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PROGRAMMING THE NICOLET 1080 STORED PROGRAM COMPUTER

I. BASIC CONCEPTS

A. Introduction

The Nicolet Instrument Corporation 1080 computer operates in both a wired program and a stored program mode. In the wired program mode, wired logic directs the analog to digital conversion, memory addition, sweep counting and display. In the stored program mode, another set of wired circuitry can be directed to perform certain elementary operations, called the Instruction Set, by the setting of certain bits in the Instruction Register. The Instruction Register (IR) is set by calling binary numbers from a preselected portion of the computer memory. Thus, the binary numbers stored in the 1080 memory can be either data or program instructions, depending on how they are addressed.

B. Architecture

1. Description of Memory

The 1080 consists of a wired processor and a programmable processor sharing the same memory and some of the same registers. The memory consists of planes of ferrite cores which can be magnetized into one of two states, representing either binary 1 or 0. The cores are logically divided into units called words. Each word is a string of 20 cores or 20 bits, and can be considered a logical unit containing one number, either data or an instruction.

Since each bit can be one or zero, it is convenient to consider each word a 20-bit binary number. Thus, any number between 0 and $2^{20}-1$ can be represented in a 20-bit word. The bits in each memory word, and in the registers, are numbered from 0 to 19, corresponding to the power of two they represent. Thus the rightmost bit is bit 0 and the leftmost bit, bit 19.

2. Addressing Scheme

For mechanical reasons, memory is provided in stacks of 4096 words, or 4K, each. The typical 1080 system consists of one stack for program storage and one or more stacks for data storage. The words in memory are addressed (or numbered) sequentially with the program memory starting at address 0000000 and the data memory at 100000_8.

This is an arbitrary distinction and the number of stacks in data memory vs. program memory can be adjusted internally. The only difference between the two segments is that wired program data storage begins at

100000 and proceeds through as many stacks as are indicated by the Measure Memory Allocation buttons. The Protect Program button protects the stored program segment (the first 4K) from being destroyed by the wired program. This could happen if the number of data points selected exceeded the number of data stacks in the machine.

Nothing in the design of the 1080 prevents one from storing and executing programs in the data section of memory, as long as the wired program is prevented from overwriting them.

3. 290 Front Panel Controls

The panel of the 1080 system containing the row of 20 toggle switches, labeled 290 Display Control, is extremely useful to the programmer. The row of seven pushbuttons to the left of the Execute and Stop buttons can be effectively used during program checkout and are described below. The function of each of these buttons is enabled by depressing it and then pressing Execute.

START - starts execution of program instructions at location 0. Note that this is used only for programs whose starting address (SA) is zero. All other programs must be started by LOAD PC followed by CONTINUE.

CONTINUE - begins execution at the location set in the Program Counter (PC).

LOAD PC - the contents of the 20 toggle switches (the switch register) are loaded into the PC. Each switch in the up position has the value 1. Thus, to start a program with a SA other than 0, set the SA in the switch register, depress LOAD PC, press Execute, depress CONTINUE and press Execute.

SINGLE INS - depression of this switch immediately halts the stored program if running, and each time the Execute button is pressed, one instruction is executed. The AC, PC and IR may then be examined to determine the result of each instruction. Remember that the address in the PC represents that of the next instruction to be executed.

EXAMINE - the contents of the location whose address is in the PC are loaded into the AC for examination. If STEP is depressed, the next sequential location is loaded into the AC each time Execute is pressed.

DEPOSIT - the number set in the switch register is deposited in the location set in the PC. If STEP is depressed, the PC is incremented so that one need only load the PC once to deposit numbers in successive locations.

The STOP button on the 290 panel has the same function as the Stored Program Stop button. It does not halt the wired program.

C. Octal Representation of Binary Numbers

Since binary numbers are tedious to write out, it is common to abbreviate them in the octal (base 8) numbering system. This has the advantage over the decimal system that each group of three bits represents an octal number, making interconversion easy. There are two concepts one must learn to understand the octal system: first, $7 + 1 = 10_8$ and second, the interconversion table given below:

Octal	Binary
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111
10	1 000

To reiterate, binary numbers, if divided into groups of three can be virtually instantaneously converted into their octal equivalent. For example,

BINARY	OCTAL	DECIMAL
0 0 1 1 1 0 0 0 0 1 1 0	1 6 0 6	902
1 1 1 0 0 1 1 0 0 1 0 1 0 0 0	7 1 4 5 0	29,486
0 0 0 0 0 1 1 1 1 0 0 1	1 7 1	121
0 1 1 1 0 1 1 0 0 0 1 1	3 5 4 3	1,891

D. Conversion

Conversion between number bases is a common operation discussed in great detail in many elementary mathematics texts. We will just remind the reader that a number in any base simply represents a series of multipliers times successive powers of the base.

Thus, the octal number 71450 means

$$\begin{aligned} 7 \times 8^4 = 7 \times 4096 &= 28,678 \\ + 1 \times 8^3 = 1 \times 612 &= 512 \\ + 4 \times 8^2 = 4 \times 64 &= 256 \\ + 5 \times 8^1 = 5 \times 8 &= 40 \\ + 0 \times 8^0 = 0 \times 1 &= 0 \\ & \overline{29,486_{10}} \end{aligned}$$

The binary number 0 1 1 0 1 0 means

$$
\begin{aligned}
0 \times 2^5 &= 0 \times 32 = \\
1 \times 2^4 &= 1 \times 16 = 16 \\
1 \times 2^3 &= 1 \times 8 = 8 \\
0 \times 2^2 &= 0 \times 4 = 0 \\
1 \times 2^1 &= 1 \times 2 = 2 \\
0 \times 2^0 &= 0 \times 1 = 0 \\
& \qquad\qquad\quad 26_{10}
\end{aligned}
$$

E. Mnemonics

Since strings of 20-bit binary numbers are extremely cumbersome for the average person to assimilate, there exists a program called the Assembler, which converts simple alphabetic abbreviations for the computer instructions into their binary equivalents. Thus, it is not generally necessary to learn the actual binary numbers which cause the computer to perform certain operations; it is merely necessary to learn a few simple abbreviations called mnemonics. The complete list of mnemonics accepted by the Assembler is given in Table I. They are explained in more detail following the list.

II. NUMERICAL CONCEPTS IMPORTANT TO THE 1080

A. Complements

The ones complement (or simply the complement) of a number is defined as the complementing of each bit: all 1's become 0's and all 0's become 1's. Thus, the 20-bit octal number 2341610 (10 011 100 001 110 001 000) becomes 1436167 (01 100 011 110 001 110 111) when complemented.

B. Two's Complement Notation

The two's complement of a number is defined as the one's complement plus one. The NIC-1080 is a two's complement machine, meaning that it considers the two's complement of a positive number its negative. This may be more clearly illustrated by the following example:

```
 3 0000003
 2 0000002
 1 0000001
 0 0000000
-1 3777777
-2 3777776
-3 3777775
```

By convention, then, half of all possible integers are considered positive and half negative. The half which are considered negative always have bit 19 (the left most bit) = 1, so that bit 19 is generally considered the "sign bit."

Now, since we have defined the negative of a number as its two's complement, let us see what the result of addition of positive and negative numbers is.

```
  3     0000003
 -1     3777777     (Remember that 7 + 1 = 10, so 7 + 3 = 12)
  2   1 0000002
```

The sum of 3 and -1 is found to be 2. The one at the extreme left is the "carry out" or overflow to the 21st bit. This value will be found in the Link, which acts as a 21st bit of the accumulator. Testing of the Link may be used to detect carry out so that one may discover when a number has become too large for storage in a single word, or when "subtraction" has occurred.

C. The Logical AND

The instructions in Table I are more or less self-defining. However, the AND instruction may be less familiar to the user. In this operation, if both arguments are 1, the result is 1, and if the two arguments are different or zero, the result is zero. Using the exclamation point to represent the AND operation, 1!1 = 1 and 1! 0 = 0!1 = 0!0 = 0 or

	0	1
0	0	0
1	0	1

The AND operation is always carried out between the AC and a memory location and may utilize any of the three addressing modes. It is most useful for masking out unnecessary bits so that one can examine only those of interest. For instance, if one were interested only in bits 0-2 of a number, he could mask that number as follows:

Number	2163015	10 001 110 011 000 001 101
Mask for bits 0-2	0000007	00 000 000 000 000 000 111
Result	0000005	00 000 000 000 000 000 101

This is carried out in the computer by the instructions:

```
     MEMA NUMBER      /PUT THE NUMBER IN THE AC
     ANDA MASK        /PERFORM THE LOGICAL AND
     ACCM RESULT      /STORE THE RESULT
NUMBER, 2163015
MASK, 7
RESULT, 0             /THE NUMBER 5 IS DEPOSITED HERE
```

TABLE I

GROUP I INSTRUCTIONS

Octal	Mnemonic	Source (Operator)
0500000	A+M	Add accumulator (AC) and memory
0520000	AMP	Add accumulator, memory and 1
0460000	A-M	Subtract memory from the accumulator
0320000	M-A	Subtract the AC from memory
0440000	ACM	Accumulator plus the complement of memory
0300000	CAM	Complement of the AC plus memory
0000000	AND	Logical AND between accumulator and memory
0100000	MEM	Take the contents of memory
0120000	MPO	Memory plus 1
0700000	MMO	Memory minus 1
0060000	MNG	Negative of memory
0040000	ACC	Accumulator
0420000	APO	Accumulator plus 1
0540000	AMO	Accumulator minus 1
0200000	ACP	Complement of the accumulator
0220000	ANG	Negative of the accumulator
0160000	ZER	Take the number zero*
0020000	ONE	Take the number 1
0140000	MON	Take the number -1
0740000	MTO	Take the number -2*
0000000	JMP	Jump
2000000	JMS	Jump to a subroutine, leave PC in first address

Destination (Suffix)

0010000	A	Accumulator
0004000	M	Memory
0002000	Z	Zero test unit Skip if result is 0

*These instructions, if loaded into the AC, will change the state of the Link.

GROUP II INSTRUCTIONS

Shift Group

0005000	LASH n	Left arithmetic shift of AC, Link unaffected
0005020	RASH n	Right arithmetic shift
0005040	LLSH n	Left logical shift
0005060	RLSH n	Right logical shift

$0 \leq n \leq 17_8$

Skip Group

0005100	SKIP on	0400020	ZAC	Zero AC
		0420000	MOAC	Minus one AC
		0540020	POAC	Plus one AC
0005140	EXCT on	0000010	AC$\emptyset$	AC bit $\emptyset$ = 1
		0000004	AC19	AC bit 19 = 1
		0000001	L	Link = 1

Miscellaneous Group

0005220	STOP	Processor halts
0005210	CLL	Clear the link
0005204	STL	Set the link = 1
0005202	TLAC	Transfer the link to bit 19 of the AC, bits 0-18 and link unchanged
0005201	TACL	Transfer bit 19 of the AC to the link, bit 19 unchanged

Input-Output Instructions

0006454	TTYRF	Skip when the Teletype keyboard reader is ready
0044453	RDTTY	Read the Teletype keyboard-reader buffer into the AC
0006444	TTYPF	Skip when the Teletype printer is ready for a new character
0004443	PRTTY	Print the character contained in the AC
0006464	HSRF	Skip if the high speed reader is ready
0044463	RHSR	Read the next character from the high speed reader into the AC
0006474	HSPF	Skip if the high speed punch is ready
0004473	RHSP	Punch the contents of the AC

Hardware Access Instructions

0105000	VDSH	Shift AC by amount controlled by vertical display scale switch
0004371	REDS	Reset Data Scaler to start new digitization
0004372	STDG	Start digitization
0004364	RDG	Read Digitizer result into AC
0006362	DWSK	Skip on Dwell Time flag
0004361	ASRMP	Advance Sweep Ramp
0004364	RSWP	Reset Sweep Ramp
0044034	STATUS	Read hardware settings into AC. See Appendix III.

Automatic Arithmetic Instructions

0505320	MULT	Multiply contents of MQ by next location
0465300	DIVD	Divide AC-MQ by contents of next location
0004354	TACMQ	Transfer AC to MQ
0004343	TMQAC	Transfer MQ to AC
0044354	ZRAM	Zero AC and MQ
0004347	BITINV	Bit invert the AC
0405000	RISH	Right integer shift of AC

Display Instructions

0214001	TACXD	Transfer AC to X display register (AC is complemented)
0214012	TACYD	Transfer AC to Y display register
0214014	INCSC	Increment x-axis
0214011	INTENS	Intensify display

D. Registers Used in the 1080

From the programmer's viewpoint, all arithmetic operations take place in the accumulator (AC). Memory data is loaded into the AC for calculation from memory through the memory buffer. The Program Counter indicates the address of the next instruction. The PC is one greater than the current instruction address unless a jump or skip is generated.

The Group I operands describe the source of data, for example, A+M means accumulator plus memory. The suffixes define the destination of this data: A, the Accumulator; M, Memory; and Z, the Zero Test Register. If zero is loaded into the zero test register, the next instruction is skipped. As is apparent from Figure 1, the suffixes merely open "gates" allowing the calculated quantity to be loaded into various registers.

It is important to note that all such transfers are non-destructive. The source is never harmed by the operation. Thus, A+MM TEMP adds the AC and memory to memory without changing the AC, and A-MZ TEMP loads the zero test register without changing either the AC or memory. No matter what register or combination of registers are loaded from the AC, the AC is never cleared.

III. ADDRESSING MODES

A. Immediate

The Nicolet 1080 has three addressing modes, immediate, direct and indirect. The immediate mode is the simplest to understand. In the Assembler the immediate mode is symbolized by the left parenthesis before the number or tag to be operated on.

```
MEMA (123       /PLACE 123 IN THE AC
```

The above instruction is in the immediate mode. The right hand 10 bits of the instruction are the data. Thus any number from -2000_8 to 2000_8 can be represented:

```
MPOA (1777      /SET AC = 2000
MNGA (36        /SET AC = -36
A+MA (15        /ADD 15 TO THE AC
MCPA (1777      /SET AC = -2000
```

B. Direct

In the direct mode, each instruction refers to another location which is tagged with some label. A label may have up to six characters and may contain

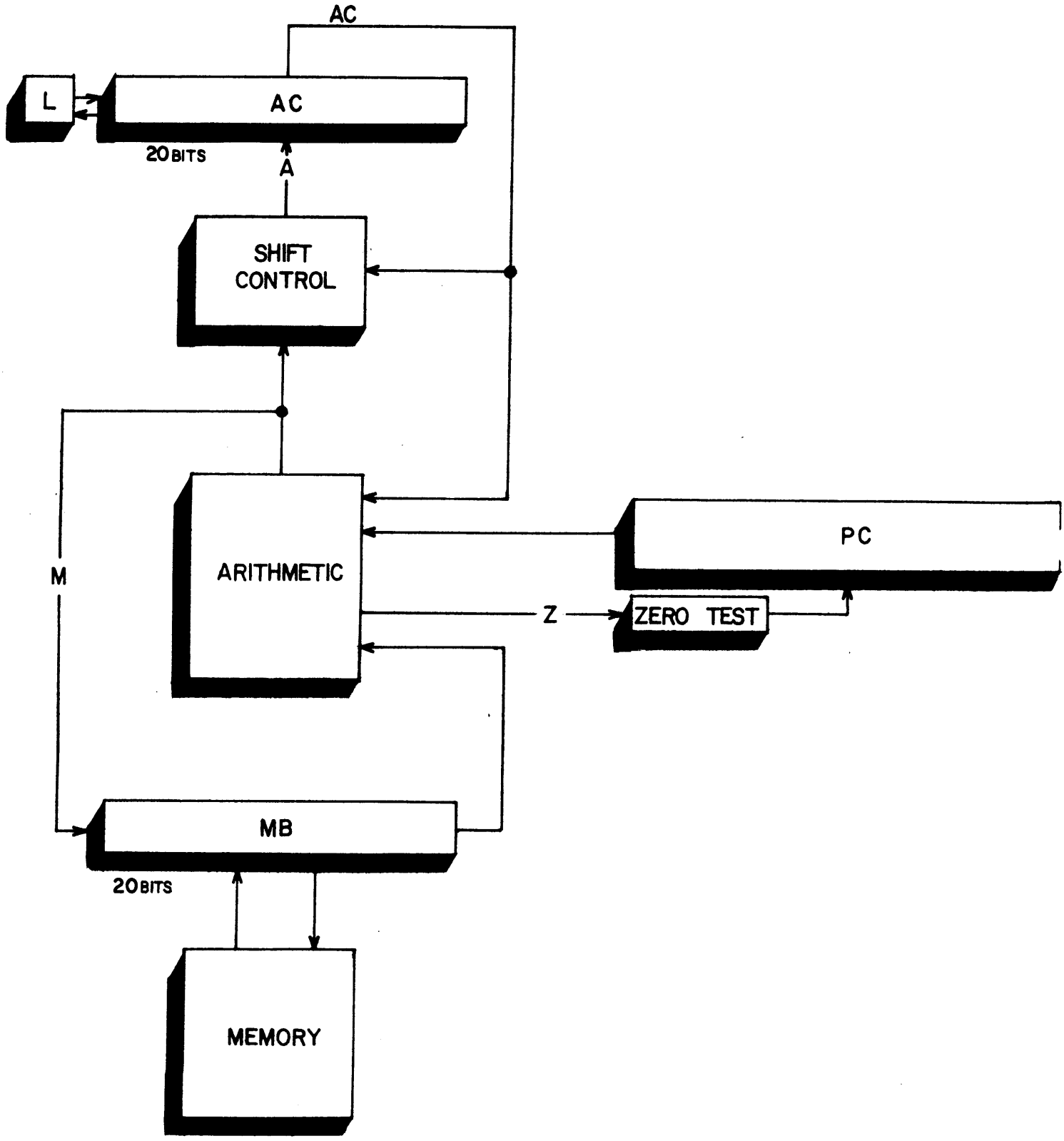

AC
L
AC
20 BITS
A
SHIFT
CONTROL
M
ARITHMETIC
PC
Z
ZERO TEST
MB
20 BITS
MEMORY

FIGURE – 1

any combination of letters and numbers. However, the first character must be alphabetic. In the direct mode, the left ten bits comprise the actual instruction as before. However, the right ten bits represent a relative address.

Since one can only represent 2000_8 (1024_{10}) addresses with ten bits, the convention has been adopted that these refer to a relative address on that memory page. Each memory page consists, therefore, of 2000_8 words, beginning at even octal thousands. In the lowest 4K, for example, the pages start at 0000000, 0002000, 0004000 and 0006000. Thus, one can address any of the 2000_8 locations on this memory page directly:

```
        *2000           /START AT ADDRESS 2000

MEMA T1         /PUT CONTENTS OF LOCATION T1 IN AC
LASH 3          /SHIFT 3 PLACES LEFT: OR MULTIPLY BY 8
ACCM T2         /AND STORE RESULT IN T2

STOP
T1,         5631
T2,         0
```

Note that a tagged location is defined by any one to six character name, followed by a comma.

C. Indirect Addressing

The indirect addressing mode is provided to address locations off the current memory page. The location ultimately addressed may contain a constant or be the destination of a jump. In the indirect mode, there must be a pointer location on the current page, which contains the address of the location indirectly addressed:

```
        *2000

MEMA @ PTEMP        /GET THE CONTENTS OF LOCATION TEMP
                    /INDIRECTLY

ACCM LOCAL          /AND STORE IT
JMP @ POINTER       /JUMP TO ROUTINE PNTER ON P. 6000

PTEMP,  TEMP
LOCAL,  Ø
POINTR, PNTER

        *6000

TEMP,  12345
PNTER, RLSH 15      /ROUTINE CONTINUES FROM HERE, SHIFT AC
    .               /15 BITS RIGHT
    .
    .
```

IV. DESCRIPTION OF INSTRUCTIONS

A. Group I Instructions

All Group I instructions involve a transfer of data from a source to a destination. There may be one or more destinations, specified by the suffixes A, M and Z but without at least one suffix, the instruction is meaningless and causes an error message from the Assembler. (This does not apply to JMP and JMS)

The extreme versatility of the 1080 instruction set is exemplified by the instruction A+MMZ TEMP, in which the contents of the accumulator are added to the contents of the location tagged TEMP, stored in TEMP and the result tested for zero. If this sum is zero, the next instruction is skipped. The accumulator remains unchanged. Note that it is legal to test for zero without putting the result anywhere except in the zero test register: A-MZ TEMP2. This leaves both the AC and memory unchanged, but generates a skip if the result is zero.

B. Jump Instruction

The instruction JMP DESTN simply causes jump to the location tagged DESTN. A typical example of the utility of the jump might be the following program for adding 20_8 sequential numbers stored starting at DATA1.

```
MEMA (20                  /GET THE NUMBER 20
ACCM COUNT                /AND PLACE IN THE REGISTER COUNT
MEMA PDATA                /GET THE ADDRESS OF THE FIRST WORD
                          /OF DATA
ACCM POINT                /AND SAVE AS POINTER

/NOW ADD TOGETHER 20 LOCATIONS STARTING AT DATA1
ZERA                      /ZERO THE AC
REPEAT, A+MA @ POINT      /ADD NEXT LOCATION TO AC
MPOM POINT                /INCREMENT DATA POINTER
MMOMZ COUNT               /DECREMENT COUNT AND SKIP WHEN IT
                          /REACHES ZERO
JMP REPEAT                /JUMP BACK TO ADD ANOTHER VALUE
ACCM SUM                  /PLACE SUM IN LOCATION "SUM"
STOP
COUNT, 0                  /COUNTER
PDATA, DATA1              /POINTER TO FIRST DATA LOCATION
POINT, 0                  /POINTER TO CURRENT DATA LOCATION
SUM, 0                    /CONTAINS FINAL SUM
DATA1, 0                  /FIRST DATA POINT IN LIST
     .
     .
     .
```

C. JMS Instruction

The JMS or jump to subroutine instruction is the most useful instruction in the 1080's repertoire. It provides a method of writing reusable routines which can be called from many different spots in memory without any modification of the actual routine. When a JMS SUBRTN instruction is executed, the address of the instruction following JMS SUBRTN is placed in the first location of the routine SUBRTN. This provides a pointer address for the return from the subroutine to the main program. Consider the following example:

```
        *2000
      /THIS IS THE MAIN PROGRAM
2000    START, MEMA (324    /PUT THE ASCII EQUIVALENT OF "T" IN
                            /THE AC
2001    JMS TYPE            /JUMP TO THE TYPE SUBROUTINE
2002    MEMA (305
              .
              .
              .
2100    TYPE, 0             /THE FIRST LOCATION OF A SUBROUTINE IS
                            /ALWAYS ZERO.  THE ADDRESS 2002 IS AUTO-
                            /MATICALLY DEPOSITED IN LOCATION 2100
                            /WHEN TYPE IS CALLED FROM ADDRESS 2001
2101    T1, TTYPF           /WAIT FOR THE TELETYPE FLAG, SKIP WHEN
                            /READY
2102    JMP T1              /WAIT IN THIS LOOP UNTIL TTY IS READY TO
                            /PRINT
2103    PRTTY               /PRINT THE ASCII CHARACTER IN THE AC
2104    JMP @ TYPE          /EXIT FROM TYPE BY INDIRECT JUMP THROUGH
                            /POINTER IN LOCN 2100
```

In the above example, the routine TYPE is called from location 2001 by JMS TYPE. The address following the call, in this case 2002, is placed in location TYPE (address 2100) by the JMS instruction. Execution of instructions then begins automatically at the second location of the subroutine. The location TYPE thus contains the return address and the instruction JMP @ TYPE causes a JMP to the location pointed to by TYPE, or location 2002. Thus, an automatic return is generated. Note that it is not necessary to know what location the subroutine was called from in advance, or indeed, what page it was called from. The instruction JMS @ PTYPE where PTYPE points to location TYPE on some other page will still cause the address following that instruction to be deposited in location TYPE.

D. Shift Instructions

There are three kinds of shifts possible with the 1080: logical, arithmetic and integer. The number of places shifted is controlled by an integer following the instruction, which can vary from 0 to 17_8. A logical shift is an end-around

shift of the bits of the accumulator, so that the instruction RLSH 1 causes all bits to move one place right, and bit 0 to move around to bit 19. The direction is simply reversed by a left logical shift (LLSH).

The arithmetic shift is signed shift. It causes the sign bit to be propagated to the right during right shifts. During left arithmetic shifts, bits are dropped off the left end. Thus, if bit 19 (the sign bit) is 1, indicating a negative number, the instruction RASH 3 will cause bits 0 - 18 to be shifted three places right. Bits 0 - 2 will be lost, bit 18 will have moved to bit 15 and so forth. The sign bit will be copied into bits 18 - 16, making bits 19 - 16 all ones. This is illustrated below:

AC before instruction 10 001 010 110 011 100 101 (2126345 octal)

RASH 3

AC after instruction 11 110 001 010 110 011 100 (101 lost) 3612634_8

The RISH instruction (automatic arithmetic option) causes the bits of the AC to be shifted right without regard to sign, with the least significant bits "falling off" the end. While LISH does not exist, LASH has the same effect.

The number of shifts performed in one instruction can vary from 0 to 15_{10} or 0 to 17_8. There is no need for successive shift instructions, since up to 15 shifts can be performed in a single instruction. When the instruction is assembled, bits 0 - 3 contain the number of shifts to be performed. None of the shift instructions affect the Link.

E. Skip Instructions

The 1080 can test for several conditions and generate program branches when these conditions exist or do not exist. The test for zero is part of the Group I instructions and generates a skip of the next instruction if the calculated quantity is zero:

```
A-MZ TEST1      /SUBTRACT TEST1 FROM AC AND SKIP IF
                /RESULT IS ZERO
JMP A           /JUMP TO A IF NON-ZERO
JMP B           /JUMP TO B IF ZERO
```

The other conditions which one can test for are

ZAC	Zero accumulator
MOAC	Minus one accumulator
POAC	Plus one accumulator
ACØ	Bit Ø of the AC = 1, useful to test for odd or even numbers, or rotation overflow
AC19	The sign bit = 1, the number is negative
L	The Link is one

One can execute the next instruction (EXCT) or skip the next instruction (SKIP) for any of the above conditions. A typical sequence would be:

```
JMS READ          /READ A CHARACTER FROM THE TELETYPE
                  /KEYBOARD
A-MA (260         /SUBTRACT ASCII BIAS OF 260
EXCT AC19         /SKIP IF RESULT IS POSITIVE
JMP ERR           /GO TO ERROR ROUTINE IF LESS THAN 260 =
                  /AC NEGATIVE
JMP DOIT          /GO DO WHATEVER COMES NEXT
READ,Ø            /SUBROUTINE TO READ FROM THE KEYBOARD
                  /OR LSR
R1,TTYRF          /SKIP WHEN CHARACTER STRUCK
JMP R1            /WAIT LOOP UNTIL KB STRUCK
RDTTY             /READ TTY
JMP @ READ        /AND EXIT FROM SUBROUTINE
```

F. Miscellaneous Instructions

The miscellaneous group contains the instructions that operate on the Link. As mentioned earlier, the Link is a one-bit register which operates as an extension to the accumulator, so that when overflow or carryout occurs, the state of the Link changes. Since this change is only meaningful if the original state is known, the following instructions can be used on the Link:

CLL	Clear the Link: set it = 0
STL	Set the Link = 1
TLAC	Transfer the Link to AC bit 19. The Link and bits 0 - 18 of the AC are unchanged
TACL	Transfer bit 19 of the AC to the Link. Bit 19 is unchanged

Finally, the instruction STOP halts the stored program processor at the end of a memory cycle.

G. Input/Output Instructions

Any instruction which directs the computer to transfer data to or from an external device, such as a Teletype* is called an input/output or I/O instruction. Since these physical devices are much slower than the computer, they depend on the use of a flag to tell the computer when they are ready to transfer information. If the Teletype is not printing, the flag is up (=1). Thus, the Teletype printer flag goes up when it has finished printing the previous character,

*Teletype is a registered trademark of the Teletype Corporation.

indicating that it is ready to accept another. Since the Teletype keyboard and reader are physically linked, there is only one flag associated with them. It is normally down (=Ø) unless (a) the keyboard has been struck, or (b) there is tape in the reader and it is turned to READ. It should be noted that when the Teletype is switched to Line, striking a character does not cause it to be typed unless there is a program in operation to do this. The following code is necessary for the computer to read and type a character from the Teletype:

```
JMS ECHO          /READ AND TYPE A CHARACTER
ACCM KBD          /AND STORE IT AWAY FOR LATER USE
     .
     .
     .
ECHO, Ø
KWAIT,TTYRF       /WAIT FOR CHARACTER
JMP KWAIT
RDTTY             /READ IT INTO THE AC
PWAIT,TTYPF       /WAIT FOR PRINTER READY
JMP PWAIT
PRTTY             /PRINT IT
JMP @ ECHO        /AND EXIT WITH CHAR IN AC
```

To reiterate, the keyboard and low speed tape reader of the ASR-33 are physically linked on-line as well as off. The keyboard and printer mechanisms are entirely separate and must be driven under software control. Setting bit 14 of the IR during an I/O instruction causes the AC to be cleared before the transfer. This is generally done doing read instructions: RDTTY (44453), RHSR (44463). If a read command is issued without bit 14 set, the reader buffer is ORed into the AC.

H. Hardware Instructions

The following instructions cause the stored program to interact with devices normally associated with the wired program mode:

1. Digitizer Instructions

REDS	Reset data scaler; reset digitizer for new value
STDG	Start digitizing new number
RDG	Read digitized result. There must be a 20 usec delay between the STDG and the RDG commands. This is equivalent to five 4-usec instructions.

The REDS, STDG and RDG commands are micro-combinable. This is the same as saying that they can be issued simultaneously, causing all three events to happen during the same memory cycle. This is done by entering both on the same line in the program. Thus, the instruction RDG REDS STDG causes the value in the digitizer to be read into the AC, and a new digitization to begin.

2. Display Instructions

TACXD	Transfer AC bits 0 - 13 to the x-axis display register (14 bit). If 12 bit, AC bits 2-13 are used. The AC is complemented.
TACYD	Transfer AC bits 6 - 19 to the y-axis display register (14 bit). If 12 bit, AC bits 8-19 are used.
INTENS	Intensify the point held in the x and y registers
INCXD	Increment the x-axis display register
VDSH	Vertical display scale shift. Shifts the AC left by the number of positions set on the vertical display scale knob of the 1080

3. Sweep Ramp Instructions

In the NIC 1080, the sweep ramp is a separate digital to analog converter than that used by the display. It can be advanced and reset separately. Its instructions are:

RSWP	Reset sweep ramp
ASRMP	Advance (increment) sweep ramp

The timing of the sweep is, of course, set by the Dwell Time thumb wheel. Whenever a pulse from this clock is received, the dwell signal level goes high and a skip can be generated by the instruction DWSK/skip on dwell.

I. Automatic Arithmetic Instructions

The Automatic Arithmetic logic utilizes an additional register, called the Multiplier-Quotient Register or MQ. It is used to extend the accumulator to contain double precision integers. The instructions are described below.

TACMQ	Transfer the AC to the MQ, AC unaffected
TMQAC	Transfer the MQ to the AC, MQ unaffected
BITINV	Bit Invert the AC (used in Fourier transform routines) By bit inversion it is meant that bit 19 is interchanged with bit 0, bit 18 with bit 1 and so forth.
ZRAM	Zero the AC and MQ
MULT	The 20-bit number contained in the MQ is multiplied by the number contained in the location following the MULT instruction. The state of the AC is unimportant. At the completion of the instruction, the result is contained in the AC and MQ, with the high order part in the AC and the low order 20 bits in the MQ.

To multiply 3 by 4 the following code would be used.

```
MEMA (4                 /GET 4
ACCM MPLCND             /STORE IN LOCN FOLLOWING MULT
MEMA (3                 /GET 3
TACMQ                   /PLACE IN MQ
MULT                    /PERFORM MULTIPLICATION
MPLCND, ø               /LOCATION OF MULTIPLICAND
ACCM HIWORD             /HIGH WORD IN AC; STORE IT
TMQAC                   /GET LOW WORD
ACCM LOWORD             /AND STORE IT
```

RISH n — Right Integer shift. Right shift of AC, with least significant bits dropped off right end. ($ø \leq$ shifts $\leq 17_8$)

DIVD — Integer divide. The 38 bit dividend placed in the AC and MQ left shifted one place, is divided by the contents of the location following the instruction. At the conclusion of the operation, the quotient is in the MQ and the remainder in the AC. The remainder is left shifted one bit, the quotient is correct as it appears.

The reason for the shifting instructions is that it makes the treatment of numbers in the floating point format more efficient. This is utilized in the Floating Point Package version NIC 80/S-7005f,g. Only a 38 bit number can be accurately divided because there is no 20-bit quotient which can be produced by a 39 dividend and a 20-bit divisor.

For single precision division, especially in cases where the remainder is unimportant, the simple code below is representative:

/ROUTINE TO DIVIDE SINGLE PREC # DIVDND BY DIVSOR

```
MEMA DIVSOR             /GET THE DIVISOR
ACCM D1                 /PUT IT IN DIVD LOCATION + 1
MEMA DIVDND             /GET THE DIVIDEND
LASH 1                  /AND LEFT SHIFT IT
DIVD                    /DIVIDE BY D1
D1, ø
TMQAC                   /GET THE QUOTIENT, IGNORE REMAINDER
ACCM QUOT               /AND STORE IT
```

A typical double precision integer divide routine is given below:

```
/ROUTINE TO DIVIDE THE DOUBLE PRECISION NUMBER DBLDVH-DBLDVL
/BY DIVISOR

        CLL
        MEMA DBLDVL
        EXCT AC19
        STL             /SET LINK AS FLAG FOR OVERFLOW
        LASH 1          /SHIFT LEFT ONE PLACE
        TACMQ           /PLACE IN MQ
        MEMA DBLDVH     /GET HIGH-ORDER WORD
        LASH 1          /AND SHIFT IT
        EXCT L          /TEST LINK
        APOA            /INCREMENT AC IF DBLDVL OVERFLOWED
        DIVD            /EXECUTE THE DIVISION
        DIVSOR, nnnnnn  /NUMBER ALREADY STORED HERE FOR
                        /DIVISOR

        RISH 1
        ACCM REMNDR     /SHIFT AND SAVE THE REMAINDER
        TMQAC           /GET THE QUOTIENT
        ACCM QUOT       /AND SAVE IT
```

It should be noted that the hardware multiplication and division is unsigned, and that the signs must be tested for independently by the user.

During operations between numbers in the floating point format, the binary point is assumed between bits 19 and 18, and bit 19 is always zero since the division is unsigned. No shifts need be performed before division, and if bit 19 of the quotient is 1, the exponent is incremented by 1. A RISH 1 is then performed.

V. THE ASSEMBLER

A. Introduction

This section describes the actual use of the Assembler Program. It specifically refers to the tape NIC 80/S-7006E-B.

The Nicolet Assembler is especially suited for those with only low speed I/O equipment, but also recognizes the high speed reader and punch. It allows the user to create and store programs in data memory while occupying only locations 2000-4601. While it is a two-pass assembler, no tapes need be reloaded, since it operates entirely on the source text as stored in data memory. The release version allows only one data field of memory for text storage, but the size allowed can be changed using NICOBUG.

A typical storage arrangement would be:

0 - 1777	free for user programming
2000 - 4601	Assembler - Editor
4602 - 4777	free
5000 - 5215	Nicobug
5216 - 5347	free
5350 - 7577	Floating Point
7600 - 7777	Binary Loaders

B. Special Characters

The following special characters are recognized by the assembler:

/ Starts a comment. All characters beyond the slash except $ are ignored by the Assembler until a carriage return is encountered.

$ Signifies the end of the program. Cannot appear elsewhere in a tag, instruction or comment.

, Designates a tagged address; the first six characters following the previous Return and before the comma are taken as the name of the tag. A tag need not be six characters, but any after six are ignored.

(Designates immediate address mode.

space Used to separate operators from operands. There must not be a space between the operator and its suffix, if any.

@ Designates an indirect instruction. An indirect immediate instruction is flagged as an error.

* Designates the starting address of the code that follows.

= Allows the definition of symbols. For example, TTY2RF = 6434 defines the flag of a second Teletype, with I/O code 43.

The Assembler recognizes only printing characters as meaningful. All non-printing characters are ignored.

C. Syntax

1. Spaces may be used freely to improve legibility. They are not required anywhere except between a Group I instruction and its operand.

Their omission here will generate the error message IS (Illegal Suffix).

2. A comment may contain any character except a dollar sign.

3. All non-printing characters are ignored on input and are not stored.

4. Numbers can be entered only as positive octal integers.

5. Tags

a. Must be separated from the location contents by a comma. No space is required following the comma, but is recommended for legibility reasons.

b. Must start with an alphabetic character but may contain any combination of alphabetic and numeric characters after the first.

c. May contain up to six characters. Tags differing only in characters beyond the sixth are treated as identical.

d. May begin with three characters identical to a Group I instruction except when that tag is later referenced as a single address on a line by itself. In this case the message IS (Illegal Suffix) will be generated to remind the user of the potential ambiguity. The tag is assembled correctly as the address to which it refers in this case. (An example of a tag used in a list of addresses appears in the programming example in the next chapter.)

D. Addresses

The asterisk is used to indicate the starting address for a series of lines of code. The octal number following the asterisk is taken as that address. No test is made by the Assembler for code overflowing pages. The Assembler assumes that each line following the starting address contains code to be placed in successive locations unless (a) the line is blank - extra carriage returns may be inserted for legibility, (b) the line contains only a comment, (c) a new address is defined with an asterisk, or (d) only a symbol definition using an equals sign appears.

E. Loading and Startup

The Assembler tape is loaded using the standard Binary Loader. It is started at 2000 by

1. Place 2000 in the switch register (00 000 000 010 000 000 000)
2. Depress Load PC
3. Press Execute
4. Depress Continue
5. Press Execute

F. Assembler Commands

The program should start by typing a Return and Line Feed and type out ASSEMBLER. The program is then ready to receive commands:

R - Read a source tape into memory. The source tape is stored in the data memory and replaces any data or source programs stored there previously. The tape must end with a $-sign to return the Assembler to receive more commands. The tape is read from the Low Speed Reader (LSR) if the ADD button on the 1080 is depressed. If the SUBTRACT button is depressed the program is read from the High Speed Reader.

E - Perform an Error Analysis of the source code. The computer will seem to pause for up to several minutes if the program is lengthy. All errors will be typed out followed by their locations and the offending code. When the analysis is finished, a dollar sign will be typed. The errors detected are as follows:

IS - Illegal Suffix
II - Illegal Immediate
DU - Dubious Syntax
NL - No Label (or Tag) Found
DL - Duplicate Label - two identical tags are found

B - Punch out a binary tape of the program on the LSP. Prefixing the command by an H (see below) causes the output to be on the high speed punch. This tape can be read by the standard Binary Loader.

L - List the assembled code. The listing is divided into pages by a row of dashes. Each page is titled with the first line of code in the program. This line, therefore, should be a program title. The listing can be punched on the HSP by prefixing the L command with an H. Such a tape can then be listed off-line while the computer is doing something else.

H - Causes all output from the Assembler to be to the High Speed Punch, until the program returns to receive another command. All output includes the words ASSEMBLER and EDIT. To punch a binary tape on the HSP, type HB; to punch a listing type HL; to punch out the source tape type H,Control/E,W, and when the punching is done, FORM, before turning off the punch.

Control/E - Enter the Editor. Control/E (WRU) is produced by holding down the CTRL key and typing E. The program will respond by typing EDIT.

G. Editor Commands

W - Write out the source tape. If H was typed before entering the Editor, this will be done on the high speed punch.

A - Append more text to that already in memory. This differs from the Read command in that any previous text remains in storage, whereas the Read command erases all previous code. As with the Read command, if the ADD button is pressed, the code is input to the Low Speed Reader and if the SUBTRACT button is pressed input is from the HSR. A dollar sign must terminate the new code.

Pm nnnn - Print. The command P will be followed by either O or A depending on whether the current mode is Octal or Absolute. The user then types an octal number which represents the line to be printed. If the mode is octal, the line which has that octal address will be typed. If the mode is Absolute, each line, whether it contains code or not is numbered. The mode can be changed from Octal to Absolute or back again at any time by typing A or O immediately following the P (or D or I).

Dm nnnn - Delete line nnnn.

N - Type out the Next line following the one just operated on.

Im nnnn - Insert text just before line nnnn until Control/D(EOT) is typed.

Control/L - (FORM) Exit from the Editor and return to the Assembler.

The Editor remembers the last line number entered, so that it need not be retyped. Therefore to change line 37, the following is sufficient.

```
PA 37
MEMQ TEMP
DA                    (The underlined parts are typed by the EDITOR)
IA
MEMA TEMP
CTRL/D
```

TABLE II

Nicolet Assembler Command Summary

SA = 2000

R - Read in Source Tape
from LSR if ADD is depressed
from HSR if SUBTRACT is depressed

B - Punch Binary Tape

E - Error Analysis

L - List Assembled Code

H - Causes output of B, L, W to be on HSP

Control/E - (WRU) Enter Editor

Editor

W - Write out the Source tape

P - Print line
A - Absolute
O - Octal

I - Insert
EOT to exit (Control/D)

D - Delete

N - Print Next line

A - Append more text to buffer
from LSR if ADD is depressed
from HSR if SUBTRACT is depressed

FORM - (Control/L) exit to Assembler

H. Cautionary Notes

The Assembler can be restarted at any time by pressing STOP and restarting at location 2000.

Since neither Read nor Append echo at the keyboard, programs can best be created from scratch by typing R, Return, Return, $ to zero previous text and create a two-line blank program. One can then Insert all the text needed by starting with IA 1. The command IA Ø is not legal.

The first character read by the RDTTY command after turning on power is garbage, so it is good practice to start each program with an RDTTY command to clear the flag.

The Assembler recognizes the instruction

MEMA (TAG

as an instruction to get the relative address of the tagged location. The operand becomes the 10 least significant bits of the address TAG. While this has limited general use, it becomes extremely useful on page zero (locations 0-1777), where the relative and absolute addresses are identical and in calling the Floating Point routines.

VI. A PROGRAMMING EXAMPLE

A. Apologia

There is absolutely no way to learn assembly language programming short of doing it. No amount of reading or class attendance will be of any use until one plugs through a few examples which are of enough interest to encourage perseverance. Because personal interests and needs vary so widely, it is difficult to provide examples which will be stimulating to all readers. However, some general rules for good programming can be gleaned from this program and, hopefully, these at least will be rapidly assimilated.

B. Outline of Good Programming Practices

1. Define the task clearly

    a. In sentences, preferably on paper
    b. In flow charts, dividing the task into small, concise steps

2. Initialize all devices and registers

    a. Type a Carriage Return and Line Feed so the position of the Teletype carriage is known

b. Set all constants from an independent source, i.e., MEMA CSET, ACCM CTEMP. Zero all counters and pointers. Never assume that a location contains a zero. It won't unless you set it to zero.

c. Be sure the program is serially reusable.

d. Be sure the program is not "gullible." It should not expect only numbers in a certain range. Tests should be made for zero, negative and out of range values.

e. Read the keyboard buffer to clear it of power-on "garbage."

3. Write the program in small independent segments.

   a. Plan the exact relation between routines before you start writing them.

   b. Use recallable subroutines whenever possible.

   c. Be sure the program has no large volume point or part through which all the rest must flow.

4. Comment each section of the program thoroughly.

   a. For use in debugging.

   b. To aid others who will need to use it.

5. Obtain an accurate listing, and binary and source tapes whenever a new program verion is generated. The smallest changes may have the most astonishing effects. Be sure to date and number each version and discard obsolete versions to avoid confusion.

6. Most of the time spent in programming is spent in debugging. Be sure tl allow plenty of time for this. Write the program so that it is easily "debuggable." Plan on using NICOBUG (NIC 80/S-7110-B) whenever possible.

C. Definition of a Sample Program

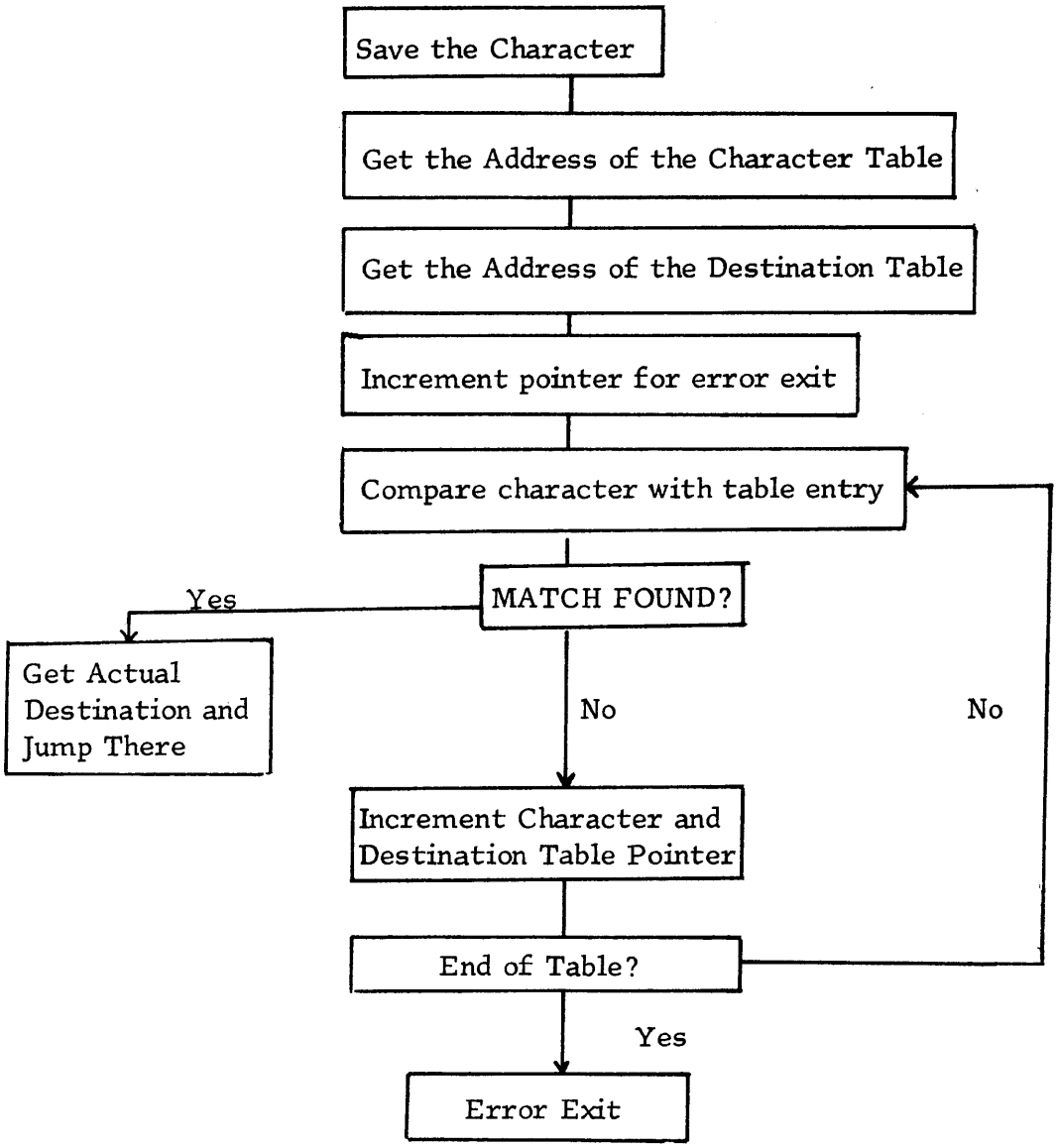
The problem is to search a table of characters for a match, and if a match is found, jump to a location found in a table of destinations. It must be called as a subroutine in the form

```
JMS TBSRCH      /ENTER WITH DESIRED CHARACTER IN AC
CTABLE          /STARTING ADDRESS OF CHARACTER TABLE
DTABLE          /STARTING ADDRESS OF DESTINATION TABLE
JMP ERROR       /RETURN HERE IF NO MATCH IN CHARACTER TABLE
```

If no match is found, the subroutine exits to a third location following the call. The tables may be of any length, but the value zero must be used as the last entry in the character table, indicating the end of the table.

This sort of routine is commonly used to route a Teletype input command to the proper calculation routine. It can also be used to cause extensive branching on a calculated result.

D. Flow Chart of the Program



E. Discussion

Several points should be noted in examining the listing on the following pages, not the least of which is the extensive commenting. It is absolutely essential that every program be well documented, even if the author is the only one who will ever use it. Often a program will need change or updating long after it was written. Figuring out the method (or "algorithm") that a program uses is extremely tedious work without thorough commenting.

A second feature of interest is the instruction ZERZ which is used to generate an unconditional skip in locations where the non zero case requires more instructions than the zero case. It literally means "load the zero test register with zero and skip if the zero test register is zero."

Still a third useful feature is that of calling a subroutine with arguments. This is roughly equivalent to the FORTRAN subroutine call CALL SUBR (A,B) where A and B are values transmitted to the subroutine. In this case the two values transmitted are the addresses of the two tables. These addresses can thus vary with each call and are page independent of the location of TBSRCH or its call.

The location TBSRCH on the call JMS TBSRCH contains the address of the location following the call, or 4. The content of 4 is the address of CTABLE, or 35. Incrementing TBSRCH causes it to point to location 5, where the address of the destination table is stored. Thus, MEMA @ TBSRCH allows access to the address of CDEST, and incrementing TBSRCH again causes it to point to the return address, where "?" is typed.

Finally, the routine at DSET converts the pointer to the destination address to the address itself. If the character B were struck, DESTN would contain the address 43. MEMA @ DESTN produces the actual location of routine B on the AC, or in this case 47.

F. Conclusion

The above described program contains a large number of concepts crucial to effective assembly language programming. When the reader thoroughly understands this example, he should start trying his own simple routines.

Some possible programs might include

(a) A program to type out octal numbers from memory
(b) A program to pack two ASCII characters into a single word and unpack them again. (How could you pack three?)
(c) A program to draw a box on the scope.

GOOD LUCK!

VII. TABLE SEARCHING ROUTINE

```
/TABLE SEARCHING ROUTINE
*0  /STARTING ADDRESS = 0

    /DRIVER ROUTINE
/ADDRESS - CONTENTS

      0   44453  START,  RDTTY   /CLEAR READER BUFFER
      1 2000011  S1, JMS CRLF  /INITIALIZE TTY CARRIAGE
      2 2000017    JMS ECHO  /READ AND ECHO CHARACTER
      3 2000052    JMS TBSRCH /SEARCH TABLE FOR LEGAL COMMAND
      4      35    CTABLE     /ADDRESS OF START OF TABLE OF CHARS
      5      42    CDEST     /START OF TABLE OF DESTINATI S
      6  110277    MEMA (277   /ERROR EXIT IF NO MATCH FOUND
      7 2000030    JMS TYPE    /TYPE ?
     10       1    JMP S1    /AND RETURN FOR NEW CHARACTER

     11       0  CRLF, 0  /TYPES CARRIAGE RETURN AND LINE FEED
     12  110215    MEMA (215  /ASCII FOR CR
     13 2000030    JMS TYPE
     14  110212    MEMA (212  /ASCII FOR LF
     15 2000030    JMS TYPE
     16 1000011    JMP @ CRLF  /EXIT

     17       0  ECHO, 0  /READS AND ECHOES CHAR FROM TTY
     20 2000023    JMS READ
     21 2000030    JMS TYPE
     22 1000017    JMP @ ECHO

     23       0  READ, 0  /READS CHAR FROM TTY
     24    6454  R1, TTYRF  /WAIT FOR CHAR TO BE STRUCK
     25      24    JMP R1
     26   44453    RDTTY  /READ IT
     27 1000023    JMP @ READ  /AND EXIT WITH CHAR IN AC

     30       0  TYPE, 0  /TYPES CHAR IN AC
     31    6444  T1, TTYPF  /WAIT FOR PRINTER TO BE READY
     32      31    JMP T1
     33    4443    PRTTY
     34 1000030    JMP @ TYPE  /EXIT

/TABLE OF LEGAL INPUT CHARACTERS (ASCII CODES)
     35     301  CTABLE,  301  /A
     36     302    302 /B
     37     303    303 /C
     40     304    304 /D
     41       0    0   /ZERO MARKS END OF THE TABLE

/TABLE OF DESTINATIONS (ALL DUMMY)
     42      46  CDEST, A
     43      47    B
     44      50    C
     45      51    D
```

```
/DUMMY DESTINATIONS -ALL STOPS IN THIS EXAMPLE
     46     5220  A, STOP
     47     5220  B, STOP
     50     5220  C, STOP
     51     5220  D, STOP


/TABLE SEARCHING SUBROUTINE

     52        0  TBSRCH, 0
     53 2404076    ACCM CHAR     /STORE AC IN LOCN "CHAR"
     54 3110052    MEMA @ TBSRCH     /GET CONTENTS OF ADDRS FOLLOWING CAL
     55 2404077    ACCM TABL     /STORE STRING ADDRS OF CHAR TABLE
     56 2124052    MPOM TBSRCH   /INCREMENT POINTER TO 2ND LOCN
     57 3110052    MEMA @ TBSRCH   / GET CONTENTS OF 2ND LOCN
     60 2404100    ACCM DESTN     /STORE ADDRESS OF DESTINATION TABLE
     61 2124052    MPOM TBSRCH      /INCREMENT POINTER FOR ERROR EXIT
     62 3112077  TBLOOP,  MEMAZ @ TABL  /GET CHAR FROM TABLE; SKIP IF =0
     63  162000    ZERZ        /UNCONDITIONAL SKIP
     64 1000052    JMP @ TBSRCH  /ERROR EXIT IF CHAR = 0
     65 2322076    M-AZ CHAR    /COMPARE WITH CHAR JUST TYPED
     66  162000    ZERZ        /CREATE ZERO AND SKIP
     67      73    JMP DSET   /IF MATCH, GO TO THAT LOCATION
     70 2124077    MPOM TABL  /INCREMENT TABLE POINTER
     71 2124100    MPOM DESTN  /INCR DESTINATION POINTER
     72      62    JMP TBLOOP  /TRY NEXT CHARACTER IN TABLE

/CONVERT POINTER TO DESTINATION TO ACTUAL DESTINATION
     73 3110100  DSET, MEMA @ DESTN
     74 2404100    ACCM DESTN  /AND STORE IN SAME LOCATION
     75 1000100    JMP @ DESTN  /THEN JUMP THERE


     76        0  CHAR, 0  /STORE ACTUAL INPUT CHARACTER
     77        0  TABL, 0  /POINTS TO CHARACTER TABLE
    100        0  DESTN, 0  /POINTS TO DESTINATION TABLE
```

APPENDIX I

ASCII CHARACTER CODES

The following list contains the 8-bit octal codes produced by standard ASR-33 Teletypes. This code is known as ASCII (American Standard Code for Information Interchange).

Character	Code	Character	Code
A	301	!	241
B	302	"	242
C	303	#	243
D	304	$	244
E	305	%	245
F	306	&	246
G	307	'	247
H	310	(	250
I	311	)	251
J	312	*	252
K	313	+	253
L	314	,	254
M	315	-	255
N	316	.	256
O	317	/	257
P	320	:	272
Q	321	;	273
R	322	<	274
S	323	=	275
T	324	>	276
U	325	?	277
V	326	@	300
W	327	[	333
X	330	\	334
Y	331	]	335
Z	332	↑	336
0	260	←	337
1	261	EOT	204
2	262	WRU	205
3	263	RU	206
4	264	BELL	207
5	265	TAB	211
6	266	Line Feed	212
7	267	FORM	214
8	270	Return	215
9	271	Space	240
		ALT MODE	375
		Rub Out	377

Several things should be noted about this code:

(a) The integers are biased by 260.
(b) The alphabet starts at 301.
(c) Most non-printing characters are less than 240.
(d) The CTRL key removes bit 6 from whatever key is typed: E = 305, CTRL/E = 205.
(e) The Shift key adds bit 4 to whatever key is typed: N = 316, SHIFT/N = ↑ = 336.
(f) Leader-Trailer (200) tape can be generated by holding down SHIFT, CTRL, REPT and P. Release in opposite order.
(g) The characters [and] are generated by SHIFT/K and SHIFT/M respectively.

APPENDIX II

MODIFYING THE ASSEMBLER (NIC-80/S-7106e-B)

The following modifications may be desirable for certain advanced users and can be easily accomplished from the switch register or by using Nicobug.

1. Changing the size of data storage. The locations SIZE, KMAX and LLIMIT define the storage area for text as one 4096 word stack starting at address 100000. These locations are located as follows:

	Address	Contents	
LLIMIT,	2342	100000	/STARTING ADDRESS
SIZE,	2343	10000	/ONE MEMORY STACK
KMAX,	4461	10000	/PAGE 4000 COPY OF SIZE /MUST BE MODIFIED IF SIZE /IS CHANGED

2. Changing the Append Command to echo at the Teletype. This can be used to generate error free source tapes or as an alternative method to Insert for adding new code.

Change location 3677 from	2024403	ONEM SUPSWT
to	2164403	ZERM SUPSWT

3. Changing the High Speed Reader-Punch I/O device codes. High speed equipment installed by users may utilize different I/O codes than those used by NIC. These are located as follows:

4565	44463	RHSR
4566	6464	HSRF
4522	6474	HSPF
4523	4473	PHSP

APPENDIX III

STATUS WORD INTERPRETATION

READOUT MEMORY ALLOCATION:

STARTING

1K (pushbutton in = "1")	Bit 0
2K (pushbutton in = "1")	Bit 1
4K (pushbutton in = "1")	Bit 2
8K (pushbutton in = "1")	Bit 3

SIZE

1K (pushbutton out = "1")	Bit 4
2K (pushbutton out = "1")	Bit 5
4K (pushbutton out = "1")	Bit 6
8K (pushbutton out = "1")	Bit 7

MEASURE MEMORY ALLOCATION:

STARTING

1K (pushbutton in = "1")	Bit 8
2K (pushbutton in = "1")	Bit 9
4K (pushbutton in = "1")	Bit 10
8K (pushbutton in = "1")	Bit 11

SIZE

1K (pushbutton out = "1")	Bit 12
2K (pushbutton out = "1")	Bit 13
4K (pushbutton out = "1")	Bit 14
8K (pushbutton out = "1")	Bit 15

INPUT DATA ADD/SUBTRACT:

ADD (Pushbutton in = "1")	Bit 16

VIEW INPUT/MEMORY/CONTINUOUS

INPUT (pushbutton out = "1")	Bit 17
MEMORY (pushbutton out = "1")	Bit 18

MEASURE (pushbutton in = "1")	Bit 19

APPENDIX IV

DECIMAL-OCTAL CONVERSION TABLE

	0	1	2	3	4	5	6	7	8	9
0000	0000	0001	0002	0003	0004	0005	0006	0007	0010	0011
0010	0012	0013	0014	0015	0016	0017	0020	0021	0022	0023
0020	0024	0025	0026	0027	0030	0031	0032	0033	0034	0035
0030	0036	0037	0040	0041	0042	0043	0044	0045	0046	0047
0040	0050	0051	0052	0053	0054	0055	0056	0057	0060	0061
0050	0062	0063	0064	0065	0066	0067	0070	0071	0072	0073
0060	0074	0075	0076	0077	0100	0101	0102	0103	0104	0105
0070	0106	0107	0110	0111	0112	0113	0114	0115	0116	0117
0080	0120	0121	0122	0123	0124	0125	0126	0127	0130	0131
0090	0132	0133	0134	0135	0136	0137	0140	0141	0142	0143
0100	0144	0145	0146	0147	0150	0151	0152	0153	0154	0155
0110	0156	0157	0160	0161	0162	0163	0164	0165	0166	0167
0120	0170	0171	0172	0173	0174	0175	0176	0177	0200	0201
0130	0202	0203	0204	0205	0206	0207	0210	0211	0212	0213
0140	0214	0215	0216	0217	0220	0221	0222	0223	0224	0225
0150	0226	0227	0230	0231	0232	0233	0234	0235	0236	0237
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