Reference Manual

IBM 7080 Console Operation

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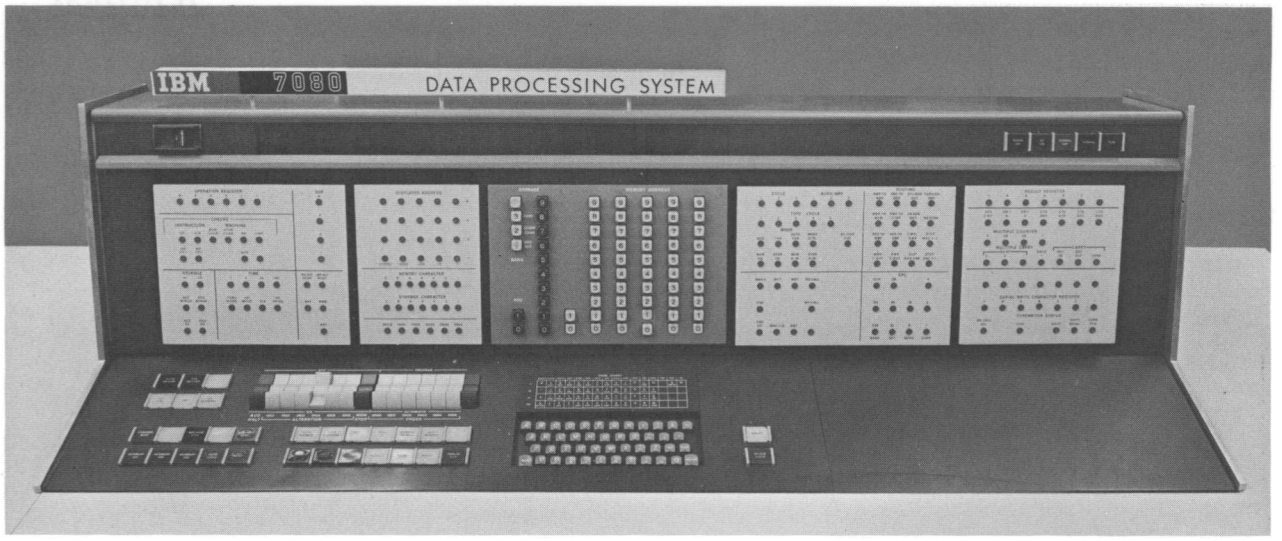


Operator's Console—IBM 7080 Data Processing System

Preface

This guide is designed to be used as a field education aid. Operators, programmers, and others requiring a familiarity with the 7080 Console will find it a ready reference and study aid.

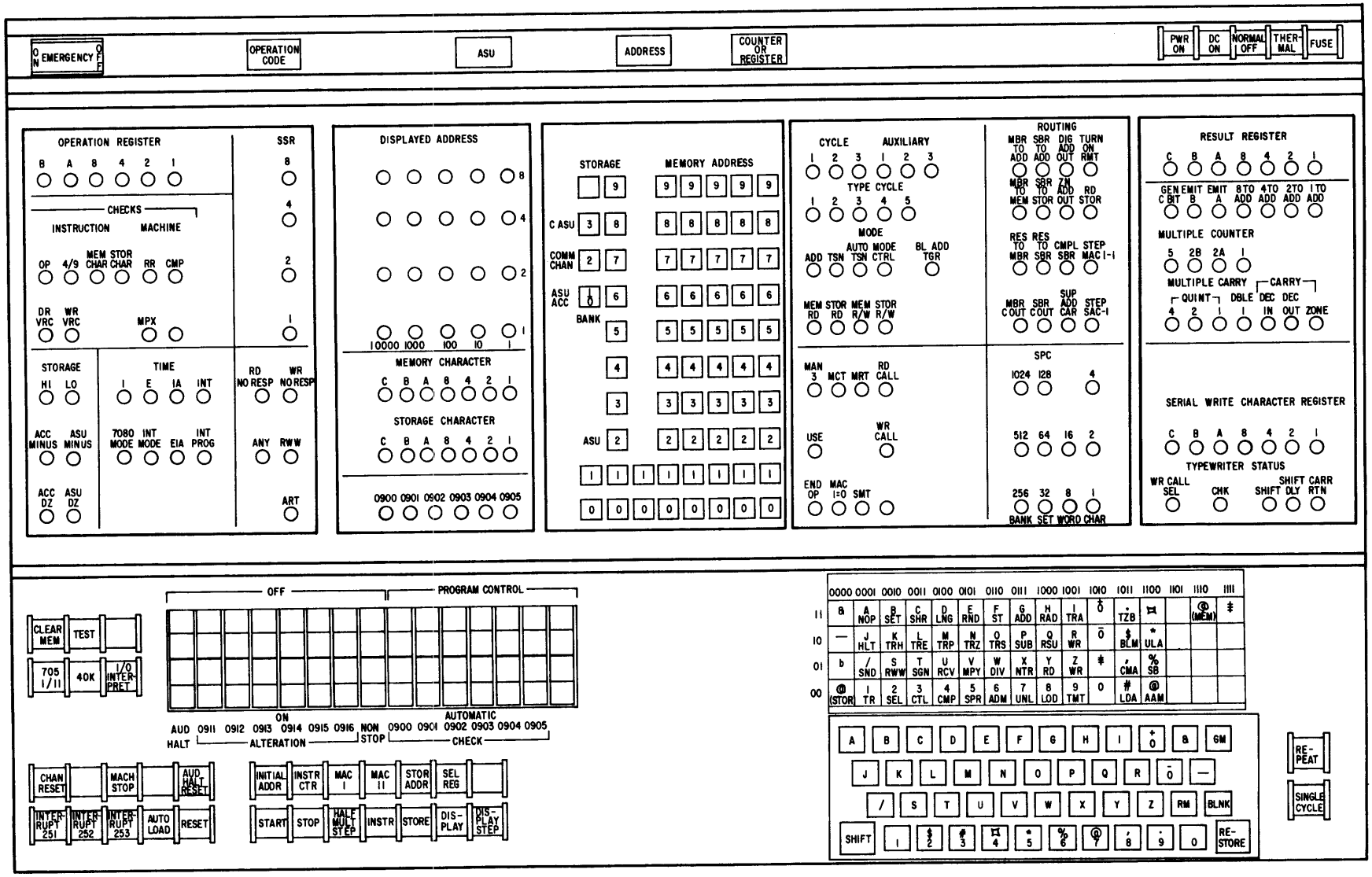
It will be most effective if this guide is used after the student has satisfactorily completed the Basic Computer Systems Course (S-1000) at the IBM District Education Center. Study of this manual should be supplemented by assistance to the student from a qualified Systems Engineer. Machine time for demonstration and exercises, if readily available, should be beneficial.

A list of 7080 abbreviations is presented at the end of this manual.

MAJOR REVISION (February, 1962)
This edition, Form A22-6638-1, obsoletes Form A22-6638. Significant changes have been made throughout the manual, and this new edition should be reviewed in its entirety.

Address comments concerning this manual to:
IBM Corporation
Customer Manuals, Dept. 298
P. O. Box 390
Poughkeepsie, N. Y.

Contents



Panel Board—IBM 7080 Console

The console serves as the control of the 7080 system; it is used to:

1. Control the machine manually.
2. Correct errors.
3. Determine the status of 7080 circuits, registers, and counters.
4. Determine the contents of memory and central storage.
5. Revise the contents of memory and central storage.
6. Serve as an aid for the customer engineer in performing preventive maintenance and diagnosing error conditions.

Timing Cycle of the 7080

The central processing unit operates in a prescribed logical sequence to read, interpret, and execute instructions. Control is provided by the specific instruction to be performed, together with certain timing impulses from an electronic clock. The timing impulses occur at the rate of ten million a second, or, each pulse is one-tenth microsecond long. Ten pulses constitute a machine cycle, the amount of time used to perform a specific machine function. The time of the basic clock cycle is one microsecond.

The first two cycles of each 7080 instruction to be performed are the instruction cycles that occur during instruction time (I-time). During I-time, the five characters composing a particular instruction are read from memory. The operation part of the instruction is interpreted and controlling circuits to be used in the operation are activated. The address portion of the instruction is set in certain counters and registers for reference. The instruction is then placed back in memory.

The two instruction cycles may be followed by one or more execution cycles, referred to as execution time (E-time). During execution time, the operations necessary to perform the instruction are carried out. The number of cycles making up execution time depends upon the particular instruction being executed.

Display Unit

A display unit is a projection device with a capacity of twelve individual "messages." A message, printed on the surface of a lens, is projected on a viewing screen that forms the front of the unit. The messages display unit (ASU), the address, and the counter or register containing the address. Fourteen units make up an operation code display (5 units), an ASU display (2), and an address display (7). No display occurs in a digit position containing an illegal character.

The displays are activated under the following conditions:

1. The machine has stopped and is in manual status.
2. The machine is unable to complete the execution of an instruction. Approximately two seconds are required to recognize this condition.
3. The half-multiple step key is depressed.

Operation Code Display

This display is one of a series of mnemonic operation codes. Units are provided with 54 codes which correspond to the basic set of 42 operations for 705 III mode, plus 12 operations used only in the 7080 mode (Figure 1).

AAM	EIM	MPY	SB	SUB	TRS
ADD	HLT	NTR	SEL	TCT	TRZ
ADM	LDA	NOP	SET	TIP	TZB
BLM	LFC	RAD	SGN	TMT	UFC
CMP	LIM	RCV	SHR	TR	ULA
CNO	LIP	RD	SND	TRA	UNL
CTL	LNG	RND	SPC	TRE	USB
DIV	LOD	RSU	SPR	TRH	WR
EIA	LSB	RWW	ST	TRP	WRE

Figure 1. Operation Codes That Can Be Displayed

This display is associated directly with the internal operation register. No display will occur if the register contains an unassigned operation character or if the operation character is in error.

ASU Display

A two-digit number (00-15) is displayed, corresponding to the contents of the storage select register.

Address Display

Seven units are required for this display. The first six display a 6-digit number corresponding to the contents of any one of the following registers or counters:

Instruction counter (IC)

Initial address register (IAR) (Identical to MAR on 705 machines)

Memory address counter I (MAC I)
Memory address counter II (MAC II)
Select register (SR)
Storage address register (SAR)

The last unit displays the identifying tag or mnemonic code (Figure 2) of the register or counter containing the address.

IAR	MACI	SAR
IC	MACII	SR

Figure 2. Registers or Counters Whose Address Can Be Displayed

Keys and Lights

Operation Register

The contents of the operation register are displayed as a 6-bit character in BCD code by six indicator lights. The character displayed corresponds to the mnemonic code in the operation code display unit. Illegal operation codes, while not displayed in the upper display, will be shown in the BCD lights.

As an example, if the instruction is a No Operation (NOP), the bit structure shown in the operation register will be that of an "A," or the B, A, and 1 bits.

Display Selector Keys

This group of six keys controls the information shown in the address portion of the address display unit. The keys are labeled INITIAL ADDR, INSTR COUNTER, MAC I, MAC II, STOR ADDR, SEL REG (Figure 3). The keys are back-lighted; the light is turned on when the corresponding key is depressed, indicating ON, and is turned off by depression of one of the other five keys. Once a key is depressed ON, the corresponding counter or register will continue to be selected until another key is depressed. After start, IAR display is automatically selected.

Figure 3. Display Selector Keys

Initial Address Register (IAR)

This register contains the address portion of the instruction being executed. The zoning over the tens and hundreds position is placed in the storage select register (SSR). The IAR is particularly helpful on sign check (00905) stops since it is here and not in the memory address counter I (MAC I) that the address of the unsigned character will be found. The machine stops with the unsigned character displayed as the memory character on the console.

An example would be reset and add (RAD) at 3874 using ASU 04. By depressing the initial address key, the address of the unsigned character will be displayed in the address display. The operation code, the ASU and BCD address will show in the displayed address. The operation register will show "H" or bits of B, A, and 8 for reset and add. The 00905 light will be on as the program switch for 00905 is set to automatic (Figure 4).

Storage Select Register (SSR)

The contents of the storage select register are displayed in binary by four indicator lights. The number displayed corresponds to the two decimal digits displayed in the ASU display unit.

Instruction Counter (IC)

This counter contains instruction locations. It is stepped up five positions during I-time so that at the end of I-time it is always at an address that is five positions higher than the instruction being executed. (When there is an instruction check (00900) stop, IC is stepped up, and will thus be at the address of the instruction in error plus five.) The units position of IC changes between 4 and 9. On a transfer instruction, the instruction counter is set to the address in the initial address register. Should this address not contain a units position of 4 or 9, the 7080 will stop at the end of I-time of the transfer instruction so that it is never possible to get an address ending in anything other than 4 or 9 into the instruction counter.

Memory Address Counter I (MAC I)

This counter normally contains the memory address of the character or characters to be processed during the next machine cycle.

For instructions like SET, LNG, RND, and SHR, MAC I is not needed to monitor memory information addresses. This allows MAC I to be used as a counter to determine the number of cycles required for the operation. At the beginning of the operation MAC I contains the address part of the instruction. By stepping MAC I minus one, each cycle, MAC I steps down to 00,000, then to 159,999, and causes the MAC I = 0 trigger to turn on. The output of this trigger is then available to complete or alter the operation.

During a write 01 instruction, MAC I starts with the address portion of the instruction. MAC I is stepped plus one each time a character is sent to the write bus. When MAC I reaches 19,999, 39,999, 59,999, 79,999, 99,999, 119,999, 139,999, or 159,999 and turns on a

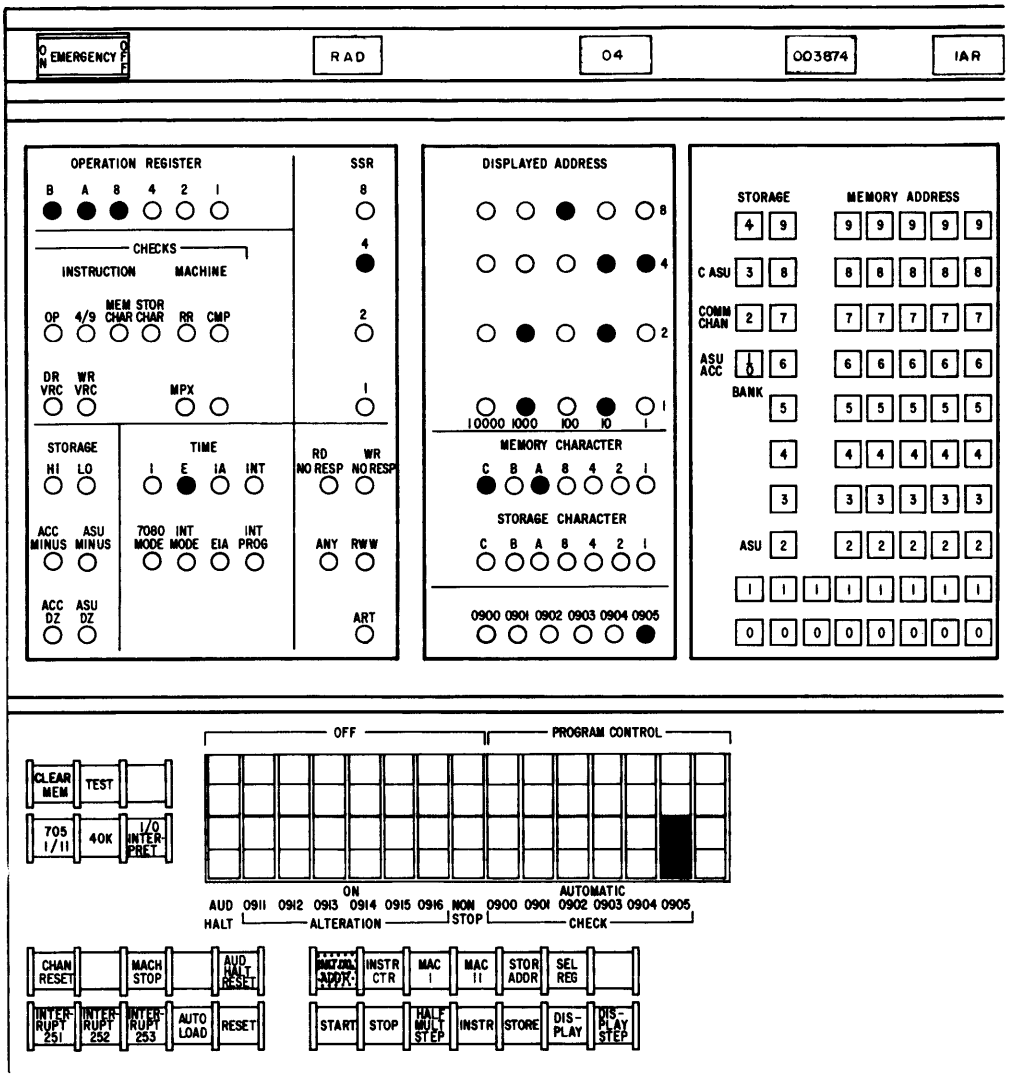


Figure 4. Initial Address Register

trigger (MAC I = 0), the end of a memory block is indicated and the operation is ended.

MAC I may or may not contain the address of the character that causes a 00901 check stop to occur.

If the address placed in MAC I during the instruction cycle is the address of an input-output unit, alteration switch, or check indicator, the select register is also set to MAC I, thereby selecting the addressed unit or device. The contents of the select register remain unchanged until another select instruction is executed.

Memory Address Counter II (MAC II)

This counter is similar to MAC I but is a 20-trigger counter used to locate an address in memory during the execution of a TMT, SND, BLM, TZB, TR 01 instruction, or a RWW operation. MAC II is used to indicate the address of information going into memory, except the TZB when it contains the address of the character being interrogated. MAC II is reset and set to MAC I or the word register (WR). When the MAC II is set to the word register, the numeric bit structure from characters 0, 1, 2, and 3 of the word register are set to the triggers of the first four positions of MAC II. The zone bits from characters 0 and 3 are set into the fifth position of MAC II. When MAC II is set to MAC I, the numeric bit lines of all five positions of MAC I set all five positions of MAC II.

During a leave interrupt program (LIP) instruction, MAC II is set to the word register to restore MAC II to its proper address. This is necessary because contents of MAC II might have been changed by the interrupt program.

MAC II can step either plus one or plus five. By stepping plus one, the units position locates the next character in the memory buffer register (MBR) to be processed. The step plus five locates the next block of five characters to be processed.

Select Register (SR)

This register displays the last I-O unit, check indicator or alteration switch selected. This register is only reset by another select instruction. Should a select address be erroneous, nothing will happen unless an attempt is made to execute an instruction which is impossible, in which case the 7080 will remain in automatic status. A select instruction cannot stop in the execution (E-time) of the instruction.

Displayed Address

Twenty indicator lamps display a five-digit BCD address corresponding to the address shown by the address display unit. The fifth position will display full binary, making possible the display of 159,999.

Information displayed in the BCD indicator lamps is also under control of the display selector keys. For example, if the IC key is depressed (Figure 5), the address of the instruction counter will be displayed both as a six-digit number and as a five-digit character address.

The start key resets the BCD display to the IAR display.

Character Registers

The memory character register contains characters coming from memory, and the storage character register contains characters coming from the storage unit.

MEMORY CHARACTER

The seven lights display the BCD character most recently read from MBR.

STORAGE CHARACTER

The seven lights display the character most recently read from SBR.

Storage Bank Selector Keys

This is a set of four keys (1/0, 2, 3, 4) that control storage bank addressing during manual display operations. The bottom key, labeled 1/0, will reset the other three keys when depressed; this key will not latch in. The other three keys will latch in when depressed. Only one key can be depressed at a time.

When the 2, 3, or 4 bank key is in, the corresponding central storage bank will be displayed starting at the setting of the starting point counter unless ASU keys are in. ASU keys work in conjunction with bank keys to address two words (16 characters) of a communication channel or CASU (except for CASU 15 with ASU 15 keyed in, which addresses four words). Thus, the storage select keys with the bank keys can be used to display the contents of storage units within these banks.

If none of the bank keys is in, corresponding to a reset state, ACC or ASU central storage banks 0 or 1 are addressed, depending upon whether or not the storage selector keys are used. The bank keys have no effect upon operations other than display.

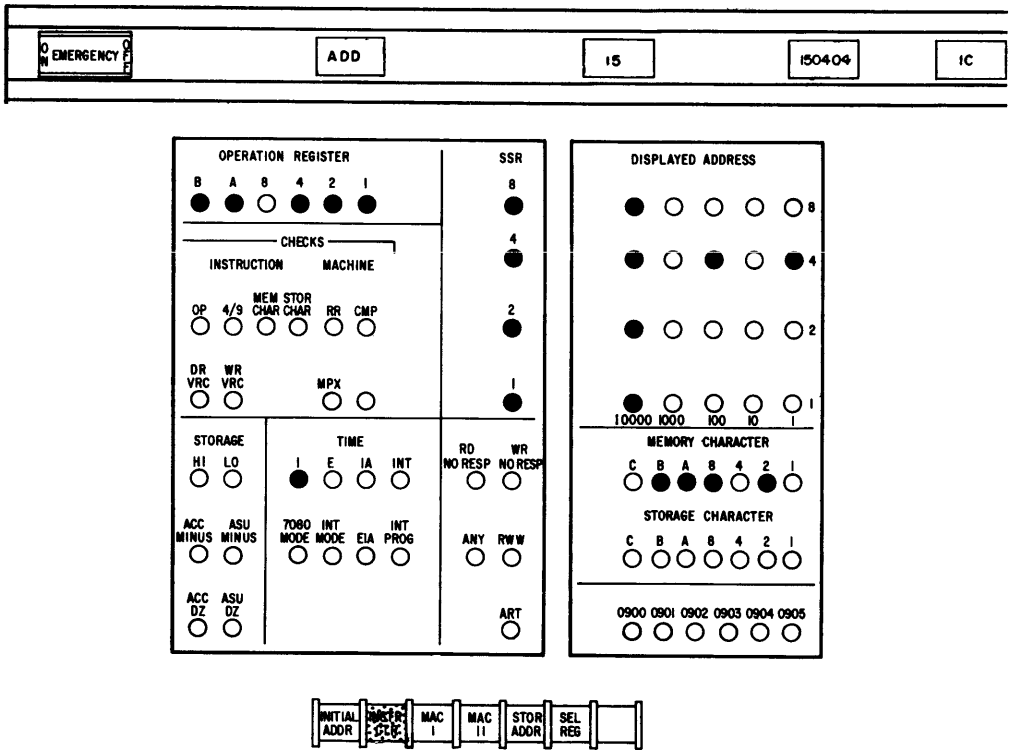


Figure 5. Instruction Counter Displayed at Location 150, 404—ASU 15—Add Operation

Storage Selector Keys

The storage selector keys select the storage unit used in a manual instruction or in display operations. The selection is made by keying the decimal number of the storage unit (00-15): the units digit in one of the ten keys in the right-hand vertical row, the tens digit in one of the two keys in the left-hand vertical row. Each key will remain down when depressed and will release any other key in the row. Therefore, only one key in a row can be down at one time. The bank and ASU selector keys (only) are automatically restored when any of the following three situations takes place:

1. The machine leaves DISPLAY status.
2. The machine leaves INSTRUCT or STORE status for reasons other than going into DISPLAY status.
3. The reset or machine stop keys are depressed when in other than STORE, DISPLAY or INSTRUCT status.
4. After execution of each instruction, when in instruct status.

Memory Address Selector

Memory address selector keys are arranged in five vertical rows of ten keys each and one row of two keys. Each row corresponds to one position of a six-digit memory address.

The memory address selector keys are used to set up an address when performing the manual operations of instruct, store, or display. Each key will remain down when depressed and will release any other key.

Instruction Check Lights

OPERATION CHECK (OP CHK)

This indicator turns on when the operation part of an instruction is not one of the 54 operation codes of the 7080, or when comma operations are given in other than 7080 mode.

4 OR 9 CHECK

The indicator turns on when the units position of the address of any transfer, five-character transmit, send, or indirect address instruction is not 4 or 9. In the case of a TCT instruction, the indicator turns on if the units position of the address is not a 9.

DATA REGISTER CHECK (DR VRC)

This check results if any one of the five characters from the memory data register is in error, but in IA time only characters 1, 2, 3, and 4, will be checked.

Channel Check Indicators

There is a channel check indicator corresponding to each communication channel of the 7080. (These are located in the 7621 Tape Control and the 7908 Data Channel.) The turning on of any channel check indicator will turn on the MPX indicator on the console. There is no associated switch for these indicators. The error conditions are under program control and may be interrogated with a transfer on signal 02 or 03 (TTC or TSA) after prior selection of the channel.

The channel check indicator will turn on for any error encountered in a channel read or write operation. This indicator is similar to the PCT check indicator in the 705 III.

If an error is detected in the data memory address during a read 00 operation, the channel check indicator is turned on, the read 00 instruction is converted to a read 01 instruction and no data are read into memory.

When reading is through communication channels, data are entered into memory in blocks of five characters, rather than character by character. If the last block of five characters from the input record is not completely filled, group marks are inserted in the unfilled positions. Any character code error detected during transmission turns on the channel check indicator of the appropriate channel.

After the read instruction on a channel is initiated, the program proceeds to the next sequential instruction. At the end of the read operation, an automatic interrupt results if the machine is in the interrupt mode and not in the interrupt program, and the program is directed to the channel interrupt word (word 0, characters $0-3$) to find the address of the next instruction to be performed. If the machine is not in the interrupt mode, the completion of the read operation must be determined by interrogating the readiness of the channel.

Should a read instruction be given where the size of the record will exceed the end of memory, the channel check indicator in the 7621 Tape Control will be turned on and the read instruction will be converted to a read 01 instruction, thus blocking any further transfer of information.

In programming, note that the size of memory is dependent on the setting of console switches and the operating mode of the machine. The changing of modes during read or write operations may lead to erroneous results. For example, consider the machine to be in the 7080 mode and the console switches 705 I-II off and 40K off; assume also that the next instruction to be executed is read 79,900, and that a 150-character record is to be read from tape. Should a leave-7080-mode instruction be executed before the read operation is completed, the record would now be subject to the memory limitations of the 705 III (80K); thus, end of memory would be at 79,999, a channel check would result, and the last 50 characters would not enter memory.

MULTIPLEXOR CHECK (MPX)

This indicator is turned on when any error is detected in a selected communication channel. This check is similar to the DSU check in the 705 III. The following checks will cause an MPX check:

1. A channel check, which results from: (a) A check during data transfer between the data register and storage from either a read or write instruction. (b) Any read or write operation exceeding the absolute end of memory (overflow). (c) Read errors. (d) Address check resulting from no 0 or 5 in character 4 or a VRC in the address characters.
2. A tape adapter unit check (TAU) which results from: (a) Read or write errors in the 7621 Tape Control. (b) Failure to write ("no echo" error).

Machine Checks

MEMORY CHARACTER CHECK (MEM CHAR)

This indicator is turned on when the character from the memory buffer register is invalid.

STORAGE CHARACTER CHECK (STOR CHAR)

This indicator is turned on when the character from the storage buffer register is invalid.

RESULT REGISTER CHECK (RR CHK)

This indicator is turned on when an invalid character is detected in the result register.

COMPARE CHECK (CMP CHK)

This indicator is turned on if, after a compare instruction, (1) the auxiliary 1 and neither or both of the high, low indicators are on, or (2) all three indicators are on.

Storage Indicators

HIGH (HI)

This indicator is turned on during a compare operation when the field in storage is higher in sequence than the field in memory.

LOW (LO)

This indicator is turned on during a compare operation when the field in storage is lower in sequence than the field in memory.

ACCUMULATOR MINUS (ACC MINUS)

This indicator is turned on when the sign of the storage field in the accumulator is minus. Normally, the accumulator is bank 0, but, by use of SPC instruction, any bank can be made to be the accumulator.

AUXILIARY STORAGE UNIT MINUS (ASU MINUS)

This indicator is on when the sign of the field in the last used ASU is minus. The ASU may be any one of fifteen storage units contained in either bank 1 or bank 3.

ACCUMULATOR DIGIT ZERO (ACC DZ)

This indicator is on when the contents of the accumulator to the right of the first storage mark consist of characters having zero numeric portions. Accumulator may be any storage bank.

AUXILIARY STORAGE UNIT ZERO (ASU DZ)

This indicator is on when the field in the last used ASU consists of characters with zero numeric portions. The ASU may be any of the storage units in either bank 1 or bank 3.

Time and Mode Indicators

The time indicators, instruction (I), execution (E), indirect address (IA), and interrupt (INT), when on, indicate the actual internal operating time in which the computer is functioning.

7080 MODE

This indicator is on when the computer is operating in the 7080 mode. The machine is normally in 705 operating status and must be programmed to enter the 7080 mode. It will remain in 7080 mode unless instructed to leave 7080 mode or by depressing the auto-load, reset, or clear memory key.

INTERRUPT MODE (INT MODE)

This indicator is on when the machine is operating in the interrupt mode. The machine can enter interrupt mode by programming. It is turned off by the instruction leave interrupt mode or by the depression of the auto load, reset, or clear memory key.

INTERRUPT PROGRAM (INT PROG)

This light is turned on by: automatic interrupt, manual interrupt key, non-stop operation, or an instruction to transfer to an interrupt program. The system remains in the interrupt program until instructed to leave and return to the main program. It is also turned off by the clear memory, reset, or auto-load key.

ENABLE INDIRECT ADDRESS (EIA)

This indicator is turned on when the machine is instructed to execute, via the EIA instruction, the next instruction as if it had an indirect address. It is turned off during execution of the indirectly addressed instruction.

Input-Output Indicators

READ NO RESPONSE (RD NO RESP)

This indicator is turned on when the selected input unit does not respond. The light is turned on, for example, when an input unit that is not connected to the system or is not in ready status is selected and instructed to read.

WRITE NO RESPONSE (WR NO RESP)

This indicator is turned on when a selected output unit does not respond; for example, when the selected output unit is given a write instruction and it is not connected to the system or is not in ready status.

READ WHILE WRITE (RWW)

The indicator turns on during the execution of a read-while-write instruction. It will normally be turned off by the following write instruction (754 only) or by a send instruction when in 705 III or 7080 mode.

ANY

An error condition that turns on a check indicator also turns on the ANY indicator, unless the corresponding indicator switch (00900-00905) is set to automatic and nonstop switch is off, causing a check stop.

NOTE: The nonstop switch is considered an alteration switch. Depression of the start key does not reset the ANY indicator or those check indicators whose corresponding switches are set to PROGRAM. These conditions apply to all modes of operation, including the 705 I-II, 705 III, and 7080; however, depression of autoload, reset, or clear memory key does turn ANY off.

AUTOMATIC RESTART (ART)

This indicator is turned on whenever the 7080 does not complete the execution of an instruction, other than a read or write operation, in approximately two seconds. A reading or writing operation can take more than two seconds. In this case, the indicator is turned on if no data are sent or received by the CPU during a two-second interval and the read or write operation has not been completed.

The automatic restart indicator is turned off by a transfer auto restart instruction, the reset key, and the clear memory key.

Check Indicators and Alteration Switches

Two classifications of checks are carried out by the 7080 to insure the accuracy of data processing:

1. Checks on the reading and writing of data by the input-output units including channel checks.
2. Checks on the internal processing of data within the CPU.

Each of the six basic check indicators is associated with a switch (00900-00905) (Figure 6). The switches may be set to AUTOMATIC or to PROGRAM. When the switch is set to AUTOMATIC, the error detected by the corresponding check indicator causes an automatic machine stop (except under conditions as explained in "Nonstop Operation"). Corrective action is under manual control of the operator. Instruction executions may or may not be completed, depending upon the type of error. In the case of an error due to a 00900, 00902, or 00903, pressing the start key resets the indicator, and automatic operation is resumed. However, if the error is due to a 00901, 00904, or 00905, the machine store key or a manual keyboard operation key (display, store, instruct) must be pressed before the start key is effective in turning off the indicator and for resuming automatic operation.

When the switches are set to PROGRAM, an error does not stop the machine and corrective action may or may not be taken under program control.

Switches may be set so that some are under program control while others cause a machine stop.

Check indicators under program control are normally examined or interrogated at points in the procedure where it is desirable to check the processing.

When in the 705 I-II mode, two instructions are used: select, and transfer on signal; in the 705 III or 7080 mode, direct interrogation (TRS 10-15) can be used. The select instruction address specifies the indicator; the transfer on signal is a conditional branching instruction. If the indicator is on, a transfer is made to the location of an instruction specified by the transfer-on-signal address. This transfer is usually to the first instruction of a subroutine that will direct the machine to take corrective action automatically. The indicator is turned off by the transfer-on-signal instruction.

All checking devices are used entirely at the discretion of the programmer. In many cases it is not necessary to interrupt machine operation when an error condition is detected. The programmer can include special branch programs to handle certain types of errors as exceptions. An error in reading a record from tape, for example, may be programmed to backspace the tape and reread the record. If a correct reading is obtained the second time, normal machine operation continues. If the error persists, machine operation can be interrupted or the incorrect record can be noted and operation continued.

Check indicators and their assigned addresses are:

Instruction check indicator	00900
Machine check indicator	00901
Read-write check indicator	00902
Record check indicator	00903
Overflow check indicator	00904
Sign check indicator	00905

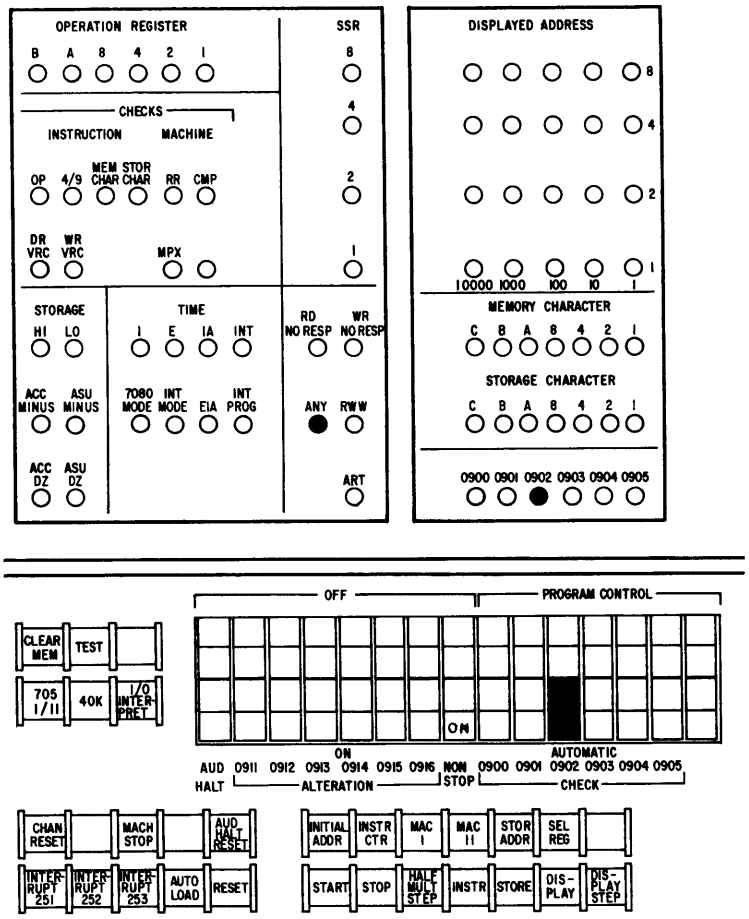


Figure 6. 0902 and ANY On

In addition to the six check indicators associated with switches, there is one additional check indicator for which there is no associated switch. This check indicator is under program control; it is the channel check indicator (MPX indicator).

ALTERATION SWITCHES

Six alteration switches are located on the console. Each switch can be turned on or off by the operator and can be interrogated by the program. Alteration switches are selected and tested by select and transfer-on-signal instructions in the same manner as check indicators. However, in the 705 III or 7080 mode, a switch can be interrogated by a transfer-any instruction without a previous select instruction.

Alteration switches are assigned the address 00911-00916.

INSTRUCTION CHECK INDICATOR, 00900

The instruction check indicator turns on when the following conditions occur:

1. OP CH: A character code error is detected, an invalid operation code is encountered in the operation register, the operation code is incorrectly interpreted, or any of the comma operation codes is given in any mode other than the 7080 mode.
2. 4/9 CH: The units position of the address part of any transfer, AAM, ULA, LDA instruction, or a transmit instruction specifying accumulator 00, is not 4 or 9; the send instruction is checked in the 705 III and the 7080 modes; or, the field addressed by an indirect address coded instruction does not end in a 4 or 9. A TCT instruction address must end in 9.
3. DR VRC: Any of the five characters from the memory buffer register is invalid (during I-time), or an invalid character appears (during IA-time) in character positions 1, 2, 3, or 4.

With the switch set to AUTOMATIC, the machine stops during the character cycle in which the error occurred.

As a suggested correction routine, the program error or redundancy should be corrected with reference to the program listing and then a transfer made to the corrected instruction. These corrections may be made from the console. The normal procedure will be to take a memory print and make the system available for the next operation.

MACHINE CHECK INDICATOR, 00901

The machine check indicator is turned on when a character code error is detected during the execution of all instructions in which data is transferred from central storage or memory. Exceptions are all read instructions and write instructions over a communication channel. The channel check will indicate these errors. The word register check circuit checks all eight characters from the storage register for a VRC, and an address check circuit for a 0/5 check in WR character 4.

When the indicator switch is turned to AUTOMATIC, the machine stops during the character cycle in which the error occurred, except when an error occurs during the execution of write or write and erase. In this case, the indicator will be turned on but no automatic stop will occur. Such an error may be detected by programming, as the read-write check indicator will also be turned on.

In general it is not possible to give a suggested correction routine for 00901 errors as the correction routine will depend upon the instruction involved. For example, on an add instruction a redundant character might occur in the middle of the field to be added. In this event, the numbers from the units position of the field up to and including the redundant character have been added; consequently, if the redundancy is corrected and a transfer made to the add instruction, a part of the field will be added twice. Corrective action on a machine check stop will usually involve either reprocessing of a record or returning to a check point.

READ-WRITE CHECK INDICATOR, 00902

The read-write indicator turns on when a character code error is detected during the execution of a read, write, read-while-writing, or write-and-erase instruction except when using a communication channel. The indicator also turns on when an error is detected in reading the holes in the card or by the longitudinal check in tape reading. The indicator, therefore, checks the transmission of data from all input units to memory. It also checks the transmission of all output data from memory to the drum, tape unit, and other input-output units that are not on a channel. The indicator also turns on if an attempt is made to read or write beyond the limits of the drum or if an error occurs in recording a tape mark.

When the indicator switch is turned to AUTOMATIC, an error stops the machine after the instruction is executed.

This switch will normally be in the program position for 705 I and II programs. 705 III and 7080 programs will use transfer transmission check (TTC) and transfer synchronizer any (TSA) instructions. The TTC and TSA instructions must be used when using a communication channel. The serial card reader and the typewriter are the two normal means of turning on the 00902 check indicator in the 7080.

RECORD CHECK INDICATOR, 00903

The record check indicator turns on when an error is detected by the brush-compare method on the punch and by the echo-check method on the printer. An error in card punching is detected as the card passes a brush station after it has been punched. If an error occurs, the record check indicator turns on during the execution of the next write or write-and-erase instruction to that card punch.

An error in printing is detected by sensing the position of each print wheel during the print cycle. If an error occurs, the indicator turns on during the execution of the next write or write-and-erase instruction involving that printer.

In both cases, when the switch for this indicator is on AUTOMATIC, an error stops the machine at the end of the punching or printing cycle during which the indicator was turned on. At this time, the error card is the last card to go into the punch stacker. The incorrect line of printing immediately precedes the last printed line.

The 00903 indicator will normally be on program control for 705 I and II.

OVERFLOW CHECK INDICATOR, 00904

The overflow check indicator is turned on during an add or subtract operation when the number of digits in the result is greater than the number of digits in the longer of the two fields. An overflow is indicated as a result of a round operation, if a carry-over is made out of the high-order position of the accumulator storage field. The overflow check also turns on if the units position of the addressed field of a RAD instruction contains a special character whose digit value is more than 10 (i.e., 8-3).

The indicator is turned on by a divide instruction when the divisor does not have a greater absolute value than an equal number of digits taken from the left end of the dividend. When the error switch for this indicator is turned to AUTOMATIC, an error stops the machine during the execution of the instruction.

On the add, subtract, and round instructions, the computer stops after completing the instruction. On the divide instruction the operation is not completed. In general it is best not to try to correct this type of error from the console but to take a memory print and make the system available for the next operation. In particular, this is true if the stop were caused by a divide instruction. This check stop would normally occur only while a program is being debugged.

SIGN CHECK INDICATOR, 00905

The sign check indicator turns on if a memory field addressed by an arithmetic instruction (add, subtract, multiply, etc.) does not have plus or minus zoning over the low-order digit.

When the switch for this indicator is set to AUTOMATIC, an error stops the machine in the same cycle in which the error is detected.

As with the overflow check stop, no general corrective action can be suggested.

Nonstop Operation

The nonstop operation feature of the 7080 permits continuous operation of the machine in automatic status.

When execution of an instruction is not completed within approximately two seconds, or when manual status would normally be entered for reasons other than a manual stop, the machine may be conditioned to interrupt to a program in a location specified by interrupt word 250. In this way, a transfer can be made automatically to a special routine which may analyze the instruction being executed or attempted and may then take appropriate programmed action.

This feature is under the control of a console nonstop switch. When the nonstop switch is off, the 7080 stops under the following conditions:

1. A halt instruction.
2. Any condition which turns on one or more of the 00900-00905 check indicators, provided the corresponding switch for these indicators is set to AUTOMATIC.
3. Any condition which turns on the automatic restart indicator.

When the nonstop operation switch is on, and one of the above conditions occurs, machine operation depends on whether or not the 7080 is processing an interrupt program. If the nonstop switch and the interrupt mode trigger are on, and the interrupt program trigger is off, the machine will automatically interrupt to the location specified by interrupt word 250. All of the normal interrupt procedures will be followed.

When in the interrupt program at the time any of the above conditions occur, the machine will stop.

When a program is executed with the nonstop switch on, *the 7080 should normally be in the interrupt mode* as conditioned by the instruction enter interrupt mode (EIM).

An interrupt associated with interrupt word 250 takes precedence over all other types of interrupts. Console and communication channel interrupts will be taken in turn after the interrupt with word 250 has been satisfied.

After an interrupt with word 250 has occurred, channel ASU 15 contains the status of the main program at the time the interrupt took place. The check indicators 00900-00905 are reset according to the status bits stored in the interrupt word. In order to test whether one of these indicators caused the interruption, it is necessary to test the proper status bit in CASU 15. To turn off an indicator before returning to the main program, the appropriate status bit must be set to zero.

The automatic restart indicator is not altered as a result of the interrupt nor is it stored in CASU 15. The indicator is tested and turned off in the interrupt program by execution of the TAR instruction.

Depression of the stop, machine stop, instruct, store, or display keys on the console will effect a stop regardless of the setting of the nonstop switch.

The setting of the nonstop switch may be interrogated by a transfer-any (TRA 07-TNS) instruction when the machine is operating in the 705 III or the 7080 mode.

The nonstop switch is ignored when not in interrupt mode.

AUDIBLE HALT SWITCH

When this switch is on and the machine hangs up in automatic or enters manual status for reasons other than the depression of the stop, store, display, or instruct keys, an audible tone sounds at timed intervals. If the switch is off, the audible halt feature is inoperative.

AUDIBLE HALT RESET KEY

Depressing this key turns off the audible signal if it is on. The signal will not sound again unless the start key is depressed and another audible halt condition occurs.

RESET

Depressing the reset key restores all checking circuits to normal, resets (off) the 7080 mode, interrupt mode, and interrupt program triggers, and sets the starting point counter to bank 0. It also resets the instruction counter to 00004 (Figure 7). This reset also occurs with power coming on. The reset key is operative only when the machine is in manual status.

START KEY

Depressing the start key when the machine is in manual status (stop key lighted) causes the system to operate at its normal high-speed rate. Operation continues in automatic status (green back-light on) until a programmed stop occurs or until the machine is manually stopped by depressing machine stop, stop,

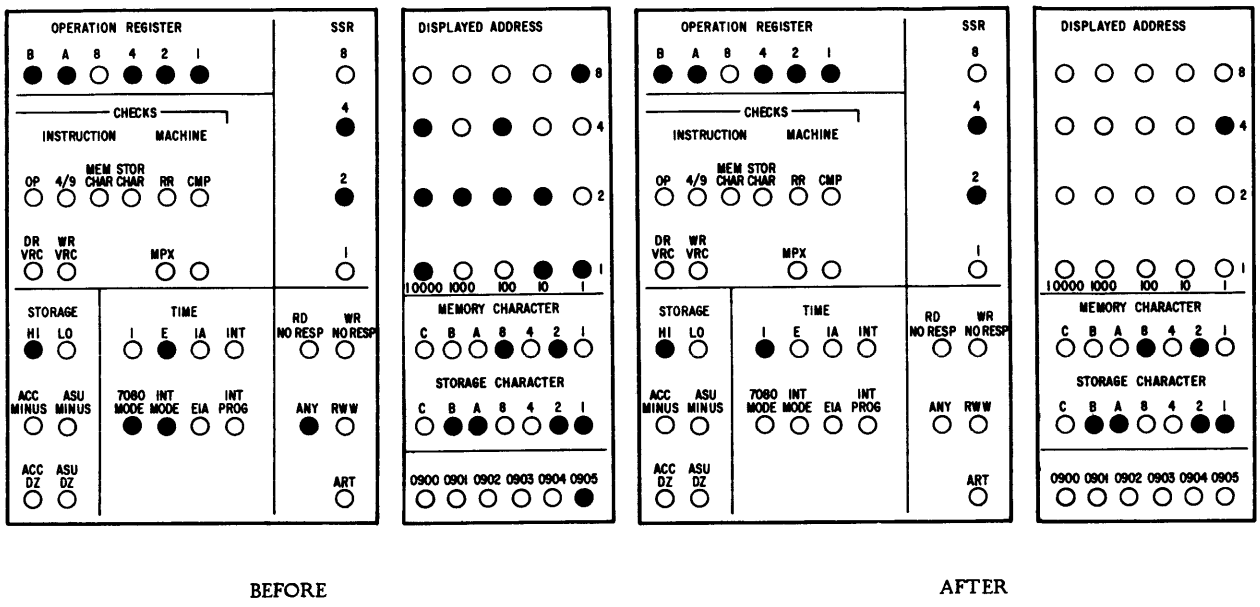


Figure 7. Console Before and After Using Reset Key

or other keys provided for this purpose, or until an auto-stop condition occurs.

Depressing the start key resets those check indicators with corresponding switches set to AUTOMATIC, but does not reset indicators with corresponding switches set to PROGRAM.

When an instruction error (00900) occurs, and the switch (00900) is set to AUTOMATIC, the operator must manually correct the instruction or transfer to another instruction before restarting the machine.

When a machine error has occurred and its 00901 check switch is set to AUTOMATIC, the machine may stop before completely executing the instruction involving the error. Depressing the start key turns off the indicator, but an attempt to complete the instruction turns it on again at once. A correction must be made before operation can continue.

When a 00902, 00903, 00904, or 00905 error has occurred with associated switches set to AUTOMATIC, depressing the start key causes the machine to execute the next instruction. The indicator is reset off.

STOP KEY

Depressing the stop key causes the machine to stop after the current instruction has been executed and turns on the red back-light. This is the normal way to halt machine operation. After the stop key is depressed, the machine remains in manual status and is ready to respond to any manual function or to start operation if the start key is depressed. Other keys (store, instruction, display, and half multi-step) also cause the machine to stop before their special function begins.

HALF MULTI-STEP

Depressing this key causes the machine to operate in half steps. For example, one depression causes the machine to read an instruction (I time). A second depression causes the machine to execute the instruction (E time). Indirect address time is also treated as a "half step." That is, an indirectly addressed instruction will be stepped through all three phases of its execution (I-time, IA-time, and E-time) by three successive depressions of the key.

This feature can be helpful for investigating an error condition, program or otherwise. This feature allows the operator to "step" through a portion of the program in half steps to pinpoint the trouble area.

Interrupt time is also treated as a "half step." That is if the interrupt time indicator is turned on following E-time, the next depression will result in INT being executed. The key depression following that will put the machine in I-time.

If the key is held depressed for more than three-fourths of a second, the machine alternately reads and executes instructions at the rate of about ten half-steps per second, for as long as the key is held down. If the machine is in automatic status when the key is depressed, it stops after executing the current instruction. Depressing the start key causes the machine to

enter automatic status, starting at the point where it stopped after the half multi-step key was last depressed.

The operator must be very cautious in using the half multi-step key. If the computer is in enable indirect address (EIA) time, the store, instruct, or display keys must not be depressed, as inconsistent results will follow. If the store, instruct, or display keys must be used, continue to half-step until the EIA display light on the console is not on.

As a good rule, to avoid possible inconsistent results while half-stepping, always condition the computer to I-time before depressing the start key.

INSTRUCT

The following procedure is used to instruct the machine manually:

1. Depress the instruct key. If the machine is in automatic status, it stops after the current instruction has been executed, exactly as if the stop key had been depressed.
2. Key the address part of the instruction in the memory address selector either before or after depressing the instruct key.
3. Key the desired storage unit in the storage selector, either before or after depressing the instruct key.
4. Key the operation part of the instruction in the keyboard. This final action causes the instruction to be executed.

NOTE: A 00900 check will occur if the program attempts to perform a 7080 instruction in any mode other than the 7080 mode, yet it is possible to perform a 7080 instruction manually, regardless of mode, and a 00900 check will not occur.

The machine remains in instruct status after completion of the instruction. Subsequent instructions may be keyed without further depressions of the instruct key; however, the storage selector and bank keys are automatically restored after each instruction execution; hence, must be re-keyed.

Depressing the start key causes the machine to continue in automatic status from the point in the program where it entered instruct status unless one or more transfer instructions were executed under manual control.

STORE

The following procedure is used to store information manually in memory:

1. Depress the store key. If the machine is in automatic status, it stops after execution of the current instruction exactly as if the stop key had been depressed.
2. Key the memory location into the memory address selector where the first character (i.e., the highest order) is to be stored. (The order of 1 and 2 can be reversed.)
3. Key the characters to be stored into the keyboard. The first character is entered into memory at the location specified by the memory address selector. Successive characters are entered into successively higher address positions of memory.

After one or more characters have been stored, the operator may select another address on the memory address selector. The store key must be depressed a second time to place the next character in the memory location specified by the second setting of the memory address selector.

The store status continues (white back-light on) until superseded by another mode of operation.

It is desirable to take the 7080 out of store status as soon as the desired storing has been completed, otherwise any accidental touching of the character keyboard may result in unwanted storing of information.

DISPLAY AND DISPLAY STEP

Depressing the display key when the machine is in automatic status causes the machine to stop as though the stop key had been depressed. In addition, it prepares the machine for reading a character from memory and from storage by subsequent depression of the display-step key.

The character read from memory is displayed in the memory character (MBR) lights in BCD code. If an invalid character is displayed, the MBR character check light is turned on, but the error does not turn on the machine check indicator.

The first memory character displayed is the one located at the address specified by the memory address selector. Subsequent characters are displayed from successively lower memory positions by depressions of the display step key.

The character read from storage is displayed in the storage character (SBR) lights as a BCD character. If an invalid character is displayed, the SBR character check light is turned on but the error does not turn on the machine check indicator.

The first storage character displayed is the one located at the right-hand position of the storage unit selected by the storage selector switches. Successive characters to the left are displayed by additional depressions of the display step key. The bank of central storage is selected by the storage bank selector keys.

The position of the next memory character to be displayed in memory character lights is shown as the address of MAC I.

Depressing the display key after the display step key causes the next character to be displayed from the position specified by the memory address or storage selector keys.

DISPLAY OF STORAGE BANKS

To display the accumulator, press the 0 and 1 key of storage bank, then press display, and then press display step. The characters will be displayed from right to left, one at a time, in the storage character. To display ASU 01 through 15, follow the same procedure but press the ASU keys you want to display.

Figure 8 shows the make-up and assigned storage locations of central storage. Section A shows:

Bank 0 – the accumulator storage, a 256 character ring

Bank 1 – auxiliary storage, subdivided into storage units 01-15

Bank 2 and Bank 4 – communication storage, subdivided into channels and interrupt words

Bank 3 – channel auxiliary storage, subdivided into word sets. Bank 3 also shows a character position that can be displayed following a set starting point counter instruction

Sections B, C, D, and E show the expanded view of their correspondingly shaded channels and words with their assigned character positions. They show, at a glance, the central storage locations for all information stored during the various operations.

Section F shows the detailed bit assignment of the four program status characters for the channels, CASU 15, and the interrupt words.

The communication channels and the channel ASU will be displayed in two places: character for character at the console, or eight characters (word) at a time on the panel of the IBM 7305 Central Storage and I-O Control. The display for channel 20 of the data memory address (SMAC) is in bank 2, word 1. (See Section B.) To display this address, depress bank 2 and ASU 01. The ninth through the twelfth positions contain the address of five positions higher than the last group of five read into memory. To find the length of the record, subtract the starting address from the setting of SMAC minus 5. If the record is not divisible by five, additional group mark characters are inserted in the data buffer and transferred to memory. Channel 21 SMAC would be in bank 2 ASU 03.

Here is an easy method of remembering which ASU displays the channel or interrupt word you seek to display:

BANK 2	
Channel 20	ASU 01 words 0 and 1; ASU 02 words 2 and 3
Channel 21	ASU 03 words 0 and 1; ASU 04 words 2 and 3
Channel 22	ASU 05 words 0 and 1; ASU 06 words 2 and 3
Channel 23	ASU 07 words 0 and 1; ASU 08 words 2 and 3
	ASU 09 not used; ASU 10 not used
Interrupt words	ASU 11 word 250 and 251; ASU 12 words 252 and 253
	ASU 13 not used; ASU 14 not used
	ASU 15 not used

DISPLAY CHANNEL AUXILIARY STORAGE UNITS (CASU)

To display the CASU's, press bank 3, then the ASU that you want to display. (See Section D.) The ASU's from 01-14 operate in the same manner as the ASU 1's in storage bank 1. ASU 15 is used for automatic interrupt. For this purpose, CASU 15 is divided into four 8-character words.

Word 0: 0-3 contain the location of the next instruction to be executed in the main program. When control is transferred from the interrupt program back to the main program, 4-7 contain the status indicators.

Word 1: 0-3 contain the setting of starting point counter; 4-7 are not used.

Word 2: 0-3 contain the address of MAC II; 4-7 are not used.

Word 3: 0-3 contain the contents of the select register; 4-7 storage marks are placed here.

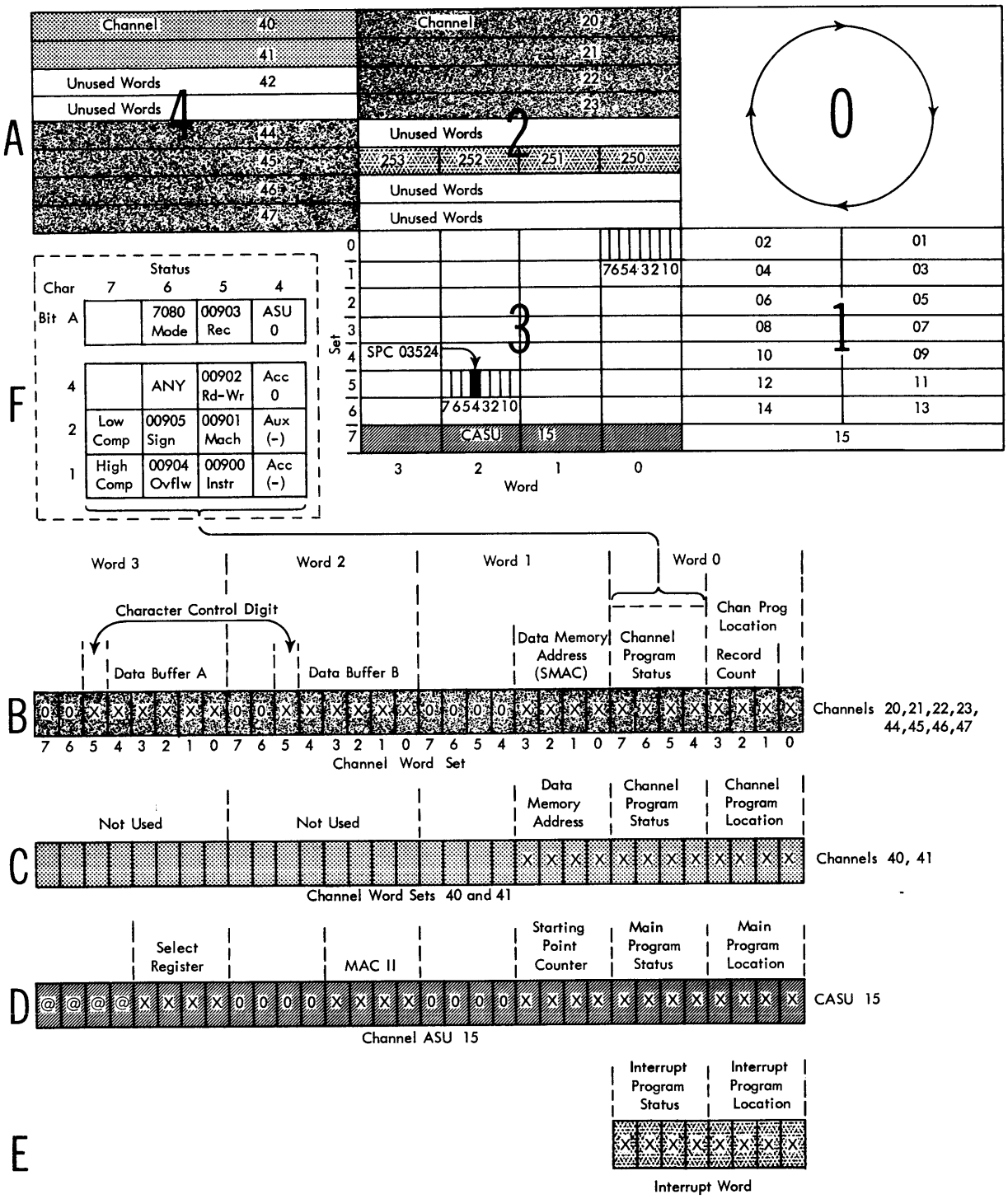


Figure 8. Central Storage Banks

Keyboard

A modified card punch keyboard (Figure 9) is used to enter data or instructions in memory while the machine is in store status. The operation part of the instruction is keyed on the keyboard while the machine is in instruct status. (Refer to instruction and store keys.)

The mnemonic and BCD bit configuration is illustrated over the keyboard for operator convenience.

Alphabetic characters on the keyboard are arranged in sequence from left to right on the top three rows of keys. The bottom row has numeric digits in the lower case position, and special characters in the upper case position. An upper case key and reset key are also provided.

Customer Engineering Panel Indicators

The customer engineering panel indicators are primarily for the use of customer engineers. These indicators assist in diagnosing machine performance by indicating the status of their related triggers. On an

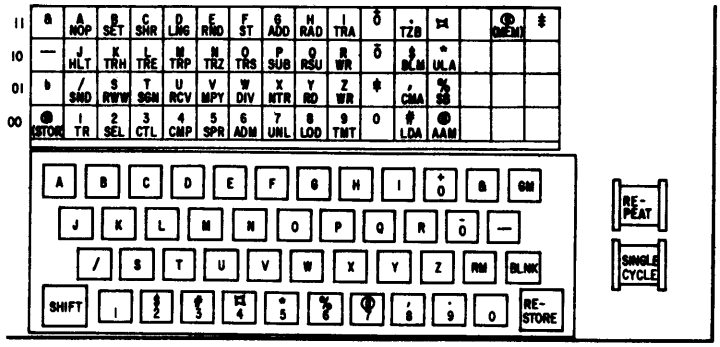


Figure 9. Operator Keyboard

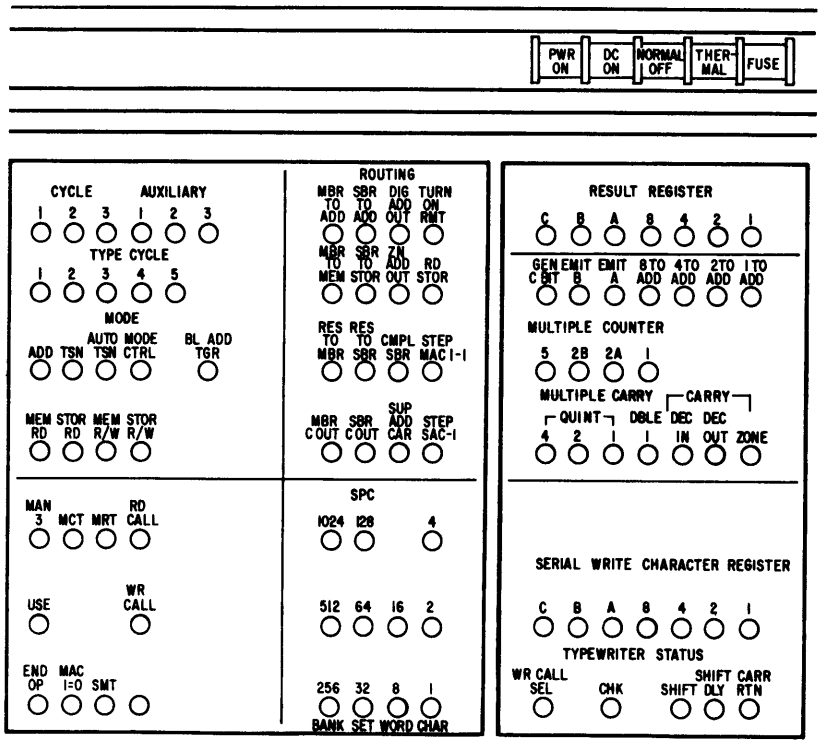


Figure 10. Customer Engineering Panel

error condition, a notation of the status of these indicators can greatly assist the customer engineer in diagnosing the trouble. (Figure 10).

The repeat and single-cycle keys are used in conjunction with the customer engineer indicators and test switch.

Control Keys and Lights

POWER-ON

Depressing the power-on key turns on the AC and DC voltages sequentially in the machine and turns on the back-light under the key. When the voltages are properly stabilized, the machine is automatically reset. The instruction counter is set to address 00004, all positions of central storage are set to storage marks, all memory positions are set to blanks, and all check indicators are turned off.

DC-ON (LIGHT)

This light indicates that DC voltages in the system are at the required levels.

NORMAL-OFF

Depressing this key turns off the AC-DC voltages sequentially in the machine. The cooling system continues to run and is automatically turned off several minutes later.

THERMAL (LIGHT)

This light being off indicates that temperatures in the various units of the system are below specified levels.

FUSE (LIGHT)

This light turns on when any DC fuse in the system is blown.

CLEAR MEMORY

Depressing the clear memory key, regardless of mode, in manual or automatic status resets all positions of memory to blank characters (1 01 0000) and central storage to storage marks (0 00 0000). All check indicators are turned off, channel reset is forced, and the instruction counter is set to 00004. The 7080 mode, interrupt mode, and program triggers are reset off. SPC is set to bank 0. These functions are also performed automatically whenever the power is turned on and the machine voltages have reached their required levels.

TEST

This light signals (1) that the CPU is in memory test or storage test, (2) that the 7080 is under bias conditions (marginal check), (3) a 7621 is in test status. Memory test and diagnostic operations are under control of the customer engineer.

705 I-II

When this key is depressed the machine operates internally as a 705 I or II. The back-light under the key is also turned on. Depressing the key, when it is on, turns off the light and returns the machine to the 705 III mode (Figure 11).

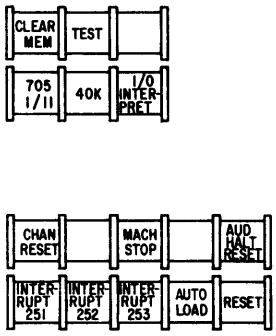


Figure 11. Control Keys and Lights

40K

Depressing this key sets the capacity of memory to 40,000 positions in the 705 I-II or 705 III modes. The back-light under the key is also turned on. With the switch off, the capacity of memory is set to 20,000 positions in the 705 I-II mode, and to 80,000 positions in the 705 III mode. The back-light under the key is also turned off. The condition of the key has no effect when the machine is in the 7080 mode. In this case the CPU operates as though a 160,000 position memory were being used. Actual capacity of memory, however, is determined by the model 7302 Core Storage Unit connected to the system.

I-O INTERPRET FEATURE

This special feature operates in conjunction with the modified conversion program, INT 580. The feature is under control of the I-O interpret switch on the console (Figure 11) and is normally used with the 00900 switch in automatic and the nonstop switch on. This feature (in addition to the normal interrupt conditions) causes a 00900 check to occur for the following instructions to force an interrupt to the address specified by interrupt word 250.

Read
Write
Write erase
Transfer on signal
Any control instruction (except enter 80 mode)
Read while writing

Limitations: The limitations imposed on this feature are:

1. In the 705 I-II or III mode, the address of an alteration switch, program check switch, or the

typewriter in the select register will prevent the 00900 check and the interrupt for the above instructions.

2. In the 705 I-II or III mode, a select register setting, other than those mentioned in (1), will allow an interrupt for the instructions listed above.
3. In the 705 III mode, a transfer on signal instruction with ASU coding 04-15 will not cause a 00900 with interrupt.

CHANNEL RESET

Depression of this key resets all check and status indicators in the communication channels and all tape controls attached. In addition, a channel reset will result from power on (all operation voltage levels reached), or the depression of the clear memory key, or the depression of the auto-load key.

INTERRUPT

Depression of any one of these may initiate an interrupt sequence commencing with the instruction whose address is in interrupt word 251, 252, or 253. The key provides a means of interrupting the program manually from the console, for example, to load a program while another program is in progress, or to program a reset and start operation without actually stopping the computer and depressing the reset key. The machine must be in interrupt mode and not in the interrupt program.

MACHINE STOP

When an internal operation is being performed, depression of the machine stop key stops the 7080 immediately. The stop can occur during the execution of an instruction such as an arithmetic or serial writing operation. The key may be used to halt serial input-output operations or to stop the 7080 when the manual stop key is not effective. Depressing the key during typewriter operation stops writing with a line space and a carriage return, in addition to bringing the CPU to a halt. (It should not normally be used when 7080 is in automatic. It may be useful for serial I-O, no response, invalid control instruction such as backspace typewriter, etc.)

AUTO-LOAD

The following operations are performed by depressing the auto-load key:

1. An input unit is selected. The address of the unit is keyed in the memory address selector.
2. All check indicators are reset and the instruction counter is set to 00004.
3. In 7080 mode, the interrupt mode, the 7080 mode, and the interrupt program triggers are reset off, and the starting point counter is set to bank 0.
4. One record is read into memory, beginning at location 00000.
5. Automatic operation is started.

Use of this key simplifies and speeds up the loading of a program into memory. (The key is not effective for loading 705 I-II programs.)

If the correct address is not keyed in the memory address selector, machine stop will put the computer in manual status. Then correct the memory address selector keys and again depress AUTO-LOAD.

Compatibility

The 7080 can operate as any one of three systems: 705 I-II, 705 III, or 7080 using programs prepared for any of the three systems. This program compatibility, however, assumes normal instruction usage and that the proper I-O units are available.

A 705 I-II switch and a 40K memory size switch are provided on the console for 705 compatibility and memory size. Their settings are shown below.

705 I-II SWITCH	40K MEMORY SIZE SWITCH	MODE	MEMORY SIZE
On	Off	705 I	20,000 positions
On	On	705 II	40,000 positions
Off	On	705 III	40,000 positions
Off	Off	705 III	80,000 positions

705 I-II MODE

The 705 I-II compatibility switch establishes this mode. When the switch is on, the 7080 operates internally as a 705 I-II until program-instructed to enter the 7080 mode. Therefore, programs written for the 705 I or II require no modification to operate in the 7080.

1. All 705 I-II input-output units must be connected to the central processing unit through the 7622 Signal Control.

2. All transfer instructions function exactly as they do in the 705 I or II. The 705 III transfer instructions with zoning over the tens and hundreds positions of the operand are deactivated. Operations such as add and subtract are terminated in the same manner as in the 705 I or II.

3. Indirect addressing, a feature of the 705 III, does not apply. Zoning over the units position of an instruction operand is ignored.

4. If the 40K memory size switch is off, the size of memory available to the program is restricted to 20,000 positions. If it is on, 40,000 positions are available.

5. Communication channels may not be selected.

6. Internal processing is carried out at the speed of the 7080.

7. Any 7080 instruction with a comma operation code will give a 00900 check.

705 III MODE

When the 705 I-II compatibility switch is off, the 7080 operates internally as a 705 III until program-instructed to enter the 7080 mode. Therefore, programs written for the 705 III will operate in the 7080 with no modification required.

1. The 729 II or IV tape units, a 7621 Tape Control, and a communication channel are substituted for the 729 I or III tape units and a 767 Data Synchronizer. Complete 705 III program compatibility is maintained regardless of this substitution of tape units and controls. The function of a 767 Data Synchronizer is simulated by communication storage and a communication channel in the 7305.
2. All 705 III transfer instructions are activated.
3. The indirect method of addressing is activated and zoning over the units position of an instruction address is treated in the same way as in the 705 III.
4. If the console 40K memory size switch is off, the size of memory available to the program is restricted to 80,000 positions. If this switch is on, 40,000 positions will apply.
5. The internal processing is carried out at the speed of the 7080.

7080 MODE

When the system is instructed to enter the 7080 mode, all the existing features of the 705 systems are available, together with the features of the 7080.

1. The capacity of memory is 160,000 positions for the 7302 Model 1, 80,000 positions for the Model 2, regardless of the settings of the console switches.
2. Wrap-around of the memory address counters and the instruction counter will always be at 160,000 positions, in 7080 mode.
3. The A bit in the units position of an instruction address specifies the memory locations 80,000 to 159,999, not indirect addressing.
4. The address modification instructions automatically handle the six-digit addresses of the 160,000 position memory.

Operating Controls--7502 Console Card Reader

Start Key and Ready Light

The first card from the hopper is positioned for reading by two depressions of the start key. The ready light is turned on to indicate that the card reader is ready for operation under program control.

Stop Key

Depressing the stop key turns off the ready light and removes the reader from 7080 program control.

Feed Key

When the ready light is off, this key provides a manual feed without reading cards. The key also turns off the read and eject station check lights.

Card Code Check Light

This light turns on when unacceptable card punching is detected in any column.

BCD Code Check Light

This light turns on when an unacceptable six-bit BCD character is detected.

Parity Check Light

This light turns on when a parity error is detected in a character sent to 7080 memory.

Another checking feature of the 7502 is the response check. This check insures that exactly 80 columns of the card are read. (With cards containing a reader storage mark, responses prior to the reading of the reader storage mark are counted, and column emitter pulses are counted before and after the record storage mark.) If more or less than 80 are indicated by the column counter, the read-write indicator (00902) is set.

There is no associated indicator light for the response check on the 7502. This check is indicated, however, when the 00902 indicator is on, the other three data check indicators (card code check, BCD code check, and parity check) are off, and the card column indicator is not at 80.

Read Station Check Light

When this light is on, it indicates improper positioning or registration of the card before reading begins. It also indicates malfunctioning of the light source or photoelectric cells between consecutive cards. The ready light is turned off and operation of the reader is halted.

Eject Station Check Light

This light indicates improper movement of the card at the eject station. The ready light is turned off and operation of the reader is halted.

Check Reset Key

This key manually resets a read error caused by a BCD code, card code, or parity check and resets the column counter.

Column Counter

The counter is a row of seven lights, each having an assigned binary value: 1, 2, 4, 8, 16, 32, or 64. The counter steps from 1 to 80 as each column of the card is read. It is automatically reset between cards unless an error occurs. The stepping of the counter is stopped when a BCD code, card code, or parity check error is detected. The reading of the counter at this point displays the number of the column where the error occurred.

NOTE: When using the 7502 Console Card Reader the last card will pass the read station and give a card reader end-of-file.

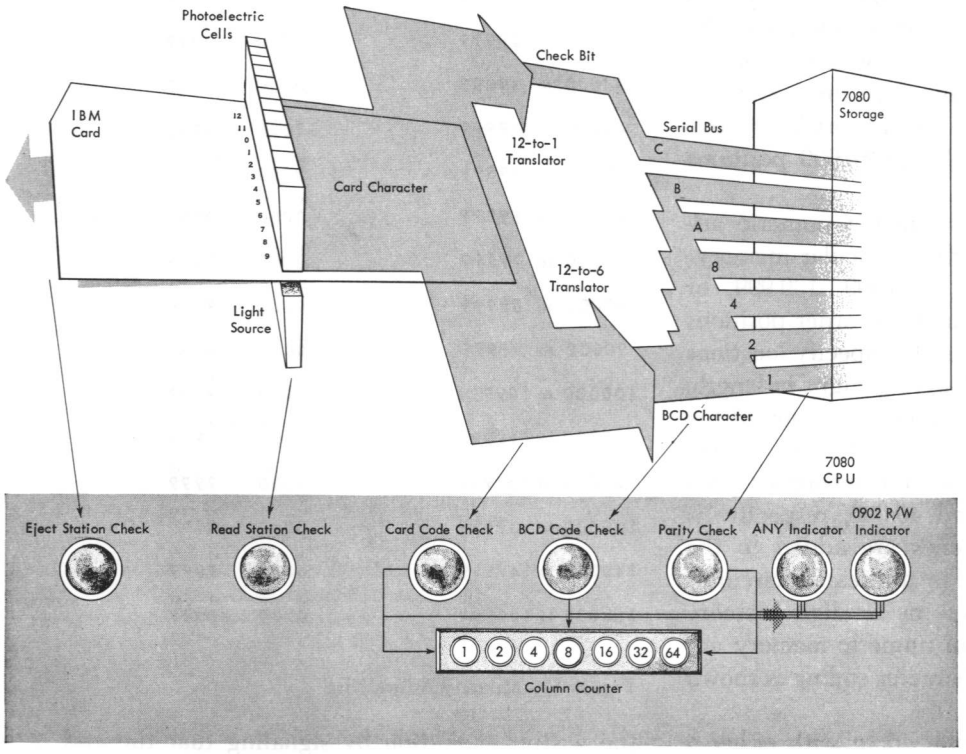


Figure 12. Data Flow and Checks—IBM 7502 Console Card Reader

Addressing

Memory and Memory Addressing

Memory is a core storage device containing a specific number of character locations. When the system is operating in the 705 I-II or 705 III mode, the capacity of memory available to the program is determined by the setting of the memory size switch. Memory capacity is thus made compatible with these systems. In the 7080 mode, the capacity of memory is 160,000 positions for the 7302 Model 1 and 80,000 positions for the 7302 Model 2.

Each memory location is assigned a numeric address from zero to the end of the particular memory: 19,999, 39,999, 79,999, 99,999, 119,999, 139,999, or 159,999. Zoning over the high- and low-order positions of the instruction operand are used to specify locations with addresses that are more than four digits in length. The A and B zones over the high-order position of the operand have decimal values of 10,000 and 20,000, respectively; A and B zones over the low-order position have values of 80,000 and 40,000, respectively. The decimal values of the zones are added to the numeric portion of the operand by addressing circuitry of the CPU to produce a five- or six-digit memory address as required. A chart of numeric memory addresses with equivalent four-character coding is shown in Figure 13.

Actual Memory Address	Four-Character Memory Address	
00000 to 09999	0000	9999
10000 to 19999	^{01}0000	^{01}9999
20000 to 29999	^{10}0000	^{10}9999
30000 to 39999	^{11}0000	^{11}9999
40000 to 49999	0000^{10}	9999^{10}
50000 to 59999	$^{01\ 10}$0000	$^{01\ 10}$9999
60000 to 69999	$^{10\ 10}$0000	$^{10\ 10}$9999
70000 to 79999	$^{11\ 10}$0000	$^{11\ 10}$9999
80000 to 89999	0000^{01}	9999^{01}
90000 to 99999	$^{01\ 01}$0000	$^{01\ 01}$9999
100000 to 109999	$^{10\ 01}$0000	$^{10\ 01}$9999
110000 to 119999	$^{11\ 01}$0000	$^{11\ 01}$9999
120000 to 129999	0000^{11}	9999^{11}
130000 to 139999	$^{01\ 11}$0000	$^{01\ 11}$9999
140000 to 149999	$^{10\ 11}$0000	$^{10\ 11}$9999
150000 to 159999	$^{11\ 11}$0000	$^{11\ 11}$9999

Figure 13. Memory Addressing

All memory positions are referred to with either a five- or six-digit address, depending upon the size of memory to be discussed. That is, memory address 525 appears either as 00525 or 000525; 73525 either as 73525 or 073525. Exceptions are illustrations where attention must be drawn to the zone structure of the characters. In such cases, zones are shown above the digits, as in Figure 13, where the B zone 1 or 0 is followed by the A zone 1 or 0. Thus, the address 73525 can be shown as: $^{11}3\ 5\ 2\ ^{10}5$

No specific areas of memory are reserved for either data or instructions; the only distinction is the way in which the stored information is handled by the CPU. Records may be separated or defined by a special character called a record mark. The mark may also be used to terminate the transfer of information from one area of memory to another. The information can be either data or instructions.

The end of a record, a group of records, or a block of information is normally defined by a group mark. When information is written from memory by an output device, the group mark can be used to terminate the writing operation by signaling that the end of a specified block of data has been reached.

The record mark is represented by the BCD configuration 1 01 1010; the group mark by 0 11 1111. Each mark occupies one character position.

Central Storage and Storage Addressing

The 7080 is provided with five 256-character banks of central storage.

Banks 0 and 1, Accumulator and Auxiliary Storage

Banks 0 and 1 of storage are normally used only as accumulator and auxiliary storage, respectively, in all modes of operation: 705 I-II, 705 III, and 7080. Information from memory is stored temporarily in the storage units. Operations may then be performed on this information without changing the original field or record that remains in memory. The various operations are not actually performed by these units, however, but are executed in the arithmetic and logical unit.

The number 00 identifies the accumulator (bank 0) as a single storage unit with a capacity of 256 characters. Bank 1 is subdivided into fifteen auxiliary units, identified by the numbers 01 through 15 (Figure 14). Units 01 through 14 have a capacity of 16 characters each; unit 15 has a capacity of 32 characters.

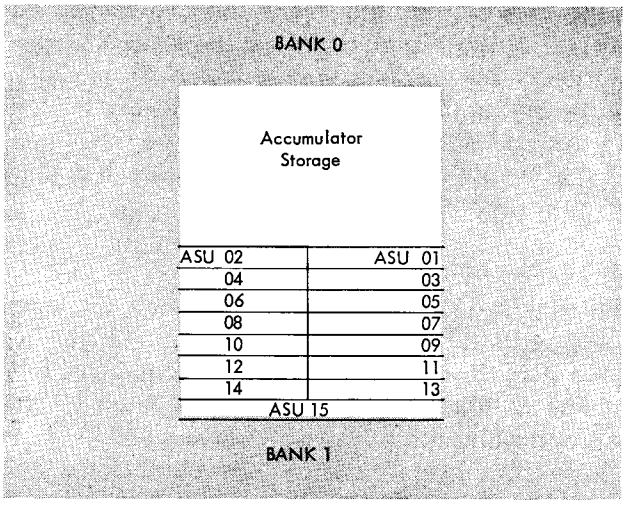


Figure 14. Divisions of Central Storage—Banks 0 and 1

Instructions using or involving accumulator or auxiliary storage must indicate the storage unit to be used. Zone coding (B and A bits) of the characters located in the tens and hundreds positions of the address part of the instruction specify the particular unit. The B and A bits of the character in the tens position have an assigned decimal value of 2 and 1, respectively. The B and A bits of the character in the hundreds position have an assigned decimal value of 8 and 4, respectively. The decimal sum represented by the presence of B and A bits in these two character positions indicates the addressed storage unit (Figure 15).

ASU indications can be shown in parentheses following the address as in ADD 04759 (13), unless attention is being drawn to the bits themselves. In this case, the address will be shown as $0\ 4\ \overset{11}{7}\ \overset{01}{5}\ 9$. Where the zoning over a digit is 00, no zoning will be shown; i.e., $0\ 4\ \overset{00}{7}\ \overset{00}{5}\ 9$ will be shown simply as 0 4 7 5 9.

A special character called a storage mark normally occupies at least one position of accumulator and auxiliary storage. The character marks the left limit of the storage contents and automatically appears in the proper position next to the highest-order character of the storage field. The mark is represented in text and programs by the letter a, and internally in 7080 storage by the BCD code 000 0000. A "no-bit" character in memory is considered an invalid character. A storage mark when transmitted to memory by

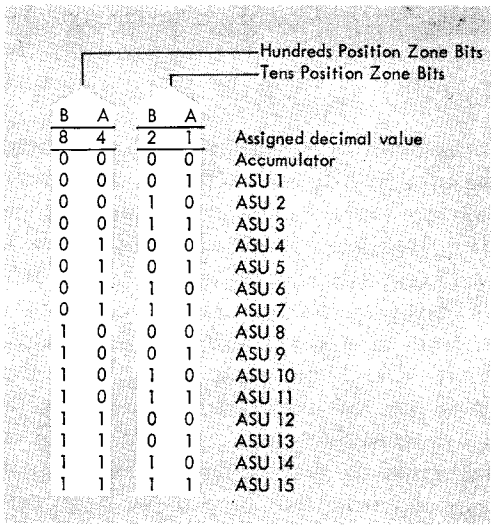


Figure 15. Storage Coding

unload storage bank instruction is converted to a special character called a delta (Δ) and has a bit configuration (1 11 1110).

A field in either accumulator or auxiliary storage can be shortened from or extended to the left by proper positioning of the storage mark. If the field is extended, zeros are automatically inserted between the storage mark and the high-order position of the field.

The starting point counter, containing the location of the right-hand character of the stored field, sets the right-hand limit of a field in the accumulator. Operations involving data in the accumulator, therefore, usually operate only on those characters between the storage mark and the starting point counter. However, certain instructions can handle a specified number of characters to the left of the starting point counter without regard for the position of the storage mark. Other instructions can load or unload the entire contents of the bank.

The location of a field in the accumulator can be shown by representing the bank as a circle with 256 available character positions around its circumference. Figure 16 shows a field of six positions defined by the storage mark and the starting point counter. The field

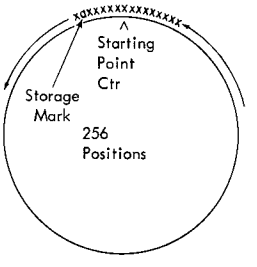


Figure 16. Accumulator Storage

can be shortened from or lengthened to the right by shifting the counter. When it is lengthened, zeros are automatically inserted as far as the new position of the counter.

The right-hand limit of a field in auxiliary storage is fixed by the arbitrary division of the storage bank into fifteen separate units. A field in auxiliary storage is therefore defined as being located between the division point of the particular unit and the next left storage mark. Auxiliary storage can also be represented in the form of a circle with a 256-character capacity (Figure 17). A field can extend from the division point of one unit into one or more adjacent units around the circle. The left limit of the field is set by the position of the storage mark. Two or more auxiliary storage units can thus be coupled to accommodate a field of data up to the 256-character capacity of the entire bank.

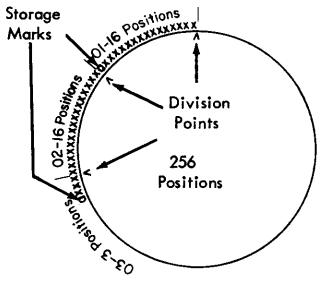


Figure 17. Auxiliary Storage

Positive and negative fields are stored as true numbers in accumulator or auxiliary storage. Two sets of sign indicators register the sign of the fields; one set serves accumulator storage, and the other set serves all auxiliary storage units. The sequence of operations within a procedure may be changed depending upon whether the sign of the accumulator or auxiliary storage is plus or minus, or the result is zero.

A field in an auxiliary storage unit or in the accumulator may be compared with another field in memory. Comparison indicators register the results of the comparison as high, equal, or low. One set of indicators serves the accumulator and all auxiliary storage units.

The sequence of operations within a program may be varied, depending upon whether the factor in the particular storage unit is higher, lower, or equal to a specified factor in memory.

When arithmetic operations are performed, the ACC or the ASU contains one of the two fields to be used in a calculation. The second field is in memory. To calculate A + B = T, the factor A is in a storage unit while factor B is in memory. After the addition operation is completed, the result T replaces factor A in the storage unit. The result of the calculation always replaces the original field in the ACC or the ASU, with the exception that a result may be added directly to a field in memory from a storage unit. In this instance, the ACC or the ASU remains unchanged.

Accumulator (ACC) and auxiliary storage unit (ASU) can be used to rearrange data in memory. Fields, records, or any portion of either, can be taken from one location in memory to a storage unit and from there can be relocated in another part of memory to form any desired arrangement. Data cannot be transferred directly from one storage unit to another but must first pass through memory.

Bank 2, Communication Storage

This bank is divided into two logical parts, as shown in Figure 18.

1. Four "channel word sets" each containing four 8-character words. There is a channel word set for each of the four communication channels (20-23).
2. Sixteen words of eight characters each, four of which serve as interrupt words. Twelve are unused.

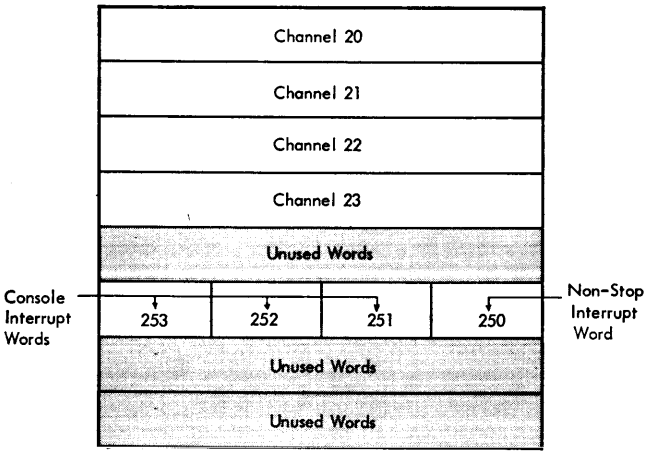


Figure 18. Communication Storage

Channel Word Set

Figure 19 shows the subdivision of a channel word set into the four 8-character words.

WORDS 2 AND 3

Positions 0-4 (from right to left) of each of these two words serve as data buffers. Information reading into the channel from tape is placed serially, one character at a time, into one of these buffers. When a buffer is filled, the five characters are transmitted as one 5-character block into memory while the alternate buffer is being filled. When information is written on tape from memory, the process is reversed. Character

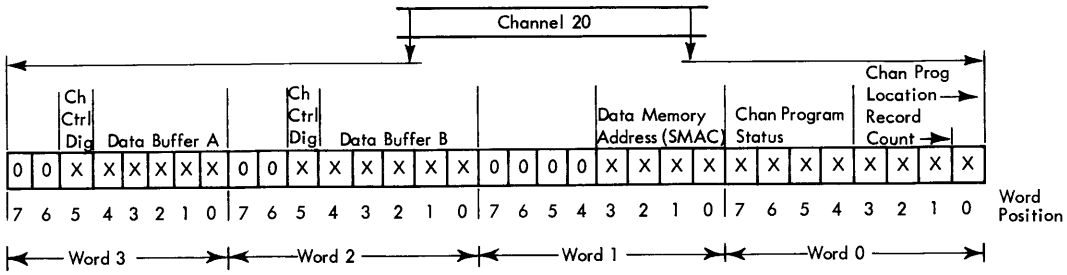


Figure 19. Channel Word Set

position 5 of each word contains a character control digit which controls the positioning of characters, one at a time, as they are received or sent to tape. Positions 6 and 7 of both words are not used.

The data buffers operate in an identical manner in both the 7080 and 705 III modes. They perform the same functions as the input-output buffers in the 767 Data Synchronizer used with the 705 III system. Therefore, the 7080 can operate as a 705 III without the use of data synchronizers.

WORD 1

Positions 0-3 contain the address in memory to or from which the next five-character block in the data buffer is to be transmitted. For example, in reading a tape record, the address of the read instruction is initially placed in position 0-3. After the first five characters are read into memory, this address is incremented by five for each additional block in the record until the end-of-record gap is sensed on tape. In writing on tape, the write address is incremented in the same manner until the writing operation is terminated by sensing a group mark in memory at the end of a record. If the number of characters in the record being read is not divisible by five, additional group mark characters are inserted in the data buffer and transferred to memory. Positions 4-7 are not used.

This word performs the same functions as the SMAC in the 767 Data Synchronizer. At the end of a read or write operation, the counter contains a memory address five positions higher than the last memory reference, that is, the 0 or 5 address of the last group of five memory characters handled by the instruction. For a write instruction, the last group handled is the group after the one containing the group mark.

WORD 0

The reading or writing of data through a communication channel is normally controlled by a separate subroutine, called the interrupt program. Positions 0-3 of word 0 contain the location of the next instruction to be executed when an automatic interrupt occurs for that particular channel.

When an automatic interrupt occurs, status indicators in the 7080 are set in accordance with the bit configuration contained in positions 4-7 of word 0 for that channel. This information includes the status of indicators for high and low comparison, accumulator plus and zero, auxiliary storage units plus and zero, indicators 00900 to 00905 on or off, transfer-any indicator on or off, and the 7080 mode indicator on or off. (The functions of the indicators are explained in detail in the pertinent sections.)

The storage of machine status is as follows:

STATUS INDICATOR	STORAGE WORD CHARACTER	BIT POSITION	INDICATOR CONDITION, BIT STATE=1
High comparison	7	1	on
Low comparison	7	2	on
Overflow check (00904)	6	1	on
Sign check (00905)	6	2	on
Transfer any	6	4	on
7080 mode	6	A	on
Instruction check (00900)	5	1	on
Machine check (00901)	5	2	on
Read-write check (00902)	5	4	on
Record check (00903)	5	A	on
Accumulator sign	4	1	minus
ASU sign	4	2	minus
Accumulator zero	4	4	zero
ASU zero	4	A	zero

Thus, whenever an interrupt program is to be executed, the 7080 is automatically placed in the proper status for that particular program. All indicators are restored to the status they registered after the completion of the last instruction executed in the interrupt program. The initial status for the program is established by appropriate housekeeping.

Tape reading or writing instructions may be given that cause a specified number of records to be placed in or transmitted from memory. In this case, word 0 has an alternate use as a record counter. Such instructions are normally given only in the 705 III mode and when the machine is not in the interrupt mode. Positions 1-3 simulate the action of the record counter in the 767 Data Synchronizer. Positions 4-7 are not used.

Interrupt Words

The portion of bank 2 which would normally be channel 25 is divided into four interrupt words. The format and function of these words are identical to those

of word 0 in a channel word set (Figure 17). Positions 0-3 contain the location of the next instruction to be executed when an interrupt occurs. Positions 4-7 are used for storage of machine status (Figure 20).

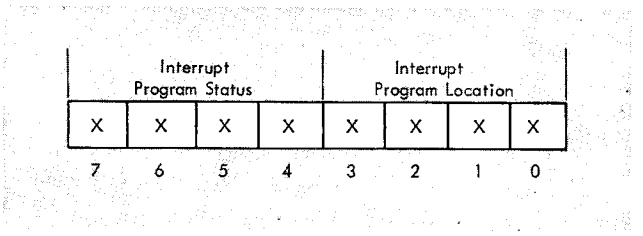


Figure 20. Interrupt Word

Each interrupt word is associated with a specific interrupting condition as follows:

Interrupt Word 250: This word is associated with the nonstop operation feature and its function is explained under that section.

Interrupt Words 251, 252, and 253: These words are associated with console interrupt keys 251, 252, and 253, respectively. Depression of any of the three keys causes an automatic program interrupt to the location specified in positions 0-3 of its related word, if the system is in interrupt mode and not in interrupt program.

Bank 3, Channel Auxiliary Storage Units

Instructions in an interrupt program which specify the use of auxiliary storage automatically use these units unless special instructions are used to refer to the normal ASU's in storage bank 1. They operate in the same manner as those in storage bank 1; however, CASU 15 is used to store the status of the main program before a transfer is made to the interrupt program. For this purpose, CASU 15 is divided into four 8-character words as follows (Figure 21).

WORD 0

Positions 0-3 contain the location of the next instruction to be executed in the main program when control is transferred from the interrupt program back to the main program. Positions 4-7 contain the status of indicators as previously explained for these positions in word 0 of a channel word set.

WORD 1

Positions 0-3 contain the setting of the starting point counter. Positions 4-7 are not used.

WORD 2

Positions 0-3 contain the address indicated by MAC II. Positions 4-7 are not used.

WORD 3

The contents of the select register are stored in positions 0-3. Storage marks are placed in positions 4-7 (Figure 22).

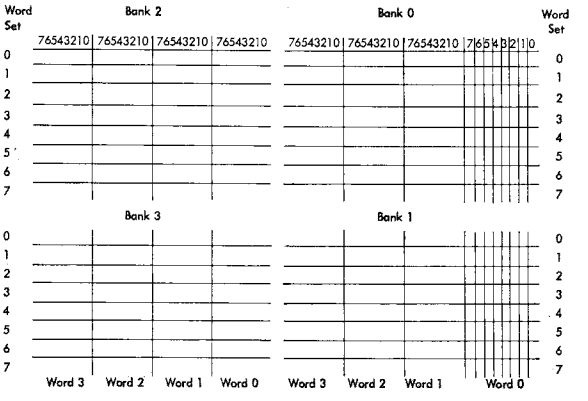


Figure 22. Central Storage Address System

Bank 4, Disk Storage

A fifth bank (bank 4) of the IBM 7305 Central Storage and I-O Control, in conjunction with the IBM 7908 Data Channel, provides six additional channels to attach the IBM 7631 File Control for the IBM 1301 Disk Storage and IBM 7640 Hypertape Control for the IBM 7340 Hypertape Drive.

This bank is similar to bank 2. The channel word sets 44-47 are identical in make-up and operation to channel word sets 20-23. However, the high-speed

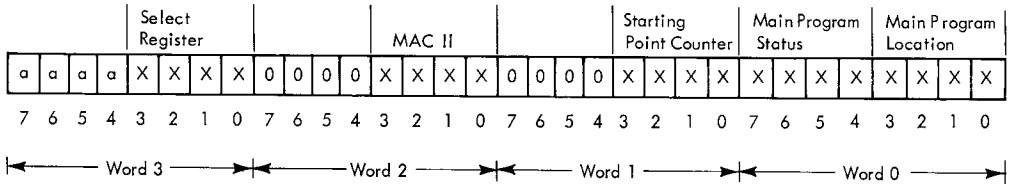


Figure 21. Channel ASU 15

channel word sets 40-41 are different: words 2 and 3 are not used because the assembly and disassembly of the five character blocks is performed in the 10 character buffer within the 7908 Data Channel.

Bank 4 is an integral part of central storage of the 7305 Central Storage and I-O Control. Thus, any portion of this storage bank may be addressed, provided that the starting point counter has been properly positioned within the bank. Any position addressed, that is not an active part of a channel word set, will always contain storage marks. Instructions with ASU coding executed with the starting point counter in this bank will nevertheless refer to bank 4, and treat it as though it were a normal ASU storage bank.

Starting Point Counter

All instructions that use or involve central storage are executed with reference to the previous setting of the starting point counter. One counter is provided for all banks. The counter may be set to any position within any bank by program instruction.

The addressing scheme for central storage is shown in Figure 22. The five 256-position banks are numbered 0, 1, 2, 3 and 4. (Bank 4 is not shown.) Each bank is divided into eight 32-position word sets numbered 0-7. Each word set is further subdivided into four 8-position words numbered 0-3, and each word has eight character positions numbered 0-7. The thousands position of a set-starting-point-counter instruction address specifies the bank, the hundreds position the word set, the tens position the word within the set, and the units position the character within the word. The address 2713, for example, refers to bank 2, word set 7, word 1, and character 3.

Any instruction using storage that does not have ASU coding automatically specifies as an accumulator the bank of central storage indicated by the current setting of the starting point counter. Instructions with ASU coding specify an ASU in (a) bank 1, if the starting point counter is set to any position within bank 0 or 1, (b) bank 3, if the counter is set to any position within bank 2 or 3. The fixed divisions of ASU storage are maintained for all storage reference instructions that specify these units, regardless of the bank used.

The flexibility of central storage is such that any bank can be used as an accumulator, while either banks 1 or 3 can be used as ASU's by proper manipulation of the starting point counter. However, the programmer must be aware that communication storage, bank 2, and channel ASU 15, bank 3, are involved with the functions of data flow and priority processing. These positions of central storage are normally used only for this purpose.

Execution of an automatic interruption or a program transfer to an interrupt program automatically places the starting point counter at position 2000. Therefore, subsequent references to central storage without ASU coding specify communication storage, bank 2, as an accumulator. Since bank 2 is involved with the flow of data to and from the channels, all instructions in an interrupt program using central storage should refer to an ASU, thereby properly utilizing the channel ASU's in bank 3 provided for this purpose.

Input-Output Component Addressing

Each input-output (I-O) component of the 7080 System is assigned a specific address to provide a means of selecting one particular device from all those attached to the CPU. A component address is distinguished from a memory address by the operation part of the instruction.

705 I-II Mode

Only input-output equipment attached to the 7622 Signal Control can be selected in this mode. Addresses remain the same as when this equipment is attached to a 705 I or II and the units are operated in the same manner. Communication channels are not available to the program. The following addresses are assigned:

I-O ADDRESSES	CONTROL UNIT	ATTACHED UNITS
00100-00199	759 Card Reader Control	(1) 714 Card Reader
00100-00109		(1) 7502 Console Card Reader
00200-00299	754 Tape Control	(10) 727 Magnetic Tape Units
00200-00299	760 Control and Storage, Model 1	(1) 720 Printer (2) 727 Magnetic Tape Units
00200-00299	760 Control and Storage, Model 2	(1) 730 Printer (2) 727 Magnetic Tape Units
00300-00399	758 Card Punch Control	(1) 722 Card Punch
00400-00499	757 Printer Control	(1) 717 Printer
00400-00499	774 Tape Data Selector	(1) 407/408 Accounting Machine or 519 Document Originating Machine
00500		(1) Typewriter
00501		(1) Real Time Clock
00600-00699	777 Tape Record Coordinator	(8) 727 Magnetic Tape Units
01000-01899		(1) 734 Magnetic Drum Storage

NOTE: Addresses above 01899 are reserved for the communication channels in either the 705 III or 7080 modes.

705 III and 7080 Modes

A 705 III program may call for the use of data synchronizers with either 729 I or III tape units. As previously stated, the data synchronizer cannot be used with the 7080 system. Tape select addresses in such a program will select instead a 7621 Tape Control and the attached 729 II or IV tape units. Address switches provided on the 7621 units must be set to correspond with the addresses specified by the program. For example, a 705 III select address 00214 specifies tape operation, DS 1, tape unit 4. On the 7080, SEL 00214 will specify tape operation, tape unit 4 on the communication channel whose associated 7621 address switch is set to 1. The channel word set used to simulate operation of the DS will be the one associated with the selected communication channel. This may be any one of the four communication channels available with the 7080.

When both 754 tape controls and a data synchronizer are called for by the program, the address switch of the 754 must be set to a number which does not correspond with the address switch of any 7621. For example, assume that the address switch of the 754 is 0, and that the address switches of a 7621 Model 2, are set to 1 and 2. In this case, a SEL 00204 will operate tape unit 4 attached to the 754. SEL 00214 will operate tape unit 4 attached to the first communication channel with which the 7621 is associated; SEL 00224 will operate tape unit 4 attached to the second communication channel with which the 7621 is associated.

In the 7080 mode, a tape operation using a communication channel is initiated by specifying the channel number in the two high-order positions of the select address, digits 20-23. The tens position of the address must always be zero; the units position specifies the particular tape unit required, digits 0-9. The setting of the address switch on the 7621 attached to the selected channel is immaterial. For example, SEL 02004 initiates tape operation on channel 20, tape unit 4, regardless of the setting of the 7621 address switch. The channel word set used corresponds to the channel selected.

Communication channels may also be addressed in the 705 III mode in the same manner as described for the 7080 mode, and 705 III type addressing can be used in the 7080 mode.

When 705 I-II input-output units are also used in the 7080 mode, their addresses remain the same as when used with the 705.

All stops, except for the instruction check stop, occur in execution time. The instruction counter will contain, at all stops, the location of the current instruction plus five. During an instruction check stop, the I-time indicator is on. The initial address register will show the address of the current instruction. The operation code of the current instruction will be shown in the operation register. This is even true of invalid operation codes, which will not be shown in the operation code display. The storage select register will give in true binary form the ASU selected in the current instruction. This is also shown in the ASU display when initial address register key is depressed. The select register will always contain the last input-output unit, check indicator, or alteration switch selected.

I-O No Response

This can be a RD NO RESPONSE or a WR NO RESPONSE stop.

CAUSE

These stops are caused during execution time of a RD, WR, or WRE instruction.

EXAMPLES

1. The unit selected is not on line, which may mean that it is non-existent (e.g., SEL 00024). It may mean the address selector switch of the relevant tape drive has not been set as required, not ready, or file protected and attempting to write.

2. The combination of the unit last selected and the RD, WR, or WRE instruction being executed is impossible. For example, the following are impossible conditions:

RD with typewriter selected.

WR with card reader selected.

WRE with 00902 selected.

CORRECTIVE ACTION

Remedial action does, of course, depend on the cause of the stop. It should be noted that as the 7080 remains in automatic status, it will be necessary sometimes to make a simple adjustment to the relevant input-output unit; e.g., (1) push the start key on a tape unit to put it in ready status or (2) set the address selector switch of the proper tape unit as required without manipulating any of the 7080 console keys. As soon as corrective action is completed, the 7080 will continue operation.

If manual operation is necessary, there are two choices. The first should be to interrupt words 251, 252 or 253 if they are programmed. The primary functions of the interrupt keys involve their use with AUTOMATIC STOP conditions in the main program. The correct word would depend upon the installation programming of these words or utility program use of them. The other is the machine stop key. Manual operation after depressing machine stop key at the console must then include depressing the instruct key and changing the selected unit.

NOTE: A SEL instruction merely sets the select register to the address contained in IAR. Therefore, an impossible or inappropriate SEL instruction will result in stops only when RD, WR, WRE, or CTL instructions are directed to the unit last selected.

Program Stops

As implied by its designation, this type of stop has been planned by the programmer to occur under predetermined conditions.

As the 7080 halts at the end of E-time, depression of the start key will cause the system to operate on the next sequential instruction. The program stop, which should be identifiable by its address, is used mainly to indicate existence of some special condition or completion of some phase of the program, or to allow the operator to make a decision and/or take some special action. In order to minimize delay at the console, a clearly indexed sheet, containing a concise statement of the reason and the necessary action for each program halt, should be included in instructions to the operator. Each program halt, after which resumption of operation may be desirable, should be followed by instructions which allow continuation by merely depressing the start key.

Check Stops

Instruction Check, 00900

This check stop is the only type of stop that may occur during I-time, while the current instruction is being read and interpreted by the 7080. An instruction check

stop may be caused by any, or a combination of, the following error conditions.

MEMORY CHARACTER CODE CHECK

This check results when a redundancy exists in any character of the current instruction. In memory, a character consisting of no bits is also treated as a redundant character.

OPERATION CODE CHECK

The operation code of the current instruction is not recognized as a proper operation code by the 7080. The character serving as the operation code is (1) redundant or (2) a blank, zero, or a special character other than those assigned as instruction codes.

4 OR 9 CHECK

The numeric part of the units position of the address of any transfer, AAM, ULA, LDA instruction, or an indirect address instruction is not a 4 or a 9. (Also a TCT must end in 9.) The 4 or 9 check tests only the numeric part of the units position of the address. The units position of the address may have any zoning whatever without interfering with proper operation. As the instruction check stop takes place during I-time, it is immaterial, in the case of a conditioned transfer, whether the conditions for carrying out an actual transfer exist or not. The 4 or 9 check will be turned on as soon as the machine recognizes that the current instruction is violating the above rule.

CORRECTIVE ACTION

Corrective action depends on the condition which gave rise to the stop and on the surrounding circumstances. The operator should realize, however, that the instruction in question is incapable of being properly executed until the underlying error condition has been corrected. Any error condition involving the operation code or the units position of the address of the instruction can be seen on the console without any manual operation. If any of the characters in the tens, hundreds, or thousands positions of the instruction is redundant, these characters must be displayed manually to identify the offending character. After storing the correct character in the current instruction, it is necessary to depress the start key to commence interpretation and execution of the current instruction.

00900 EXAMPLE (FIGURE 23)

Load Four Character Instruction: Trying to perform a 7080 instruction when not in 7080 mode will cause a 00900 check.

IAR – 23304	Address of units position of field to be loaded.
IC – 23249	Instruction location is 23244.
MAC I – 23304	Same as IAR.
SAR – 00000	Position of ASU 02 instruction at which first character should be loaded.
MAC II and SR	No significance.

The invalid operation was detected at start of E-time and caused an immediate end operation.

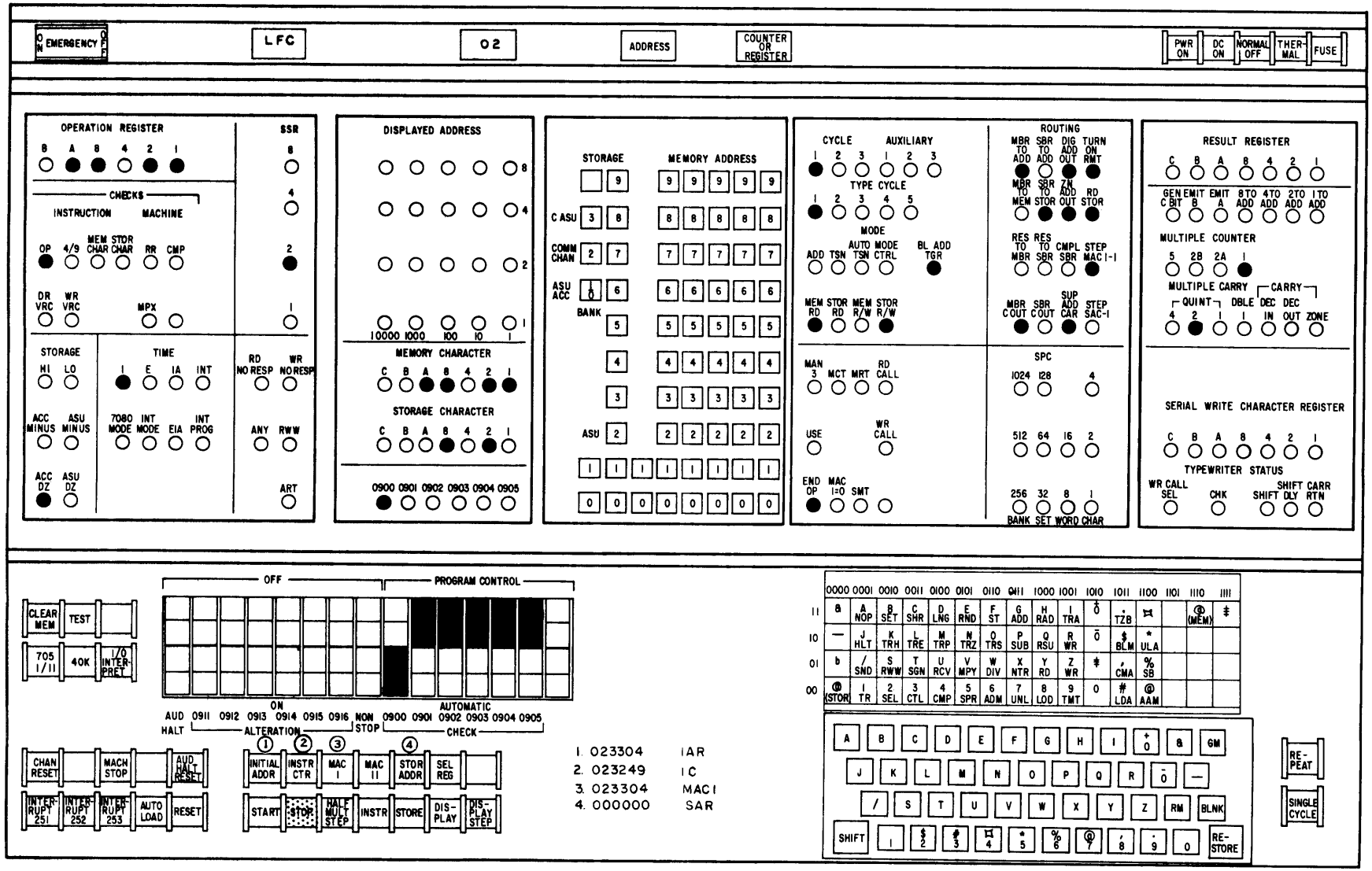


Figure 23. 00900 Example—Instruction Check

Machine Check, 00901

The machine check indicator is turned on when a character code error is detected during the execution of all instructions in which data is transferred from central storage or memory. Note that if a machine check occurs during an instruction which is intended to move a field or record containing the redundant character, the redundant character may have been moved. In such cases, therefore, the redundant character may exist in two locations. During high-speed transmission, the five- or ten-character group containing the redundant character is the last one to be transmitted before the 00901 machine check stops the computer.

In practice, during program testing it will usually be best to get off the machine and to examine the instructions of the program to determine whether the machine check has been created by the program, as by storing nonnumeric or by bringing in redundant characters from input unit.

00901 EXAMPLE (FIGURE 24)

Load Four Character Instruction: The third character of memory field is redundant, causing a 00901 check.

IAR – 37129	Address of units position memory field.
IC – 36909	Instruction location is 36904.
MAC I – 37125	Has stepped 2 beyond the redundant character.
(MAC I does not indicate the location of the redundant character.)	
SAR – 000114	Has stepped +2 from initial SPC setting.
MEMORY CHARACTER	Shows redundant character.

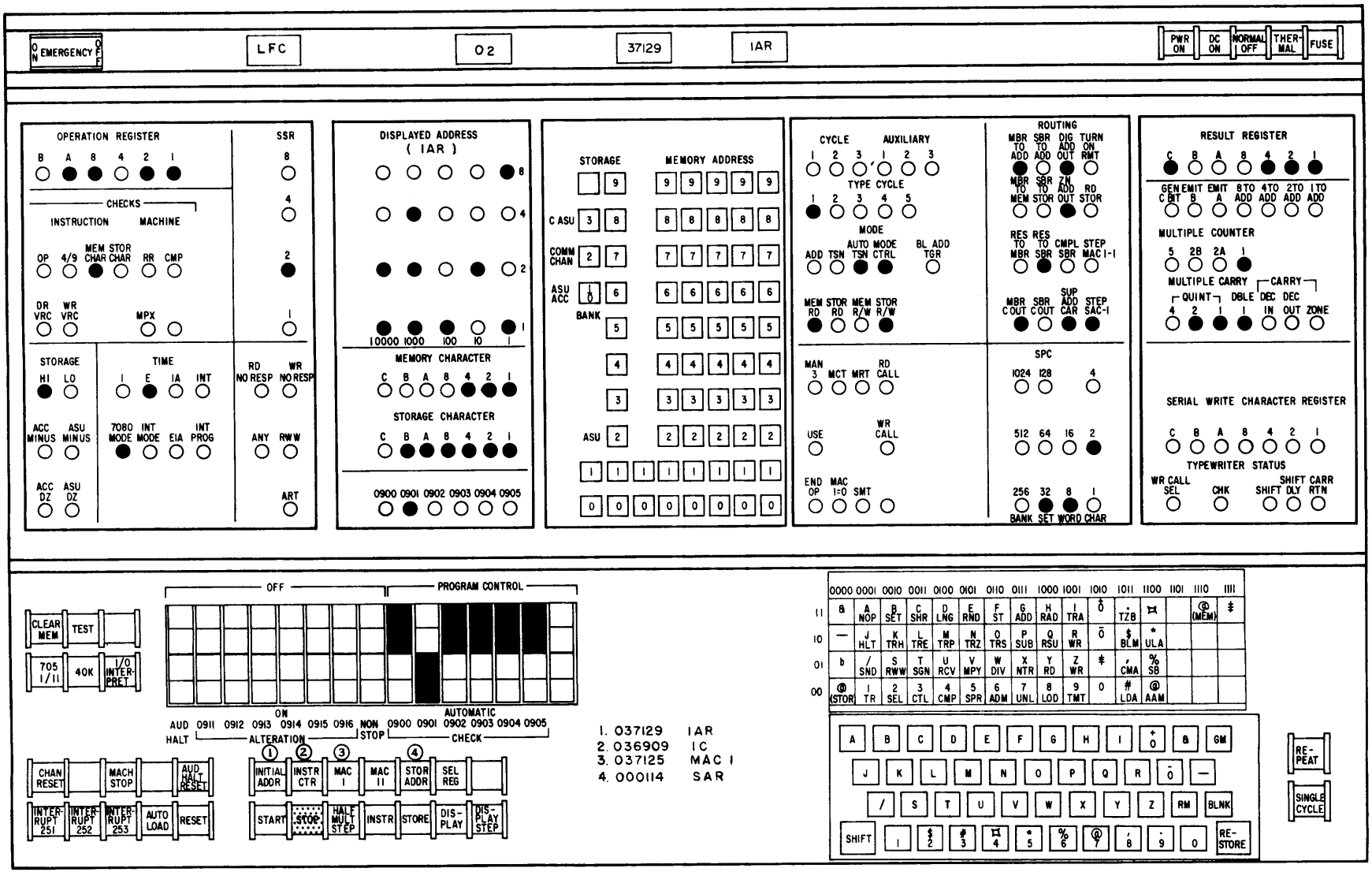


Figure 24. 00901 Example—Machine Check

Read-Write Check Indicator, 00902

The read-write indicator turns on when a character code error is detected during the execution of a read, write, read-while-writing, or write-and-erase instruction except when using a communication channel.

The indicator turns on when an error is detected in reading the holes in the card or by the longitudinal check in tape reading. The indicator, therefore, checks the transmission of data from all input units to memory. It also checks the transmission of all output data from memory to the drum, tape unit, and other input-output units that are not on a channel. The indicator also turns on if an attempt is made to read or write beyond the limits of the drum or if an error occurs in recording a tape mark.

If the 00901 check indicator light is on, the record written is redundant, i.e., it contains at least one redundant character. If writing of that record is repeated, every write instruction will be followed by a 00901 and 00902 check. Re-creation of the output record is then a prerequiste to writing it successfully on an output unit.

Notes for Figure 25: Write operation using the typewriter. Redundant character in write field causes 00901 and 00902.

IAR – 000115	Starting address of write field.
IC – 000029	Instruction location is 000024.
MAC I – 000166	One above location of group mark.
SR – 000500	Shows typewriter selected.
MEMORY CHARACTER	Shows the character beyond the group mark.

The 00902 in AUTOMATIC caused the machine to stop. The 00901 in AUTOMATIC will *not* cause a stop in this example.

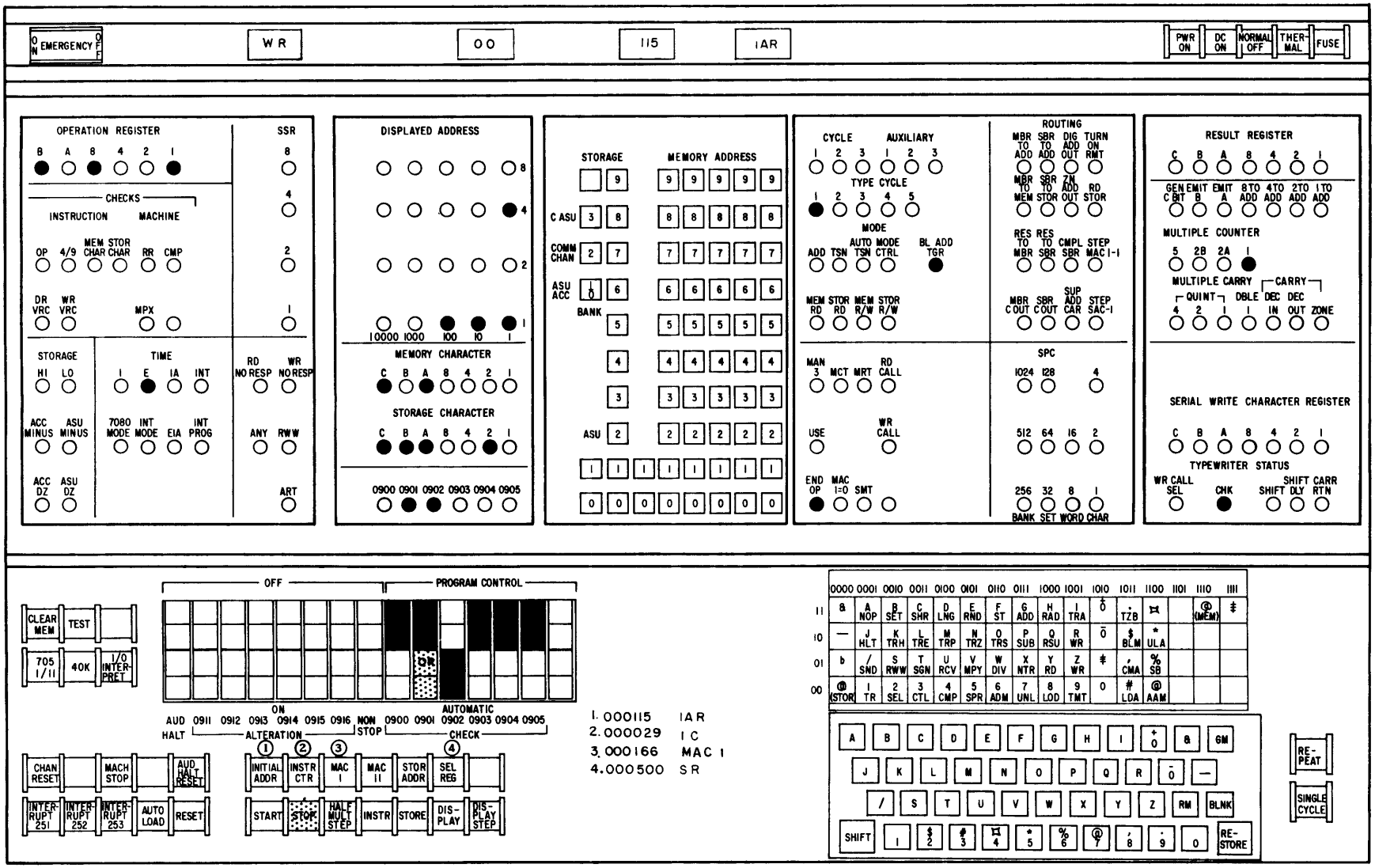


Figure 25. 00902 Example—Read-Write Check

Record Check Indicator, 00903

The record check indicator turns on when an error is detected by the brush-compare method on the punch and by the echo-check method on the printer. In both cases, when the switch for this indicator is on automatic, an error stops the machine at the end of the punching or printing cycle during which the indicator was turned on.

This error will only occur if the printer and punch are connected to the 7080.

Overflow Check, 00904

The overflow check indicator is turned on when the storage positions allowed for arithmetical operations are exceeded. It will occur upon an add or subtract instruction if the resulting field has more digits than either of the data fields in memory and storage, and when a carry beyond the high-order position results from the execution of a round instruction. It also indicates a violation of the absolute value rule of division. The absolute value rule provides that the divisor shall be numerically greater than the same number of high-order positions of the dividend. When the absolute value rule is violated, and the 00904 check indicator switch is set to AUTOMATIC, an error stops the machine during the execution of the instruction.

The correct result of the operation causing the overflow check appears in storage. Occurrence of an overflow usually indicates that the program has not worked out as anticipated, during testing. The dividend appearing in storage before start of the divide instruction has been destroyed. Furthermore, violation of the absolute value rule of division usually indicates a basic error in program or data. Therefore, it will usually be best to take a memory print and get off the machine.

Notes for Figure 26: Add Instruction (G 31689). Adding a +9 from 31689 to storage field of @ 9+ causing a 00904 overflow.

IAR – 31689	Address of units position of the add field.
IC – 31659	Instruction location is 31654.
MAC I – 31686	Has stepped −3; of no significance.
SAR – 00705	Has stepped +1 from the initial setting of SPC.

The character in memory is a nonnumeric character which limits the memory add field. The 00904 was caused by trying to carry into a storage mark. The fact that the 00904 was in automatic prevented the carry from occurring.

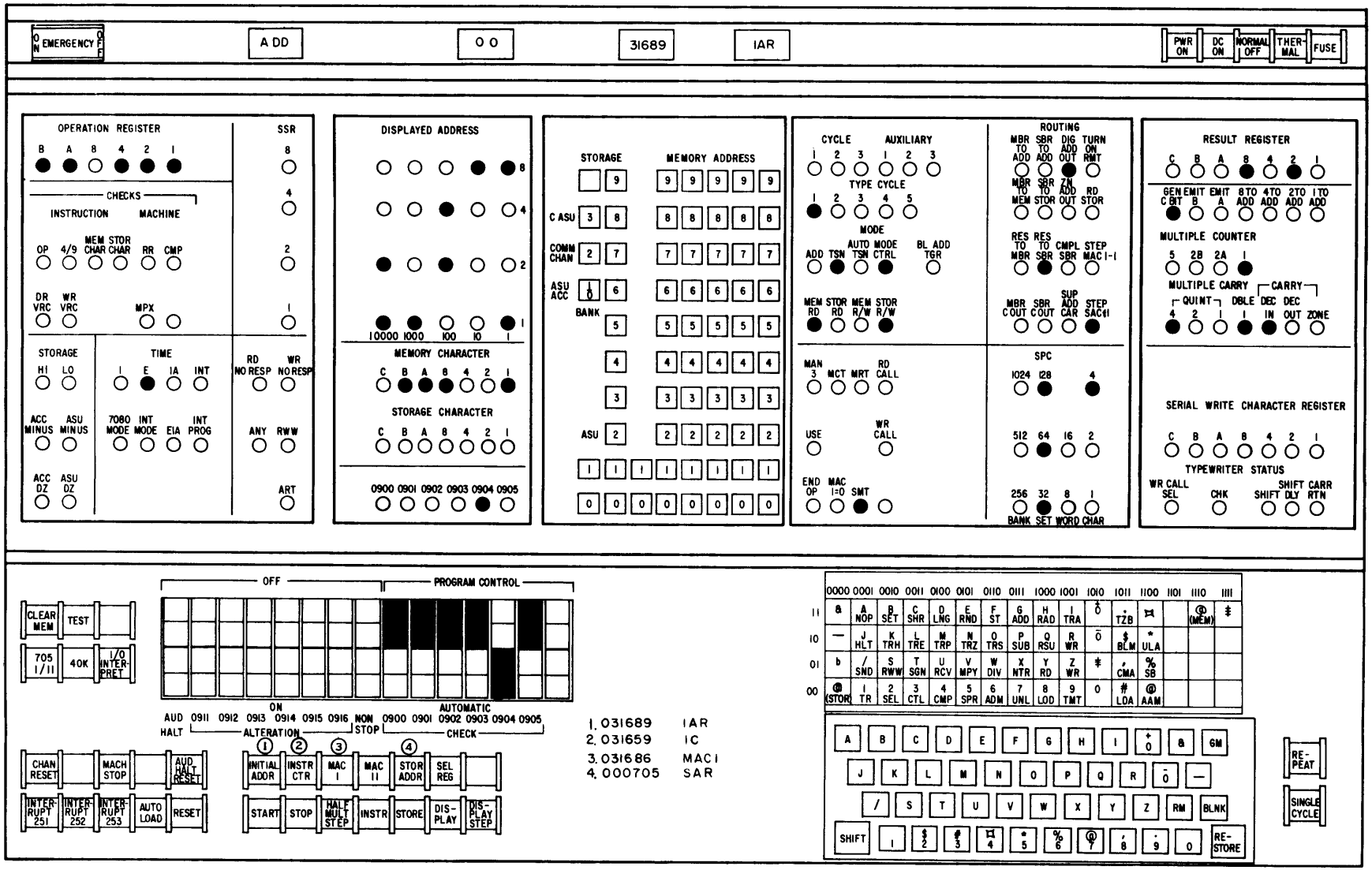


Figure 26. 00904 Example—Overflow Check

Sign Check, 00905

The sign check indicator turns on if a memory field addressed by an arithmetic instruction (add, subtract, multiply, etc.) does not have plus or minus zoning over the low-order digit.

When the switch for this indicator is set to AUTOMATIC, an error stops the machine in the same cycle in which the error is detected.

When a 00902, 00903, 00904, or 00905 error has occurred with associated switches set to AUTOMATIC, depressing the start key causes the machine to execute the next instruction. The indicator is reset off.

Notes for Figure 27:

Reset and Add	H32294 addresses an unsigned zero.
IAR – 32294	Shows address of unsigned character.
IC – 32244	Instruction location is 32239.
MAC I – 32292	Has stepped −2; of no significance.
SAR 00011	Set to SPC.
MEMORY CHARACTER	Shows the unsigned character.

The ANY indicator is not on. When 00900-00905 switches are in AUTOMATIC, the ANY indicator does not turn on before the machine stops, if the nonstop switch is off.

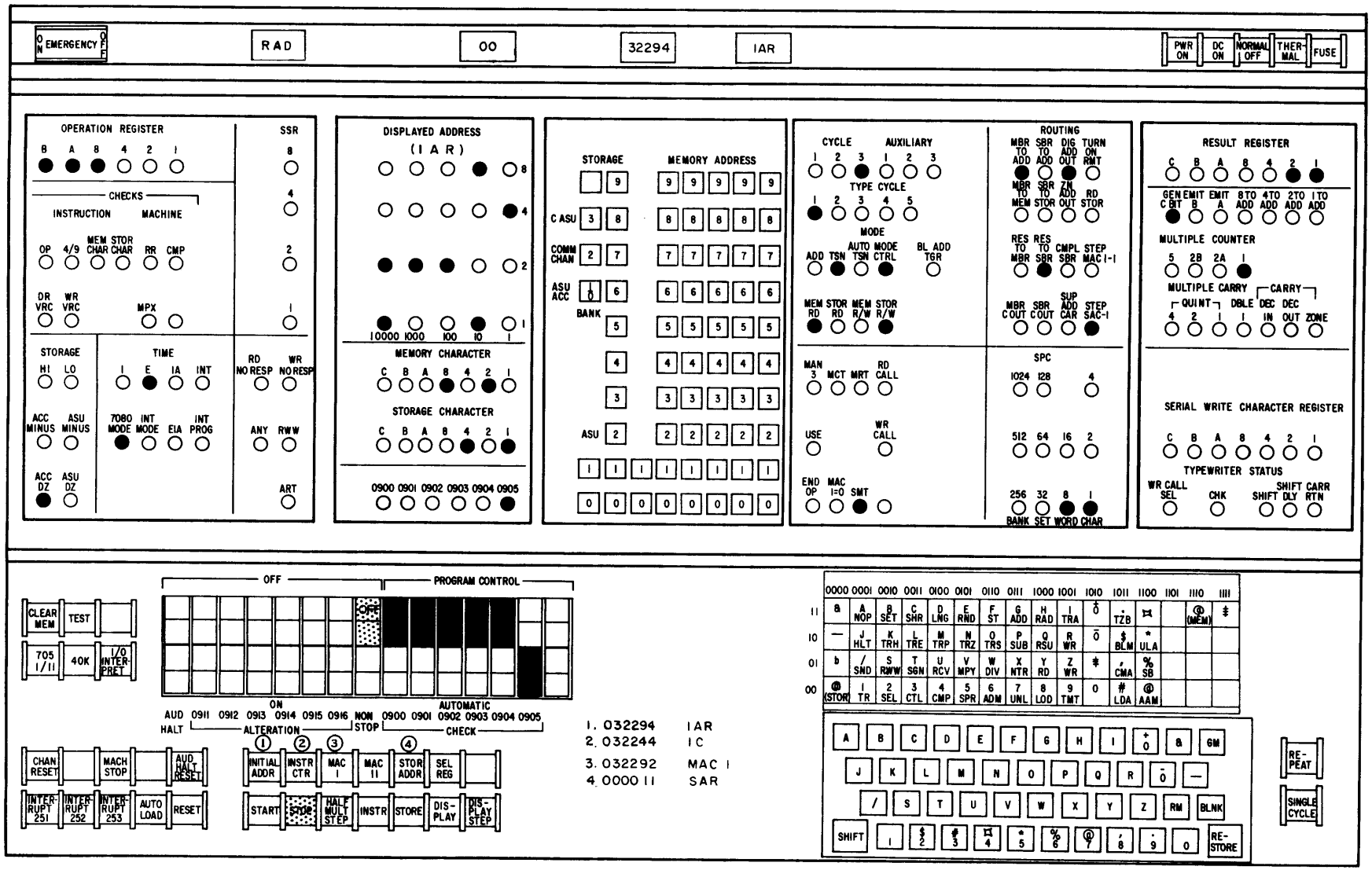


Figure 27. 00905 Example—Sign Check

Abbreviations For 7080

ADDER	Arithmetic unit
ART	Automatic restart trigger
AW	Address word
AWT	Address word transfer
BCD	Binary coded decimal
CAR	Character address register
CASU	Channel ASU
CCR	Character control register (storage)
CHR	Channel reset
CNO	Comma no operation (instruction)
CWD	Channel word decoder
CWS	Channel word set
DR	Data register (memory)
DRW	Decrement record word
DWT	Data word transfer
EIA	Enable indirect address (instruction)
EIM	Enter interrupt mode (instruction)
EEM	Enter 7080 mode (instruction)
IAR	Initial address register
IC	Instruction counter
LFC	Load four characters (instruction)
LEM	Leave 7080 mode (instruction)
LIM	Leave interrupt mode (instruction)
LIP	Leave interrupt program (instruction)
LSB	Load storage bank (instruction)
MAC I	Memory address counter I
MAC II	Memory address counter II
MAR	Memory address register
MAS	Memory address selector
MBR	Memory buffer register
MBR RECOG	Equivalent to 705 III CR 1 recognition
MBR VRC	Equivalent to 705 III CR 1 code check
MCT	Memory cycle trigger
MDS	Memory decoder switch
MPX	Multiplexor
MRT	Memory request trigger
OP REG	Operation register
RDD	Read disconnect delay
RMT	Read memory trigger
RR	Result register
SAC	Storage address counter
SAS	Storage address switch
SAR	Storage address register
SBR	Storage buffer register
SBR RECOG	Equivalent to 705 III CR 2 recognition
SBR VRC	Equivalent to 705 III CR 2 code check
SCT	Single character transfer
SDH	Set density high (instruction)
SDL	Set density low (instruction)
SEL REG	Select register
SPC	Starting point counter
SPC	Set SPC (instruction)
SSR	Storage select register
TAR	Transfer auto restart (instruction)
TAU	Tape adapter unit
TCT	Ten character transmit
TIP	Transfer to interrupt program (instruction)
UFC	Unload four characters
USB	Unload storage bank (instruction)
WR	Word register (storage)
WTC	Word transfer call

Collating Sequence

blank	.	□	Δ	‡	&	$	*	-	/	,	%	#	@	$\overset{+}{0}$
A to I			$\bar{0}$		J to R		‡		S to Z				0 to 9	

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