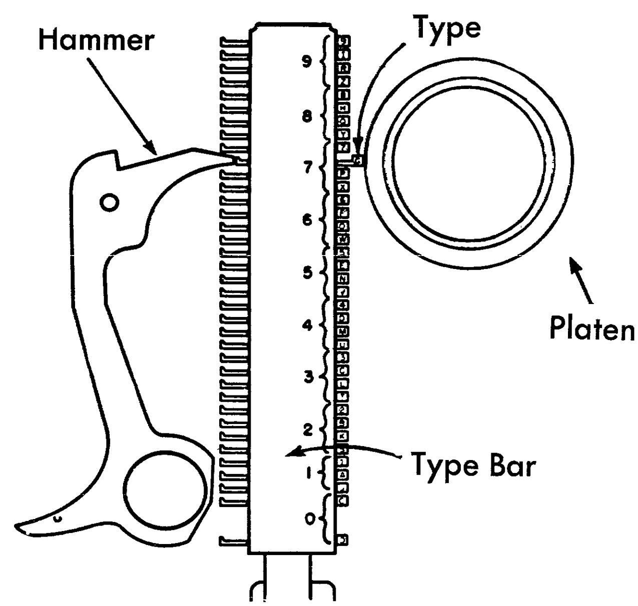


FIGURE 22. TYPE 403 PRINT MECHANISM

betic characters, 10 numerical characters, one special character (&), and one extra zero).

During the time a card is being read, the typebars are moving. When the reading is completed all typebars are positioned so that the selected piece of type is opposite the line on the report about to be printed. At this instant 88 hammers, one for each typebar, strike the ends of the type pieces opposite the printing line and produce 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.

REVIEW QUESTIONS

1. In order to make a typebar in the 403 Accounting Machine print an alphabetic character, should the zone or the numerical impulse be received first?
2. The wiring required to make a typebar on the 403 Accounting Machine print a numerical character is ....?
3. The wiring required to make a typebar on the 403 Accounting Machine print an alphabetic character is ....?
4. Why is there a difference between the wiring for alphabetic and numerical printing on the 403 Accounting Machine?
5. What is a "hammer," and what does it do?

PUNCHING

WHEN a machine prints information, it is writing it in language which our eyes can read. Many times, however, a machine must record information in a form which can be read by other machines. In this case the machine must write in its own language, the language of punched holes. 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, as Figure 23 indicates, is the actual cutting element, which cuts the hole in the card. The lie serves to support the card, and the stripper supports the punch and strips off the card when the punch is withdrawn.

In some machines (like the card punches and the 602A Calculating Punch) the cards feed through the punching mechanism column by column, from right to left.

The punch mechanism covers one column at a time and is equipped with 12 punches to permit punching any of the 12 possible holes or combinations of holes which may be needed in a column of the card (Figure 24).

In most of the machines, such as the 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 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 punch, the card moves, all 0's punch, etc. (Figure 25).

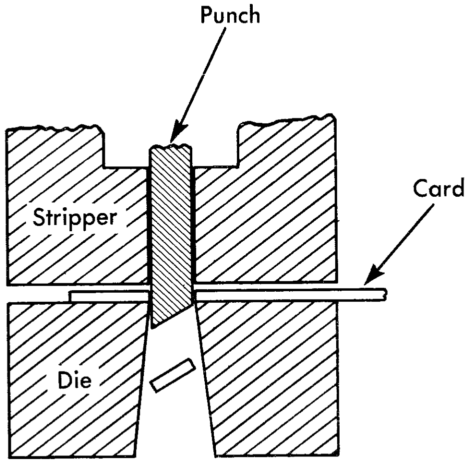


FIGURE 23. PUNCHING COMPONENTS

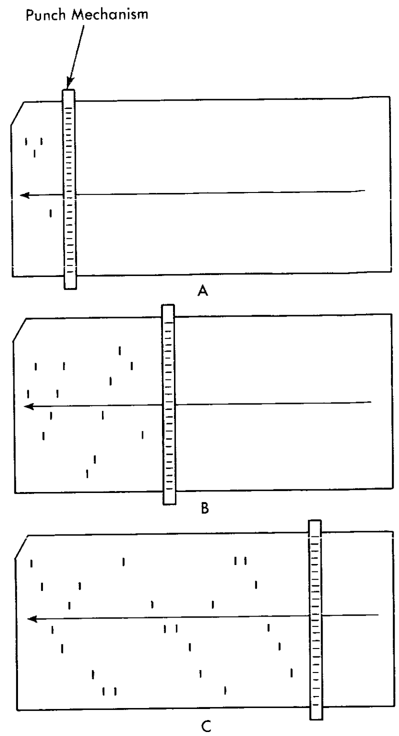


FIGURE 24. COLUMN BY COLUMN PUNCHING

To copy information from one card to another only two things are necessary:

1. The card from which we wish to take information passes under a set of reading brushes at the same time that the card into which we wish to copy it passes under a punch, and

2. the proper card columns to read and punch for the particular job are connected by control panel wires (Figure 26).

Frequently it is necessary to copy information from one set of cards and punch it in another set. Depending on the particular job, we may wish to copy all or only a portion of the information. Sometimes we wish

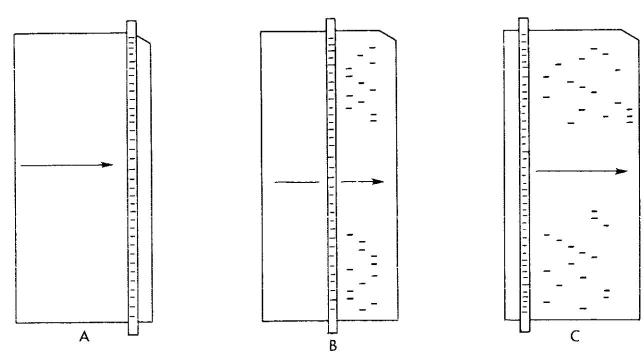


FIGURE 25. DIGIT BY DIGIT PUNCHING

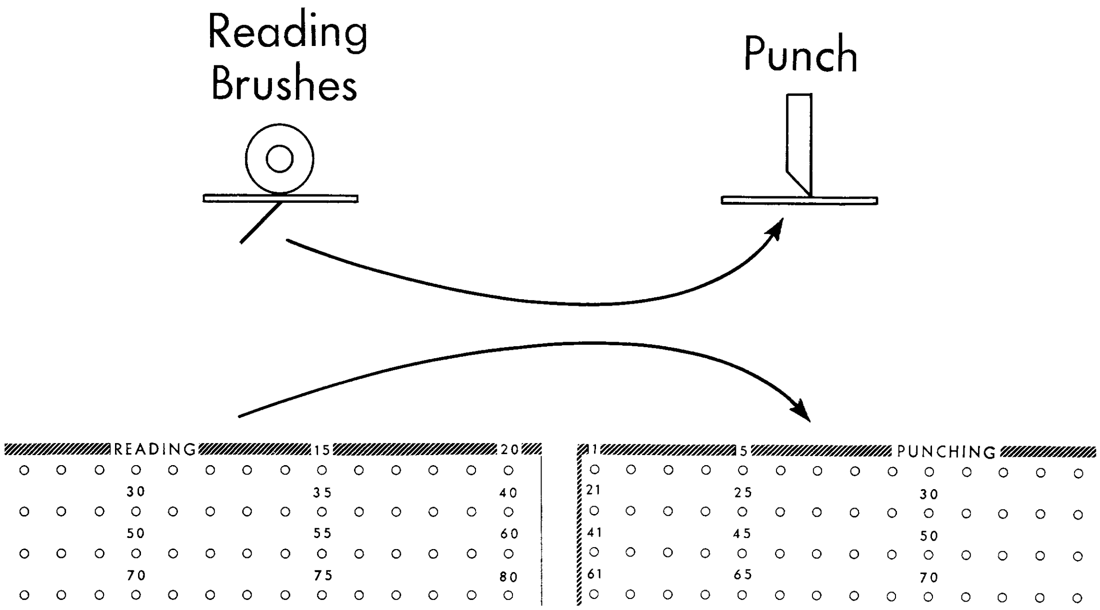


FIGURE 26

to punch this information into the new set of cards in the same card columns as those from which it is being copied. At other times, however, it is necessary to punch this information into different columns than it occupied in the original set of cards (Figure 27).

Several types of reproducing punches have been designed to perform operations of this kind. The control panel wiring shown is for a 514 Reproducing Punch and would permit information punched in card columns 31-35 of one set of cards to be punched into card columns 65-69 of another set of cards (Figure 28).

When information is punched into the same card columns as those from which it was read, the operation is called *column-for-column* punching.

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

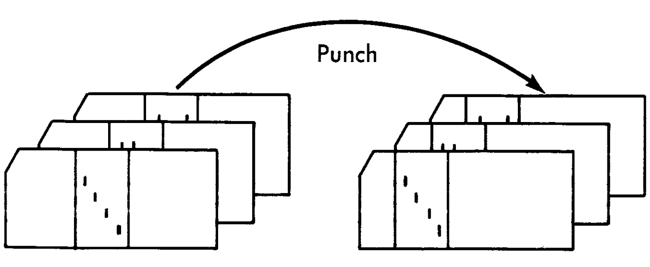


FIGURE 27. PUNCHING FROM A FIELD IN ONE CARD INTO A DIFFERENT FIELD

This operation can be represented by means of a control panel wiring diagram such as you have just seen. It can also be expressed in symbols which represent the elements of the machine that perform the

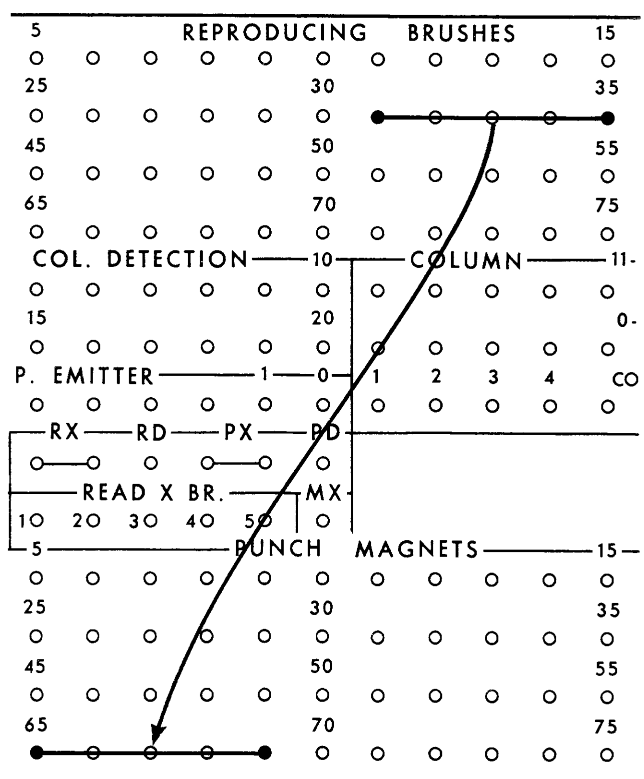


FIGURE 28

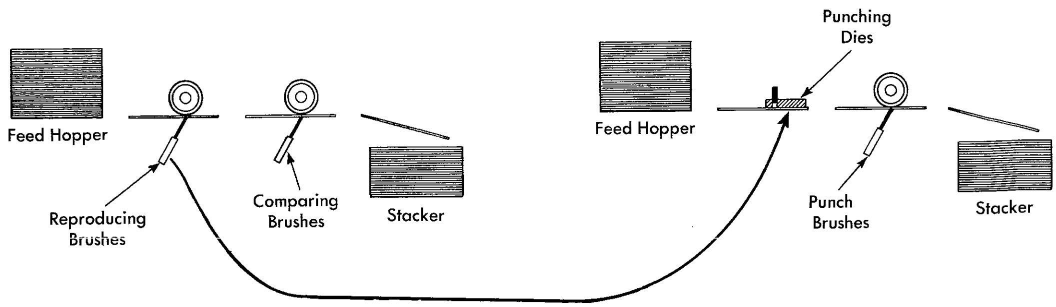


FIGURE 29. SCHEMATIC FOR REPRODUCING (TYPE 514)

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

The schematic shown (Figure 29) expresses in symbols the operation of reproducing on a 514 Reproducing Punch. This is the same operation that we just saw expressed as a control panel diagram.

Punch entry hubs frequently receive information from reading-brush exit hubs, but this is not the only source from which information may be brought to the entry hubs. Some machine units which have not yet been discussed also serve as sources from which we draw information to be taken to a punch unit. For the moment, it is important only to realize that reading brushes are not the sole source of information which can be punched (Figure 30).

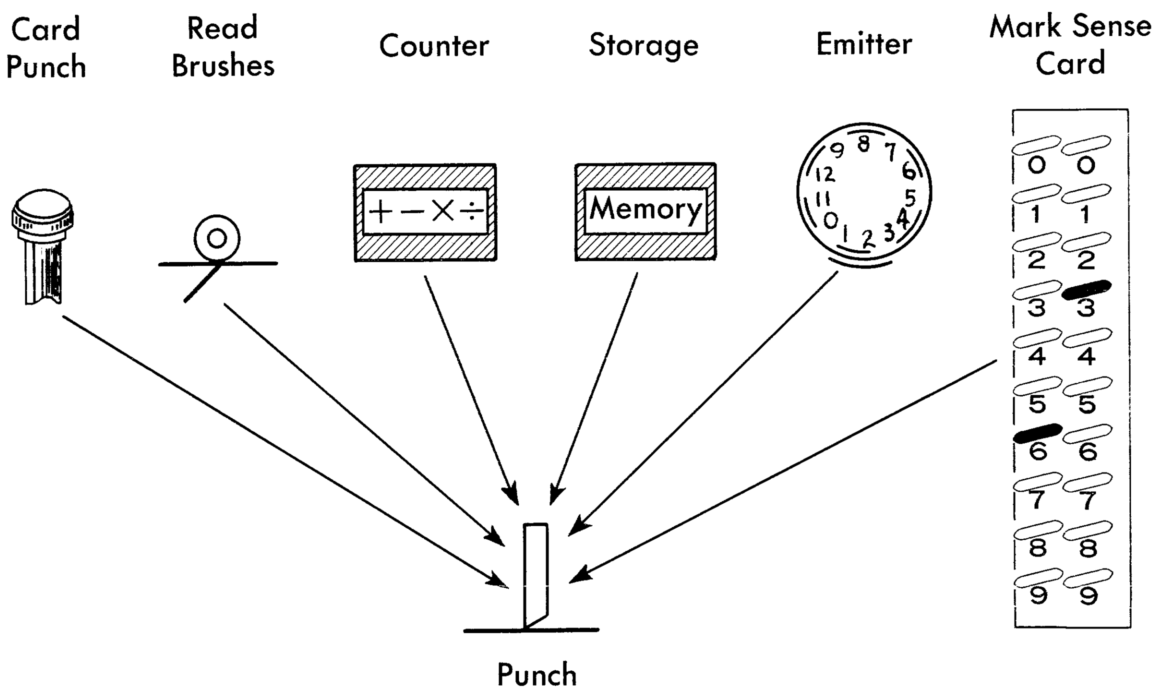


FIGURE 30

REVIEW QUESTIONS

1. What is a punch? Die? Stripper? 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. What exit and entry hubs must be connected?
5. Is the punching described in Question 4 *offset* or *column-for-column*?

EMITTING

FREQUENTLY we wish to print or punch repetitive information which cannot originate in the normal manner, that is, from a brush reading a punched card. We may have cards passing a set of brushes, but these cards may not be punched with the information we need.

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 when a card column with every position punched is read by a brush.

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

Digit Emitters. A digit emitter is nothing more than a switch with twelve positions (Figure 31). Each position is wired to the control panel and numbered to correspond with a punching position.

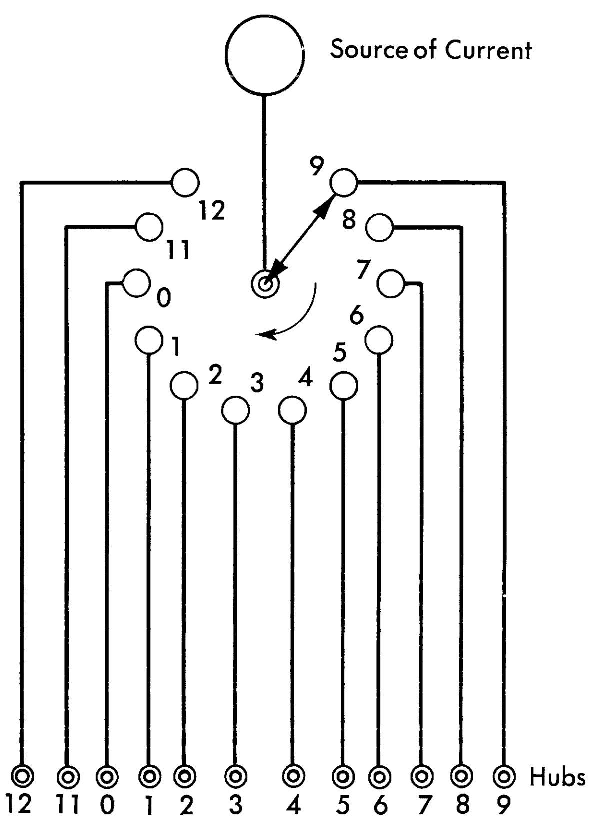


FIGURE 31. DIGIT EMITTER

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-hole emits when 11-holes 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 emitter exit hubs may be arranged differently, depending on the type of machine, but they are all used for the same basic functions (Figure 32).

Out of the EMITTER exit hub labelled "2" there is available an impulse during the 2-time of each card-feed cycle. This 2 can be used to perform any function a 2 punched in a card could do.

If, for example, this emitted digit were connected by a control panel wire to a punch entry hub, then each card passing the punches would be punched with a "2."

Digit Selectors. The emitter just described had the source of electricity permanently wired. Some emitters are arranged in a more flexible manner by allowing the operator to wire the source of electricity into the emitter. These emitters are usually called digit selectors. A common (C) hub connects to the rotating part of the emitter. Otherwise, the emitter operates in exactly the same manner.

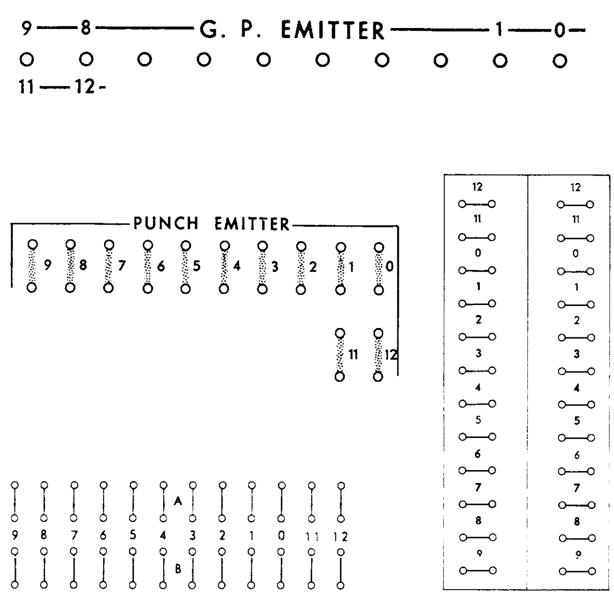


FIGURE 32. EMITTER EXIT HUBS

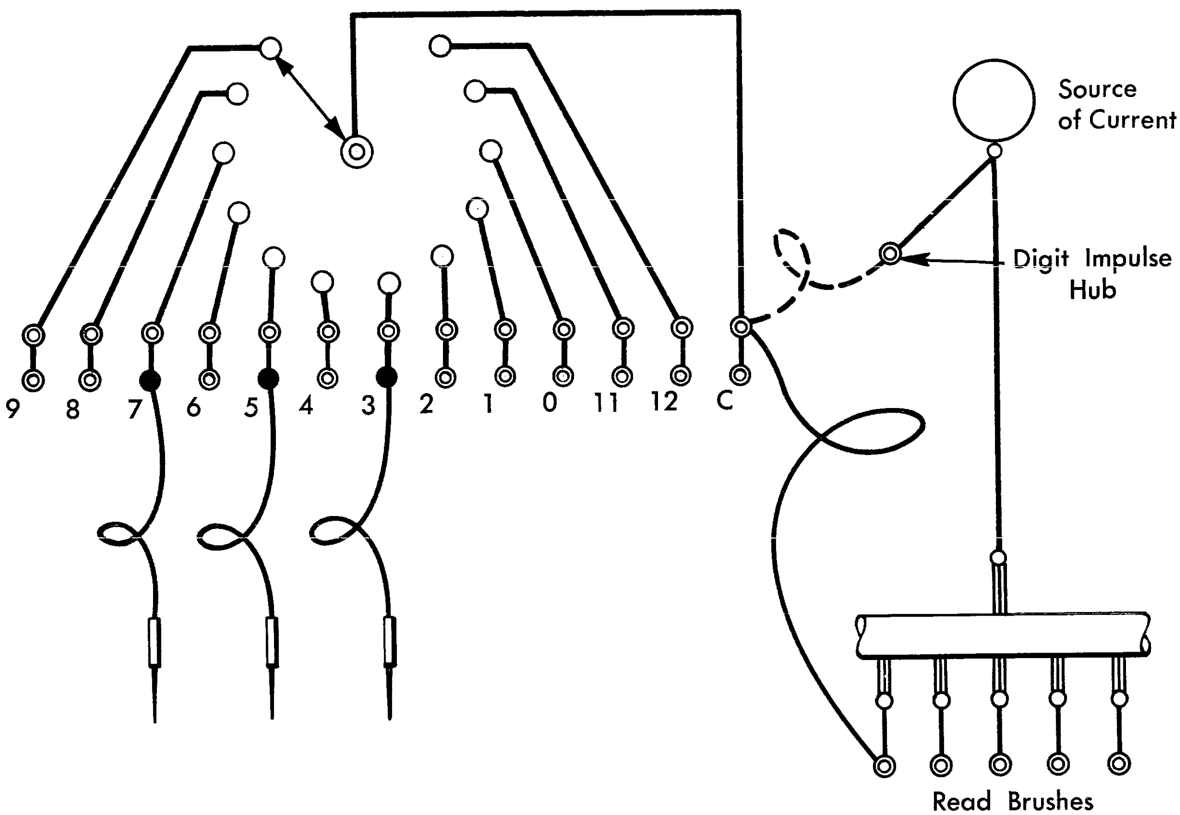


FIGURE 33. DIGIT SELECTOR

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 33). The broken line represents a control panel wire which connects the *digit impulse* hub to the common hub of the digit selector. When this wiring has been done, the digit selector operates exactly like a digit emitter. However, other impulses may be wired into the common hub *instead* of the digit impulses. For example, a reading brush may 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 column. An impulse will be emitted from the 7-hub at 7-time if a 7 is punched in the column the connected brush is reading.

Figure 34 shows some examples of digit selectors from IBM machines. The first example is called a digit emitter because it is more frequently used to emit digits, with the two hubs at the top of each column connected by jackplugs. However, because the impulses to the common hub may be wired, this device is better classified as a digit selector.

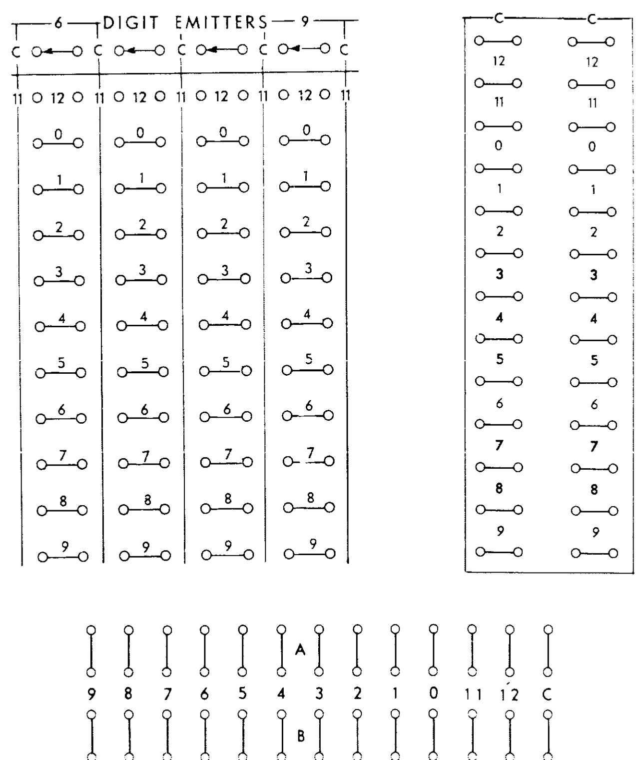


FIGURE 34. DIGIT SELECTOR CONTROL PANEL HUBS

Wiring for Emitting—Reproducing Punch

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

Let's review why we would need an emitter in a reproducing punch. If you will recall the reproducing operation discussed in a previous section of the book, you will remember that we read information from one deck of IBM cards and punched it in another deck of cards. Frequently, however, the original deck of cards may not have all the information we wish 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, an alphabetic description, etc., are often required in all the cards of the new deck.

Let's see how this emitting is done on the reproducing punch.

As you can see in the schematic diagram (Figure 35) instead of taking the information from the cards by means of the reproducing brushes, we now take this constant information from an EMITTER exit hub directly to a punch entry hub.

An example of control panel wiring for *numerical* punching is shown with the wiring necessary to punch the date 9 17 42 into each card as it passes the punch station (Figure 36).

Alphabetic information can be emitted and punched also by wiring both a zone impulse and a digit impulse to the same punching position. The example of alphabetic punching from an emitter shown is for the word ART (Figure 37). You can see that split wiring is necessary to accomplish this punching. The word ART was very carefully 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 four. If we split-wire to add the D, then it will connect the 12-zone to both the 1 and 4 impulse. This will cause 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 accomplished from emitted impulses, some precaution must be taken to eliminate the *back-circuits* from causing incorrect punching.

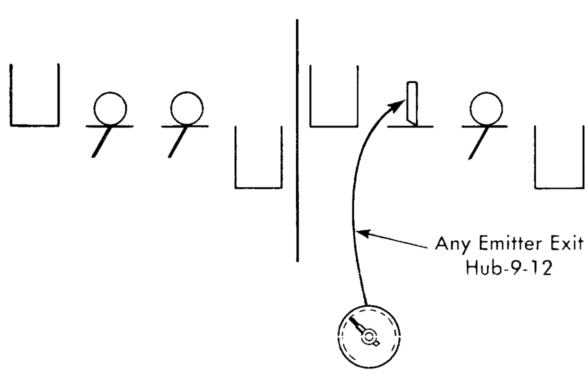


FIGURE 35. PUNCHING EMITTED INFORMATION

One device that will accomplish this is a column split which is to be studied later. We will leave the solution of this problem until these devices are studied and state at this time that alphabetic information can be accomplished directly for words, such as ART where zone and digit impulses are used only once.

Wiring for Emitting—The Accounting Machine

When cards are passing through an accounting machine we often wish to print repetitive information which is not punched in the cards.

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

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

There are two major differences between an emitter on a reproducing punch and an emitter on an accounting machine.

First, there is a difference in name. The accounting machine emitter has two uses. It may be used as an emitter, but it may also be used as a digit selector. The latter use will be discussed in detail in a later section of this book, but for now just remember that it is this second use which gives the accounting machine 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 the emitter brush receives its impulse internally and automatically. This is not so in the accounting machine. An impulse must be wired to the emitter brush.

Which impulse do we use? On the control panel there is a hub labelled DI. This stands for digit im-

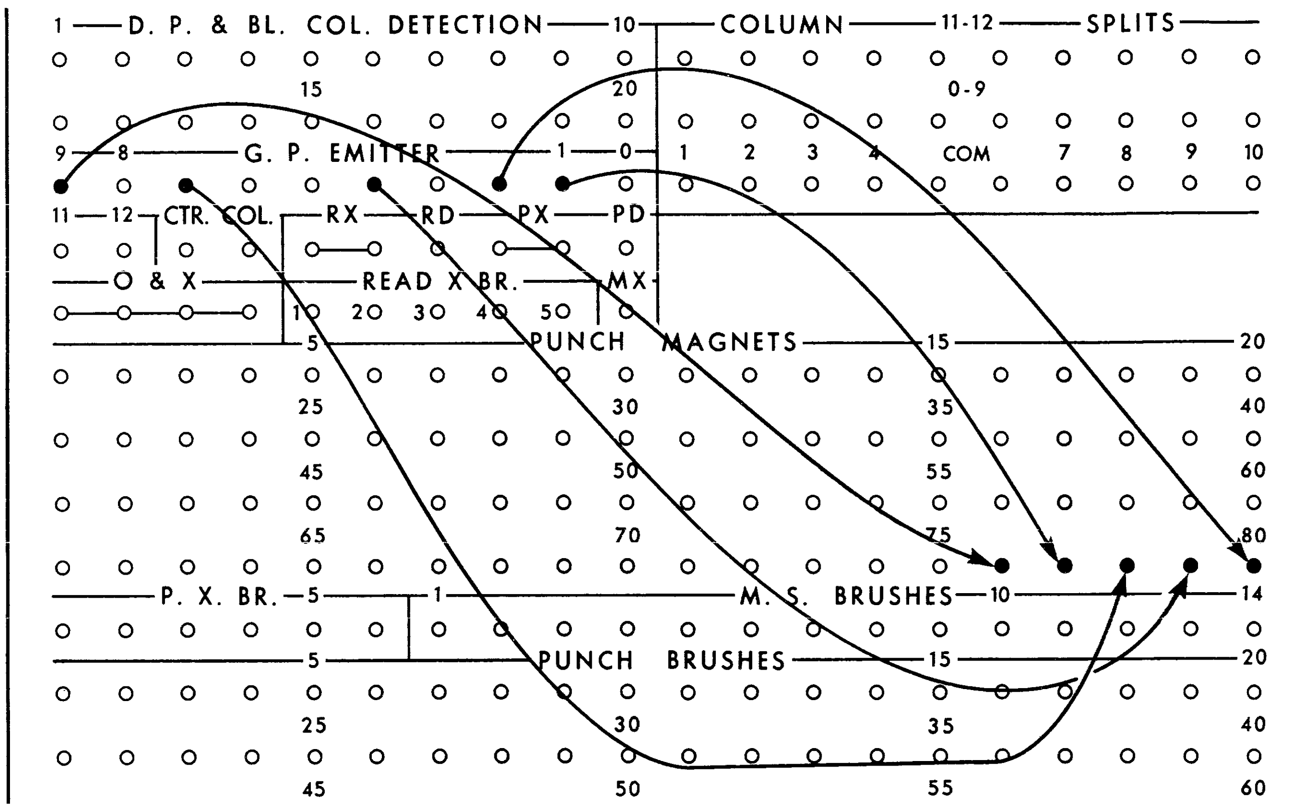


FIGURE 36

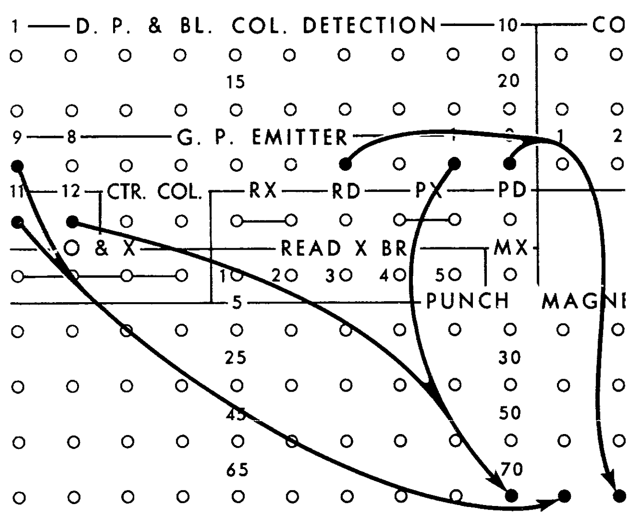


FIGURE 37. CONTROL PANEL WIRING TO PUNCH "ART"

pulse. A digit impulse exit hub emits 12 *timed* electric impulses corresponding to the 12 punching positions of a card (9-12). These impulses are wired to an entry hub labelled C, or COMMON, which is the direct entry to the emitter brush.

The illustration shown (Figure 38) is a schematic drawing of the digit impulses being fed to the emitter common through control panel wiring. The impulses then are available at the emitter control panel exit hubs.

The wiring for numerical printing is the same as it was for punching numerical information from an emitter (Figure 39).

The wiring for alphabetic printing requires two wires for each letter, just as it did to punch alphabetic information.

If you will recall the section on printing, you will remember that, in order to make the accounting machine print a letter, we had to take 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 ALPHAMERICAL PRINT entry hub.

When emitting alphabetic information we must still 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 40). However, it was not necessary in this case to use split wiring because the zone is not con-

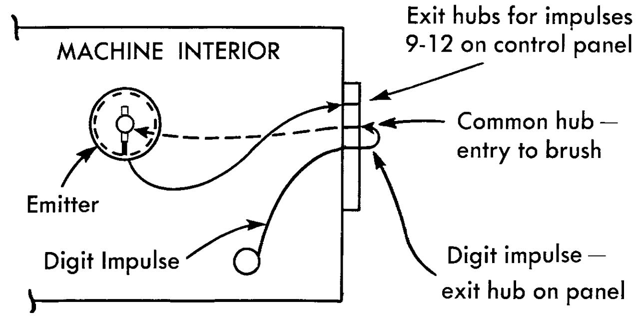


FIGURE 38. EMITTER SCHEMATIC

nected to the numerical impulse, but goes to its own entry. The word DART could have been used and no difficulty experienced. The 12-impulse could be split to several zone entries, and the corresponding numerical information wired to print entry with no back-circuit resulting.

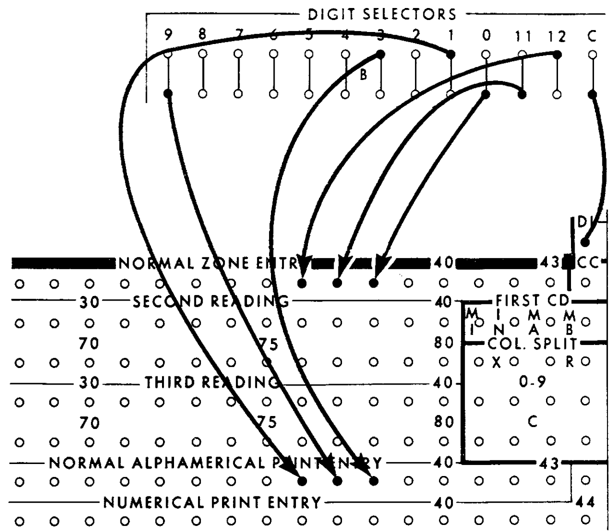


FIGURE 40. CONTROL PANEL WIRING TO PRINT ART

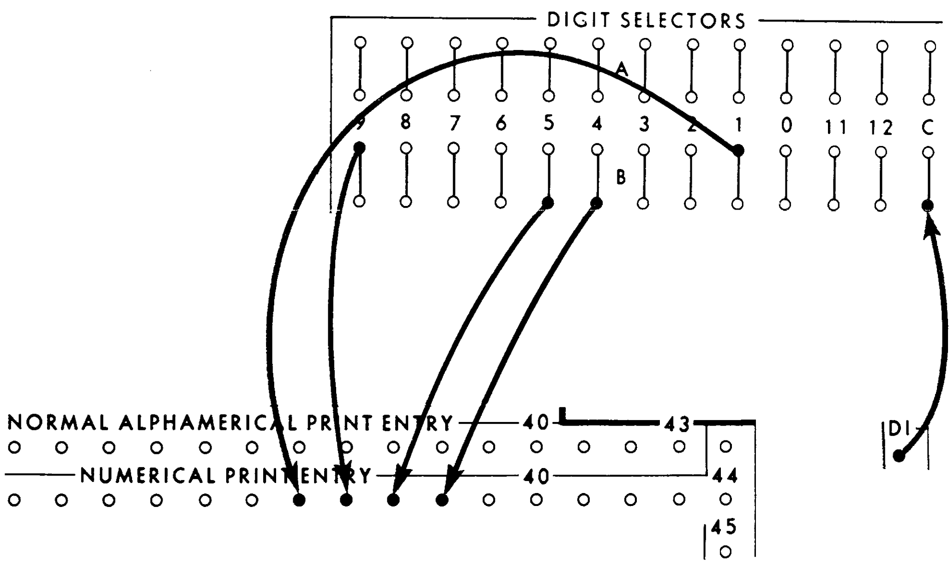


FIGURE 39. CONTROL PANEL WIRING TO PRINT NUMERICAL INFORMATION

REVIEW QUESTIONS

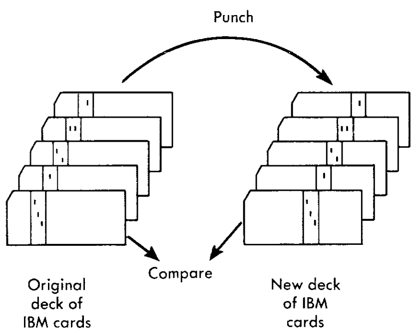
1. When do you need to use an emitter?
2. What is a digit emitter?
3. What is a digit selector?
4. How are the impulses available at the exit hubs on the control panel?
5. When are the impulses available at the exit hubs on the control panel?
6. What are the two methods of impulsing the emitter brush?
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 from an emitter?
10. Is it possible to print alphabetic information using an emitter? If so, how?
11. What is a DI impulse? What is it used for?

COMPARING

Comparing, in its usual sense, is the process of looking at two things to find out in what way they are alike or in what way they are different.

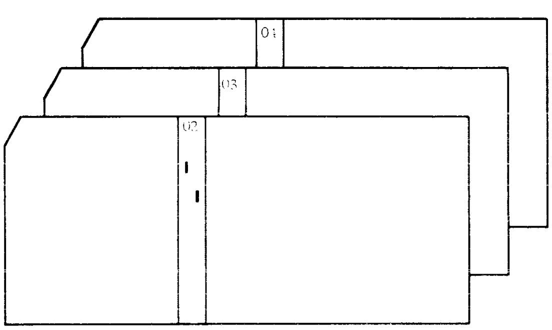
Comparing, when used as a term to describe an IBM accounting machine function, means much the same thing and is the process of looking for likenesses or differences in punching of one or more IBM cards for the purpose of (1) verification, or (2) control.

Verification — a process of testing for the correctness of punching. For example, after having 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 in order to verify the accuracy of the punching.

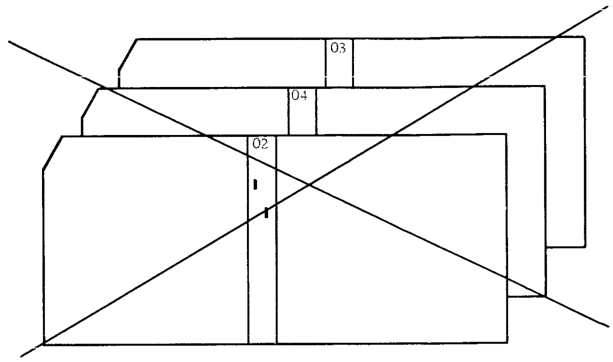


Control — the process of directing a machine to perform specific operations. For example, you may need to check a file of IBM cards to make sure that they are in correct ascending or descending order, or sequence. It is necessary to *compare* the first card with the second card, the second card with the third, the third card with the fourth, etc. If a card were out of order (sequence) you would want to *control* the machine to stop so that you could locate the card which was out of sequence and refile it in its correct place.

The cards shown are in ascending numerical sequence: 02, 03, 04.



The cards in the next illustration 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 may be controlled to stop.



Another example of the need for comparing in order to *control* machine operations is shown in Figure 41.

This is a report prepared by an IBM accounting machine. As cards were fed through the accounting machine we printed commodity number, unit cost, quantity, and sales amount automatically from each card.

Commodity Number	Unit Cost	Quantity	Sales Amount
11102	556	4	276
11102	556	2	138
11102	556	20	1380
		26	1794 *
11202	664	40	3320
11202	664	15	1245
11202	664	40	3320
11202	664	40	3320
11202	664	3	249
11202	664	40	3320
		178	14774 *
13102	673	75	6300
13102	673	45	3780
13102	673	25	2100
13102	673	75	6300
		220	18480 *
14202	709	15	1320
14202	709	4	352
14202	709	15	1320
14202	709	15	1320
14202	709	30	2640
14202	709	20	
		99	
14203	768		
14203	76		

Figure 41

At the same time we 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 recognized, by means of its comparing feature, a difference in commodity number from one card to another, the machine was told to stop and print a total for sales amount.

The total for the three cards for commodity number 11102 was $17.94. The total for the six cards for commodity number 11202 was $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*.

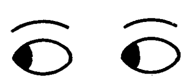
Now, let us see how comparing is done.

The 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. You would use your eyes and mind.

The Machine Method

The IBM machines compare cards by substituting mechanical units for your eyes and mind which were used in the manual method.

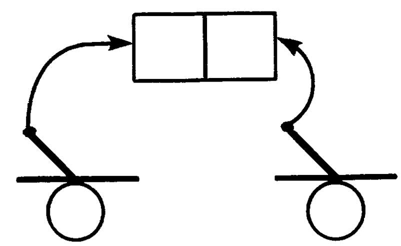


Eyes. The eyes of an IBM machine are its reading brushes. In order to compare any two cards at the same time we must have two sets of reading brushes. One set of brushes reads one card *at the same time* the other set of brushes reads the other card.

When two cards are being 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.

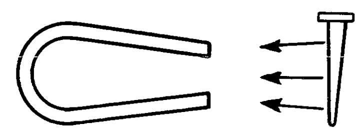
The Mind. The place where the comparing operation takes place in IBM machines is called the *comparing magnets.* They are described in detail in the following pages, but, for now, remember that they are the place where the card punches are analyzed. The result of this analysis directs the IBM machines to perform the desired operations.

Comparing Magnets



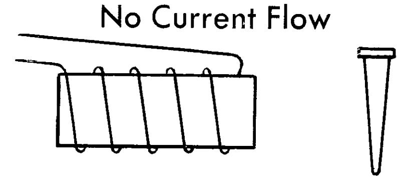
Comparing Magnets

You should understand what a comparing magnet is before we get any further into a discussion of comparing. It would 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 which you already know. The horseshoe magnet will attract a nail or a piece of metal, and this attraction, or magnetism, is permanent.

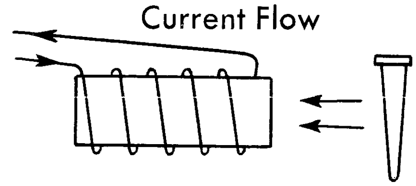


IBM machines have magnets which are slightly different from the horseshoe type. They are nothing more than a piece of iron (called a *core*) that becomes a strong magnet when an electric impulse goes through a length of wire (called a *coil*) wrapped around the core. When the electric impulse is *not* going through the coil, the core is not magnetized. When an electric impulse is going through the coil, the core becomes a magnet.

No Current Flow



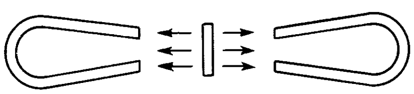
Current Flow



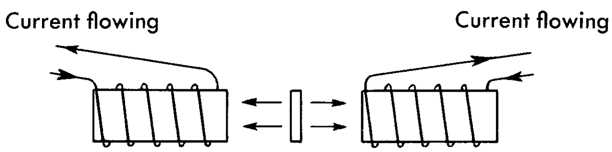
Therefore, you can see that the difference between the horseshoe magnet and the magnets used in IBM machines is that in the IBM type, the magnetism can be turned off and on by the presence or absence of an electric impulse.

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

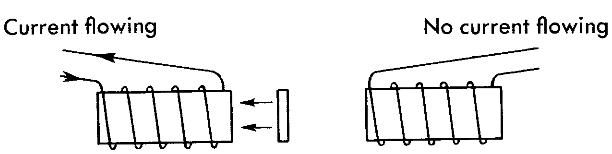
If we put a metal bar between two identical horseshoe magnets, the magnetic force would be equal from both magnets, and the bar would not move to either magnet.



If we put a metal bar between two identical electro-magnets and took identically *timed* electric impulses to each of these magnets, then too, the metal bar would stay in place and not move to either magnet.



However, if at a given time, only *one* of the two electro-magnets received an impulse and were magnetized, then the bar would be attracted to the magnet which had received the electric impulse.



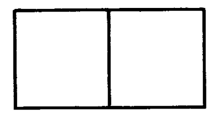
IBM machines use electro-magnets in pairs in order to perform the comparing operation. Each pair of electro-magnets is called a *comparing position* or a pair of *comparing magnets.* Therefore, there are two halves to each comparing position or magnet.

Whenever you are using a comparing position, it must be remembered 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 comparing position 5 to record the reading of the other card.

In the illustrations to follow, the magnets themselves will be shown shaded if they are energized or impulsed, and plain if not impulsed.

In schematic diagrams comparing magnets are shown as two squares side by side representing the two sides of a comparing unit.

Comparing Magnets



How do comparing magnets do their work?

Let's assume we wish to compare two cards which are punched identically in column 15. Both card A and card B have a 5-punch.

You will remember that the IBM machines must read both cards, so Figure 42 shows we have two sets of reading brushes.

The impulse resulting from a punch in card A will energize the left-hand magnet. An impulse resulting from a punch in card B will energize the right-hand magnet. This is 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-

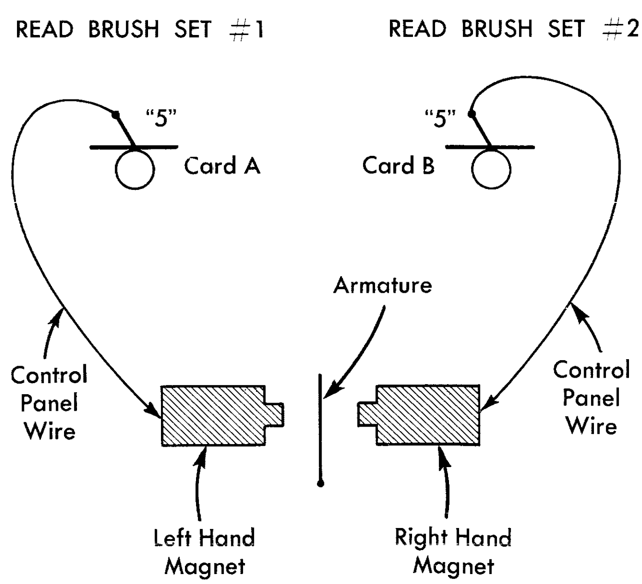


FIGURE 42. COMPARING—EQUAL CONDITION

nets will be energized at the same time, and the metal bar in the center, called an *armature,* will remain in the position shown. This is called an *equal* condition.

Now let's 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 will permit the brush and the contact roller to complete an electric circuit, and the resulting impulse will be carried over the external wire on the control panel to the left-hand magnet. This impulse will then energize the magnet for the duration of 5-time (Figure 43).

As there was no punch in card B in the 5-position, no impulse will be available, and the right-hand magnet will remain inactive. This will create an unequal condition of magnetism in the two magnets, and the metal bar (armature) will be attracted to the left-hand magnet.

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 will be impulsed, and the left-hand magnet will remain inactive (Figure 44). The unequal condition will cause the armature to be attracted to the right-hand magnet.

This movement of the armature is the reason for having the contact roller, the brushes, the external wires, and the magnets.

PAIR 1

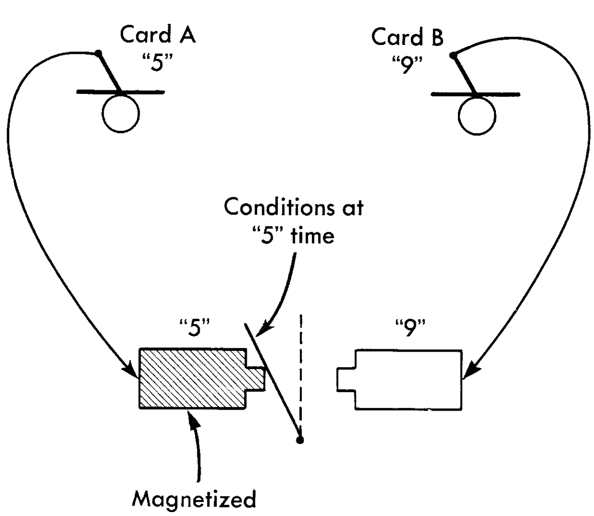


FIGURE 43. COMPARING—UNEQUAL CONDITION

PAIR 2

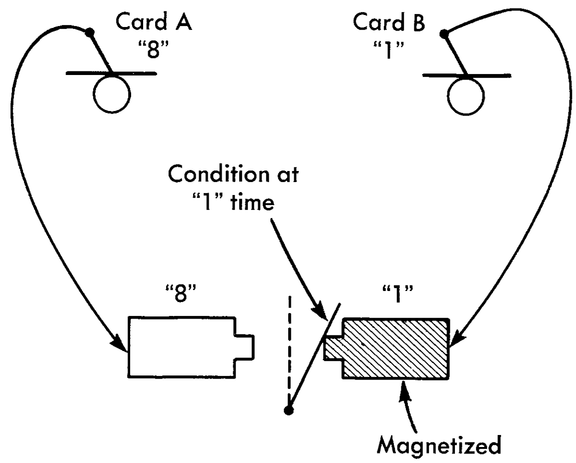


FIGURE 44. COMPARING—UNEQUAL CONDITION

The armature, when moved by impulsing of the magnets, 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.*

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 45 B and C. It is normal in Figure 45A.

We see how this switch is useful to us when we add electric light bulbs and a few wires.

In Figure 46A, 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.

In Figure 46B, however, the electric light has been lit. When the left-hand magnet was energized, it pulled the armature to the left where it made contact with the wire leading to the bulb. The current that was connected to the armature had a completed path to the light bulb, and the bulb lit. This was accomplished by the transfer of the armature.

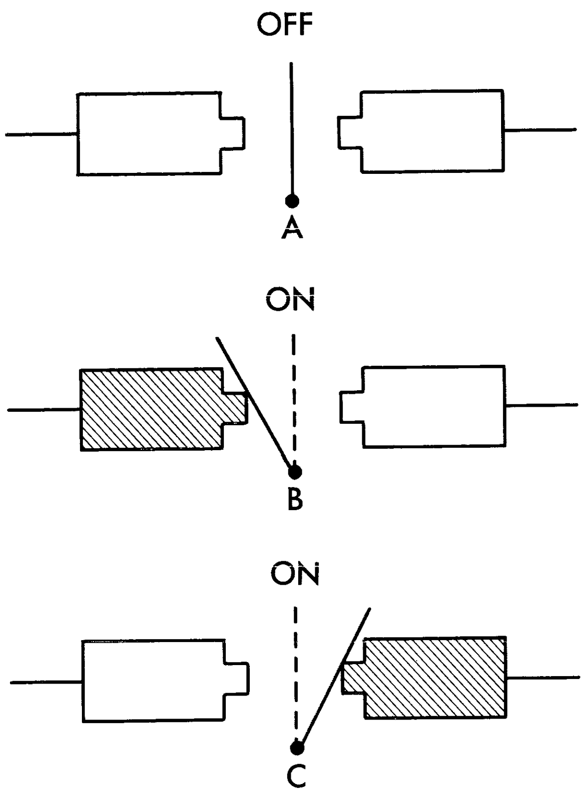


FIGURE 45

In Figure 46C the bulb also lit. This time, the right-hand magnet was energized, and pulled the armature to the right where it made contact with the right-hand wire leading to the bulb. Again, the bulb lit because a circuit was completed by the transfer of the armature.

In Figure 46A the electric circuit was not completed. In Figures 46B and C the transfer of the armature completed the electric circuit, and the light bulb was turned on.

When these armatures transfer they complete electric circuits. The completion of a circuit can tell a machine:

1. That the two cards being compared have the same punches . . . are "equal".
2. That the two cards being compared have different punches . . . are "unequal".

One type of machine can further analyze an unequal condition to tell which card has the lower number.

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 will compare 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 47).

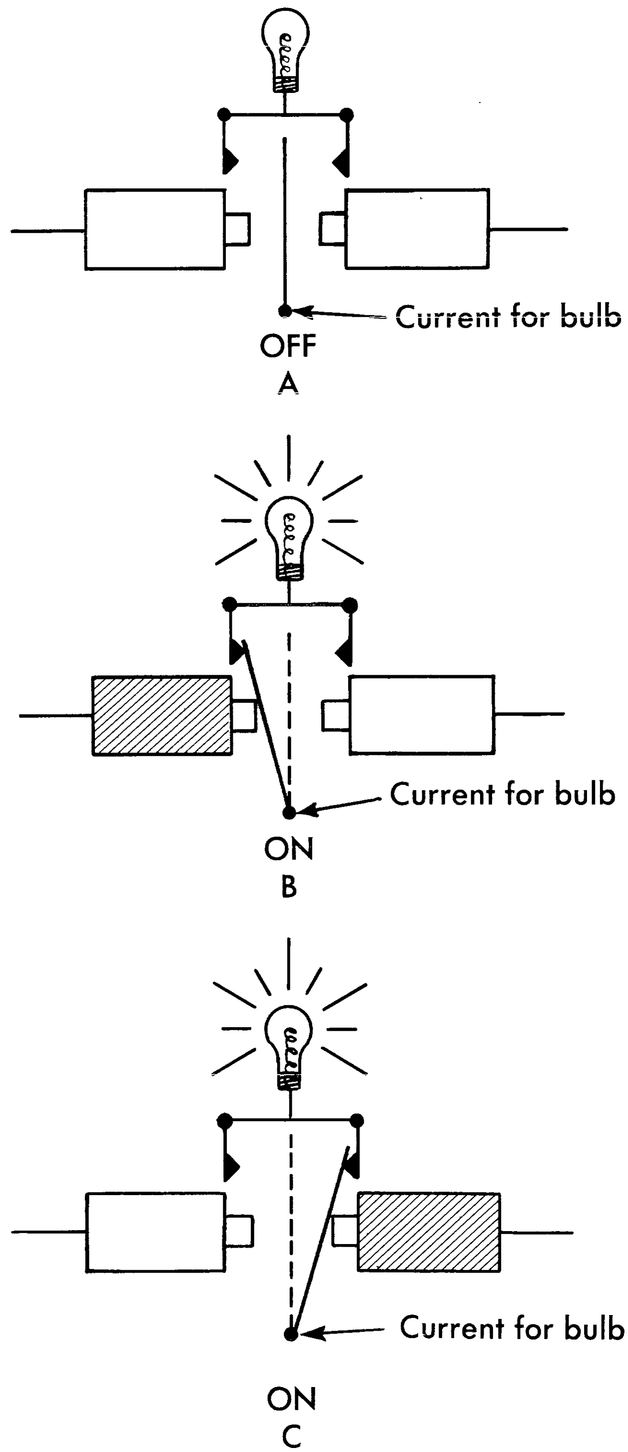


FIGURE 46

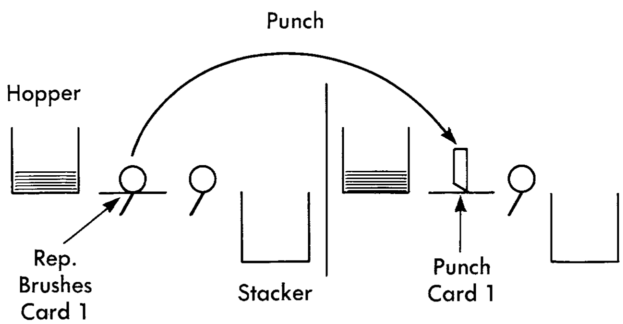


FIGURE 47. SCHEMATIC OF REPRODUCING PUNCH

When looking 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 rather, are in motion.

If you will recall the previous discussion of punching, you will remember that you wired from the READING BRUSHES to PUNCH. This control panel wiring is shown in the schematic by the arrow labelled "punch".

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

In the schematic, Figure 48, 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 will *internally and automatically* direct 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, and
3. raise mechanical fingers which will point out to the operator the pair of comparing magnets in which the unequal condition exists.

The reproducing (read) brushes are wired to the punch magnets just as they were when punching was

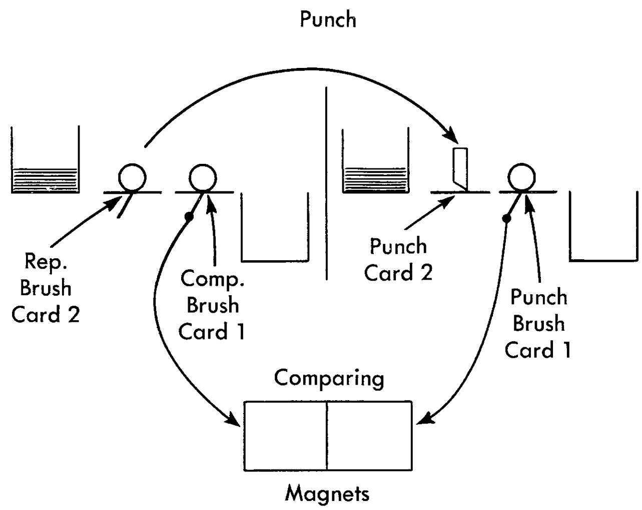


FIGURE 48. SCHEMATIC OF REPRODUCING PUNCH

studied. The punch brushes, which read the card that has just passed the punch station, are wired to one side of six comparing magnets (Figure 49). They were actually wired to comparing magnets 15-20 because it is easy to wire card columns to the corresponding comparing magnets, but it is not necessary at all. They could just as well have been wired to any six comparing magnets.

The comparing brushes are wired to the other side of the same comparing magnets that the punch brushes are wired to—in this case 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.

Wiring to Compare—The Collator

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

Because of two separate feeds, the primary and the secondary, the collator can perform a variety of operations, but we will discuss just one function — sequence checking.

Sequence checking is deciding whether or not a file of IBM cards is in ascending 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

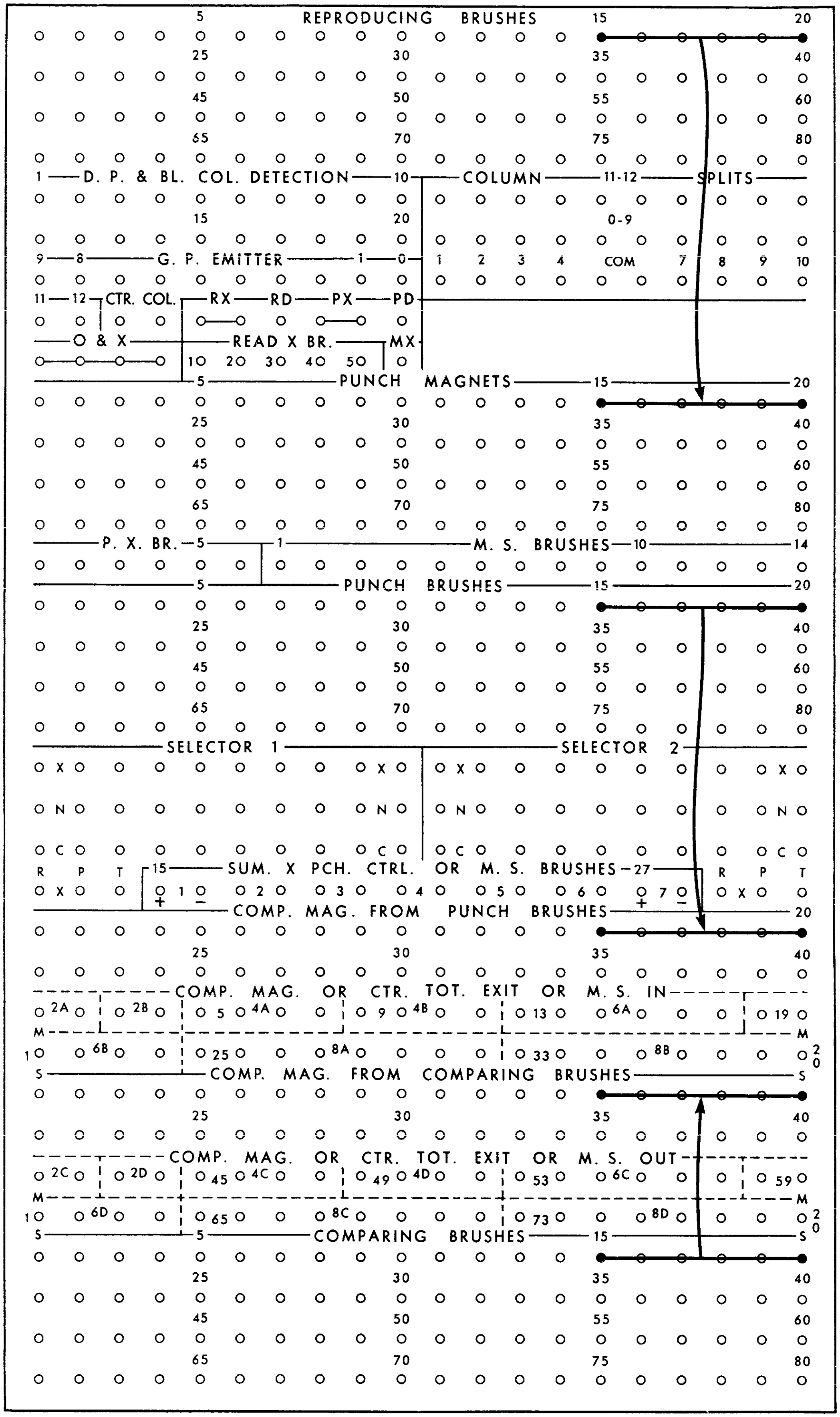

REPRODUCING BRUSHES
D. P. & BL. COL. DETECTION
COLUMN 11-12 SPLITS
0-9
COM
G. P. EMITTER
CTR. COL.
RX
RD
PX
PD
O & X
READ X BR.
MX
PUNCH MAGNETS
P. X. BR.
M. S. BRUSHES
PUNCH BRUSHES
SELECTOR 1
SELECTOR 2
SUM. X PCH. CTRL. OR M. S. BRUSHES
COMP. MAG. FROM PUNCH BRUSHES
COMP. MAG. OR CTR. TOT. EXIT OR M. S. IN
COMP. MAG. FROM COMPARING BRUSHES
COMP. MAG. OR CTR. TOT. EXIT OR M. S. OUT
COMPARING BRUSHES

FIGURE 49

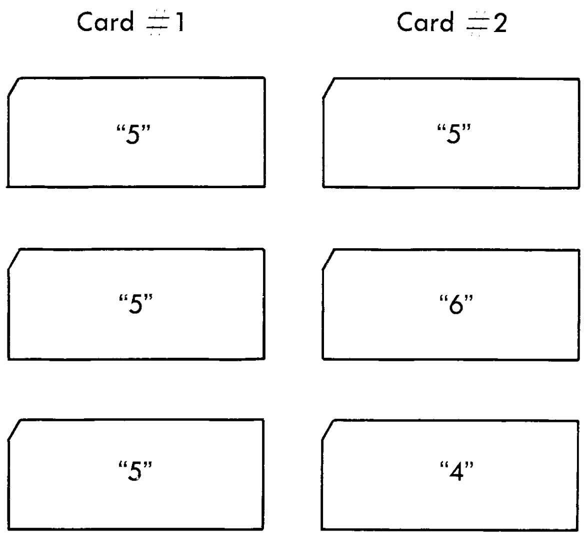


FIGURE 50

order to determine which of the conditions listed below 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.

3. The second card has a LOWER number punched in it than the immediately preceding card.

If you look at a series of numbers to determine which condition exists between each two of them, you would look at the number you were interested in at the moment and then look at the one to the left to make the comparison (Figure 50).

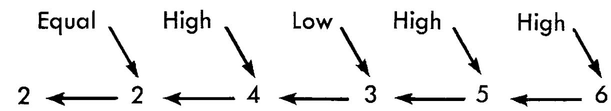


FIGURE 51

If the cards were in the order illustrated (Figure 51) the card out of order is the three or the one with the *low* condition. 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* or out-of-order number.

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.

Let's look at the schematic diagram of the collator (Figure 52) to see how the comparing operation takes place.

What is needed in any machine in order to compare cards? Two sets of brushes and comparing magnets. You will see by looking at the schematic that the collator has these units.

The collator has two feeds, the lower or primary feed, and the upper or secondary feed. Which feed can be used for this sequence checking operation? The primary feed can be used because it has two sets of reading brushes.

The reading brushes on the left are called the *primary read* as they are located in the primary feed.

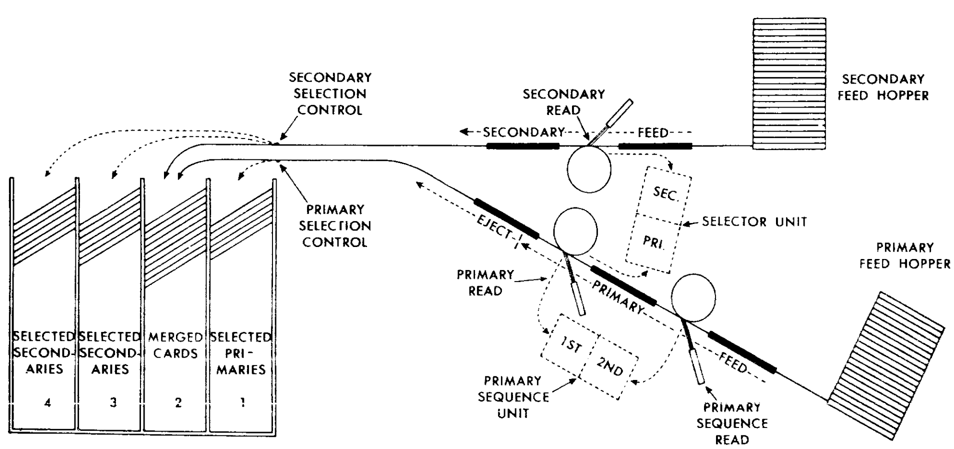


FIGURE 52

The brushes on the right are called the *primary sequence read* brushes because they are located in the primary feed and actually allow us to sequence-check or compare the second card with the preceding card.

We also have pairs of comparing magnets. They are called *primary sequence magnets.* In order to distinguish the left and right side of a pair of magnets, they are labelled *1st* and *2nd.*

The wiring of the control panel for comparing is simple, and is very like that needed on the reproducing punch. We must wire the reading brushes to the comparing entry, for no comparison can take place until the punches in the cards have been received by the magnets.

In Figure 53 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 case we have an *equal primary sequence* condition. (The second card in the primary feed is equal to the first card in the primary feed.)

In Figure 54 we have a *high primary sequence* condition. (The second card in the primary feed is higher than the first card in the primary feed.)

In Figure 55 we have a *low primary sequence* condition. (The second card in the primary feed is lower than the first card in the primary feed.)

How do the comparing magnets analyze the card punches to tell us whether we have an equal primary sequence, a high primary sequence, or a low primary sequence condition?

In a way that is very much like that used in the reproducing punch.

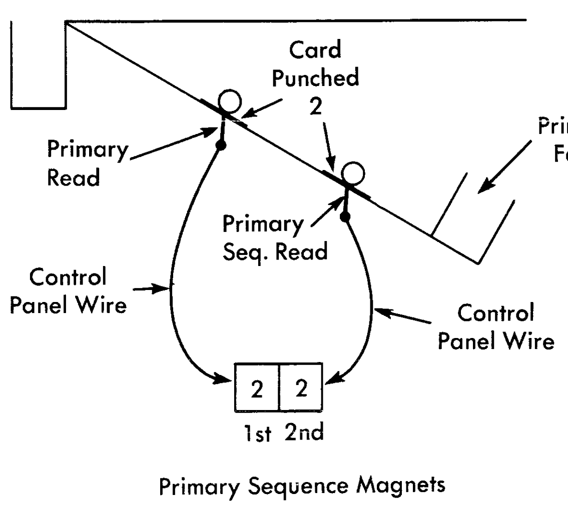


FIGURE 53

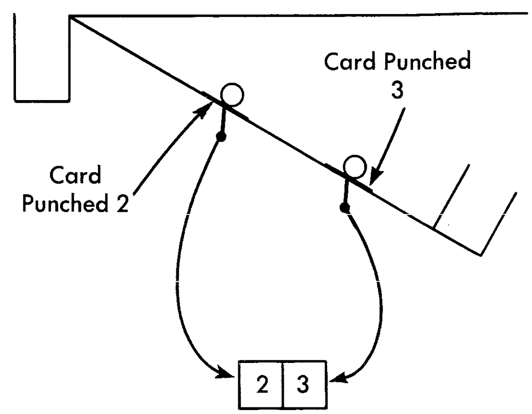


FIGURE 54

If neither magnet were impulsed, or if both are impulsed at the same time, we have an equal primary sequence condition, and the armature stays in its normal position (Figure 56). The control input impulse going to the armature will be available out of the control panel exit hub labelled EQUAL PRIMARY SEQUENCE. In the schematics used to illustrate these comparing principles the path for current flow is drawn as a heavier line for clarification.

If the 1st primary-sequence magnet is impulsed, and the 2nd primary-sequence magnet is not impulsed, this would indicate a low primary sequence condition. How would the machine know?

Let's look at the schematic diagram (Figure 57).

The cards are fed 9-edge first. Therefore the higher number would be read first. If the higher number were under the primary brushes, then the 1st primary-sequence magnet would be impulsed, and the 2nd primary-sequence magnet would not be impulsed.

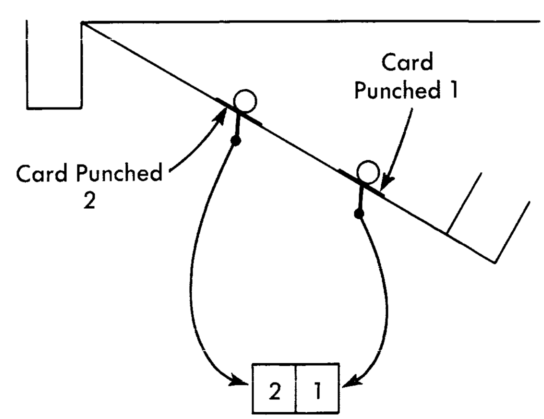


FIGURE 55

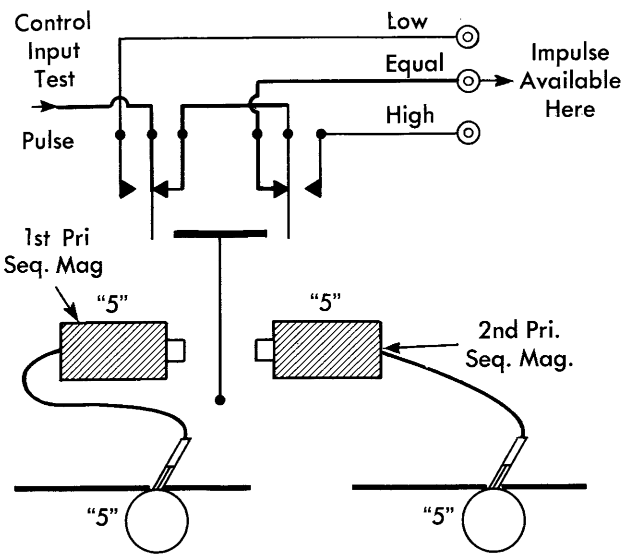


FIGURE 56

The armature would transfer to the left, and the impulse from the armature would become available out of the low-primary-sequence exit hub on the control panel.

How do we get an indication of *high-primary sequence?*

The right-hand magnet would be energized first, attracting the armature and completing a circuit to the high-primary-sequence hub on the control panel

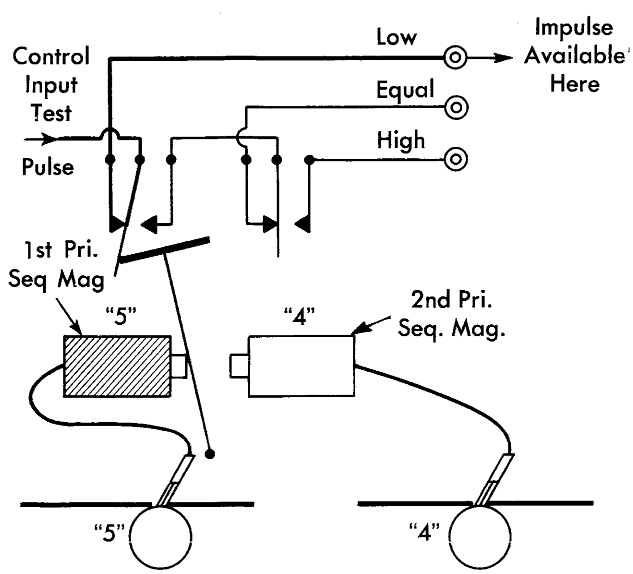


FIGURE 57

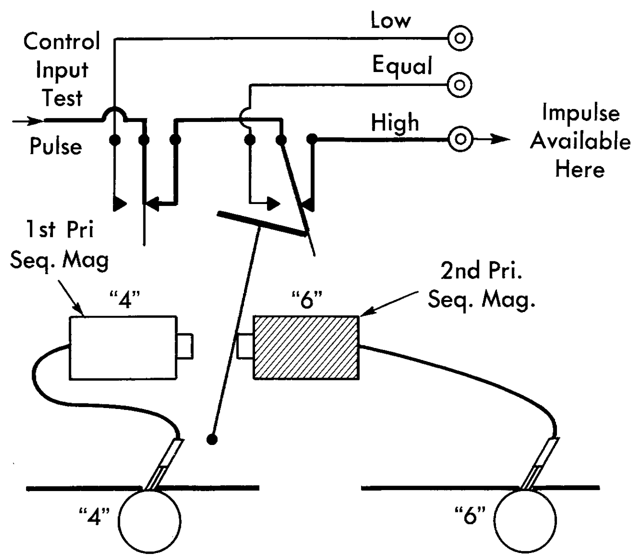


FIGURE 58

We have now covered how the machine can recognize the difference between the three possible comparing conditions. If you will recall the reproducing punch, once a condition was recognized by the machine, it was *internally and automatically* controlled to stop, light a bulb, and to indicate which comparing magnet had the unequal condition.

This is not true of the collator. We must decide which condition will require us to stop the machine, and then *externally* wire the selected condition to an entry hub which, when impulsed, will cause the machine to stop.

Let's look at the control panel diagram (Figure 59).

In the lower section we show the wiring of column 15 from the primary sequence read brushes to the comparing magnets. These wires are identified by the number 1.

In the upper section we show the wire which will cause the machine to stop when a low primary sequence condition is recognized by the magnets. This wire is indicated by the number 2.

If we had wished the machine to stop whenever duplicate cards went through the machine, we would have wired from the equal-primary sequence exit hub to error stop.

We have also added three jack plugs to the control panel. They can be found in the middle of the right-hand side.

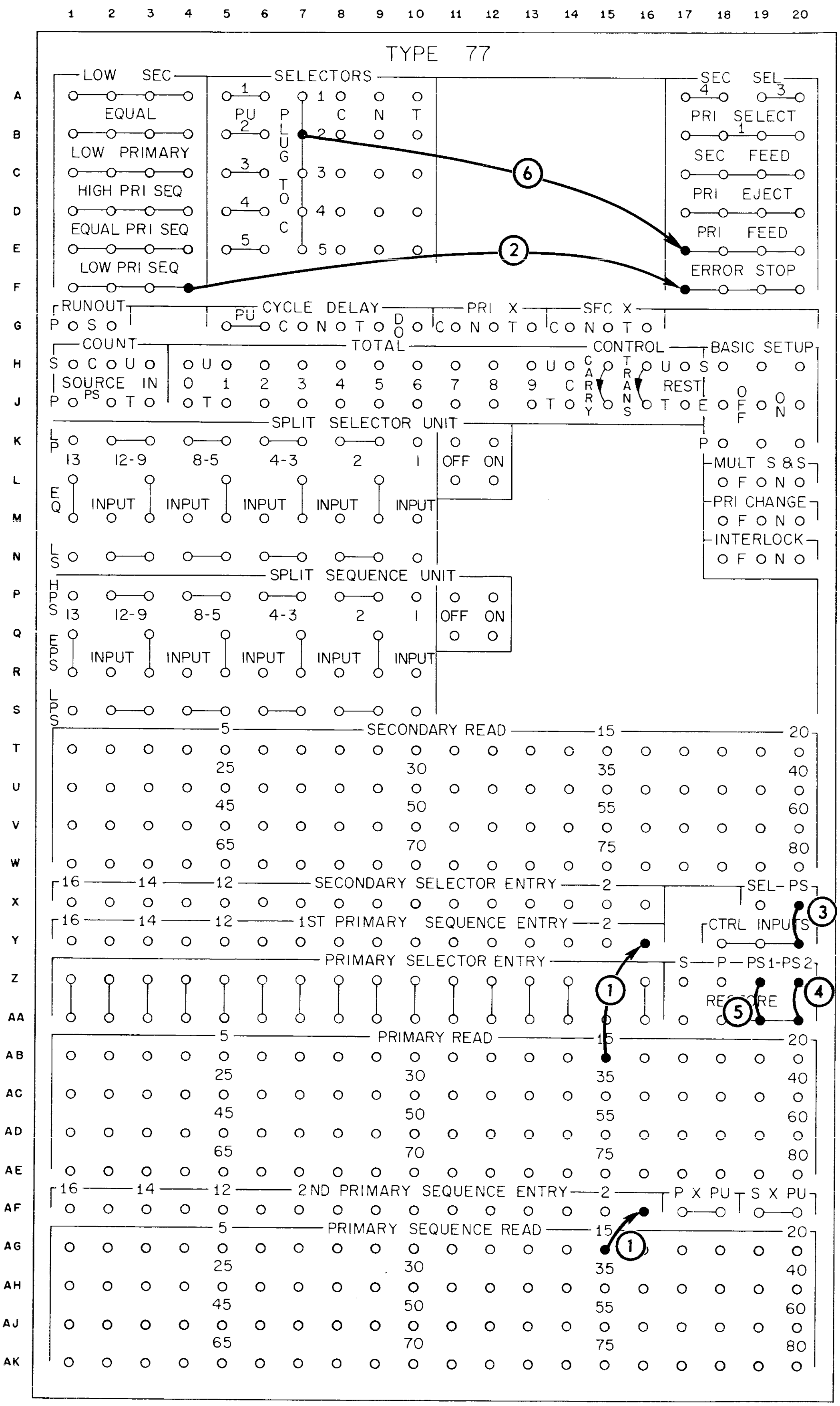

TYPE 77
LOW SEC
SELECTORS
SEC SEL
EQUAL
PRI SELECT
LOW PRIMARY
SEC FEED
HIGH PRI SEQ
PRI EJECT
EQUAL PRI SEQ
PRI FEED
LOW PRI SEQ
ERROR STOP
RUNOUT
CYCLE DELAY
PRI X
SEC X
COUNT
TOTAL
CONTROL
BASIC SETUP
SOURCE IN
REST
SPLIT SELECTOR UNIT
OFF ON
MULT S & S
PRI CHANGE
INTERLOCK
INPUT
SPLIT SEQUENCE UNIT
SECONDARY READ
SECONDARY SELECTOR ENTRY
SEL-PS
1ST PRIMARY SEQUENCE ENTRY
CTRL INPUTS
PRIMARY SELECTOR ENTRY
RESTORE
PRIMARY READ
2ND PRIMARY SEQUENCE ENTRY
P X PU
S X PU
PRIMARY SEQUENCE READ

Figure 59

The number 3 jack plug connects a hub labelled CONTROL INPUT with a hub labelled PS.

In the reproducing punch the current flows to the armature internally and automatically. In the collator we must wire this impulse to the armature. As we are using primary-sequence magnets, we jackplug any one of the common control-input exit hubs to the PS (primary sequence) inlet hub.

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

You will note that jack plug number 4 connects one of the common restoring-magnet exit hubs with the PS2 entry hub. Jack plug number 5 connects another of the common restoring-magnet hubs with the PS1 entry hub.

We are using both sides of the pairs of comparing magnets; therefore, we must restore PS1 and PS2 before we can enter a new card reading.

The situation in the collator is different in that it actually does more than just compare two impulses. The collator comparing unit is also a storage unit. The information to the comparing magnet actually causes that information to be stored (covered in the section on storage), and then it can be compared. 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. The information put into storage will remain in storage until the unit is told to restore or read-in again.

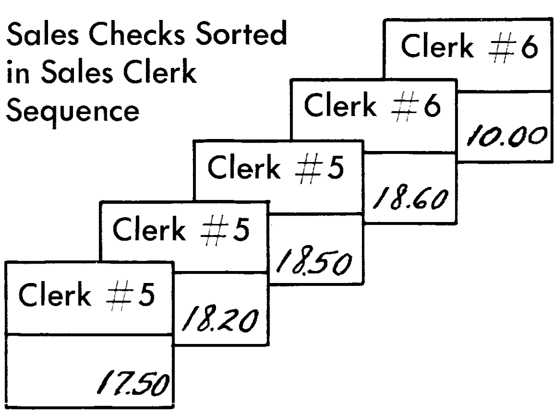


FIGURE 60

One half can be restored without the other so that the reading from one card may be retained and compared to several others.

Another difference between the collator and other machines such as the reproducing punch is that they will feed cards without instructions from the control panel. The collator will feed cards only when told to do so by control panel wiring. Wire number 6 performs this function. A constant impulse is available from the exit hubs labelled PLUG TO C. One of these common plug-to-C hubs wired to the primary feed hub will cause continuous feeding of cards in the primary feed.

Wiring to Compare—The IBM Accounting Machine

Comparing magnets are used in IBM accounting machines (sometimes called "tabulators") to recognize the difference between groups of IBM cards.

In order to better understand the need for comparing, let's discuss a manual operation, and then the same operation in terms of the machine.

THE MANUAL METHOD

If you were the manager of a section of a department store, at the end of each day you would be interested in finding 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?

In order to obtain the answers you would first have had to collect all the sales checks written during the day.

The next step would be to arrange, or sort them so that all checks for one clerk were together, and then arrange the groups of checks in sequence by sales clerk name or number (Figure 60).

Your next step would be to copy the information from the sales checks to a work sheet. At the end of a group of checks for one sales clerk, you would have stopped, added up the amounts, and written down the total amount for that sales clerk (Figure 61).

How would you have recognized that you had reached the last sales check for a particular sales clerk? By comparing the sales clerk number for one check, with the sales clerk number on the following check.

After you had copied down all the amounts for

CLERK # 5 $ 17.50
CLERK # 5 18.20
CLERK # 5 18.50
$ 54.20 (SUB, OR MINOR TOTAL)

CLERK #6 18.60
CLERK #6 10.00
$ 28.60 (SUB, OR MINOR TOTAL)
$ 82.80 (FINAL TOTAL)

FIGURE 61

each check, and added up these amounts to get sub, or minor, totals for each sales clerk, you would then have added the entire list of amounts to arrive at a final total for a day's sales.

THE MACHINE METHOD

We would punch one IBM card for each item sold, check the punching to make sure it was accurate, and then arrange the cards in sequence by sales clerk number. This would be done by the IBM Sorter.

The next step would be to run the cards through the feed of an IBM accounting machine. The accounting machine, as you have seen in the section on *Printing,* can print automatically any or all of the information punched in each IBM card as it passes under the reading brushes.

In addition, the accounting machine has the ability to accumulate numerical amounts, for it is equipped with counters. Because of its comparing magnets, the machine can automatically 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 and print the totals accumulated in the counters (Figure 62).

The accounting machine's comparing magnets recognize the difference between sales clerk number 5

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

FIGURE 62

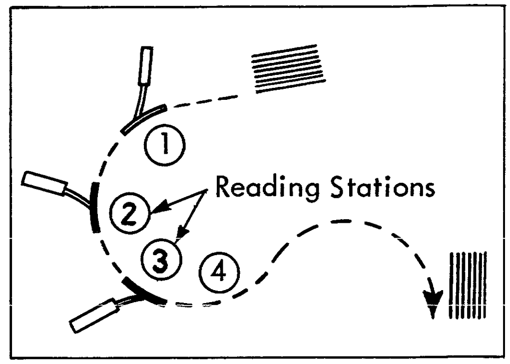


FIGURE 63. TYPE 403 ACCOUNTING MACHINE FEED SCHEMATIC

and number 6 as an unequal condition. And the impulse resulting from this unequal condition can be used to control the machine functions.

Let's go through the operation of the comparing magnets.

First, the accounting machine has two sets of brushes which are used for comparing purposes. They are labelled SECOND and THIRD READING BRUSHES (Figure 63).

These brushes are connected to the comparing magnets by control panel wiring. The comparing

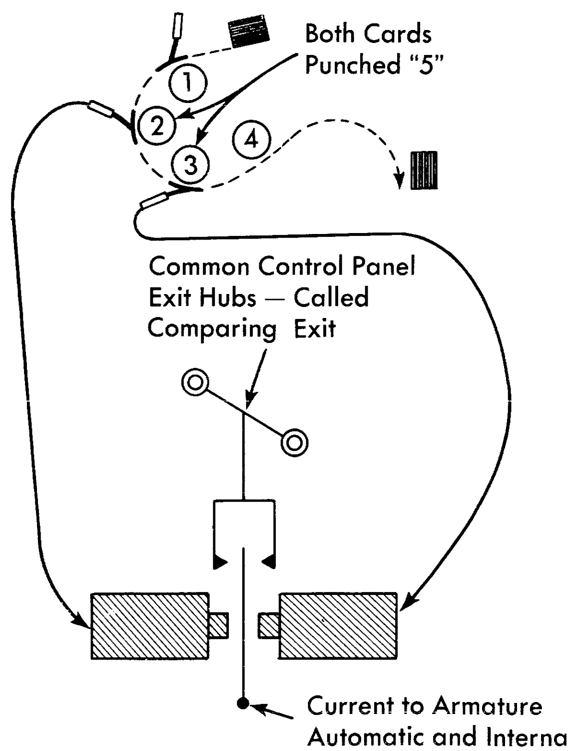


FIGURE 64. TYPE 403 ACCOUNTING MACHINE FEED SCHEMATIC

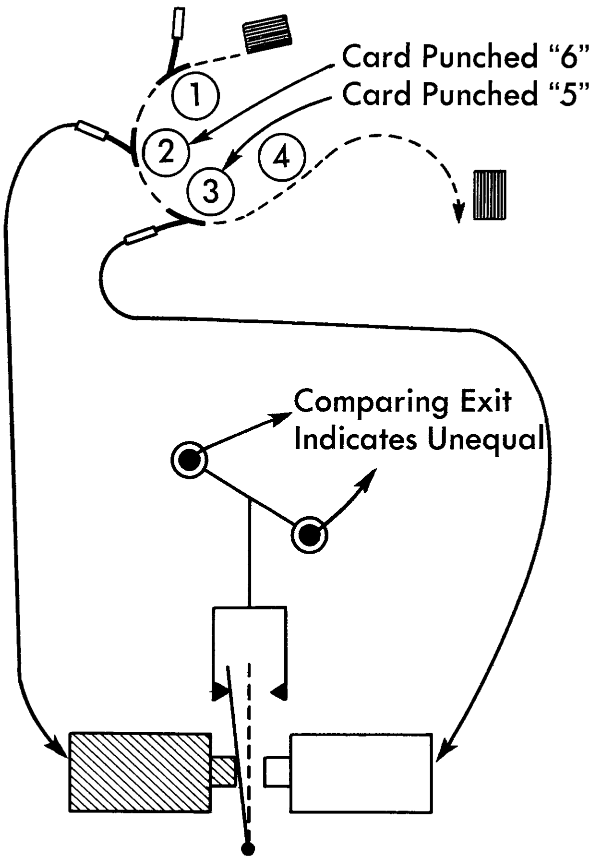


FIGURE 65

magnets are labelled COMPARING ENTRY on the control panel.

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, so the armature remains in its normal position, and the two common exit hubs are inactive (Figure 64).

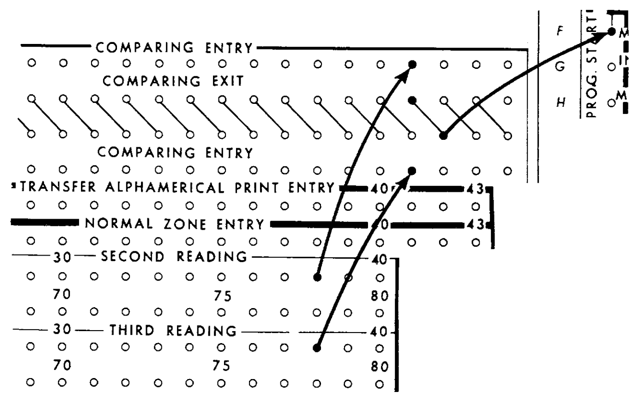


FIGURE 66

In the next case, the left-hand magnet has been impulsed, as the 6-punch would be read first. The armature has been transferred, and it made contact with the relay point connected to the common exit hubs on the control panel (Figure 65).

The same impulse would have been available out of the control panel exit hubs if the right-hand magnet had been impulsed.

An impulse will be available out of the exit hubs whenever an unequal condition exists in the magnets.

This comparing exit impulse is used to control the machine by wiring either of the common exit hubs to an entry hub labelled MINOR PROGRAM START.

The control panel wiring for comparing numerical information is as shown in Figure 66.

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

How information is read into the counters, and how the counters may be controlled to print their totals, is covered in a later section.

REVIEW QUESTIONS

1. What do we mean by the word *comparing*?
2. Why do we need to compare in IBM machines? What are the two reasons given?
3. What must IBM machines have in order to compare?
4. Describe an electro-magnet. 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 must be connected on the control panel in order 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 Collator?
12. What is meant when we say a *high primary sequence* condition exists in the IBM Collator?
13. What is meant when we say an *equal primary sequence* condition exists in the IBM Collator?

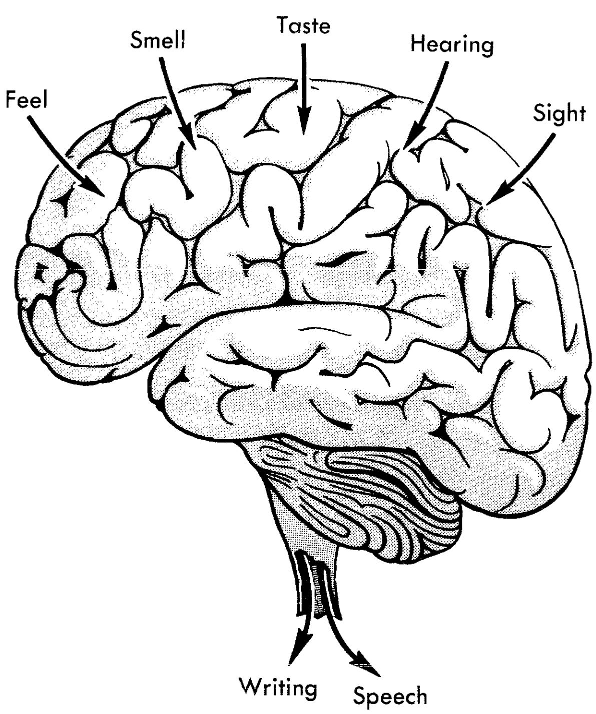
STORAGE

You may find that some information, read by a machine in order to be printed, punched, or compared, may be 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 would like the machine to be able to remember this information for later use.

The information to be remembered must be sent to a memory or storage unit, accepted by it, and remembered. In addition, the information to be of use later, must be sent, at the time it is needed, to the unit which is to use it.

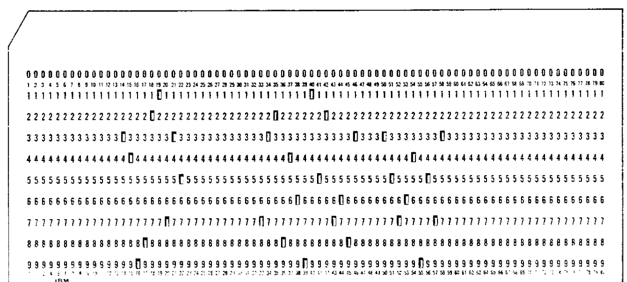
We can say then that a storage unit must meet these three requirements: 1) accept information (read-in), 2) remember that information (store), 3) send out that information when needed (read-out).

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 or 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 by either speaking or writing.



A machine storage unit is considerably simpler than the brain since it has 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, 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.



A storage unit does not function unless it is instructed to do so. It will not accept information unless you instruct it to read in by control panel wiring. If it has been instructed to read in, it will then accept information and store it. Similarly, it will not read out information it has stored unless you instruct it to do so.

To illustrate the principles of storage and the details of the control panel wiring needed to control the storage units, storage units on three types of machines will be discussed: 602A Calculating Punch, 407 Accounting Machine, and the 77 Collator.

602A 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 602A type storage unit and be a little more specific.

The storage unit in the 602A is a type which will accept only digit information from 9 to 0. It also reads out the information in digit form. We mean by this that if it stores a five, for example, it will read out a five.

We said that when this unit accepts a five, it will read out a five. Now, what is a five? Actually, if we

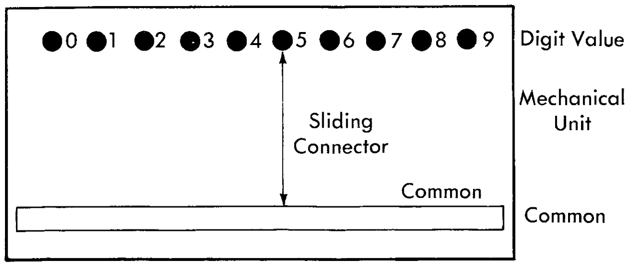


FIGURE 67

think back to the section on reading and timing we realize that a five is just an impulse which can be recognized as a five by the machine. The next question to ask ourselves is, what makes it recognizable as a five? The answer is, of course, the time in the cycle that it is available. That time being 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 602A 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 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.

If this fact is firmly imbedded in our mind, we can begin talking about how the 602A type storage meets these requirements.

Figure 67 is a block representing a single position of the 602A 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 will realize 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 only way that the sliding connector can be made to move is by impulsing the read-in hub of the unit. If only the read-in hub is impulsed, the sliding connector will be moved, by mechanical means, to make a connection between the zero spot and common. This would indicate that nothing is stored in this position. The movement of the sliding connector is always done 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 may come from various sources including the reading brushes which we will assume in this case. The read impulse would be wired to storage entry to tell the sliding connector where it should stop. If it receives a 5-impulse, it would be stopped on the 5-spot, if it received a 9-impulse it would stop 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 will stop on the zero spot.

Figure 68 shows the control panel wiring necessary to cause a storage unit to accept and store information. 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 will be 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 67. Each unit then can store up to twelve digits of information. Also, each unit is divided into two sides, a right and a left. All storage units, except storage unit 1, have 6 positions on each side, storage unit 1 has 4 on the left and 8 positions on the right. In either case, an impulse to read in causes all twelve positions to be operative.

Figure 68 also shows that the information in column 30 of the card will be 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 will be stored in the first position of 4R which is also the first position of storage unit 4.

The sliding connector will remain in any given position until the unit again receives an impulse to read in. This means that information may be read out as many times as desired and the information will still be 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 which is read-out.

Figure 69 will be used to explain this principle. You can see that the spots representing digit values are connected to emitter impulses which 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

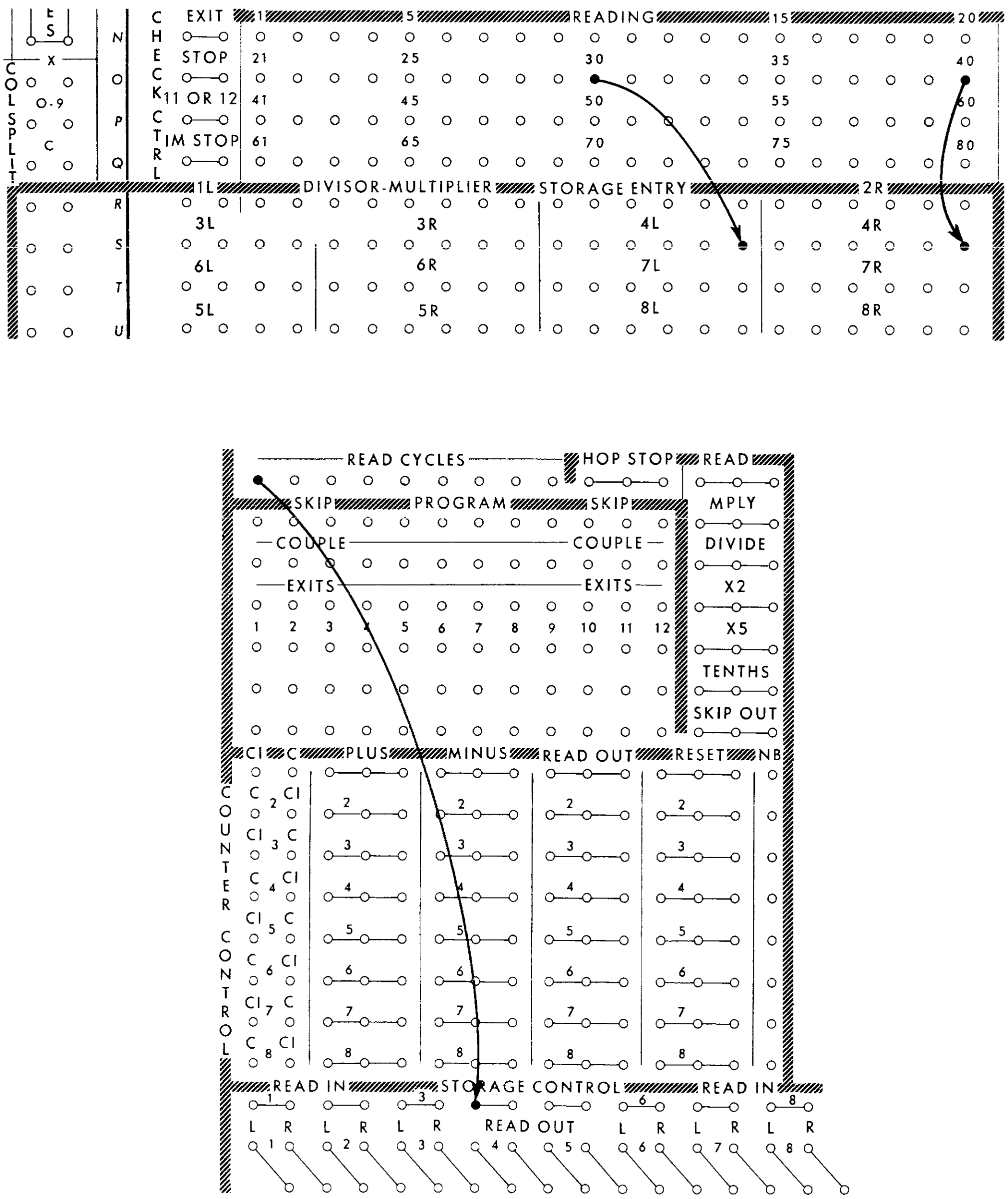


FIGURE 68

read-out contact is closed, the impulse would be available at the exit hub and we would read out of storage.

The read-out contact can be 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 was done so it would be possible to read out of either side without the other. However, both sides may be wired to read out at the same time.

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 is shown in Figure 70.

A practical application of a storage unit is not used at this time, because it would involve units which you have not yet studied, such as counters and programming. However, in later sections storage units are used in practical applications. Therefore, we are again using card cycles to impulse the read-out and read-in hubs to illustrate the principles of read-out.

On a read cycle the read-out hubs for both the left and right side of storage unit four are impulsed. As a result impulses are available from the first positions of 4L and 4R corresponding to the digits stored in

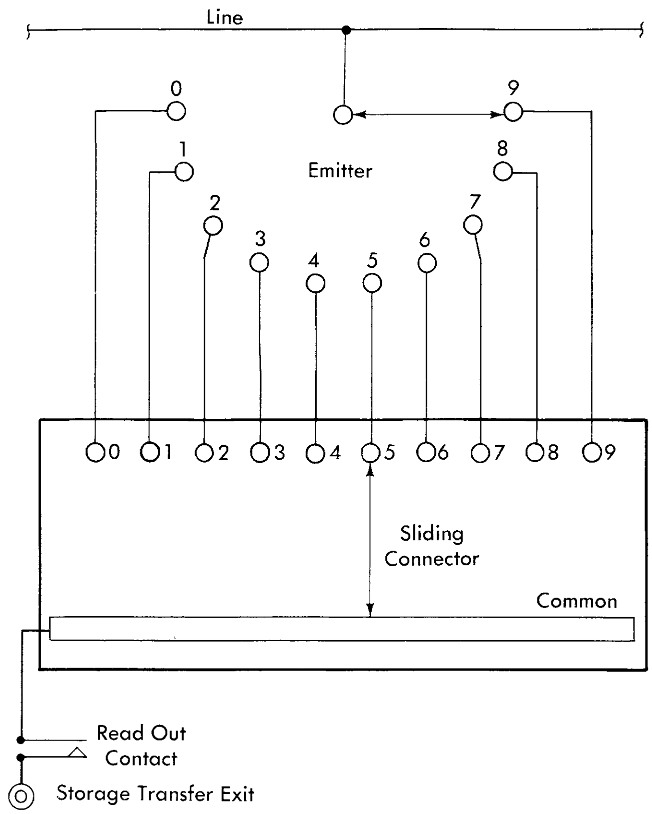


FIGURE 69

these positions. By control panel wiring these impulses are directed to the entry hubs of 2R. Storage unit 2 will accept and store this information since the read-in hub for this unit is also impulsed from read cycles.

407 Accounting Machine

The 407 storage units are of the same general type as the 602A units, and meet the same three requirements of storage: read-in, store, and read-out. One difference between the two is capacity. A 407 type storage unit has 16 storage positions instead of 12. The 407 has four of these units which are lettered STORAGE UNITS A, B, C, and D. However, the basic difference in the two units is the ability of the 407 type to store zones. As it may be desirable to store alphabetic information in a 407 storage unit, it has a position for 11- and 12-impulses, and a blank position, in addition to the digits 9 through 0, as shown in Figure 71.

In this unit, as in the 602A, when instructed to read in, the sliding connector will be operative. It will stop in the position corresponding to the impulse (9-12) it receives. However, in this unit, if it receives

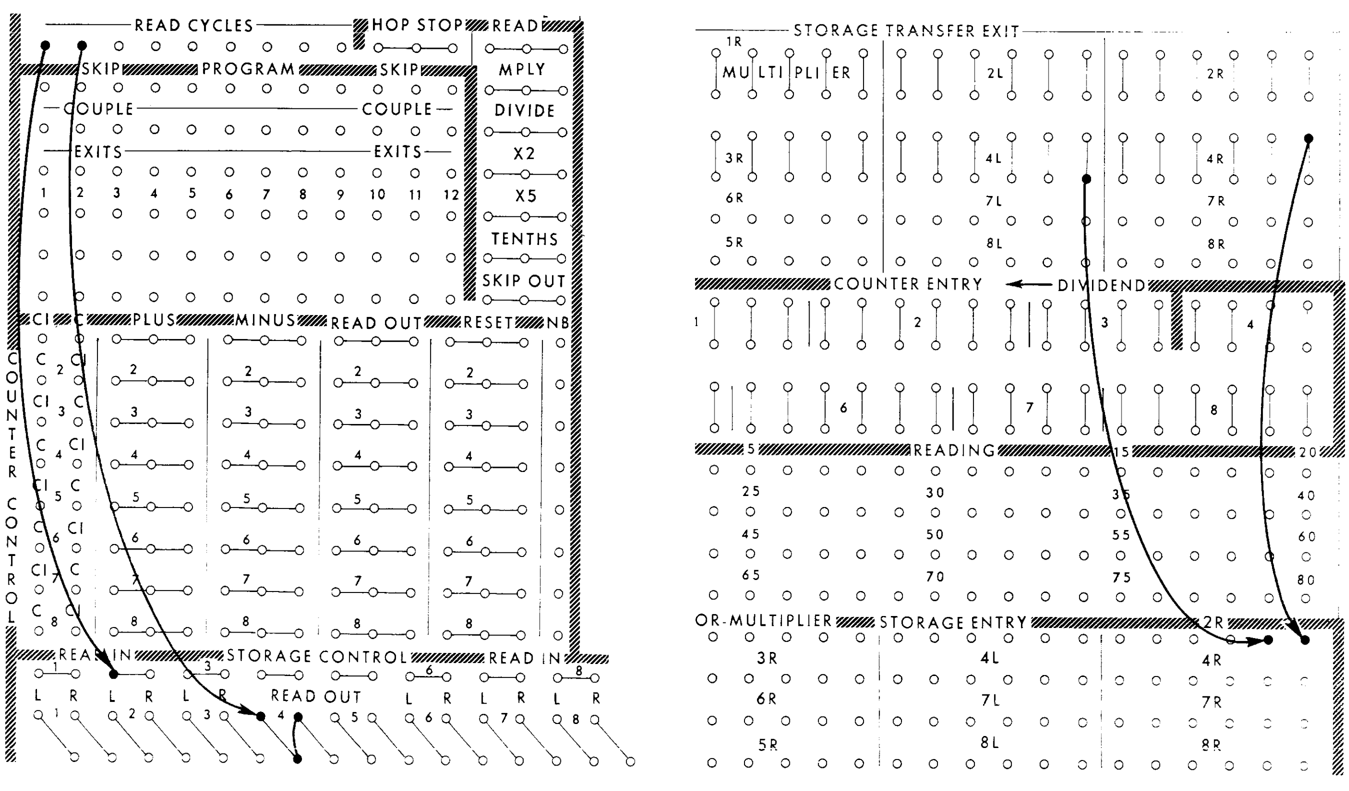


FIGURE 70

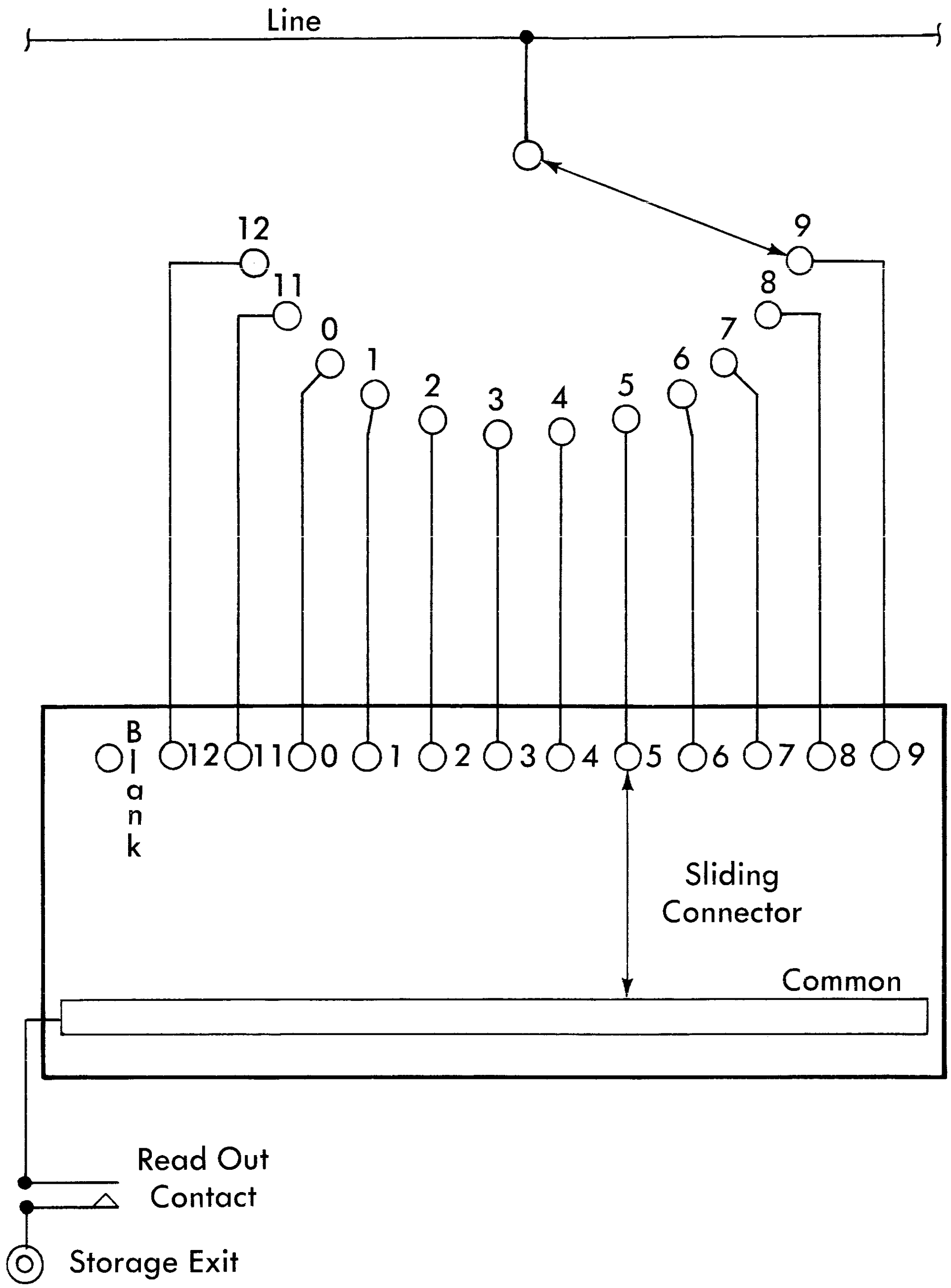


FIGURE 71

no impulse, the sliding connector will move to the blank position.

To read out of this unit the read-out hubs must be impulsed. The impulse corresponding to the digit stored will then be available at the storage-exit hub for that position.

There is also an important difference between the 407 and 602A units where control is concerned. On the 602A type, when you impulsed the read-in or read-out hubs, the unit acted immediately and either read in or out on the same cycle. On the 407, however, this is not true. Figure 72 shows the control panel hubs to control both read-in and read-out. There are several hubs to control each of the four units to read in, and several more to control the read-out. In each case the action is the same, but the difference between them is in the type of impulses they will accept to cause the unit to operate, and the time that the unit will operate.

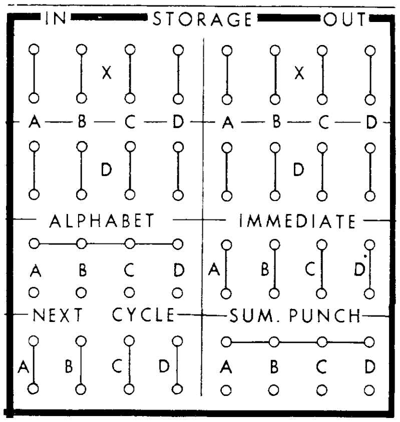


FIGURE 72

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

Now let's look at the read-out hubs. Again we find an X and a D read-out hub and in addition there is an immediate read-out hub. The X will accept only 11- and 12-impulses while the D-hub will accept all digits, 11, 12, and cycle impulses. The read-out action will be exactly the same, regardless of which receives the impulse. The read-out will occur 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 will wait for a card-feed cycle.

There is no next-cycle read-out hub, but if it is desired to read out on a specific cycle, or type of cycle, then a corresponding cycle impulse can be wired to the immediate read-out hub. The unit will begin to read out immediately on the same cycle. This then is exactly the same as the read-out hubs on the 602A.

The hubs selected to control the read-in and read-out will be 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 at the same time information from an X-70 card prints.

The solution for this is shown in Figure 73. 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 it is wired from the first-reading brushes. As the unit will read in on the next card-feed cycle, the card will be passing second reading when the read-in occurs. This is the reason for wiring SECOND READING to the storage-entry hubs. The delay in operation is also the reason why the impulse to read out is wired from first read instead of second read. It should be noted that column 70 did not go through digit selector, because the X-hub will only accept an 11- or 12-impulse.

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 will not be discussed in detail in this book, but in general these hubs would be jack-plugged 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 the storage of alphabetic information. You will recall that earlier it was stated that the 11, 12, and blank positions were provided on this unit to enable it to store alphabetic information. Actually a single position can still only store one digit or zone. We know an alphabetic character code consists of a digit and a zone punch. This requires two positions of storage, one for the digit and one for the zone. To make wiring easier, the alphabet hubs were placed on the machine to automatically separate the digits from the zones.

It does, however, place a new limitation on the storage unit capacity. Instead of 16 positions, the storage unit has only 8 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 8-position alphabetic field is shown in Figure 74. The digit information, 9-1 in this case, from columns 25-32 will be

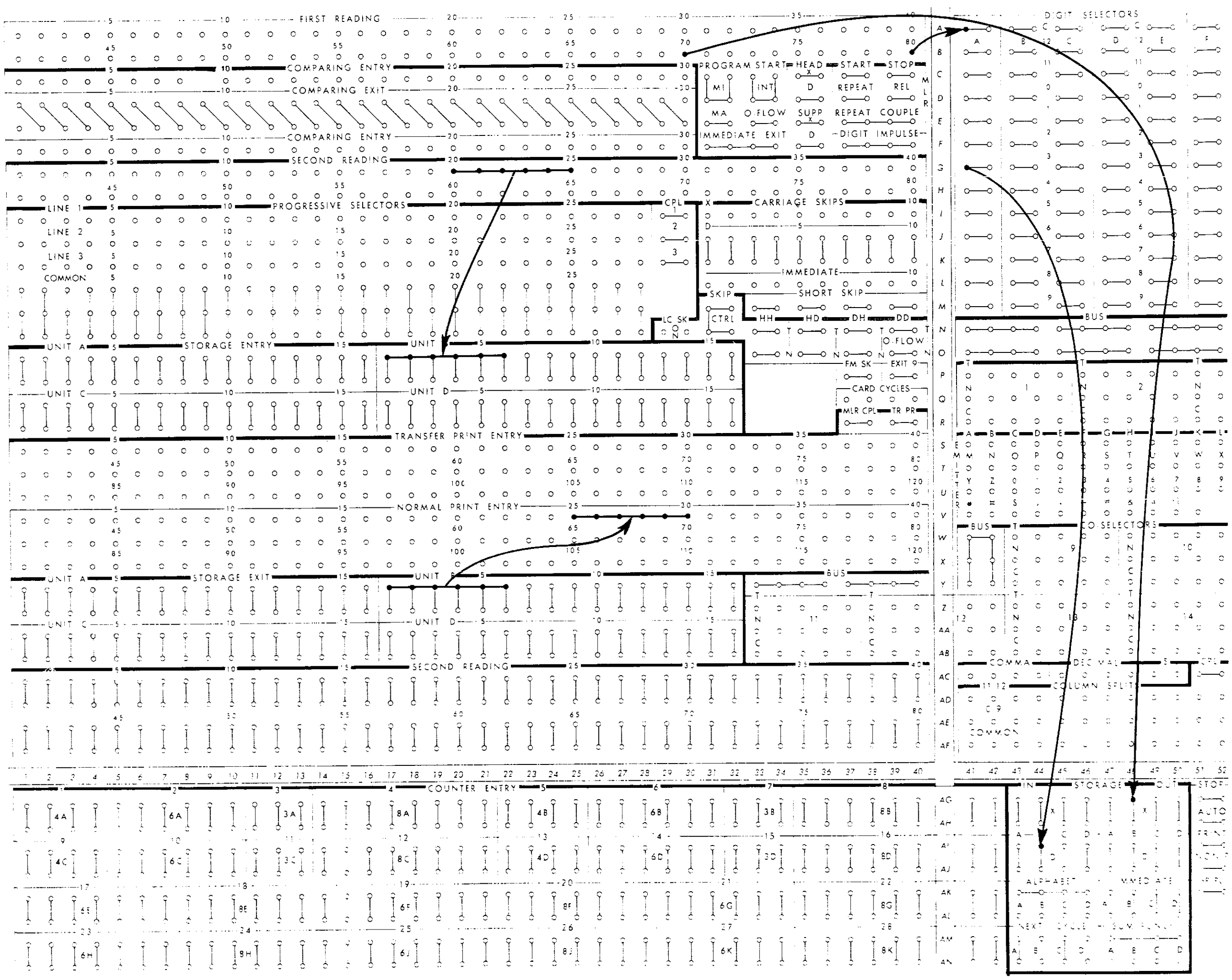


FIGURE 73

stored in positions 1-8 of storage unit B. However, because we have jackplugged the alphabet hubs for storage unit B, the impulses will be 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 . . . 8 and 16, provide an 8-position alphabetic storage unit.

On the read-out, and due to the jackplugged alphabet control, the first and ninth positions are recombined to cause the letter to be printed by print wheel 25. The other positions are also recombined automatically so that it is only necessary to wire from storage exit to print entry. However, when wired for alphabetic operation, it must be remembered that none of the entries or exits from 9 to 16 will be operative.

77 Collator

The *77* is an unusual type of storage unit in that it does not meet all of the requirements of storage. The storage unit on the *77* is actually a combination comparing and storage unit. The comparing principles have already been studied in the section on comparing and will not be covered again in this section.

The storage portion of the unit is the same as the 602A and 407 units as far as read-in and storage are concerned. However, this unit does not read out the information which it stores. It therefore meets only

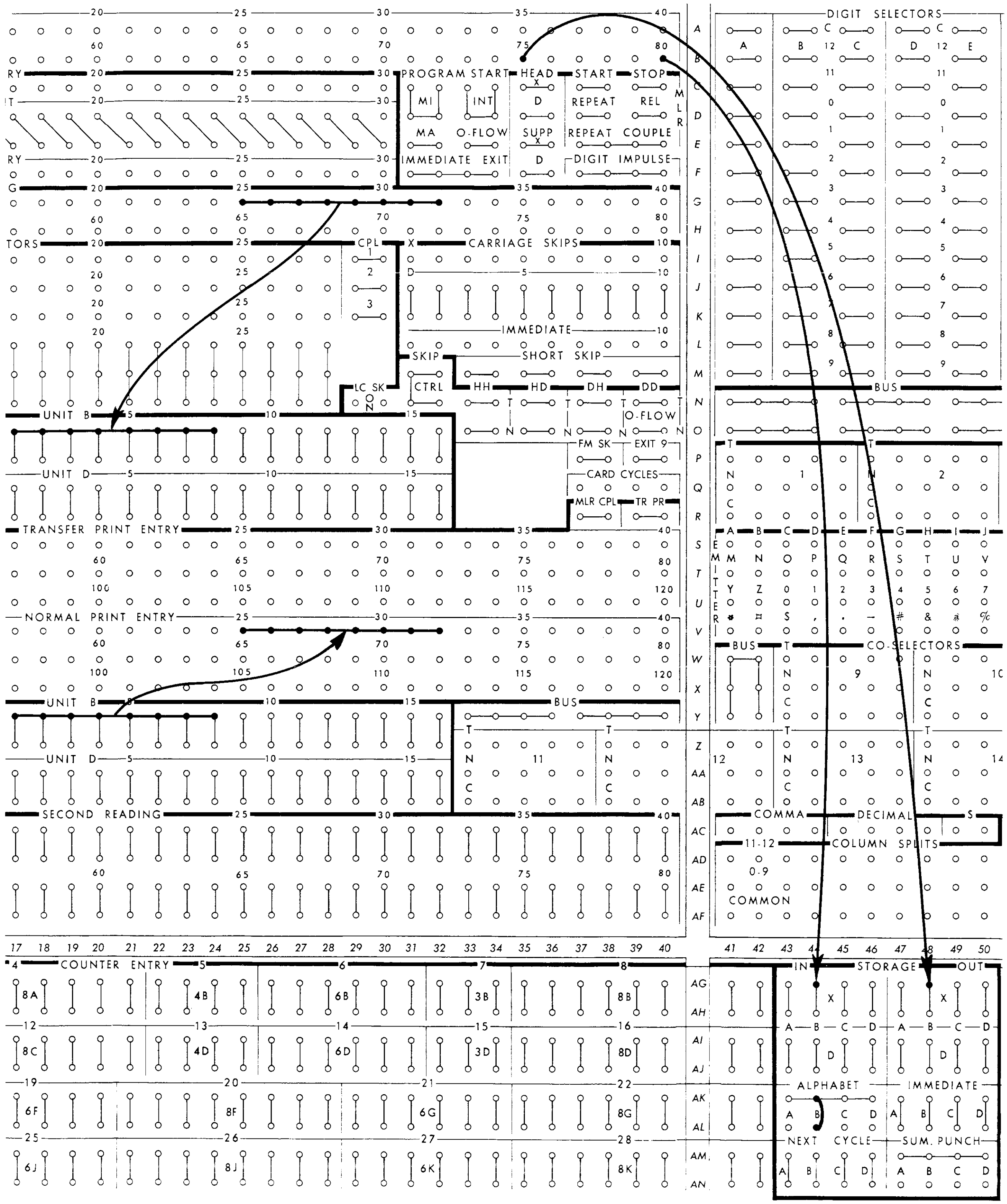

DIGIT SELECTORS
PROGRAM START
HEAD
START
STOP
MI
INT
REPEAT
REL
MA
O-FLOW
SUPP
COUPLE
IMMEDIATE EXIT
DIGIT IMPULSE
CPL
CARRIAGE SKIPS
IMMEDIATE
SKIP
SHORT SKIP
LC SK
CTRL
UNIT B
UNIT D
FM SK
EXIT 9
CARD CYCLES
MLR CPL
TR PR
TRANSFER PRINT ENTRY
NORMAL PRINT ENTRY
BUS
CO-SELECTORS
SECOND READING
COMMA
DECIMAL
COLUMN SPLITS
COMMON
COUNTER ENTRY
STORAGE
IN
OUT
ALPHABET
IMMEDIATE
NEXT CYCLE
SUM. PUNCH

FIGURE 74

two of the three requirements of a storage unit.

The *77* type storage unit has the ability to store only digits, 0-9, as does the 602A type storage unit. As in both types previously described, this unit requires an instruction to read in before the unit becomes operative, but the name of the controlling hub on the control panel is RESTORING MAGNETS.

You are somewhat familiar with this situation as a result of studying comparing. However, let's take a look at the control panel shown in Figure 75. It can be seen that the names of the hubs for the two storage units are different. This is due to the use of this unit as a comparing unit. The restore hubs are the same as read-in hubs, and the sequence and selector entry hubs are the same as storage entry hubs, and there are no storage exit hubs.

Sixteen positions of information may be compared in either the sequence or selector units. This means that each position must have the ability to store the two digits to be compared. As a result each unit has 32 positions of storage, and this is seen on the control panel as 32 entry hubs.

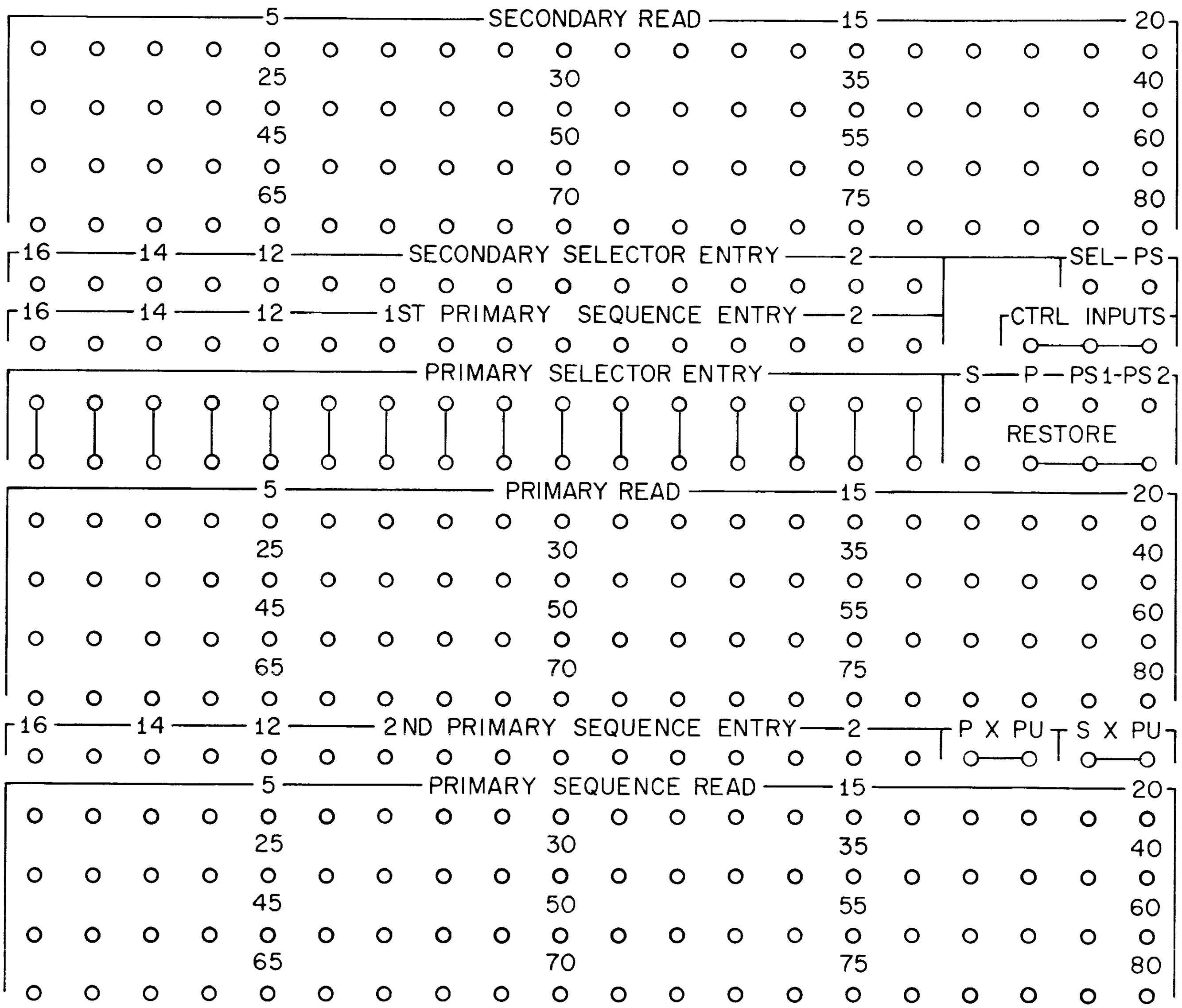


FIGURE 75

As stated in the comparing section, the actual comparison is made mechanically but an electrical test of the unit is wired to give the result of the comparison. This is similar to read-out even though it is not a true read-out of information.

Even though this unit is a storage unit, and is treated as such in this section, the control panel wiring will not be shown here. The control panel wiring along with an explanation was shown in the section on comparing, where it more logically belongs.

REVIEW QUESTIONS

1. What are the three requirements of a storage unit?
2. The 602A type storage unit will accept what type of information?
3. Information in the 602A type storage unit will remain in storage until when?
4. When a 602A type storage unit is instructed to read in, will all positions of the unit accept information?
5. Do all positions of the 602A storage unit necessarily operate as a result of an instruction to read out?
6. What is the basic difference between the 602A and 407 types of storage?
7. In the 407 type storage unit what kind of impulses will the X and D read-in and read-out hubs accept, and when will the unit be operative?
8. Can a digit and a zone for an alphabetic character be stored in a single position of the 407 type storage?
9. The 77 type storage unit serves what other function besides storing?
10. What on the 77 control panel corresponds to the read-in hubs on the 407 and 602A types?
11. What type of information can the 77 type 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?

COLUMN SPLITS

In the report in Figure 62 we compared on sales clerk number in order 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 necessary to tell the machine that a different type of card is passing the brushes, and an X-punch is the 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 the X is not in all cards. How can we eliminate these occasional X-punches from a field on which we wish to compare (Figure 76)? By the use of a column split.

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 wanted 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. How can we prevent the X from being reproduced when we reproduce the digit in column 80 (Figure 77)? By the use of a column split.

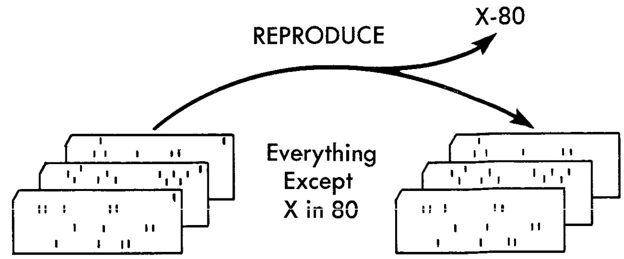


Figure 77

If we were to interpret a deck of IBM cards which happened to have an X punched over one of the amount fields we wished to print, we would have printed alphabetic information instead of the desired numerical information. This would happen because an X and a digit form a letter. How can we prevent the X-punch from reaching the typebars, and print just the digit (Figure 78)? By the use of a column split.

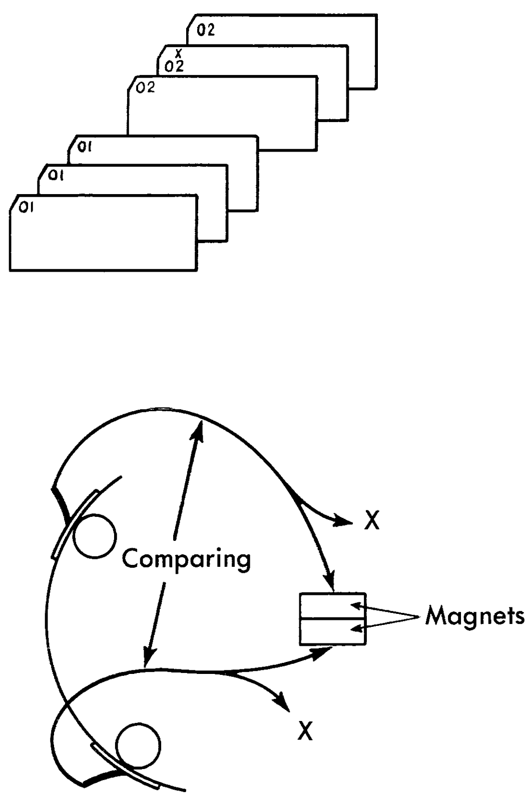


Figure 76

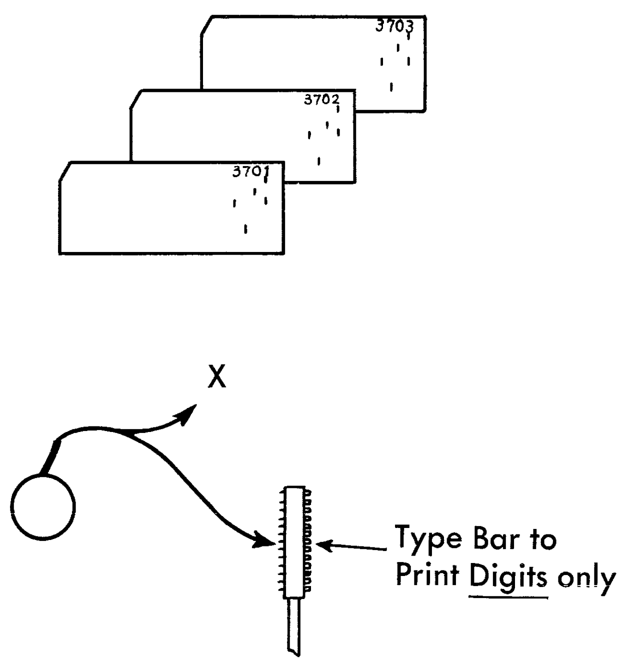
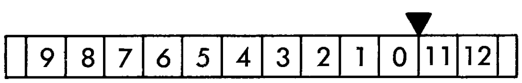


Figure 78

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

Now that we have shown a need for column splits, let's find out what they really are.

Splitting a column, to us, 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 were punched with the 12 through 9 punches, all twelve punches would be available out of the reading-brush exit hub. We already know that often it is necessary to divide the punches of a column into two separate groups, 0-9 and 11 and 12.



Let's see what a column split looks like, and how it operates.

The column split is nothing more than your old friend the magnet.

The magnet shown is like the comparing magnet we've already discussed.

There is a magnet, an armature, and control panel hubs (Figure 79). You will notice that the hub leading to the armature is shown between the 0-9 and 11-12 hubs, and labelled COMMON because it is at all times in contact with either the 0-9 or the 11 and 12 hub.

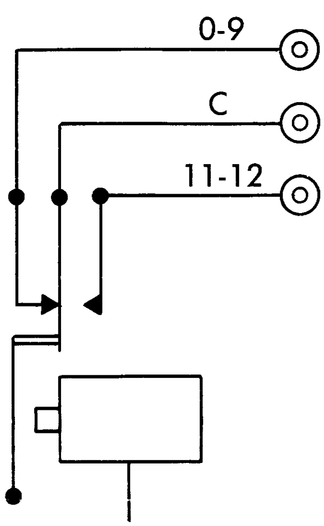


FIGURE 79

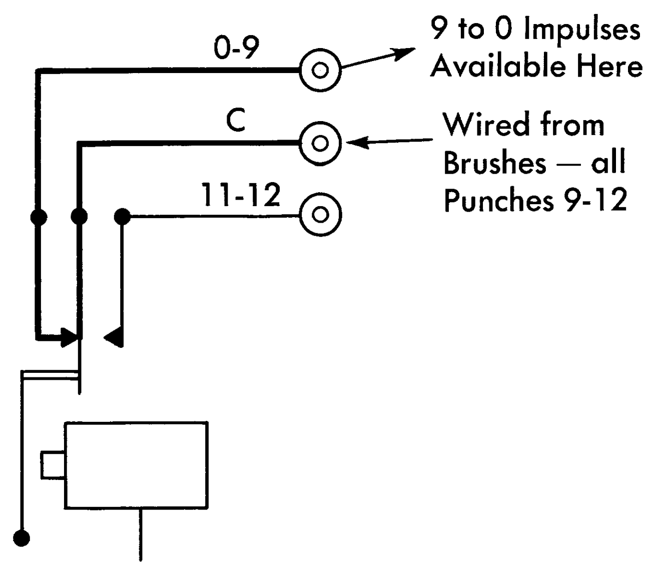


FIGURE 80

If you will remember, the comparing magnet was 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 the common hub 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 the common hub will be available out of the 0-9 hub (Figure 80).

When the magnet *is* impulsed (during 11-12 time) the armature is transferred; that is, is attracted to the magnet, and makes contact with the path leading to the 11-12 hub. An 11 or 12 impulse put into the common hub will be available out of the 11-12 hub (Figure 81).

After the 11 and 12 positions of the card pass the reading brushes, the impulse to the magnet is stopped, and the armature is "dropped out." The armature returns to its normal position.

Look at Figure 82 and you will see that the card, which has been fed into the machine 9-edge first, has

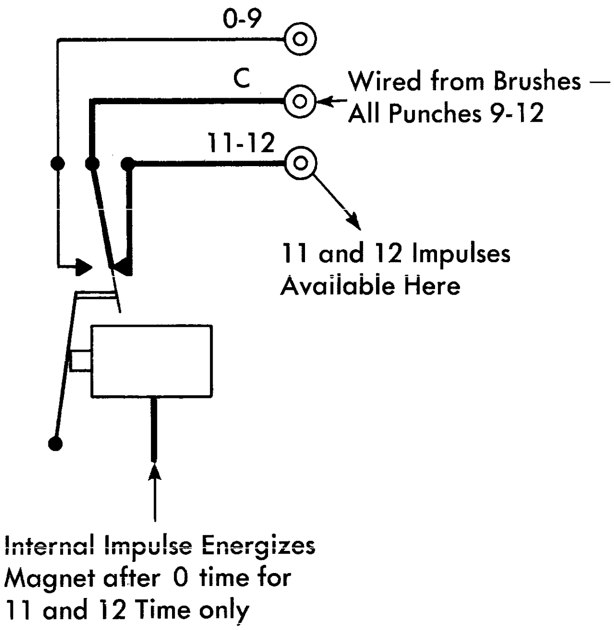


FIGURE 81

the 4-position under the reading brush. At this time the armature is still in its normal position, and the connection is between the common and the 0-9 hub.

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

If you look at Figure 83, you will see that the 11-position of the card is now under the reading brush. As the armature transferred automatically between 0- and 11-time, the connection is now between the common hub and the 11-and-12 hub.

If a card column were wired to the common hub, any 11- or 12-punch would be available out of the 11-and-12 hub.

We have shown the impulse coming from a reading brush to the common hub of a relay, and out of either the 0-9 (normal) hub, or out of the 11-12 (Transferred) hub.

Actually, we could have wired a card column at the 0-9 hub, and have had an impulse come out of the

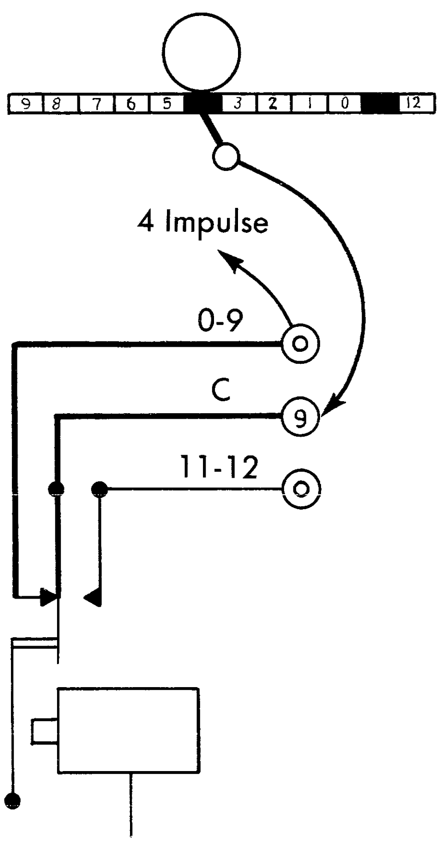


FIGURE 82

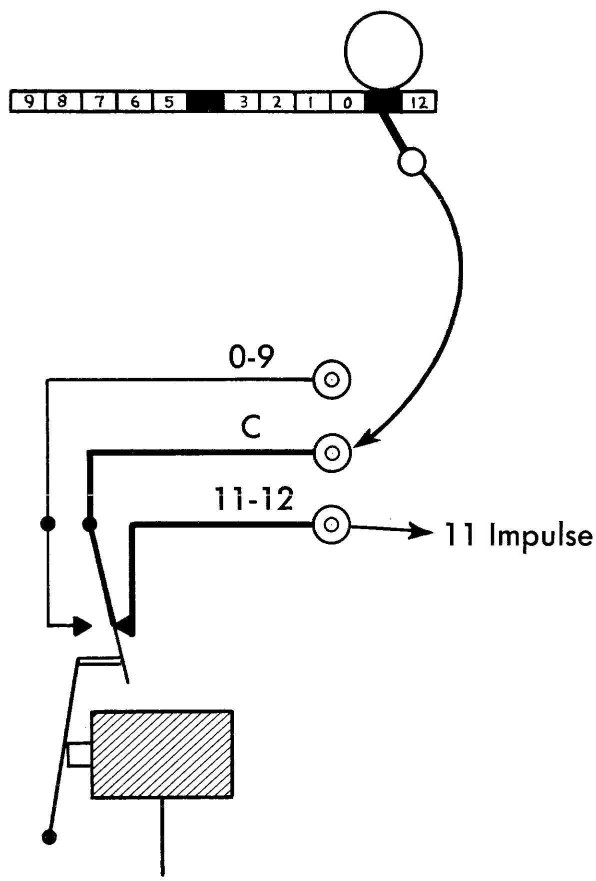


FIGURE 83

common hub. In other words, the common hub can be either an EXIT or an ENTRY hub. Also, the 0-9 hub and the 11-12 hub can be either EXIT or ENTRY hubs.

The path we have set up for impulses to travel can be considered a two-way street.

In the examples previously shown we wired the card column to the common side of the relay, and 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 84). Assume that the card column had been completely punched. What would have been available out of the common hub?

Only the 0-9 impulses would be available out of the common hub.

What happened to the 11- and 12-punches? At 11- and 12-time the armature would have been connected to the 11-12 hub. Any impulses wired to the 0-9 hub

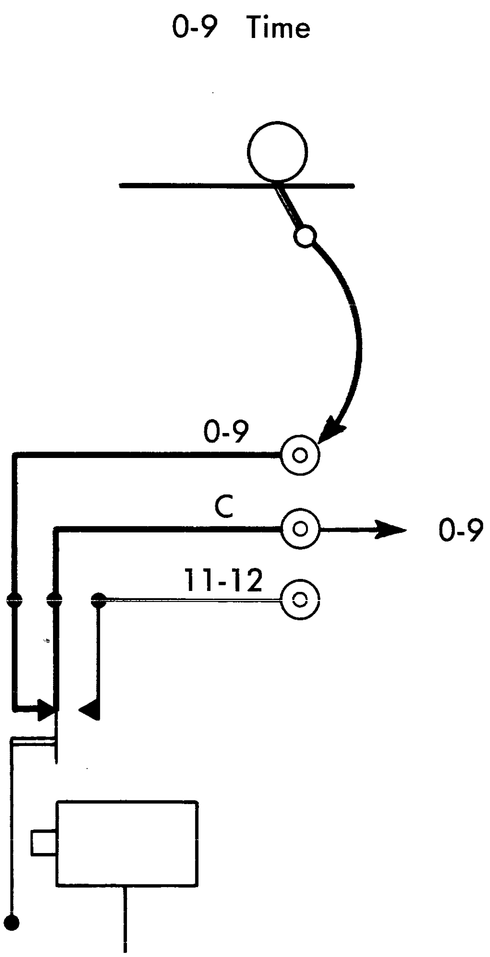


FIGURE 84

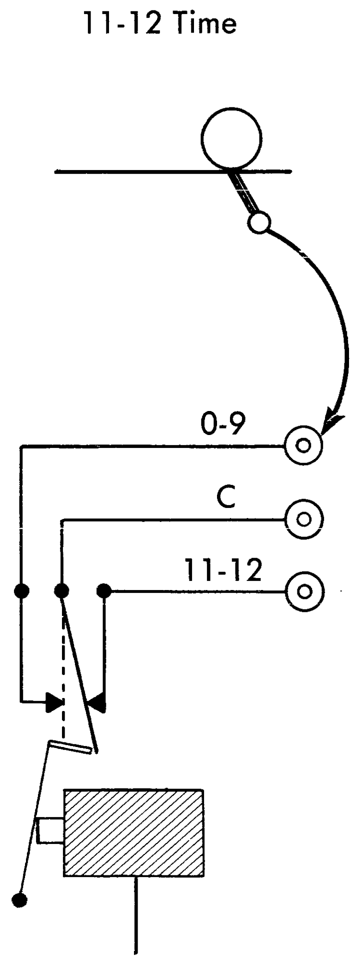


FIGURE 85

would have had no place to go (Figure 85).

In Figure 86 we have wired a fully punched card column to the 11-12 hub of the column split relay. What would be available out of the common hub?

Only the 11- and 12-impulses. You can see that during 11- and 12-time of the card-feed cycle the 11-12 hub and the common hub are connected to each other (Figure 87). At no other time during the card cycle are they connected.

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

When we wired the card column to the common hub, we divided the card column in two. The 0-9 impulses were available out of one hub on the control panel, and the 11-12 impulses were available out of another hub on the control panel.

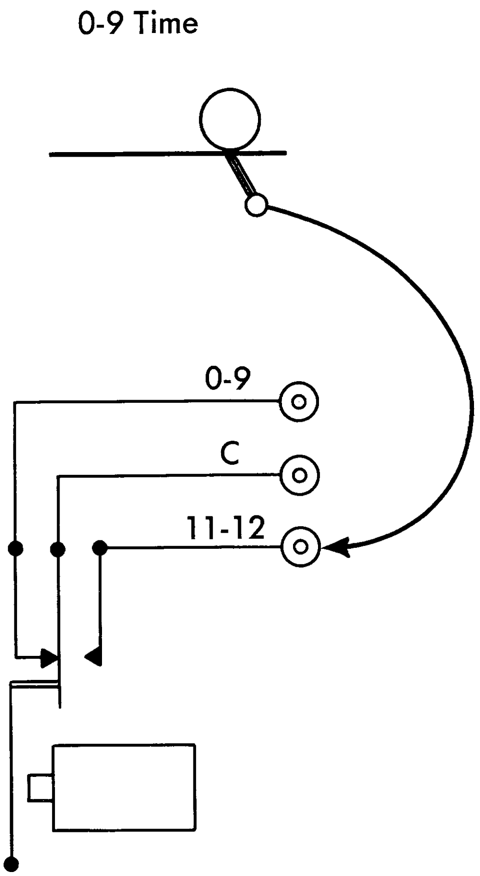


FIGURE 86

When we wired the card column to the 11-12 hub we were eliminating any 0-9 punches from our common hub.

When we wired the card column to the 0-9 hub, we were eliminating any 11-12 punches from the common hub.

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 88.

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 will vary 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 will find that there is 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 one column split position. The three hubs go together to make a vertical column split unit. Make sure that if you use the extreme left-hand common hub, that you also use the 0-9 or 11-12 hubs directly above or below the common hub used.

Now, let's go back and see how we can use what we've learned about column splits.

Early in the chapter we stated that we needed a column split when we wished to interpret an amount field which happened to be over-punched with an X (11). Normally, the combination of an X, which is a zone punch, with a digit will give us an alphabetic character. We wish the number, not the letter, to print, and we must eliminate the X-punch.

In the example shown (Figure 89) 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.

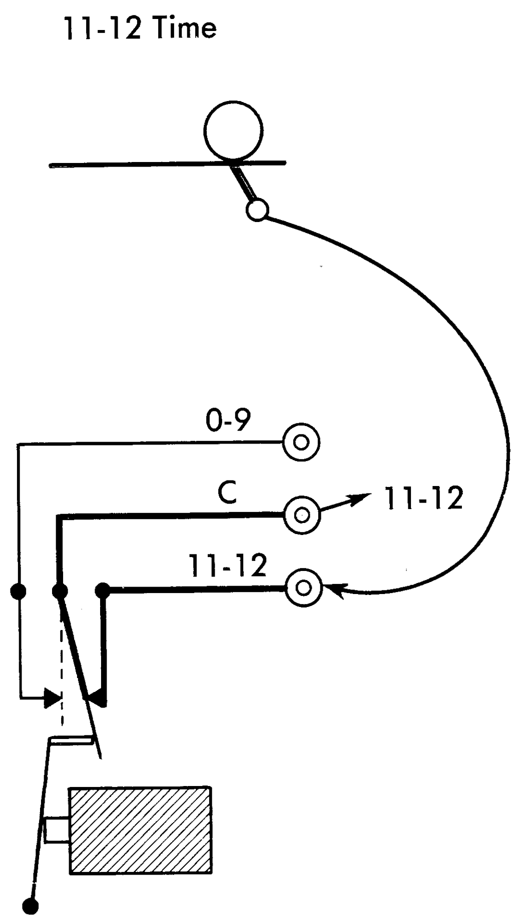


FIGURE 87

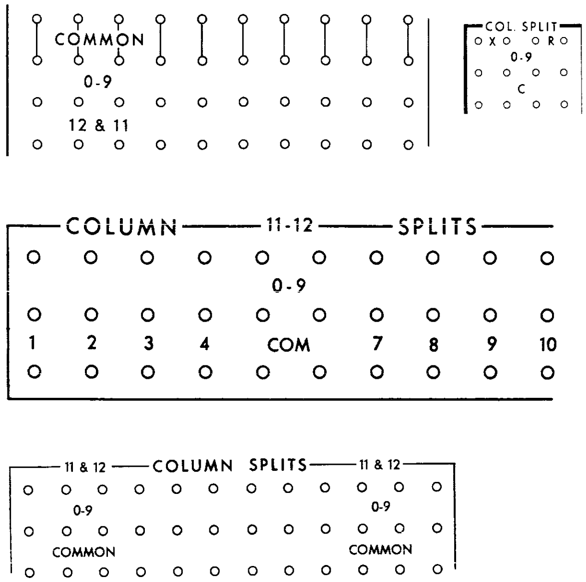


FIGURE 88

You will see that 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 the common hub of the X-eliminator (another name for a column split). We then wired from the 0-9 hub to the typebar. How does this wiring keep 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 the common and the 11-12 hub. As we have not wired from the 11-12 hub to the typebar, the impulses which would be available are not used. At 0-9 time the common hub and the 0-9 hub are connected. The digits in the amount field can get to the typebar.

Would we have had a different result if we had wired the card column to the 0-9 hub, and then come

ALPHABETIC INTERPRETER, TYPE 552, CONTROL PANEL

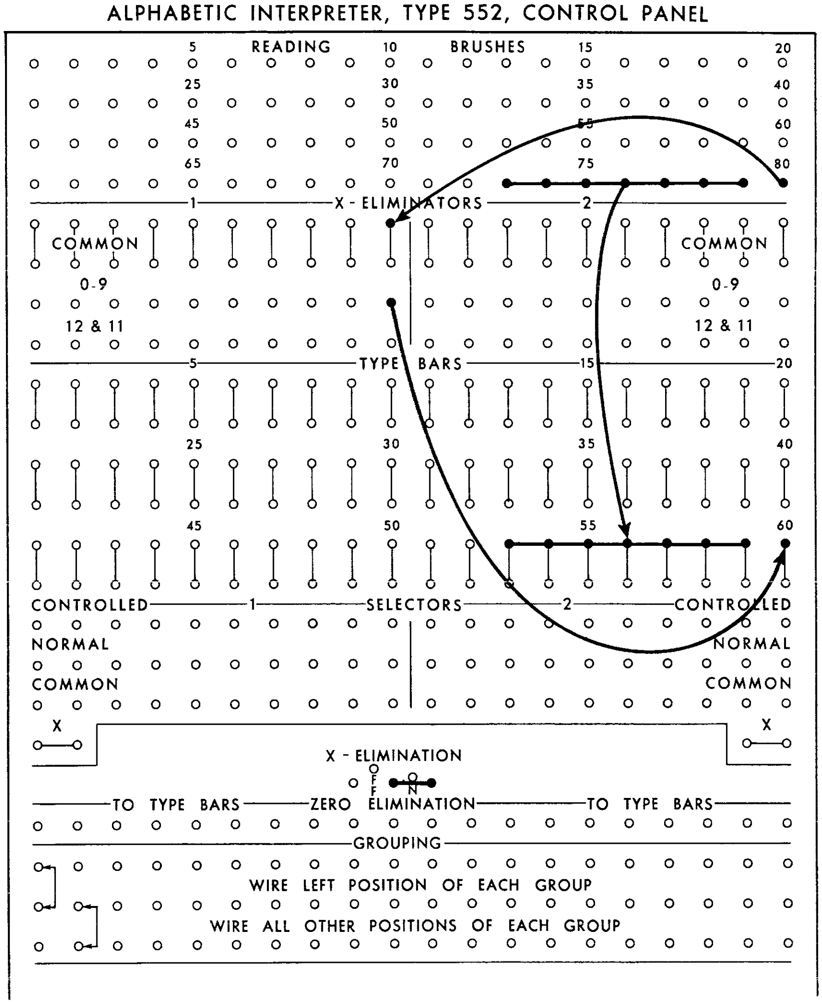


FIGURE 89

out of the common hub to print?

No. We would still have printed the numbers and eliminated the X-punches.

There is one other difference in the Interpreter column split which must be mentioned.

In the interpreter, the column split is operative only if the hubs labelled X-ELIMINATOR ON are wired as shown in the diagram.

The magnet will not be impulsed for each card-feed cycle unless this connection is made. When the connection is made on the control panel, the armature will transfer between 0- and 11-time of each card-feed cycle.

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

The schematic diagram of the operation is shown in Figure 90. We wish to punch the digits, but must eliminate the X-punches. We wish to compare the digits punched, but again must eliminate the X-punches or we would have unwanted unequal conditions in the comparing magnets.

The control panel wiring labelled "1" (Figure 91) is for the elimination of the X from card column 80. The new card will be punched with the digit *only* in column 80.

The wiring labelled "2" is for the elimination of the X from the original card as it passes under the comparing brushes. If the column split were not used for comparing, each card would cause an error light because the original card still had the X-punch, while

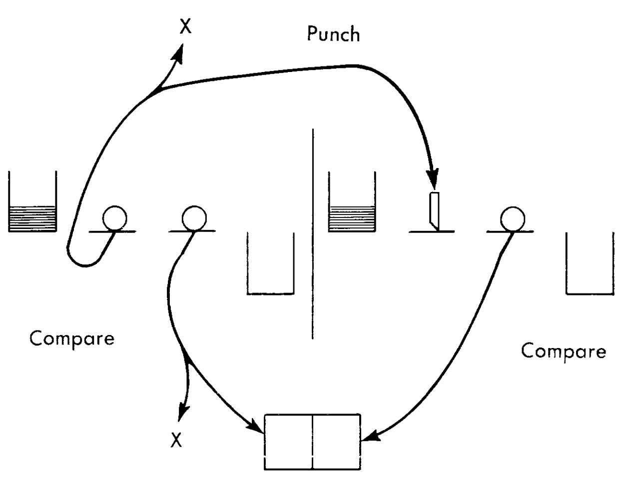


FIGURE 90

the new card does not have an X-punch. This would cause an unequal condition in the comparing magnets.

Now, let's go back and pick up the situation where we had an occasional X-punch over a field on which we wished to compare (Figure 92).

It is obvious that we must arrange to eliminate the X-punches from both the second and third reading-brush exit impulses.

Figure 93 shows how the column split on an accounting machine would be used to prevent the possibility of unwanted unequal impulses while comparing on card columns 32-33.

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 94). 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 to the 4-emitter hub and punch magnet 47 wired to the 1-emitter hub. This wiring should enable us to punch a D in column 46 (12-4) and an A in column 47 (12-1). However, we have a back circuit which will punch a 12-1-4 in columns 46 and 47. Let's trace this back circuit. The 12-impulse will be the first to be emitted which will punch a 12 in columns 46 and 47.

The next impulse that we are using is a 1-impulse which is wired to column 47, punching a 1 in column 47. Now this 1-impulse can also flow from punch magnet hub 47 up through the split wire to the 12-emitter hub, back down through another split plugwire to punch-magnet hub 46, punching a 1 in column 46 which we don't want. The same back circuit exists at 4-time. The impulse will be emitted from the 4-emitter hub down to punch-magnet hub 46 back up to the 12-emitter hub and then down again to punch-magnet hub 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 95). At 1-time the impulse will reach punch-magnet hub 47 punching a 1 in that column, but when it goes up through the split plugwire to the *common* hub of column split 1, it is lost and cannot get through to punch-magnet hub 46,

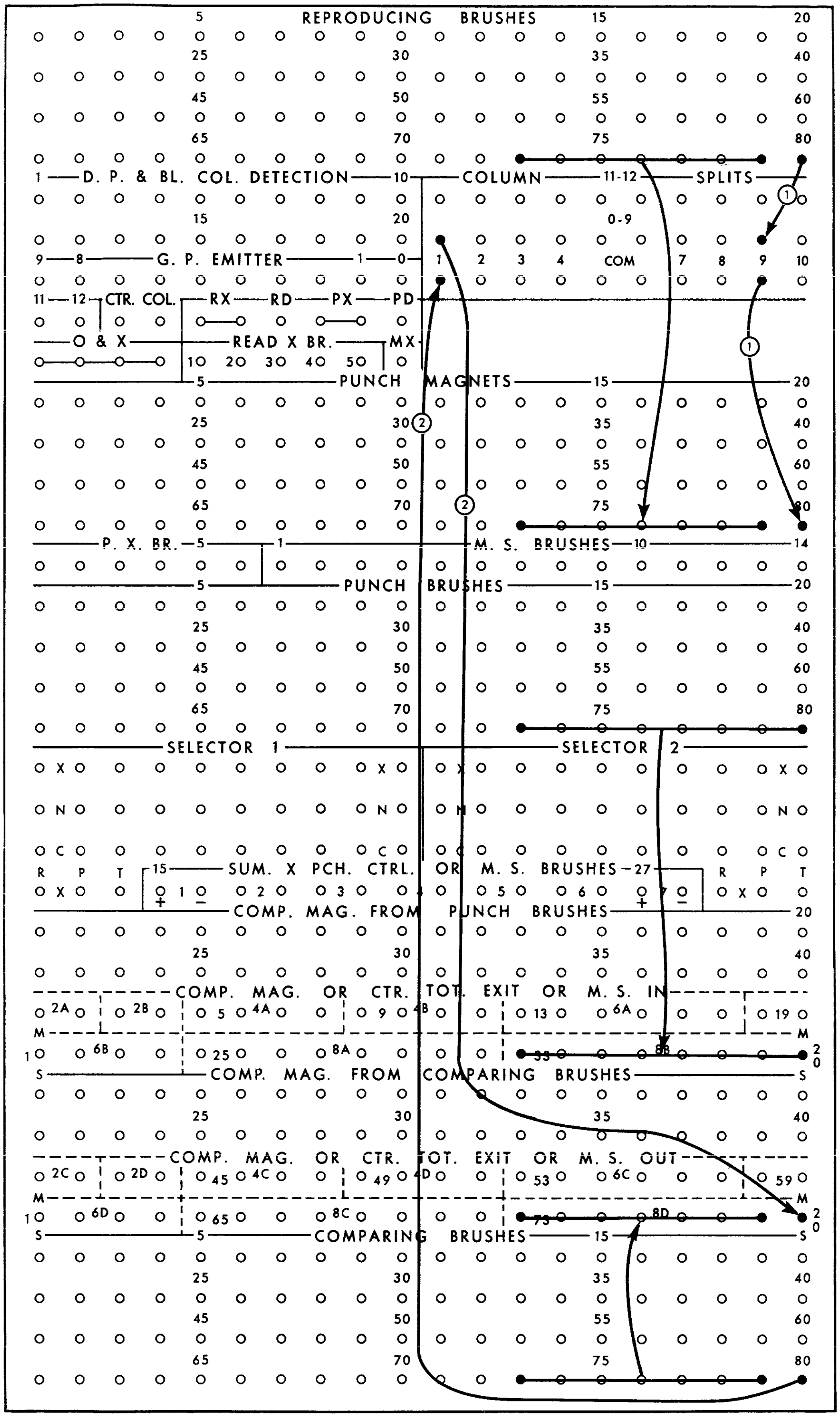

REPRODUCING BRUSHES
D. P. & BL. COL. DETECTION
COLUMN
SPLITS
11-12
0-9
G. P. EMITTER
COM
CTR. COL.
RX
RD
PX
PD
O & X
READ X BR.
MX
PUNCH MAGNETS
P. X. BR.
M. S. BRUSHES
PUNCH BRUSHES
SELECTOR 1
SELECTOR 2
SUM. X PCH. CTRL. OR M. S. BRUSHES
COMP. MAG. FROM PUNCH BRUSHES
COMP. MAG. OR CTR. TOT. EXIT OR M. S. IN
COMP. MAG. FROM COMPARING BRUSHES
COMP. MAG. OR CTR. TOT. EXIT OR M. S. OUT
COMPARING BRUSHES

Figure 91

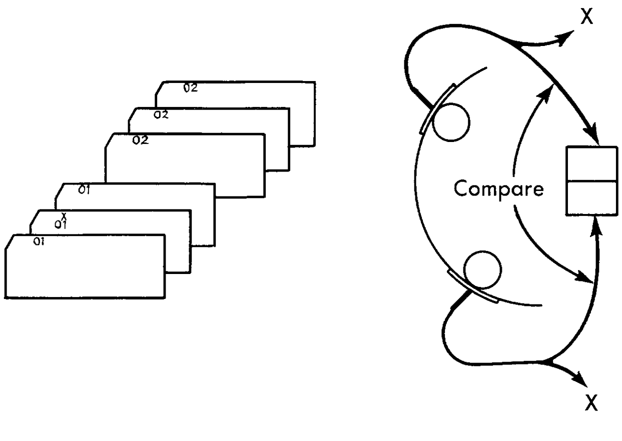


Figure 92

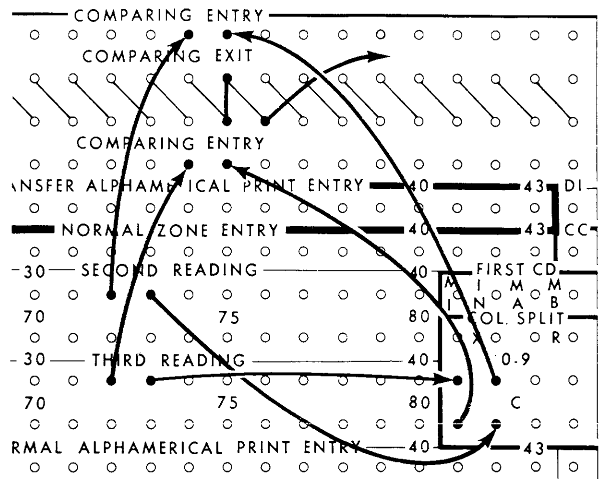


Figure 93

because at 1-time the common and 11-12 hubs of the column split are not connected. The same holds true at 4-time. The 4-impulse will reach punch-magnet hub 46 but cannot get through the column split and back to punch-magnet hub 47. At 12-time, however, the common and 11-12 hubs of the column split are connected and the 12-impulse will reach punch magnet 47, which is what we want. Once again a column split proves to be a valuable device for eliminating unwanted information.

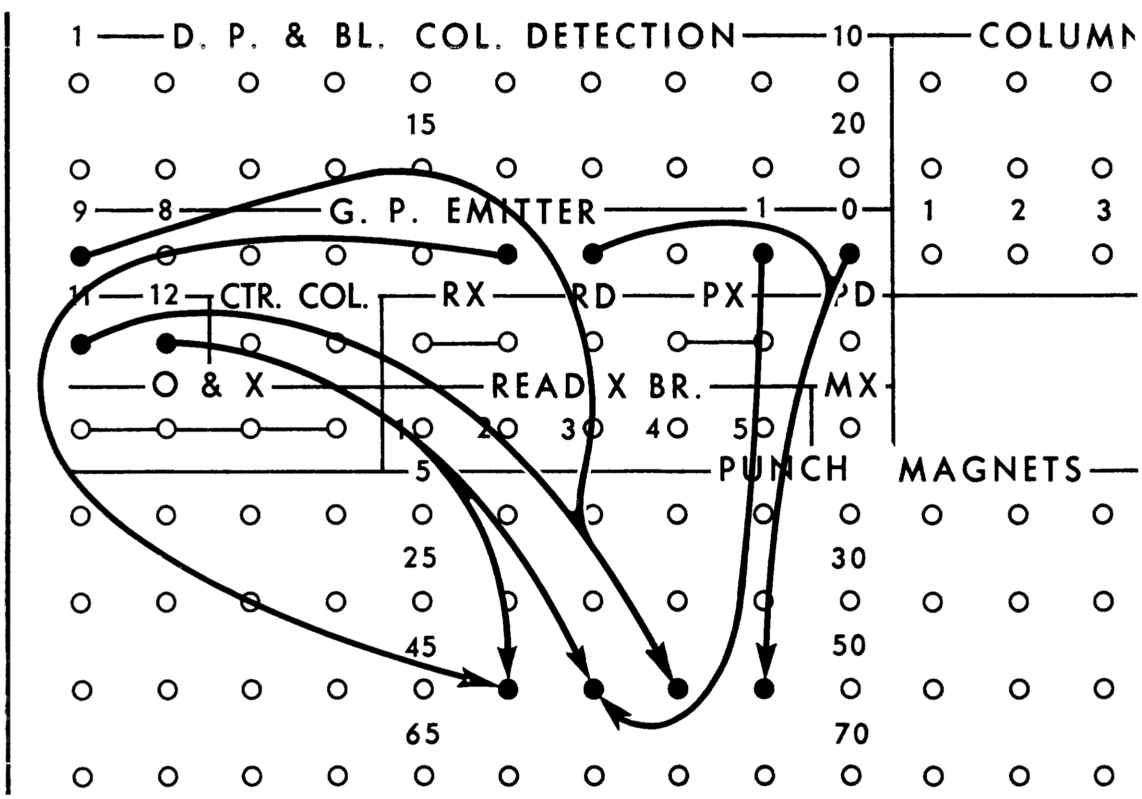


Figure 94

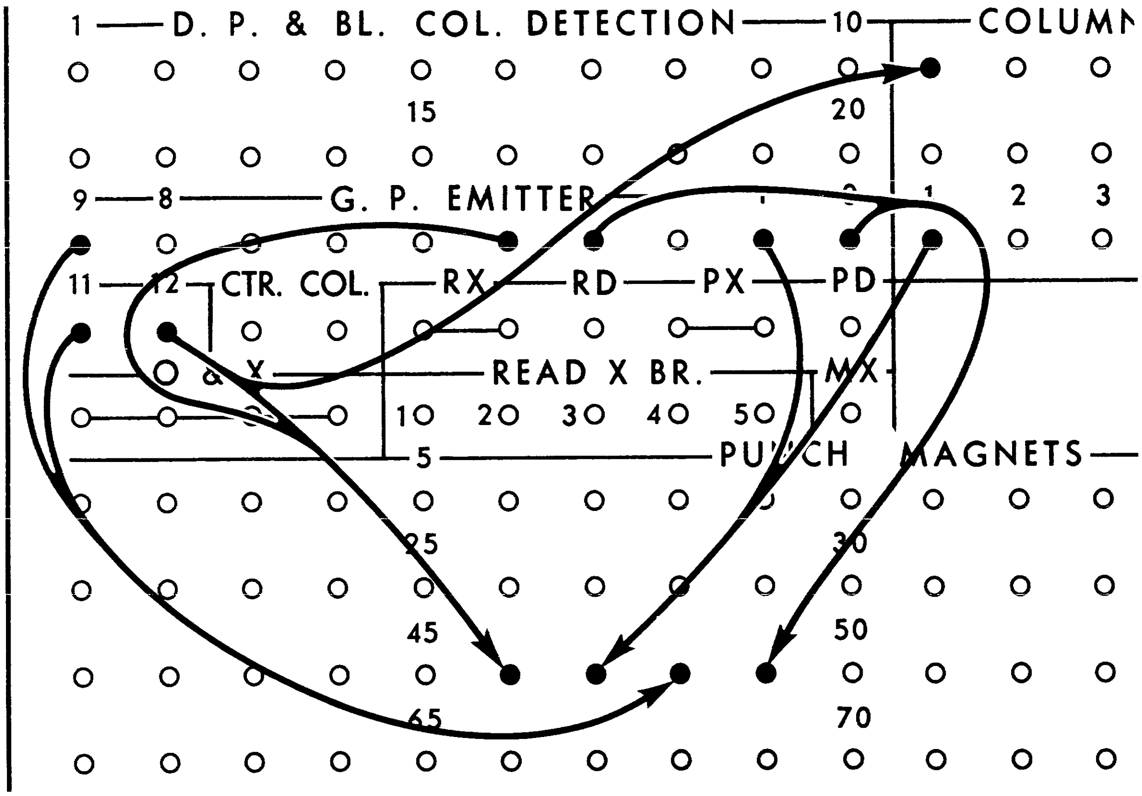


FIGURE 95

REVIEW QUESTIONS

1. What does a column split do? Why would you want to 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 would be used to eliminate an X-punch and retain the digit punches?

SELECTION

What do we mean by the word *selection?* 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*.

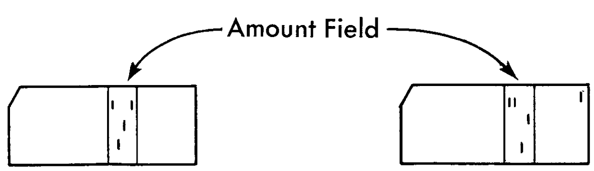
The use of selection is basic in most IBM machines. While the operation of the selectors may be slightly different on different machines, their basic operations are the same.

The understanding of this principle of selection and its uses are fundamental to the full understanding of the operation of IBM machines.

A few examples may help you see when a selector must be used.

1. Let's assume that you are employed by the IBM department of the local gas and electric company. Each month you must send your customers a bill. In order to prepare such a bill, you will have punched one or more IBM cards for each customer — one card showing the amount owed for gas used during the month, and another IBM card showing the amount owed 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 card.



GAS CARD ELECTRIC CARD

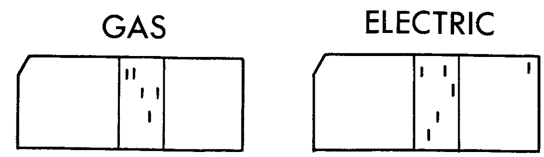
How can IBM machines tell the difference between these two cards?

Corner cuts or colored stripes across the face of the card would tell you the difference, but machines cannot tell the difference with this type of identification.

The eyes of IBM machines are their brushes, and they can read punched holes only. Therefore, each different type of card must have a distinguishing punch, or lack a distinguishing punch.

These distinguishing punches are sometimes any of the digits 0-9, or they can be a 12-punch. Most often, however, they are X-, or 11-punches.

In order to have the IBM machines recognize the difference between a gas and an electric card, we punched an X in card column 80 of each electric card. The gas cards do not have an X in card column 80.

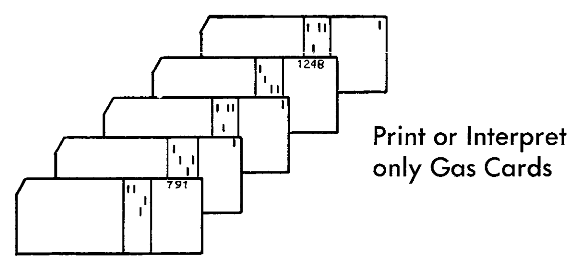


The cards for all customers were sorted together on customer number. Without disturbing the sequence of the card file, you must prepare a report on the IBM Accounting Machine showing the value of the gas sold and the value of the electricity sold.

How can you tell an IBM machine to add the gas amount in one counter and the electricity amount in another counter?

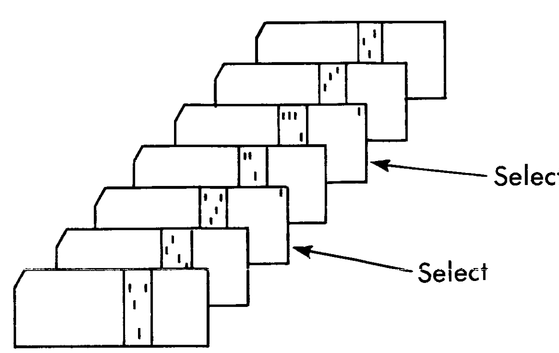
By the use of a selector, for a choice or a decision must be made.

2. What would you need if you were required to run the entire file of gas and electric cards through an IBM Interpreter and were asked to print the gas amounts only?



A selector, because again a choice or decision must be made.

3. What would be needed if you decided to use the IBM Collator to separate the gas and electric cards into two files?

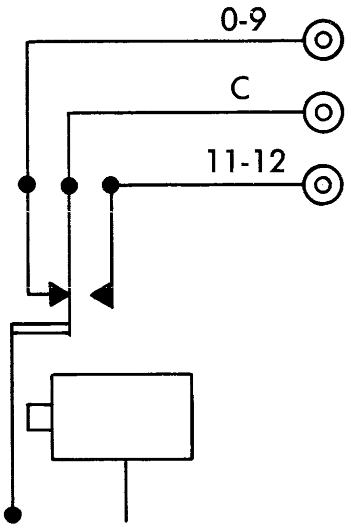


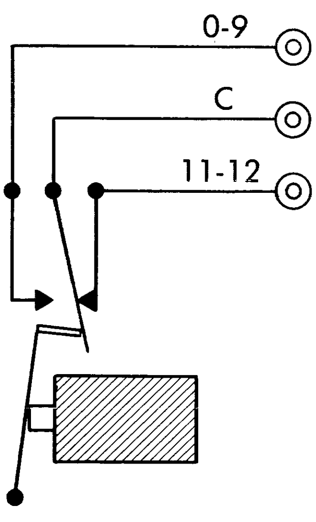
A selector, because again a choice or decision must be made.

How does a selector work and what is it?

Remember the column split. Fundamentally, it is a selector.

The column split consists of the C or common hub, 0-9, and 11-12 hub, an armature, and a magnet which was energized at between 0- and 11-time automatically.



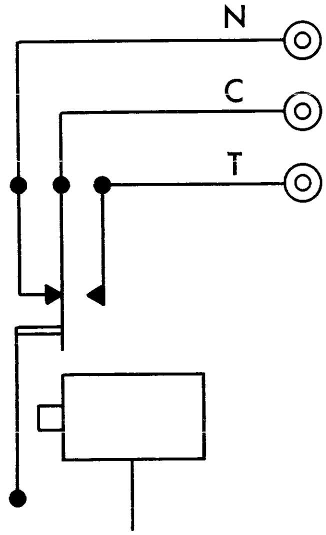


A selector consists of the same parts: a magnet, an armature, and three control panel hubs.

How does a selector differ from a column split?

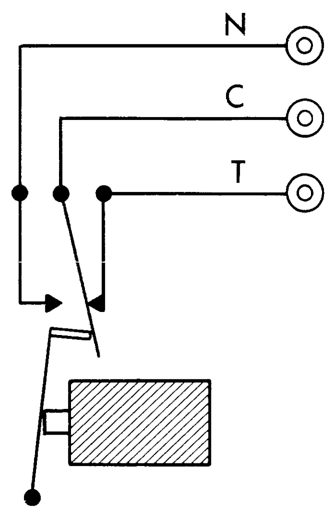
1. The labelling on the control panel is different. Both the selector and the column split have a C or common hub. The function of these hubs is the same in both cases, for the C hub is internally connected by means of the armature to either one of the other hubs at any one time.

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



The normal hub gets its name from the fact that when the magnet is *not* energized, the armature is in its usual (or normal) position, and the internal connection is between the C 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 C and the transferred hub.



2. The transfer of the armature is *not* automatic. If you recall the column split you will remember that the armature transferred from the 0-9 to the 11-12 connection each card-feed cycle, and that this trans-

fer was automatic. No special control panel wiring was required to energize the magnet and cause the transfer of the armature.

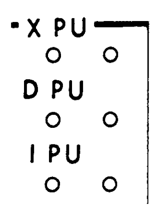
The selector differs in that the armature will *never* transfer without special external control panel wiring.

Each selector has one or more PICKUP hubs which are direct entries to the magnet. The magnet will not be energized, and the armature will 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 the impulsing of the magnet caused the armature to transfer.

Selector Pickup Hubs

Selectors may be picked up in a variety of ways. Accordingly, the selector pickup hubs vary as to the type of impulses they accept to cause the transfer of the selector. Illustrations of different types of hubs are shown. Although their labelling may differ, their basic function is the same, for in each case they are the entry hub to the selector magnet. When they are impulsed, and they accept the impulse given them, the magnet will be energized and the selector will transfer.



X-Pickup

The X-pickup hubs are so labelled 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.

D-Pickup

The D-pickup hubs are designed so that they will accept all the digits 0-9, and the 11 and 12 impulses. Any card impulse-wired to the D-pickup will reach the magnet and transfer the selector. Frequently the selector is designed so that any machine impulse may be wired to the D-pickup to cause the selector to transfer.

I-Pickup

When you want a selector to transfer *immediately,* the I-pickup is impulsed. This hub will accept any impulse, just as the D-pickup hubs did.

Examples of Selectors

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

Let us look at some examples of actual selectors and see how they differ in appearance (Figure 96).

You will 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, 5, or 10 may work together from the same pickup hub.

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

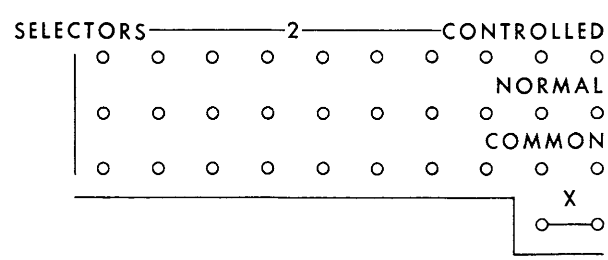
In each case they are identical in purpose.

The C is the common hub. The NX or N hub is the normal hub. The X, T, or CONTROLLED is the transferred hub.

Use of a Selector in an Interpreter

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

A selector must be used, and interpreters can be equipped with selectors. You will notice, however, that the interpreter selector has only one pickup hub. This is the X-pickup hub in the lower right-hand corner of the selector.



The X-pickup hub will accept either 11- or 12-punches. Any impulse may be read by the brushes and wired to the X-pickup hub, but only the 11- and 12-impulses will get through to the magnet.

This elimination of the 0-9 punches happens in the interpreter between the pickup hub and the magnet

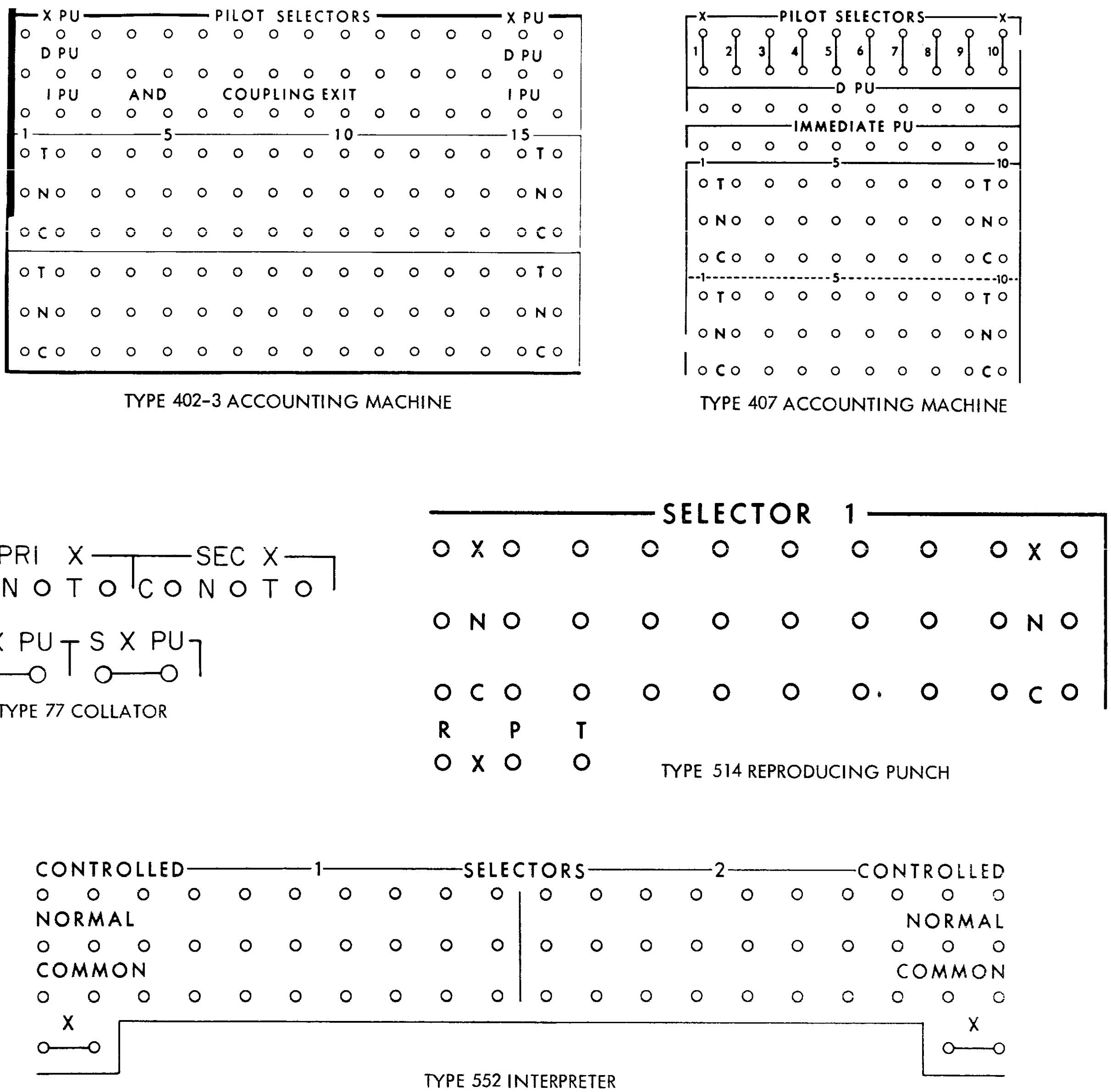


FIGURE 96. SELECTOR CONTROL PANEL HUB ARRANGEMENTS FOR SELECTORS

itself because there is a special contact called an 11-12 contact (Figure 97). This contact is open (or breaks the circuit) at all times except during 11- and 12-time. As electric current can flow only when a circuit is completed, the 0-9 impulses cannot get through to the magnet. The relay closes automatically during 11- and 12-time, and allows the 11- and 12-impulses to get to the magnet.

When an 11- or 12-impulse reaches the magnet, the selector transfers, and it remains transferred for the rest of that same card cycle and for printing time (Figure 98).

You should have noticed that the interpreter selector has ten sets of vertical hubs. When the selector transfers, all ten common hubs 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 interpreter diagram illustrated we show the wiring necessary to print the gas amount on the gas cards and ignore the electric amount punched in the electric cards.

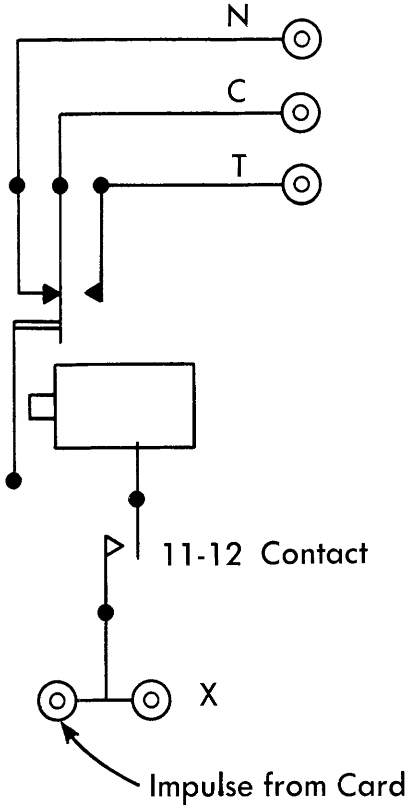


FIGURE 97

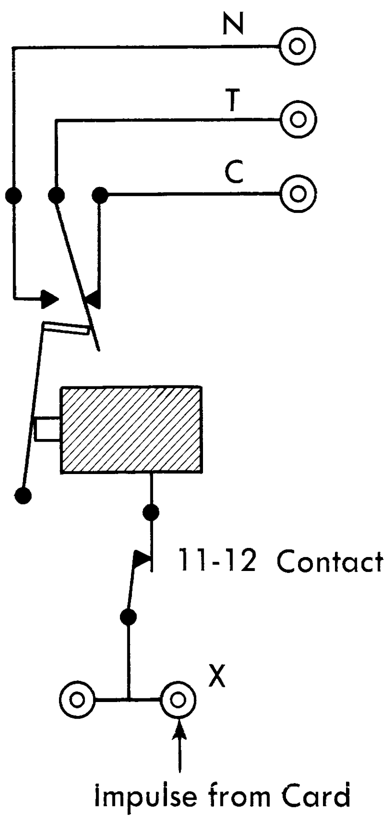


FIGURE 98

As you will remember, the gas and the electric amounts are punched in the same card columns, let's say columns 51-55. The two types of cards are sorted together on customer number, and can be told apart because of the presence of an X-punch in card column 80 of each electric card.

The amount field, 51-55, is wired to the common side 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.

The X-punch is in the electric cards. Therefore the sensing of an X in card column 80, will cause the transfer of the selector. We know, then, that out of the controlled side of the selector we can get the punching in card columns 51-55, of the X, or electric cards. Out of the normal side of the selector we can get the punching in columns 51-55 of the no-X, or gas cards.

We said we wanted to print the gas cards only. Therefore, we must wire the normal side of the selector to the typebars (Figure 99).

If we had wired the controlled side of the selector to the typebars we would have printed the amounts for the electric cards.

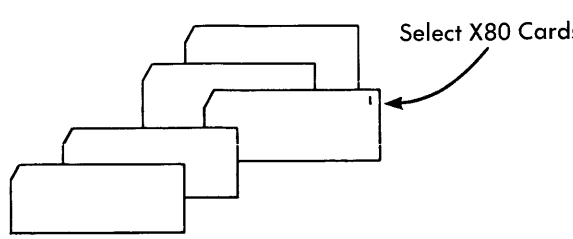
Figure 100 shows the position of the interpreter selector when a no-X, or gas card, is being read by the brushes.

Figure 101 shows the position of the interpreter selector when an X, or electric card, is being read by the brushes.

Use of a Selector in a Collator

In order 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, we must use a selector.

If you refer to the problem illustrated, you will see that we are planning to pull the electric cards from the file, and leave the no-X, or gas cards, in the file.



ALPHABETIC INTERPRETER, TYPE 552, CONTROL PANEL

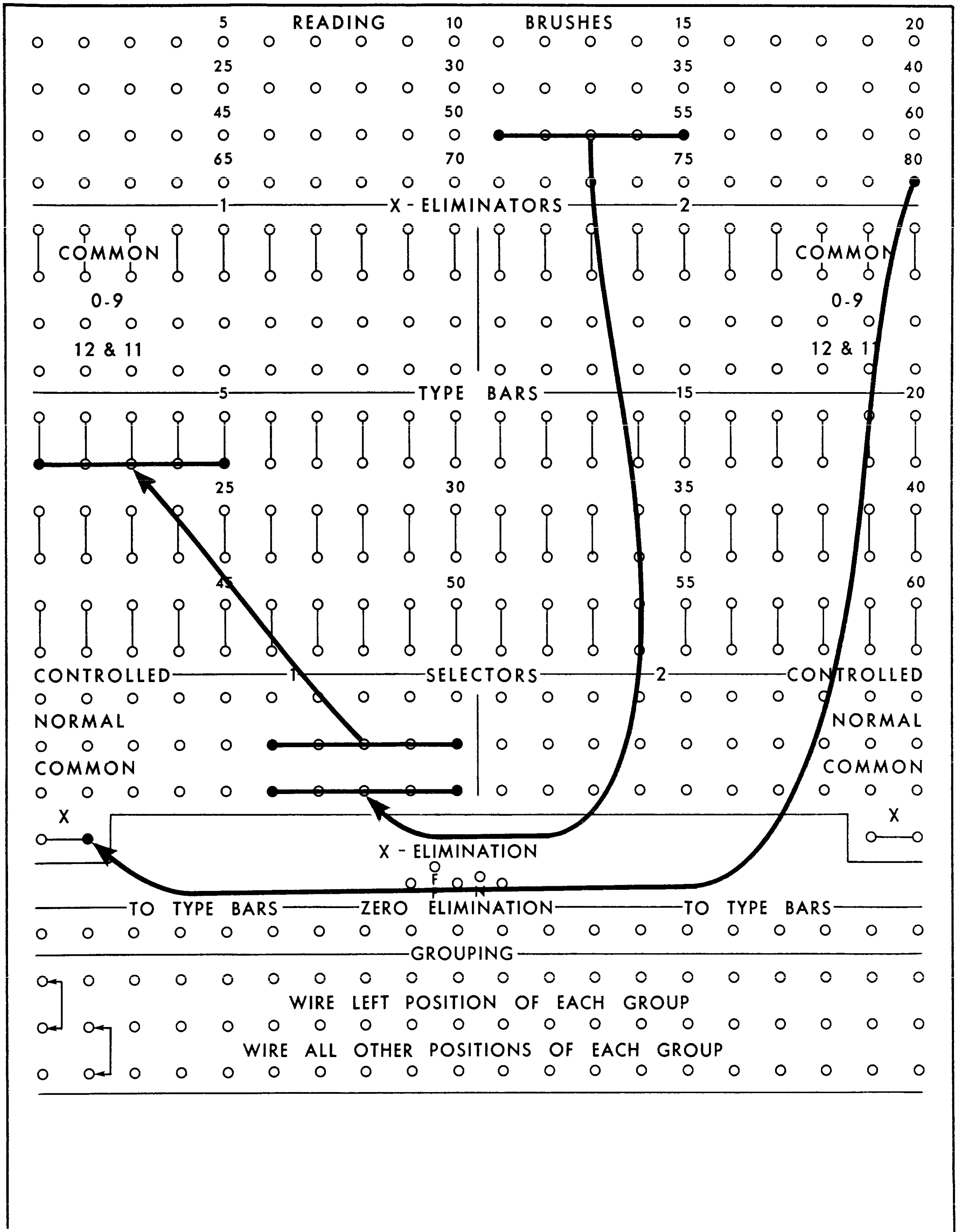


FIGURE 99

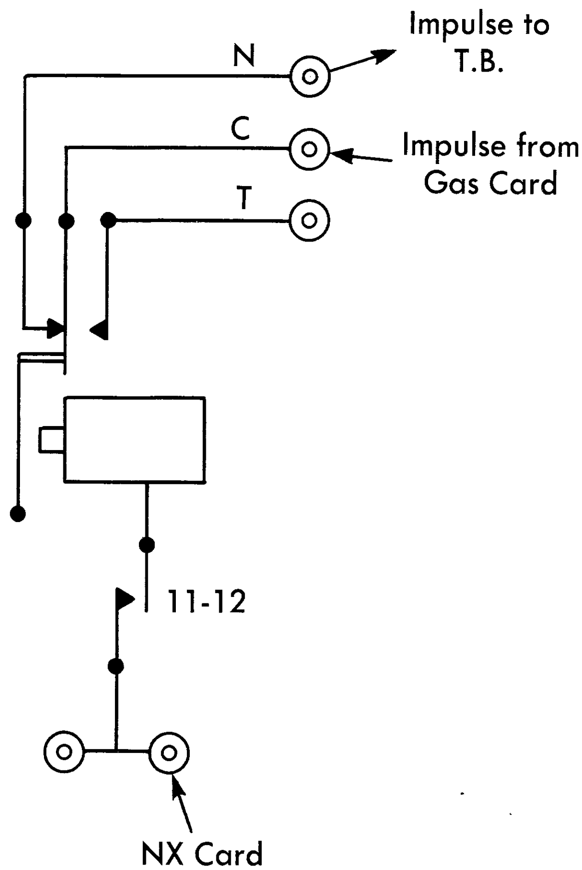


FIGURE 100

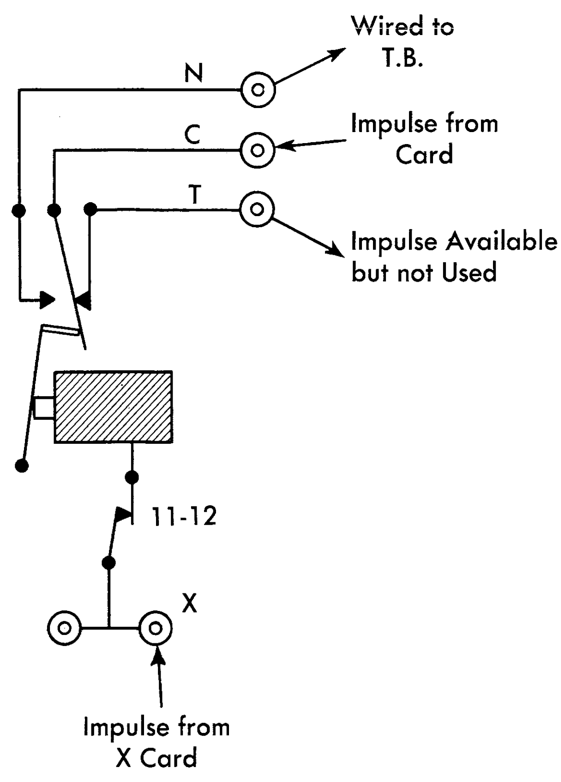
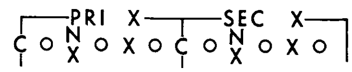


FIGURE 101

The collator selector we'll use to accomplish our purpose looks very different from the one we used on the interpreter. Yet, basically, they are much alike. The name is different, and their physical location and appearance are different, but their operation is basically the same.

The collator has two selectors which are shown.

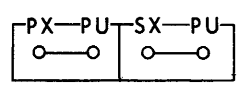


The selector on the left, PRI X, stands for primary X, SEC X stands for secondary X.

The words primary and secondary are used because the collator has two feeds, the primary feed and the secondary feed. The PRI X selector is used normally to control the cards in the primary feed. The SEC X selector is used normally to control the cards in the secondary feed.

The hubs in both selectors are labelled C, NX, and X. This is just another set of names for *common, normal,* and *transferred.*

The pickup hubs of the collator selectors are not located right next to the selector hubs themselves, but instead are in the lower right-hand corner of the control panel. These hubs are labelled PXPU and SXPU. PXPU means primary-X-pickup hub. SXPU means secondary-X-pickup hub.



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

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

As in the interpreter, there is a contact between the pickup hub and the selector magnet (Figure 102). Yet, the contact on the collator is different from that on the 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.

The collator selector will transfer only for an X-punch in the card.

The wiring diagram illustrates the wiring necessary to select X-80 cards from the file (Figure 103).

1. Wire 1 is used to pick up or energize the

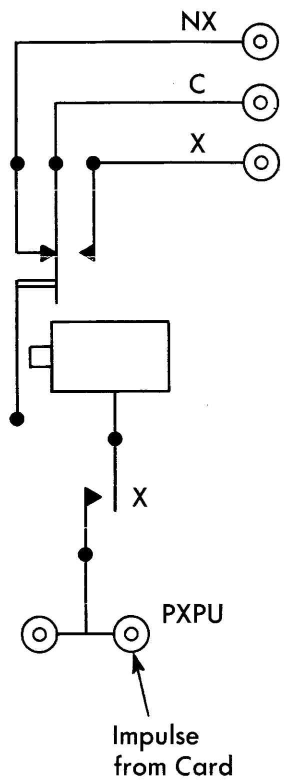


FIGURE 102

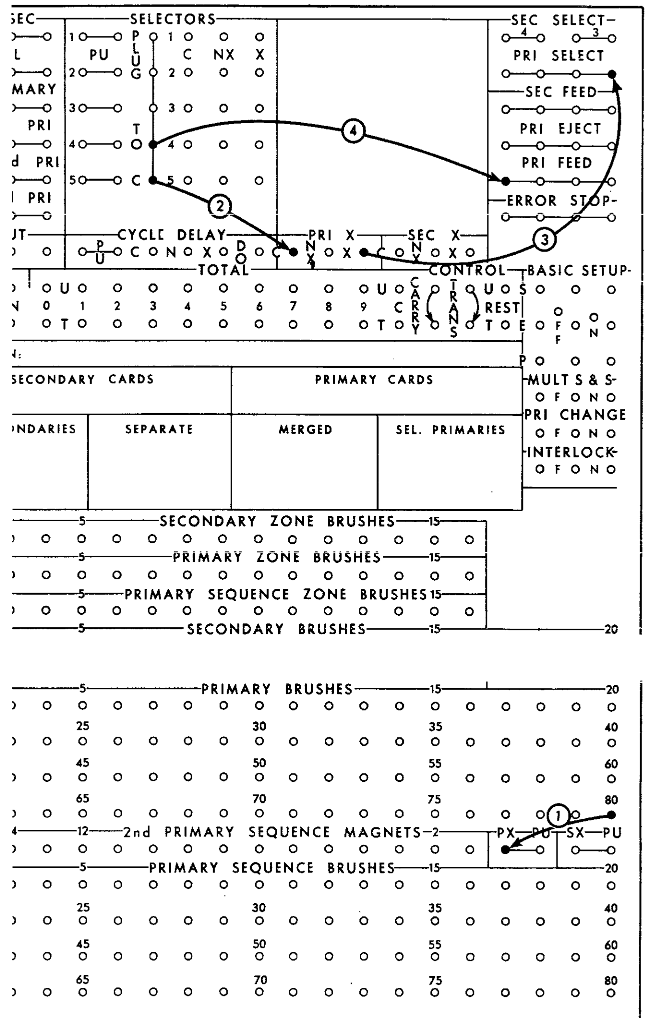


FIGURE 103

selector when an X-80 card passes the primary brushes (Figure 104).

2. Wire 2 is a PLUG TO C impulse which is nothing more than a constant impulse available every card cycle. When the PLUG TO C is wired to the common side of a selector, it is normally available out of the normal or NX side of the same selector as shown (Figure 105).

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 X-side of the selector, as shown (Figure 106).

3. Wire 3 is the selected plug-to-C impulse. This impulse will travel to the primary-select hub *only* if the selector has been transferred by the sensing of an X-punch in column 80. In every other case it will be available at the NX-hub, and as it is not wired anywhere, cause no action.

When the primary-select hub receives the plug-to-C impulse, it will direct a card into the first pocket of the collator. Therefore, all X-cards will be directed to pocket 1; all no-X cards will continue on to pocket 2 (Figure 107).

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

Use of a Selector in an Accounting Machine

We decided we needed a selector when we wished to add the gas cards in one counter, and add the electric cards in another counter (Figure 108).

We stated that selection is necessary to solve this particular problem. What should be selected?

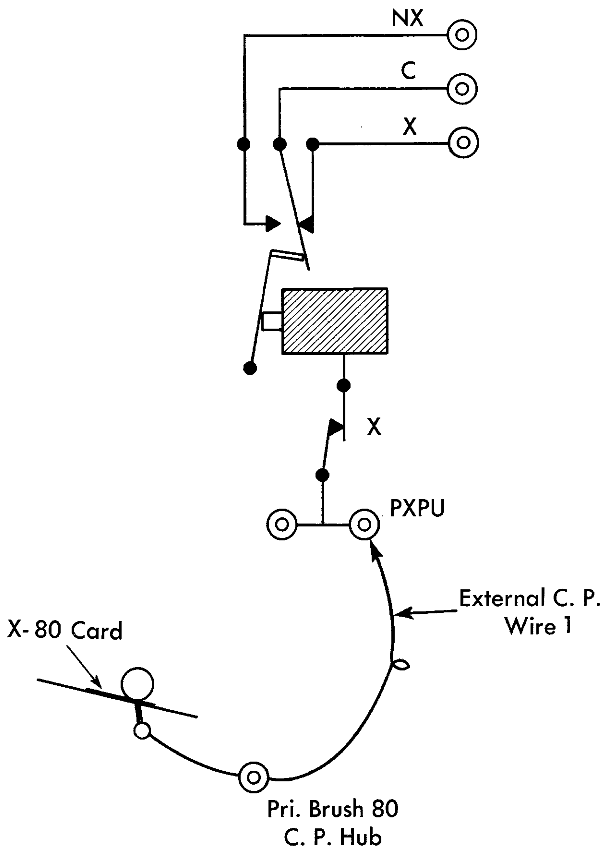


FIGURE 104

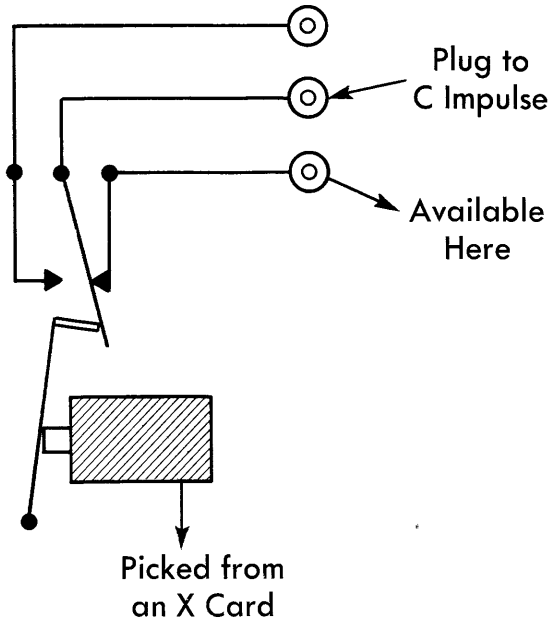


FIGURE 106

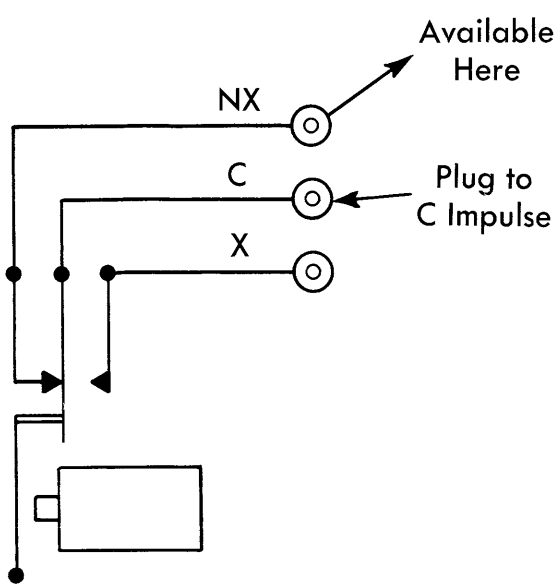


FIGURE 105

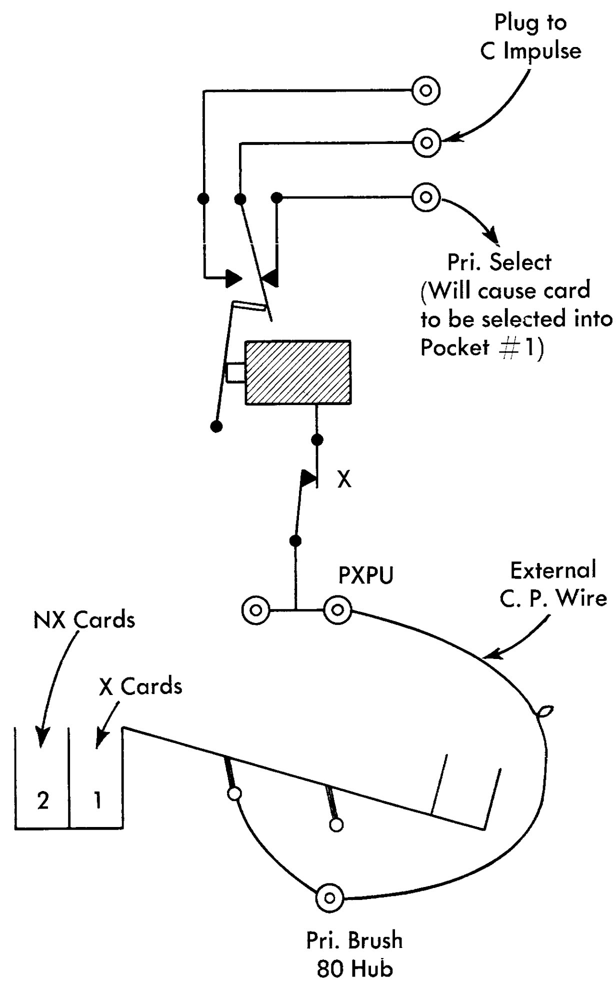


FIGURE 107

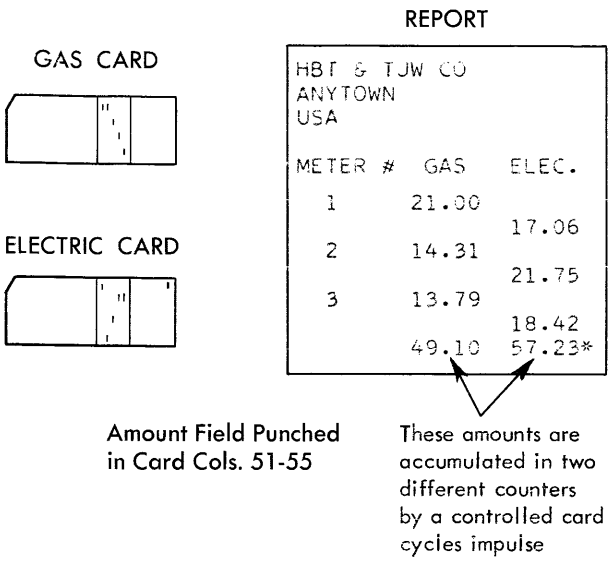


FIGURE 108

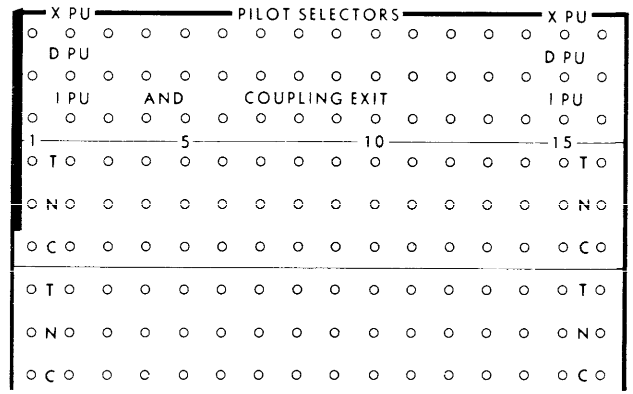


FIGURE 109

The card-cycles impulse. Why? Because this is the only impulse which can control the movement of the counter wheels, and the addition of amounts into the counters.

A card-cycle impulse is an internally manufactured impulse available during the time a card is passing the third brushes and at no other time. This impulse is usually used to pick up the counter-controlled plus or counter-controlled minus relays, depending on whether an amount is to be added or subtracted in the counter. This topic will be discussed more thoroughly in the chapters on *Addition* and *Subtraction.*

Somehow we must wire the control panel so that the card-cycles impulse will go to one counter when X-cards are passing third reading, and to another counter when no-X cards are passing third reading.

Let's see what the selectors on a 403 Accounting Machine look like.

A full capacity 403 Accounting Machine has 16 PILOT SELECTORS, 11 standard and 5 optional, which are shown (Figure 109). They are called pilot selectors because, through their operations, other selectors may be controlled. In other words, the pilot selectors take the lead.

Each selector is arranged vertically, with two sets of hubs labelled C, N, and T. The operation of these selectors is very similar to any other selector we've discussed so far. The schematics illustrated (Figures 110 and 111) show you that their operations must be

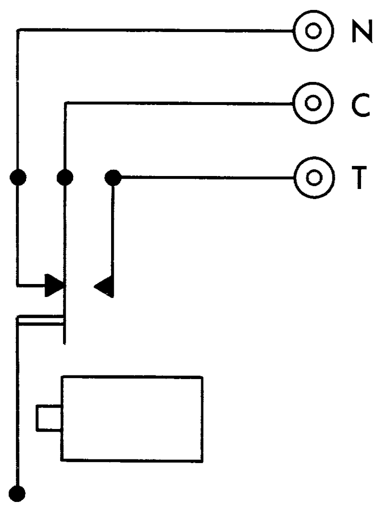


FIGURE 110

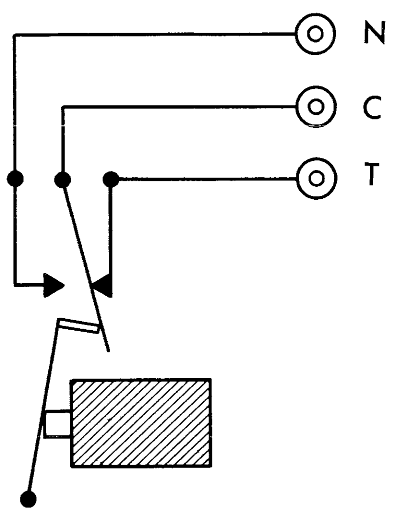


FIGURE 111

basically the same, for the schematics are practically identical with others we've already seen.

We are discussing the 403 Accounting Machine selectors in detail in the following pages, for in doing so we will illustrate some basic ideas which are found in many other IBM machines.

Up to now the selectors we've discussed have had only an X-pickup hub. The 403 Accounting Machine is an example of a machine which has more than one pickup hub.

Up to now we've assumed that the selector armature has transferred as soon as the impulse was received by the pickup hub. You will see in the following explanations that the armature may transfer at a later time.

Look at the schematic shown (Figure 112). As we discuss the pickup hubs, see if you can trace a path for the impulse to the magnet.

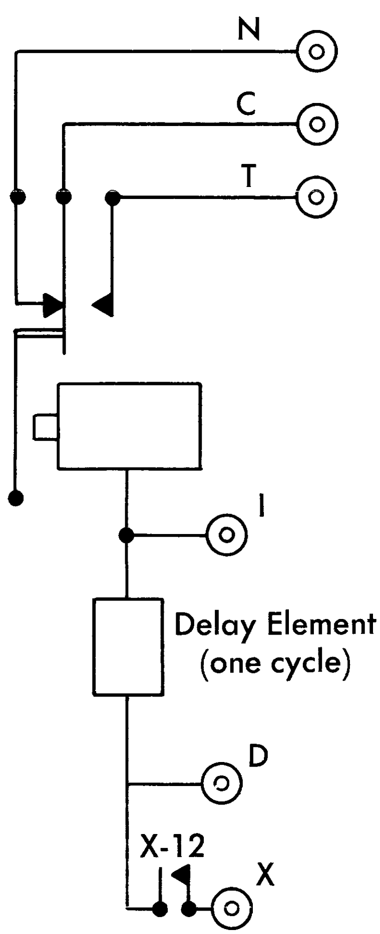


FIGURE 112

X-Pickup Hub—403 Accounting Machine

The X-pickup hub will accept only an 11- or 12-impulse from the card because of the 11-12 relay which 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 will remain transferred through the next card-read cycle.

Therefore, if we wired from the second-reading brushes to the X-pickup hub, and an X-punch were sensed, the selector would not transfer until late in this cycle. In this case, the selector remains transferred through the cycle in which the card with the X-punch passes third reading. In other words, the selector will remain transferred during any intervening cycles.

As an additional example, if the X-punch were wired from the first-reading brushes to the X-pickup hub, the selector will be transferred through the cycle in which the X-punched card passed second reading.

D-Pickup Hub—403 Accounting Machine

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

As we are using the same delay relay we used when we wired the X-pickup hub, the effect will be exactly the same.

Therefore, if we wired from the second-reading brushes to the D-pickup hub, and any 9-12 punch were sensed, the selector would not transfer immediately. Instead, the selector would be transferred for the cycle in which the card with the digit punch passes third reading.

I-Pickup Hub—403 Accounting Machine

As you can tell by looking at the schematic (Figure 112), the I, or IMMEDIATE PICKUP hub will accept any impulse from the card, and the selector will transfer immediately.

Why? Because there is neither an 11-12 relay nor a delay relay between the pickup hub and the selector magnet.

How Long Does a Selector Remain Transferred?

The answer to this question depends entirely on the type of machine.

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

Even turning off the main source of power has no effect.

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

This type of selector will return to normal only when a hub called drop-out is impulsed.

The pilot selectors shown (Figure 113) are to be found on the 528 Accumulating Reproducer. They look very much like the pilot selectors on the 403 Accounting Machine. 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 common hubs called DROP OUT.

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

The selectors we've been talking about previously, those in the Interpreter, Collator, and the 403 Accounting Machine, are very different from the latch-type selectors.

The non-latch type of selector remains transferred only as long as its magnet is energized.

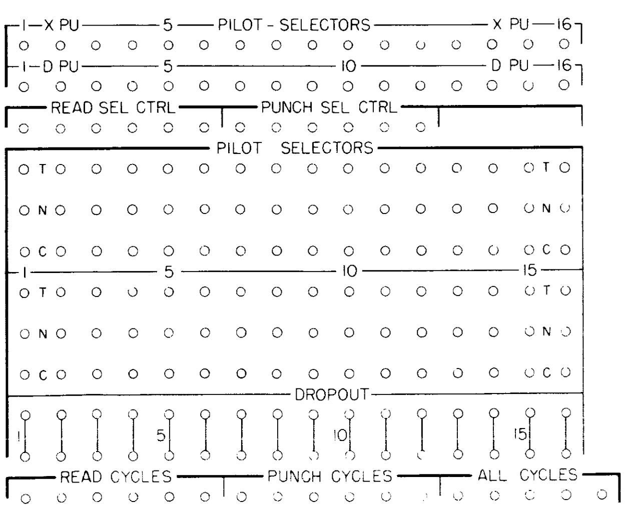


FIGURE 113

Not one of the types of selectors we've been talking about requires a drop-out hub, for their armatures will return to normal as soon as the magnet is no longer energized.

We've already stated that if we wire the X- or D-pickup hub of a 403 Accounting Machine pilot selector from second reading, the selector magnet will be energized and the armature transferred, as the X- or D-card passes third reading.

The 403 Accounting Machine pilot selector will remain transferred until the end of the cycle in which the X- or D-card passed third reading.

How can an impulse, available only during a very small portion of the card cycle, cause the magnet to be energized from an *entire* cycle?

In effect, the machine stretches the short X or digit impulse which was used to energize the magnet, to a longer one. The 403 Accounting Machine has an internal electric circuit which 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 114).

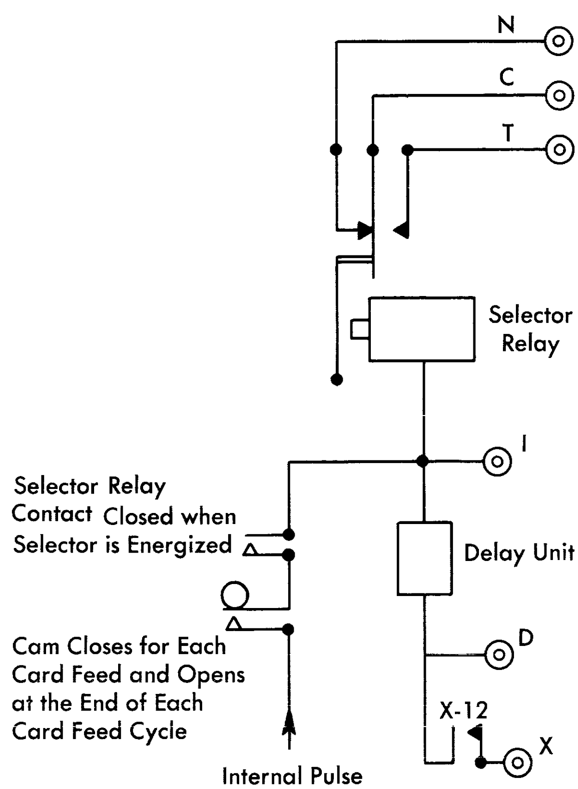


FIGURE 114

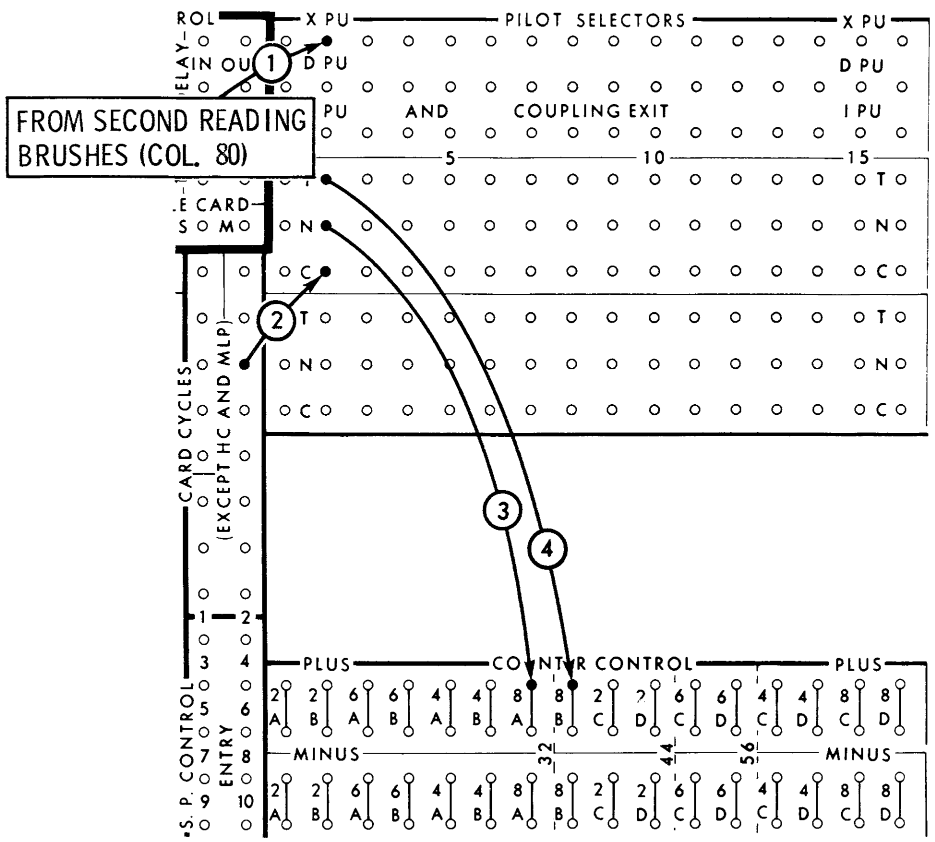


FIGURE 115

The longer impulse which travels through the hold circuit is always available, but 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 the energizing of the selector magnet, and then the *hold* impulse takes over and keeps the selector magnet energized for the rest of the cycle.

Figure 114 shows the operation of the hold circuit better than words.

Now that we've discussed the 403 Accounting Machine pilot selector in detail, let's see what wiring is necessary on the control panel in order to add the gas cards in one counter, and add the electric cards in another counter (Figure 115). 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 will see that we have not wired card cycles directly to each counter which 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 403 Accounting Machine 9-edge first. Therefore, as we are adding from third brushes, the reading of the X would have been too late. All of the digits to be added

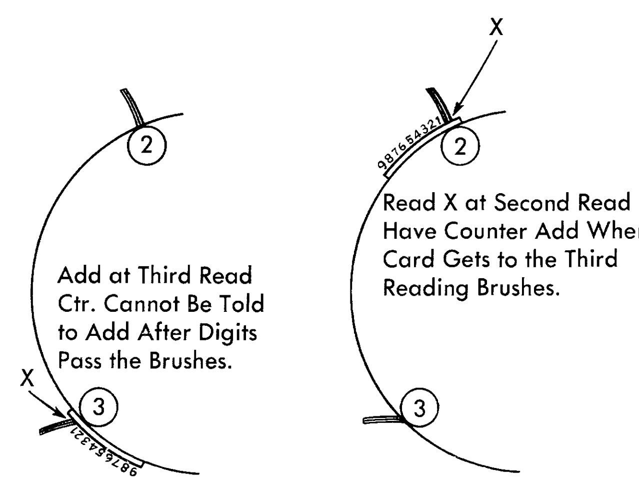


FIGURE 116

would have passed third reading before the X-punch had been sensed.

The schematic (Figure 116) will illustrate why we must wire the X-punch from the second reading brushes. Wire 2 is connected to the card-cycles impulse which is the impulse being selected. Wire 3 — if we have a no-X or gas card passing through the machine, it will add into counter 8A. The card-cycles impulse will come out of the normal side of the selector to the counter-control-plus hub, and cause counter 8A to add *only* when no-X cards are passing the third-reading brushes. Wire 4 — if we have an X or electric card passing through the machine, it will add into counter 8B. The card-cycles impulse will come out of the transferred side of the selector to the counter-control-plus hub, and cause counter 8B to add only when X-cards are passing the third-reading brushes.

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 digit-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 a 403 Accounting Machine?
10. What is the effect of the delay relay in the 403 Accounting Machine 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?

ADDITION

ADDITION is the accumulation of individual amounts to arrive at total sums.

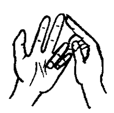
Totals for single-digit numbers could be obtained with ease, but when larger numbers had to be added together, it took time to arrive at accurate totals.

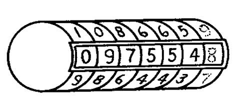
When simple numbers were being added, it wasn't necessary to provide the human mind with help, but as the numbers became larger, and their use more frequent, it was necessary to relieve the individual of this work. Machines were developed to enable the individual to spend his time more productively.

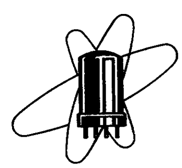
```
 2
 2
 4
```

```
  65849370
  13582968
   5483920 1
 134271539
```

Primitive man depended on his fingers to arrive at totals. Modern man has been given help in the form of *counters*. Counters may be counter wheels, such as the mileage indicator in an automobile, or they may be electronic tubes.







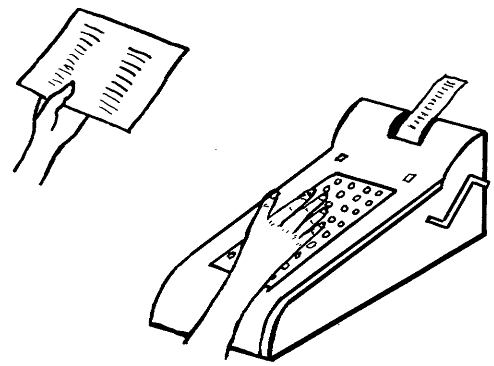
Basic Steps in Addition

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

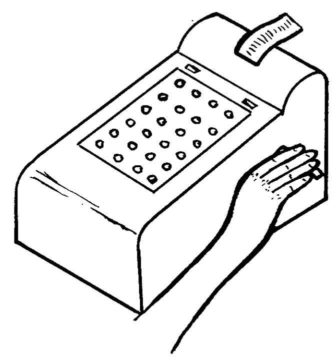
You are familiar with desk adding machines. Let's review the basic steps needed to make this type of machine add, and then how the same four basic steps are used in the IBM machine method.

The Adding Machine Method

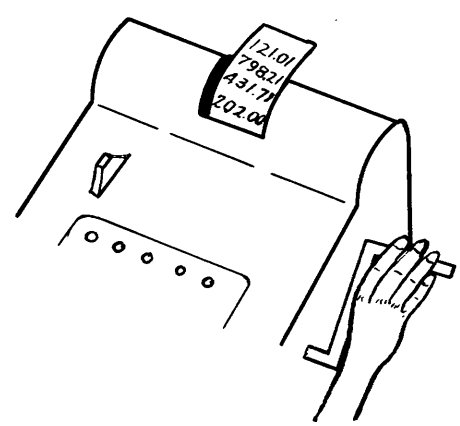
1. The operator must READ the number to be added, and take it to a counter by depressing the proper keys on the keyboard.



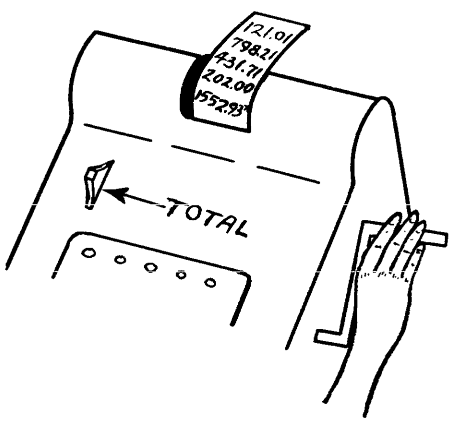
2. The operator must tell the machine to ADD the number into the counter by pulling a handle.



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.



4. The operator must tell the machine to print the TOTAL by depressing a total key on the key board, and pulling the handle.



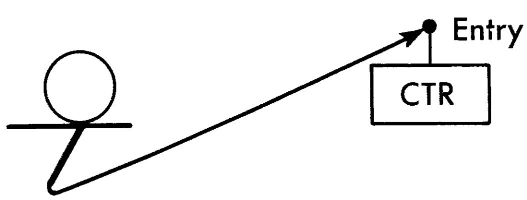
Therefore, the four basic steps are:

1. READ
2. ADD
3. PRINT
4. TOTAL

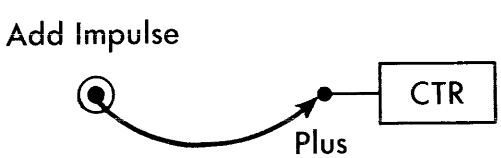
The *only* difference between the desk adding machine method and the IBM method is that in the IBM machines, control panel wiring is substituted for the manual operations.

The IBM Method

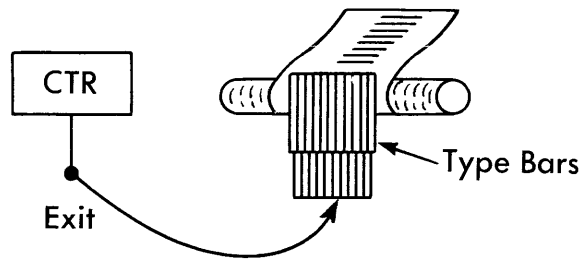
1. The information to be added is READ from an IBM card by a set of brushes and, by means of control panel wires, is taken to the counter.



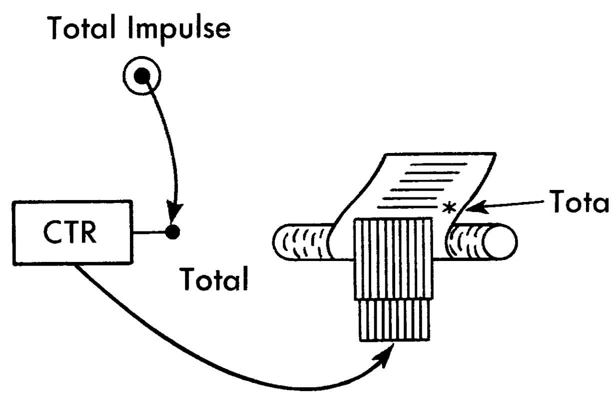
2. The counter will ADD the information when told to do so. On the adding machine we pulled a handle. On IBM machines we must wire a special impulse to the counter to tell it to add.



3. IBM machines equipped with paper and type can PRINT the information being added in the counters. On the adding machine we pulled a handle to force the printing. On the IBM machine we connect the counter and the typebars by control panel wires.

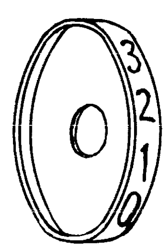


4. IBM counters must be told to print the TOTAL. On the adding machine, when the operator recognized the end of a group, she depressed the total key, and pulled a handle. On the IBM machine, the comparing magnets recognized the end of a particular group of cards, and the resulting impulse is wired to the counter to tell it to stop and print the total.

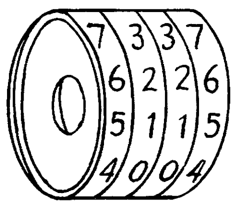


Counter Wheels

The general arrangement of a counter wheel from an IBM machine is shown. 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 group. IBM machines may have as many as 168 counter wheels, but these are arranged in counter groups, or counters of two, three, four, six, or eight counter wheels.



All the wheels in one counter group are entirely separate from the wheels of another counter group. In order to eliminate any possibility of confusion on the control panel, the counter groups have been given separate names.

For example, in an IBM machine with 80 counter wheels, you will find 16 separate counters, each with a different name. The digit indicates the number of counter wheels in that particular counter group. The letter identifies the particular counter group, as there are four of each size.

There are four 2-position counters, four 4-position counters, four 6-position counters, and four 8-position counters.

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

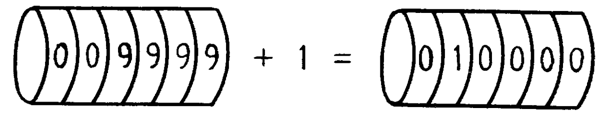
Within a counter group each wheel is internally connected to the wheel immediately to its left. Why should this be necessary?

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

$$\begin{array}{r} 9{,}999 \\ 1 \\ \hline 10{,}000 \end{array}$$

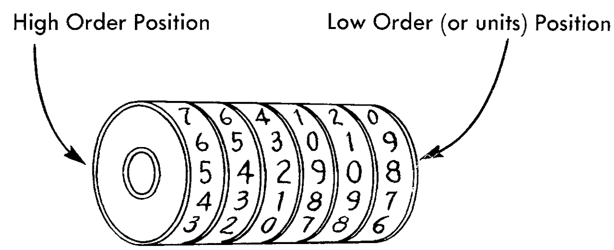
The addition of a 1 in the units wheel changed the wheel from 9 to 10. As the wheel does not have a 10 character, it turned back to 0 and the 1 was internally carried over to the counter wheel to its left.

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.



Each time the counter wheel moved from the 9-position to the 0-position, the wheel to its left within the same counter group, automatically moved one position.

The right-hand wheel in a counter group, and the left-hand wheel in each counter, have been given special names.



An understanding of counter capacity is necessary before we discuss the wiring of a specific machine. A two-position counter can add up to a total of 99. A six-position counter can accumulate a total of 999,999. An eight-position counter can accumulate a total of 99,999,999. Therefore, when we decide which size counter to use, we must know how large a total we expect to accumulate.

Wiring the Accounting Machine to Add

In order to fix in your mind the basic steps necessary for addition, let's see how you would make the 403 Accounting Machine prepare the report shown.

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

Step 1: READ

We must read the information from the card columns in which it is punched, and take it to the counter.

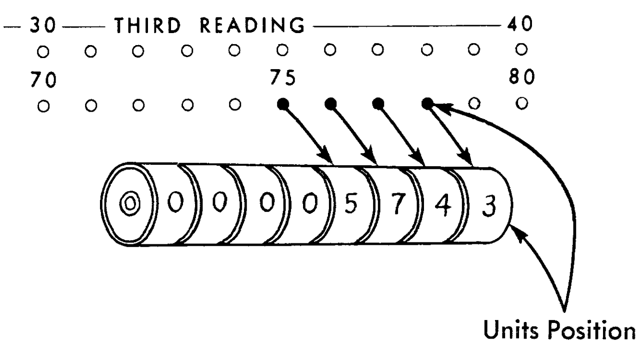
Therefore, we must wire from third reading to a counter entry. Which card columns and which counter should we use?

We wish to add the amount which 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 four-position counter.

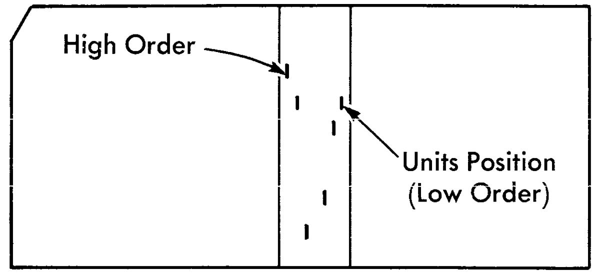
Would we need a counter larger than four positions? Yes. We know from past experience that a clerk in this department can sell as much as $999.99 worth of goods in one day. We also know that no one has ever sold more than this amount.

Therefore, our total may run as high as five positions, but no higher, and we must use a six- or eight-position counter.

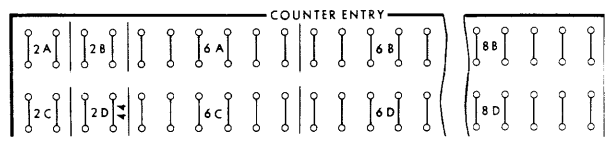
When wiring information into a counter group from a set of brushes reading a card field, you *must always* wire the units position of the card field to the units position of the counter group, the 10's position of the card field to the 10's position of the counter group, etc.



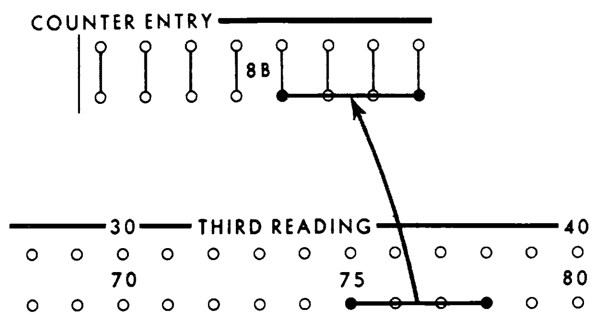
Because of this rule you may sometimes hear the columns in a card field called *high order* and *low order*. It has the same meaning as when used in talking about a counter group. The left-hand position is the *high-order* position, and the right-hand column is the *low-order* column.



How do we read the information into a counter? By using COUNTER ENTRY hubs. Counter-entry hubs for counters 2A, 2B, etc., are shown below.



The wiring required to take the information from card columns 75-78 to counter 8B is shown below.



After wiring the information from the third-reading-brush exit hubs to the counter-entry hubs, we must still tell the counter to add. The schematic diagram (Figure 117) shows us why we must give the machine special instructions to make it add.

In order to get the impulses wired to the counter-entry hubs into the counter itself, we must complete a circuit.

In the schematic you will see a relay between the counter-entry hubs and the counter. In order to get the digits to the counter to be added, we must transfer this relay and thereby complete a circuit.

The relay is called *counter control plus,* and will close only when its magnet is energized. Looking at the schematic you will see that a pair of common

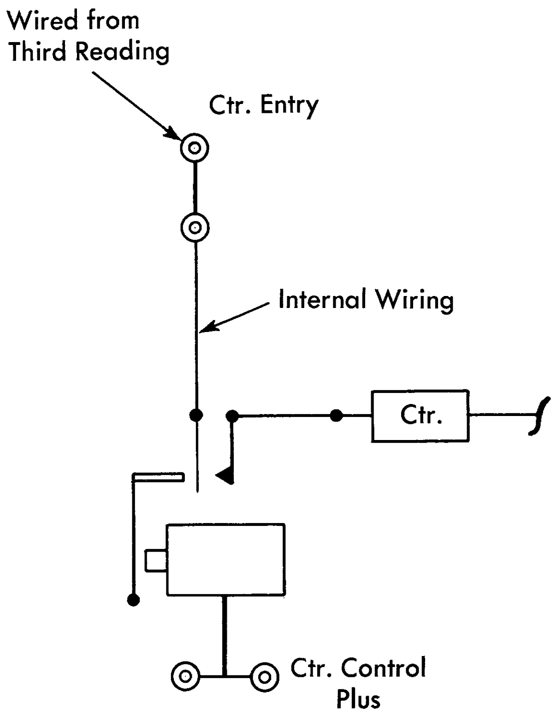
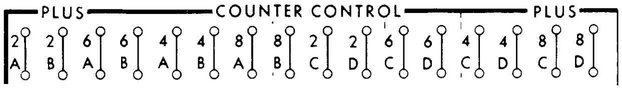


FIGURE 117

control panel hubs, labelled COUNTER CONTROL PLUS, lead to the magnet. If an impulse is wired to either of the two common hubs for this relay, the magnet will be energized, and it will transfer the relay.

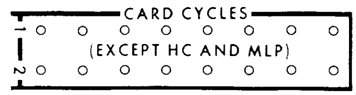
This transfer of the armature will complete a circuit and allow an impulse to get from the counter-entry hubs to the counter.

Each counter group has its own counter-control-plus hubs.



What impulse can we use to transfer the counter-control-plus relay, and cause addition? You must realize that we wish to add from each card as it is passing the third-reading brushes. Therefore, we must transfer the counter-control-plus relay whenever a card passes third reading.

On the control panel there are 16 hubs labelled CARD CYCLES. Each one of these 16 independent hubs emits a manufactured impulse during the time a card is passing third reading, and *at no other time*. This, then, is the impulse which we can use to transfer the counter-plus relay and complete the circuit to the counter.



If we wire any one of the 16 card-cycles impulses to either of the two common counter-control-plus hubs for the particular counter we are using, we will close the counter-control-plus relay whenever a card is passing third reading (Figure 118).

Any information read by the third-reading brushes and wired to the counter-entry hub, will add into the counter.

Digit impulses read into the counter-entry hub can now get to the counter.

Let's see how this looks on the control panel (Figure 119).

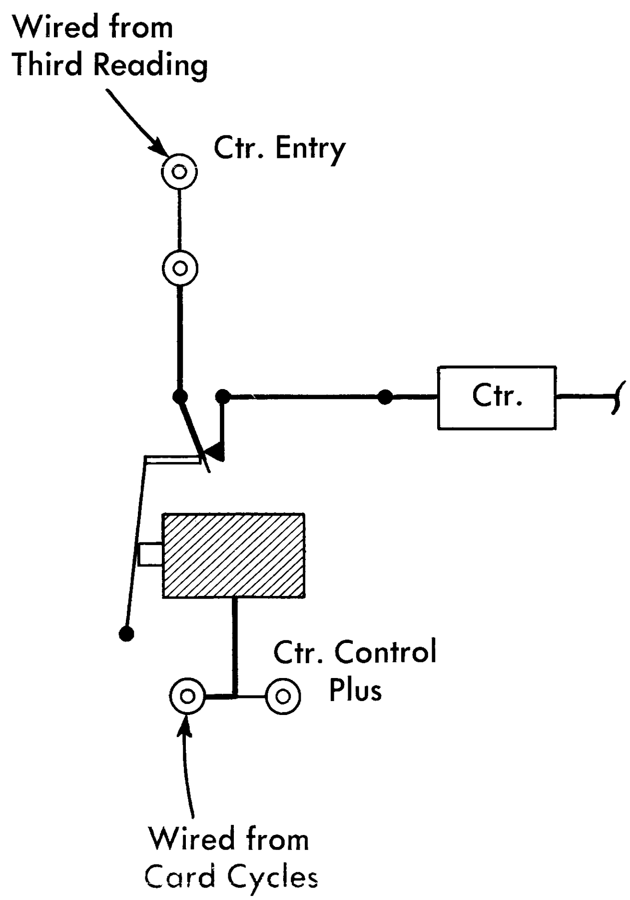


FIGURE 118

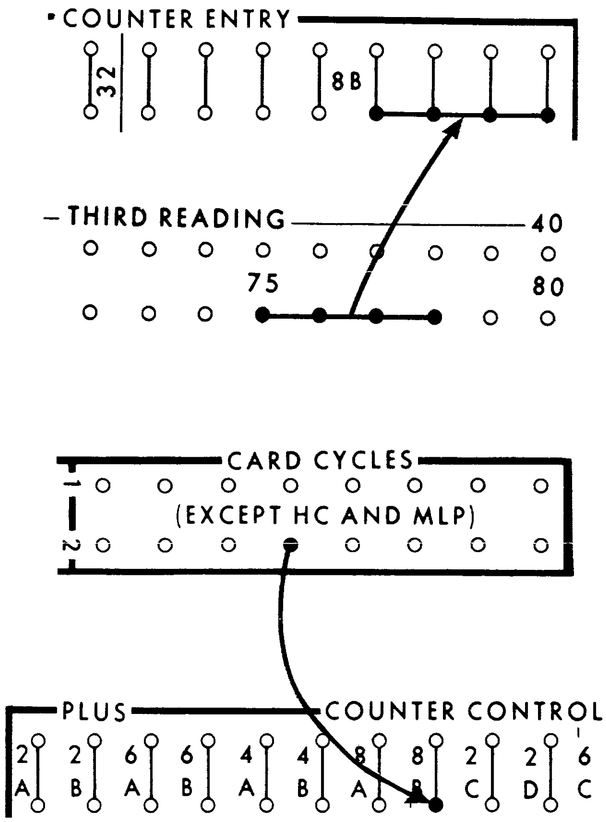


FIGURE 119

Why does this CARD CYCLES to COUNTER CONTROL PLUS wiring cause addition?

Step 2: ADDING

When we impulsed the plus hub, we allowed the digits punched in the card to reach the counter wheels. When the first card passed through the 403 Accounting Machine, 9-edge first, the wheels of all the counters stood at 0. As soon as the impulses from the card reached the counter, the wheels started turning.

The counter is standing at 0 and the impulse from the hole in the card has just reached the counter wheel, as shown in Figure 120.

As soon as the impulse from the hole in the card reached the counter wheel, the wheel started to move in time with the movement of the card past the reading brushes. From the time the wheel started to move, until it stopped at 0-time, four positions of the card went past the third-reading brushes. While the four punching positions of the card were going past the reading brushes, the counter wheel advanced four numbers and stopped at 0-time.

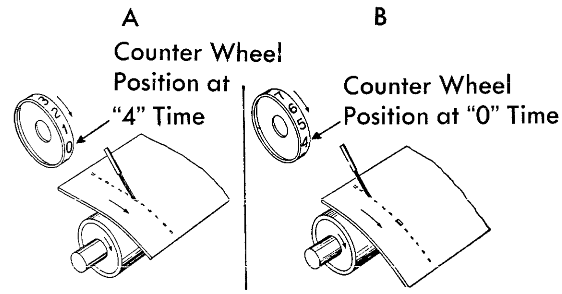


FIGURE 120

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

When adding into a counter it is only necessary to electrically *start* the adding wheel in motion. Stopping the wheel is done mechanically and automatically at 0-time of the machine cycle. The previous illustration showed a 4 being added into a counter wheel. Let's show this on a counter chart (Figure 121). Let's as-

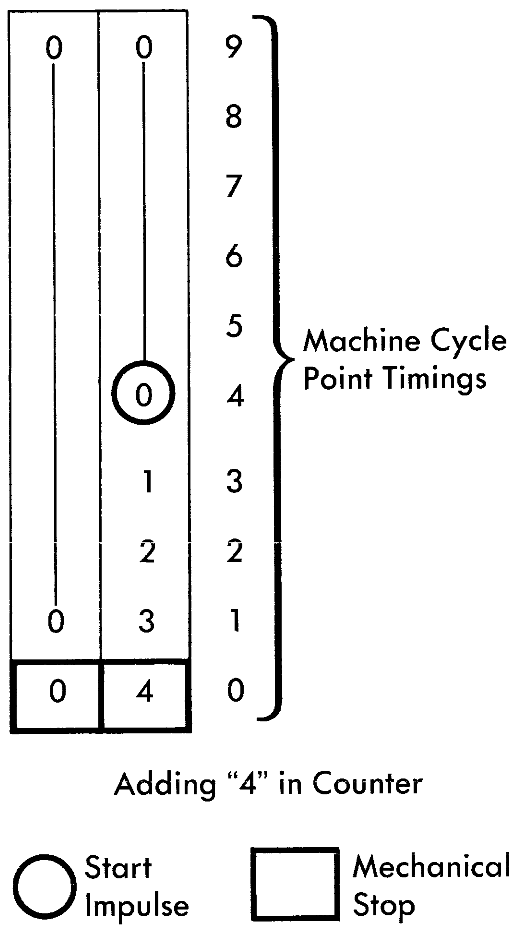


FIGURE 121

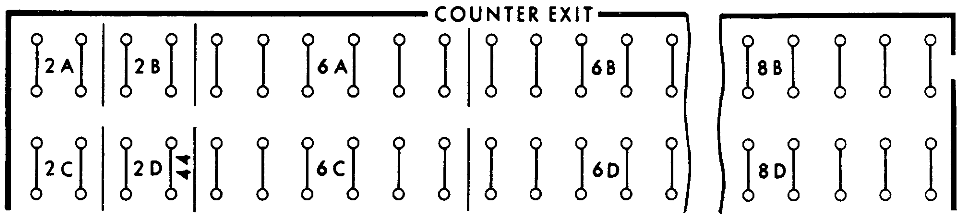


FIGURE 122

sume we have zeros in the counter wheels and that we are using a 2-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 is directed to the start magnet which will start the wheel moving. The adding wheel will continue to turn until it is stopped mechanically at 0-time of the machine cycle.

The tens-position adding wheel never did 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.

Step 3: PRINT

In the preceding steps we took the information from each card into a counter, and caused the counter to add.

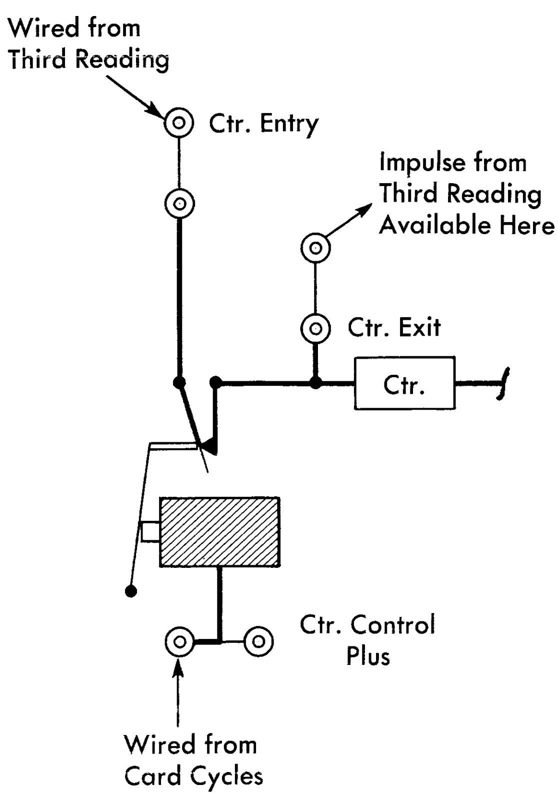


FIGURE 123

How can we print the numbers from each individual card as it passes the brushes? By using the COUNTER EXITS which are provided for each counter as shown in Figure 122.

Looking at the schematic diagram (Figure 123) you will see that, whenever we impulse the counter-control-plus hub of a counter, anything we put into the counter-entry hubs will go to two places:

1. To the counter wheels to be added, and
2. to the counter-exit hubs.

If, on the control panel, we wire the counter-exit hubs to the typebar entry hubs, we can 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 can be available at the counter-exit hubs.

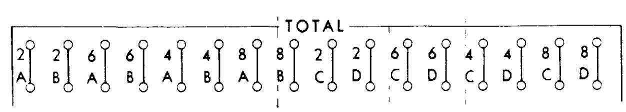
Let's see what we have added to the control panel to provide this path to the typebars (Figure 124).

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. If you look at the counter schematic again (Figure 125), you will see that there is a path from the counter itself to the counter-exit hubs.

From each counter on the control panel there are two common hubs labelled TOTAL.



Impulsing a total hub for a particular counter causes the counter wheels to reset to 0. When this reset occurs, the digits that stood in the counter wheels are emitted (or read out) of the counter-exit hubs.

Therefore, we can tell the counter to print the total

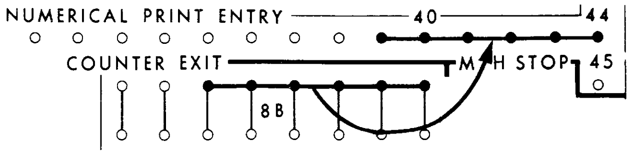


FIGURE 124

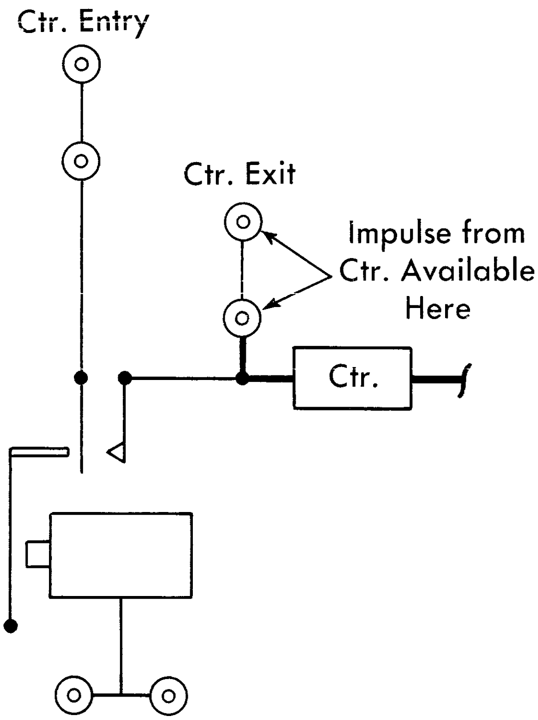


FIGURE 125

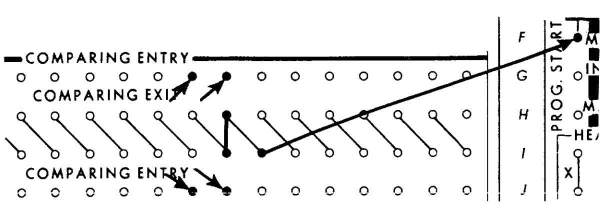


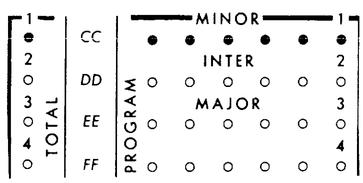
FIGURE 126

by impulsing the total hub. But *when* do we want the total hub impulsed?

Only when the end of a particular group of cards is reached. If you will recall 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 126).

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

1. The feeding of cards stopped.
2. Hubs on the control panel labelled MINOR PROGRAM emit impulses which you can use to tell the counters to read out and reset.



These two things happened only because the wiring of an unequal impulse to the minor-program-start hub told 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 printed.

Because we impulsed the minor-program-start hub when the end of a group of cards was recognized, we will have an impulse available out of the minor-program hubs, which we will wire to the total hub of the counter we wish to read out and reset (Figure 127).

The schematic diagram (Figure 128) shows how the minor-total-program impulse will become available when the minor-program-start hub is impulsed.

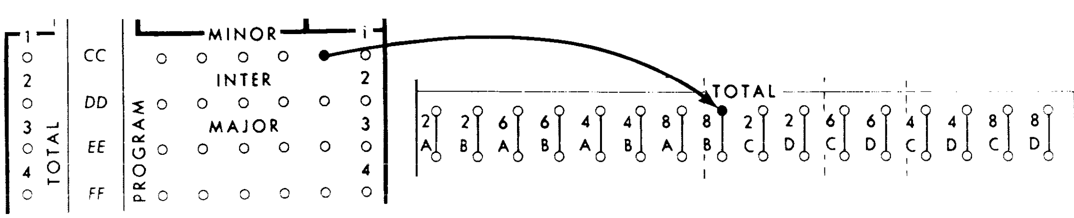


FIGURE 127

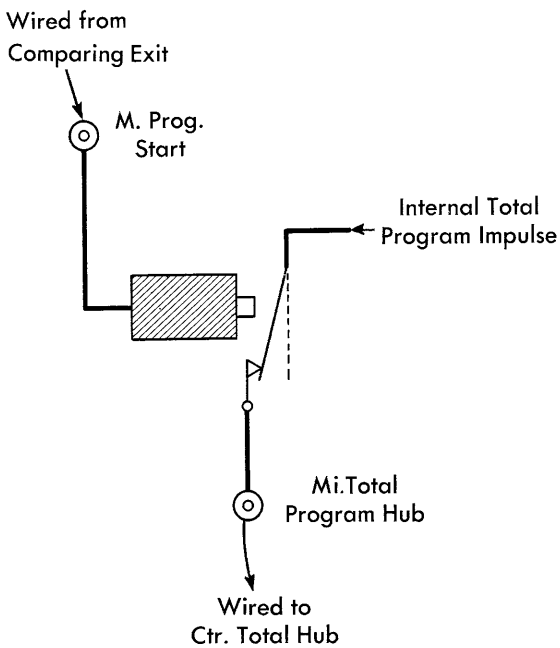


FIGURE 128

If you look carefully at the diagram shown (Figure 129) you will notice that we have one wire which has not yet been discussed. This is the wire shown connecting one of the hubs labelled ALL CYCLES with one of the two common hubs labelled LIST.

When one of the list hubs is impulsed, it will cause the typebars to rise, and after printing has taken place, will advance the paper roller (or platen) one space to allow for the printing of the next line of information.

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

The list hub must, therefore, be impulsed by an impulse which is 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 an IBM Accounting Machine accumulate and print a total.

The four basic steps which apply to a desk adding machine or an IBM Accounting Machine are:

1. READ
2. ADD
3. PRINT
4. TOTAL

Other IBM machines besides the accounting machines are capable of adding. On some of them 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 being printed. If you substitute PUNCH for PRINT in step 3 above, you still have the same four basic steps.

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. The high-order position of a counter means ....?
4. The low-order position of a counter means ....?
5. Which exit and entry hubs must be connected on the IBM Accounting Machine 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 which allows a counter to add?
8. Explain how the movement of a counter wheel causes adding.
9. What exit and entry hubs must be connected to take the total from the counter to the typebars?
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 accounting machine to make the typebars operate and the platen move? What impulse is wired to this hub? Why?

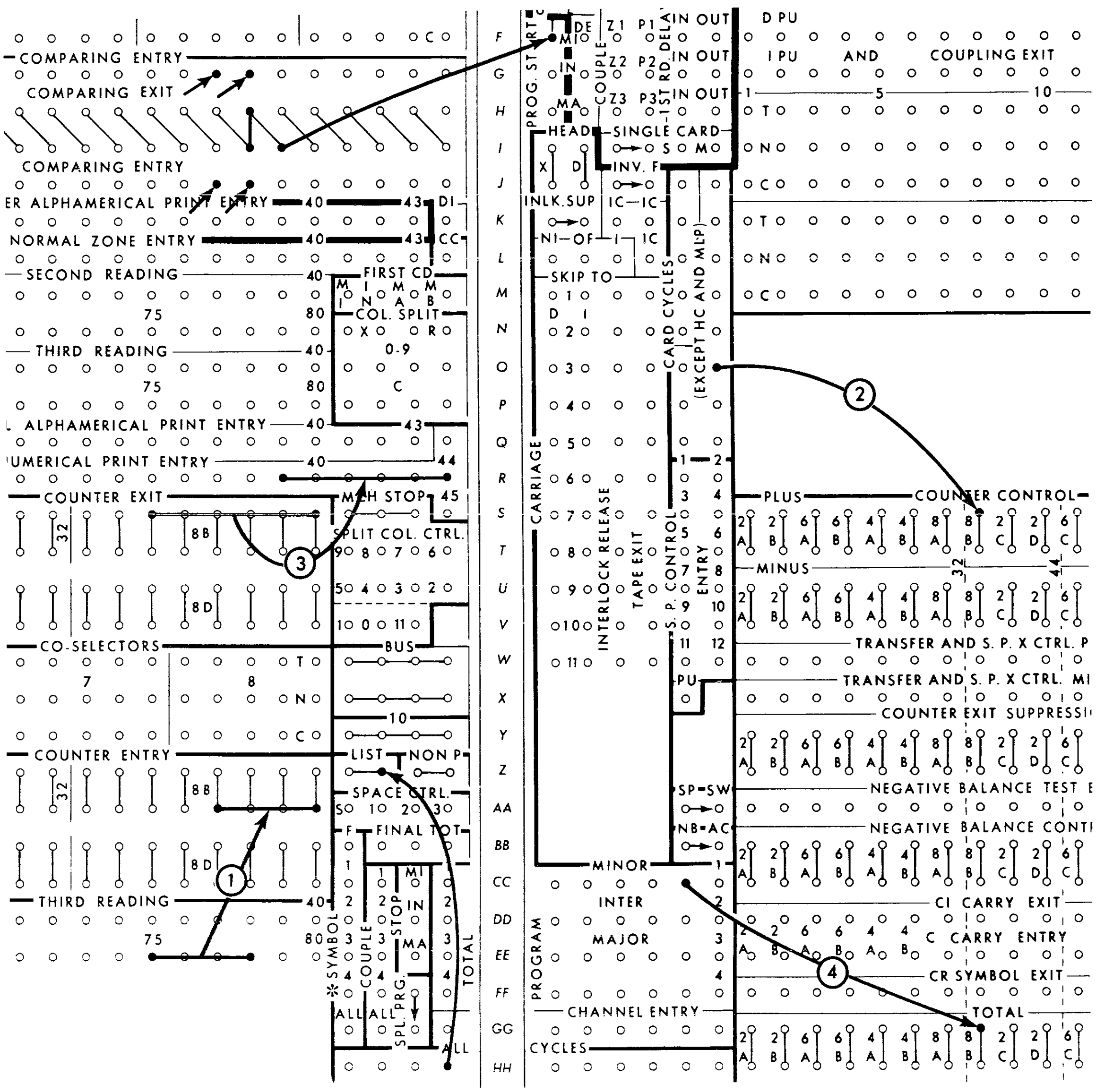

COMPARING ENTRY
COMPARING EXIT
COMPARING ENTRY
ALPHAMERICAL PRINT ENTRY
NORMAL ZONE ENTRY
SECOND READING
FIRST CD
COL. SPLIT
THIRD READING
ALPHAMERICAL PRINT ENTRY
COUNTER EXIT
SPLIT COL. CTRL.
CO-SELECTORS
BUS
COUNTER ENTRY
LIST
SPACE CTRL.
FINAL TOT
THIRD READING
SYMBOL
COUPLE
SPL. PRG.
STOP
TOTAL
PROG. START
COUPLE
HEAD
SINGLE CARD
INV. F
INLK.SUP
SKIP TO
CARRIAGE
INTERLOCK RELEASE
TAPE EXIT
S. P. CONTROL
ENTRY
CARD CYCLES
(EXCEPT HC AND MLP)
MINOR
INTER
MAJOR
PROGRAM
CHANNEL ENTRY
CYCLES
D PU
I PU
AND
COUPLING EXIT
PLUS
COUNTER CONTROL
MINUS
TRANSFER AND S. P. X CTRL.
COUNTER EXIT SUPPRESSI
NEGATIVE BALANCE TEST
NEGATIVE BALANCE CONT
CI CARRY EXIT
C CARRY ENTRY
CR SYMBOL EXIT
TOTAL

FIGURE 129

SUBTRACTION

We will often find it necessary to subtract a certain amount in a counter as well as add. An example of this would be income tax deductions when preparing payroll checks. You will find that it is possible to subtract as well as add into a counter of an electric accounting machine. Each operation must be handled separately by the counter during one machine cycle. It is impossible to add and subtract into one counter group during one machine cycle.

Due to its construction, it is impossible to turn a counter wheel backwards when subtracting. Because of this fact 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. 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 2 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

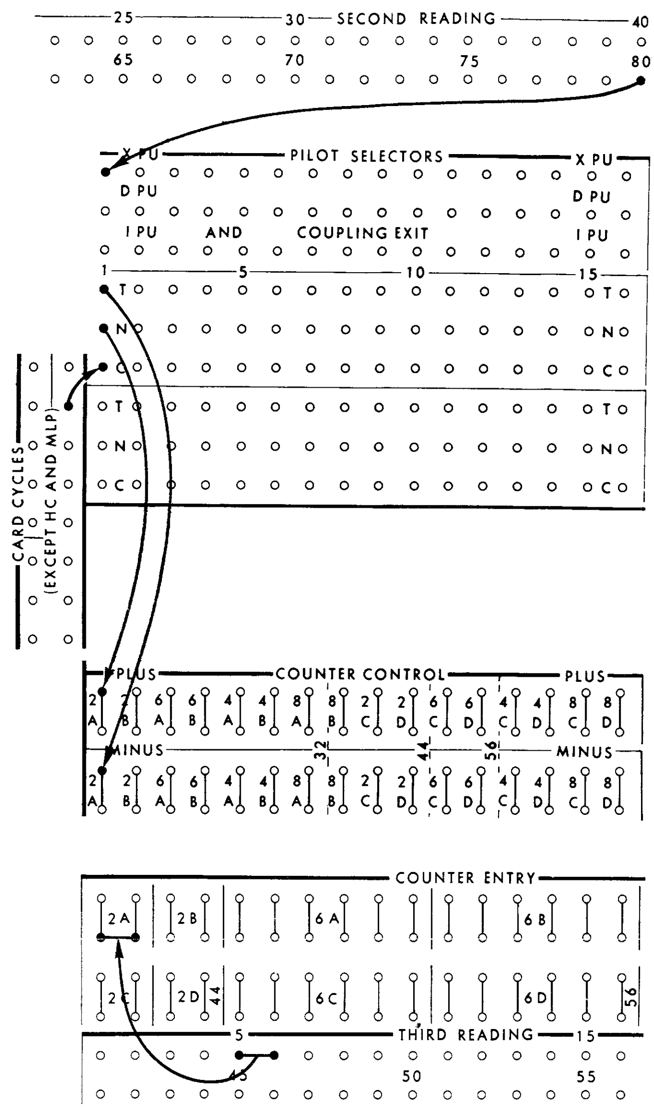


Figure 130

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. Or, in other words, add all no-X-punched cards and subtract all X-punched cards.

In order to make this possible we must employ the use of a decision-making device, a *selector*. Any pilot selector may be used for this purpose. In order to operate this selector we must wire the X-pickup hub to the second-reading brush for the column of the card containing the X-punch. The selector will then be picked up one cycle later as the card to be subtracted is being 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 will add as previously explained. When the minus relays are picked up the counter will subtract. Let's see how this looks on the control panel (Figure 130).

When adding into a counter it was only necessary 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 will be

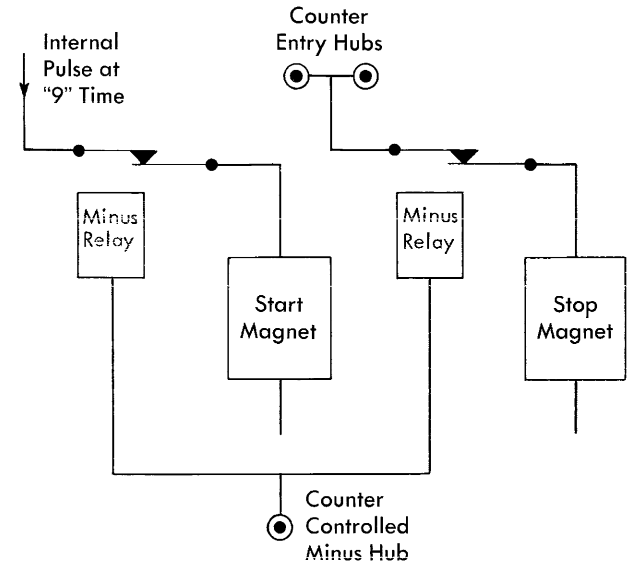
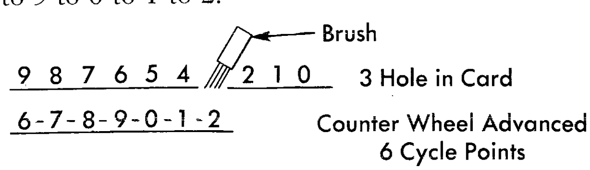


FIGURE 131

shown with a start magnet and a stop magnet. When the start magnet is energized, the wheel will start moving, and when the stop magnet is energized, the wheel will stop 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 131). The wheels will 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 132). The next card to pass the third-reading brushes is a subtract card with 03 punched in the amount field. Because the minus relays will be picked up, we will start advancing both counter wheels at 9-time. The units-position wheel will not be stopped 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 below 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.



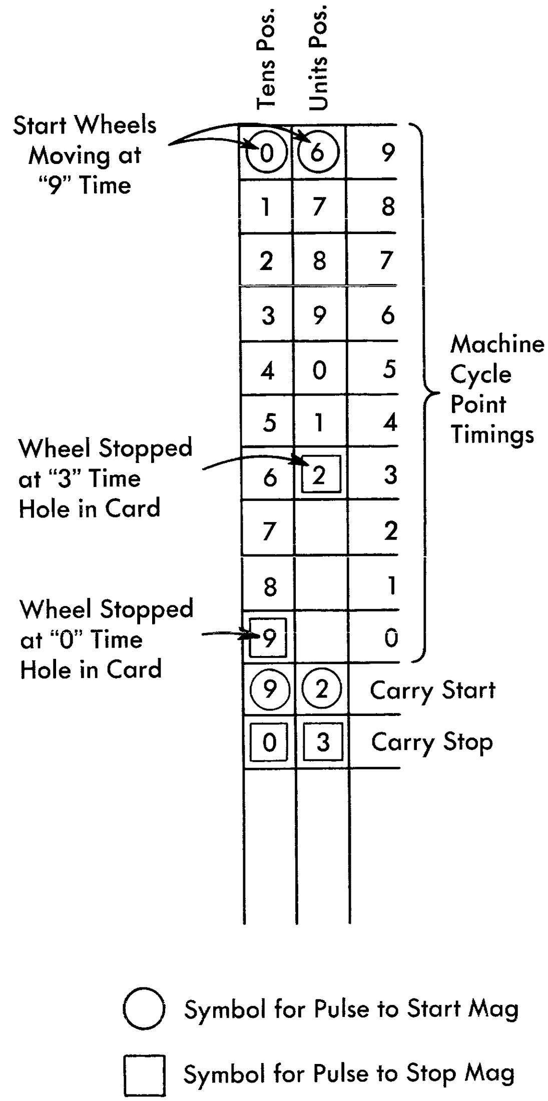
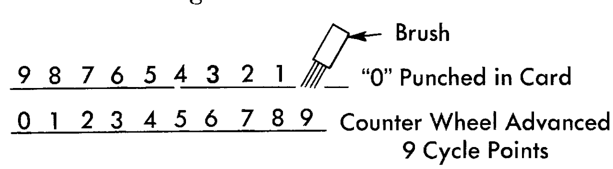


FIGURE 132

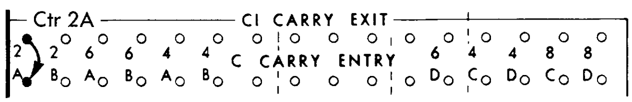
The tens-position counter wheel was treated in the same manner, only in this position we have a 0 punched in the card and we started with a 0 standing in the counter wheel.

You will notice that the wheel was advanced 9 cycle points before being stopped. The counter wheels are now standing at 92.



As previously explained, each time a counter wheel moves from 9 to 0, the wheel to its left within the same counter group automatically moves one position.

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 hub to the carry-entry hub. 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.



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 1 position.

06	In counter
96	Nines complement of 03 added
92	
11	Carry
03	Amount in counter end of cycle

So we complete this card cycle with 03 standing in the counter wheels, which is the correct total for our problem of 06 minus 03.

There is probably a question in your mind about now, and that is, suppose the amount being subtracted in a counter group is larger than the positive amount we already have accumulated in the counter. The counter will then turn negative. For example let's use a 4-position counter group and assume we already have 0745 accumulated in the counter. From this amount we will subtract 0856.

Manual computation:	−0856	
	+0745	
	−0111	
Machine computation:	0745	Standing in Counter
	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 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 will always be standing 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 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 as shown below. Assume the next card is positive and the amount is 0245.

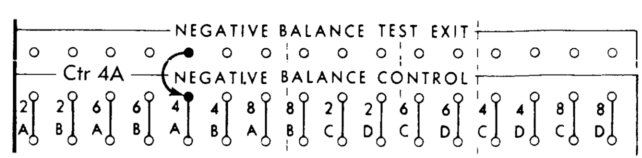
Manual Computation	Machine Computation	
+0245	9888	Amount in Wheels
−0111	+0245	+ Amount in Card
+0134	9023	
	1111	Carry
"0" Indicates Positive Amount →	0134	Total

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

When subtracting we have 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 change and signalled for this counter to print a total, the total printed would have been 9888. If this happened, the operator may 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.

In order to have conversion take place we must wire the control panel as shown below. Assume we are using counter group 4A.

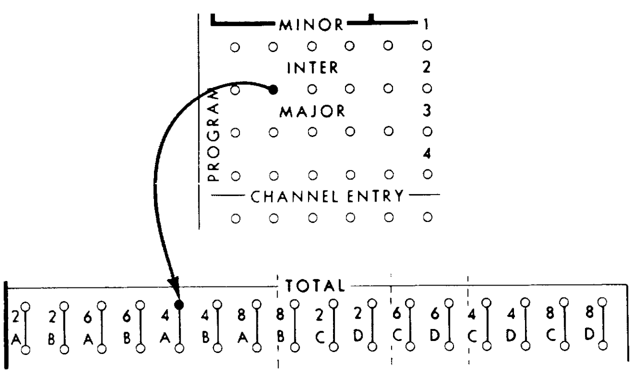


The fact that we have the NEGATIVE BALANCE TEST exit hub wired to the NEGATIVE BALANCE CONTROL hub allows the machine to test the high-order position of the counter group. If there is a 9 present the machine will know that the amount is negative and should be converted before printing takes place. The total cycle will then be held up and the machine will take a conversion cycle. During a conversion cycle the machine will add 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:

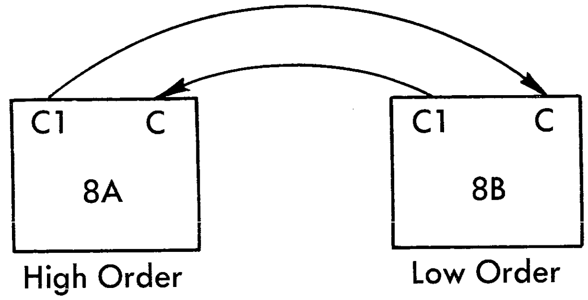
9888
1333 Added during conversion cycle
0111

The 1333 added came from internal circuits established when the machine decided conversion was necessary for this counter. The high-order position of a counter group is tested for the presence of a 9 *only* when the machine senses the type of control change, or a higher control change than, the counter is wired to total-print on.

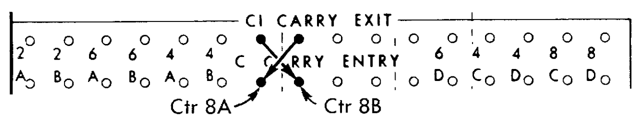
If counter group 4A is wired to total-print on an intermediate total cycle, the counter would not be tested when a minor control change is sensed. However, it would be tested before the intermediate total cycle if an intermediate or major control change was sensed.



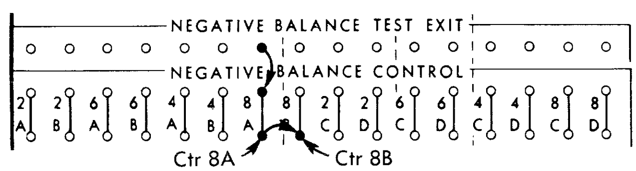
How do we wire the control panel if two counter groups are coupled together to form a larger counter group? Assume we are coupling counter groups 8A and 8B together to form one 16-position counter group.



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-hub of counter 8A to the C-hub of counter 8B.



What control panel wiring would be necessary in order 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 counter groups combined 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 hub for counter group 8A must be wired to the 8A negative-balance-control hub. We must also wire the negative-balance-control hub of counter 8A to the negative-balance-control hub of counter 8B, otherwise only 8A will be converted.



We have already found out that when conversion takes place, a true figure is printed such as 1.11 in-

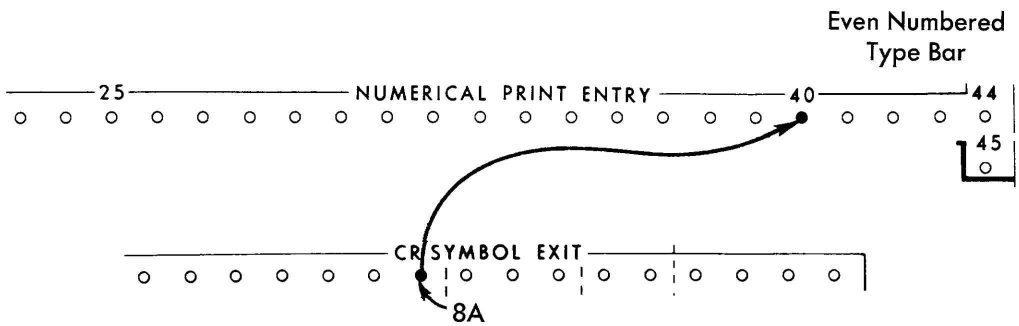


FIGURE 133

stead of 9888. However, we must have some way of identifying the 1.11 as being a credit amount. We must wire the CR SYMBOL EXIT hub of the counter being used to some *even*-numbered numerical typebar (Figure 133). Only the even-numbered typebars are equipped with CR type.

If two counter groups are coupled together, such as 8A and 8B, the credit-symbol exit hub of counter 8A is wired to the typebar. The total then would appear on the report as 1.11CR.

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 in order to add into a counter group?
3. What relays must be picked up in order to subtract into a counter group?
4. When subtracting into a counter, what starts the adding wheel in motion?
5. When subtracting into a counter, what stops the movement of the adding wheel?
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 in order 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 in order to couple two counter groups together?
14. What control panel wiring is necessary in order to print a CR symbol?
15. Can a CR symbol be printed from any typebar on a 402?

PROGRAMMING AND CALCULATING

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.

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

P. M.
1:30 Canoe Race

We have basically the same type of programs in IBM machines, with the exception that these programs are wired rather than printed. The fact still remains that 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 are 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 which will begin after a card-read operation, but not necessarily after *every* card-read operation. Also it can be said that, after the program steps have been completed, another card-read operation will occur. 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 will, in some cases, be determined by the type of machine used. In other cases, it will be determined by control panel wiring to give no more than the number required to perform the operations wanted. Each machine will have a maximum number of steps which can be obtained.

You should realize that not all machines have a program unit, and, as a result, do not have program steps available.

The program steps that we have spoken of are a series of hubs on the control panel which emit impulses in sequence (Figure 134). These impulses can then be used to control other machine features to perform specific operations. For instance, on any given program step a storage unit could be instructed to read in or read out, a counter could be instructed to add, subtract, read out, or reset, or perhaps to read out and reset on the same cycle.

Calculating

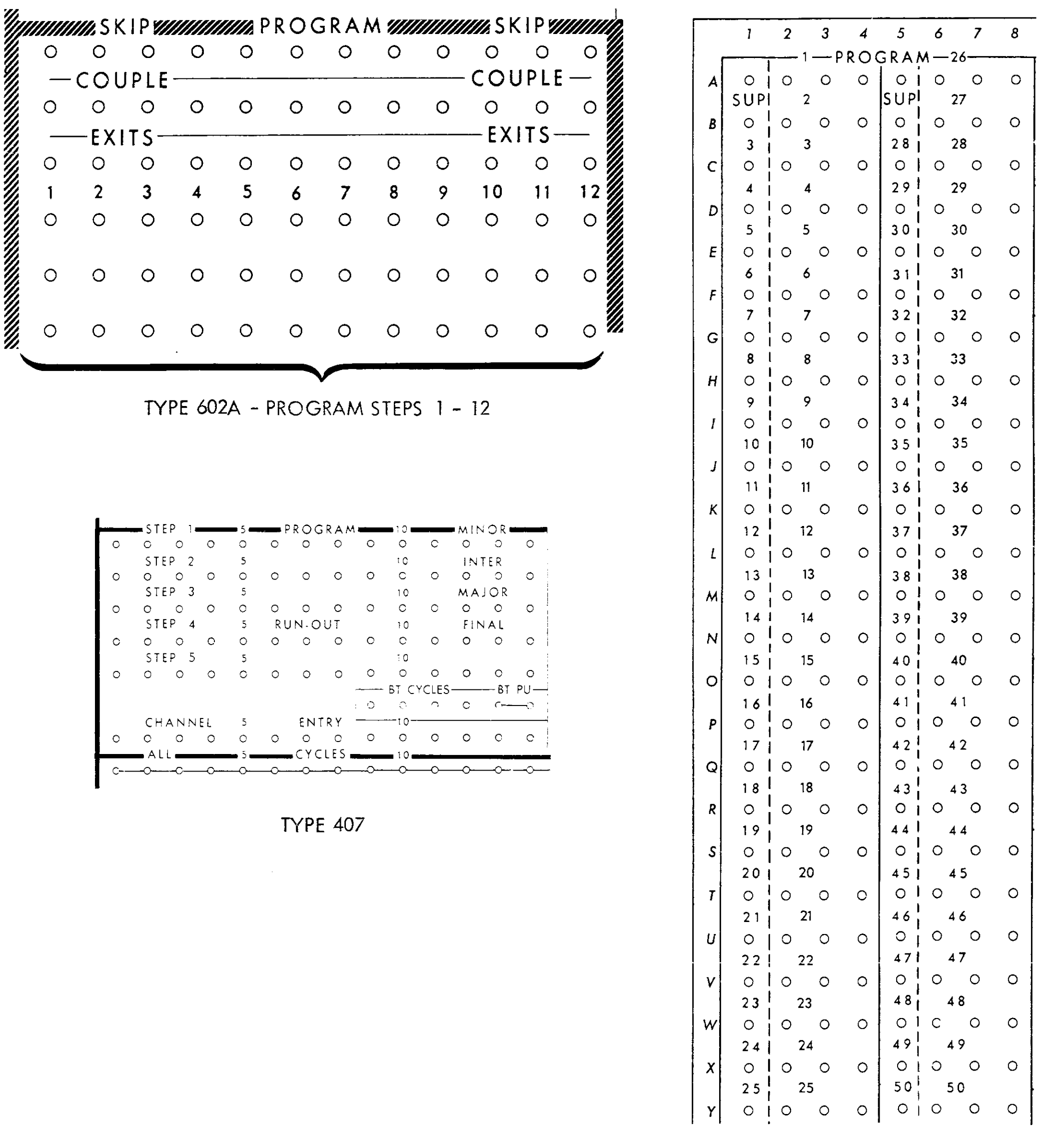
The program steps just described are also used in a calculate operation. In many machines, programming cannot be separated from calculating because program steps are *only* used for calculations. For example, this is true of the 602A Calculating Punch and the 604 Electronic Calculating Punch.

Before we go any further, let's see what is meant by calculating. Actually calculating is very familiar to all of us because each of us comes in daily contact with some form of calculating. We may only be adding and subtracting to check our bank balance, but this is calculating. We may also do some multiplication or division to see if our pay envelope or check is correct. 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.

Normally we make calculations because we want to solve a problem or answer a question. In order to solve a problem, the calculations are usually done in a definite order. In other words, one step in the calculation logically follows the one just before. The actual order of these steps is determined by the problem.

As stated previously, many of our machines have a program unit which provides us with a series of steps, or cycles, occurring in sequence. We may, therefore, use these program steps to control counters and storage units to operate in the order needed to solve our problems.

To explain how programming would be used and also how calculations could be performed and controlled by control panel wiring, let's work a problem.



TYPE 602A - PROGRAM STEPS 1 - 12

TYPE 407

TYPE 604

FIGURE 134

It should be stated, however, 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 we will solve a problem that will require a multiplication which both the 602A and 604 calculating punches can do. We will first use the problem to explain 602A programming and wiring, then the 604 will be explained using the same problem.

602A Calculating Punch

Before the problem is stated, you should know how the program unit on the 602A operates. While all programming involves a series of program steps, the details of each machine differ slightly.

The program unit on the 602A Calculating Punch does not require an instruction to start it working. Immediately following a read cycle, the program cycles begin. Program step one, or exit-one hub, will emit a cycles impulse on the cycle following the read cycle; then program-exit-two hubs will emit on the next cycle. This advancement will continue through the twelve program steps available unless you stop it.

You can stop the advancing from one program step to another by instructing the machine to read another card. To do this you would wire from the last program step needed to the hubs labelled READ. For example, if you only needed four program steps to do whatever you want to do, you would wire from PROGRAM EXIT FOUR to a read hub (Figure 135). This causes the program to stop, and the next cycle will be a read cycle.

One of the read hubs will always have to be wired in order to get another read cycle. Programming will advance to program step 12, and then go back to program step 1 and continue to repeat programming if none of the program steps are 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 then could be determined by knowing two facts: how many hours you worked, and your hourly pay rate for these hours. We will also assume that none of these hours are overtime hours so that they will all be at the same hourly rate.

The first step would be to calculate the total number of hours worked in the week by adding the hours worked each day. This weekly total would then be 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 should happen step by step. This would greatly help you to wire the control panel. A planning chart for the 602A 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, we will 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, and to be able to work with these factors better, letters can be assigned to each.

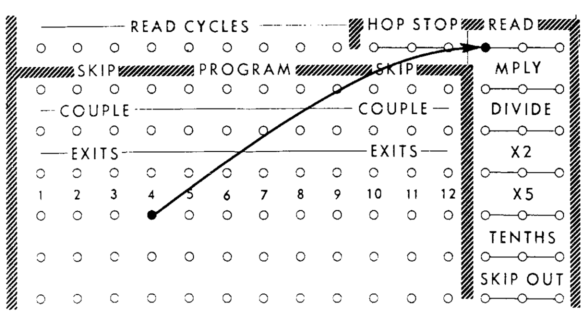


FIGURE 135

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

The problem can now be stated as a formula which would be $(A+B+C+D+E)\ R=P$. 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 would have $(8+6+8+8+5)\ 1.25=P$. The next thing you would do would be to add 8 to 6, then 8 to 14, 8 to 22, and 5 to 30 to obtain the total hours worked of 35. At this point, you would have $(35)\ 1.25=P$. You would then multiply 35 by 1.25 or perhaps you would 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 would be 43.75 gross pay.

The machine approach to this problem is very similar to this manual method. One basic difference, however, is that, where you were able to use either quantity as a multiplier and the other as the multiplicand, depending upon which is smaller, the machine must always use the same multiplier. In other words, the machine will either multiply by the rate in each case or by the total hours worked in each case, and it will not change from problem to problem. For our wiring solution, we will wire for the rate (R) to be the multiplier.

Now to get back to the similarities between the machine and manual method. The first thing that we did in the manual method was to record all of the known factors in the formula. In the machine method, the first thing to be done also is to record those known factors. In the machine these are recorded in counters or storage units. This will be done on a read cycle when these factors can be read from the card. Figure 136 shows the planning for this, and also the control panel wiring to cause it. Notice that factors A and B are to be put into counters 1 and 2 respectively and factors C, D, and E into storage units 2L, 2R, and 3L. The rate is to go into storage unit 1R. Remember we said that the rate is always to be our multi-

PROGRAM STEP	OPERATION	STORAGE UNIT		COUNTER						STORAGE UNITS					
			DIVR.–MULT.	DIVIDEND											
		1L	1R	1	2	3	4	5	6	2L	2R	3L	3R	4L	4R
	READ CYCLE		READ IN R X00	ADD A XX	ADD B XX					READ IN C XX	READ IN D XX	READ IN E XX			

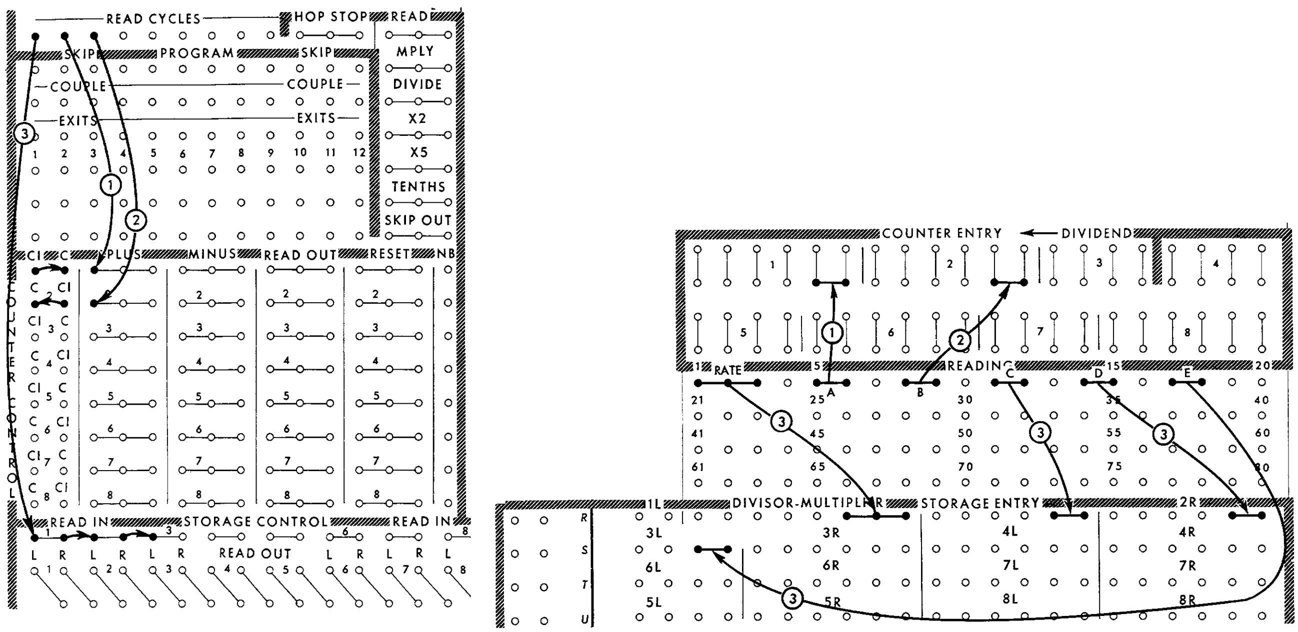


FIGURE 136

plier. The reason it was necessary to choose one or the other is that storage unit 1R must always contain the multiplier in a problem involving multiplication. Since the rate came directly from the card, and could be placed in the multiplier storage at the time it was 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 have been wired from a read-cycles hub to do this. The wiring on the right shows the wiring to entry of the units so that the information in the card is available to the various units. This will be referred to as position wiring, as opposed to control wiring.

The next thing that we did manually was to begin adding the hours worked daily to obtain the total hours worked for the week. Therefore, the next thing we want to do in the machine is to begin accumulating to obtain the total hours worked for the week.

Since counters may be operated separately, two counters may 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 is shown in Figure 137. At the end of program step 1, counter 1 has in it the sum of A+C and counter 2 has the sum of B+D. By similar wiring on program step 2 we can add E in counter 2, so that, at the end of the cycle, counter 2 will now contain the sum of B+D+E.

On program step 3 we can cause counter 2 to read out and reset, and counter 1 to add. As a result, counter 1 will now contain 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 138.

The multiplier is in storage unit 1 where it was stored on the read cycle, and the multiplicand is in

PROGRAM STEP	OPERATION	STORAGE UNIT 1L	DIVR.-MULT. 1R	COUNTER DIVIDEND 1	2	3	4	5	6	STORAGE UNITS 2L	2R	3L	3R	4L	4R
1	ADD C to A ADD D to B			ADD C XX	ADD D XX					READ OUT	READOUT				

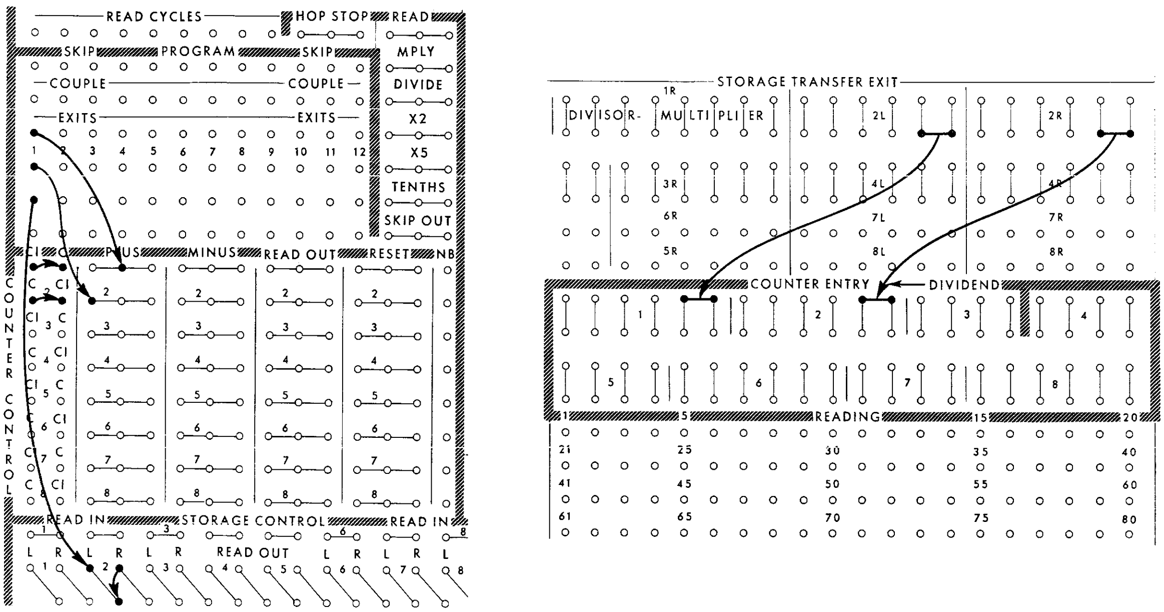


FIGURE 137

PROGRAM STEP	OPERATION	STORAGE UNIT 1L	DIVR.-MULT. 1R	COUNTER DIVIDEND 1	2	3	4	5	6	STORAGE UNITS 2L	2R	3L	3R	4L	4R
2	ADD E to (B+D)				ADD E							READ OUT			
3	ADD (B+D+E) to (A+C)			ADD (B+D+E) XX	READOUT & RESET										

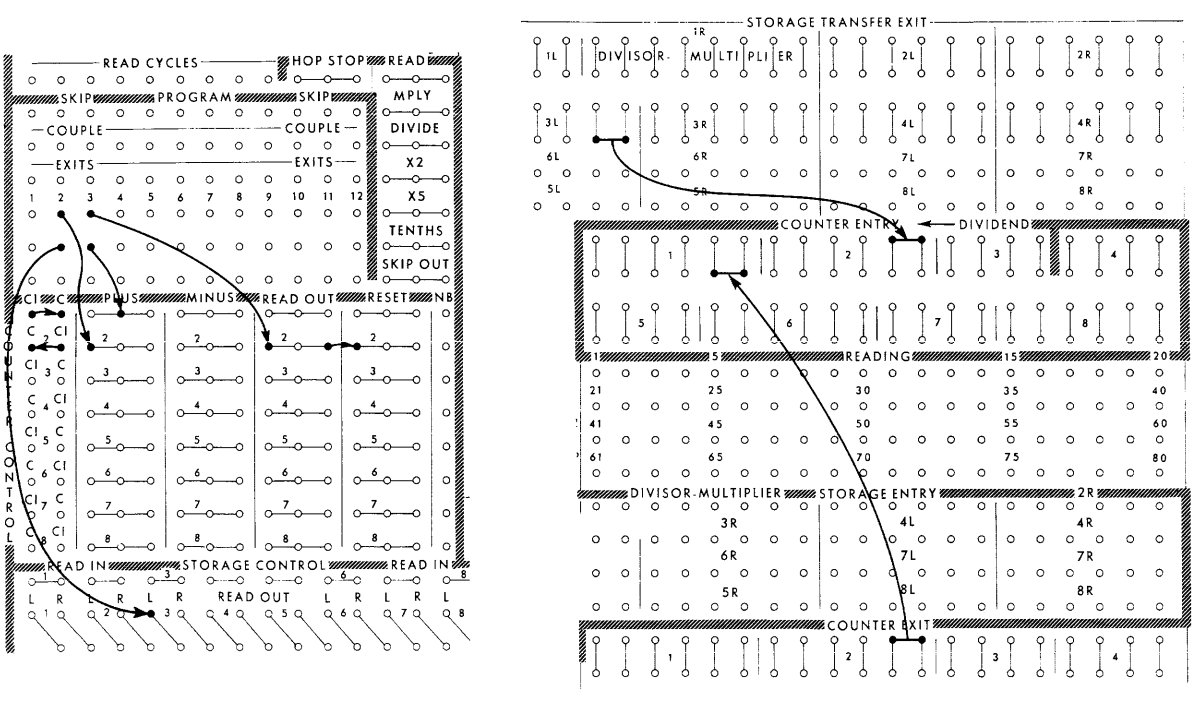


FIGURE 138

counter 1 as a result of the calculations up to this point. We have now reached the point where 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 would then multiply by the tens position of the multiplier and write that down under the first. We would continue in this way until we had used all of the positions of the multiplier. We would then add all of the individual products to get the final answer, which in this case would be gross pay.

```
   35
X 1.25
------
  1 75
  7 00
 35 00
------
 43.75
```

The following, then, are requirements of multiplication:

1. The multiplier must be stored in such a way 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 that we multiply by a different digit.

3. Some means must be provided to accumulate the individual products to get the total or final product.

You should remember that we said earlier that the multiplier had to go into storage unit 1. This is necessary to satisfy requirement 1 of multiplication. Circuits have been built into the machine for storage unit 1 to test each position individually for a multiplier factor when the multiply hub on the control panel is impulsed.

Requirement 2 of multiplication was satisfied by having the multiplicand in counter 1 where it can be read out as often as it is needed. The multiplicand may be in a counter or a storage unit, but must be wired to read out on the same program step that the multiply hubs are impulsed.

The last requirement is satisfied only by a counter, but any counter group of large enough capacity may be used. The counter group selected must be large enough to contain the product. 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) should be wired to add on the same program step from which the multiply hubs were wired.

Figure 139 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 hubs from counter exit 1 hubs 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 would then advance to the next step, or read another card, depending upon the control panel wiring.

Figure 140 shows the entire planning chart and control panel diagram for the problem we have just worked out. The next step of programming is not wired because no statement was made to tell us what we were to do with the product. However, the planning and wiring completed should illustrate the operation of programming and how calculation can be accomplished on the 602A.

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 on the 521 also reads the card to enter 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 very high speed compared to 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 card. This is considerably less than a 521 cycle. The 604 operates on a cycles basis also, but they are electronic cycles and, as indicated previously, they are much faster.

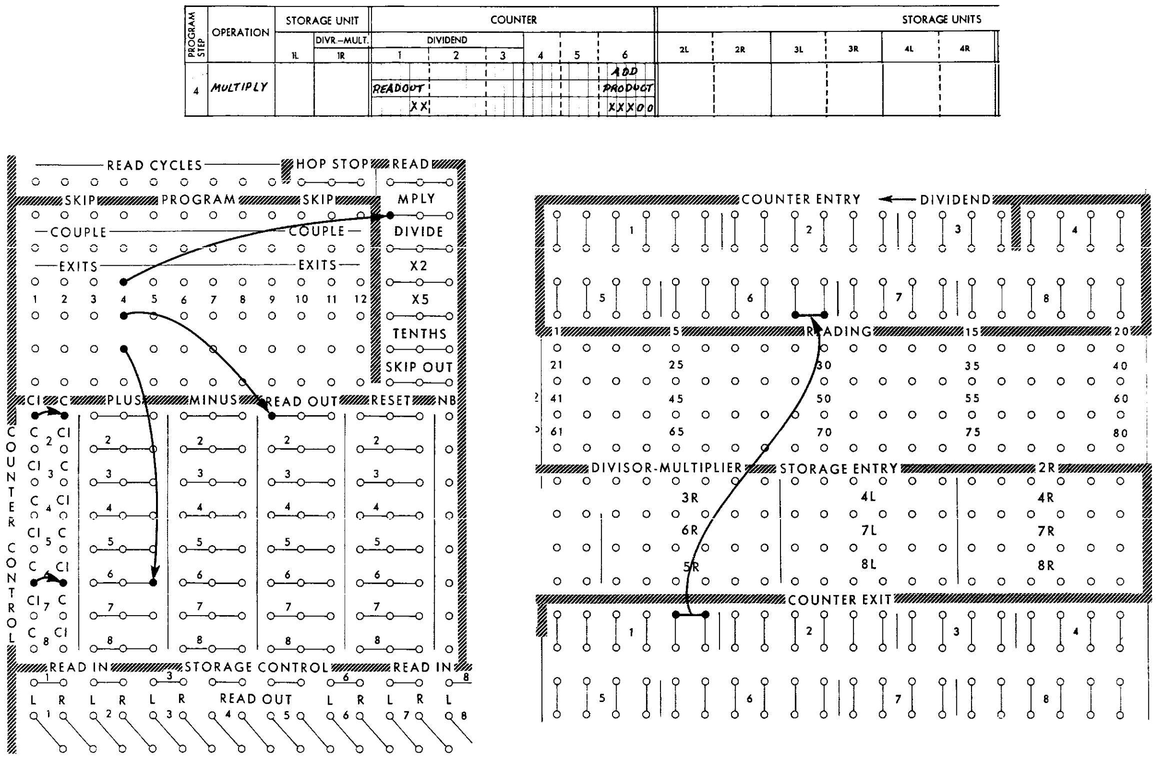


FIGURE 139

Actually, during the interval of time allowed for calculating there is time for 231 electronic cycles.

The program cycles are again automatically started following the reading of a card in the 521. The standard machine has 20 program steps but it may have 40, or 60, program steps if desired. The program steps, as in the 602A, will progress from program step 1 through the last step provided on the machine —20 on 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 for programming to be completed before the next card is read or the results are punched.

Now let's work the same problem that we did with the 602A, using the 604.

We must first read and store all of the factors concerning the problem, just as we did in the 602A and the manual method. This is done on a card cycle when the card is being read at first reading in the 521. It can be seen in Figure 141 that A is entered into factor storage unit 1 (FS1), B into factor storage unit 2 (FS2), C into FS3, D into FS4. E is put into general storage unit 1 (GS1) since we only have four factor storage units. It can also be seen that the rate is entered into the multiplier quotient unit (MQ). It was necessary to put the rate into this unit since it is to be the multiplier. All of the factors have now been entered into the 604 and the calculation can begin.

The planning chart and control wiring for the 602A were built together step by step. However, in the 604 we will plan it first and then wire the control panel, which is the normal way of arriving at the answer.

Figure 142 shows the first 5 programs steps planned, which is complete planning for getting the multiplicand developed.

As the planning chart 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 has to be developed by adding one factor at a time into the counter in a manner similar to the way we did it manually. There-

Program Suppress	Program Step	Operation	Storage Unit 1L	Storage Unit 1R (Divr.–Mult.)	Counter 1 (Dividend)	Counter 2 (Dividend)	Counter 3 (Dividend)	Counter 4	Counter 5	Counter 6	Storage Units 2L	2R	3L	3R	4L	4R	Punch Units 6L	6R	7L	7R
		READ CYCLE		READ IN R X00	ADD A XX	ADD B XX					READ IN C XX	READ IN D XX	READ IN E XX							
	1	ADD C to A ADD D to B			ADD C XX	ADD D XX					READ OUT	READ OUT								
	2	ADD E to (B+D)				ADD E XX							READ OUT							
	3	ADD (B+D+E) to (A+C)			ADD (B+D+E) XX	READ OUT & RESET														
	4	MULTIPLY			READ OUT XX					ADD PRODUCT XXX00										

*UNITS POSITION MUST BE WIRED TO PUNCH

CALCULATING PUNCH – TYPE 602A – CONTROL PANEL

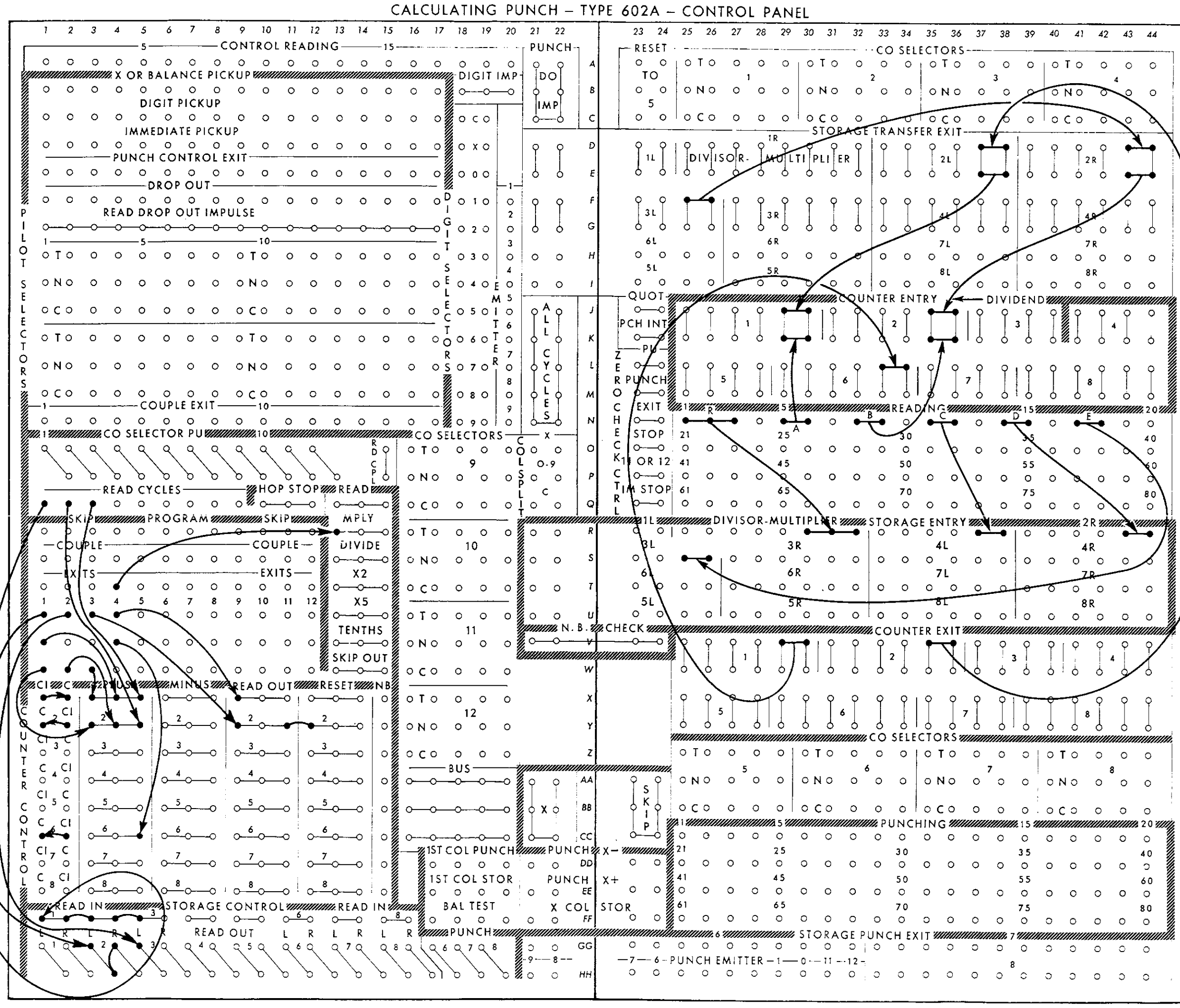


FIGURE 140

fore, 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 can satisfy 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. A counter to accumulate the product.

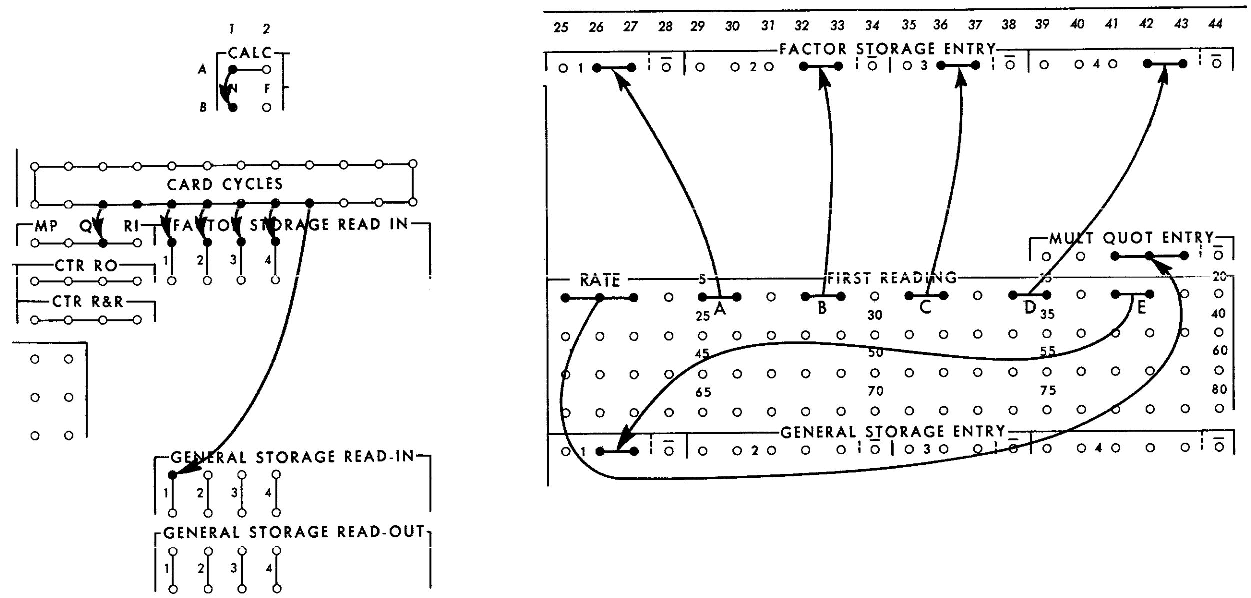


FIGURE 141

The first requirement was satisfied on the read cycle when the rate, or multiplier, was placed in the MQ unit. This unit is similar to 602A storage unit 1 in that 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 which we know is needed for the third requirement. Therefore, to satisfy both the second and third requirements, the multiplicand will have to be 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 can be a multiplication operation. The completed planning chart is shown in Figure 143.

The control panel wiring necessary on the 604 to do this problem is shown in Figure 144. On the first five program steps, the counter is impulsed to read in while the storage units are wired to read out on the program step indicated by the planning chart.

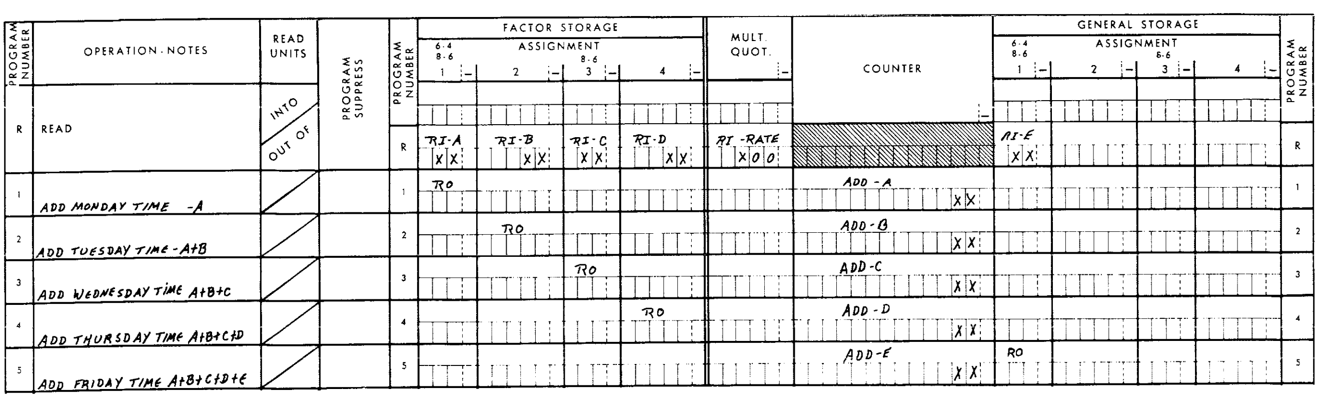


FIGURE 142

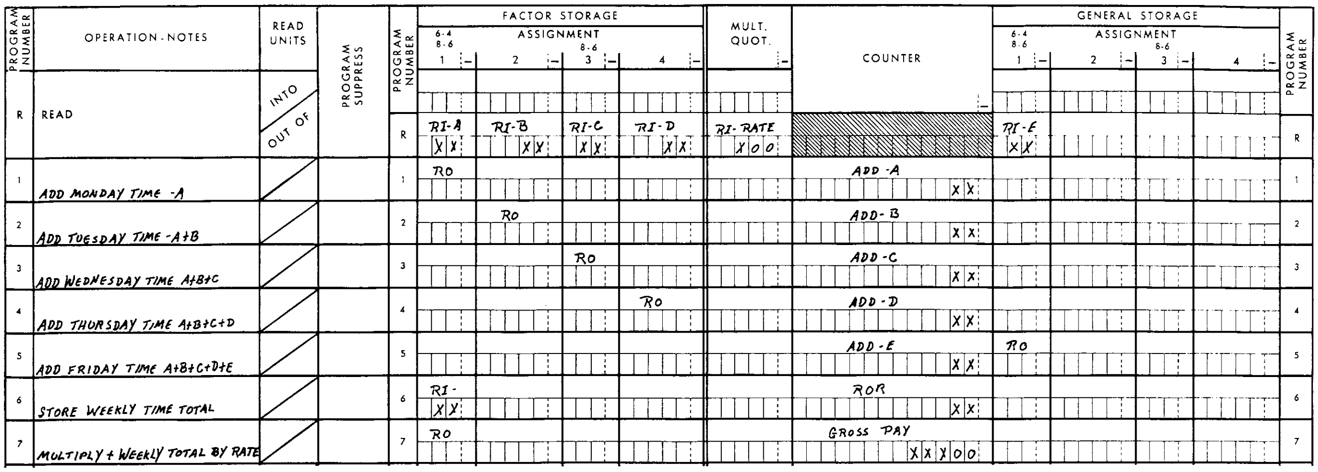


FIGURE 143

It should be apparent to you at this point that there is no position wiring on the 604 as there was on the 602A. All of the units in the 604 are wired together internally so that information read out of any unit could be accepted by any or all of the others if impulsed to read in. Of course, if a unit has not been impulsed to read in, then the impulses will have no effect on it.

The wiring on program step 6 is primarily to empty the counter so the product may be accumulated during the multiply operation. You will see that the counter was wired to read out and reset.

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 it goes into the counter, and since we want it to add rather than subtract we will do a multiply +. Now, go back to the planning chart and notice that we did indicate a multiply plus operation. There is no need for extra counter control wiring, since there is only one counter; it is impulsed internally as a result of the multiply + impulse. It is only necessary, then, to impulse the storage unit which has the multiplicand in it to read out and we have completed the control panel wiring.

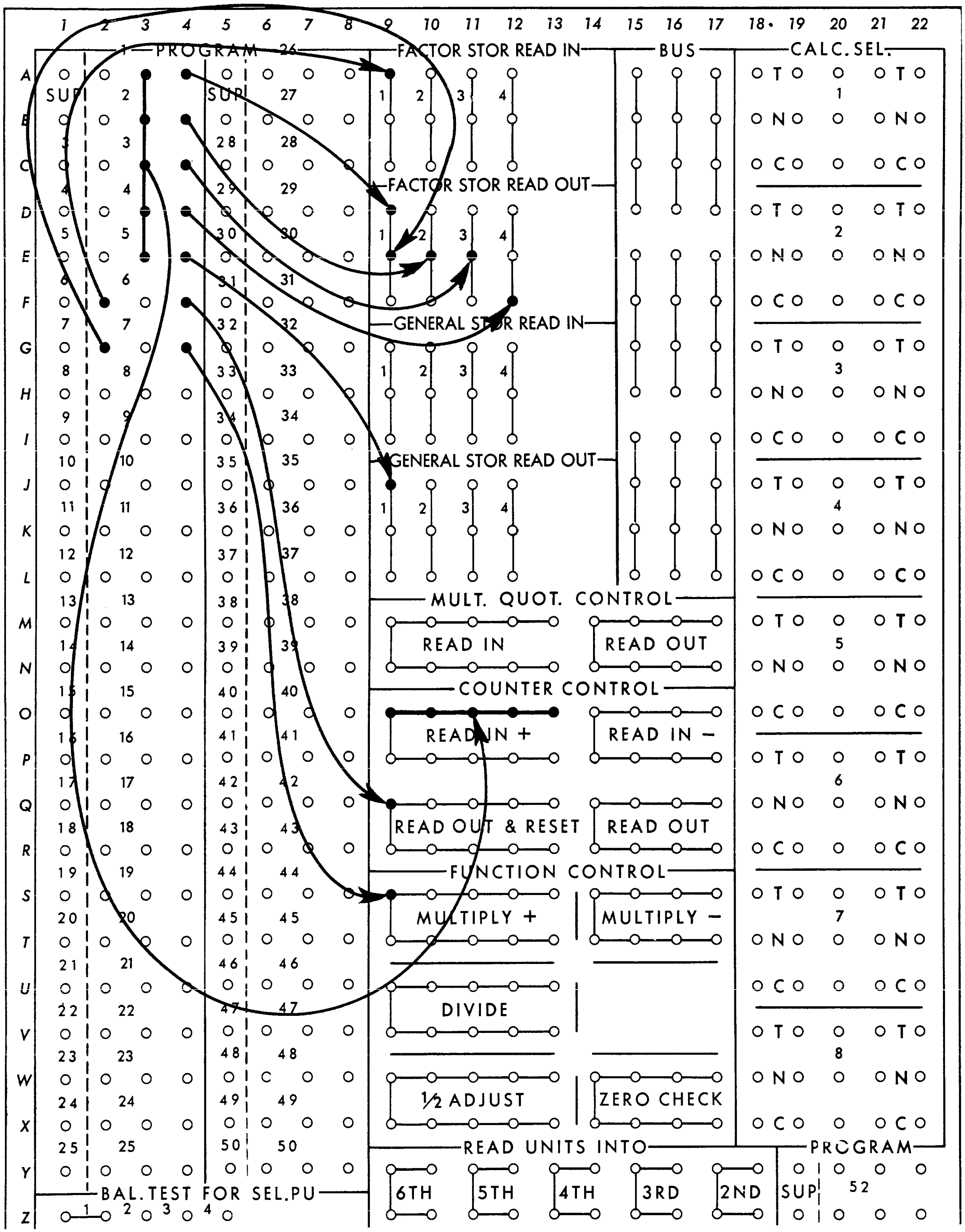
As you know, programming will continue to advance through all steps on the machine regardless of whether they are wired to control anything or not. However, it should again be pointed out that multiplication of this type cannot be completed in one cycle. The number of cycles required will depend upon the multiplier just as it did in the 602A. Again, as in the 602A, the 604 programming will remain in program step 7 and take as many cycles as necessary to complete multiplication before it advances.

The program steps following step 7 could be wired to perform any other calculations necessary and the results would normally be punched in the card that the factors were read from.

407 Accounting Machine

The program units that have been discussed up to this point are normally used for some type of calculation; secondly, 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 402-3 and 407 Accounting Machines. There are some differences between the program units used on the 402-3 and those used on the 407, but they are the same in principle and application. As a result, only the 407 will be discussed.

All of the general statements about programming made in the beginning of this section are also true of the 407 program unit. However, this unit is not used, as a rule, to perform calculations which involve multiplication. A multiplication operation can be done if it is not very complex, but there is no multiply hub which could be wired to cause it automatically. The usual type of calculating done on this machine is that of adding and subtracting. For example, a problem such as A+B+C could be done.



PROGRAM
FACTOR STOR READ IN
BUS
CALC. SEL.
SUP
FACTOR STOR READ OUT
GENERAL STOR READ IN
GENERAL STOR READ OUT
MULT. QUOT. CONTROL
READ IN
READ OUT
COUNTER CONTROL
READ IN +
READ IN −
READ OUT & RESET
READ OUT
FUNCTION CONTROL
MULTIPLY +
MULTIPLY −
DIVIDE
½ ADJUST
ZERO CHECK
READ UNITS INTO
6TH
5TH
4TH
3RD
2ND
BAL. TEST FOR SEL. PU

FIGURE 144

This is similar to the calculation of the weekly total of man hours worked in the problem we did on the 602A and 604. This type of calculation is generally referred to as crossfooting, which is not an uncommon application.

The normal use for the 407 type program unit is printing various types of totals which have been accumulated (Figure 145). 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 wanted to carry this a little further we could get a total sales amount for each state. As the cards pass through the machine, certain information, such as product and sales amount, will be printed from each card. This happens at the same time that the counters are accumulating the amounts from the amount field.

The total sales for each salesman would be printed as soon as all of his transactions have been accumulated. Similarly the total sales for each office and state would be printed as soon as all of the transactions for a given office or state have been accumulated. The totals by salesman would normally be printed on program step 1, the totals by office on program step 2, and the totals by state on program step 3.

The total of the office would include the sales made by all salesmen in the office, or, in other words, is the sum of all of the individual salesmen's totals. The state totals would be the sum of 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 often 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

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 *		
		2	A	28.64		
			B	4.26		
			C	42.63		
				75.53 *		
					137.48 *	
	2	1	A	10.16		
			B	4.22		
				14.38 *		
	2	2	B	42.50		
			C	53.72		
			D	10.81		
				107.03 *		
					121.41 *	
						258.89 *
2	1	1	A	48.21		
			B	33.33		

FIGURE 145

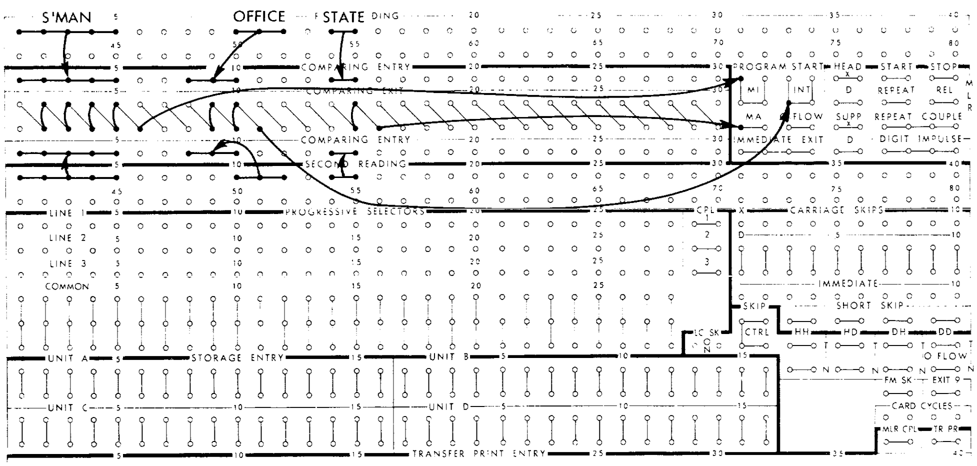


FIGURE 146

case total by office. The second program step is referred to as intermediate even though only two classes of totals may be 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 under the heading of *Accounting Machines*.

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 generally used. In the 602A you should remember that the number of program steps taken could be determined by wiring the last program step needed to the read hubs. However, in the 602A the same number of program steps was normally used for each card. In the 407 we want to vary the number of program steps taken depending upon the type of change in group which we will not refer to as a control change. We will use the impulses from the comparing unit to start programming. The number of program steps taken will be dependent upon how the programming is started. There are three different entries to start programming which are labeled, MINOR, INTERMEDIATE, and MAJOR. If the minor start hub is impulsed, then programming will automatically stop after program step 1. Programming will stop 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 146.

Since we have already studied accumulation, we will not be concerned about how counters are wired to add and subtract at this point. Now let's take a look at the wiring needed to cause totals to print according to the pattern we have established.

Assume that the total for salesmen is being accumulated in counter 4B, for office in counter 6B, and for state in counter 8B. It becomes a simple matter, then, to wire these counters to read out and reset on their respective program steps, and wire the counter exits to PRINT ENTRY. This is done as shown in Figure 147, and will give the type of report shown in Figure 145.

As you looked at the diagram in Figure 147, you perhaps noticed that there were more than three program steps labeled. However, it is true that only the first three are the normal programs in this machine. The remaining steps can be obtained by special programming which is a feature not covered in this manual.

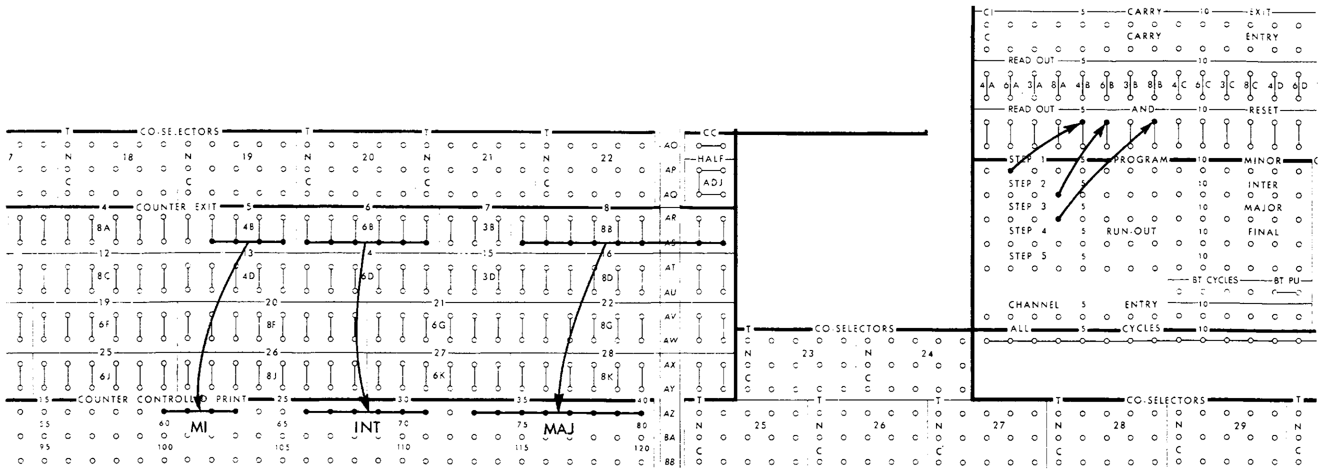


FIGURE 147

REVIEW QUESTIONS

1. In general terms, what is programming?
2. What is meant by calculating?
3. What causes programming to begin on the 602A?
4. Can the number of program steps taken by the 602A be determined by control panel wiring? If yes, what would you wire to control it?
5. On the 602A the multiplier must always be placed in what unit?
6. How would you instruct the 602A 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 would you wire to control it?
9. How would 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 would you wire to control it?
13. The program steps in the 407 have special names; what are they?

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