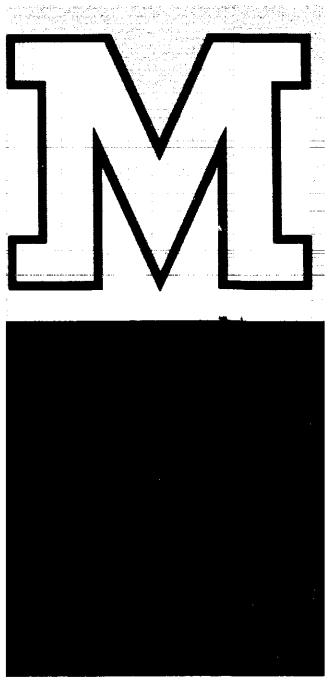

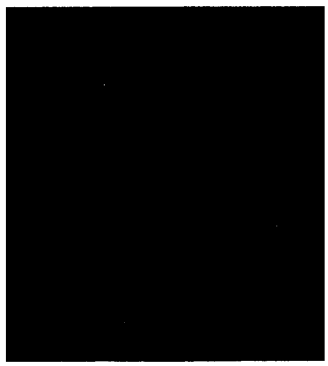

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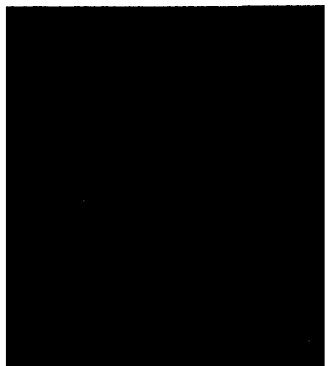

# Reference Manual

# Operator's Guide for

# IBM 7090 Data Processing System

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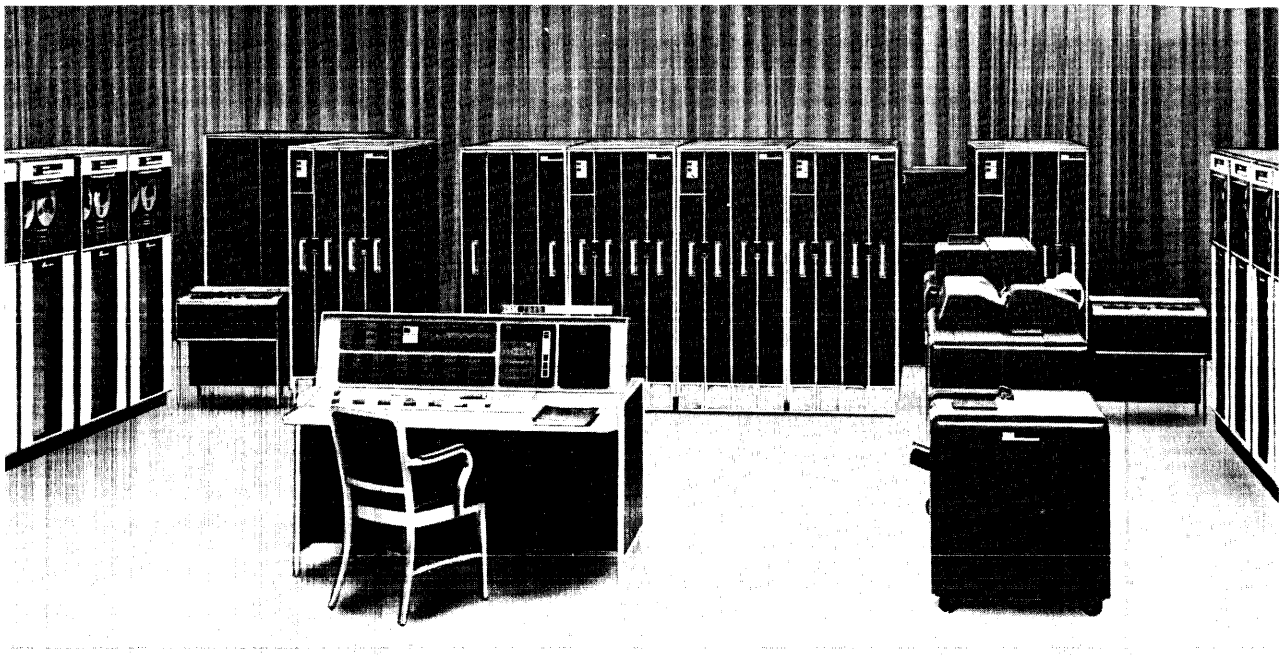
# IBM 7090 Data Processing System

# Contents



IBM 7090 Data Processing System

# Operator's Guide for IBM 7090 Data Processing System

The IBM 7151 Console Control (Figure 1) is a separate unit providing centralized control of the IBM 7090 Data Processing System. It contains indicators, switches, keys, and register displays for the operator's use. Channel indicators for data channel operation are provided and the register displays are grouped for convenience. Data in any storage location can be displayed and/or changed by manual insertion through use of the entry keys and switches.

A maintenance feature, marginal checking device, is also a part of the console. This feature can be used to vary voltages and operating frequencies during programmed diagnostic testing to detect potential difficulties before actual failure of components occurs.

The IBM 7617 Data Channel Console (Figure 2) provides increased input-output flexibility and efficiency between the 7090 computer system and its operator. One data channel is associated with each channel console. The console may be located up to 50 feet away from the data channel, permitting the console control and data channel consoles to be grouped for greater operating efficiency.

Instead of being intimately associated with the central processing unit, operator's consoles are logically separated from the main computer on the 7090 system. Some of the console keys and switches are subject to programmed interpretation and control. This interpretive approach provides close communication between man and computer when human intervention is desired or necessary. These features are provided because intelligent human intervention and supervision can often bring a problem to completion more quickly than computation alone.

Several operations may be performed from the data channel console when the console is in a manual mode (auto-manual switch in the manual position):

Data Transmission Operations
Non-data (Skipping) Tape Operations
Data Loading Operations
Data Storing Operations

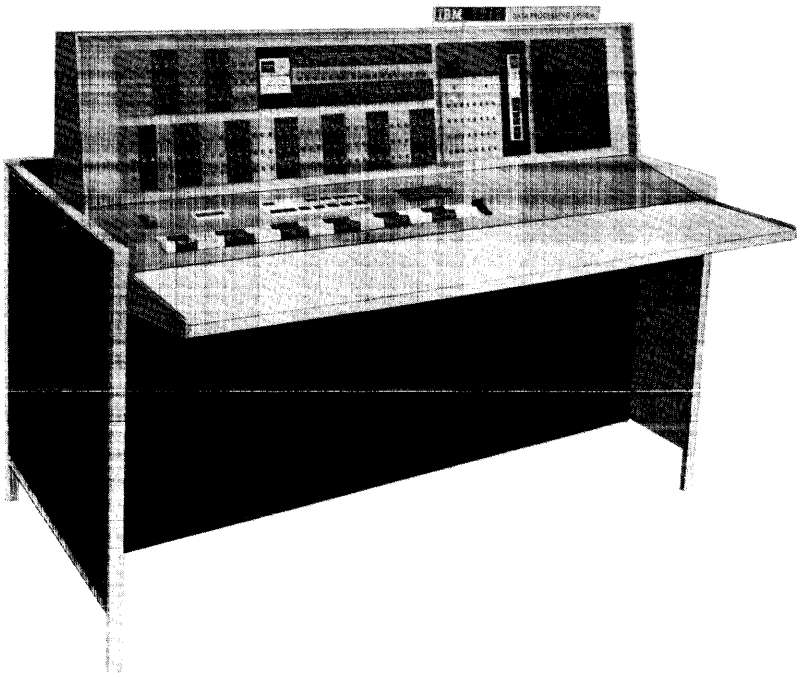


Figure 1. IBM 7151 Console Control

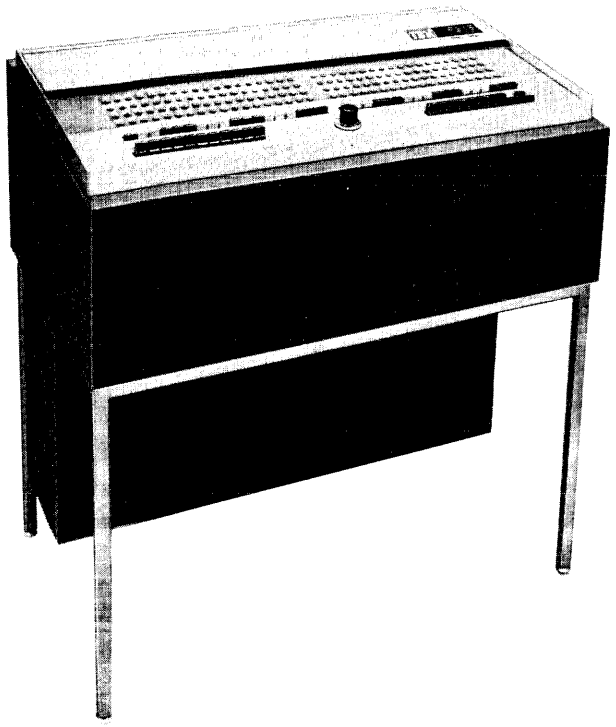


Figure 2. IBM 7617 Data Channel Console

3. To locate the operand, if any, in core storage as specified by the instruction's address field.

The units involved in an I cycle are shown in Figure 3, together with appropriate flow lines. The I cycle begins when the instruction counter furnishes the location of the instruction (to be executed) to the address register. From the address register, the location is sent to a word-locator in core storage, the storage address register. The controls for reading the instruction out of core storage are automatically set up and the instruction-word goes into the storage buffer register, and then to the storage bus. From the bus, the instruction is read into the storage register in the CPU and then the instruction register. With the new operation code in the instruction register, the operation decoders begin to set up the execution control circuits to perform the operation specified by the instruction.

While this execution control is being set up, the address part of the instruction is sent from the storage register to the adders. From the adders, where it can be modified by index register action, the address is routed to the address switches. At the beginning of

### Instruction and Data Flow

With a computer program in storage, the machine can operate and process data to produce desired results. The computer, then, is directed to perform each of its operations by an instruction which is interpreted by the central processing unit as an operation to be performed. Also, if data are involved, the instruction must necessarily tell the computer where it can find the data on which it is to operate.

All conditions and registers that affect the flow of information through the entire 7090 system are described in this section. The basic computer or machine cycle is 2.18 microseconds for the 7090 system. Four different types of cycles are used: instruction (I), execute (E), logic (L), and buffer (B). An understanding of the cyclic make-up of instructions is especially useful when testing and correcting or single-stepping through a stored program.

### Instruction Cycle

All instructions start with an I or instruction cycle. This cycle has three purposes:

1. To locate and obtain the instruction from core storage.
2. To establish the execution control circuits for that instruction.

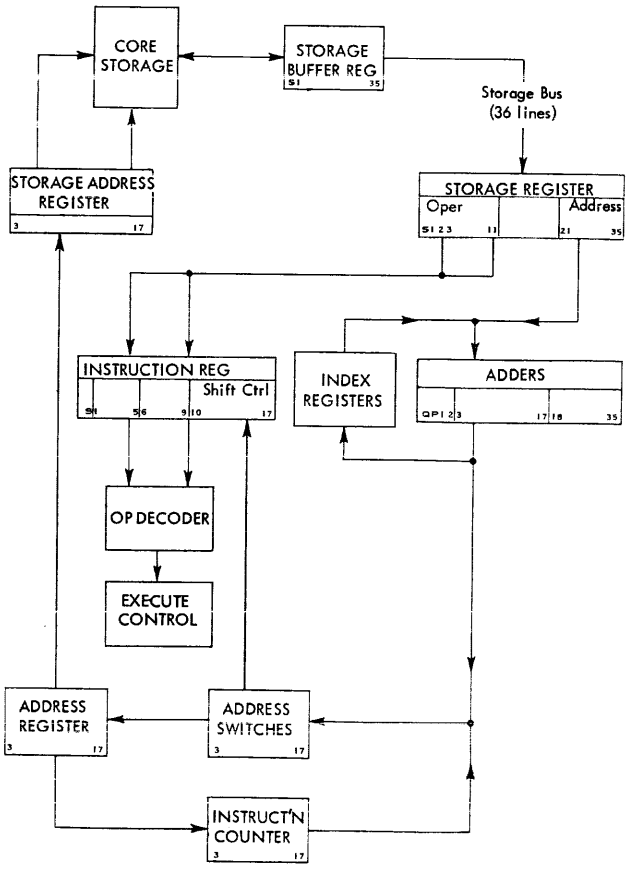



Figure 3. Instruction Flow

the next cycle, the address is placed in the address register, and if the cycle is an E cycle, the controls are set up to read or store a word at this location in core storage.

### Execution Cycle

The E or execution cycle is used when a reference to core storage is needed. All instructions requiring an operand must have an E cycle following the I cycle.

Indirect addressing of an instruction always requires an extra E cycle. In other words, an instruction that normally goes from I to E to be executed will go to I, E, and again to E if it is indirectly addressed.

### Logic Cycle

The L cycle is an execute cycle that does not require a reference to core storage. Many instructions use both E and L cycles, when information is required from storage and the instruction cannot be completed during an E cycle. Other instructions require no reference to storage and, therefore, use only I and L cycles for their completion.

Generally, those instructions whose operating coding is 0200 through 0667 have an E cycle immediately following the I cycle. The remaining instructions usually go from I to L.

### Buffer Cycle

A buffer or B cycle is used by the data channels to get information from or to put information into core storage. This information can be either data or data channel commands. All demands for B cycles come from the channels themselves. Because of the nature of input-output devices, the demand for a B cycle must take precedence over an instruction being performed in the CPU. Otherwise, the information coming from or going to the data channel might not be transmitted in time.

When an instruction having multiple L cycles is being executed and a B cycle is demanded, the data channel shares cycles (B and L) with the CPU. This means that during any given cycle, both L and B cycles may be performed together. If a convert instruction, using many E cycles, is being executed, a B cycle demand can interrupt the CPU for its storage reference.

### Information Flow, 7090

The information flow through the entire 7090 system is shown in Figures 4 and 5.

CENTRAL PROCESSING UNIT REGISTERS

*1. Instruction Counter (IC).* The instruction counter is 15 positions long to accommodate the largest core storage address.

The IC is used to tell the computer the location of the next instruction to be performed. It may be reset to zero at the start of a program or may be set to a predetermined address. Once the program is started, the IC counts sequentially unless a transfer instruction is executed. In this case, the IC is set to the address specified by the transfer instruction and is again stepped sequentially starting with this new address. The highest location in core storage and location zero are treated as consecutive addresses.

The IC is normally advanced at the end of each I cycle. However, some instructions cause the computer to skip one or two instructions and, therefore, the IC may be advanced as many as three times while the instruction is being completed. If a halt occurs during the execution of a divide or halt instruction or a halt and proceed instruction, the IC has the address of the instruction being executed *plus one*. Upon execution of a halt and transfer instruction, the IC contains the address of the halt instruction.

If the auto-manual switch is depressed to suspend the execution of a CPU program, the IC contains the address of the instruction to be executed.

*2. Address Switch (AS).* The address switch consists of a matrix of 17 positions. Its purpose is to allow either the contents of the IC or the contents of the adders to be placed in the address register, the storage bus switch, or the shift counter.

At the beginning of an I cycle, the IC is sent to the address switch in preparation for locating the instruction. Following an I cycle, the IC is blocked and the effective address is sent through the adders to the address switch. When a transfer takes place, the address register retains this address through the following I cycle.

The address switch is also used to take the adders to the storage bus switch for storing the index registers. Similarly, the instruction counter is stored by way of the address switches. During a shifting instruction, the number of places to be shifted is sent from the adders through the address switch to the shift counter. This is true of all instructions in which the address field refers to the operation rather than to a storage address. Input-output addresses and sense addresses are routed to the shift counter through the address switches.

*3. Address Register (AR).* The address register receives its information from the AS at the beginning of a storage reference cycle (I or E cycle). The contents

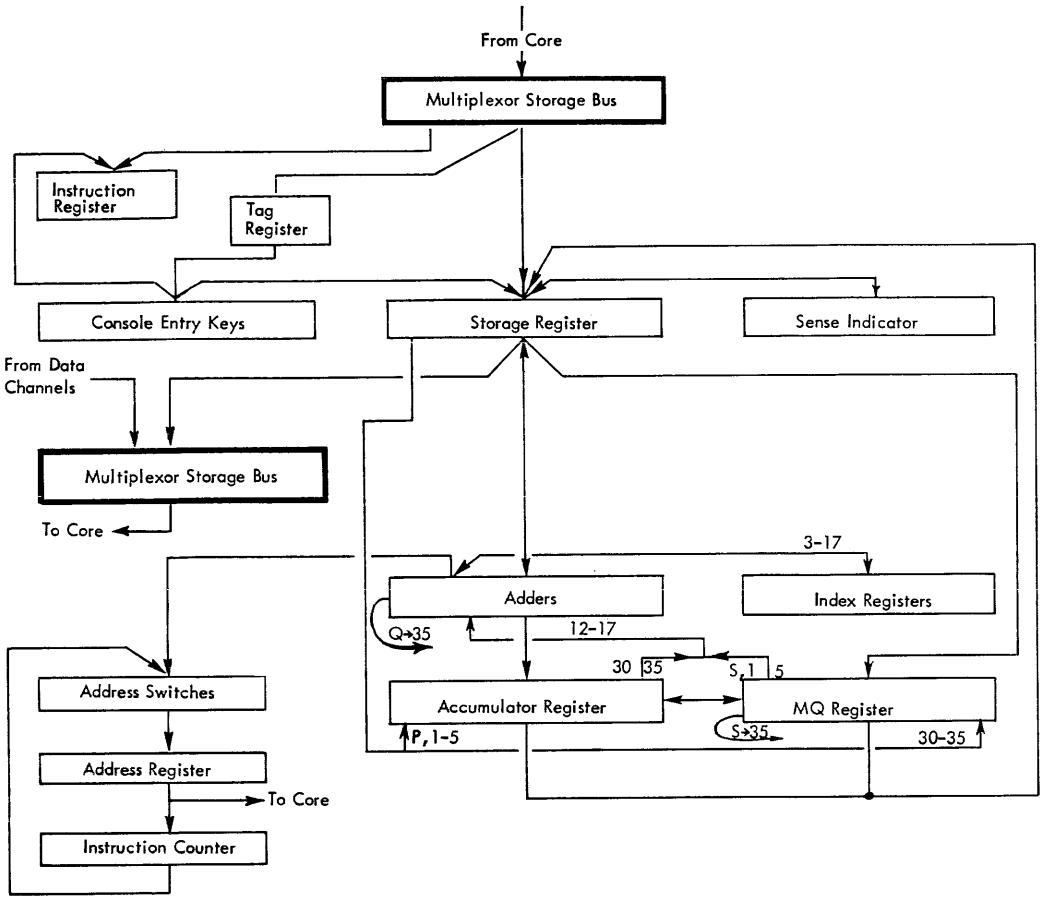



Figure 4. Central Processing Unit Registers, 7090

of the AR are sent to the storage address register to set up the proper core storage location to be used.

*4. Instruction Register (IR).* Instructions and data are both in the form of 36-bit words, and the computer finds the difference between the two in the following manner:

1. Any word brought into the computer during an I cycle is treated as an instruction.
2. A word brought in during E time is treated as data.

All information coming into the CPU from core storage is placed in the storage register. Since it is desirable to hold an instruction until it is completely executed, instructions are also held in the instruction register to make room in the storage register for data that may be required by the instruction.

The IR is divided into two parts. Positions S, 1-9 always contain the operation part of the instruction, while positions 10-17 form a counter known as the "shift counter." In shifting, multiplication, division, and floating-point instructions, the number of shifts to be made is placed in this shift counter. When the shift counter is not being used for shifting, positions 10 through 17 may contain:

A sense instruction address.

Operation codes for those instructions which require an address part.

The class and unit codes for input-output instructions.

NOTE: Data channel addresses are decoded from the storage register itself.

*5. Storage Register (SR).* The storage register is composed of 36 positions and performs many functions in the computer. As the name implies, it is used to store all information that comes to the CPU from core storage. From the SR, this information is routed to the other registers in the system.

*6. Adders.* The adders contain 37 positions. Positions 1 through 35 are normally used for arithmetic operations and positions Q and P are for overflow from these operations. The primary purpose of the adders is to add numbers. However, the adders also

furnish a path for data going from the storage register or index registers to various other registers in the computer.

*7. Accumulator Register (AC).* The accumulator register has 38 positions. They allow the AC to handle a 35-bit word with a sign, and provide two extra positions for overflow conditions. The AC is used to hold one factor during arithmetic operations and to receive results from the adders.

Information may be shifted into the accumulator from the MQ register, one bit at a time, or from the AC to the MQ, one bit at a time. All other flow paths are for the full 36-bit word.

*8. Multiplier-Quotient Register (MQ).* The MQ register has 36 positions. During a multiply instruction, this register contains the multiplier; during a divide instruction, it receives the quotient. It can store and shift a full 36-bit word. In addition to shifting right or left, it can also "ring shift" or "rotate." That is, bits shifted out of the sign position enter position 35.

*9. Sense Indicator Register (SI).* The sense indicator register is 36 positions long and is used to store words or parts of words for use in a calculation, or for matching or comparing results. It is controlled by the program and is not used by the computer as a part of its arithmetic operations. It is normally used as a set of switches which are set and tested by the program to determine the progress of a program.

*10. Index Register (XR).* There are three 15-position index registers in the system. They are parallel in operation and are used for address modification. They are called into use by the tag positions of an instruction and can be used singly or in parallel combinations. They modify an address by adding the 2's complement of their contents to the address. In effect, the address is reduced by the contents of the index register.

Many instructions operate on the index registers and make them useful programming tools for such functions as counting, word alteration, and program loop control.

*11. Tag Register (TR).* This register holds the tag field of the instruction being executed. Tag bits enter the register from console entry keys or the input multiplexor storage bus.

*12. Console Entry Keys.* These keys enable the operator to enter a word of information into the storage register. Data may also be fed directly to the instruction and tag registers. A bit configuration (1 if the key is down, 0 if up) may be set up in these keys, and if an enter key instruction is executed, the contents of the keys are entered into the MQ register.

### Data Channel Registers

The registers contained in the data channel (Figure 5) are:

*13. Location Counter (LC).* Each data channel has a 15-position location register. When a reset and load instruction loads the channel with a command from location $y$, the channel LC is set to $y + 1$. Then, when a new command is called for, the LC gets the next sequential command located at $y + 1$. The LC is advanced every time a command is loaded from the core storage.

It is possible to use more than one command after a select instruction. Control indicators S and 1 tell when a new command is needed. Control indicator 2 allows the new command to come from a different area of core storage and resembles the transfer instruction operation in the CPU. If control indicator 2 is off, the next command comes from the location of the last command plus one.

*14. Data Register (DR).* The data register consists of 36 positions, handling all words in a parallel fashion. It is similar in operation to the storage buffer register. All words coming into or out of the data channel must pass through the DR. Inputs to the data register come from core storage, tape shift register, and the card-reader reading brushes. Outputs from the data register are core storage, tape shift register, and the calculator exit register.

*15. Operation Register.* Positions S, 1, 2 and 19 of the data channel command contain the operation coding of the command. These positions are set into the operation register. Positions S, 1, and 2 contain the coding for one of the possible eight commands. Position 19 modifies these commands by indicating whether the data being handled are sent to core storage or not. The transfer-in-channel command may not be modified.

*16. Word Count Register (WR).* This register of 15 positions is set from positions 3-17 of the command. The WR is reduced once for every data word transmitted from the data channel. Once the word count reaches zero, no more words can be transmitted until a new command puts another word count into the WR.

*17. Channel Address Counter (CAC).* The channel address register is 15 positions long to use the largest core storage location. The address portion of the command usually contains the storage address of the first data word. This address is set into the CAC when the command is loaded into the channel. After each data word is handled, the CAC is stepped to the next sequential address. When a data word is stored or read out of core storage, the CAC sets the storage address

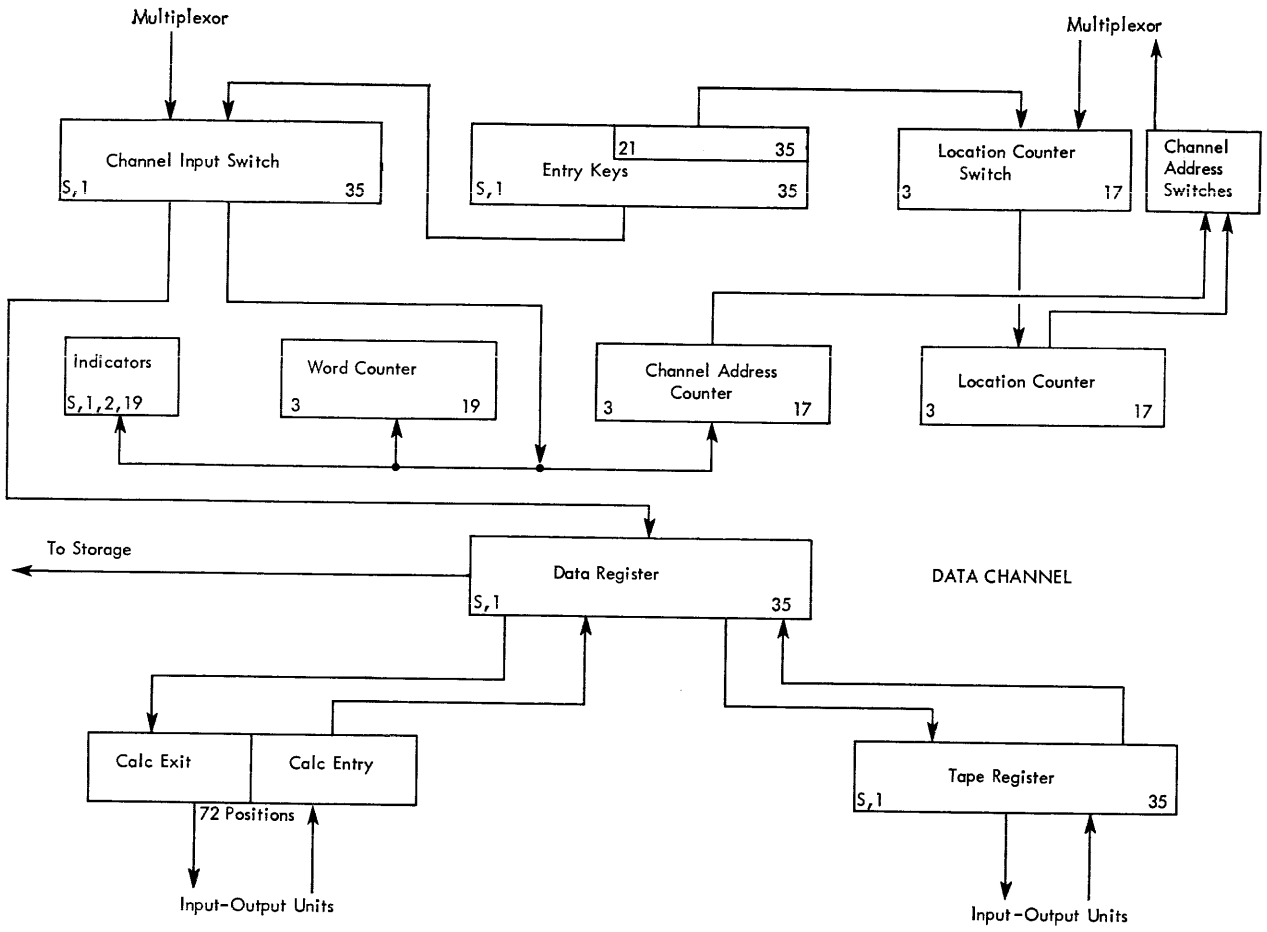



Figure 5. Data Flow, 7090

register. When a channel transfer is recognized, the contents of the CAC are returned to the storage address register to locate a new command.

*18. Calc Exit-Entry.* To punch or print the 72 possible positions for a row of information, two separate words must be brought from core storage. These words are stored in the 72-position exit-entry register because all punch or print magnets must be energized at about the same time. At the proper time, all 72 positions are sent to the output device being used.

*19. Tape Register.* Tape words coming from the data register are transmitted in parallel. Likewise, words going to the data register from the tape shift register are sent in parallel. Words going to and from the tape unit must, however, go in six-bit groups.

In writing a word on tape, the word is first sent from the data register to the tape shift register, and is then sent to the tape unit, six bits at a time. After the first six-bit group has been sent to the tape unit, the contents of the tape shift register are shifted six positions to the left. This process is repeated six times until the entire word has been written on tape.

In the case of reading, groups enter from the right of the tape shift register and are shifted left until a full word has been assembled.

*20. Data Channel Entry Keys.* These keys are similar in action to the console entry keys on the CPU. There is one set on each data channel console.

This section describes the operation of input-output devices that may be attached to the 7090 system. In addition to the information about operation of keys and lights, general information about magnetic tape and basic card machine features is included.

These devices are inherently mechanical and, once started in motion, will continue to move for a predetermined time. The tape unit moves tape from record gap to record gap, file gap to file gap, record gap to file gap, file gap to record gap, or from record or file gaps to the load point. The card equipment (card reader and card punch) motion is from card to card. Printer motion is from line to line. This motion, once started, cannot normally be stopped.

## Magnetic Tape Unit

### Magnetic Tape Handling

#### Dust Prevention

Foreign particles on tape can reduce the intensity of reading and recording pulses by increasing the distance between the tape and the read-write head. Be extremely careful to protect magnetic tape from dust and dirt.

Keep the tape in a dust proof container whenever it is not in use on a tape unit. When a reel of tape is removed from a tape unit, immediately place it in a container. Always place sponge rubber grommets or special clips on the reels as they are stored, to prevent the free end from unwinding in the container.

While the tape is on the machine, close the container; put it in some location where it is not exposed to dust and dirt.

Store tapes in some type of cabinet elevated from the floor and away from sources of paper or card dust. This should minimize the transfer of dust from the outside of the container to the reel during loading or unloading operations.

Never use the top of a tape unit as a working area. Placing materials on top of the units exposes them to heat and dust from the blowers in the unit. It might also interfere with the cooling of the tape unit.

To label a reel of tape for identification, other than by means of the provided card holder, use a material that can be removed without leaving a residue. Adhesive stickers that can be applied and removed easily are satisfactory. Never use an eraser to alter the identification on a label.

#### Damage Prevention

Information is recorded within .020 inch of the edge of the tape. Proper operation requires that the edge of the tape be free from nicks and kinks.

Handle reels near the hub whenever possible. In picking up reels, grip the reel between the center hole and the outer edge. Gripping the reel so as to compress its outer edges pinches the few turns of the tape near the outer edge of the reel. Persons handling tape reels inside and outside the machine room should be instructed to avoid pinching the reels or having contact with the exposed edges of the tape.

Dropping a reel of tape can easily damage both the reel and the tape. Never throw or mishandle reels even while they are protected in their containers.

#### Cleaning Tape and Tape Containers

To clean a tape, gently wipe the tape with a clean, lint-free cloth moistened with an IBM recommended tape transport cleaner.

Inspect containers periodically. Remove any accumulation of dust by washing with a regular household detergent.

#### Tape Break

If a tape break occurs, divide the reel into two smaller reels. It may be necessary to make a temporary splice in order to recover information; however, splicing is not recommended as a permanent correction procedure. In making a temporary splice, be sure to use the special low-cold-flowing splicing tape.

#### Dropped-Tape Inspection

If a reel of tape has been dropped, the reel may be broken or bent (bending is less likely, as a strain sufficient to bend a reel usually breaks it), the edge of the tape may be crimped, and the tape may be soiled. To test for and remedy these defects, proceed as described below:

1. Inspect the tape reel immediately. Breaking or bending of the reel can usually be found by visual inspection. In addition, check the reel for bending by mounting it on the hub of a tape unit. If the reel has been bent or broken, it obviously should not be used again but the tape may be serviceable.
2. Inspect the tape itself.
   a. If there is no evidence of crimping or other tape damage, and the reel is undamaged, thoroughly clean the tape (exposed or unwound) and reel. The tape is then in good operating condition. If at all possible, test to verify that the tape operates properly before using it on subsequent runs.
   b. If there is no evidence of tape damage, but the reel is damaged, thoroughly clean the tape (exposed or unwound) and rewind it on another reel. If possible, test to verify that the tape operates properly.
   c. If the edge of the tape is crimped, the action to be taken depends on whether the tape contains essential information. If the tape does not contain essential information, discard the crimped footage. If the tape contains essential information, thoroughly clean the tape and attempt to reconstruct this information through a tape-to-printer or other machine operation. Should reconstruction fail, the records in question must be rewritten from cards or from another source.

### Manual Operation of the Tape Units

On each tape unit, manual operations are performed by using the keys and lights appearing in Figure 6.

The tape address selector switch on a tape unit determines which one of the tape addresses may select this unit. If the switch is set to 1, the unit may be addressed by 201 in the BCD mode or 221 in the binary mode. This switch should not be rotated during any tape operation.

The select light is turned on only when the calculator selects the tape unit. The tape unit is in ready status (the ready light is on), provided the tape is loaded into the columns, the reel door interlock is closed, and the tape unit is not in the process of finding the load point (rewind or load operation). Manual control is indicated when the ready light is off, provided the tape unit is not rewinding or loading and the reel door is closed.

Pressing the start key places the tape unit under control of the data channel (and, indirectly, the calculator) and causes the ready light to be turned on, provided the tape unit is in ready status. Pressing the reset key removes the tape unit from the calculator's control. It turns off the ready light, and resets all controls to their normal positions. It also stops any tape operation which has been initiated (except high-speed rewind, which will revert to low-speed rewind). After the tape is loaded into the vacuum columns and low-speed rewind is in progress, press the reset key again to stop the low-speed rewind.

When the door is open, the reel door interlock prevents operation of the reel drive motors. If the reel door is closed and the ready light is off, pressing the load rewind key causes a fast rewind (if the tape is more than 450 feet from its load point) at the end of which the tape is loaded into the vacuum columns and searched in a backward direction for the load point. Pressing the unload key causes the tape unit to remove the tape from the vacuum columns and raise the head cover, regardless of the distribution of

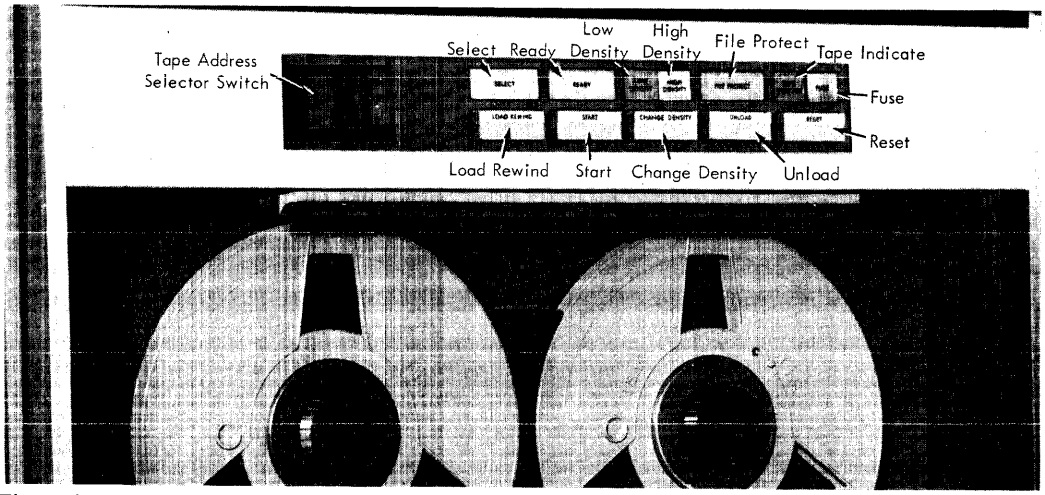


Figure 6. IBM 729 II and IV Keys and Lights

the tape on the two reels. If the tape is not at the load point when the operator wishes to change it, the operator starts a load point search by pressing the load-rewind key.

The EOT indicators in the channel and tape unit are turned on when the tape breaks or when the physical end of tape is reached during a write operation. The end of tape test (ETT) may be used in a program to interrogate the status of the end-of-tape indicator in a data channel. The status of the EOT indicator has no effect upon tape operation.

The end-of-tape indicator and light may be turned off by pressing the reset key on the tape unit and then pressing the unload key on the tape unit. Execution of the ETT instruction will turn off the EOT indicator in the data channel.

The change density key will change the density mode (high or low) when depressed. The stored program instruction will also accomplish the same density setting. Whatever density mode the tape unit is operating in will be reflected in either the high density or the low density lights.

The plastic tape reels are 10½ inches in diameter and are designed so that the front and back sides of the reel are different (Figure 7). In normal operation, a special ring is inserted in a groove in the back side of the reel to depress a pin which is then under spring tension. If the special ring is removed from the reel, the pin rides freely in this groove and a writing interlock is automatically set. Also, the file protect light is turned on to inform the program that it is impossible for the program to write on tape. However, this tape may be read, backspaced, or rewound freely when the file protect light is on.

The fuse light indicates, when on, that a fuse has burned out. Notify a customer engineer of this condition.

The tape transport mechanism of the 729 II and 729 IV tape units is shown in Figure 8.

### Tape Unload Procedure

To unload tape, use the following procedure:

1. Depress the reset key (tape unit) to turn off the ready light. Depressing the reset key is necessary only if the ready light is on.

2. Depress the load rewind key to rewind the tape.

3. When the load point has been reached, depress the unload key.

4. Open the reel door when the head cover is fully raised, the tape is out of the columns, and the load point is under the photoelectric cell. Do not open the door of the tape unit until the tape drive mechanism has completed the unloading sequence.

5. Hold depressed the reel release key and manually rewind the file reel by turning it in a counterclockwise direction with the finger pressed in the finger hole of the reel.

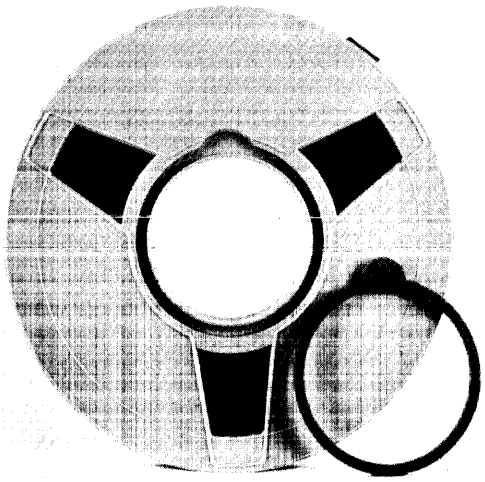


Figure 7. Protect Ring

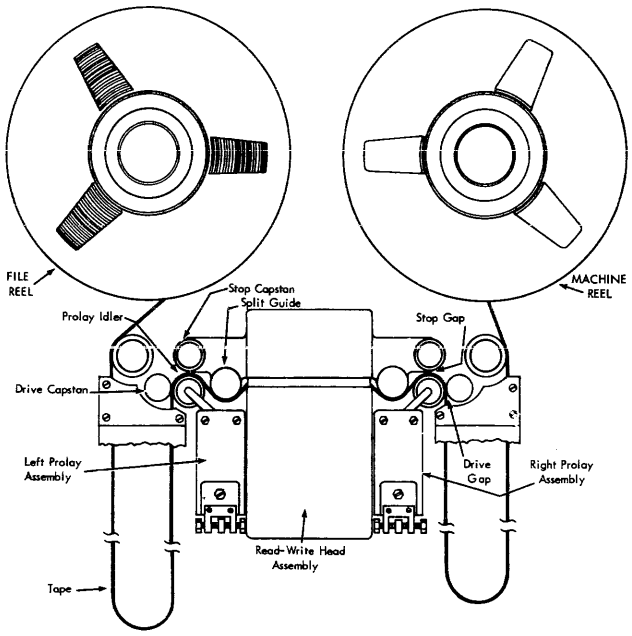



Figure 8. Schematic, Tape Feed

6. When the tape has been completely rewound, loosen the hub knob and remove the reel. If resistance is encountered in removing a reel, exert pressure from the rear of the reel with the hands as near the hub as possible. Never rock a reel by grasping it near the outer periphery in such a way as to pinch the edges of the outer turns of tape.

7. Check the removed reel to determine whether it is to be file protected and whether it has been labeled correctly. Place the reel in the container. If the file protection ring has been removed and the file protect light fails to go on, notify the customer engineer immediately.

### Tape Load Procedure

Before the tape load procedure is initiated, the magnetic tape unit should be in an unload condition and tape removed from the machine.

1. Check the reel to be loaded to determine if it should have the file protection ring inserted or removed. The file protection ring must be used in card-to-tape operation. Mount the reel to be loaded on the left mounting hub and tighten the hub knob (Figure 8). Place an empty reel on the right mounting hub and tighten the hub knob. The hub contains a rubber rim that grips the reel tightly when the knob in the center of the hub is tightened. When loading, push the reels firmly against the stop on the mounting hub to insure proper alignment. Always be careful that the hub knobs have been tightened during loading. However, do not use excessive force when tightening the hub knobs, for this tends to strip the threads.

2. Hold the reel release key depressed and rotate the file reel in a clockwise direction, unwinding about four feet of tape.

3. Place the tape over the left roller through the read-write head assembly and over the right roller (Figure 8). Place and hold the end of the tape between the index finger and the hub of the machine reel. Depressing the reel release key, wind the tape on the machine reel in a clockwise direction for at least two turns beyond the load point marker. When placing tape on the machine reel, align it carefully to prevent damage to the edge on the first few turns. When winding the tape to load point, rotate the machine reel with the finger in the reel finger hold or near the hub and on the reel. Rotating the reel with the finger in the cutout can result in nicking or curling the edge of the tape.

4. Close the reel door. Make sure that the door interlock switch is closed.

5. Set the address selector switch to the correct address position.

6. Depress the load rewind key to: (1) load tape into the vacuum columns, (2) lower the head assembly, and (3) rewind the tape to the load point.

7. Depress the start key. This places the tape unit under automatic control and turns on the ready light.

NOTE: Do not turn power off with the tape unit in a load status because the head assembly must be up for removal of tape. If power is turned off after leaving load point, it will be necessary to begin a new start procedure to resume operation.

## Punched Cards

In most applications, magnetic tape is used as the principal input medium. It may be desirable to use IBM cards as input in some situations, where the volume of input is sufficiently small to permit an economical operation. In either case, IBM cards are used as the medium for initially recording data because of their great flexibility and because of the availability of apparatus for key punching, verifying, and duplicating. Errors are easily detected and corrected, input data may be readily prepared on several key-punches simultaneously, and the cards may be collected before entry into the computer.

Cards are particularly useful when manual access to a file is desired. Punched card input and output may represent any alphabetic character, special symbol, or binary punching if the programs which manipulate this information are designed to recognize the code used (Figure 9).

Entering a program on cards may be done in such a way that instructions are punched, one to a card, in the form most desirable to the programmer. The computer can then be supplied with a translation program, to assemble the instructions in the desired order. Then, if errors are detected or if changes must be made, the error cards are removed, the correct ones are added, and the computer prepares the new program. Note that all cards need not be punched again; only the ones that were in error.

The card feeding mechanism in the card reader includes two sets of 80 reading brushes. Correspondingly, there are 80 punching magnets and 80 punch brushes in the card punch. Only 72 columns of the standard IBM card, however, can be read into core storage, and only 72 positions can be punched from core storage during one given cycle. Any 72 columns of the card can be selected through control panel wiring. For simplicity in the following discussion, as-

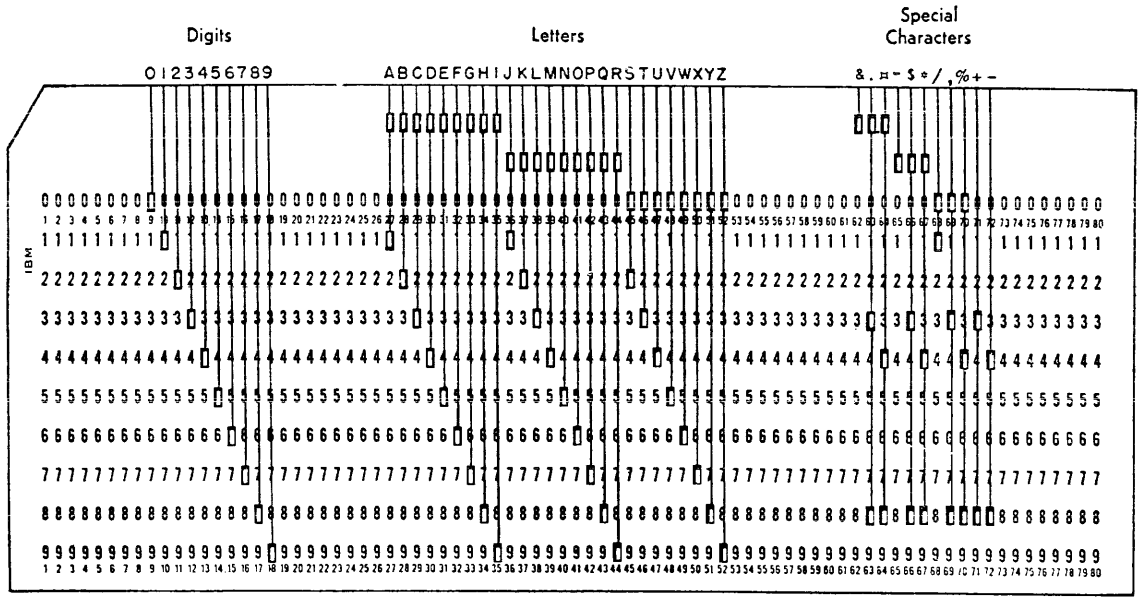



Figure 9. Standard IBM Card Code

sume that columns 1-72 are used for both reading and punching.

Binary information is represented on a card as follows: each of the 12 rows of the card is split into two parts, the left half consisting of columns 1 to 36 and the right half of columns 37-72; each half-row can be treated as a 36-bit word and read into a location in core storage.

Figure 10 shows how the card is divided. In this particular example, the first 72 columns of the card are used. Each of the rows is split into half-rows of 36 columns each. Thus, the half-row identified by the circled 9 is named the 5-row left. Similarly, the row identified by the circled 10 is named the 5-row right. Thus, there are 24 half-rows in the card. One full word of binary information (including sign) can be punched in any half-row. The machine regards any punched hole as a binary 1. No punch indicates a binary 0. Likewise, an 8-punch in column 36 of the card is regarded by the machine as a binary 1 in the least significant position of the binary word punched in the 8-row left. The left-most position of each half-row is reserved for the sign bit of the word. A binary 1 represents a negative sign, while a binary 0 represents a positive sign.

Observe that this card representation of 24 binary words does not mean that the cards must always be punched with true binary information. The holes in

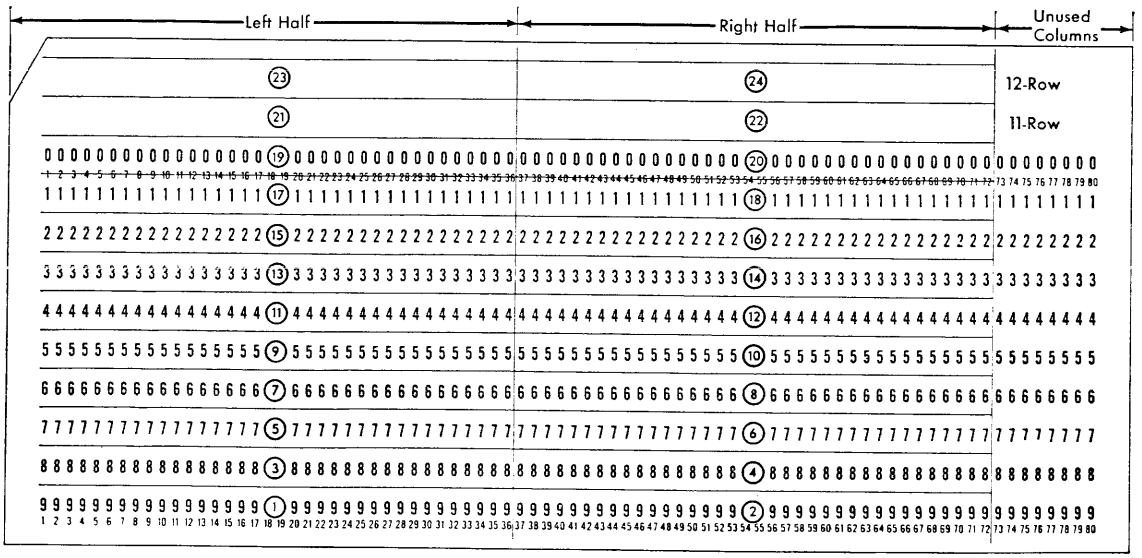



Figure 10. Sequence of Reading or Punching

the card can just as well be numerical punching in the standard decimal card code, alphabetic punching, or control punching.

Decimal information may be converted to or from binary code without reducing the standard rate of 250 cards-per-minute for reading and 100 cards-per-minute for punching. Faster conversion times result between BCD and binary if the computer's convert instructions are used.

Feed cards face down, 9-edge first in both the card reader and the card punch. The internal card circuits are arranged so that the 24 half-rows of the card are read or punched in the sequence indicated by the circled numbers in Figure 10. The sequence of reading or punching full cards is then as follows: 9-row left, 9-row right, 8-row left, 8-row right, and so on, to the 12-row right.

For reading and punching cards, a record is defined as the information contained in one card. A file consists of any number of cards (records). It takes the form of a deck of cards. Note that definitions of records and files are usually different, depending on the particular input or output component being discussed.

Certain basic features that are used in most punched card machines are described briefly in the following sections.

## Basic Card Machine Features

### Emitting

Frequently it is necessary to print or punch repetitive information that is not punched in a card. 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, IBM machines have two types of digit emitters. These are called digit emitters and digit selectors.

### Digit Emitters

A digit emitter is basically a switch with twelve timed positions (Figure 11). Each position is wired to the control panel and numbered to correspond with a punching position.

The switch is operated by the machine so that the 12 positions are connected to the common, one at a time. Thus, the 12 hub emits an impulse at 12 time, the 9 hub at 9 time, and so on. The common is the source of power and is internally connected.

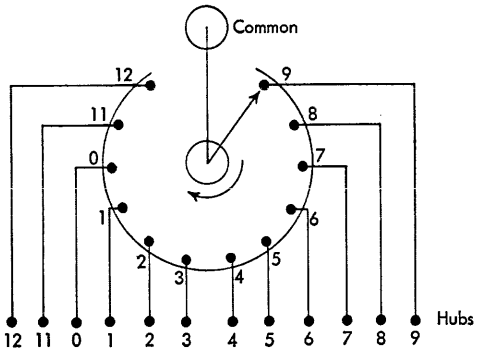


Figure 11. Digit Emitter

### Digit Selector

The emitter just described had the source of power (common) permanently wired. The digit selector operates in exactly the same manner as the digit emitter with the exception that the common is not internally connected. This gives greater flexibility in allowing the operator to wire the source of power (common) into the emitter. The common hub may be connected to a digit impulse hub to make the selector operate as an emitter.

### Column Splits

When a brush reads a card column that has all holes punched, all 12 punches are available at the read brush hub. Often it is necessary to divide the punches of a column into two separate groups, 0-9 and 11-12. This may be done by use of a column split. The column split on the control panel consists of common, 0-9, and 11-12 hubs (Figure 12). From 0 through 9

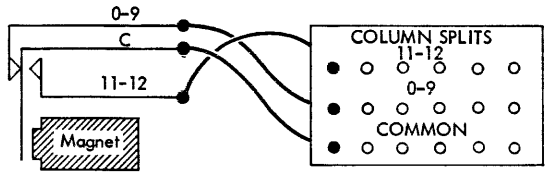


Figure 12. Column Split

time, the common hub is connected to the 0-9 hub. For 11-12 time the common hub is connected to the 11-12 hub. Any of the hubs of the column split may be used for an exit or an entry hub. When using a column split, be careful to use the common, 0-9 and 11-12 hubs belonging to the same column-split position.

### Selectors (Pilot, Co-selectors)

Fundamentally, the selector (Figure 13) is like the column split. The main difference between the two

is the same that exists between the digit emitters and selectors. One is picked up automatically (column split and digit emitter), while the other one must be picked up from control panel wiring. The control panel hubs are sometimes labeled differently but the principle is the same; there is a common hub, a transferred hub, and a normal hub. Selectors may be picked up or energized in a variety of ways. Some pickups are immediate while some are delayed. Particular types will be explained in greater detail when they are encountered.

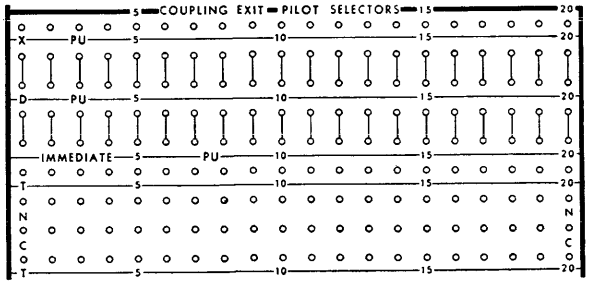



Figure 13. Selector Hubs

### Filters

An impulse that is used to perform several functions is sometimes wired through a filter (Figure 14) which serves to distribute that impulse without causing back-circuits. The filter prevents back-circuits from the exit (out) hub to the entry (in) hub, and from one exit hub to another. All impulses except those from another filter may be wired through a filter. If more than two exits are needed, the entries of two or more filters should be wired in parallel from the impulse source.

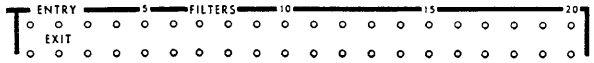



Figure 14. Filter Hubs

## Card Reader

### Manual Operation

To prepare the card reader for control by the channel once the control panel is in place, it is necessary only to fill the hopper with cards and hold the start key down until the ready light comes on. Figure 15 shows the card path through the reader, and indicates the relative locations of the card levers, contacts and reading brushes as the cards move through the reader under control of the stored program. After the reader has been prepared for channel control and the ready light is on, there are two cards in the reader, and all card contacts (upper and lower card levers, and the hopper contact) are closed.

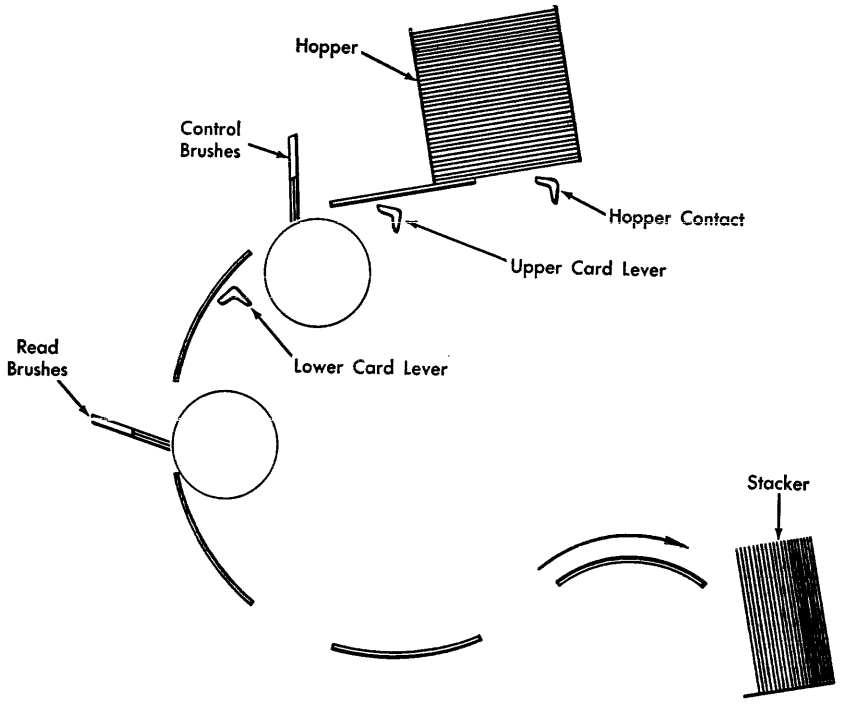



Figure 15. Card Path in Card Reader

### Keys and Lights

The following section (Figure 16) describes the operation of the various keys and lights on the reader.

*Start Key.* This serves to run in cards initially and to turn control of the reader over to the channel. The key is operative only if power is on, no fuses are blown, there is no card-feed failure, and the control panel calculator switch is wired on. If there is no card waiting ahead of the read brushes, press the start key to operate the card feed for one or more card cycles until the key is released or until the card enters the station just ahead of the read brushes. When the first card reaches this station, the start key causes control of the reader to be turned over to the channel and the ready light to go on.

If there is a card waiting ahead of the read brushes, pressing the start key merely turns control of the reader over to the channel and the ready light is turned on. Without cards in the hopper or the card station ahead of the read brushes, pressing the start key turns on the ready light and allows the channel to set up an end-of-file condition. While the ready light is on, the start key is inoperative.

*Stop Key.* This key, when depressed, turns off the ready light and prevents operation of the reader by the channel. If a card is being read at the time the stop key is pressed, the stop action is delayed, and the reader continues until the end of the current card feed cycle. If reading of another card is called for by the channel, the reader select light remains on and the channel remains in operation, but no data transmission will occur. The main program continues unless another transmitting select instruction addresses the channel to which the reader is attached; in this event both the main program and the channel are held up until the reader is restored to a ready status.

*Feed Key.* If the ready light is off, depressing this key causes cards to feed without reading into the channel. The feed key is normally used to run out the last cards after reading is completed. Five cards remain in the feed after the hopper becomes empty; two cards remain after sensing an end of file.

*Ready Light.* This light indicates tnat the card reader is under control of the channel. The ready light is turned on by the start key and is turned off as follows:

1. By the stop key.
2. When there is a card-feed failure.
3. When a fuse is blown or power goes off.
4. When the control panel is removed.
5. When the stacker is full.

The hopper contact opens when the hopper runs out of cards. This turns off the ready light and stops the reader. The reader may be restarted by pressing the start key regardless of whether more cards were placed in the hopper.

*Select Light.* This light goes on when the channel calls for a card feed cycle from the reader. The light goes off when the cycle called for has started.

*Card Feed Stop Light.* This light is on whenever there is a card feed failure.

*Power-on Light.* This light indicates that the power (DC) is on in the reader.

*Fuse Light.* This light indicates a blown fuse in the reader if the main power is still on.

### Card Feed Failure

When a card feed failure occurs, the card feed stop light is turned on. The start key is inoperative until the following procedure is accomplished:

1. Remove all cards from the hopper and repair the card that did not feed.
2. Run out the cards in the feed unit by use of the feed key.
3. Press the stop key (to reset the card feed stop light).
4. Obtain the last card run out of the feed from the stacker and place it in the hopper in front of the cards remaining to be read.
5. Depress the start key until the ready light goes on.

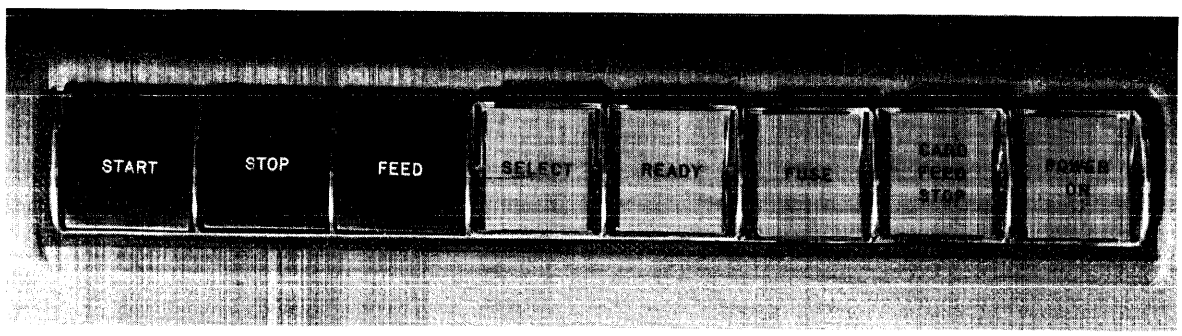



Figure 16. Keys and Lights of Card Reader

The stop key will not reset the card feed stop light if there are still cards in the hopper or in the feed station ahead of the read brushes.

### Control Panel

The following hubs are shown on the control panel illustrated in Figure 17. For convenient reference, vertical rows of hubs are numbered 1 through 22 and the horizontal rows are lettered A through HH.

*Card Cycles (A, 113).* A 0° to 216° impulse is emitted from these hubs every card feed cycle.

*Digit Impulses* (R, 21-22). Digit impulses are available at these hubs each cycle that a card is being read under control of the channel.

*Control Brushes (Q-T, 1-20); Read Brushes (X-AA, 1-20).* These brushes (read and control) emit impulses according to the information read from the card.

*Split Column Control* (D, 11-21). Each hub of this group emits an impulse half-way between the associated digit impulse and the next lower digit impulse; i.e., the 9 hub emits an impulse between the 9 and 8 digit impulses, hub 8 emits between the reading of the 8 and 7 rows, and so on.

*Calc Entry Left and Right (EE-HH, 1-20).* These hubs are entries for impulses from the reading of the card, to be transmitted to core storage. Successive word transmission through the channel takes words alternately from 36 left hubs and then 36 right hubs.

*On (A-B, 22).* This pair of hubs must be wired together for the reader to operate under channel control.

*Pilot Selectors (D-M, 1-10).* These selectors have three sets of pickup hubs labeled 11-12, 9-12, and immediate. Whenever the 11-12 or the 9-12 hubs are used to pick up a selector, the selector contacts transfer at 240° and remain that way until 225° of the next card cycle. The 11-12 hubs accept only 11 and 12 digit impulses. For example, a card cycles impulse or the impulse emitted by the split column control 11 hub would be acceptable. The 9-12 hubs accept any impulse whatsoever. Once the hub is impulsed, the common and normal contacts of the selector remain connected until 240°, at which time the selector transfers until 225° of the following cycle.

Immediate pickup hubs are also responsive to all impulses emitted by the reader. When the immediate hub is impulsed, the selector transfers almost immediately and remains that way until 225°. Note that a split column control impulse will cause a pilot selector to transfer before the next digit impulse occurs.

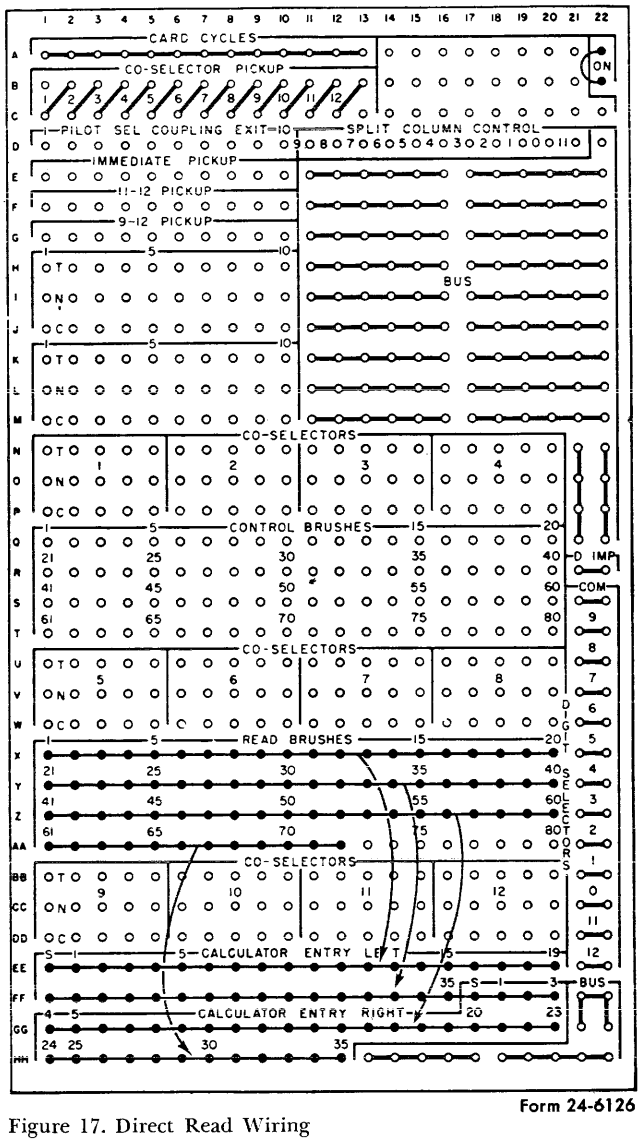



Figure 17. Direct Read Wiring

*Pilot Selector Coupling Exit (D, 1-10).* One of these hubs is associated with each of the ten pilot selectors. Picking up a selector with either the 11-12 or 9-12 hubs will cause an impulse to be emitted at the coupling exit from 340° to 16°. If this exit is wired to a co-selector pickup hub, the co-selector will be picked up with the pilot selector.

*Co-selectors (N-P, U-W, BB-DD, 1-20).* The action of the co-selector pickup hubs is the same as that of the immediate pickup hubs on the pilot selectors. Any impulse emitted by the reader is sufficient to pick up the co-selector and, once this is done, the selector remains that way until 225°.

*Digit Selectors (R-EE, 21-22).* With the common hub wired from the card cycles hub, the digit selector hubs will emit an impulse at the time marked on the specific hub; i.e., the 9 hub will emit at 9 time, the 8 hub at 8 time, and so on.

*Bus Hubs.* The bus hubs connected by a heavy line are common to each other. They are normally used as connecting points where more than two wires are needed to or from any given hub. They are not internally connected to any machine function.

### Control Panel Wiring

The control panel wiring shown in Figure 17 is for direct reading (without selector control) of the first 72 card columns of each card into core storage under calculator control. A selective read operation could be wired as shown in Figure 18. Assume that only detail cards, with a 12 punch in card column 75, are to be read into core storage. All other cards are to be spaced over and not read into core storage. The following procedure is used:

1. The split column control 11 hub is wired to the immediate pickup hub of pilot selector 1.
2. The control brush for card column 75 is wired to the common of pilot selector 1.
3. The transferred hub of pilot selector 1 is wired to the pickup hub of pilot selector 2.
4. The card cycles hub is wired to the common of pilot selector 2.
5. The transferred hub of selector 2 is wired to pick up all other pilot selectors and co-selectors that are being used.
6. Read brushes for card columns 1-60 are wired to the commons of co-selectors 1 to 12.
7. The transferred hubs of these co-selectors are wired to calculator entry left S-35 and right S-23.
8. Read brushes for card columns 61-72 are wired to commons of pilot selectors 5-10.
9. Transferred hubs of pilot selectors 5-10 are wired to calculator entry right 24-35.

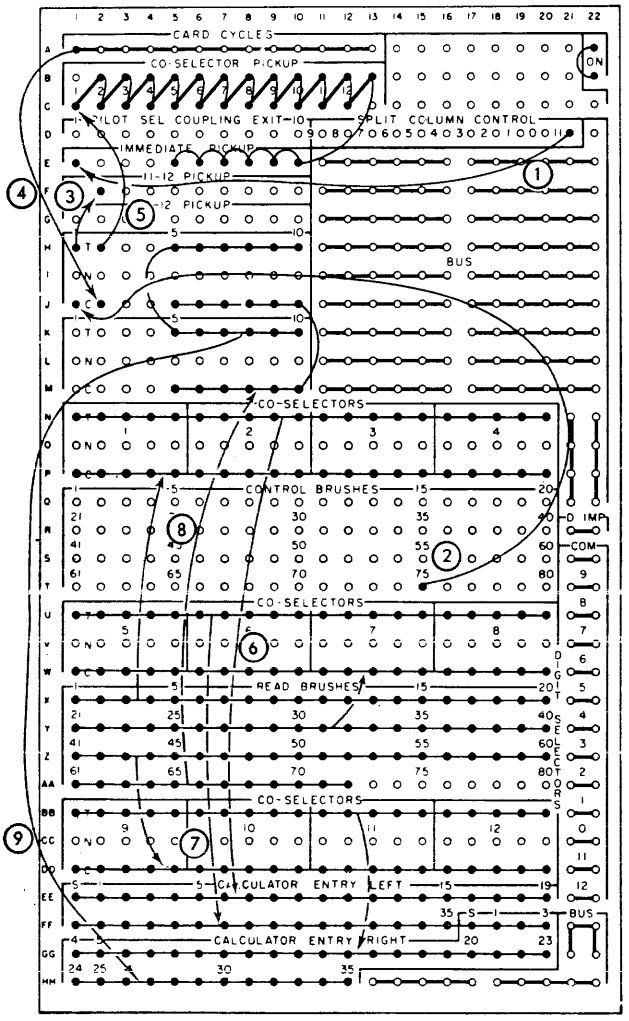



Figure 18. Selective Read Wiring

## Card Punch

### Manual Operation

Keys and lights on the punch (Figure 19) are similar to the corresponding controls on the reader.

To turn control of the card punch over to the channel (with the appropriate control panel in the punch) it is necessary to place cards to be punched in the hopper (Figure 20) and hold the start key down until the ready light goes on. The first card is fed into position above the die card lever before the ready light is turned on, and this card is thus positioned for punching whenever the punch is selected

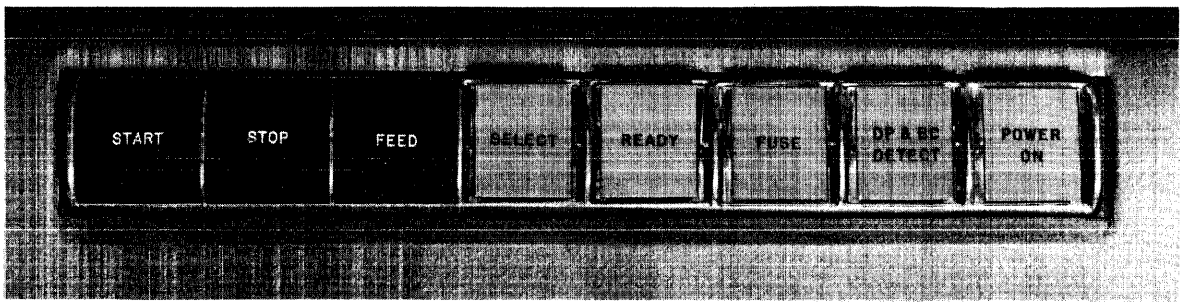



Figure 19. Keys and Lights of Card Punch

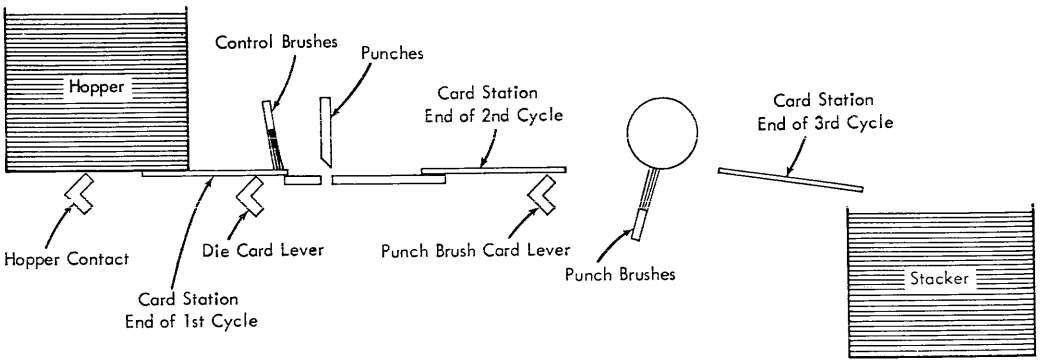



Figure 20. Card Path in Card Punch

by the channel. The ready light is turned off if, for any reason, one of the card contacts along the card path is not closed.

Whenever the hopper is empty, the punch cannot be restored to ready status until cards are added to the hopper. The ready light is also turned off by any of the following conditions: power off, blown fuse, full stacker, control panel not in the machine, or the gang-punch hubs wired.

### Control Panel Hubs

Figure 21 illustrates the hubs on the card punch control panel. For convenient reference, the vertical rows are numbered 1 through 22 and the horizontal rows are lettered A through HH. The following hubs are the same as those on the reader and will not be explained here: digit selector, selector pickups, and card cycle.

*Column Split (B-D, 1-10).* The column split acts as an internally wired selector. If a card cycle impulse is wired to the common hub, the 0-9 hub would emit an impulse from 0 time through 9 time and the 11-12 hub would emit an impulse from 11 time through 12 time.

*Sense Exits (A, 17-18).* Impulses are available at these hubs through execution of a PSE in the main program. They may be used to pick up selectors and control other operations.

*Punch Brushes (Q-T, 1-20).* Punch brush hubs wired to punch magnet hubs will read holes punched in one card and punch this same information in the next card (gang punching).

*Control Brushes (C, 17-22).* These hubs will sense a control punch (8 row) hole in the card and produce an impulse from 13.1 to 13.5 time.

*PD (Punch Delay) Out (B, 17-18).* These hubs emit a control punch one cycle after it is sensed, with the control brush wired to punch control IN.

*PC-In (B, 19-20).* These hubs are used with the punch delay OUT hub.

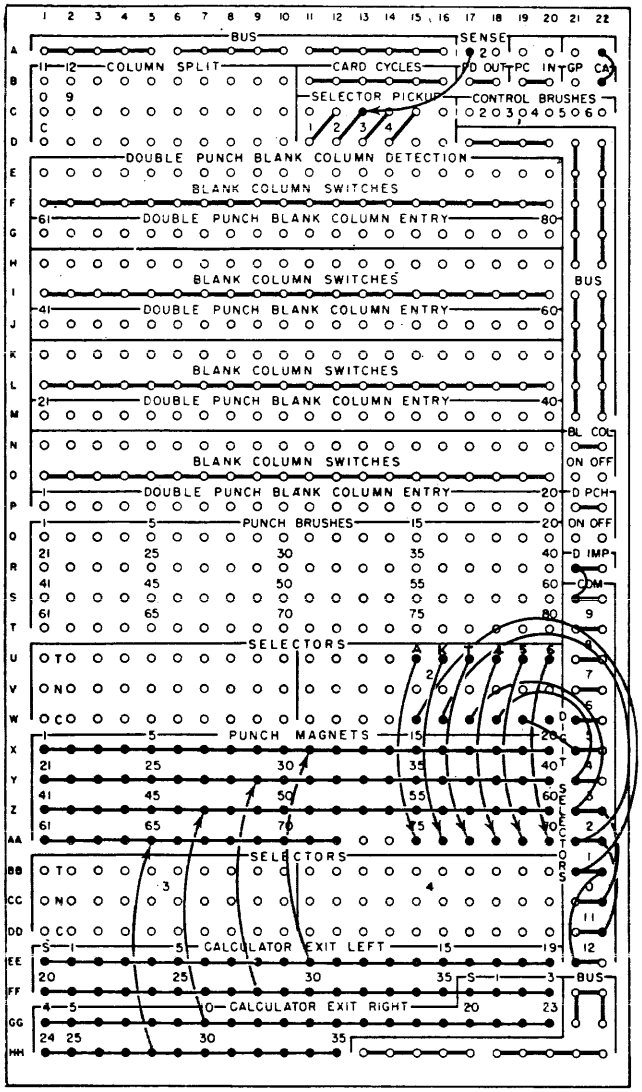
*Punch Magnets (X-AA, 1-20).* When these hubs are impulsed, a hole is punched. They are normally wired from calc exit hubs or punch brushes.

*Calc Exit Left and Right (EE-HH, 1-20).* These are exit hubs for information en route from core storage to the punch magnets. The first word transmitted during a punch cycle is available at the 36 calc left hubs and the second word produces impulses from the 36 calc right hubs; the process continues for the remaining words.

*CA (A-B, 22).* The calculate hubs must be wired together to enable the punch to operate under channel control.

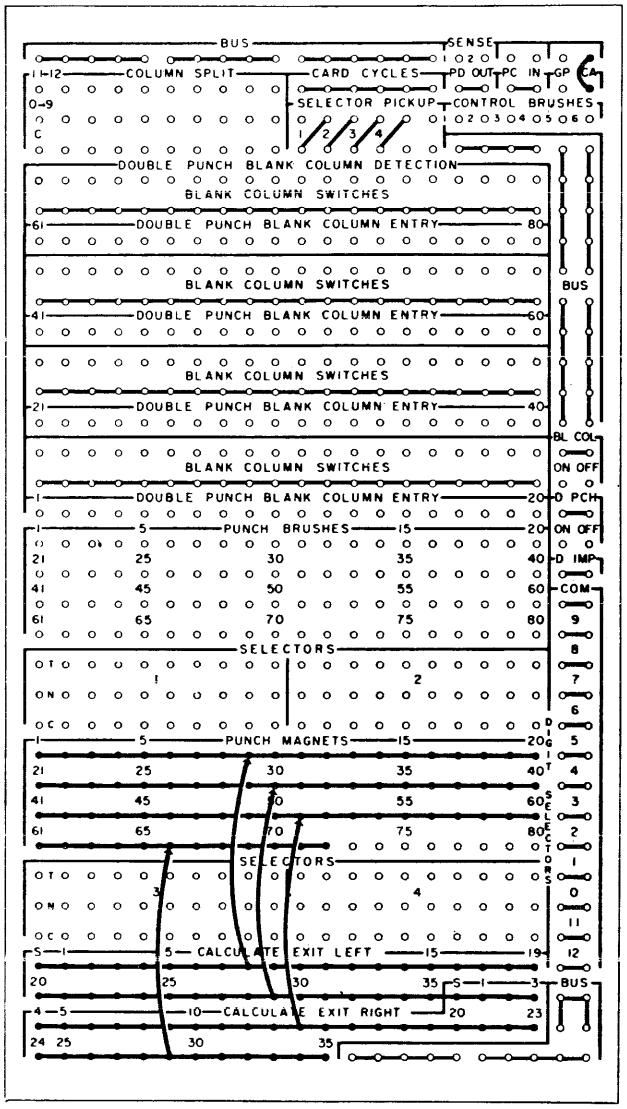
*GP (A-B, 21).* If the gang punch hubs are wired, instead of the calculate hubs, the punch may be used as a standard gang punch operating independently of the computer. With the GP hubs wired, the punch cannot be put in a ready status and in this event the punch cannot be selected by the channel. If an attempt is made to select the punch, the select instruction ties up the channel for an indefinite period. If the GP wiring is removed and the CA hubs are wired, the punch becomes accessible to the select instruction and the program may resume its normal course. With the punch under channel control, gang punching operations may also be utilized by wiring from the punch brush hubs to the punch magnet hubs.

*Double Punch Blank Column (E-P, 1-20).* By proper wiring, information being punched may be checked in such a way that the occurrence of a double-punched or blank column turns on a special indicator light (on the punch) and turns off the ready light. This indicator may be turned off by depressing the stop key on the punch. The punch is then restored to ready status by pressing the start key. The double-punch blank-column circuits may not be used to check binary cards or cards with alphabetic data punched in them.




Form 24-6128

Figure 21. Selective Punch Wiring




Form 24-6128

Figure 22. Direct Punch Wiring

## Control Panel Wiring

Figure 22 illustrates the control panel wiring which makes possible the direct punching of information from core storage through the data channel, into the IBM cards. The example provides that information from core storage be punched in card columns 1-72, but it is possible to punch 72 bits from a pair of words in storage into any 72 columns.

The control panel wiring shown in Figure 21 depicts a selective punching operation where detail cards (identified in the main program) are punched with a specific code in card columns 75 to 80. Reference to the timing requirements of a PSE instruction should be made if this type of punching operation is desired.

The instruction sequence is WRS-punch, PSE with an appropriate address, and an IOCD command. Punching will continue until the punch is disconnected by this IOCD command. The wiring necessary for this operation is as follows:

1. Sense exit 1 wired to the pickup hub of selector 2.

2. Digit impulse hub wired to the common of the digit selector.

3. Identifying code (A, K, T, 4, 5 and 6) wired from the digit selector hubs to the common of selector 2.

4. Transferred hubs of selector 2 wired to punch magnets 75 to 80.

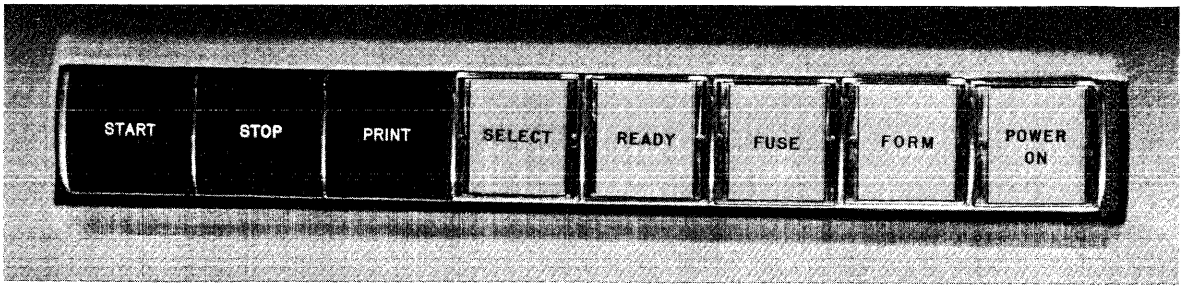



Figure 23. Printer Keys and Lights

## Printer

### Manual Operation

Keys and lights on the printer (Figure 23) are similar to those on the reader, with the following exceptions:

1. The feed key is replaced by a print-cycle key.
2. The card-feed stop light is replaced by a form-stop light.
3. The stop-before-printing, test, and form-stop switches are added.

The following is a general discussion of printer controls with special emphasis on the differing features.

To prepare the printer for control by the channel once the control panel is in place, it is necessary only to hold the start key until the ready light goes on. The ready light is turned off by any of the following conditions: test switch on; a form stop, indicated by the form-stop light, when the form-stop switch is on; depressed stop key on the carriage; depressed stop key on the printer; power off; blown fuse. (The test switch is discussed below.) If the form-stop switch is on (Figure 24), the form-stop light goes on when the printer runs out of paper.

Turning the test switch on causes the ready light to go off.

The print cycle key starts a print cycle only under the following conditions:

1. When the ready light is off (as when the test switch is on).
2. When the ready light is on, the stop-before-printing switch is on, and the program supplies an RDS or WRS instruction for the printer.

With the test switch on, the ready light is off. Depressing the print cycles key causes the printer to go through print cycles until the key is released. To switch control back to the channel, turn off the test switch, and press the printer start key.

With the test switch on and the ready light off, depressing the print key causes the printer to go through print cycles until the key is released. Such print cycles are not under control of the CPU or the channel, and the test switch is primarily for the use of customer engineers in testing the printer. To return control to the channel, turn off the test switch and press the printer start key.

When the printer ready light is off for any reason, no printer operations may be performed by the channel. The channel suspends operation when an attempt is made to select the printer, and the CPU suspends operation if a second select addresses the blocked channel.

With the stop-before-printing switch on, the channel suspends operation until the printer is selected. Pushing the print-cycles key will cause the print cycle to be taken and one line to be printed. Depressing the print-cycles key again permits the second line to

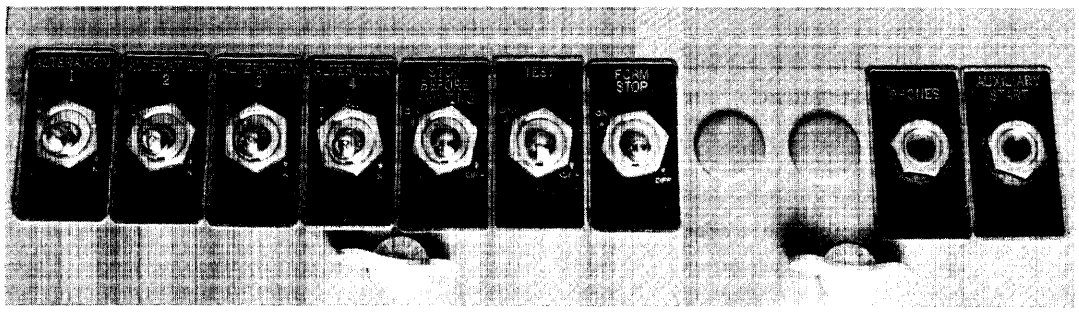



Figure 24. Printer Test Panel

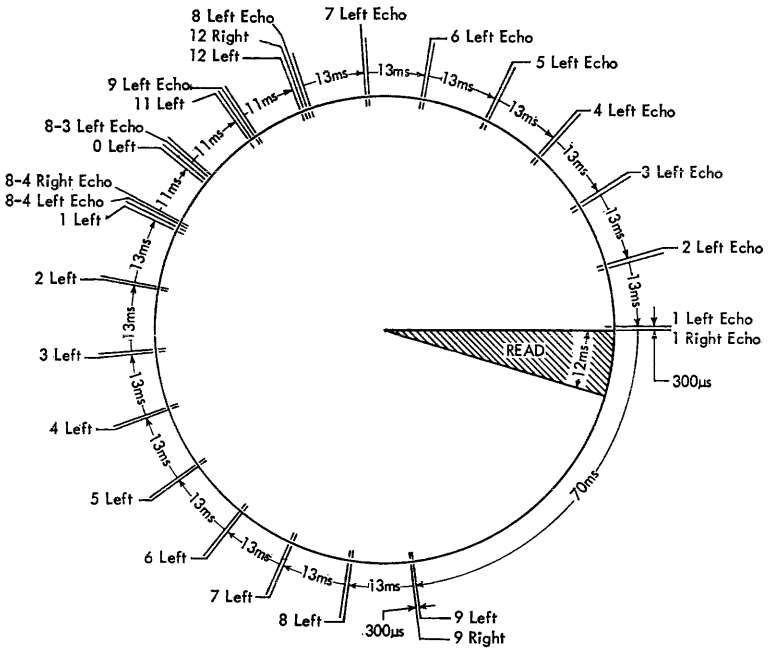



Figure 26. Printer Read Timing Circle

be printed. The effect of the stop-before-printing switch is, thus, to remove the printer from automatic status prior to the printing of each line.

### Control Panel Hubs

Most control panel wiring can be accomplished without reference to the synchronous relations between the CPU and the printer. When these are of importance, the relationship between the timing chart (Figure 25) and the timing circle (Figure 26) should be considered.

The 12 printing and emitter impulse bars represent the times during which impulses may be available from the calc exit left and right hubs and may be received by the print entry hubs. The calc exit hubs, whose impulses each began 6° before a cycle point, are activated by the transmission of words from the card image in core storage. Thus, the time point at which the 9-left word is transmitted to the printer is equivalent to 9° in terms of the timing chart. Approximately 300 µs. later, the 9-right word is transmitted, activating the calc exit right hubs. The channel then continues transmission of card image words at appropriate times throughout the cycle, sending the 8-left word at 24°, and so on.

In a similar way, the print-wheel echo impulses (bars) denote the times at which echo words are sent from the printer to core storage. During continuous printing without echo checking, the end-of-record occurs at 189°; with echo checking it occurs at 294°.

In general it is necessary to arrange the execution of load channel instructions at word-transmission times (or as responses to end-of-record conditions) in order to synchronize the CPU with any point in the print cycle. A few exceptions will be shown in subsequent paragraphs.

*Calc Exit Left, Calc Exit Right.* These hubs are exits for words being sent from core storage to a printer by a channel. Card image words are sent alternately to these two sets of hubs, beginning with calc exit left and then with calc exit right.

*Print Entry.* When these hubs are wired to calc exit hubs, they serve as entries for impulses to individual type wheels in storage.

Timing chart bars shown for print-wheel echo impulses indicate impulse timings for the following hubs:

*Print Echo Exit.* These hubs are exits for echo impulses generated by the individual type wheels.

*Calc Echo Entry Left and Right.* These hubs may accept print-wheel echo impulses. When such impulses are entered in these hubs they are transmitted to core storage in the form of left and right echo words.

*Pilot Selector.* If a pilot selector is impulsed between 5° and 300° the selector transfers at 315° and remains so until 286° of the following print cycle. However, when a sense exit pulse is used (plus sense instruction), one selector transfers *immediately*.

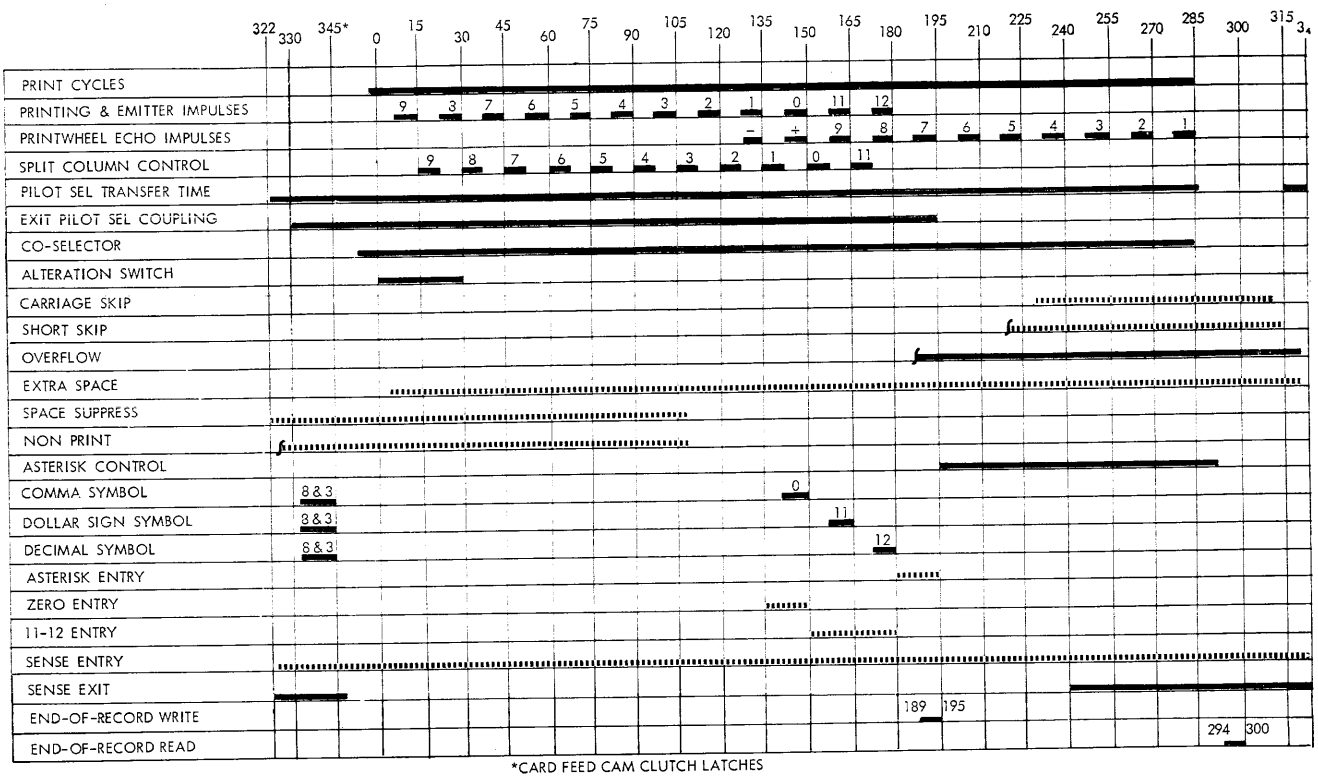



Figure 25. Printer Timing Chart

*Co-Selectors.* Twenty co-selectors are provided, each with two common pickup hubs. These hubs are of the immediate type and, when impulsed between 350° and 270°, cause the co-selector to transfer within the next 9°. The selector then remains transferred until 285° of the print cycle.

The following hubs, whose timings are shown in Figure 25, provide impulses to pick up selectors.

*Coupling Exit.* Each pilot selector has an associated coupling hub. When a pilot selector is transferred at 315°, an impulse is emitted by this hub from 330° until 195°. If a coupling exit hub is wired to a co-selector pickup hub, the pilot and co-selector are both picked by a single impulse directed to the pilot selector pickup hub.

*Print Cycles.* These hubs emit impulses during each print cycle from 355° to 285°.

*COPC.* These hubs should be used to pick up co-selectors or pilot selectors. The impulse starts at 355° and ends at 10°.

*Split-Column Control Emitters.* These hubs emit impulses between normal digit impulses, that is, printer and emitter pulses. For example, the hub between numbers 9 and 8 (Figure 25) emits an impulse between 9-time and 8-time. If wired to a co-selector pickup hub, this impulse would cause the co-selector to transfer before 8 time but after 9 time.

*Alteration Switches.* These hubs emit an impulse each print cycle between 0° and 30° when the corresponding toggle switch on the printer is in the ON position. Co-selectors are subject to immediate pickup and pilot selectors will transfer at 315° when their pickup hubs are impulsed.

*Sense Exit.* The sense exit impulses, described under the PSE instruction, may be used to pick up pilot selectors under control of PSE instructions in the main program. Once a PSE is used directly to transfer a pilot selector, the selector will be transferred on every succeeding print cycle until the printer is disconnected. After once initiated by the stored program, the sense exit is repeated during each such succeeding cycle.

*PR (Printer) On.* These hubs must be jackplugged if the printer is to be used under channel control.

*Filter In-Out.* These hubs permit the passage of an impulse in only one direction, into the IN hub and out of the OUT hub. The OUT hub of one filter should not be wired to the IN hub of another, either directly or indirectly (through a selector).

*ZC (Zero Control).* With these hubs jackplugged, zero print wiring on the control panel is active. If the hubs are not wired, only those type wheels which receive a numerical impulse (9-1) will print, regardless of the zero print control wiring.

*Zero Print Control.* The 120 pairs of these hubs, each pair corresponding to a particular type wheel, are not operative unless the zero control (zc) hubs are wired. Each pair of hubs corresponds to a print entry position; the manner in which the pair of hubs is wired to its neighbor controls the printer's response. The zero print control functions only during zone (0, 11, 12) time and N (no-zone) time and can have no effect upon the printing in a position that has received a digit impulse during a given print cycle. Thus, the only special characters that can be controlled are those consisting of only zone impulses (zero, check-protecting asterisk, plus sign, and minus sign) or those emitted from special hubs on the control panel (dollar sign, period, and comma). The specially emitted symbols provide for setting the print wheel to the proper sector without using the usual combination digit punching.

Note that zero-print control hubs cannot operate correctly when used in groups of more than ten at a time. Groups larger than this should be split and wired independently.

### Carriage Control Spacing

The paper in the printer may be physically spaced either before or after a line is printed. Before-print spacing, printing of the line itself, and after-print spacing begin about 120°, 300°, or 338°. Before-print spacing (normal spacing) is controlled by either space 1 or space 2 hubs (single or double spacing) or by the selective space hubs (irregular spacing).

Before-print spacing is automatically initiated during the print cycle, and the function of these hubs is to terminate spacing at the appropriate time. Hence, one of them must be wired, or uncontrolled and continuous spacing will result.

With the two extra-space hubs connected, the hubs which control before-print spacing also cause and control after-print spacing. Before-print spacing may always be suppressed (whether after-print spacing is used or not) by impulsing the space suppress hub.

*Space 1-2.* The carriage will single-space (six or eight lines to the inch) before printing if the 1 hub is connected to either of the two common exit hubs above it, and will double-space if the 2 hub is connected in a like manner.

### Carriage Control Tape Punching

A small tape punch (Figure 27) is provided for punching the paper tape. The tape is punched to conform to printing line positions on the form used with the printer. The tape is then cut to the length of the form or, in the case of a very short form, the tape may represent more than one form length. After punching, the tape is glued into a loop to provide for repetitive operation.

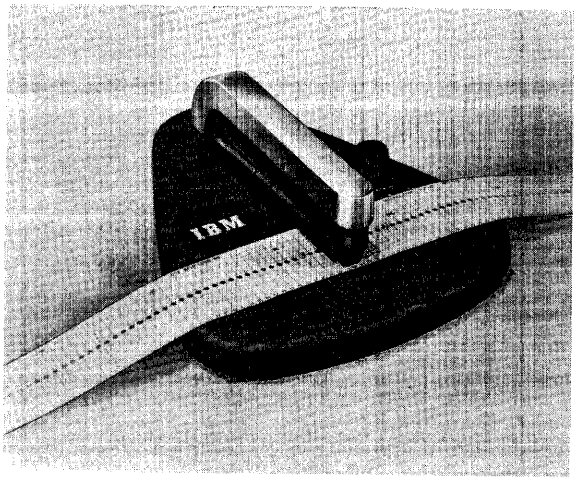



Figure 27. Carriage Tape Punch

### Inserting the Tape in the Carriage

Figure 28 shows a tape inserted in the carriage. Tilt back the cover of the carriage to gain access to the tape reading mechanism. Turn the platen clutch to a disengaged position (to the right) and raise the brush assembly, by moving to the left the latch located on the side of the brush holder. With the tape held so that the printed captions can be read, place one end of the loop over the pin-feed drive cylinder so that the pins engage the center drive holes. Place the opposite end of the loop over the nearest half-circle guide piece. Remove the excess slack from the tape loop by lifting the lever away from the notched bar and by moving the guide piece to the right. The tape should be just tight enough to give slightly when the top and bottom portions of the loop are pressed together as shown in Figure 28. If it fits too tightly, the pin feed holes of the tape will be damaged.

After the tape is in position, press the brush assembly down and close the top cover. Depress the restore key to bring the tape to its home position and turn the platen clutch knob back to its engaged position. The carriage is now ready to operate.

### Control Tape and Skipping

When the tape is installed in the carriage and the carriage is in motion, the tape is advanced in synchronous movement with the paper form. The

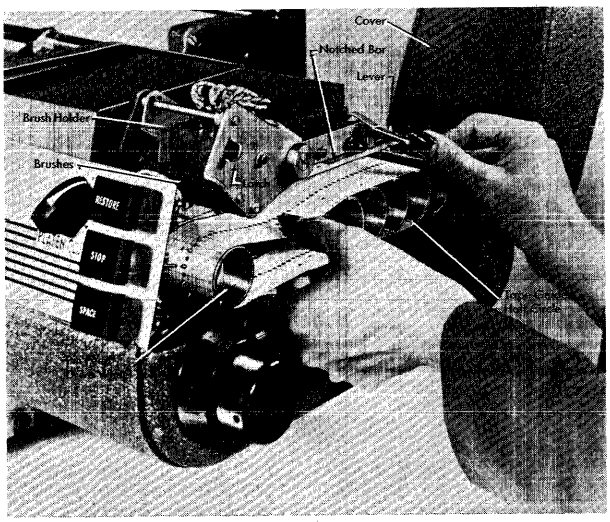



Figure 28. Inserting Tape in Carriage

punched paper tape may be used to control carriage movement as follows:

An impulse to a given carriage skip hub (ten possible hubs, one for each of the first ten channels on the tape) will cause the form to skip until the control tape and the form reach the position where there is a punched hole in the channel corresponding to a given hub. Channel 11 on the tape controls selective spacing and the 12 channel has a special function explained in connection with the overflow hub. The following hubs are associated with skipping.

*Carriage Skips.* When any of these hubs is impulsed between 230° and 310°, a form skip is started that does not stop until a punched hole is encountered in the corresponding channel of the control tape. Note that at 345°, following the impulsing of one of these hubs, the print unit is latched and a delay of at least one print cycle occurs while skipping is carried out. As explained before in connection with the PSE instruction, the transmission of words from storage by the channel is automatically delayed during the interlock period.

*Short Skip.* For a skip of two inches (12 lines) or less, impulsing any of these hubs at the same time that a carriage-skip hub is impulsed has the effect of preventing normal interlock operation. Such a skip can then occur without reducing the 150-line printing speed. The impulse which starts skipping should be wired to one of these hubs and to the appropriate carriage-skip hub.

Short-skip hubs are receptive during 230° to 310° when carriage-skip hubs are used. If the short-skip hub is wired to overflow, the length of the skip must not exceed one inch.

*Space-Sel (Selective Space).* These hubs permit spacing one to three lines before printing, under control of the carriage control tape. When these hubs are connected, before-print spacing (automatically started during each cycle) continues until a punch in channel 11 of the carriage tape is encountered. There is only time for spacing a maximum of three lines before printing, however, and if channel 11 is punched in such a way as to cause more than this, printing may occur while the paper is in motion. (The machine is not interlocked in any way to prevent this.)

*Extra Space.* These hubs are receptive between 280° and 341°. When impulsed, the before-print spacing function is repeated as an after-print operation. Thus, if the space 2 hub is wired, an extra double space results after printing. If the selective-space hubs are connected and one of the extra-space hubs is impulsed, selective spacing occurs both before and after printing; i.e., once before and once after printing the carriage is moved until a hole is encountered in channel 11 of the control tape. The tape should be punched so that neither space operation exceeds three lines. One punch on the tape may be used to space six lines continuously if spacing is made entirely an after-print operation by impulsing a space-suppress hub as well as an extra-space hub.

*SUP (Space Suppress).* If one of these hubs is impulsed between 320° and 110°, the normal before-print spacing initiated at about 120° is suppressed.

*Non-print.* An impulse directed to this hub between 330° and 110° prevents printing, before-print spacing, and ribbon spacing. NOTE: On the cycle following any skip operation, normal before-print spacing is suppressed.

*OVFL (Overflow).* An impulse is available from this hub when a hole is encountered in channel 12 of the carriage tape during a spacing operation. Whether after-print or before-print spacing has been used, the overflow impulse lasts until 320° of the cycle in which a skip is initiated. In terms of the channel, this period includes the time between the 6-left echo word (of the cycle when the 12 hole is sensed) and the end of the hatched portion of the cycle in which the skip is initiated, or, during printing without echo checking, the time between end-of-record condition and the end of the hatched portion. This hub is frequently wired to a carriage-skip hub to control skipping from the last line of a form to the first line on the next form. When this is done, a punched hole in channel 12 of the carriage tape corresponds to the last line and any of the channels 1 through 10 may be used to position the first line.

## Forms Tractors

Two IBM forms tractors are available for the printer. The F2 (Figure 29) is standard but the F4 (Figure 30) may be specified in place of, or in addition to, the F2. Each of these devices is used for feeding marginally punched continuous forms and each has two adjustable tractor-type pin-feed units, one for each side of the form.

The F2 provides the choice of spacing either six or eight lines to the inch; the F4 either four or six lines to the inch. Make this adjustment on the F2 by moving the shift cam until its pointer is positioned between the two scribed lines at either the 6 or 8 on the side frame. Adjust the F4 in the same way for spacing of four or six lines per inch.

### Procedure for Using the Forms Tractor

1. After the forms tractor is in position, make sure that the platen and the forms tractor can be freely moved by hand.

2. If a narrow form is to be used, remove the center paper guide supporting the form in the center.

3. Move the left lower paper guide and tractor slightly to the left of the first printing position. Place the first form between the left and right lower paper guides and move the right guide in against the edge of the form. Allow a slight clearance so that the form slides freely between both guides. Tighten both lock assemblies to hold the guides in place.

4. With the pressure rolls engaged, insert the form under the carriage between the round rod and the platen and then into the pressure rolls. Turn the platen by hand (platen clutch disengaged) until the end of the form can be grasped.

5. Raise the pressure plates away from the pins.

6. Release the pressure roll, draw up the form, and attach the pin feed holes to the tractor pins.

7. Lower the pressure plates.

8. Set the form so that the first printing line is even with the first printing line indicator mark on the lower part of the pressure plates.

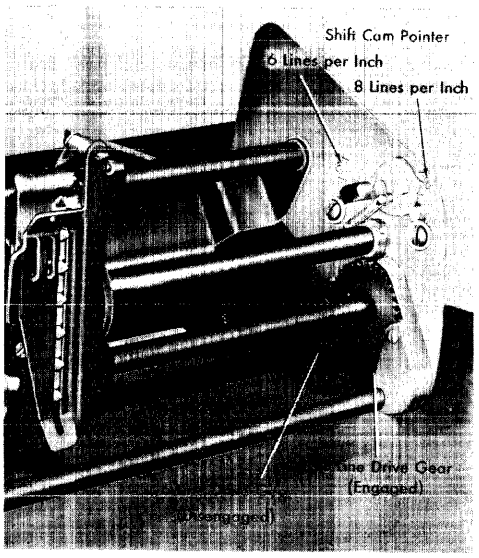



Figure 29. IBM F2 Forms Tractor

### Tractor Adjustments

The tractor adjustment wheels may be turned to provide a one-eighth inch lateral movement of the tractors. The wheels are used to make the chain pins line up exactly with the center of the marginal holes in the paper after the paper guides have been set.

## Plus Sense Instructions

A PSE instruction may be used either to cause the emission of an impulse from one of the sense exit hubs or to test whether an impulse is present at the sense entry hub. The address of the PSE determines whether it is impulse-sending or impulse-testing and, if it is impulse-sending, also specifies a particular sense exit hub. (Refer to the definition of the PSE for list of addresses.) For instructions addressing the sense exit hubs:

1. The PSE is normally given immediately after the WRS or RDS that starts printing. When this is done, an impulse is available at the addressed sense exit hub from 345° to 350°. From 240° until 350° for a write operation, and 298° to 350° for a read operation, the impulse is emitted again on the next cycle and is repeated every succeeding print cycle until the printer is disconnected. If, following the disconnect, the printer is reselected in the hatched portion of the cycle, the emitted impulse then drops out at 340° and is not available unless another PSE is executed by the stored program.

2. If a PSE is given between 4° and 235° of the first print cycle after the WRS, an impulse is available from 345° to 350° of the print cycle and 240° to 350° (write) or 298° to 350° (read) of every succeeding cycle until a disconnect occurs. In terms of stored program, the PSE falls in this interval if given between the 9-left word and the 4-right echo word transmissions. For a PSE given between 235° and 340°, the impulse is available within 5° (6 ms.), is continuously emitted until

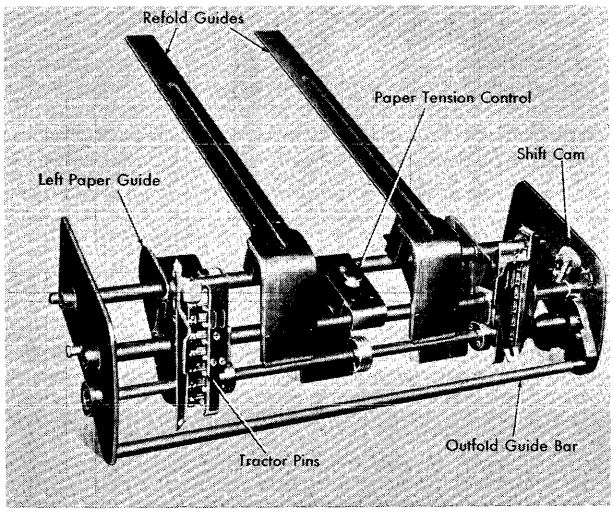


Figure 30. IBM F4 Forms Tractor

350°, and is emitted from 240° to 350° (write) or 298° to 350° (read) of every succeeding print cycle until the printer is disconnected. The PSE will fall between 235° and 340° if issued any time between the 4-right echo transmission and the end of the hatched portion of the cycle. Note that the impulse is terminated at 340° only during cycles in which a carriage skip is started. After a disconnect no exit impulse is available.

3. In general it is not advisable to give an impulse-initiating PSE instruction between the end of the hatched portion of the cycle and the 9-left transmission time. In particular, a PSE given during this period may fall between 354° and 4° of the print cycle, in which case it is not effective this cycle but will be effective on following cycles.

4. If a PSE addressing the printer is given at any time when the printer is not selected, the instruction is interpreted as a NOP.

5. Up to ten PSE instructions may be given during a block of continuous printing (printer selected).

6. When the printer is disconnected, the print unit latches at 345°. The drive shaft, after latching the print unit, continues motion and coasts to a stop at an arbitrary position. If a PSE is given immediately after a new printer select instruction, the impulse is available at the specified sense exit hub within 6 ms. The new select initiates motion in the drive shaft and, when the shaft reaches the latch point, the print unit is unlatched and the print cycle begins in a normal manner.

7. During a cycle in which a carriage skip hub is impulsed, a sense exit impulse is terminated at 340°. At 345° the print unit is latched after carriage skip impulsing. At least one print cycle is lost while the skip is taking place. Transmission of words from storage is automatically delayed by the channel until the skip is completed and the print unit unlatches again at 345°. Conditions prevalent at 345° are, in general, not altered during the interlock period (selectors in the transfer position are held that way). Note that cams controlling the three special symbol emitters (comma, dollar sign, and decimal) are attached directly to the print unit drive shaft and are not interlocked at 345° either during carriage skip cycles or when the printer disconnects. These emitters should not be used for control operations (e.g., to pick up pilot selectors) because between the initial select and the latch point they may or may not emit impulses, and during carriage skip cycles their impulses come effectively (relative to other hubs) at 345° rather than at the usual times as indicated in the timing chart.

The sense entry hub is an input hub for the printer and is receptive at all times. An appropriately addressed PSE tests whether, at the time when the PSE is executed, this hub is being impulsed. The sense entry is intended primarily to be used with the overflow hub (for carriage control) which, when activated, emits an impulse before 190° and lasting until 320° of the cycle in which a skip is initiated. In terms of the stored program, this impulse is available between the 6-left echo word transmission of the cycle when the 12 hole is sensed and the end of the hatched portion of the cycle (with echo checking) in which the skip was initiated.

### Printing Control

As an example, the control wiring in Figure 31 provides for printing any digit (including zero), letter, or special character that has been coded in the card image being copied. The wiring also provides for echo checking of the digits 9 through 1 in all positions except 11 and 64. In positions 11 and 64, provision is made for checking the special codes corresponding to the plus and minus signs (8-3 and 8-4). Although this wiring is valid for printing any character, assume that binary numbers will be printed here.

In the specific example, characters being printed are separated into groups of three each to help translation from the binary to the octal system. Any other arrangement could be made.

The control panel wiring shown in Figure 31 is as follows:

1. The calculator exit hubs (two sets of hubs labeled, S, 1-35; the left half-row and the right half-row, respectively) are wired to the print entry hubs in this order:

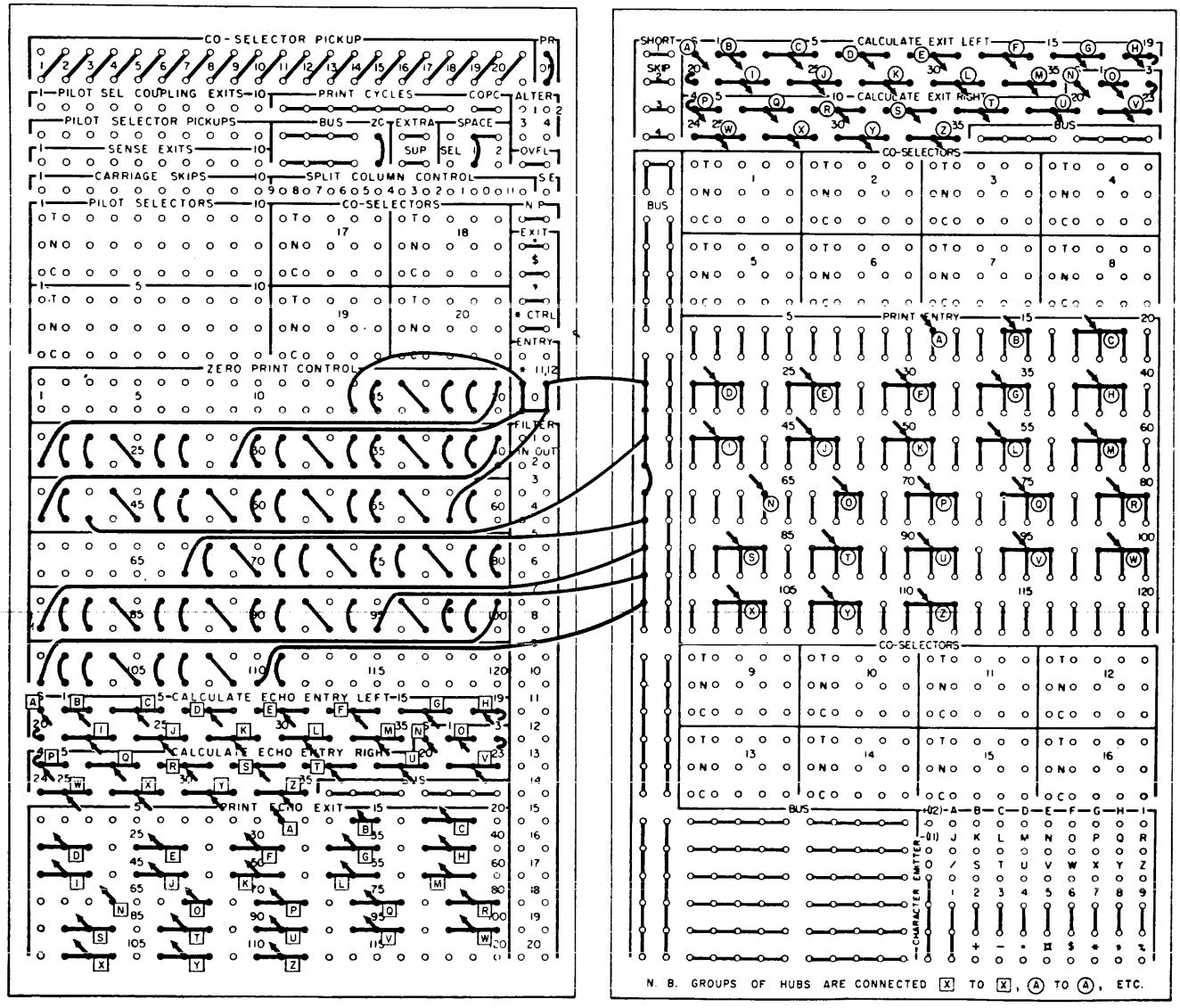
Left half-row

| CALC EXIT | PRINT ENTRY |
|---|---|
| S | 11 |
| 1, 2 | 14, 15 |
| 3, 4, 5 | 17, 18, 19 |
| 6, 7, 8 | 21, 22, 23 |
| . | . |
| . | . |
| . | . |
| 33, 34, 35 | 57, 58, 59 |

Right half-row

| | |
|---|---|
| S | 64 |
| 1, 2 | 67, 68 |
| 3, 4, 5 | 70, 71, 72 |
| . | . |
| . | . |
| 33, 34, 35 | 110, 111, 112 |

2. The wiring from the calculator echo entry hubs (two sets of hubs labeled in the same way as the calculator exit hubs) to the print echo exit is the same as that described in paragraph 1 above, if the words "calculator echo entry" and "print echo exit" are substituted for "calculator exit" and "print entry," respectively. Use of echo impulses is explained below.




Form 24-6127

Figure 31. Zero Print Control Wiring

3. The ZC hubs are wired. This allows the zero print control to operate. Note that all of the zero print control wiring, described in the next paragraph, could be eliminated if the ZC hubs were not wired. The zero print control is brought into play here only to illustrate appropriate wiring.

4. The pairs of zero print control hubs (described below) are numbered to correspond to the print entry hubs. All pairs of zero print control hubs corresponding to the print entry positions enumerated in paragraph 1 are connected (i.e., the upper hub at a position is wired to the lower hub at the same position) except the pairs that are at the first of a subgroup (the hubs corresponding to positions 11, 14, 17, 21, ... 57, 64, 67, 70, ... 110). The lower hubs at positions 14 and 67 will be wired to the zero entry. A *further exception* to the system described above occurs because the zero print control hubs should not be wired in groups of greater than ten pairs of hubs. To separate the zero print control wiring into independent groups of appropriate size, the lower hubs of some positions are wired to zero entry. The remainder of the zero print control hubs at the first of a group are connected diagonally from the lower hub of the pair to the upper hub immediately at the left (corresponding to a blank position in the printing).

5. The PR and ON hubs are coupled.

6. The space hub is wired to 1 to provide single spacing between lines of print.

To check the printing of a number and its sign, wire the print echo exits, corresponding to the print wheels that printed the number, to the calculator echo entries corresponding to the calculator exits from which the information was originally taken. It is then possible, by programming, to read these impulses into core storage and to perform a programmed check on the original information.

In general, the program for this checking relies upon the fact that the echo impulses occur in a given order: 8-4, 8-3, 9, 8, 7, 6, 5, 4, 3, 2, 1. Each print wheel emits an echo impulse timed to indicate the sector within which it was set up to print. Since no provision is made for checking the zones within these sectors, the checking is restricted to numerical printing. For example, at 8-echo time, the print echo exits, corresponding to the print wheels set up to print in the 8 sector, emit an impulse. The program copies these impulses into core storage in the form of a binary word to be compared with the word in the card image corresponding to the 8-row.

# IBM 7090 System Consoles

## IBM 7151 Console Control

Description of the IBM 7151 Console Control (Figure 32) keys and lights is divided into three sections. The first section concerns indicator lights, the second section concerns incandescent lamps (including the color of the lamp cover) and panel keys and switches, and the third section concerns data channel indicator lights.

### Indicator Lights

*1. Instruction Counter.* The instruction counter is 15 positions long and is used to tell the computer the location of the next instruction to be performed. The instruction counter (IC) may be reset to zero at the start of the program or may be set to a predetermined address. Once the program is started, the IC counts sequentially unless a transfer instruction is executed. In this case, the IC is set to the address specified by the transfer instruction and is again stepped sequentially starting with this new address. The highest location in core storage and location zero are treated as consecutive addresses.

The IC is normally advanced at the end of the I cycle. However, some instructions cause the computer to skip one or two instructions and, therefore, the IC may be advanced as many as three times while the instruction is being completed. If a halt occurs during the execution of a divide or halt instruction or a halt and proceed instruction, the IC has the address of the instruction being executed plus one. Upon execution of a halt and transfer instruction, the IC contains the address of the instruction.

If the auto-manual switch is depressed during the execution of a CPU program, the IC contains the address of the instruction to be executed, *plus one.*

*2. Instruction Register.* Instructions and data are both in the form of 36-bit words, and the computer finds the difference between the two in the following manner:

a. Any word brought into the computer during an I cycle is treated as an instruction.
b. A word brought in at any other time is treated as data.

The instruction register (IR) is divided into two parts: positions S, 1-9 contain the operation part of the instruction, while positions 10-17 form a counter known as the "shift counter." In shifting, multiplication, and division instructions, the number of shifts to be made is placed in this counter.

With an I-O instruction, the address part of the instruction is placed into the shift counter. The counter

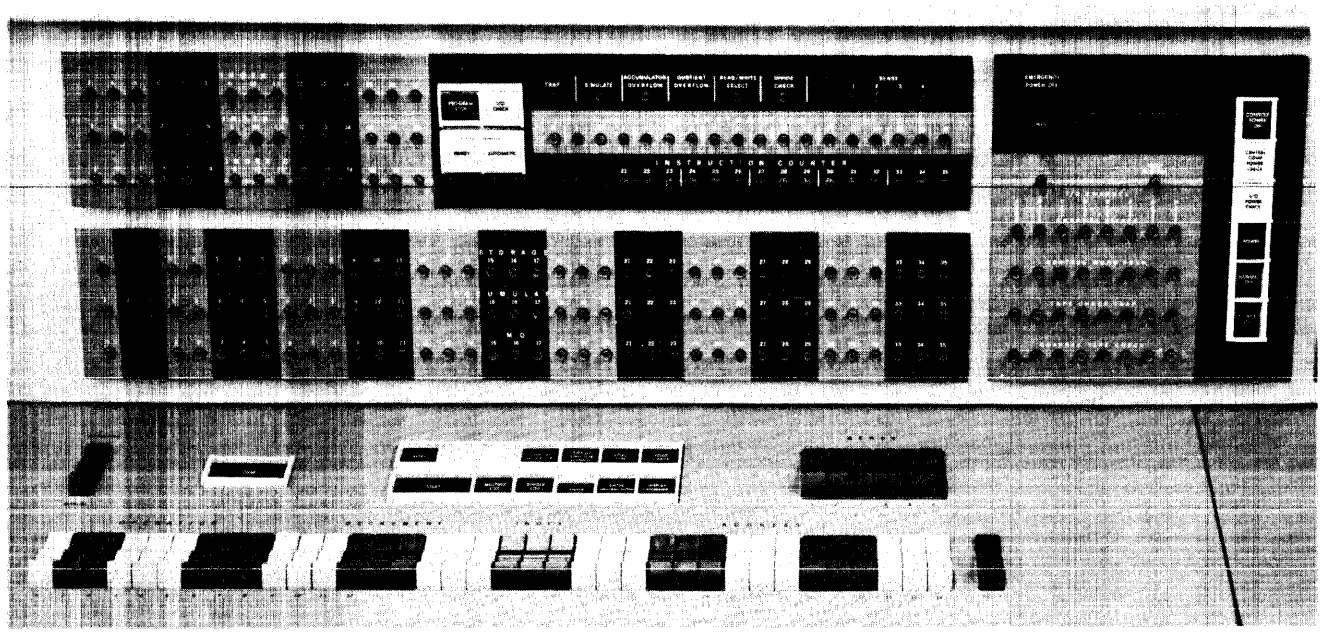


Figure 32. IBM 7151 Console Control

in turn sets the class and unit selectors for the type of instruction (such as read, write, and so forth) and the exact unit involved.

*3. Internal Registers.* The contents of the internal registers (storage, accumulator, and MQ) are displayed on the console. The display is marked off in groups of three, making the direct conversion from binary notation to octal a matter of sight.

*4. Index Registers.* Three rows of lights display the contents of index registers A, B, or C.

*5. Trap.* The trap light goes on whenever the CPU is operating in the transfer trap mode.

*6. Simulate.* The simulate light will be turned on when the 7090 is operating in the following modes associated with the 704-709 compatibility feature:

Input-output select and sense trap mode
Copy and load drum address trap mode
Storage nullify mode

*7. Accumulator Overflow.* This light will be turned on at any time (during fixed point operation or shifting operations) when a carry out of position 1 of the accumulator occurs. It may be turned off by the TNO or TOV instructions.

*8. Quotient Overflow.* This light will be on whenever an MQ overflow occurs and the calculator is using the compatibility program.

*9. Read-Write Select.* The read-write select light will be turned on when an input-output unit has been selected for reading or writing. The light goes off when the input-output unit is disconnected.

*10. Divide Check.* The divide check light will be turned on (fixed point division) if the dividend (accumulator) is greater than or equal to the divisor (storage). On floating point division a divide check occurs if the divisor is zero or if the magnitude of the fraction of the dividend is greater than or equal to twice the magnitude of the fraction of the divisor. The divide check indicator is tested by the DCT instruction.

*11. Sense.* These four sense lights may be turned on, turned off, or tested through use of the proper plus or minus sense instructions.

*12. Trap Control.* This light is on when the channels are not executing a channel trap. It is off when any channel enters a trap condition. While the light is off, no channel traps may be executed. Channel traps may be executed only when the light is on at the same time as any of the command trap or channel tape check lights are on.

*13. Channel Select.* These lights (eight, one for each channel) will be turned on according to the channel that is in operation. They will be turned off if the channel is not in operation.

NOTE: Both the tape check and the channel select lights are duplicated on the data channel console.

*14. Command Trap.* These lights indicate which data channel is enabled for a trap on command or end-of-file conditions. The lights are turned off when the channels are disabled.

*15. Tape Check Trap.* These lights indicate which data channel is enabled to trap on a tape check. The lights are off when the channels are disabled.

*16. Channel Tape Check.* These lights indicate a tape error while writing, or if both the high and low check registers are in error while reading. The lights may be turned off by execution of a transfer on redundancy check instruction.

### Incandescent Lamps

*17. Program Stop (Red).* This lamp will be turned on when the computer executes a halt instruction.

*18. I-O Check (White).* The I-O check lamp will be turned on by any of the following conditions:

a. If a reset or load channel instruction is executed and the specified channel has not been selected.

b. If, when writing, a data channel data register has not been loaded with a word from storage by the time its contents are to be sent to the output unit.

c. If, when reading, a data channel data register has not transmitted its contents to core storage by the time new information is to be loaded into it from an input unit.

*19. Ready (White).* This lamp indicates all computer power circuits are at operating level and remains on except when the computer is in automatic status.

*20. Automatic (Yellow).* This lamp is on whenever the computer is executing instructions in the automatic mode or whenever a data channel is in operation.

*21. Console Power On (Red).* This lamp is on whenever power is applied to the console.

*22. Computer Components Power Check (Yellow).* This lamp is on whenever a fuse or circuit breaker is actuated in the central processing unit, multiplexor, or core storage. It also lights when core storage has improper oil temperature or low oil pressure.

*23. I-O Power Check (Yellow).* The I-O power check lamp is turned on whenever a fuse or circuit breaker

is actuated in a data channel or a fuse in card equipment is blown. A power failure in a data channel or its attached card equipment does not light this lamp if a data channel is switched off-line for testing purposes.

*24. Power (Red).* This lamp is turned on whenever power is applied to the entire 7090 system.

### Panel Keys and Switches

*25. Auto-Manual Switch.* Pressing this switch down stops the computer after it has completed the execution of the instruction then being processed, unless an I-O unit is connected to the logical unit. In this case, the computer stops after the I-O unit in use has been disconnected. The automatic light goes out, and all of the switches and the following keys become effective: display sense indicators, enter MQ, enter instruction, display effective address, display A, display B, display C, multiple step, and single step. The clear key and load key become ineffective.

*26. Clear Key.* With the computer in automatic status, pressing the clear key sets all magnetic cores to zero. In addition, all registers and indicators are reset as with the reset key depression. The clear key is inoperative when the computer is in true manual status.

*27. Reset Key.* Pressing the reset key resets all registers and indicators in the logical section of the machine, except the SI. That is, the SR, AC, MQ, instruction location counter, instruction register, and index registers are set to zero and all indicators are turned off. The panel lights are all turned off with the exception of power and ready. Core storage is not affected by the reset key. Any channels in automatic status, and their associated registers, are also reset.

*28. Display Indicators.* This key, when depressed, allows the true value of the sense indicators to be displayed in the storage register indicator lights.

*29. Display Effective Address Key.* Assume that the computer is in manual status, an instruction is in the SR, and the display effective address key is pressed. The difference between the contents of the address field in the SR and those of the index register tagged in that instruction (if one is tagged) will appear in the address field of the SR, where it may be read from the SR lights.

*30. Load Keys.* The load keys let the operator initiate the loading of a self-loading program stored on binary cards or a tape. If a self-loading program is stored on the tape whose logical identification is 221 and is attached to channel A, pressing the load-tape key causes the computer to perform the following sequence of instructions:

Read select channel A for tape unit 221.

Reset load channel A with a bit in position S, a word count of 3, and an address of 0000. (The first three words are sent to core storage.)

Send the contents of location zero to channel A as a command.

Transfer to core storage location 0001.

This sequence of instructions starts the loading of a program stored on tape 221.

Pressing the load card key causes the same sequence of instructions to be executed, except that the address in the first instruction is 321, selecting the reader instead of the tape unit.

When loading is started, it is essential that the particular input unit from which information is to be loaded into storage be in ready status. Depressing the load keys resets the channels. Note that the MQ register will not be reset. The keys are operative only when the auto-manual switch is in automatic and the 7090 is in a ready status.

*31. Start Key.* Pressing the start key continues calculation at high speed if the computer has halted at a program stop, or if it has been returned to automatic operation after having been in manual status. Pressing the start key will reset the program stop light, and calculation starts with the operation specified in the instruction counter. Pressing the start key (CPU in manual) resets the program stop or I-O check light. All register contents are not destroyed. An index register may then be displayed or the program may be stepped at slow speed.

*32. Single Step and Multiple Step Keys.* These keys enable the operator, when the 7090 is in manual status, to proceed with his program either step-by-step (one step at a time) or at a slow automatic rate of speed. If an instruction is executed which causes an input-output device to be connected to the computer, the computer operates in the automatic mode until the I-O unit is disconnected. When this occurs, the computer returns to the manual mode.

*33. Enter MQ Key.* If the operator manually keys a given word of information into the panel input keys and if the enter-MQ key is pressed while the computer is in manual status, then the keyed-in word replaces the contents of the MQ. The contents of the SR are destroyed by this operation.

*34. Enter Instruction Key.* If the operator presses the enter instruction key while the computer is in manual status, the word in the keys is executed.

*35. Display Storage Key.* If, while the computer is in manual status, the operator keys a storage location into the address part of the panel entry keys and presses the display storage key, the contents of the address appearing in the keys are displayed in the SR where they may be read from the SR lights. In storage nullify mode, only the portion of storage not nullified may be displayed.

*36. Sense Switches.* Six sense switches give the operator manual control over the program while it is being executed by the computer at high speed. At various points in the program, giving sense instructions with the addresses of the sense switches causes the computer to follow one of two courses, depending on whether or not the sense switch tested is depressed. The sense switches are also effective while the computer is in manual status.

*37. Panel Input Switches.* These 36 panel input switches enable the operator to insert a word of information into the MQ or the instruction registers of the computer if it is in manual status and the enter-MQ or enter-instruction key is depressed. When a panel input switch is down, it represents "1"; when up it represents a "0". (A bit configuration may be set in these keys, and with the calculator in automatic mode, an ENK instruction will set the input switches' contents into the MQ.)

*38. Reset Switch.* This switch causes all panel input switches to be reset to the off or zero position.

*39. Emergency Power Off.* This is a pull-type switch that should only be used in an emergency, such as fire or excessive water.

## IBM 7617 Data Channel Console

As with the operator's console, the data channel console has all registers, counters, and associated indicators of the data channel displayed on its console. In addition, input-output selection, operation, and several special indicators are included (Figure 33).

### Indicator Lights

*1. Data Register.* These lights show the contents of the data register.

*2. Word Counter.* The word count minus one is indicated with these lights.

*3. Address Counter.* The core storage address is indicated with these lights.

*4. Location Counter.* These lights contain the address of the core storage location of the next command to be executed.

*5. I-O Check.* This light turns on for lack of a storage reference cycle on one-channel operation.

*6. Tape Check.* This light is turned on if any error is detected while reading or writing on tape. The channel tape check indicator light parallels the tape check light on the 7151 console control.

*7. End of Tape.* The end-of-tape light will be turned on, during a write operation, whenever the end-of-tape reflective spot of the selected tape passes the read-write head.

*8. Beginning of Tape.* This light is turned on whenever a backspace record or backspace file instruction moves a tape to its load point or attempts to backspace it beyond its load point.

*9. End of File.* When a disconnect occurs because an end of file is sensed while reading cards or tape, this light is turned on.

*10. Word Count Equal to Zero.* This light will be turned on whenever the word count is equal to zero.

*11. Read Gate, Write Gate, Data Register Loaded.* These three lights are customer engineering aids.

*12. Input-Output Indicators: Read Tape, Write Tape, BCD, WEOF, Rewind, Backspace Record, and Backspace File.* These lights are turned on whenever the individual operations are being executed or stacked in the channel.

*13. Unit Select.* In automatic operation, these lights indicate which I-O unit is selected. Under manual conditions, they will reflect the setting of the unit select switch.

*14. Operation Register.* These lights reflect the operation part of the command being executed by the data channel. They pertain to the type of data transmission as follows:

Sign (S) position: Data transmission under count control

One (1) position: Data transmission under record control

Two (2) position: Data transmission under transfer control

Nineteen (19) position: Data transmission inhibited under read control

Eighteen (18) position: Controls indirect addressing of all commands

*15. Read Card Reader, Write Printer, Write Punch, Read Printer, Print Binary.* One of these lights will be turned on whenever a card machine is being used.

*16. LRCR Register.* These lights reflect the contents of the longitudinal redundancy register. They hold the contents of the transmitted character be-

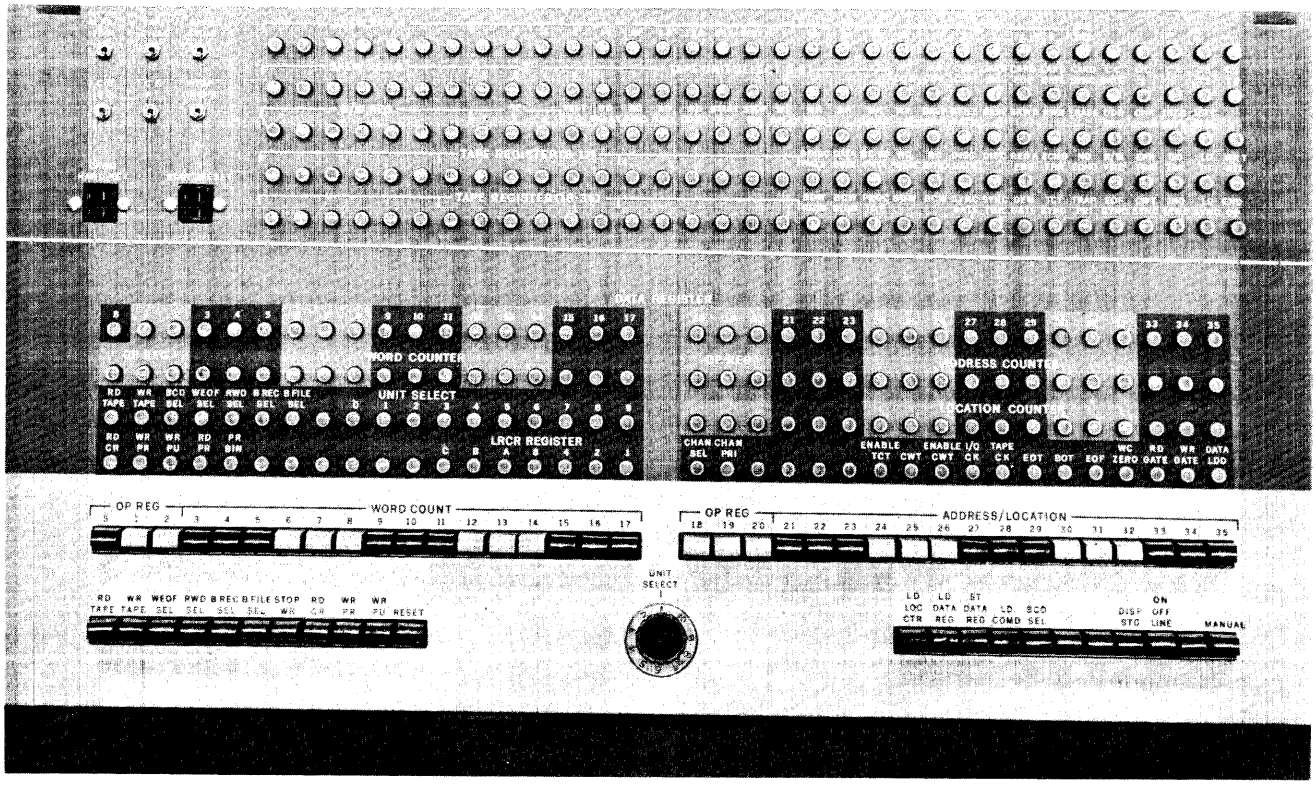



Figure 33. Operating Keys and Lights for IBM 7617

tween the disconnect and reselection of tape control circuits.

*17. Channel Select.* This light is on whenever the channel is in operation.

*18. Channel Priority.* This light is on whenever the channel has priority.

*19. Enable Tape Check Trap.* This light is on whenever an enable instruction is executed for this channel.

*20. Command Word Trap.* This light is on whenever a command word trap is being or is waiting to be executed.

*21. Enable Command Word Trap.* This light is on whenever an enable instruction is executed for this channel.

## Keys and Switches

*1. Entry Keys.* There are 36 entry keys, one for each position of the 7090 word. When a key is depressed, it remains in the position until reset by the reset key for the entry keys. These keys are operative only when the channel is in manual status.

*2. Write Punch, Write Printer, Read Tape, Write Tape, Read Reader.* These keys control some phase of input-output operation when a channel is in manual status. They are inoperative if the channel is in automatic status. They are explained as a group because their operation is identical except for class of operation. One example of their use is in punching a card:

a. The auto-manual switch for channel A is in manual.
b. A command with a count of 24 (keys 13 and 14) and an address of 100 (keys 29, 30, and 33) is set up in the channel entry keys.
c. The load control key of the channel is depressed, entering the command set up in step 2.
d. The write-punch key is depressed.

These steps would result in writing 24 words from core storage, starting at core location 100. Upon completion of the punching operation, the last word transmitted to the punch would be retained in the data register, the word count would be reduced to zero, and the address register would have advanced once for each word that was punched.

In another example, reading a tape, the sequence of operations would be the same as those in the first example for steps a, b, and c. Step d would change in three ways:

The tape select switch for the appropriate channel would be set to the tape unit desired.

The mode, BCD or binary, would be set by use of the BCD switch.

The rest of the operation would be the same as example 1 except that the first 24 words on the selected tape unit would be stored in locations 100 through 123.

*3. Rewind, Write End-of-File, Backspace Record, Backspace File.* These keys are also grouped because their operation is the same except that they refer to the non-data type of operation and are concerned only with tape. Depending on the setting of the select switch, the specified tape unit would, according to which key was depressed, rewind, write an end-of-file, backspace one record, or backspace one file.

*4. Stop Write.* This switch is effective only if the channel is in manual status. It is primarily a service aid and is used in conjunction with the write tape switch to interrupt write tape operations.

*5. Reset Key.* This key is operative only if the manual switch is in manual. Depression of the reset key resets all indicators, registers, and counters which are under manual control.

*6. Load Location Counter.* Depression of this key causes the information set up in the channel entry keys (21-35) to be entered into the location counter.

*7. Load Data Register.* Depression of this key sets the condition of the entry keys into the data register of a channel in manual status. The key has no effect if channels are in automatic.

*8. Store Data Register.* This key, when depressed, will cause the contents of the data register, for a channel in manual status, to be stored in core storage at the address in the address register of the channel. After the word is stored, the address register is increased by one and the word count register is decreased by one. When channels are in automatic, this key is inoperative.

*9. Load Command.* This key, when depressed, causes information set up on the channel entry keys to be entered into the indicators, word counter, and address register of whichever channel is in manual status. Entry keys S, 1, 2, 18 and 19 are entered into the indicators, keys 3-17 are sent to the word counter, and keys 21-35 are sent to the address register.

*10. BCD.* The BCD switch is operative only in manual status and, when depressed, forces a BCD mode of operation.

*11. Display Storage.* Depression of this key will cause the contents of the storage location, whose address appears in the channel's address register, to be displayed in the data register of a channel in manual status. The key is inoperative if channels are in automatic status.

NOTE: If either the store data register or the display storage key is depressed more than one time, for each depression the next sequential storage location will either receive the contents of the data register or be displayed in the data register.

*12. On-Off Line.* This switch is effective only if the channel is in manual status. In the on-line position, data may be transmitted to or from storage. In the off-line position, data cannot be sent to or from storage. When the channel is writing in the off-line position, the contents of the data register are repeatedly written.

*13. Manual.* In automatic position, this switch permits normal channel operation. In manual position, this switch activates the other manual controls and entry keys. With this switch in the manual position, the following instructions will be affected as indicated:

Transfer on channel in-operation will not transfer.

Transfer on channel not-in-operation will transfer.

Transfer on channel EOF will not transfer.

Transfer on channel redundancy-check will not transfer.

Store channel probably will store zeros, but may store any combination of zeros and ones.

The execution of any of the following instructions will result in "hanging up" the CPU:

Load channel or reset and load channel.

Read channel or write channel.

Rewind channel or write end-of-file channel.

Backspace record channel or backspace file channel.

If either sense-printer or sense-punch instruction is executed, it will be treated as no-operation. With the execution of either beginning-of-tape-test or end-of-tape-test, the program will skip the next instruction and then proceed.

*14. Unit Select.* The positions of this rotary switch, numbered 1 through 10, control unit selection under manual status. For example, assume that the select switch is turned to position 3 with the channel in manual status. Any tape unit attached to that channel whose individual select switch is set at 3 will be selected for manual operation under the control of the channel tape control keys.

In addition to its tape function, the switch is active when a printer or punch select key is depressed to activate the corresponding sense exit on the printer or punch control panel. If no sense exit is to be set, the switch must be set to an unlabeled position.

The keys and lights located under the cover across the top of the channel console are customer engineering aids.

## IBM 7151 Operations

### Entering Information

Information may be entered into core storage from the IBM 7151 Console Control. The sequence of operations necessary to enter a constant or new information is as follows (assume that the instruction clear and add 0100 is to be inserted into storage):

1. With the auto-manual switch in the manual position, set the bit configuration for the instruction (0500 . . . 0100) into the panel entry keys (switch down equals 1, switch up equals 0).
2. Depress the enter MQ key to store the contents of the entry keys into the MQ register.
3. Now place the bit configuration for the store MQ instruction (—0600 . . . xxxx) into the keys. The xxxx or address portion may be any storage location (assume 0200). If the enter instruction key is now depressed, the contents of the MQ register (CLA . . . 0100) are stored at core location 0200.

### Load Key Operation

The load keys let the operator initiate the loading of a self-loading program stored on binary cards or a magnetic tape. If a self-loading program is stored on the tape whose logical identification is 0221, and is attached to data channel A, pressing the load tape key causes the computer to perform the following sequence of instructions (auto-manual switch must be in auto position):

1. Read select channel A for tape unit 221.
2. Reset load channel A with a bit in position S, a word count of 3, and an address of 0000 (first three words are sent to core storage).
3. Send the contents of location zero to channel A as an input-output command.
4. Program transfer to location 0001 for an instruction.

This sequence of instructions and operations starts the loading of a program stored on magnetic tape unit 221.

Pressing the load card key causes the same sequence of instructions to be executed, except that the address of the read select instruction is 0321, which selects the card reader attached to channel A, instead of the tape unit.

When loading is started, it is essential that the particular input unit to be used be in ready status. Depressing the load keys automatically resets channel registers. Note that the MQ register will not be reset and load keys are operative only if the console is in automatic status (auto-manual switch in auto and the 7090 in a ready status).

## IBM 7617 Console Operations

Several operations may be performed from the data channel console when the console is in a manual mode (manual switch depressed). These include:

1. Data transmission operations
2. Non-data tape operations
3. Loading operations
4. Storing operations

### Data Transmission Operations

Five different types of data transmission operations include: write printer, write punch, write tape, read cards, and read tape. Depression of any of these keys will initiate read or write operations. For tape operations, the tape unit selected is specified by the data channel console unit select switch. The unit selected for transmission must be in a ready condition and an input-output command must be loaded into the data channel registers prior to depressing any data transmission key. For example, assume that information contained in core storage locations 5000 through 5100 is to be written on tape unit 1 attached to data channel A. The following steps would be taken:

1. Place the auto-manual switch in manual.
2. Set the bit configuration for an IOCD command with a word count of 77 and a starting address of 5000 (0 00077 0 05000).
3. Depress the load command key.
4. Turn the unit select switch to its 1 position.
5. Depress the write tape key. With the BCD switch depressed, tape will be written in the BCD mode; in its normal position, a binary tape will be written (assuming one of the tape units attached to that channel has its selector switch set at 1 and that the tape unit is in a ready status).

Other types of data transmission may be accomplished by depression of a different transmission key in step 5.

The on-off line switch is effective only when the channel is in manual status. In the on-line position, data may be transmitted to or from storage concurrently with computing. In the off-line position, data cannot be sent to or from storage but the contents of the data register may be repeatedly written. The word counter does not operate with this switch in the off-line position.

### Non-Data Tape Operations

Four non-data tape operations may be performed:

1. Backspace Record
2. Backspace file
1. Write end-of-file
4. Rewind

When one of these keys is depressed, the operation is performed on the tape unit selected by the channel console select switch. As with data transmission operations, the unit selected must be in ready status or the operation will not occur, and the particular light (backspace record, write end-of-file, and so on) will remain on signifying that the operation has not been completed. If it is impossible for the operation to occur (i.e., backspacing a tape unit beyond its load point) the data channel will completely ignore the operation and the light will not be turned on.

### Loading Operations

Three loading operations may be performed from the data channel console:

1. Load data register
2. Load command
3. Load location counter

Depressing the load data register key places the contents of the data channel entry keys (S, 1-35) into the data channel data register. The load command key loads the contents of the data channel console entry keys into the: operation register (keys S, 1, 2, 18 and 19), word counter register (keys 3-17) and channel address register (keys 21-35). If, after a command is loaded, a data transmission key is depressed, the channel performs any function not involving the central processing unit. For example, input-output proceed type commands will function, but load channel or channel trap operations will not. If a load data register operation precedes a load command operation, the data in the data register will be destroyed.

Indirectly addressed commands cannot be loaded when the data channel is in a manual mode, because indicator 18 is recognized only when it is brought from storage. This is true also of the transfer in channel command. An indirectly addressed command in storage may be referred to with the data channel in a manual mode and will then be processed in the normal manner.

The load location counter operation takes the contents of the data channel entry keys and places them in the corresponding positions of the location counter whenever the load location counter key is depressed.

When the display storage key is depressed, the contents of the core location specified by the channel address register are displayed in the data register lights. With each depression, the contents of the word counter and channel address register are increased by one, accomplishing sequential core location displays. This key provides the ability to display storage concurrently with computing.

### Storing Operations

Depressing the store data register key stores the contents of the data register at an address in core storage specified by the channel address register. Again, the word counter and channel address register are increased by one, allowing sequential storing operations with successive depressions of the store data register key. Storing occurs concurrently with computing.

# Appendix A. Listing of Operation Codes

"Page" refers to 7090 Reference Manual, A22-6528

## Alphabetic Listing

| OPERATION CODE ALPHA | OCTAL | INSTRUCTION | MODIF'N | INDEXABLE | INDIRECTLY ADDRESSABLE | PAGE |
|---|---|---|---|---|---|---|
| ACL | 0361 | Add and Carry Logical Word | | X | X | 21 |
| ADD | 0400 | Add | | X | X | 20 |
| ADM | 0401 | Add Magnitude | | X | X | 20 |
| ALS | 0767 | Accumulator Left Shift | 7 | X | | 31 |
| ANA | —0320 | AND to Accumulator | | X | X | 48 |
| ANS | 0320 | AND to Storage | | X | X | 48 |
| ARS | 0771 | Accumulator Right Shift | 7 | X | | 32 |
| AXC | —0774 | Address to Index Complemented | | | | 45 |
| AXT | 0774 | Address to Index True | | | | 45 |
| BSF | —0764 | Backspace File | 8 | X | | 59 |
| BSR | 0764 | Backspace Record | 8 | X | | 58 |
| BTT | 0760..xxxx | Beginning of Tape Test | | X | | 41 |
| CAL | —0500 | Clear and Add Logical Word | | X | X | 20 |
| CAQ | —0114 | Convert by Addition from MQ | 6 | | | 57 |
| CAS | 0340 | Compare AC with storage | | X | X | 43 |
| CHS | 0760..0002 | Change Sign | | X | | 49 |
| CLA | 0500 | Clear and Add | | X | X | 20 |
| CLM | 0760..0000 | Clear Magnitude | | X | | 49 |
| CLS | 0502 | Clear and Subtract | | X | X | 20 |
| COM | 0760..0006 | Complement Magnitude | | X | | 49 |
| CRQ | —0154 | Convert by Replacement from MQ | 6 | | | 56 |
| CVR | 0114 | Convert by Replacement from AC | 6 | | | 56 |
| DCT | 0760..0012 | Divide Check Test | | X | | 42 |
| DVH | 0220 | Divide or Halt | | X | X | 24 |
| DVP | 0221 | Divide or Proceed | | X | X | 24 |
| ECTM | —0760..0006 | Enter Copy Trap Mode | | X | | 66 |
| EFTM | —0760..0002 | Enter Floating Trap Mode | | X | | 66 |
| ENB | 0564 | Enable | | X | X | 63 |
| ENK | 0760..0004 | Enter Keys | | X | X | 35 |
| ERA | 0322 | Exclusive OR to Accumulator | | X | X | 48 |
| ESNT | —0021 | Enter Storage Null and Transfer | | X | X | 65 |
| ESTM | —0760..0005 | Enter Select Trap Mode | | X | | 65 |
| ETM | 0760..0007 | Enter Trapping Mode | | X | | 36 |
| ETT | —0760..xxxx | End of Tape Test | | X | | 41 |
| FAD | 0300 | Floating Add | 3 | X | X | 26 |
| FAM | 0304 | Floating Add Magnitude | 3 | X | X | 27 |
| FDH | 0240 | Floating Divide or Halt | 5 | X | X | 30 |
| FDP | 0241 | Floating Divide or Proceed | 5 | X | X | 30 |
| FMP | 0260 | Floating Multiply | 1 | X | X | 29 |
| FRN | 0760..0011 | Floating Round | | X | | 28 |
| FSB | 0302 | Floating Subtract | 3 | X | X | 27 |
| FSM | 0306 | Floating Subtract Magnitude | 3 | X | X | 28 |
| HPR | 0420 | Halt and Proceed | | | | 35 |
| HTR | 0000 | Halt and Transfer | | X | X | 36 |
| IIA | 0041 | Invert Indicators from AC | | | | 52 |
| IIL | —0051 | Invert Indicators of Left Half | | | | 53 |
| IIR | 0051 | Invert Indicators of Right Half | | | | 53 |
| IIS | 0440 | Invert Indicators from Storage | | X | X | 53 |
| IOT | 0760..0005 | Input-Output Check Test | | X | X | 42 |
| LAC | 0535 | Load Complement of Address in Index | | | | 45 |
| LAS | —0340 | Logical Compare Accumulator with Storage | | X | X | 43 |
| LBT | 0760..0001 | Low- Order Bit Test | | X | | 42 |
| LCHA | 0544 | Load Channel A | 8 | X | X | 65 |
| LCHB | —0544 | Load Channel B | 8 | X | X | 65 |
| LCHC | 0545 | Load Channel C | 8 | X | X | 65 |
| LCHD | —0545 | Load Channel D | 8 | X | X | 65 |
| LCHE | 0546 | Load Channel E | 8 | X | X | 65 |
| LCHF | —0546 | Load Channel F | 8 | X | X | 65 |

## Alphabetic *(Continued)*

| OPERATION CODE ALPHA | OCTAL | INSTRUCTION | MODIF'N | INDEXABLE | INDIRECTLY ADDRESSABLE | PAGE |
|---|---|---|---|---|---|---|
| LCHG | 0547 | Load Channel G | 8 | X | X | 65 |
| LCHH | —0547 | Load Channel H | 8 | X | X | 65 |
| LDC | —0535 | Load Complement of Decrement in XR | | | | 45 |
| LDI | 0441 | Load Indicators | | X | X | 51 |
| LDQ | 0560 | Load MQ | | X | X | 33 |
| LFT | —0054 | Left Half Indicators, Off Test | | | | 55 |
| LFTM | —0760..0004 | Leave Floating Trap Mode | | X | | 66 |
| LGL | —0763 | Logical Left Shift | 7 | X | | 32 |
| LGR | —0765 | Logical Right Shift | 7 | X | | 32 |
| LLS | 0763 | Long Left Shift | 7 | X | | 32 |
| LNT | —0056 | Left Half Indicators, On Test | | | | 54 |
| LRS | 0765 | Long Right Shift | 7 | X | | 32 |
| LSNM | —0760..0010 | Leave Storage Nullification Mode | | X | | 65 |
| LTM | —0760..0007 | Leave Trapping Mode | | X | | 37 |
| LXA | 0534 | Load Index from Address | | | | 44 |
| LXD | —0534 | Load Index from Decrement | | | | 45 |
| MPR | —0200 | Multiply and Round | 1 | X | X | 22 |
| MPY | 0200 | Multiply | 1 | X | X | 22 |
| MSE | —0760 | Minus Sense | | X | | 41 |
| NOP | 0761 | No Operation | | | | 35 |
| NZT | —0520 | Storage Not-Zero Test | | X | X | 43 |
| OAI | 0043 | OR Accumulator to Indicators | | | | 51 |
| OFT | 0444 | Off Test for Indicators | | X | X | 54 |
| ONT | 0446 | On Test for Indicators | | X | X | 54 |
| ORA | —0501 | OR to Accumulator | | X | X | 48 |
| ORS | —0602 | OR to Storage | | X | X | 48 |
| OSI | 0442 | OR Storage to Indicators | | X | X | 51 |
| PAC | 0737 | Place Complement of Address in XR | | | | 46 |
| PAI | 0044 | Place Accumulator in Indicators | | | | 50 |
| PAX | 0734 | Place Address in XR | | | | 46 |
| PBT | —0760..0001 | P-bit Test | | X | | 42 |
| PDC | —0737 | Place Complement of Decrement in XR | | | | 46 |
| PDX | —0734 | Place Decrement in Index | | | | 46 |
| PIA | —0046 | Place Indicator in Accumulator | | | | 51 |
| PSE | 0760 | Plus Sense | | X | | 40 |
| PXA | 0754 | Place Index in Address | | | | 47 |
| PXD | —0754 | Place Index in Decrement | | | | 47 |
| RCHA | 0540 | Reset and Load Channel A | | X | X | 64 |
| RCHB | —0540 | Reset and Load Channel B | | X | X | 64 |
| RCHC | 0541 | Reset and Load Channel C | | X | X | 64 |
| RCHD | —0541 | Reset and Load Channel D | | X | X | 64 |
| RCHE | 0542 | Reset and Load Channel E | | X | X | 64 |
| RCHF | —0542 | Reset and Load Channel F | | X | X | 64 |
| RCHG | 0543 | Reset and Load Channel G | | X | X | 64 |
| RCHH | —0543 | Reset and Load Channel H | | X | X | 64 |
| RCT | 0760..0014 | Restore Channel Traps | | X | | 64 |
| RDS | 0762 | Read Select | 8 | X | | 58 |
| REW | 0772 | Rewind | 8 | X | | 59 |
| RFT | 0054 | Right Half Indicators, Off Test | | | | 55 |
| RIA | —0042 | Reset Indicators from Accumulator | | | | 52 |
| RIL | —0057 | Reset Indicators of Left Half | | | | 52 |
| RIR | 0057 | Reset Indicators of Right Half | | | | 52 |
| RIS | 0445 | Reset Indicators from Storage | | X | X | 52 |
| RND | 0760..0010 | Round | | X | | 22 |
| RNT | 0056 | Right Half Indicators, On Test | | | | 54 |
| RQL | —0773 | Rotate MQ Left | 7 | X | | 32 |

## Alphabetic *(Continued)*

| OPERATION CODE ALPHA | OCTAL | INSTRUCTION | MODIF'N | INDEXABLE | INDIRECTLY ADDRESSABLE | PAGE |
|---|---|---|---|---|---|---|
| RUN | —0772 | Rewind and Unload | | X | | 59 |
| SBM | —0400 | Subtract Magnitude | | X | X | 21 |
| SCHA | 0640 | Store Channel A | | X | X | 64 |
| SCHB | —0640 | Store Channel B | | X | X | 64 |
| SCHC | 0641 | Store Channel C | | X | X | 64 |
| SCHD | —0641 | Store Channel D | | X | X | 64 |
| SCHE | 0642 | Store Channel E | | X | X | 64 |
| SCHF | —0642 | Store Channel F | | X | X | 64 |
| SCHG | 0643 | Store Channel G | | X | X | 64 |
| SCHH | —0643 | Store Channel H | | X | X | 64 |
| SDN | 0776 | Set Density | | X | | 59 |
| SIL | —0055 | Set Indicator of Left Half | | | | 51 |
| SIR | 0055 | Set Indicator of Right Half | | | | 51 |
| SLQ | —0620 | Store Left Half MQ | | X | X | 33 |
| SLW | 0602 | Store Logical Word | | X | X | 33 |
| SSM | —0760..0003 | Set Sign Minus | | X | | 50 |
| SSP | 0760..0003 | Set Sign Plus | | X | | 50 |
| STA | 0621 | Store Address | | X | X | 34 |
| STD | 0622 | Store Decrement | | X | X | 34 |
| STI | 0604 | Store Indicators | | X | X | 51 |
| STL | —0625 | Store Instruction Location Counter | | X | X | 34 |
| STO | 0601 | Store | | X | X | 33 |
| STP | 0630 | Store Prefix | | X | X | 33 |
| STQ | —0600 | Store MQ | | X | X | 33 |
| STR | —1000 | Store Location and Trap | | | | 34 |
| STT | 0625 | Store Tag | | X | X | 34 |
| STZ | 0600 | Store Zero | | X | X | 34 |
| SUB | 0402 | Subtract | | X | X | 21 |
| SXA | 0634 | Store Index in Address | | | | 46 |
| SXD | —0634 | Store Index in Decrement | | | | 47 |
| TCNA | —0060 | Transfer on DSC A Not in Operation | | X | X | 44 |
| TCNB | —0061 | Transfer on DSC B Not in Operation | | X | X | 44 |
| TCNC | —0062 | Transfer on DSC C Not in Operation | | X | X | 44 |
| TCND | —0063 | Transfer on DSC D Not in Operation | | X | X | 44 |
| TCNE | —0064 | Transfer on DSC E Not in Operation | | X | X | 44 |
| TCNF | —0065 | Transfer on DSC F Not in Operation | | X | X | 44 |
| TCNG | —0066* | Transfer on DSC G Not in Operation | | X | X | 44 |
| TCNH | —0067* | Transfer on DSC H Not in Operation | | X | X | 44 |
| TCOA | 0060 | Transfer on DSC A in Operation | | X | X | 43 |
| TCOB | 0061 | Transfer on DSC B in Operation | | X | X | 43 |
| TCOC | 0062 | Transfer on DSC C in Operation | | X | X | 43 |
| TCOD | 0063 | Transfer on DSC D in Operation | | X | X | 43 |
| TCOE | 0064 | Transfer on DSC E in Operation | | X | X | 43 |
| TCOF | 0065 | Transfer on DSC F in Operation | | X | X | 43 |
| TCOG | 0066 | Transfer on DSC G in Operation | | X | X | 43 |
| TCOH | 0067 | Transfer on DSC H in Operation | | X | X | 43 |
| TEFA | 0030 | Transfer on DSC A End of File | | X | X | 44 |
| TEFB | —0030 | Transfer on DSC B End of File | | X | X | 44 |
| TEFC | 0031 | Transfer on DSC C End of File | | X | X | 44 |

## Alphabetic *(Continued)*

| OPERATION CODE ALPHA | OCTAL | INSTRUCTION | MODIF'N | INDEXABLE | INDIRECTLY ADDRESSABLE | PAGE |
|---|---|---|---|---|---|---|
| TEFD | —0031 | Transfer on DSC D End of File | | X | X | 44 |
| TEFE | 0032 | Transfer on DSC E End of File | | X | X | 44 |
| TEFF | —0032 | Transfer on DSC F End of File | | X | X | 44 |
| TEFG | 0033 | Transfer on DSC G End of File | | X | X | 44 |
| TEFH | —0033 | Transfer on DSC H End of File | | X | X | 44 |
| TIF | 0046 | Transfer if Indicators Off | | X | X | 53 |
| TIO | 0042 | Transfer if Indicators On | | X | X | 53 |
| TIX | 2000 | Transfer on Index | | | | 40 |
| TLQ | 0040 | Transfer on Low MQ | | X | X | 39 |
| TMI | —0120 | Transfer on Minus | | X | X | 38 |
| TNO | —0140 | Transfer on No Overflow | | X | X | 38 |
| TNX | —2000 | Transfer on No Index | | | | 40 |
| TNZ | —0100 | Transfer on No Zero | | X | X | 37 |
| TOV | 0140 | Transfer on Overflow | | X | X | 38 |
| TPL | 0120 | Transfer on Plus | | X | X | 38 |
| TQO | 0161 | Transfer on Quotient Overflow | | X | X | 38 |
| TQP | 0162 | Transfer on MQ Plus | | X | X | 38 |
| TRA | 0020 | Transfer | | X | X | 36 |
| TRCA | 0022 | Transfer on DSC A Redundancy Check | | X | X | 44 |
| TRCB | —0022 | Transfer on DSC B Redundancy Check | | X | X | 44 |
| TRCC | 0024 | Transfer on DSC C Redundancy Check | | X | X | 44 |
| TRCD | —0024 | Transfer on DSC D Redundancy Check | | X | X | 44 |
| TRCE | 0026 | Transfer on DSC E Redundancy Check | | X | X | 44 |
| TRCF | —0026 | Transfer on DSC F Redundancy Check | | X | X | 44 |
| TRCG | 0027 | Transfer on DSC G Redundancy Check | | X | X | 44 |
| TRCH | —0027 | Transfer on DSC H Redundancy Check | | X | X | 44 |
| TSX | 0074 | Transfer and Set Index | | | | 39 |
| TTR | 0021 | Trap Transfer | | X | X | 37 |
| TXH | 3000 | Transfer on Index High | | | | 39 |
| TXI | 1000 | Transfer with XR Incremented | | | | 39 |
| TXL | —3000 | Transfer on XR Low or Equal | | | | 40 |
| TZE | 0100 | Transfer on Zero | | X | X | 37 |
| UAM | —0304 | Unnormalized Add Magnitude | 4 | X | X | 28 |
| UFA | —0300 | Unnormalized Floating Add | 4 | X | X | 27 |
| UFM | —0260 | Unnormalized Floating Multiply | 1 | X | X | 29 |
| UFS | —0302 | Unnormalized Floating Subtract | 4 | X | X | 28 |
| USM | —0306 | Unnormalized Subtract Magnitude | 4 | X | X | 28 |
| VDH | 0224 | Variable Length Divide or Halt | 2 | X | | 24 |
| VDP | 0225 | Variable Length Divide or Proceed | 2 | X | | 24 |
| VLM | 0204 | Variable Length Multiply | 1,2 | X | | 22 |
| WEF | 0770 | Write End of File | 8 | X | | 59 |
| WRS | 0766 | Write Select | 8 | X | | 58 |
| XCA | 0131 | Exchange AC and MQ | | | | 34 |
| XCL | —0130 | Exchange Logical AC and MQ | | | | 34 |
| XEC | 0522 | Execute | | X | X | 36 |
| ZET | 0520 | Storage Zero Test | | X | X | 43 |

## Numerical Listing

| OPERATION CODE ALPHA | OCTAL | INSTRUCTION | MODIF'N | INDEXABLE | INDIRECTLY ADDRESSABLE | PAGE |
|---|---|---|---|---|---|---|
| HTR | 0000 | Halt and Transfer | | X | X | 36 |
| TRA | 0020 | Transfer | | X | X | 36 |
| TTR | 0021 | Trap Transfer | | X | X | 37 |
| ESNT | —0021 | Enter Storage Null. and Transfer | | X | X | 65 |
| TRCA | 0022 | Transfer on DSC A Redundancy Check | | X | X | 44 |
| TRCB | —0022 | Transfer on DSC B Redundancy Check | | X | X | 44 |
| TRCC | 0024 | Transfer on DSC C Redundancy Check | | X | X | 44 |
| TRCD | —0024 | Transfer on DSC D Redundancy Check | | X | X | 44 |
| TRCE | 0026 | Transfer on DSC E Redundancy Check | | X | X | 44 |
| TRCF | —0026 | Transfer on DSC F Redundancy Check | | X | X | 44 |
| TRCG | 0027 | Transfer on DSC G Redundancy Check | | X | X | 44 |
| TRCH | —0027 | Transfer on DSC H Redundancy Check | | X | X | 44 |
| TEFA | 0030 | Transfer on DSC A End of File | | X | X | 44 |
| TEFB | —0030 | Transfer on DSC B End of File | | X | X | 44 |
| TEFC | 0031 | Transfer on DSC C End of File | | X | X | 44 |
| TEFD | —0031 | Transfer on DSC D End of File | | X | X | 44 |
| TEFE | 0032 | Transfer on DSC E End of File | | X | X | 44 |
| TEFF | —0032 | Transfer on DSC F End of File | | X | X | 44 |
| TEFG | 0033 | Transfer on DSC G End of File | | X | X | 44 |
| TEFH | —0033 | Transfer on DSC H End of File | | X | X | 44 |
| TLQ | 0040 | Transfer on Low MQ | | X | X | 39 |
| IIA | 0041 | Invert Indicators from AC | | | | 52 |
| TIO | 0042 | Transfer if Indicators On | | X | X | 53 |
| RIA | —0042 | Reset Indicators from AC | | | | 52 |
| OAI | 0043 | OR Accumulator to Indicators | | | | 51 |
| PAI | 0044 | Place Accumulator in Indicators | | | | 50 |
| TIF | 0046 | Transfer if Indicators Off | | X | X | 53 |
| PIA | —0046 | Place Indicators in Accumulator | | | | 51 |
| IIR | 0051 | Invert Indicators of Right Half | | | | 53 |
| IIL | —0051 | Invert Indicators of Left Half | | | | 53 |
| RFT | 0054 | Right Half Indicators, Off Test | | | | 55 |
| LFT | —0054 | Left Half Indicators, Off Test | | | | 55 |
| SIR | 0055 | Set Indicator of Right Half | | | | 51 |
| SIL | —0055 | Set Indicator of Left Half | | | | 51 |
| RNT | 0056 | Right Half Indicators, On Test | | | | 54 |
| LNT | —0056 | Left Half Indicators, On Test | | | | 54 |
| RIR | 0057 | Reset Indicators of Right Half | | | | 52 |
| RIL | —0057 | Reset Indicators on Left Half | | | | 52 |
| TCNA | —0060 | Transfer DSC A Not in Operation | | X | X | 44 |
| TCNB | —0061 | Transfer DSC B Not in Operation | | X | X | 44 |
| TCNC | —0062 | Transfer DSC C Not in Operation | | X | X | 44 |
| TCND | —0063 | Transfer DSC D Not in Operation | | X | X | 44 |
| TCNE | —0064 | Transfer DSC E Not in Operation | | X | X | 44 |
| TCNF | —0065 | Transfer DSC F Not in Operation | | X | X | 44 |

## Numerical (*Continued*)

| OPERATION CODE ALPHA | OCTAL | INSTRUCTION | MODIF'N | INDEXABLE | INDIRECTLY ADDRESSABLE | PAGE |
|---|---|---|---|---|---|---|
| TCNG | —0066 | Transfer DSC G Not in Operation | | X | X | 44 |
| TCNH | —0067 | Transfer DSC H Not in Operation | | X | X | 44 |
| TCOA | 0060 | Transfer DSC A in Operation | | X | X | 43 |
| TCOB | 0061 | Transfer DSC B in Operation | | X | X | 43 |
| TCOC | 0062 | Transfer DSC C in Operation | | X | X | 43 |
| TCOD | 0063 | Transfer DSC D in Operation | | X | X | 43 |
| TCOE | 0064 | Transfer DSC E in Operation | | X | X | 43 |
| TCOF | 0065 | Transfer DSC F in Operation | | X | X | 43 |
| TCOG | 0066 | Transfer DSC G in Operation | | X | X | 43 |
| TCOH | 0067 | Transfer DSC H in Operation | | X | X | 43 |
| TSX | 0074 | Transfer and Set Index | | | | 39 |
| TZE | 0100 | Transfer on Zero | | X | X | 37 |
| TNZ | —0100 | Transfer on No Zero | | X | X | 37 |
| CVR | 0114 | Convert by Replacement from AC | 6 | | | 56 |
| CAQ | —0114 | Convert by Addition from MQ | 6 | | | 56 |
| TPL | 0120 | Transfer on Plus | | X | X | 38 |
| TMI | —0120 | Transfer on Minus | | X | X | 38 |
| XCL | —0130 | Exchange Logical Accumulator and MQ | | | | 34 |
| XCA | 0131 | Exchange Accumulator and MQ | | | | 34 |
| TOV | 0140 | Transfer on Overflow | | X | X | 38 |
| TNO | —0140 | Transfer on No Overflow | | X | X | 38 |
| CRQ | —0154 | Convert by Replacement from MQ | 6 | | | 56 |
| TQO | 0161 | Transfer on Quotient Overflow | | X | X | 38 |
| TQP | 0162 | Transfer on MQ Plus | | X | X | 38 |
| MPY | 0200 | Multiply | 1 | X | X | 22 |
| MPR | —0200 | Multiply and Round | 1 | X | X | 22 |
| VLM | 0204 | Variable Length Multiply | 1,2 | X | | 22 |
| DVH | 0220 | Divide or Halt | | X | X | 24 |
| DVP | 0221 | Divide or Proceed | | X | X | 24 |
| VDH | 0224 | Variable Length Divide or Halt | 2 | X | | 24 |
| VDP | 0225 | Variable Length Divide or Proceed | 2 | X | | 24 |
| FDH | 0240 | Floating Divide or Halt | 5 | X | X | 30 |
| FDP | 0241 | Floating Divide or Proceed | 5 | X | X | 30 |
| FMP | 0260 | Floating Multiply | 1 | X | X | 29 |
| UFM | —0260 | Unnormalized Floating Multiply | 1 | X | X | 28 |
| FAD | 0300 | Floating Add | 3 | X | X | 26 |
| UFA | —0300 | Unnormalized Floating Add | 4 | X | X | 27 |
| FSB | 0302 | Floating Subtract | 3 | X | X | 27 |
| UFS | —0302 | Unnormalized Floating Subtract | 4 | X | X | 28 |
| FAM | 0304 | Floating Add Magnitude | 3 | X | X | 27 |
| UAM | —0304 | Unnormalized Add Magnitude | 4 | X | X | 28 |
| FSM | 0306 | Floating Subtract Magnitude | 3 | X | X | 28 |
| USM | —0306 | Unnormalized Subtract Magnitude | 4 | X | X | 28 |
| ANS | 0320 | AND to Storage | | X | X | 48 |
| ANA | —0320 | AND to Accumulator | | X | X | 48 |
| ERA | 0322 | Exclusive OR to Accumulator | | X | X | 48 |
| CAS | 0340 | Compare Accumulator with Storage | | X | X | 43 |
| LAS | —0340 | Logical Compare AC with Storage | | X | X | 43 |
| ACL | 0361 | Add and Carry Logical Word | | X | X | 21 |
| ADD | 0400 | Add | | X | X | 20 |

## Numerical *(Continued)*

| OPERATION CODE ALPHA | OCTAL | INSTRUCTION | MODIF'N | INDEXABLE | INDIRECTLY ADDRESSABLE | PAGE |
|---|---|---|---|---|---|---|
| SBM | —0400 | Subtract Magnitude | | X | X | 21 |
| ADM | 0401 | Add Magnitude | | X | X | 20 |
| SUB | 0402 | Subtract | | X | X | 21 |
| HPR | 0420 | Halt and Proceed | | | | 35 |
| IIS | 0440 | Invert Indicators from Storage | | X | X | 53 |
| LDI | 0441 | Load Indicators | | X | X | 51 |
| OSI | 0442 | OR Storage to Indicators | | X | X | 51 |
| OFT | 0444 | Off Test for Indicators | | X | X | 54 |
| RIS | 0445 | Reset Indicators from Storage | | X | X | 52 |
| ONT | 0446 | On Test for Indicators | | X | X | 54 |
| CLA | 0500 | Clear and Add | | X | X | 20 |
| CAL | —0500 | Clear and Add Logical Word | | X | X | 20 |
| ORA | —0501 | OR to Accumulator | | X | X | 48 |
| CLS | 0502 | Clear and Subtract | | X | X | 20 |
| ZET | 0520 | Storage Zero Test | | X | X | 43 |
| NZT | —0520 | Storage Not-Zero Test | | X | X | 43 |
| XEC | 0522 | Execute | | X | X | 36 |
| LXA | 0534 | Load Index from Address | | | | 44 |
| LXD | —0534 | Load Index from Decrement | | | | 45 |
| LAC | 0535 | Load Complement of Address in XR | | | | 45 |
| LDC | —0535 | Load Complement of Decrement in XR | | | | 45 |
| RCHA | 0540 | Reset and Load Channel A | | X | X | 64 |
| RCHB | —0540 | Reset and Load Channel B | | X | X | 64 |
| RCHC | 0541 | Reset and Load Channel C | | X | X | 64 |
| RCHD | —0541 | Reset and Load Channel D | | X | X | 64 |
| RCHE | 0542 | Reset and Load Channel E | | X | X | 64 |
| RCHF | —0542 | Reset and Load Channel F | | X | X | 64 |
| RCHG | 0543 | Reset and Load Channel G | | X | X | 64 |
| RCHH | —0543 | Reset and Load Channel H | | X | X | 64 |
| LCHA | 0544 | Load Channel A | 8 | X | X | 65 |
| LCHB | —0544 | Load Channel B | 8 | X | X | 65 |
| LCHC | 0545 | Load Channel C | 8 | X | X | 65 |
| LCHD | —0545 | Load Channel D | 8 | X | X | 65 |
| LCHE | 0546 | Load Channel E | 8 | X | X | 65 |
| LCHF | —0546 | Load Channel F | 8 | X | X | 65 |
| LCHG | 0547 | Load Channel G | 8 | X | X | 65 |
| LCHH | —0547 | Load Channel H | 8 | X | X | 65 |
| LDQ | 0560 | Load MQ | | X | X | 33 |
| ENB | 0564 | Enable | | X | X | 63 |
| STZ | 0600 | Store Zero | | X | X | 34 |
| STQ | —0600 | Store MQ | | X | X | 33 |
| STO | 0601 | Store | | X | X | 33 |
| SLW | 0602 | Store Logical Word | | X | X | 33 |
| ORS | —0602 | OR to Storage | | X | X | 48 |
| STI | 0604 | Store Indicators | | X | X | 51 |
| SLQ | —0620 | Store Left Half MQ | | X | X | 33 |
| STA | 0621 | Store Address | | X | X | 34 |
| STD | 0622 | Store Decrement | | X | X | 34 |
| STT | 0625 | Store Tag | | X | X | 34 |
| STL | —0625 | Store Instruction Location Counter | | X | X | 34 |
| STP | 0630 | Store Prefix | | X | X | 33 |
| SXA | 0634 | Store Index in Address | | | | 46 |
| SXD | —0634 | Store Index in Decrement | | | | 47 |
| SCHA | 0640 | Store Channel A | | X | X | 64 |
| SCHB | —0640 | Store Channel B | | X | X | 64 |
| SCHC | 0641 | Store Channel C | | X | X | 64 |
| SCHD | —0641 | Store Channel D | | X | X | 64 |

## Numerical *(Continued)*

| OPERATION CODE ALPHA | OCTAL | INSTRUCTION | MODIF'N | INDEXABLE | INDIRECTLY ADDRESSABLE | PAGE |
|---|---|---|---|---|---|---|
| SCHE | 0642 | Store Channel E | | X | X | 64 |
| SCHF | —0642 | Store Channel F | | X | X | 64 |
| SCHG | 0643 | Store Channel G | | X | X | 64 |
| SCHH | —0643 | Store Channel H | | X | X | 64 |
| PAX | 0734 | Place Address in Index | | | | 46 |
| PDX | —0734 | Place Decrement in Index | | | | 46 |
| PAC | 0737 | Place Complement of Address in XR | | | | 46 |
| PDC | —0737 | Place Complement of Decrement in XR | | | | 46 |
| PXA | 0754 | Place Index in Address | | | | 47 |
| PXD | —0754 | Place Index in Decrement | | | | 47 |
| PSE | 0760 | Plus Sense | | X | | 40 |
| MSE | —0760 | Minus Sense | | X | | 41 |
| CLM | 0760..0000 | Clear Magnitude | | X | | 49 |
| LBT | 0760..0001 | Low-Order Bit Test | | X | | 42 |
| PBT | —0760..0001 | P-bit Test | | X | | 42 |
| CHS | 0760..0002 | Change Sign | | X | | 49 |
| EFTM | —0760..0002 | Enter Floating Trap Mode | | X | | 66 |
| SSP | 0760..0003 | Set Sign Plus | | X | | 50 |
| SSM | —0760..0003 | Set Sign Minus | | X | | 50 |
| ENK | 0760..0004 | Enter Keys | | X | | 35 |
| LFTM | —0760..0004 | Leave Floating Trap Mode | | X | | 66 |
| IOT | 0760..0005 | Input-Output Check Test | | X | | 42 |
| ESTM | —0760..0005 | Enter Select Trap Mode | | X | | 65 |
| COM | 0760..0006 | Complement Magnitude | | X | | 49 |
| ECTM | —0760..0006 | Enter Copy Trap Mode | | X | | 66 |
| ETM | 0760..0007 | Enter Trapping Mode | | X | | 36 |
| LTM | —7060..0007 | Leave Trapping Mode | | X | | 37 |
| RND | 0760..0010 | Round | | X | | 22 |
| LSNM | —0760..0010 | Leave Storage Nullification Mode | | X | | 65 |
| FRN | 0760..0011 | Floating Round | | X | | 28 |
| DCT | 0760..0012 | Divide Check Test | | X | | 42 |
| RCT | 0760..0014 | Restore Channel Traps | | X | | 64 |
| NOP | 0761 | No Operation | | | | 35 |
| RDS | 0762 | Read Select | 8 | X | | 58 |
| LLS | 0763 | Long Left Shift | 7 | X | | 32 |
| LGL | —0763 | Logical Left Shift | 7 | X | | 32 |
| BSR | 0764 | Backspace Record | 8 | X | | 58 |
| BSF | —0764 | Backspace File | 8 | X | | 59 |
| LRS | 0765 | Long Right Shift | 7 | X | | 32 |
| LGR | —0765 | Logical Right Shift | 7 | X | | 32 |
| WRS | 0766 | Write Select | 8 | X | | 58 |
| ALS | 0767 | Accumulator Left Shift | 7 | X | | 31 |
| WEF | 0770 | Write End of File | 8 | X | | 59 |
| ARS | 0771 | Accumulator Right Shift | 7 | X | | 32 |
| REW | 0772 | Rewind | 8 | X | | 59 |
| RUN | —0772 | Rewind and Unload | | X | | 59 |
| RQL | —0773 | Rotate MQ Left | 7 | X | | 32 |
| AXT | 0774 | Address to Index True | | | | 45 |
| AXC | —0774 | Address to Index Complemented | | | | 45 |
| SDN | 0776 | Set Density | | X | | 59 |
| TXI | 1000 | Transfer with XR Incremented | | | | 39 |
| STR | —1000 | Store Location and Trap | | | | 34 |
| TIX | 2000 | Transfer on Index | | | | 40 |
| TNX | —2000 | Transfer on No Index | | | | 40 |
| TXH | 3000 | Transfer on Index High | | | | 39 |
| TXL | —3000 | Transfer on XR Low or Equal | | | | 40 |

# Appendix B. Octal-Decimal Integer Conversion Table

| 0000 to 0777 (Octal) | 0000 to 0511 (Decimal) |
|---|---|

| Octal | Decimal |
|---|---|
| 10000 - | 4096 |
| 20000 - | 8192 |
| 30000 - | 12288 |
| 40000 - | 16384 |
| 50000 - | 20480 |
| 60000 - | 24576 |
| 70000 - | 28672 |

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 0000 | 0000 | 0001 | 0002 | 0003 | 0004 | 0005 | 0006 | 0007 |
| 0010 | 0008 | 0009 | 0010 | 0011 | 0012 | 0013 | 0014 | 0015 |
| 0020 | 0016 | 0017 | 0018 | 0019 | 0020 | 0021 | 0022 | 0023 |
| 0030 | 0024 | 0025 | 0026 | 0027 | 0028 | 0029 | 0030 | 0031 |
| 0040 | 0032 | 0033 | 0034 | 0035 | 0036 | 0037 | 0038 | 0039 |
| 0050 | 0040 | 0041 | 0042 | 0043 | 0044 | 0045 | 0046 | 0047 |
| 0060 | 0048 | 0049 | 0050 | 0051 | 0052 | 0053 | 0054 | 0055 |
| 0070 | 0056 | 0057 | 0058 | 0059 | 0060 | 0061 | 0062 | 0063 |
| 0100 | 0064 | 0065 | 0066 | 0067 | 0068 | 0069 | 0070 | 0071 |
| 0110 | 0072 | 0073 | 0074 | 0075 | 0076 | 0077 | 0078 | 0079 |
| 0120 | 0080 | 0081 | 0082 | 0083 | 0084 | 0085 | 0086 | 0087 |
| 0130 | 0088 | 0089 | 0090 | 0091 | 0092 | 0093 | 0094 | 0095 |
| 0140 | 0096 | 0097 | 0098 | 0099 | 0100 | 0101 | 0102 | 0103 |
| 0150 | 0104 | 0105 | 0106 | 0107 | 0108 | 0109 | 0110 | 0111 |
| 0160 | 0112 | 0113 | 0114 | 0115 | 0116 | 0117 | 0118 | 0119 |
| 0170 | 0120 | 0121 | 0122 | 0123 | 0124 | 0125 | 0126 | 0127 |
| 0200 | 0128 | 0129 | 0130 | 0131 | 0132 | 0133 | 0134 | 0135 |
| 0210 | 0136 | 0137 | 0138 | 0139 | 0140 | 0141 | 0142 | 0143 |
| 0220 | 0144 | 0145 | 0146 | 0147 | 0148 | 0149 | 0150 | 0151 |
| 0230 | 0152 | 0153 | 0154 | 0155 | 0156 | 0157 | 0158 | 0159 |
| 0240 | 0160 | 0161 | 0162 | 0163 | 0164 | 0165 | 0166 | 0167 |
| 0250 | 0168 | 0169 | 0170 | 0171 | 0172 | 0173 | 0174 | 0175 |
| 0260 | 0176 | 0177 | 0178 | 0179 | 0180 | 0181 | 0182 | 0183 |
| 0270 | 0184 | 0185 | 0186 | 0187 | 0188 | 0189 | 0190 | 0191 |
| 0300 | 0192 | 0193 | 0194 | 0195 | 0196 | 0197 | 0198 | 0199 |
| 0310 | 0200 | 0201 | 0202 | 0203 | 0204 | 0205 | 0206 | 0207 |
| 0320 | 0208 | 0209 | 0210 | 0211 | 0212 | 0213 | 0214 | 0215 |
| 0330 | 0216 | 0217 | 0218 | 0219 | 0220 | 0221 | 0222 | 0223 |
| 0340 | 0224 | 0225 | 0226 | 0227 | 0228 | 0229 | 0230 | 0231 |
| 0350 | 0232 | 0233 | 0234 | 0235 | 0236 | 0237 | 0238 | 0239 |
| 0360 | 0240 | 0241 | 0242 | 0243 | 0244 | 0245 | 0246 | 0247 |
| 0370 | 0248 | 0249 | 0250 | 0251 | 0252 | 0253 | 0254 | 0255 |

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 0400 | 0256 | 0257 | 0258 | 0259 | 0260 | 0261 | 0262 | 0263 |
| 0410 | 0264 | 0265 | 0266 | 0267 | 0268 | 0269 | 0270 | 0271 |
| 0420 | 0272 | 0273 | 0274 | 0275 | 0276 | 0277 | 0278 | 0279 |
| 0430 | 0280 | 0281 | 0282 | 0283 | 0284 | 0285 | 0286 | 0287 |
| 0440 | 0288 | 0289 | 0290 | 0291 | 0292 | 0293 | 0294 | 0295 |
| 0450 | 0296 | 0297 | 0298 | 0299 | 0300 | 0301 | 0302 | 0303 |
| 0460 | 0304 | 0305 | 0306 | 0307 | 0308 | 0309 | 0310 | 0311 |
| 0470 | 0312 | 0313 | 0314 | 0315 | 0316 | 0317 | 0318 | 0319 |
| 0500 | 0320 | 0321 | 0322 | 0323 | 0324 | 0325 | 0326 | 0327 |
| 0510 | 0328 | 0329 | 0330 | 0331 | 0332 | 0333 | 0334 | 0335 |
| 0520 | 0336 | 0337 | 0338 | 0339 | 0340 | 0341 | 0342 | 0343 |
| 0530 | 0344 | 0345 | 0346 | 0347 | 0348 | 0349 | 0350 | 0351 |
| 0540 | 0352 | 0353 | 0354 | 0355 | 0356 | 0357 | 0358 | 0359 |
| 0550 | 0360 | 0361 | 0362 | 0363 | 0364 | 0365 | 0366 | 0367 |
| 0560 | 0368 | 0369 | 0370 | 0371 | 0372 | 0373 | 0374 | 0375 |
| 0570 | 0376 | 0377 | 0378 | 0379 | 0380 | 0381 | 0382 | 0383 |
| 0600 | 0384 | 0385 | 0386 | 0387 | 0388 | 0389 | 0390 | 0391 |
| 0610 | 0392 | 0393 | 0394 | 0395 | 0396 | 0397 | 0398 | 0399 |
| 0620 | 0400 | 0401 | 0402 | 0403 | 0404 | 0405 | 0406 | 0407 |
| 0630 | 0408 | 0409 | 0410 | 0411 | 0412 | 0413 | 0414 | 0415 |
| 0640 | 0416 | 0417 | 0418 | 0419 | 0420 | 0421 | 0422 | 0423 |
| 0650 | 0424 | 0425 | 0426 | 0427 | 0428 | 0429 | 0430 | 0431 |
| 0660 | 0432 | 0433 | 0434 | 0435 | 0436 | 0437 | 0438 | 0439 |
| 0670 | 0440 | 0441 | 0442 | 0443 | 0444 | 0445 | 0446 | 0447 |
| 0700 | 0448 | 0449 | 0450 | 0451 | 0452 | 0453 | 0454 | 0455 |
| 0710 | 0456 | 0457 | 0458 | 0459 | 0460 | 0461 | 0462 | 0463 |
| 0720 | 0464 | 0465 | 0466 | 0467 | 0468 | 0469 | 0470 | 0471 |
| 0730 | 0472 | 0473 | 0474 | 0475 | 0476 | 0477 | 0478 | 0479 |
| 0740 | 0480 | 0481 | 0482 | 0483 | 0484 | 0485 | 0486 | 0487 |
| 0750 | 0488 | 0489 | 0490 | 0491 | 0492 | 0493 | 0494 | 0495 |
| 0760 | 0496 | 0497 | 0498 | 0499 | 0500 | 0501 | 0502 | 0503 |
| 0770 | 0504 | 0505 | 0506 | 0507 | 0508 | 0509 | 0510 | 0511 |

| 1000 to 1777 (Octal) | 0512 to 1023 (Decimal) |
|---|---|

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 1000 | 0512 | 0513 | 0514 | 0515 | 0516 | 0517 | 0518 | 0519 |
| 1010 | 0520 | 0521 | 0522 | 0523 | 0524 | 0525 | 0526 | 0527 |
| 1020 | 0528 | 0529 | 0530 | 0531 | 0532 | 0533 | 0534 | 0535 |
| 1030 | 0536 | 0537 | 0538 | 0539 | 0540 | 0541 | 0542 | 0543 |
| 1040 | 0544 | 0545 | 0546 | 0547 | 0548 | 0549 | 0550 | 0551 |
| 1050 | 0552 | 0553 | 0554 | 0555 | 0556 | 0557 | 0558 | 0559 |
| 1060 | 0560 | 0561 | 0562 | 0563 | 0564 | 0565 | 0566 | 0567 |
| 1070 | 0568 | 0569 | 0570 | 0571 | 0572 | 0573 | 0574 | 0575 |
| 1100 | 0576 | 0577 | 0578 | 0579 | 0580 | 0581 | 0582 | 0583 |
| 1110 | 0584 | 0585 | 0586 | 0587 | 0588 | 0589 | 0590 | 0591 |
| 1120 | 0592 | 0593 | 0594 | 0595 | 0596 | 0597 | 0598 | 0599 |
| 1130 | 0600 | 0601 | 0602 | 0603 | 0604 | 0605 | 0606 | 0607 |
| 1140 | 0608 | 0609 | 0610 | 0611 | 0612 | 0613 | 0614 | 0615 |
| 1150 | 0616 | 0617 | 0618 | 0619 | 0620 | 0621 | 0622 | 0623 |
| 1160 | 0624 | 0625 | 0626 | 0627 | 0628 | 0629 | 0630 | 0631 |
| 1170 | 0632 | 0633 | 0634 | 0635 | 0636 | 0637 | 0638 | 0639 |
| 1200 | 0640 | 0641 | 0642 | 0643 | 0644 | 0645 | 0646 | 0647 |
| 1210 | 0648 | 0649 | 0650 | 0651 | 0652 | 0653 | 0654 | 0655 |
| 1220 | 0656 | 0657 | 0658 | 0659 | 0660 | 0661 | 0662 | 0663 |
| 1230 | 0664 | 0665 | 0666 | 0667 | 0668 | 0669 | 0670 | 0671 |
| 1240 | 0672 | 0673 | 0674 | 0675 | 0676 | 0677 | 0678 | 0679 |
| 1250 | 0680 | 0681 | 0682 | 0683 | 0684 | 0685 | 0686 | 0687 |
| 1260 | 0688 | 0689 | 0690 | 0691 | 0692 | 0693 | 0694 | 0695 |
| 1270 | 0696 | 0697 | 0698 | 0699 | 0700 | 0701 | 0702 | 0703 |
| 1300 | 0704 | 0705 | 0706 | 0707 | 0708 | 0709 | 0710 | 0711 |
| 1310 | 0712 | 0713 | 0714 | 0715 | 0716 | 0717 | 0718 | 0719 |
| 1320 | 0720 | 0721 | 0722 | 0723 | 0724 | 0725 | 0726 | 0727 |
| 1330 | 0728 | 0729 | 0730 | 0731 | 0732 | 0733 | 0734 | 0735 |
| 1340 | 0736 | 0737 | 0738 | 0739 | 0740 | 0741 | 0742 | 0743 |
| 1350 | 0744 | 0745 | 0746 | 0747 | 0748 | 0749 | 0750 | 0751 |
| 1360 | 0752 | 0753 | 0754 | 0755 | 0756 | 0757 | 0758 | 0759 |
| 1370 | 0760 | 0761 | 0762 | 0763 | 0764 | 0765 | 0766 | 0767 |

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 1400 | 0768 | 0769 | 0770 | 0771 | 0772 | 0773 | 0774 | 0775 |
| 1410 | 0776 | 0777 | 0778 | 0779 | 0780 | 0781 | 0782 | 0783 |
| 1420 | 0784 | 0785 | 0786 | 0787 | 0788 | 0789 | 0790 | 0791 |
| 1430 | 0792 | 0793 | 0794 | 0795 | 0796 | 0797 | 0798 | 0799 |
| 1440 | 0800 | 0801 | 0802 | 0803 | 0804 | 0805 | 0806 | 0807 |
| 1450 | 0808 | 0809 | 0810 | 0811 | 0812 | 0813 | 0814 | 0815 |
| 1460 | 0816 | 0817 | 0818 | 0819 | 0820 | 0821 | 0822 | 0823 |
| 1470 | 0824 | 0825 | 0826 | 0827 | 0828 | 0829 | 0830 | 0831 |
| 1500 | 0832 | 0833 | 0834 | 0835 | 0836 | 0837 | 0838 | 0839 |
| 1510 | 0840 | 0841 | 0842 | 0843 | 0844 | 0845 | 0846 | 0847 |
| 1520 | 0848 | 0849 | 0850 | 0851 | 0852 | 0853 | 0854 | 0855 |
| 1530 | 0856 | 0857 | 0858 | 0859 | 0860 | 0861 | 0862 | 0863 |
| 1540 | 0864 | 0865 | 0866 | 0867 | 0868 | 0869 | 0870 | 0871 |
| 1550 | 0872 | 0873 | 0874 | 0875 | 0876 | 0877 | 0878 | 0879 |
| 1560 | 0880 | 0881 | 0882 | 0883 | 0884 | 0885 | 0886 | 0887 |
| 1570 | 0888 | 0889 | 0890 | 0891 | 0892 | 0893 | 0894 | 0895 |
| 1600 | 0896 | 0897 | 0898 | 0899 | 0900 | 0901 | 0902 | 0903 |
| 1610 | 0904 | 0905 | 0906 | 0907 | 0908 | 0909 | 0910 | 0911 |
| 1620 | 0912 | 0913 | 0914 | 0915 | 0916 | 0917 | 0918 | 0919 |
| 1630 | 0920 | 0921 | 0922 | 0923 | 0924 | 0925 | 0926 | 0927 |
| 1640 | 0928 | 0929 | 0930 | 0931 | 0932 | 0933 | 0934 | 0935 |
| 1650 | 0936 | 0937 | 0938 | 0939 | 0940 | 0941 | 0942 | 0943 |
| 1660 | 0944 | 0945 | 0946 | 0947 | 0948 | 0949 | 0950 | 0951 |
| 1670 | 0952 | 0953 | 0954 | 0955 | 0956 | 0957 | 0958 | 0959 |
| 1700 | 0960 | 0961 | 0962 | 0963 | 0964 | 0965 | 0966 | 0967 |
| 1710 | 0968 | 0969 | 0970 | 0971 | 0972 | 0973 | 0974 | 0975 |
| 1720 | 0976 | 0977 | 0978 | 0979 | 0980 | 0981 | 0982 | 0983 |
| 1730 | 0984 | 0985 | 0986 | 0987 | 0988 | 0989 | 0990 | 0991 |
| 1740 | 0992 | 0993 | 0994 | 0995 | 0996 | 0997 | 0998 | 0999 |
| 1750 | 1000 | 1001 | 1002 | 1003 | 1004 | 1005 | 1006 | 1007 |
| 1760 | 1008 | 1009 | 1010 | 1011 | 1012 | 1013 | 1014 | 1015 |
| 1770 | 1016 | 1017 | 1018 | 1019 | 1020 | 1021 | 1022 | 1023 |

# Octal-Decimal Integer Conversion Table

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 2000 | 1024 | 1025 | 1026 | 1027 | 1028 | 1029 | 1030 | 1031 |
| 2010 | 1032 | 1033 | 1034 | 1035 | 1036 | 1037 | 1038 | 1039 |
| 2020 | 1040 | 1041 | 1042 | 1043 | 1044 | 1045 | 1046 | 1047 |
| 2030 | 1048 | 1049 | 1050 | 1051 | 1052 | 1053 | 1054 | 1055 |
| 2040 | 1056 | 1057 | 1058 | 1059 | 1060 | 1061 | 1062 | 1063 |
| 2050 | 1064 | 1065 | 1066 | 1067 | 1068 | 1069 | 1070 | 1071 |
| 2060 | 1072 | 1073 | 1074 | 1075 | 1076 | 1077 | 1078 | 1079 |
| 2070 | 1080 | 1081 | 1082 | 1083 | 1084 | 1085 | 1086 | 1087 |
| 2100 | 1088 | 1089 | 1090 | 1091 | 1092 | 1093 | 1094 | 1095 |
| 2110 | 1096 | 1097 | 1098 | 1099 | 1100 | 1101 | 1102 | 1103 |
| 2120 | 1104 | 1105 | 1106 | 1107 | 1108 | 1109 | 1110 | 1111 |
| 2130 | 1112 | 1113 | 1114 | 1115 | 1116 | 1117 | 1118 | 1119 |
| 2140 | 1120 | 1121 | 1122 | 1123 | 1124 | 1125 | 1126 | 1127 |
| 2150 | 1128 | 1129 | 1130 | 1131 | 1132 | 1133 | 1134 | 1135 |
| 2160 | 1136 | 1137 | 1138 | 1139 | 1140 | 1141 | 1142 | 1143 |
| 2170 | 1144 | 1145 | 1146 | 1147 | 1148 | 1149 | 1150 | 1151 |
| 2200 | 1152 | 1153 | 1154 | 1155 | 1156 | 1157 | 1158 | 1159 |
| 2210 | 1160 | 1161 | 1162 | 1163 | 1164 | 1165 | 1166 | 1167 |
| 2220 | 1168 | 1169 | 1170 | 1171 | 1172 | 1173 | 1174 | 1175 |
| 2230 | 1176 | 1177 | 1178 | 1179 | 1180 | 1181 | 1182 | 1183 |
| 2240 | 1184 | 1185 | 1186 | 1187 | 1188 | 1189 | 1190 | 1191 |
| 2250 | 1192 | 1193 | 1194 | 1195 | 1196 | 1197 | 1198 | 1199 |
| 2260 | 1200 | 1201 | 1202 | 1203 | 1204 | 1205 | 1206 | 1207 |
| 2270 | 1208 | 1209 | 1210 | 1211 | 1212 | 1213 | 1214 | 1215 |
| 2300 | 1216 | 1217 | 1218 | 1219 | 1220 | 1221 | 1222 | 1223 |
| 2310 | 1224 | 1225 | 1226 | 1227 | 1228 | 1229 | 1230 | 1231 |
| 2320 | 1232 | 1233 | 1234 | 1235 | 1236 | 1237 | 1238 | 1239 |
| 2330 | 1240 | 1241 | 1242 | 1243 | 1244 | 1245 | 1246 | 1247 |
| 2340 | 1248 | 1249 | 1250 | 1251 | 1252 | 1253 | 1254 | 1255 |
| 2350 | 1256 | 1257 | 1258 | 1259 | 1260 | 1261 | 1262 | 1263 |
| 2360 | 1264 | 1265 | 1266 | 1267 | 1268 | 1269 | 1270 | 1271 |
| 2370 | 1272 | 1273 | 1274 | 1275 | 1276 | 1277 | 1278 | 1279 |

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 2400 | 1280 | 1281 | 1282 | 1283 | 1284 | 1285 | 1286 | 1287 |
| 2410 | 1288 | 1289 | 1290 | 1291 | 1292 | 1293 | 1294 | 1295 |
| 2420 | 1296 | 1297 | 1298 | 1299 | 1300 | 1301 | 1302 | 1303 |
| 2430 | 1304 | 1305 | 1306 | 1307 | 1308 | 1309 | 1310 | 1311 |
| 2440 | 1312 | 1313 | 1314 | 1315 | 1316 | 1317 | 1318 | 1319 |
| 2450 | 1320 | 1321 | 1322 | 1323 | 1324 | 1325 | 1326 | 1327 |
| 2460 | 1328 | 1329 | 1330 | 1331 | 1332 | 1333 | 1334 | 1335 |
| 2470 | 1336 | 1337 | 1338 | 1339 | 1340 | 1341 | 1342 | 1343 |
| 2500 | 1344 | 1345 | 1346 | 1347 | 1348 | 1349 | 1350 | 1351 |
| 2510 | 1352 | 1353 | 1354 | 1355 | 1356 | 1357 | 1358 | 1359 |
| 2520 | 1360 | 1361 | 1362 | 1363 | 1364 | 1365 | 1366 | 1367 |
| 2530 | 1368 | 1369 | 1370 | 1371 | 1372 | 1373 | 1374 | 1375 |
| 2540 | 1376 | 1377 | 1378 | 1379 | 1380 | 1381 | 1382 | 1383 |
| 2550 | 1384 | 1385 | 1386 | 1387 | 1388 | 1389 | 1390 | 1391 |
| 2560 | 1392 | 1393 | 1394 | 1395 | 1396 | 1397 | 1398 | 1399 |
| 2570 | 1400 | 1401 | 1402 | 1403 | 1404 | 1405 | 1406 | 1407 |
| 2600 | 1408 | 1409 | 1410 | 1411 | 1412 | 1413 | 1414 | 1415 |
| 2610 | 1416 | 1417 | 1418 | 1419 | 1420 | 1421 | 1422 | 1423 |
| 2620 | 1424 | 1425 | 1426 | 1427 | 1428 | 1429 | 1430 | 1431 |
| 2630 | 1432 | 1433 | 1434 | 1435 | 1436 | 1437 | 1438 | 1439 |
| 2640 | 1440 | 1441 | 1442 | 1443 | 1444 | 1445 | 1446 | 1447 |
| 2650 | 1448 | 1449 | 1450 | 1451 | 1452 | 1453 | 1454 | 1455 |
| 2660 | 1456 | 1457 | 1458 | 1459 | 1460 | 1461 | 1462 | 1463 |
| 2670 | 1464 | 1465 | 1466 | 1467 | 1468 | 1469 | 1470 | 1471 |
| 2700 | 1472 | 1473 | 1474 | 1475 | 1476 | 1477 | 1478 | 1479 |
| 2710 | 1480 | 1481 | 1482 | 1483 | 1484 | 1485 | 1486 | 1487 |
| 2720 | 1488 | 1489 | 1490 | 1491 | 1492 | 1493 | 1494 | 1495 |
| 2730 | 1496 | 1497 | 1498 | 1499 | 1500 | 1501 | 1502 | 1503 |
| 2740 | 1504 | 1505 | 1506 | 1507 | 1508 | 1509 | 1510 | 1511 |
| 2750 | 1512 | 1513 | 1514 | 1515 | 1516 | 1517 | 1518 | 1519 |
| 2760 | 1520 | 1521 | 1522 | 1523 | 1524 | 1525 | 1526 | 1527 |
| 2770 | 1528 | 1529 | 1530 | 1531 | 1532 | 1533 | 1534 | 1535 |

| 2000 | 1024 |
|---|---|
| to | to |
| 2777 | 1535 |
| (Octal) | (Decimal) |

| Octal | Decimal |
|---|---|
| 10000 - | 4096 |
| 20000 - | 8192 |
| 30000 - | 12288 |
| 40000 - | 16384 |
| 50000 - | 20480 |
| 60000 - | 24576 |
| 70000 - | 28672 |

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 3000 | 1536 | 1537 | 1538 | 1539 | 1540 | 1541 | 1542 | 1543 |
| 3010 | 1544 | 1545 | 1546 | 1547 | 1548 | 1549 | 1550 | 1551 |
| 3020 | 1552 | 1553 | 1554 | 1555 | 1556 | 1557 | 1558 | 1559 |
| 3030 | 1560 | 1561 | 1562 | 1563 | 1564 | 1565 | 1566 | 1567 |
| 3040 | 1568 | 1569 | 1570 | 1571 | 1572 | 1573 | 1574 | 1575 |
| 3050 | 1576 | 1577 | 1578 | 1579 | 1580 | 1581 | 1582 | 1583 |
| 3060 | 1584 | 1585 | 1586 | 1587 | 1588 | 1589 | 1590 | 1591 |
| 3070 | 1592 | 1593 | 1594 | 1595 | 1596 | 1597 | 1598 | 1599 |
| 3100 | 1600 | 1601 | 1602 | 1603 | 1604 | 1605 | 1606 | 1607 |
| 3110 | 1608 | 1609 | 1610 | 1611 | 1612 | 1613 | 1614 | 1615 |
| 3120 | 1616 | 1617 | 1618 | 1619 | 1620 | 1621 | 1622 | 1623 |
| 3130 | 1624 | 1625 | 1626 | 1627 | 1628 | 1629 | 1630 | 1631 |
| 3140 | 1632 | 1633 | 1634 | 1635 | 1636 | 1637 | 1638 | 1639 |
| 3150 | 1640 | 1641 | 1642 | 1643 | 1644 | 1645 | 1646 | 1647 |
| 3160 | 1648 | 1649 | 1650 | 1651 | 1652 | 1653 | 1654 | 1655 |
| 3170 | 1656 | 1657 | 1658 | 1659 | 1660 | 1661 | 1662 | 1663 |
| 3200 | 1664 | 1665 | 1666 | 1667 | 1668 | 1669 | 1670 | 1671 |
| 3210 | 1672 | 1673 | 1674 | 1675 | 1676 | 1677 | 1678 | 1679 |
| 3220 | 1680 | 1681 | 1682 | 1683 | 1684 | 1685 | 1686 | 1687 |
| 3230 | 1688 | 1689 | 1690 | 1691 | 1692 | 1693 | 1694 | 1695 |
| 3240 | 1696 | 1697 | 1698 | 1699 | 1700 | 1701 | 1702 | 1703 |
| 3250 | 1704 | 1705 | 1706 | 1707 | 1708 | 1709 | 1710 | 1711 |
| 3260 | 1712 | 1713 | 1714 | 1715 | 1716 | 1717 | 1718 | 1719 |
| 3270 | 1720 | 1721 | 1722 | 1723 | 1724 | 1725 | 1726 | 1727 |
| 3300 | 1728 | 1729 | 1730 | 1731 | 1732 | 1733 | 1734 | 1735 |
| 3310 | 1736 | 1737 | 1738 | 1739 | 1740 | 1741 | 1742 | 1743 |
| 3320 | 1744 | 1745 | 1746 | 1747 | 1748 | 1749 | 1750 | 1751 |
| 3330 | 1752 | 1753 | 1754 | 1755 | 1756 | 1757 | 1758 | 1759 |
| 3340 | 1760 | 1761 | 1762 | 1763 | 1764 | 1765 | 1766 | 1767 |
| 3350 | 1768 | 1769 | 1770 | 1771 | 1772 | 1773 | 1774 | 1775 |
| 3360 | 1776 | 1777 | 1778 | 1779 | 1780 | 1781 | 1782 | 1783 |
| 3370 | 1784 | 1785 | 1786 | 1787 | 1788 | 1789 | 1790 | 1791 |

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 3400 | 1792 | 1793 | 1794 | 1795 | 1796 | 1797 | 1798 | 1799 |
| 3410 | 1800 | 1801 | 1802 | 1803 | 1804 | 1805 | 1806 | 1807 |
| 3420 | 1808 | 1809 | 1810 | 1811 | 1812 | 1813 | 1814 | 1815 |
| 3430 | 1816 | 1817 | 1818 | 1819 | 1820 | 1821 | 1822 | 1823 |
| 3440 | 1824 | 1825 | 1826 | 1827 | 1828 | 1829 | 1830 | 1831 |
| 3450 | 1832 | 1833 | 1834 | 1835 | 1836 | 1837 | 1838 | 1839 |
| 3460 | 1840 | 1841 | 1842 | 1843 | 1844 | 1845 | 1846 | 1847 |
| 3470 | 1848 | 1849 | 1850 | 1851 | 1852 | 1853 | 1854 | 1855 |
| 3500 | 1856 | 1857 | 1858 | 1859 | 1860 | 1861 | 1862 | 1863 |
| 3510 | 1864 | 1865 | 1866 | 1867 | 1868 | 1869 | 1870 | 1871 |
| 3520 | 1872 | 1873 | 1874 | 1875 | 1876 | 1877 | 1878 | 1879 |
| 3530 | 1880 | 1881 | 1882 | 1883 | 1884 | 1885 | 1886 | 1887 |
| 3540 | 1888 | 1889 | 1890 | 1891 | 1892 | 1893 | 1894 | 1895 |
| 3550 | 1896 | 1897 | 1898 | 1899 | 1900 | 1901 | 1902 | 1903 |
| 3560 | 1904 | 1905 | 1906 | 1907 | 1908 | 1909 | 1910 | 1911 |
| 3570 | 1912 | 1913 | 1914 | 1915 | 1916 | 1917 | 1918 | 1919 |
| 3600 | 1920 | 1921 | 1922 | 1923 | 1924 | 1925 | 1926 | 1927 |
| 3610 | 1928 | 1929 | 1930 | 1931 | 1932 | 1933 | 1934 | 1935 |
| 3620 | 1936 | 1937 | 1938 | 1939 | 1940 | 1941 | 1942 | 1943 |
| 3630 | 1944 | 1945 | 1946 | 1947 | 1948 | 1949 | 1950 | 1951 |
| 3640 | 1952 | 1953 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 |
| 3650 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 |
| 3660 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 |
| 3670 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 |
| 3700 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
| 3710 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
| 3720 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
| 3730 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| 3740 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| 3750 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 |
| 3760 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 |
| 3770 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 |

| 3000 | 1536 |
|---|---|
| to | to |
| 3777 | 2047 |
| (Octal) | (Decimal) |

# Octal-Decimal Integer Conversion Table

| 4000 | 2048 |
|---|---|
| to | to |
| 4777 | 2559 |
| (Octal) | (Decimal) |

| Octal | Decimal |
|---|---|
| 10000 - | 4096 |
| 20000 - | 8192 |
| 30000 - | 12288 |
| 40000 - | 16384 |
| 50000 - | 20480 |
| 60000 - | 24576 |
| 70000 - | 28672 |

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 4000 | 2048 | 2049 | 2050 | 2051 | 2052 | 2053 | 2054 | 2055 |
| 4010 | 2056 | 2057 | 2058 | 2059 | 2060 | 2061 | 2062 | 2063 |
| 4020 | 2064 | 2065 | 2066 | 2067 | 2068 | 2069 | 2070 | 2071 |
| 4030 | 2072 | 2073 | 2074 | 2075 | 2076 | 2077 | 2078 | 2079 |
| 4040 | 2080 | 2081 | 2082 | 2083 | 2084 | 2085 | 2086 | 2087 |
| 4050 | 2088 | 2089 | 2090 | 2091 | 2092 | 2093 | 2094 | 2095 |
| 4060 | 2096 | 2097 | 2098 | 2099 | 2100 | 2101 | 2102 | 2103 |
| 4070 | 2104 | 2105 | 2106 | 2107 | 2108 | 2109 | 2110 | 2111 |
| 4100 | 2112 | 2113 | 2114 | 2115 | 2116 | 2117 | 2118 | 2119 |
| 4110 | 2120 | 2121 | 2122 | 2123 | 2124 | 2125 | 2126 | 2127 |
| 4120 | 2128 | 2129 | 2130 | 2131 | 2132 | 2133 | 2134 | 2135 |
| 4130 | 2136 | 2137 | 2138 | 2139 | 2140 | 2141 | 2142 | 2143 |
| 4140 | 2144 | 2145 | 2146 | 2147 | 2148 | 2149 | 2150 | 2151 |
| 4150 | 2152 | 2153 | 2154 | 2155 | 2156 | 2157 | 2158 | 2159 |
| 4160 | 2160 | 2161 | 2162 | 2163 | 2164 | 2165 | 2166 | 2167 |
| 4170 | 2168 | 2169 | 2170 | 2171 | 2172 | 2173 | 2174 | 2175 |
| 4200 | 2176 | 2177 | 2178 | 2179 | 2180 | 2181 | 2182 | 2183 |
| 4210 | 2184 | 2185 | 2186 | 2187 | 2188 | 2189 | 2190 | 2191 |
| 4220 | 2192 | 2193 | 2194 | 2195 | 2196 | 2197 | 2198 | 2199 |
| 4230 | 2200 | 2201 | 2202 | 2203 | 2204 | 2205 | 2206 | 2207 |
| 4240 | 2208 | 2209 | 2210 | 2211 | 2212 | 2213 | 2214 | 2215 |
| 4250 | 2216 | 2217 | 2218 | 2219 | 2220 | 2221 | 2222 | 2223 |
| 4260 | 2224 | 2225 | 2226 | 2227 | 2228 | 2229 | 2230 | 2231 |
| 4270 | 2232 | 2233 | 2234 | 2235 | 2236 | 2237 | 2238 | 2239 |
| 4300 | 2240 | 2241 | 2242 | 2243 | 2244 | 2245 | 2246 | 2247 |
| 4310 | 2248 | 2249 | 2250 | 2251 | 2252 | 2253 | 2254 | 2255 |
| 4320 | 2256 | 2257 | 2258 | 2259 | 2260 | 2261 | 2262 | 2263 |
| 4330 | 2264 | 2265 | 2266 | 2267 | 2268 | 2269 | 2270 | 2271 |
| 4340 | 2272 | 2273 | 2274 | 2275 | 2276 | 2277 | 2278 | 2279 |
| 4350 | 2280 | 2281 | 2282 | 2283 | 2284 | 2285 | 2286 | 2287 |
| 4360 | 2288 | 2289 | 2290 | 2291 | 2292 | 2293 | 2294 | 2295 |
| 4370 | 2296 | 2297 | 2298 | 2299 | 2300 | 2301 | 2302 | 2303 |

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 4400 | 2304 | 2305 | 2306 | 2307 | 2308 | 2309 | 2310 | 2311 |
| 4410 | 2312 | 2313 | 2314 | 2315 | 2316 | 2317 | 2318 | 2319 |
| 4420 | 2320 | 2321 | 2322 | 2323 | 2324 | 2325 | 2326 | 2327 |
| 4430 | 2328 | 2329 | 2330 | 2331 | 2332 | 2333 | 2334 | 2335 |
| 4440 | 2336 | 2337 | 2338 | 2339 | 2340 | 2341 | 2342 | 2343 |
| 4450 | 2344 | 2345 | 2346 | 2347 | 2348 | 2349 | 2350 | 2351 |
| 4460 | 2352 | 2353 | 2354 | 2355 | 2356 | 2357 | 2358 | 2359 |
| 4470 | 2360 | 2361 | 2362 | 2363 | 2364 | 2365 | 2366 | 2367 |
| 4500 | 2368 | 2369 | 2370 | 2371 | 2372 | 2373 | 2374 | 2375 |
| 4510 | 2376 | 2377 | 2378 | 2379 | 2380 | 2381 | 2382 | 2383 |
| 4520 | 2384 | 2385 | 2386 | 2387 | 2388 | 2389 | 2390 | 2391 |
| 4530 | 2392 | 2393 | 2394 | 2395 | 2396 | 2397 | 2398 | 2399 |
| 4540 | 2400 | 2401 | 2402 | 2403 | 2404 | 2405 | 2406 | 2407 |
| 4550 | 2408 | 2409 | 2410 | 2411 | 2412 | 2413 | 2414 | 2415 |
| 4560 | 2416 | 2417 | 2418 | 2419 | 2420 | 2421 | 2422 | 2423 |
| 4570 | 2424 | 2425 | 2426 | 2427 | 2428 | 2429 | 2430 | 2431 |
| 4600 | 2432 | 2433 | 2434 | 2435 | 2436 | 2437 | 2438 | 2439 |
| 4610 | 2440 | 2441 | 2442 | 2443 | 2444 | 2445 | 2446 | 2447 |
| 4620 | 2448 | 2449 | 2450 | 2451 | 2452 | 2453 | 2454 | 2455 |
| 4630 | 2456 | 2457 | 2458 | 2459 | 2460 | 2461 | 2462 | 2463 |
| 4640 | 2464 | 2465 | 2466 | 2467 | 2468 | 2469 | 2470 | 2471 |
| 4650 | 2472 | 2473 | 2474 | 2475 | 2476 | 2477 | 2478 | 2479 |
| 4660 | 2480 | 2481 | 2482 | 2483 | 2484 | 2485 | 2486 | 2487 |
| 4670 | 2488 | 2489 | 2490 | 2491 | 2492 | 2493 | 2494 | 2495 |
| 4700 | 2496 | 2497 | 2498 | 2499 | 2500 | 2501 | 2502 | 2503 |
| 4710 | 2504 | 2505 | 2506 | 2507 | 2508 | 2509 | 2510 | 2511 |
| 4720 | 2512 | 2513 | 2514 | 2515 | 2516 | 2517 | 2518 | 2519 |
| 4730 | 2520 | 2521 | 2522 | 2523 | 2524 | 2525 | 2526 | 2527 |
| 4740 | 2528 | 2529 | 2530 | 2531 | 2532 | 2533 | 2534 | 2535 |
| 4750 | 2536 | 2537 | 2538 | 2539 | 2540 | 2541 | 2542 | 2543 |
| 4760 | 2544 | 2545 | 2546 | 2547 | 2548 | 2549 | 2550 | 2551 |
| 4770 | 2552 | 2553 | 2554 | 2555 | 2556 | 2557 | 2558 | 2559 |

| 5000 | 2560 |
|---|---|
| to | to |
| 5777 | 3071 |
| (Octal) | (Decimal) |

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 5000 | 2560 | 2561 | 2562 | 2563 | 2564 | 2565 | 2566 | 2567 |
| 5010 | 2568 | 2569 | 2570 | 2571 | 2572 | 2573 | 2574 | 2575 |
| 5020 | 2576 | 2577 | 2578 | 2579 | 2580 | 2581 | 2582 | 2583 |
| 5030 | 2584 | 2585 | 2586 | 2587 | 2588 | 2589 | 2590 | 2591 |
| 5040 | 2592 | 2593 | 2594 | 2595 | 2596 | 2597 | 2598 | 2599 |
| 5050 | 2600 | 2601 | 2602 | 2603 | 2604 | 2605 | 2606 | 2607 |
| 5060 | 2608 | 2609 | 2610 | 2611 | 2612 | 2613 | 2614 | 2615 |
| 5070 | 2616 | 2617 | 2618 | 2619 | 2620 | 2621 | 2622 | 2623 |
| 5100 | 2624 | 2625 | 2626 | 2627 | 2628 | 2629 | 2630 | 2631 |
| 5110 | 2632 | 2633 | 2634 | 2635 | 2636 | 2637 | 2638 | 2639 |
| 5120 | 2640 | 2641 | 2642 | 2643 | 2644 | 2645 | 2646 | 2647 |
| 5130 | 2648 | 2649 | 2650 | 2651 | 2652 | 2653 | 2654 | 2655 |
| 5140 | 2656 | 2657 | 2658 | 2659 | 2660 | 2661 | 2662 | 2663 |
| 5150 | 2664 | 2665 | 2666 | 2667 | 2668 | 2669 | 2670 | 2671 |
| 5160 | 2672 | 2673 | 2674 | 2675 | 2676 | 2677 | 2678 | 2679 |
| 5170 | 2680 | 2681 | 2682 | 2683 | 2684 | 2685 | 2686 | 2687 |
| 5200 | 2688 | 2689 | 2690 | 2691 | 2692 | 2693 | 2694 | 2695 |
| 5210 | 2696 | 2697 | 2698 | 2699 | 2700 | 2701 | 2702 | 2703 |
| 5220 | 2704 | 2705 | 2706 | 2707 | 2708 | 2709 | 2710 | 2711 |
| 5230 | 2712 | 2713 | 2714 | 2715 | 2716 | 2717 | 2718 | 2719 |
| 5240 | 2720 | 2721 | 2722 | 2723 | 2724 | 2725 | 2726 | 2727 |
| 5250 | 2728 | 2729 | 2730 | 2731 | 2732 | 2733 | 2734 | 2735 |
| 5260 | 2736 | 2737 | 2738 | 2739 | 2740 | 2741 | 2742 | 2743 |
| 5270 | 2744 | 2745 | 2746 | 2747 | 2748 | 2749 | 2750 | 2751 |
| 5300 | 2752 | 2753 | 2754 | 2755 | 2756 | 2757 | 2758 | 2759 |
| 5310 | 2760 | 2761 | 2762 | 2763 | 2764 | 2765 | 2766 | 2767 |
| 5320 | 2768 | 2769 | 2770 | 2771 | 2772 | 2773 | 2774 | 2775 |
| 5330 | 2776 | 2777 | 2778 | 2779 | 2780 | 2781 | 2782 | 2783 |
| 5340 | 2784 | 2785 | 2786 | 2787 | 2788 | 2789 | 2790 | 2791 |
| 5350 | 2792 | 2793 | 2794 | 2795 | 2796 | 2797 | 2798 | 2799 |
| 5360 | 2800 | 2801 | 2802 | 2803 | 2804 | 2805 | 2806 | 2807 |
| 5370 | 2808 | 2809 | 2810 | 2811 | 2812 | 2813 | 2814 | 2815 |

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 5400 | 2816 | 2817 | 2818 | 2819 | 2820 | 2821 | 2822 | 2823 |
| 5410 | 2824 | 2825 | 2826 | 2827 | 2828 | 2829 | 2830 | 2831 |
| 5420 | 2832 | 2833 | 2834 | 2835 | 2836 | 2837 | 2838 | 2839 |
| 5430 | 2840 | 2841 | 2842 | 2843 | 2844 | 2845 | 2846 | 2847 |
| 5440 | 2848 | 2849 | 2850 | 2851 | 2852 | 2853 | 2854 | 2855 |
| 5450 | 2856 | 2857 | 2858 | 2859 | 2860 | 2861 | 2862 | 2863 |
| 5460 | 2864 | 2865 | 2866 | 2867 | 2868 | 2869 | 2870 | 2871 |
| 5470 | 2872 | 2873 | 2874 | 2875 | 2876 | 2877 | 2878 | 2879 |
| 5500 | 2880 | 2881 | 2882 | 2883 | 2884 | 2885 | 2886 | 2887 |
| 5510 | 2888 | 2889 | 2890 | 2891 | 2892 | 2893 | 2894 | 2895 |
| 5520 | 2896 | 2897 | 2898 | 2899 | 2900 | 2901 | 2902 | 2903 |
| 5530 | 2904 | 2905 | 2906 | 2907 | 2908 | 2909 | 2910 | 2911 |
| 5540 | 2912 | 2913 | 2914 | 2915 | 2916 | 2917 | 2918 | 2919 |
| 5550 | 2920 | 2921 | 2922 | 2923 | 2924 | 2925 | 2926 | 2927 |
| 5560 | 2928 | 2929 | 2930 | 2931 | 2932 | 2933 | 2934 | 2935 |
| 5570 | 2936 | 2937 | 2938 | 2939 | 2940 | 2941 | 2942 | 2943 |
| 5600 | 2944 | 2945 | 2946 | 2947 | 2948 | 2949 | 2950 | 2951 |
| 5610 | 2952 | 2953 | 2954 | 2955 | 2956 | 2957 | 2958 | 2959 |
| 5620 | 2960 | 2961 | 2962 | 2963 | 2964 | 2965 | 2966 | 2967 |
| 5630 | 2968 | 2969 | 2970 | 2971 | 2972 | 2973 | 2974 | 2975 |
| 5640 | 2976 | 2977 | 2978 | 2979 | 2980 | 2981 | 2982 | 2983 |
| 5650 | 2984 | 2985 | 2986 | 2987 | 2988 | 2989 | 2990 | 2991 |
| 5660 | 2992 | 2993 | 2994 | 2995 | 2996 | 2997 | 2998 | 2999 |
| 5670 | 3000 | 3001 | 3002 | 3003 | 3004 | 3005 | 3006 | 3007 |
| 5700 | 3008 | 3009 | 3010 | 3011 | 3012 | 3013 | 3014 | 3015 |
| 5710 | 3016 | 3017 | 3018 | 3019 | 3020 | 3021 | 3022 | 3023 |
| 5720 | 3024 | 3025 | 3026 | 3027 | 3028 | 3029 | 3030 | 3031 |
| 5730 | 3032 | 3033 | 3034 | 3035 | 3036 | 3037 | 3038 | 3039 |
| 5740 | 3040 | 3041 | 3042 | 3043 | 3044 | 3045 | 3046 | 3047 |
| 5750 | 3048 | 3049 | 3050 | 3051 | 3052 | 3053 | 3054 | 3055 |
| 5760 | 3056 | 3057 | 3058 | 3059 | 3060 | 3061 | 3062 | 3063 |
| 5770 | 3064 | 3065 | 3066 | 3067 | 3068 | 3069 | 3070 | 3071 |

# Octal-Decimal Integer Conversion Table

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 6000 | 3072 | 3073 | 3074 | 3075 | 3076 | 3077 | 3078 | 3079 |
| 6010 | 3080 | 3081 | 3082 | 3083 | 3084 | 3085 | 3086 | 3087 |
| 6020 | 3088 | 3089 | 3090 | 3091 | 3092 | 3093 | 3094 | 3095 |
| 6030 | 3096 | 3097 | 3098 | 3099 | 3100 | 3101 | 3102 | 3103 |
| 6040 | 3104 | 3105 | 3106 | 3107 | 3108 | 3109 | 3110 | 3111 |
| 6050 | 3112 | 3113 | 3114 | 3115 | 3116 | 3117 | 3118 | 3119 |
| 6060 | 3120 | 3121 | 3122 | 3123 | 3124 | 3125 | 3126 | 3127 |
| 6070 | 3128 | 3129 | 3130 | 3131 | 3132 | 3133 | 3134 | 3135 |
| 6100 | 3136 | 3137 | 3138 | 3139 | 3140 | 3141 | 3142 | 3143 |
| 6110 | 3144 | 3145 | 3146 | 3147 | 3148 | 3149 | 3150 | 3151 |
| 6120 | 3152 | 3153 | 3154 | 3155 | 3156 | 3157 | 3158 | 3159 |
| 6130 | 3160 | 3161 | 3162 | 3163 | 3164 | 3165 | 3166 | 3167 |
| 6140 | 3168 | 3169 | 3170 | 3171 | 3172 | 3173 | 3174 | 3175 |
| 6150 | 3176 | 3177 | 3178 | 3179 | 3180 | 3181 | 3182 | 3183 |
| 6160 | 3184 | 3185 | 3186 | 3187 | 3188 | 3189 | 3190 | 3191 |
| 6170 | 3192 | 3193 | 3194 | 3195 | 3196 | 3197 | 3198 | 3199 |
| 6200 | 3200 | 3201 | 3202 | 3203 | 3204 | 3205 | 3206 | 3207 |
| 6210 | 3208 | 3209 | 3210 | 3211 | 3212 | 3213 | 3214 | 3215 |
| 6220 | 3216 | 3217 | 3218 | 3219 | 3220 | 3221 | 3222 | 3223 |
| 6230 | 3224 | 3225 | 3226 | 3227 | 3228 | 3229 | 3230 | 3231 |
| 6240 | 3232 | 3233 | 3234 | 3235 | 3236 | 3237 | 3238 | 3239 |
| 6250 | 3240 | 3241 | 3242 | 3243 | 3244 | 3245 | 3246 | 3247 |
| 6260 | 3248 | 3249 | 3250 | 3251 | 3252 | 3253 | 3254 | 3255 |
| 6270 | 3256 | 3257 | 3258 | 3259 | 3260 | 3261 | 3262 | 3263 |
| 6300 | 3264 | 3265 | 3266 | 3267 | 3268 | 3269 | 3270 | 3271 |
| 6310 | 3272 | 3273 | 3274 | 3275 | 3276 | 3277 | 3278 | 3279 |
| 6320 | 3280 | 3281 | 3282 | 3283 | 3284 | 3285 | 3286 | 3287 |
| 6330 | 3288 | 3289 | 3290 | 3291 | 3292 | 3293 | 3294 | 3295 |
| 6340 | 3296 | 3297 | 3298 | 3299 | 3300 | 3301 | 3302 | 3303 |
| 6350 | 3304 | 3305 | 3306 | 3307 | 3308 | 3309 | 3310 | 3311 |
| 6360 | 3312 | 3313 | 3314 | 3315 | 3316 | 3317 | 3318 | 3319 |
| 6370 | 3320 | 3321 | 3322 | 3323 | 3324 | 3325 | 3326 | 3327 |

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 6400 | 3328 | 3329 | 3330 | 3331 | 3332 | 3333 | 3334 | 3335 |
| 6410 | 3336 | 3337 | 3338 | 3339 | 3340 | 3341 | 3342 | 3343 |
| 6420 | 3344 | 3345 | 3346 | 3347 | 3348 | 3349 | 3350 | 3351 |
| 6430 | 3352 | 3353 | 3354 | 3355 | 3356 | 3357 | 3358 | 3359 |
| 6440 | 3360 | 3361 | 3362 | 3363 | 3364 | 3365 | 3366 | 3367 |
| 6450 | 3368 | 3369 | 3370 | 3371 | 3372 | 3373 | 3374 | 3375 |
| 6460 | 3376 | 3377 | 3378 | 3379 | 3380 | 3381 | 3382 | 3383 |
| 6470 | 3384 | 3385 | 3386 | 3387 | 3388 | 3389 | 3390 | 3391 |
| 6500 | 3392 | 3393 | 3394 | 3395 | 3396 | 3397 | 3398 | 3399 |
| 6510 | 3400 | 3401 | 3402 | 3403 | 3404 | 3405 | 3406 | 3407 |
| 6520 | 3408 | 3409 | 3410 | 3411 | 3412 | 3413 | 3414 | 3415 |
| 6530 | 3416 | 3417 | 3418 | 3419 | 3420 | 3421 | 3422 | 3423 |
| 6540 | 3424 | 3425 | 3426 | 3427 | 3428 | 3429 | 3430 | 3431 |
| 6550 | 3432 | 3433 | 3434 | 3435 | 3436 | 3437 | 3438 | 3439 |
| 6560 | 3440 | 3441 | 3442 | 3443 | 3444 | 3445 | 3446 | 3447 |
| 6570 | 3448 | 3449 | 3450 | 3451 | 3452 | 3453 | 3454 | 3455 |
| 6600 | 3456 | 3457 | 3458 | 3459 | 3460 | 3461 | 3462 | 3463 |
| 6610 | 3464 | 3465 | 3466 | 3467 | 3468 | 3469 | 3470 | 3471 |
| 6620 | 3472 | 3473 | 3474 | 3475 | 3476 | 3477 | 3478 | 3479 |
| 6630 | 3480 | 3481 | 3482 | 3483 | 3484 | 3485 | 3486 | 3487 |
| 6640 | 3488 | 3489 | 3490 | 3491 | 3492 | 3493 | 3494 | 3495 |
| 6650 | 3496 | 3497 | 3498 | 3499 | 3500 | 3501 | 3502 | 3503 |
| 6660 | 3504 | 3505 | 3506 | 3507 | 3508 | 3509 | 3510 | 3511 |
| 6670 | 3512 | 3513 | 3514 | 3515 | 3516 | 3517 | 3518 | 3519 |
| 6700 | 3520 | 3521 | 3522 | 3523 | 3524 | 3525 | 3526 | 3527 |
| 6710 | 3528 | 3529 | 3530 | 3531 | 3532 | 3533 | 3534 | 3535 |
| 6720 | 3536 | 3537 | 3538 | 3539 | 3540 | 3541 | 3542 | 3543 |
| 6730 | 3544 | 3545 | 3546 | 3547 | 3548 | 3549 | 3550 | 3551 |
| 6740 | 3552 | 3553 | 3554 | 3555 | 3556 | 3557 | 3558 | 3559 |
| 6750 | 3560 | 3561 | 3562 | 3563 | 3564 | 3565 | 3566 | 3567 |
| 6760 | 3568 | 3569 | 3570 | 3571 | 3572 | 3573 | 3574 | 3575 |
| 6770 | 3576 | 3577 | 3578 | 3579 | 3580 | 3581 | 3582 | 3583 |

| 6000 to 6777 (Octal) | 3072 to 3583 (Decimal) |
|---|---|

| Octal | Decimal |
|---|---|
| 10000 - | 4096 |
| 20000 - | 8192 |
| 30000 - | 12288 |
| 40000 - | 16384 |
| 50000 - | 20480 |
| 60000 - | 24576 |
| 70000 - | 28672 |

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 7000 | 3584 | 3585 | 3586 | 3587 | 3588 | 3589 | 3590 | 3591 |
| 7010 | 3592 | 3593 | 3594 | 3595 | 3596 | 3597 | 3598 | 3599 |
| 7020 | 3600 | 3601 | 3602 | 3603 | 3604 | 3605 | 3606 | 3607 |
| 7030 | 3608 | 3609 | 3610 | 3611 | 3612 | 3613 | 3614 | 3615 |
| 7040 | 3616 | 3617 | 3618 | 3619 | 3620 | 3621 | 3622 | 3623 |
| 7050 | 3624 | 3625 | 3626 | 3627 | 3628 | 3629 | 3630 | 3631 |
| 7060 | 3632 | 3633 | 3634 | 3635 | 3636 | 3637 | 3638 | 3639 |
| 7070 | 3640 | 3641 | 3642 | 3643 | 3644 | 3645 | 3646 | 3647 |
| 7100 | 3648 | 3649 | 3650 | 3651 | 3652 | 3653 | 3654 | 3655 |
| 7110 | 3656 | 3657 | 3658 | 3659 | 3660 | 3661 | 3662 | 3663 |
| 7120 | 3664 | 3665 | 3666 | 3667 | 3668 | 3669 | 3670 | 3671 |
| 7130 | 3672 | 3673 | 3674 | 3675 | 3676 | 3677 | 3678 | 3679 |
| 7140 | 3680 | 3681 | 3682 | 3683 | 3684 | 3685 | 3686 | 3687 |
| 7150 | 3688 | 3689 | 3690 | 3691 | 3692 | 3693 | 3694 | 3695 |
| 7160 | 3696 | 3697 | 3698 | 3699 | 3700 | 3701 | 3702 | 3703 |
| 7170 | 3704 | 3705 | 3706 | 3707 | 3708 | 3709 | 3710 | 3711 |
| 7200 | 3712 | 3713 | 3714 | 3715 | 3716 | 3717 | 3718 | 3719 |
| 7210 | 3720 | 3721 | 3722 | 3723 | 3724 | 3725 | 3726 | 3727 |
| 7220 | 3728 | 3729 | 3730 | 3731 | 3732 | 3733 | 3734 | 3735 |
| 7230 | 3736 | 3737 | 3738 | 3739 | 3740 | 3741 | 3742 | 3743 |
| 7240 | 3744 | 3745 | 3746 | 3747 | 3748 | 3749 | 3750 | 3751 |
| 7250 | 3752 | 3753 | 3754 | 3755 | 3756 | 3757 | 3758 | 3759 |
| 7260 | 3760 | 3761 | 3762 | 3763 | 3764 | 3765 | 3766 | 3767 |
| 7270 | 3768 | 3769 | 3770 | 3771 | 3772 | 3773 | 3774 | 3775 |
| 7300 | 3776 | 3777 | 3778 | 3779 | 3780 | 3781 | 3782 | 3783 |
| 7310 | 3784 | 3785 | 3786 | 3787 | 3788 | 3789 | 3790 | 3791 |
| 7320 | 3792 | 3793 | 3794 | 3795 | 3796 | 3797 | 3798 | 3799 |
| 7330 | 3800 | 3801 | 3802 | 3803 | 3804 | 3805 | 3806 | 3807 |
| 7340 | 3808 | 3809 | 3810 | 3811 | 3812 | 3813 | 3814 | 3815 |
| 7350 | 3816 | 3817 | 3818 | 3819 | 3820 | 3821 | 3822 | 3823 |
| 7360 | 3824 | 3825 | 3826 | 3827 | 3828 | 3829 | 3830 | 3831 |
| 7370 | 3832 | 3833 | 3834 | 3835 | 3836 | 3837 | 3838 | 3839 |

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 7400 | 3840 | 3841 | 3842 | 3843 | 3844 | 3845 | 3846 | 3847 |
| 7410 | 3848 | 3849 | 3850 | 3851 | 3852 | 3853 | 3854 | 3855 |
| 7420 | 3856 | 3857 | 3858 | 3859 | 3860 | 3861 | 3862 | 3863 |
| 7430 | 3864 | 3865 | 3866 | 3867 | 3868 | 3869 | 3870 | 3871 |
| 7440 | 3872 | 3873 | 3874 | 3875 | 3876 | 3877 | 3878 | 3879 |
| 7450 | 3880 | 3881 | 3882 | 3883 | 3884 | 3885 | 3886 | 3887 |
| 7460 | 3888 | 3889 | 3890 | 3891 | 3892 | 3893 | 3894 | 3895 |
| 7470 | 3896 | 3897 | 3898 | 3899 | 3900 | 3901 | 3902 | 3903 |
| 7500 | 3904 | 3905 | 3906 | 3907 | 3908 | 3909 | 3910 | 3911 |
| 7510 | 3912 | 3913 | 3914 | 3915 | 3916 | 3917 | 3918 | 3919 |
| 7520 | 3920 | 3921 | 3922 | 3923 | 3924 | 3925 | 3926 | 3927 |
| 7530 | 3928 | 3929 | 3930 | 3931 | 3932 | 3933 | 3934 | 3935 |
| 7540 | 3936 | 3937 | 3938 | 3939 | 3940 | 3941 | 3942 | 3943 |
| 7550 | 3944 | 3945 | 3946 | 3947 | 3948 | 3949 | 3950 | 3951 |
| 7560 | 3952 | 3953 | 3954 | 3955 | 3956 | 3957 | 3958 | 3959 |
| 7570 | 3960 | 3961 | 3962 | 3963 | 3964 | 3965 | 3966 | 3967 |
| 7600 | 3968 | 3969 | 3970 | 3971 | 3972 | 3973 | 3974 | 3975 |
| 7610 | 3976 | 3977 | 3978 | 3979 | 3980 | 3981 | 3982 | 3983 |
| 7620 | 3984 | 3985 | 3986 | 3987 | 3988 | 3989 | 3990 | 3991 |
| 7630 | 3992 | 3993 | 3994 | 3995 | 3996 | 3997 | 3998 | 3999 |
| 7640 | 4000 | 4001 | 4002 | 4003 | 4004 | 4005 | 4006 | 4007 |
| 7650 | 4008 | 4009 | 4010 | 4011 | 4012 | 4013 | 4014 | 4015 |
| 7660 | 4016 | 4017 | 4018 | 4019 | 4020 | 4021 | 4022 | 4023 |
| 7670 | 4024 | 4025 | 4026 | 4027 | 4028 | 4029 | 4030 | 4031 |
| 7700 | 4032 | 4033 | 4034 | 4035 | 4036 | 4037 | 4038 | 4039 |
| 7710 | 4040 | 4041 | 4042 | 4043 | 4044 | 4045 | 4046 | 4047 |
| 7720 | 4048 | 4049 | 4050 | 4051 | 4052 | 4053 | 4054 | 4055 |
| 7730 | 4056 | 4057 | 4058 | 4059 | 4060 | 4061 | 4062 | 4063 |
| 7740 | 4064 | 4065 | 4066 | 4067 | 4068 | 4069 | 4070 | 4071 |
| 7750 | 4072 | 4073 | 4074 | 4075 | 4076 | 4077 | 4078 | 4079 |
| 7760 | 4080 | 4081 | 4082 | 4083 | 4084 | 4085 | 4086 | 4087 |
| 7770 | 4088 | 4089 | 4090 | 4091 | 4092 | 4093 | 4094 | 4095 |

| 7000 to 7777 (Octal) | 3584 to 4095 (Decimal) |
|---|---|

# Appendix C. Octal-Decimal Fraction Conversion Table

| OCTAL | DEC. | OCTAL | DEC. | OCTAL | DEC. | OCTAL | DEC. |
|---|---|---|---|---|---|---|---|
| .000 | .000000 | .100 | .125000 | .200 | .250000 | .300 | .375000 |
| .001 | .001953 | .101 | .126953 | .201 | .251953 | .301 | .376953 |
| .002 | .003906 | .102 | .128906 | .202 | .253906 | .302 | .378906 |
| .003 | .005859 | .103 | .130859 | .203 | .255859 | .303 | .380859 |
| .004 | .007812 | .104 | .132812 | .204 | .257812 | .304 | .382812 |
| .005 | .009765 | .105 | .134765 | .205 | .259765 | .305 | .384765 |
| .006 | .011718 | .106 | .136718 | .206 | .261718 | .306 | .386718 |
| .007 | .013671 | .107 | .138671 | .207 | .263671 | .307 | .388671 |
| .010 | .015625 | .110 | .140625 | .210 | .265625 | .310 | .390625 |
| .011 | .017578 | .111 | .142578 | .211 | .267578 | .311 | .392578 |
| .012 | .019531 | .112 | .144531 | .212 | .269531 | .312 | .394531 |
| .013 | .021484 | .113 | .146484 | .213 | .271484 | .313 | .396484 |
| .014 | .023437 | .114 | .148437 | .214 | .273437 | .314 | .398437 |
| .015 | .025390 | .115 | .150390 | .215 | .275390 | .315 | .400390 |
| .016 | .027343 | .116 | .152343 | .216 | .277343 | .316 | .402343 |
| .017 | .029296 | .117 | .154296 | .217 | .279296 | .317 | .404296 |
| .020 | .031250 | .120 | .156250 | .220 | .281250 | .320 | .406250 |
| .021 | .033203 | .121 | .158203 | .221 | .283203 | .321 | .408203 |
| .022 | .035156 | .122 | .160156 | .222 | .285156 | .322 | .410156 |
| .023 | .037109 | .123 | .162109 | .223 | .287109 | .323 | .412109 |
| .024 | .039062 | .124 | .164062 | .224 | .289062 | .324 | .414062 |
| .025 | .041015 | .125 | .166015 | .225 | .291015 | .325 | .416015 |
| .026 | .042968 | .126 | .167968 | .226 | .292968 | .326 | .417968 |
| .027 | .044921 | .127 | .169921 | .227 | .294921 | .327 | .419921 |
| .030 | .046875 | .130 | .171875 | .230 | .296875 | .330 | .421875 |
| .031 | .048828 | .131 | .173828 | .231 | .298828 | .331 | .423828 |
| .032 | .050781 | .132 | .175781 | .232 | .300781 | .332 | .425781 |
| .033 | .052734 | .133 | .177734 | .233 | .302734 | .333 | .427734 |
| .034 | .054687 | .134 | .179687 | .234 | .304687 | .334 | .429687 |
| .035 | .056640 | .135 | .181640 | .235 | .306640 | .335 | .431640 |
| .036 | .058593 | .136 | .183593 | .236 | .308593 | .336 | .433593 |
| .037 | .060546 | .137 | .185546 | .237 | .310546 | .337 | .435546 |
| .040 | .062500 | .140 | .187500 | .240 | .312500 | .340 | .437500 |
| .041 | .064453 | .141 | .189453 | .241 | .314453 | .341 | .439453 |
| .042 | .066406 | .142 | .191406 | .242 | .316406 | .342 | .441406 |
| .043 | .068359 | .143 | .193359 | .243 | .318359 | .343 | .443359 |
| .044 | .070312 | .144 | .195312 | .244 | .320312 | .344 | .445312 |
| .045 | .072265 | .145 | .197265 | .245 | .322265 | .345 | .447265 |
| .046 | .074218 | .146 | .199218 | .246 | .324218 | .346 | .449218 |
| .047 | .076171 | .147 | .201171 | .247 | .326171 | .347 | .451171 |
| .050 | .078125 | .150 | .203125 | .250 | .328125 | .350 | .453125 |
| .051 | .080078 | .151 | .205078 | .251 | .330078 | .351 | .455078 |
| .052 | .082031 | .152 | .207031 | .252 | .332031 | .352 | .457031 |
| .053 | .083984 | .153 | .208984 | .253 | .333984 | .353 | .458984 |
| .054 | .085937 | .154 | .210937 | .254 | .335937 | .354 | .460937 |
| .055 | .087890 | .155 | .212890 | .255 | .337890 | .355 | .462890 |
| .056 | .089843 | .156 | .214843 | .256 | .339843 | .356 | .464843 |
| .057 | .091796 | .157 | .216796 | .257 | .341796 | .357 | .466796 |
| .060 | .093750 | .160 | .218750 | .260 | .343750 | .360 | .468750 |
| .061 | .095703 | .161 | .220703 | .261 | .345703 | .361 | .470703 |
| .062 | .097656 | .162 | .222656 | .262 | .347656 | .362 | .472656 |
| .063 | .099609 | .163 | .224609 | .263 | .349609 | .363 | .474609 |
| .064 | .101562 | .164 | .226562 | .264 | .351562 | .364 | .476562 |
| .065 | .103515 | .165 | .228515 | .265 | .353515 | .365 | .478515 |
| .066 | .105468 | .166 | .230468 | .266 | .355468 | .366 | .480468 |
| .067 | .107421 | .167 | .232421 | .267 | .357421 | .367 | .482421 |
| .070 | .109375 | .170 | .234375 | .270 | .359375 | .370 | .484375 |
| .071 | .111328 | .171 | .236328 | .271 | .361328 | .371 | .486328 |
| .072 | .113281 | .172 | .238281 | .272 | .363281 | .372 | .488281 |
| .073 | .115234 | .173 | .240234 | .273 | .365234 | .373 | .490234 |
| .074 | .117187 | .174 | .242187 | .274 | .367187 | .374 | .492187 |
| .075 | .119140 | .175 | .244140 | .275 | .369140 | .375 | .494140 |
| .076 | .121093 | .176 | .246093 | .276 | .371093 | .376 | .496093 |
| .077 | .123046 | .177 | .248046 | .277 | .373046 | .377 | .498046 |

# Octal-Decimal Fraction Conversion Table

| OCTAL | DEC. | OCTAL | DEC. | OCTAL | DEC. | OCTAL | DEC. |
|---|---|---|---|---|---|---|---|
| .000000 | .000000 | .000100 | .000244 | .000200 | .000488 | .000300 | .000732 |
| .000001 | .000003 | .000101 | .000247 | .000201 | .000492 | .000301 | .000736 |
| .000002 | .000007 | .000102 | .000251 | .000202 | .000495 | .000302 | .000740 |
| .000003 | .000011 | .000103 | .000255 | .000203 | .000499 | .000303 | .000743 |
| .000004 | .000015 | .000104 | .000259 | .000204 | .000503 | .000304 | .000747 |
| .000005 | .000019 | .000105 | .000263 | .000205 | .000507 | .000305 | .000751 |
| .000006 | .000022 | .000106 | .000267 | .000206 | .000511 | .000306 | .000755 |
| .000007 | .000026 | .000107 | .000270 | .000207 | .000514 | .000307 | .000759 |
| .000010 | .000030 | .000110 | .000274 | .000210 | .000518 | .000310 | .000762 |
| .000011 | .000034 | .000111 | .000278 | .000211 | .000522 | .000311 | .000766 |
| .000012 | .000038 | .000112 | .000282 | .000212 | .000526 | .000312 | .000770 |
| .000013 | .000041 | .000113 | .000286 | .000213 | .000530 | .000313 | .000774 |
| .000014 | .000045 | .000114 | .000289 | .000214 | .000534 | .000314 | .000778 |
| .000015 | .000049 | .000115 | .000293 | .000215 | .000537 | .000315 | .000782 |
| .000016 | .000053 | .000116 | .000297 | .000216 | .000541 | .000316 | .000785 |
| .000017 | .000057 | .000117 | .000301 | .000217 | .000545 | .000317 | .000789 |
| .000020 | .000061 | .000120 | .000305 | .000220 | .000549 | .000320 | .000793 |
| .000021 | .000064 | .000121 | .000308 | .000221 | .000553 | .000321 | .000797 |
| .000022 | .000068 | .000122 | .000312 | .000222 | .000556 | .000322 | .000801 |
| .000023 | .000072 | .000123 | .000316 | .000223 | .000560 | .000323 | .000805 |
| .000024 | .000076 | .000124 | .000320 | .000224 | .000564 | .000324 | .000808 |
| .000025 | .000080 | .000125 | .000324 | .000225 | .000568 | .000325 | .000812 |
| .000026 | .000083 | .000126 | .000328 | .000226 | .000572 | .000326 | .000816 |
| .000027 | .000087 | .000127 | .000331 | .000227 | .000576 | .000327 | .000820 |
| .000030 | .000091 | .000130 | .000335 | .000230 | .000579 | .000330 | .000823 |
| .000031 | .000095 | .000131 | .000339 | .000231 | .000583 | .000331 | .000827 |
| .000032 | .000099 | .000132 | .000343 | .000232 | .000587 | .000332 | .000831 |
| .000033 | .000102 | .000133 | .000347 | .000233 | .000591 | .000333 | .000835 |
| .000034 | .000106 | .000134 | .000350 | .000234 | .000595 | .000334 | .000839 |
| .000035 | .000110 | .000135 | .000354 | .000235 | .000598 | .000335 | .000843 |
| .000036 | .000114 | .000136 | .000358 | .000236 | .000602 | .000336 | .000846 |
| .000037 | .000118 | .000137 | .000362 | .000237 | .000606 | .000337 | .000850 |
| .000040 | .000122 | .000140 | .000366 | .000240 | .000610 | .000340 | .000854 |
| .000041 | .000125 | .000141 | .000370 | .000241 | .000614 | .000341 | .000858 |
| .000042 | .000129 | .000142 | .000373 | .000242 | .000617 | .000342 | .000862 |
| .000043 | .000133 | .000143 | .000377 | .000243 | .000621 | .000343 | .000865 |
| .000044 | .000137 | .000144 | .000381 | .000244 | .000625 | .000344 | .000869 |
| .000045 | .000141 | .000145 | .000385 | .000245 | .000629 | .000345 | .000873 |
| .000046 | .000144 | .000146 | .000389 | .000246 | .000633 | .000346 | .000877 |
| .000047 | .000148 | .000147 | .000392 | .000247 | .000637 | .000347 | .000881 |
| .000050 | .000152 | .000150 | .000396 | .000250 | .000640 | .000350 | .000885 |
| .000051 | .000156 | .000151 | .000400 | .000251 | .000644 | .000351 | .000888 |
| .000052 | .000160 | .000152 | .000404 | .000252 | .000648 | .000352 | .000892 |
| .000053 | .000164 | .000153 | .000408 | .000253 | .000652 | .000353 | .000896 |
| .000054 | .000167 | .000154 | .000411 | .000254 | .000656 | .000354 | .000900 |
| .000055 | .000171 | .000155 | .000415 | .000255 | .000659 | .000355 | .000904 |
| .000056 | .000175 | .000156 | .000419 | .000256 | .000663 | .000356 | .000907 |
| .000057 | .000179 | .000157 | .000423 | .000257 | .000667 | .000357 | .000911 |
| .000060 | .000183 | .000160 | .000427 | .000260 | .000671 | .000360 | .000915 |
| .000061 | .000186 | .000161 | .000431 | .000261 | .000675 | .000361 | .000919 |
| .000062 | .000190 | .000162 | .000434 | .000262 | .000679 | .000362 | .000923 |
| .000063 | .000194 | .000163 | .000438 | .000263 | .000682 | .000363 | .000926 |
| .000064 | .000198 | .000164 | .000442 | .000264 | .000686 | .000364 | .000930 |
| .000065 | .000202 | .000165 | .000446 | .000265 | .000690 | .000365 | .000934 |
| .000066 | .000205 | .000166 | .000450 | .000266 | .000694 | .000366 | .000938 |
| .000067 | .000209 | .000167 | .000453 | .000267 | .000698 | .000367 | .000942 |
| .000070 | .000213 | .000170 | .000457 | .000270 | .000701 | .000370 | .000946 |
| .000071 | .000217 | .000171 | .000461 | .000271 | .000705 | .000371 | .000949 |
| .000072 | .000221 | .000172 | .000465 | .000272 | .000709 | .000372 | .000953 |
| .000073 | .000225 | .000173 | .000469 | .000273 | .000713 | .000373 | .000957 |
| .000074 | .000228 | .000174 | .000473 | .000274 | .000717 | .000374 | .000961 |
| .000075 | .000232 | .000175 | .000476 | .000275 | .000720 | .000375 | .000965 |
| .000076 | .000236 | .000176 | .000480 | .000276 | .000724 | .000376 | .000968 |
| .000077 | .000240 | .000177 | .000484 | .000277 | .000728 | .000377 | .000972 |

# Octal-Decimal Fraction Conversion Table

| OCTAL | DEC. | OCTAL | DEC. | OCTAL | DEC. | OCTAL | DEC. |
|---|---|---|---|---|---|---|---|
| .000400 | .000976 | .000500 | .001220 | .000600 | .001464 | .000700 | .001708 |
| .000401 | .000980 | .000501 | .001224 | .000601 | .001468 | .000701 | .001712 |
| .000402 | .000984 | .000502 | .001228 | .000602 | .001472 | .000702 | .001716 |
| .000403 | .000988 | .000503 | .001232 | .000603 | .001476 | .000703 | .001720 |
| .000404 | .000991 | .000504 | .001235 | .000604 | .001480 | .000704 | .001724 |
| .000405 | .000995 | .000505 | .001239 | .000605 | .001483 | .000705 | .001728 |
| .000406 | .000999 | .000506 | .001243 | .000606 | .001487 | .000706 | .001731 |
| .000407 | .001003 | .000507 | .001247 | .000607 | .001491 | .000707 | .001735 |
| .000410 | .001007 | .000510 | .001251 | .000610 | .001495 | .000710 | .001739 |
| .000411 | .001010 | .000511 | .001255 | .000611 | .001499 | .000711 | .001743 |
| .000412 | .001014 | .000512 | .001258 | .000612 | .001502 | .000712 | .001747 |
| .000413 | .001018 | .000513 | .001262 | .000613 | .001506 | .000713 | .001750 |
| .000414 | .001022 | .000514 | .001266 | .000614 | .001510 | .000714 | .001754 |
| .000415 | .001026 | .000515 | .001270 | .000615 | .001514 | .000715 | .001758 |
| .000416 | .001029 | .000516 | .001274 | .000616 | .001518 | .000716 | .001762 |
| .000417 | .001033 | .000517 | .001277 | .000617 | .001522 | .000717 | .001766 |
| .000420 | .001037 | .000520 | .001281 | .000620 | .001525 | .000720 | .001770 |
| .000421 | .001041 | .000521 | .001285 | .000621 | .001529 | .000721 | .001773 |
| .000422 | .001045 | .000522 | .001289 | .000622 | .001533 | .000722 | .001777 |
| .000423 | .001049 | .000523 | .001293 | .000623 | .001537 | .000723 | .001781 |
| .000424 | .001052 | .000524 | .001296 | .000624 | .001541 | .000724 | .001785 |
| .000425 | .001056 | .000525 | .001300 | .000625 | .001544 | .000725 | .001789 |
| .000426 | .001060 | .000526 | .001304 | .000626 | .001548 | .000726 | .001792 |
| .000427 | .001064 | .000527 | .001308 | .000627 | .001552 | .000727 | .001796 |
| .000430 | .001068 | .000530 | .001312 | .000630 | .001556 | .000730 | .001800 |
| .000431 | .001071 | .000531 | .001316 | .000631 | .001560 | .000731 | .001804 |
| .000432 | .001075 | .000532 | .001319 | .000632 | .001564 | .000732 | .001808 |
| .000433 | .001079 | .000533 | .001323 | .000633 | .001567 | .000733 | .001811 |
| .000434 | .001083 | .000534 | .001327 | .000634 | .001571 | .000734 | .001815 |
| .000435 | .001087 | .000535 | .001331 | .000635 | .001575 | .000735 | .001819 |
| .000436 | .001091 | .000536 | .001335 | .000636 | .001579 | .000736 | .001823 |
| .000437 | .001094 | .000537 | .001338 | .000637 | .001583 | .000737 | .001827 |
| .000440 | .001098 | .000540 | .001342 | .000640 | .001586 | .000740 | .001831 |
| .000441 | .001102 | .000541 | .001346 | .000641 | .001590 | .000741 | .001834 |
| .000442 | .001106 | .000542 | .001350 | .000642 | .001594 | .000742 | .001838 |
| .000443 | .001110 | .000543 | .001354 | .000643 | .001598 | .000743 | .001842 |
| .000444 | .001113 | .000544 | .001358 | .000644 | .001602 | .000744 | .001846 |
| .000445 | .001117 | .000545 | .001361 | .000645 | .001605 | .000745 | .001850 |
| .000446 | .001121 | .000546 | .001365 | .000646 | .001609 | .000746 | .001853 |
| .000447 | .001125 | .000547 | .001369 | .000647 | .001613 | .000747 | .001857 |
| .000450 | .001129 | .000550 | .001373 | .000650 | .001617 | .000750 | .001861 |
| .000451 | .001132 | .000551 | .001377 | .000651 | .001621 | .000751 | .001865 |
| .000452 | .001136 | .000552 | .001380 | .000652 | .001625 | .000752 | .001869 |
| .000453 | .001140 | .000553 | .001384 | .000653 | .001628 | .000753 | .001873 |
| .000454 | .001144 | .000554 | .001388 | .000654 | .001632 | .000754 | .001876 |
| .000455 | .001148 | .000555 | .001392 | .000655 | .001636 | .000755 | .001880 |
| .000456 | .001152 | .000556 | .001396 | .000656 | .001640 | .000756 | .001884 |
| .000457 | .001155 | .000557 | .001399 | .000657 | .001644 | .000757 | .001888 |
| .000460 | .001159 | .000560 | .001403 | .000660 | .001647 | .000760 | .001892 |
| .000461 | .001163 | .000561 | .001407 | .000661 | .001651 | .000761 | .001895 |
| .000462 | .001167 | .000562 | .001411 | .000662 | .001655 | .000762 | .001899 |
| .000463 | .001171 | .000563 | .001415 | .000663 | .001659 | .000763 | .001903 |
| .000464 | .001174 | .000564 | .001419 | .000664 | .001663 | .000764 | .001907 |
| .000465 | .001178 | .000565 | .001422 | .000665 | .001667 | .000765 | .001911 |
| .000466 | .001182 | .000566 | .001426 | .000666 | .001670 | .000766 | .001914 |
| .000467 | .001186 | .000567 | .001430 | .000667 | .001674 | .000767 | .001918 |
| .000470 | .001190 | .000570 | .001434 | .000670 | .001678 | .000770 | .001922 |
| .000471 | .001194 | .000571 | .001438 | .000671 | .001682 | .000771 | .001926 |
| .000472 | .001197 | .000572 | .001441 | .000672 | .001686 | .000772 | .001930 |
| .000473 | .001201 | .000573 | .001445 | .000673 | .001689 | .000773 | .001934 |
| .000474 | .001205 | .000574 | .001449 | .000674 | .001693 | .000774 | .001937 |
| .000475 | .001209 | .000575 | .001453 | .000675 | .001697 | .000775 | .001941 |
| .000476 | .001213 | .000576 | .001457 | .000676 | .001701 | .000776 | .001945 |
| .000477 | .001216 | .000577 | .001461 | .000677 | .001705 | .000777 | .001949 |

# Appendix D. Table of Powers of Two

| $2^n$ | $n$ | $2^{-n}$ |
|---|---|---|
| 1 | 0 | 1.0 |
| 2 | 1 | 0.5 |
| 4 | 2 | 0.25 |
| 8 | 3 | 0.125 |
| 16 | 4 | 0.062 5 |
| 32 | 5 | 0.031 25 |
| 64 | 6 | 0.015 625 |
| 128 | 7 | 0.007 812 5 |
| 256 | 8 | 0.003 906 25 |
| 512 | 9 | 0.001 953 125 |
| 1 024 | 10 | 0.000 976 562 5 |
| 2 048 | 11 | 0.000 488 281 25 |
| 4 096 | 12 | 0.000 244 140 625 |
| 8 192 | 13 | 0.000 122 070 312 5 |
| 16 384 | 14 | 0.000 061 035 156 25 |
| 32 768 | 15 | 0.000 030 517 578 125 |
| 65 536 | 16 | 0.000 015 258 789 062 5 |
| 131 072 | 17 | 0.000 007 629 394 531 25 |
| 262 144 | 18 | 0.000 003 814 697 265 625 |
| 524 288 | 19 | 0.000 001 907 348 632 812 5 |
| 1 048 576 | 20 | 0.000 000 953 674 316 406 25 |
| 2 097 152 | 21 | 0.000 000 476 837 158 203 125 |
| 4 194 304 | 22 | 0.000 000 238 418 579 101 562 5 |
| 8 388 608 | 23 | 0.000 000 119 209 289 550 781 25 |
| 16 777 216 | 24 | 0.000 000 059 604 644 775 390 625 |
| 33 554 432 | 25 | 0.000 000 029 802 322 387 695 312 5 |
| 67 108 864 | 26 | 0.000 000 014 901 161 193 847 656 25 |
| 134 217 728 | 27 | 0.000 000 007 450 580 596 923 828 125 |
| 268 435 456 | 28 | 0.000 000 003 725 290 298 461 914 062 5 |
| 536 870 912 | 29 | 0.000 000 001 862 645 149 230 957 031 25 |
| 1 073 741 824 | 30 | 0.000 000 000 931 322 574 615 478 515 625 |
| 2 147 483 648 | 31 | 0.000 000 000 465 661 287 307 739 257 812 5 |
| 4 294 967 296 | 32 | 0.000 000 000 232 830 643 653 869 628 906 25 |
| 8 589 934 592 | 33 | 0.000 000 000 116 415 321 826 934 814 453 125 |
| 17 179 869 184 | 34 | 0.000 000 000 058 207 660 913 467 407 226 562 5 |
| 34 359 738 368 | 35 | 0.000 000 000 029 103 830 456 733 703 613 281 25 |
| 68 719 476 736 | 36 | 0.000 000 000 014 551 915 228 366 851 806 640 625 |
| 137 438 953 472 | 37 | 0.000 000 000 007 275 957 614 183 425 903 320 312 5 |
| 274 877 906 944 | 38 | 0.000 000 000 003 637 978 807 091 712 951 660 156 25 |
| 549 755 813 888 | 39 | 0.000 000 000 001 818 989 403 545 856 475 830 078 125 |

# Appendix E. Consecutive Number Punching Device for IBM 721

This device permits automatic punching of consecutive numbers into cards for easy identification. It allows punching of consecutive numbers from 0000 to 9999 into any four card columns. These columns are in addition to the 72 columns used for calculator exits. The device is contained in the IBM 721 Card Punch and flexibility is provided by the card punch control panel. Use of this device has no effect on the normal operations of the 721.

The device can be controlled from either the calculator or the 721 punch by means of the control panel and an X-punched master card to do the following:

1. Reset the numbering counter to 0000. The first card following will punch 0000; the next card, 0001; and so on.
2. Set any desired number between 0000 and 9999 into the numbering counter. The first card following will punch the number set into the counter and each card thereafter will punch one digit higher.

Control panel hubs used with this device are located in the normal manner. Their functions are:

*CTR-on Hubs (D, 21-22).* When these hubs are jack-plugged, the device is operative.

*Run-in Hubs (K, 21-22).* These are exit hubs, energized for one cycle during the run-in of cards (cards in the hopper and no card under the die card lever). Normally, they are wired to the reset hubs.

*Reset Hubs (J, 21-22).* These are entry hubs; when impulsed, they reset the counter to 0000. A machine cycle is required to reset the counters. These hubs can be impulsed from:

1. A run-in hub. (See above.)
2. A sense exit hub. The PSE instruction must be given no later that 20 ms after the write select instruction has started the card punch in motion.
3. A punch X control brush hub.

*Set CTR Hubs (I, 21-22).* These entry hubs must be impulsed on the cycle following reset; they condition the counters to accept a starting number during the next machine cycle. The SET CTR hub can be impulsed from:

1. The sense exit hub. The PSE instruction must be given no later than 20 ms after the WRS instruction has started the card punch in motion.
2. The punch X control brush hub.

*CTR Entry Hubs (E-H, 21).* These hubs are used to enter a starting number into a counter during the cycle following the pulsing of the SET CTR hub. CTR ENTRY may be wired from CAL EXIT or from punch brushes.

*CTR Exit Hubs (E-H, 22).* These hubs are used to emit pulses from the counter. They emit each card cycle as long as the CTR ON hubs are wired, but are inoperative during a RESET or SET CTR cycle. They are normally wired to any of the 80 punch entry hubs.

NOTE: The sense exit and punch X brush hubs referred to are standard machine hubs. No additional PSE instructions are provided with this device.

# Appendix F. Card Reader Wiring for Columnar Binary

The modification (special feature) required in order to use the IBM 714 Card Reader for auxiliary columnar binary card-to-tape operations includes the addition of nine hubs (labeled A, B, C, D, E, F, G, H and J in Figure 34) for use in control panel wiring. The functions of these hubs are:

*F and G* are common hubs and are connected to an electronic sensing circuit which recognizes the presence of the columnar binary indication (9 or 9-7). The detection of a 9-punch (or 9-7 punches) when a card is in the first read position causes that card to be treated as a columnar binary card when at the second read.

*H and J* are connected only during the portion of read time of a columnar binary card at second read. These hubs are connected through a relay contact which is transferred during 9-time only, if the columnar binary identification is a 9-punch, or during 9-, 8- and 7-time if the identification is a 9-7 combination. These hubs can be wired to prevent a 9-punch (or 9, 8, 7 punches) from being read into the record storage unit if the columnar binary identification is not to be placed on tape. (Extra bits are injected into the checking circuits when a columnar binary card is at second read, thus correcting the horizontal row count at second read.)

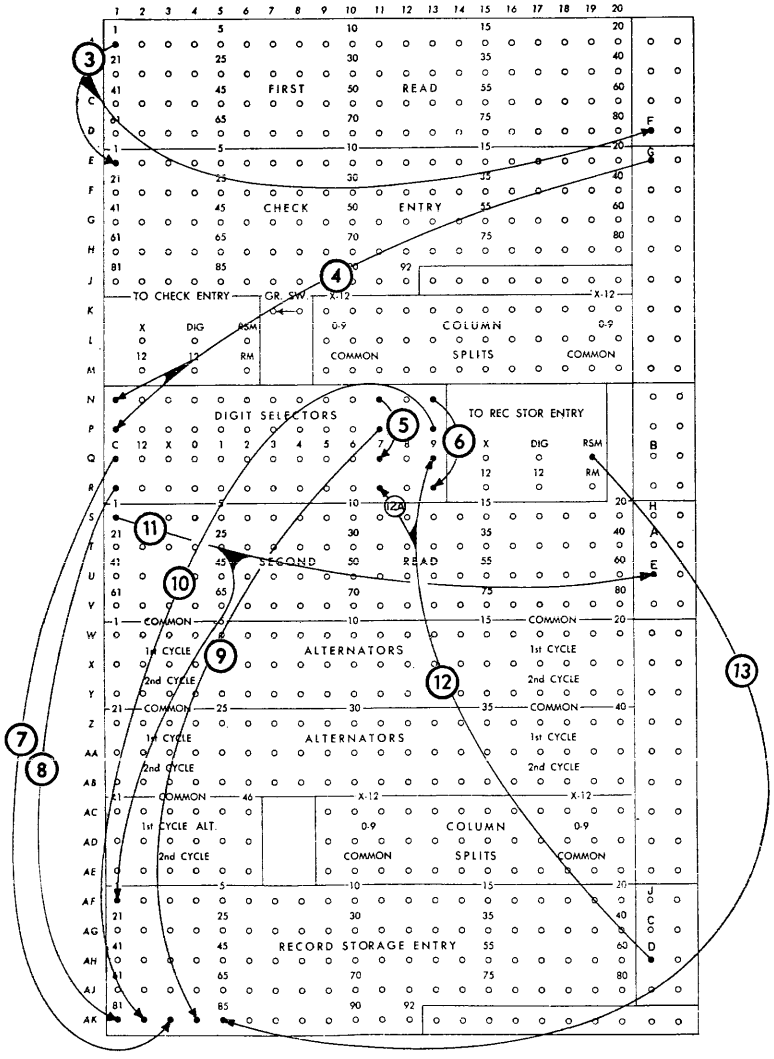



Figure 34. Columnar Binary Wiring

*A, B, C, D and E* are connected in the following manner: A and C, B and D, are connected when a BCD card is at second read. When a columnar binary card is at second read, hubs B and C, D and E, are connected.

Figures 34 and 35 show SHARE standard wiring for columnar binary card-to-tape operations. With this wiring, columnar binary is converted to standard binary tape format with the proper check bits, and the IBM card codes are converted to standard BCD tape characters with the proper check bits. The wiring in Figure 35 is straightforward and requires no explanation. However, Figure 34 wiring does require some explanation.

Hub F is wired from hub 1 of first read because column 1 will contain the columnar binary card identification. The wires numbered 4 through 10 create a "look-ahead" indication in every record to indicate the type of tape record which follows it. The wiring is such that when a columnar binary card is at first read, 9-impulses enter hubs 81 and 82, and 7-impulses enter hubs 83 and 84 of record storage entry, regardless of the type of card at second read. If the card at second read is a columnar binary card, a 7 impulse enters hub 81, and a 9 impulse enters hub 83 of record storage entry. This arrangement creates the following look-ahead words in tape records.

A. BCD Record

1. If followed by a binary tape record, the 14th word of the record will be $(xx\ xx\ 11\ 11\ 07\ 07)_8$, where *X* indicates a digit which varies from record to record.
2. If followed by another BCD record, the 14th word will be $(xx\ xx\ 00\ 00\ 00\ 00)_8$.

B. Binary Record

1. If followed by another binary record, the 27th and 28th words of the record will be: $(xxxx\ xxxx\ 0005)_8$ and $(0001\ 0005\ 0004)_8$.
2. If followed by a BCD record, the 27th and 28th words of the record will be: $(xxxx\ xxxx\ 0004)_8$ and $(0000\ 0001\ 0000)_8$.

Note that wire 12 creates redundant bits when a columnar binary card is at second read. These bits are necessary because, as previously explained, a 9 impulse or 9 and 7 impulses are injected into the checking circuit when a columnar binary card is at second read. Wire 12 compensates for these injected bits so that the horizontal row count at second read will be correct. When the columnar binary identification is a 9 punch only, wire 12a should be removed in order to prevent a read check from occurring.

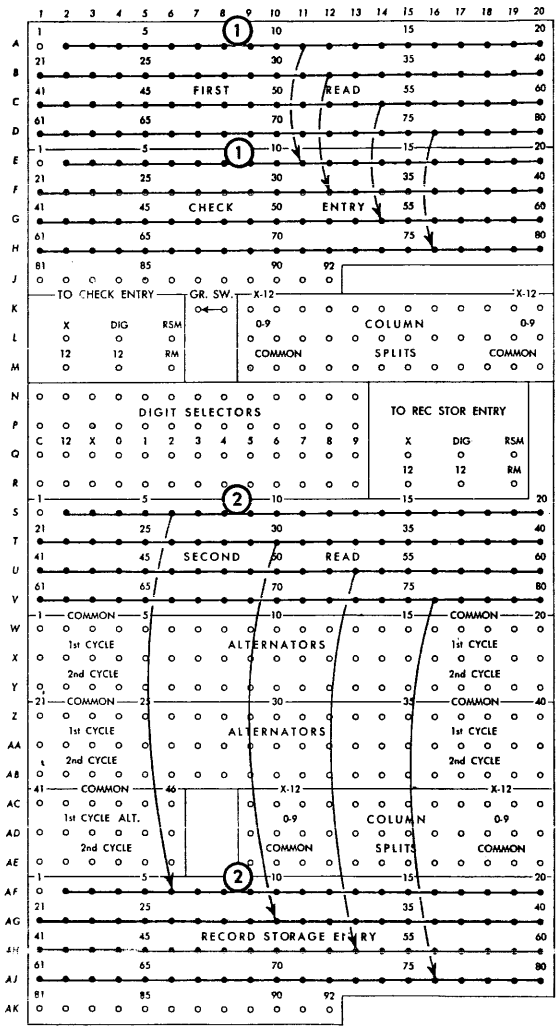



Figure 35. Columnar Binary Wiring

(1/62: 5M-FW-60)

IBM 7090 Op.Gd. Printed in U.S.A. A22-6535

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