SCELBI's FIRST BOOK of COMPUTER GAMES for the "8008"/"8080"

SCELBI COMPUTER CONSULTING INC.

SCELBI'S FIRST BOOK OF COMPUTER GAMES
for the
'8008/8080'

AUTHORS:

Nat Wadsworth
and
Robert Findley

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The Authors

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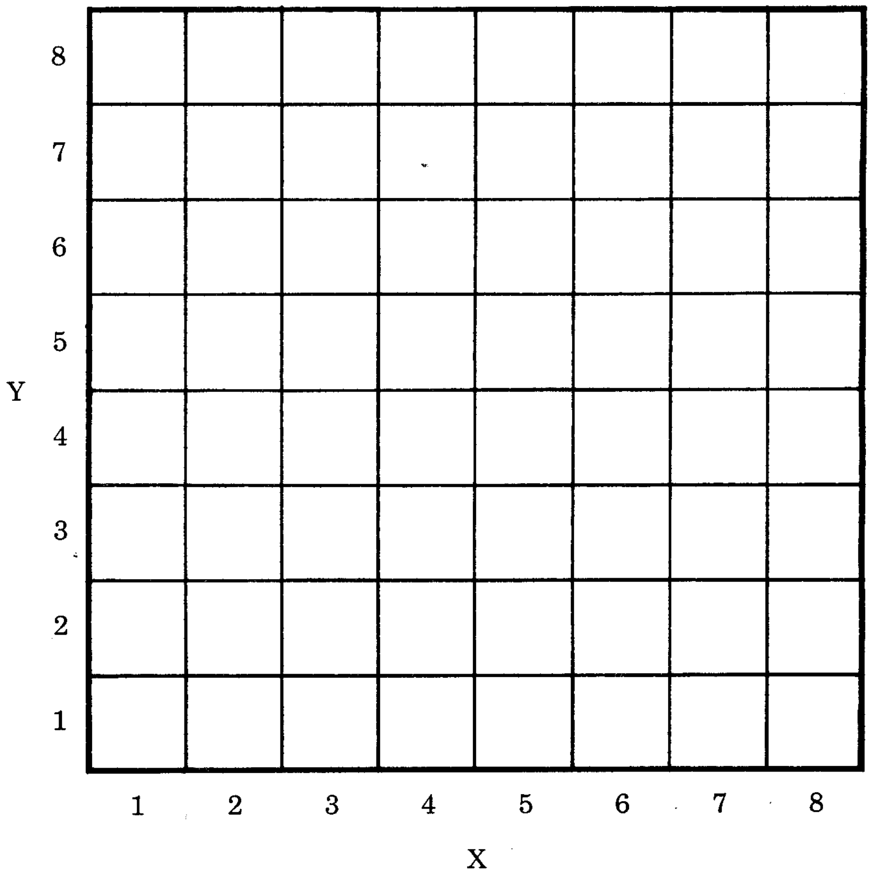
SPACE CAPTURE

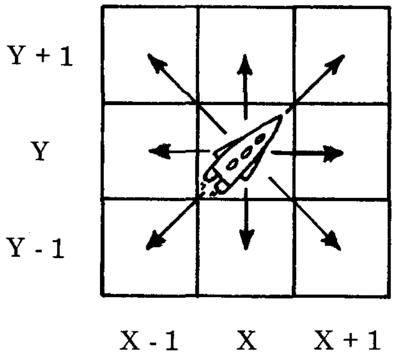
Space Capture is a game of skill and chance. The object of the game is to capture an imaginary space ship by destroying all the possible sectors that it might attempt to travel in. The game as presented herein utilizes a game board consisting of a grid containing 64 squares or sectors. The sectors are identified by X and Y coordinates. A pictorial of the playing board is illustrated below.



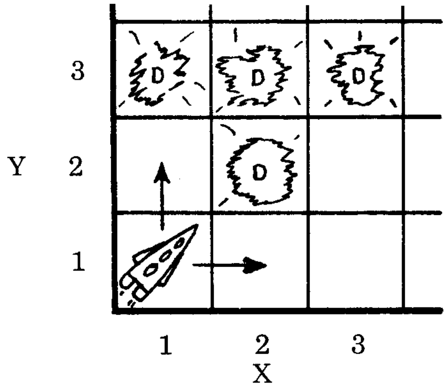
To start the game, the computer informs the player of a location where the space ship was last observed. The player is then allowed to take one PHASOR SHOT by giving the X and Y coordinates of a SECTOR. The phasor shot will destroy the sector specified thereby preventing the space ship from traveling therein in the future. However, the player must be careful! If the space ship happens to be residing in a sector at the time it is destroyed by a phasor shot, then the space ship itself is considered destroyed. Since the object of the game is to CAPTURE the ship (for its cargo of course!), destroying the vessel is a losing move for the player.

The space ship is limited to moving only one sector at a time. As already mentioned, it may not move into an area that has been previously hit by a phasor shot. The ship's movement is also restricted to the boundaries of the eight by eight grid on which the game is played.

The maximum number of different moves the space ship has to choose from at any given time is thus eight. This is illustrated in the diagram shown below. This maximum number of possible moves, for instance, would be the case at the start of a game before a player had destroyed any sectors.



However, once the game is underway, the number of possible directions in which the space ship may move can be reduced. The example illustrated next shows the space ship in a position where only two moves are possible. This is because it is bounded on two sides by the edges of the playing grid. Additionally, the diagram shows several sectors marked by a D. These represent sectors that have been destroyed by the phasor shots of the player. The space ship may not enter into those areas. Thus, in the example, the space ship is only able to move up to the position X = 1 and Y = 2 or to the right into the position X = 2 and Y = 1. The space ship would be CAPTURED in the illustration if those two sectors had also been destroyed so that it could not move out of the indicated position X = 1 and Y = 1.



The game is relatively simple as far as computer games go, but it is a lot of fun because the moves of the space ship are made essentially random by the program. One may create strategies to attempt to use to capture the space ship, but one can never be certain where the next move will be until the space ship is captured. Also, if one does not take care where one shoots the phasor shots, the elements of chance can again enter the game. Remember, destroying a sector with the space ship traveling in it at the time ends the game!

The program for the game as it will be presented here will reside with room to spare in about 5 pages (256 bytes per page) of an '8008' or '8080' microcomputer system. If a person has even less memory available, the program can readily be compacted by the removal of some non-essential text messages. More room could be saved by more effective subroutining and attention to the program's organization to reduce the number of times pointers are altered. These techniques would allow the program to fit easily in less than three pages of memory. The reader should remember that the following program was designed so that the operation of the program could be easily followed. It was definitely not designed to minimize memory usage other than in the sense that this machine language version is many times more compact that would be required if the program utilized a higher level language for compilation or interpretation!

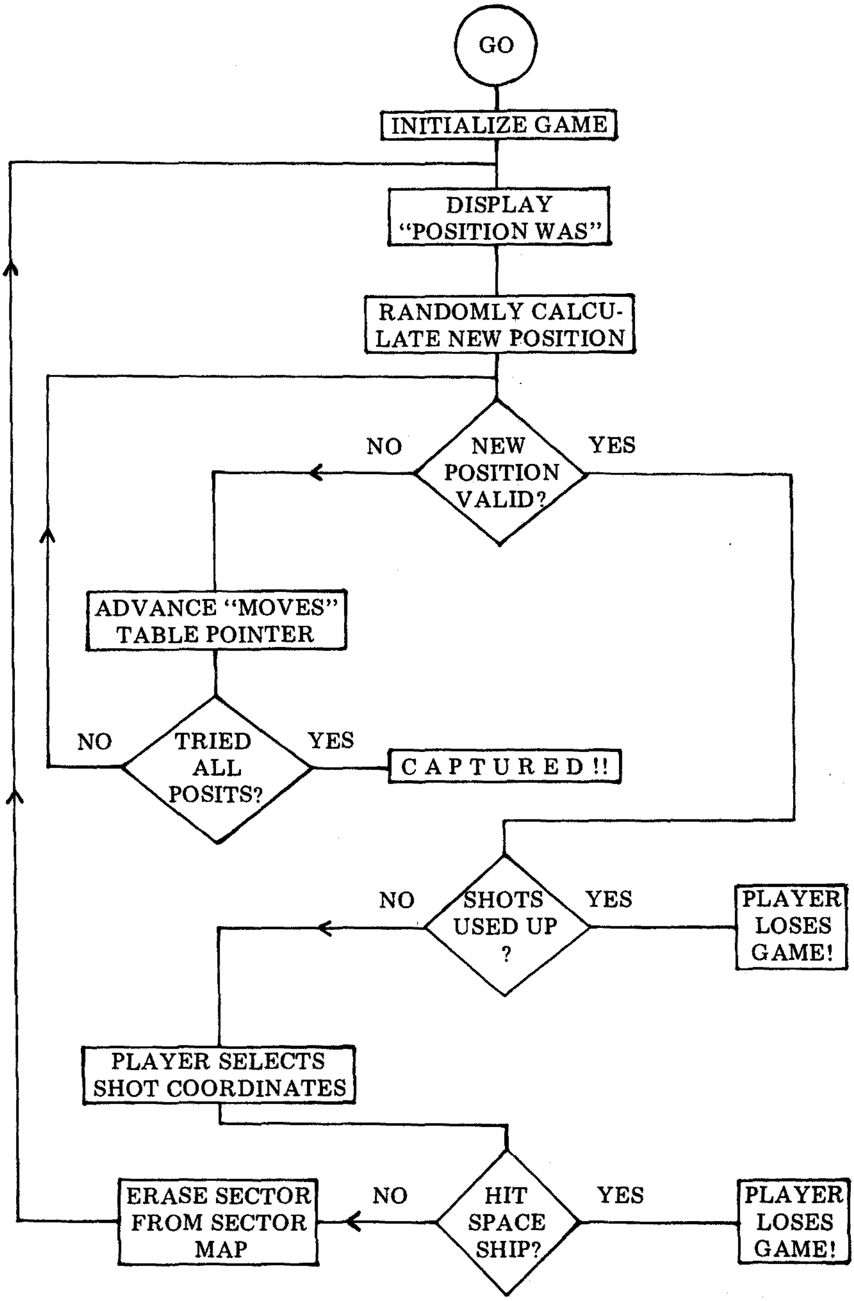
The fundamental operation of the program is outlined in the flow chart that appears on the next page. A brief verbal explanation of that chart will follow. Then the various portions of the program will be presented and discussed in detail.

OUTLINE OF THE PROGRAM'S OPERATION

At the start of the program, a brief message is presented to explain the game to a new player. Next, the program determines if the operator desires to play a game. If not, a closing message is displayed and the program ends.

Assuming that a person elects to play a game, the program proceeds to select a semi-random starting point as the initial position of the space ship that is to be captured. The position of the space ship is then displayed as the WAS position to the operator. That is, the operator is informed of the LAST POSITION in which the space ship was observed. The operator then knows one position in which the space ship cannot be because the actual current position of the ship when the player fires a phasor shot will be in a sector adjacent to its last announced position. (Unless, of course, the ship has been captured.)

Once the WAS position has been displayed, the program proceeds to calculate a new position for the space ship to move into using an essentially random method. Whenever a calculation to move into a new sector has been made, the program must perform several tests. It must make sure that the new sector is within the bounds of the playing grid. And, it must make sure that it is not moving into a sector that has been destroyed by a player's phasor shot. If either of these tests fail, a new calculation is made to try


GO
INITIALIZE GAME
DISPLAY "POSITION WAS"
RANDOMLY CALCU-LATE NEW POSITION
NO
NEW POSITION VALID?
YES
ADVANCE "MOVES" TABLE POINTER
NO
TRIED ALL POSITS?
YES
C A P T U R E D !!
NO
SHOTS USED UP ?
YES
PLAYER LOSES GAME!
PLAYER SELECTS SHOT COORDINATES
ERASE SECTOR FROM SECTOR MAP
NO
HIT SPACE SHIP?
YES
PLAYER LOSES GAME!

another one of the eight possible adjacent sectors. If the program finds that all eight possible moves are blocked, the player wins. An appropriate message is then displayed.

Assuming that the space ship does have a valid move, the new position that it occupies is saved temporarily. If the player has not already expended an allotted number of shots, the program allows the operator to enter the coordinates of the sector that is to be eliminated from further occupation by the space ship. Once the coordinates have been entered, a test is made to see whether the space ship is presently in that sector. If so, the player loses as the space ship was destroyed versus being captured. If the space ship was not hit by the phasor shot, then the sector area is erased from a SECTOR MAP. Once an entry in the sector map has been erased, the space ship will be prevented from entering that sector in the future.

The game continues until the player uses up the allotted number of phasor shots, hits the space ship, or obtains a CAPTURE. At the conclusion of a game, the program queries the player as to whether a new game is to be played. Appropriate action is then taken as indicated above.

TEXT MESSAGES USED BY THE PROGRAM

Close to a third of the memory space utilized by the program is for storing the ASCII code for various messages that are displayed during the program's operation. These messages are of esthetic value particularly if the game is to be enjoyed by those who may not be familiar with the operation of a computer. The contents of these messages may be altered by the reader as desired, including complete deletion in many instances if one desires to conserve memory space. The various message strings that are used in the program being presented are listed next.

"SPACESHIP CAPTURE. YOU HAVE 15 PHASOR SHOTS WITH WHICH TO DESTROY MY TRAVEL SECTORS. IF ALL MY ADJACENT SECTORS ARE DESTROYED I AM CAPTURED. IF YOU HIT ME OR RUN OUT OF PHASOR ENERGY, THEN YOU LOSE!"

"WANT TO PLAY?"

"POOR SPORT!"

"MY LAST POSITION WAS: X = "

", Y = "

"YOU ARE FIRING TO: X = "

YOU HIT ME!! YOU LOSE!"

YOU ARE OUT OF PHASOR ENERGY, YOU LOSE!"

"#!0# DARN! YOU HAVE ME C A P T U R E D !!"

The introductory message in particular takes almost a page of storage in memory and may readily be deleted if memory is at a premium in the user's system. The reader who wants to reduce the memory requirements some more can abbreviate the other messages if desired.

The text messages shown above are all stored in one continuous section in memory in the form of ASCII codes for the various characters in each string. (Note: In this manual the standard seven bit ASCII code will be shown with the code augmented by an eighth bit commonly referred to as the PARITY bit. The parity bit will always be assumed to be in the logic one or marking condition unless otherwise noted.)

A subroutine frequently referred to by the game program is shown below. It is labeled MSG.

```
MSG,    LAM             Fetch a character
        NDA             Set flags
        RTZ             Finished if have zero byte
        CAL PRINT       Else print character
        INL             Advance low addr pointer
        JFZ MSG         Continue display
        INH             Or adv page addr pointer
        JMP MSG         And then continue display
```

The MSG subroutine is quite simple. The calling program simply sets up the H and L memory pointing registers to the starting address of a string of characters that are to be outputted. Then, when the MSG subroutine is executed, the routine proceeds to fetch the characters from memory and output them until a zero byte is encountered. The subroutine itself calls on a subroutine labeled PRINT which must be provided by the program user. The PRINT subroutine must be an actual device operating routine that will cause the ASCII character in the accumulator to be transmitted to the output device being used by the system. The PRINT subroutine provided by the user may use the CPU registers B through E if required but it should not alter the contents of the H and L CPU registers. (Unless, of course, in doing so it is able to restore them to their original values before returning to the calling program.)

The reader will see that the MSG subroutine is used through-out the program being described. Prior to calling the subroutine, the main program will always setup the H and L registers to the starting address of the character string that is to be displayed. The character strings that will be used in the example program have been presented previously. It hardly goes without saying, that if a reader desires to modify the text messages, and by doing so alters their starting addresses, that appropriate modifications must be made to the setup address values whenever the MSG subroutine is used. This is also the case if the user decides to store the text messages at locations other than those shown in the program provided herein.

The reader may refer to the flow chart presented earlier as the discussion of the actual operating portions of the program proceeds.

The first few procedures in the program consist of merely displaying the introductory message and then asking the prospective player if the playing of a game is desired.

Following the WANT TO PLAY query, the program then waits for a response from the system's input device which must be in the form of a letter Y for YES or N for NO. If a NO response is received at this point, then no game is to be played. The program will display the closing message and end the program. These first few operations are illustrated in the program listing below.

```
START,      LHI 000         Pointer to introductory
            LLI 000         Message
            CAL MSG         Display introductory message

 OVER,      LHI 000         Pointer to WANT TO PLAY
            LLI 325         Message
            CAL MSG         Display message
INAGN,      CAL CKINP       See if have input
            NDA             Set flags
            CFS INPUTN      Fetch character if ready
            INL             Increment RANDOM cntr
            CPI 316         If input, was it N?
            JFZ NOTNO       Jump ahead if not N
            LHI 000         Pointer to POOR SPORT
            LLI 350         Message
            CAL MSG         Display message
            HLT             End of session
```

There are several instructions in the above routine that require elaboration. The reader may observe that there are references to two input subroutines. One is labeled CKINP. The other is designated

INPUTN. The subroutine labeled INPUTN is a user created subroutine that will accept a character from the system's input device. Typically, this would be an ASCII encoded keyboard. The subroutine is expected to return the inputted character in the accumulator. This subroutine is free to use CPU registers B through E in performing its function. The INPUTN subroutine should also provide an echo capability by sending the character inputted out to the system's display device. This is done so the operator may verify the character inputted. (This might be accomplished by simply calling the previously mentioned PRINT subroutine.)

The CKINP subroutine is a user provided routine that simply performs a check to see if the input device has a character waiting to be inputted. If so, the subroutine must return with the MSB of the accumulator set to '0.' If a character is not ready, the subroutine should return with the most significant bit of the accumulator set to a logic '1' state.

The importance of having a separate subroutine (CKINP) that merely ascertains if a character is waiting will be explained here. The reader can see in the previous routine that if a character is ready to be received, the INPUTN subroutine will be called to actually obtain the data. However, whether or not a character is received, CPU register L will be incremented. CPU register L is actually used as a sort of random counter. The final value in register L will be determined by how long it takes for the player to respond with an input after a query from the program. This is because if there is no input the first time the instruction sequence is executed, the routine will eventually loop back to the point in the program labeled INAGN. Each time the program has to wait and goes back through the loop, the contents of register L are incremented. Naturally, this looping operation is being performed at a many-thousands-per-second rate.

How the final value in register L is used to form an essentially random number (when a valid input finally occurs) will be illustrated shortly. It is important to note that the inclusion of the separate CKINP subroutine is vital to the proper operation of the program being described. To reiterate, the CKINP subroutine must only ascertain if the input device has a character for the computer! It does not itself form a waiting loop for such a signal. That is accomplished by the previous routine in the manner described!

The program continues with a portion to be illustrated next starting with the label NOTNO. The first part of this sequence completes the test of the player's response to the WANT TO PLAY? query. This is done by testing to see if the character Y for YES was inputted. If not, the program loops back to the label INAGN just described to continue looking for a valid input.

When a Y response is received, the routine continues in the following manner. The value in register L is transferred to the accumulator. It is trimmed by a masking operation to leave only the three least significant bits. This would leave an octal number in the range of zero to seven. A count of one is added to this value to give a number in the range 01 to 10 octal. This is the equivalent of decimal 1 to 8, or the allowed coordinates along either the X or Y coordinate of the playing grid! This value is then saved in two temporary storage locations in memory to serve as the initial position of the space ship at the start of the game. Thus, the space ship will always have a starting point along a line corresponding to the diagonal where both coordinates are the same value. However, the actual value will vary with each game because of the random manner in which the number is generated (in register L) as alluded to previously. This gives some added variety to the game right from the beginning move!

The routine then continues by taking the value in the accumulator and reducing it by a masking operation back to the octal range 0 to 7. The value is then multiplied by 2 (RLC instruction) so that it will represent an even number in the range 00 to 16 octal.

At this point the value is converted to the low portion of an address. For this particular version of the program this is accomplished by the ORI 260 command which will form a value in the range 260 to 277 (octal). This address is stored temporarily in memory for use by a routine that will be explained in detail further on. Suffice it to say at this point that the address refers to a table that will contain the possible moves that the space ship might try to take.

The routine then continues by initializing a phasor shots taken counter that will keep track of how many shots the player has fired.

Because of the point in the overall program at which the counter is decremented, this counter is initialized to a value one greater than the number of shots that the player is to be allowed.

The routine concludes by filling a block of 64 (decimal) locations with all ones. This block of memory will serve as a shots taken map. Its use will be explained in detail later.

```
NOTNO,      CPI 331         If input, was it Y?
            JFZ INAGN       If not, get a new input
            LAL             Else, move random counter
            NDI 007         To ACC & trim ASCII code
            ADI 001         Add 1 to get 1 - 8
            LHI 001         Range and set up pointer
            LLI 372         To LAST position storage
            LMA             Initialize X WAS value
            INL             Advance pointer
            LMA             Initialize Y WAS value
            LLI 377         Pointer to random cntr storage
            NDI 007         Reduce size
            RLC             Make it an even value
            ORI 260         Form table pointer
            LMA             And save table pointer
            LHI 001         Set pointer to shot counter
            LLI 376         Storage location
            LMI 020         Initialize to 16 decimal
            LHI 003         Set pointer to start of
            LLI 300         Shots taken map
            LAI 377         Fill accumulator with 1's

FILOOP,     LMA             Initialize shots taken
            INL             Map to all ones condition
            JFZ FILOOP      Until map completed
```

The next portion of the program starts by displaying the message MY LAST POSITION WAS: to the player. The routine then fetches the values of the X and Y coordinates that have been previously stored in memory and outputs those values by forming the ASCII code for the appropriate numerical values and displaying them via the output display subroutine PRINT provided by the user.

Next, a subroutine termed TRYMOV is called. The TRYMOV subroutine, which will be discussed shortly, will attempt to move the space ship into an available free sector using a technique that selects a new location in an essentially random manner. If the TRYMOV subroutine cannot move the space ship, the program will not return in the normal manner as the space ship will have been captured. If, however, the space ship is able to move to a new sector, the program will continue as illustrated in the routine. At this point, the phasor shots taken counter will be decremented in value. If the player has not used up the allotted shots, the game continues.

If the player has used up the number of allotted phasor shots, the program continues to the label PHASOR. Here the program will display the message indicating that the player is out of phasor energy and has lost the game. The program will then loop back to the label OVER presented earlier to see if the player wants to start a new game.

```
PLAYIN,    LHI 000        Set pntr to POSITION WAS:
           LLI 367        X = message
           CAL MSG        Display message
           LHI 001        Set pointer to X WAS
           LLI 372        Storage location
           LAM            Fetch value
           ORI 260        Form ASCII code
           CAL PRINT      Display position value
           LHI 001        Set pointer to Y =
           LLI 026        Message
           CAL MSG        Display message
           LHI 001        Set pointer to Y WAS
           LLI 373        Storage location
           LAM            Fetch value
           ORI 260        Form ASCII code
           CAL PRINT      Display position value
           CAL TRYMOV     Move the spaceship!
```

```
          LHI 001        Pointer to shots taken
          LLI 376        Counter storage
          LBM            Fetch counter
          DCB            Decrement value
          LMB            Restore counter
          JFZ CONTIN     Jump ahead if counter not 0

PHASOR,   LHI 001        If shots counter = 0,
          LLI 125        Set pointer and display
          CAL MSG        OUT OF ENERGY message
          JMP OVER       Go see if want new game
```

Provided that the player still has shots available with which to destroy travel sectors, the program continues at the label CONTIN. Here the message YOU ARE FIRING TO: is displayed. The program then allows the player to enter first the X and then the Y coordinate of the sector that the player wishes to destroy.

When obtaining the X coordinate, the program simply calls the subroutine INPUTN to obtain a character from the input device. The character obtained is checked to see if it is in the range of one to eight decimal. If not, the routine loops back to wait for a valid input. If so, the ASCII code is trimmed down to four bits and the value saved in a temporary location as the new value of X in memory.

The program then prepares to receive the Y coordinate from the player.

```
CONTIN,   LHI 001        Set pointer to
          LLI 036        FIRING TO message
          CAL MSG        Display message

INX,      CAL INPUTN     Fetch X value
          CPI 261        See if input is a
          JTS INX        Digit in the range
          CPI 271        of one to eight decimal
          JFS INX        Ignore input if not
          LHI 001        If valid input set pointer
```

```
        LLI 370         To new X storage location
        NDI 017         Trim off ASCII part
        LMA             Save the new X value
        LHI 001         Set pointer to
        LLI 026         Y = message
        CAL MSG         Display message
```

The input for obtaining the Y coordinate from the player is handled in the same manner that was described for the portion of the program where the player responds to the WANT TO PLAY? query. Register L is again used as a counter whose final value will depend on how long it takes the player to enter the Y coordinate. When a valid character is received (in the range one to eight decimal), the trimmed number is saved in memory as the new coordinate along the Y axis. The value in register L is then processed in the same manner as before to form an address that will be utilized by the TRYMOV subroutine that has already been referred to, and which will be described soon.

```
INY,    CAL CKINP       See if have input
        NDA             Set flags
        CFS INPUTN      Fetch character if ready
        INL             Advance random counter
        CPI 261         See if input
        JTS INY         In decimal range
        CPI 271         One to eight
        JFS INY         Else ignore input
        LBL             Save random counter value
        LHI 001         Set pointer to new Y
        LLI 371         Storage location
        NDI 017         Trim ASCII part off
        LMA             Save the new Y value
        LAB             Move random counter to ACC
        NDI 007         Reduce it in size
        RLC             Make it an even value
        ORI 260         Form random table pointer
        LHI 001         Set pointer to random table
        LLI 377         Pointer storage location
        LMA             Save random pointer
```

After the X and Y shot coordinates have been obtained from the player, the program continues at the point labeled HITEST. At this time the program must perform a check to determine whether the sector which the player has just destroyed is the same one in which the space ship might have been in. (Which is determined by the TRYMOV subroutine. Remember, the TRYMOV subroutine has already been called by the program, even though it has not yet been presented in detail in this discussion.) This is determined by testing to see if the coordinates of the player's phasor shot (stored in memory) match with the new location of the space ship (also stored in memory). If a match occurs here, then the space ship has been hit. That is a losing move for the player, and the program will display the appropriate message and return to see if the player wants to try a new game.

```
HITEST,     LHI 001          Set pointer to
            LLI 370          X phasor shot storage
            LAM              Fetch X shot value
            INL              Advance pointer to new
            INL              X spaceship location value
            CPM              Compare shot with location
            JFZ ZERSEC       If not a match, no hit
            DCL              Set pointer to Y phasor
            LAM              Shot storage and fetch
            INL              Advance pointer to new
            INL              Y spaceship location value
            CPM              Compare shot with location
            JFZ ZERSEC       If not a match, no hit

BOMB,       LHI 001          Shot hit spaceship - set
            LLI 072          Pointer to HIT message
            CAL MSG          Display message
            JMP OVER         See if want new game
```

The next section of the program begins at the label ZERSEC. This portion of the program serves to zero-out a sector in the sector map whenever a sector is destroyed by a phasor shot made by the player.

As the reader knows, there are 64 different sectors in the 8 by 8 grid on which the game is played. At the beginning of a game, an area in memory is assigned as a sector map. This area consists of 64 consecutive locations in memory. In the sample program, the memory area is assigned to locations 300 to 377 (octal) on page 03. The area is initialized (as mentioned earlier) by loading the value 377 into all 64 locations. Now, each time the player specifies a grid location by designating an X and Y coordinate, a memory location in the sector map is changed to be in a 000 (octal) condition. The location that is to be zeroed out is ascertained by performing a simple calculation. The fundamental calculation made may be expressed by the following formula:

$$V = [(X - 1) \times 8] + (Y - 1)$$

where X and Y are the respective coordinates given by the player when firing a phasor shot. The value V obtained by the calculation is then added to a base value (300 in the example program) to give an effective address in the sector map. By reviewing the above formula, the reader may verify that the calculation will yield the values from 0 to 63 decimal or 0 to 77 octal when all the possible coordinate values are considered. When added to the base value (300 in the example) this will yield a low address in the range 300 to 377 (octal).

A portion of the program (to be presented later) will prevent the space ship from moving into any location that has been zeroed-out in the sector map.

The ZERSEC portion of the program is presented next.

```
ZERSEC,     LLI 370        Get X shot value
            LAM            From storage
            SUI 001        Subtract '1'
            RLC
            RLC            Multiply by eight
            RLC
            LDA            Save in register D temporarily
            INL            Get Y shot value
            LAM            From storage
```

SUI 001	Subtract '1'
ADD	Add to previous calculations
ORI 300	Form shot table address
LLA	Set low address pointer
LHI 003	And page address of shot table
LMI 000	Zero the entry in shot table
JMP PLAYIN	Continue with game

The next portion of the program is the subroutine TRYMOV. This subroutine is the most complicated portion of the program. The subroutine serves the function of attempting to find a new location for the space ship. It does this by attempting to find a sector adjacent to the last position of the space ship that has not been destroyed by a phasor shot. The sector must also be within the boundaries of the 8 by 8 playing grid. Additionally, the direction of movement is accomplished in an essentially random manner so that the player will not be able to detect a reliable pattern of movement for the space ship!

The first few instructions of the subroutine fetch the address that points to the move table. This address is set up each time the player specifies the Y coordinate of a phasor shot (or answers the WANT TO PLAY? query at the beginning of a game). As discussed earlier, the address each time the subroutine is entered will have been selected in an essentially random manner.

The address refers to a position in a table which holds all the possible moves the space ship can make to an adjacent sector. A pictorial near the beginning of this article illustrated the eight possible moves the space ship could make if it was not bounded by the edges of the playing grid, or sectors that had been destroyed. Referral to that pictorial will show that the possible moves may be referenced by a value of -1, 0, or +1 from its present position along each axis. One can convert this information into a table that holds all the possible moves. The table used consists of eight groups of two bytes per group. The first byte in a group holds a move along the X axis. The second stores a move along the Y axis. In the example program, the table is stored in locations 260 through 277 on page 03, and appears as shown on the following page.

377	MOVES TABLE (X = -1)
001	Y = +1
000	X = 0
001	Y = +1
001	X = +1
001	Y = +1
377	X = -1
000	Y = 0
001	X = +1
000	Y = 0
377	X = -1
377	Y = -1
000	X = 0
377	Y = -1
001	X = +1
377	Y = -1

The initial value of the address to the moves table is transferred from a temporary location in memory to the accumulator at the start of the TRYMOV subroutine. Also, a moves tried counter, which will be maintained in CPU register C during the subroutine, is initialized to a value of eight (decimal). The routine then goes on to the point labeled TRYSEC which marks a looping point within the subroutine.

At TRYSEC, the address value originally in the accumulator is moved to CPU register L to set up the low portion of the address to the moves table. This value is also saved for possible later use in CPU register B. The high address of the moves table is set up in CPU register H, and an X move value fetched from the table. The X move value obtained from the table is then added to the X coordinate value representing the previous position of the space ship to form a new value along the X coordinate. At this point some tests must be made to ensure that the new value is within the boundaries of the playing grid. This is readily accomplished by checking to see that the new coordinate is between the range of 1 to 8 decimal. If the new value is within the playing grid, it is saved in a temporary location in memory. If it is not valid, the program jumps ahead to a routine that will advance the moves table pointer to the next X entry in the table

(by going to the label NOGDX which will advance the address temporarily stored in CPU register B TWO locations!)

If the new X value is O.K., the routine proceeds to advance the pointer to the moves table one location to obtain a Y move. A similar boundary checking procedure is performed again. If the new Y coordinate is valid, it too is saved in a temporary location in memory. If not, the program jumps ahead to the label NOGDY which will advance the moves table pointer just one location to the next X entry.

If the new X and Y coordinates are within the boundaries of the playing grid, the program continues by executing the portion of the subroutine labeled CHECK. This part of the program ascertains whether the new sector the space ship is attempting to move into is available. That is, that it has not been destroyed by a previous phasor shot made by the player! This is readily accomplished by using the new coordinate values to once again calculate a position in the sector map and checking to see that the position has not been zeroed out. The calculation technique is exactly the same as that used by the routine ZERSEC explained earlier. If the sector is available, the program jumps ahead to the routine labeled SAVPOS. If not, the space ship must try to find another position in the grid. This is attempted by proceeding to the point labeled NOGDY.

The portion of the routine beginning with the label NOGDX serves to advance the moves table address pointer to the next X entry in the table. Since the table occupies just 20 (octal) locations in memory (in the example program locations 260 through 277 on page 03), and since the initial value may have been at any even valued address within that range, some special operations must be performed when advancing the pointer to the next X entry. First, it may be necessary to try every possible move in the table. Since the first position tried may have been the eighth entry in the table (four least significant bits of the address equal to 16 octal), one must keep the pointer in the range of 00 to 17 octal (for the four LSB's). This is readily accomplished by a masking operation that removes the four most significant bits. Then, since the table does not reside in the first 20 (octal) locations on a page in memory, the base address value of 260 (in the example) must be tacked back on to form the complete address value. This procedure will force the moves table pointer to loop back to the value 260 when it reaches a value of 277 rather than going to 300 which would be outside the range of the table.

When the address of the next entry in the moves table has been set up, the routine checks to see if all eight possible moves have been tried by decrementing the counter being maintained in CPU register B. If not, the routine loops back to the point labeled TRYSEC. If, however, all eight possible moves have been tried, then the space ship has not been able to find a new position and it is captured. A message of defeat is then issued to the player. From that point, the program will go back to see if a new game is desired.

The portion of the routine labeled SAVPOS is executed if the space ship successfully finds a new sector to move into. This routine simply moves the X and Y coordinate values being temporarily saved in memory during the TRYMOV subroutine into the storage locations used to hold the new location. (This move actually places the new coordinates into the memory locations that are referenced the next time the message MY LAST LOCATION WAS: is displayed.)

Note that the SAVPOS routine ends with a RET instruction to conclude the subroutine. Thus, a return from the TRYMOV subroutine indicates that the space ship completed a successful move. If the space ship does not find a new sector to move into, the subroutine is not actually completed. Instead, a jump out of the subroutine to start a new game is executed.

The various portions of the TRYMOV subroutine are presented below.

```
TRYMOV,     LHI 001     Set pointer to
            LLI 377     Random counter storage
            LAM         Fetch value
            LCI 010     Set a loop counter

TRYSEC,     LLA         Set pointer to moves table
            LBA         Save pointer in B too
            LHI 003     Set pg pointer to moves table
```

```
        LAM           Fetch an X move
        LHI 001       Change pointer to
        LLI 372       X WAS storage
        ADM           Add X move to form new loc
        CPI 001       Now make boundaries test
        JTS NOGDX     No good if less than one
        CPI 011       Or more than
        JFS NOGDX     Eight decimal
        LHI 001       If OK, save in X temporarily
        LLI 374       Storage location
        LMA           For awhile
        INB           Advance pointer stored in B
        LLB           And load new pointer
        LHI 003       To Y move location
        LAM           Fetch a Y move
        LHI 001       Change pointer to
        LLI 373       Y WAS storage
        ADM           Add Y move to form new loc
        CPI 001       Now make boundaries test
        JTS NOGDY     No good if less than one
        CPI 011       Or more than
        JFS NOGDY     Eight decimal
        LHI 001       If OK, save in Y temporarily
        LLI 375       Storage location
        LMA           For awhile

CHECK,  DCL           Decrement pointer back to
        LAM           X temp storage and fetch
        SUI 001       Subtract '1'
        RLC
        RLC           Multiply by eight
        RLC
        LDA           Save in D temporarily
        INL           Advance pointer to
        LAM           Y temp storage and fetch
        SUI 001       Subtract '1'
        ADD           Add to previous calculations
        ORI 300       Form shot table address
        LLA           Set low address pointer
        LHI 003       And page address pointer
```

```
            LAM             Fetch entry from shot table
            NDA             Set flags, now see if location
            JFZ SAVPOS      Previously fired into
            JMP NOGDY       Try another location if yes

NOGDX,      INB             Advance move table pointer
NOGDY,      INB             As required to get to next
            LAB             X move, move value to ACC
            NDI 017         And make sure it is kept
            ORI 260         In bounds
            DCC             Decrement loop counter
            JFZ TRYSEC      If not 0, try another location
            LHI 001         Else set pointer
            LLI 201         To CAPTURED message
            CAL MSG         Display message
            JMP OVER        See if want new game

SAVPOS,     LHI 001         Set pointer to X temporarily
            LLI 374         Storage location
            LDM             Save value in D temporarily
            INL             Advance pointer to Y temp
            LEM             Save in E temporarily
            LLI 372         Change pointer to X WAS
            LMD             Storage and set new value
            INL             Do likewise for Y WAS
            LME             Too!
            RET             Return to calling program
```

That is all there is to the program! That is not so difficult, eh?

An assembled listing of the program for running on a 8008 system will be presented on the following pages. The program in the listing has been assembled to reside in pages 01 to 03 with page 04 reserved for the user's I/O routines. Page 00 and most of page 01 will be used to hold the various message strings mentioned previously. The ASCII data that should be stored in those locations is shown next. (Assuming the user is satisfied with the message strings illustrated.)

000	000	215	212	212	323	320	301	303	305
000	010	323	310	311	320	240	303	301	320
000	020	324	325	322	305	256	240	331	317
000	030	325	240	310	301	326	305	240	261
000	040	265	240	320	310	301	323	317	322
000	050	215	212	323	310	317	324	323	240
000	060	327	311	324	310	240	327	310	311
000	070	303	310	240	324	317	240	304	305
000	100	323	324	322	317	331	240	315	331
000	110	240	324	322	301	326	305	314	215
000	120	212	323	305	303	324	317	322	323
000	130	256	240	311	306	240	301	314	314
000	140	240	315	331	240	301	304	312	301
000	150	303	305	316	324	240	323	305	303
000	160	324	317	322	323	215	212	301	322
000	170	305	240	304	305	323	324	322	317
000	200	331	305	304	240	311	240	301	315
000	210	240	303	301	320	324	325	322	305
000	220	304	256	240	311	306	240	331	317
000	230	325	215	212	310	311	324	240	315
000	240	305	240	317	322	240	322	325	316
000	250	240	317	325	324	240	317	306	240
000	260	320	310	301	323	317	322	240	305
000	270	316	305	322	307	331	254	215	212
000	300	324	310	305	316	240	331	317	325
000	310	240	314	317	323	305	241	215	212
000	320	212	000	000	000	000	215	212	212
000	330	327	301	316	324	240	324	317	240
000	340	320	314	301	331	277	240	240	000
000	350	215	212	212	320	317	317	322	240
000	360	323	320	317	322	324	241	000	215
000	370	212	212	315	331	240	314	301	323
001	000	324	240	320	317	323	311	324	311
001	010	317	316	240	327	301	323	272	240
001	020	240	330	240	275	240	000	254	240
001	030	240	331	240	275	240	000	215	212
001	040	212	331	317	325	240	301	322	305
001	050	240	306	311	322	311	316	307	240
001	060	324	317	272	240	240	330	240	275
001	070	240	000	215	212	212	331	317	325

001	100	240	310	311	324	240	315	305	241
001	110	241	240	240	331	317	325	240	314
001	120	317	323	305	241	000	215	212	212
001	130	331	317	325	240	301	322	305	240
001	140	317	325	324	240	317	306	240	320
001	150	310	301	323	317	322	240	305	316
001	160	305	322	307	331	254	240	240	331
001	170	317	325	240	314	317	323	305	241
001	200	000	215	212	212	243	241	260	243
001	210	207	207	207	240	240	304	301	322
001	220	316	241	240	240	331	317	325	240
001	230	310	301	326	305	240	315	305	240
001	240	240	303	240	301	240	320	240	324
001	250	240	325	240	322	240	305	240	304
001	260	240	241	241	000				

The starting address for each message string may be located from the above data presentation. The beginning of each message string has been underlined. The reader may desire to change some of the messages. If the reader elects to do so, and by so doing changes the starting address of a character string, then the appropriate pointer instruction in the operating portion of the program must be modified accordingly. The assembled program for an 8008 system is presented on the next several pages.

```
001 350     307                         MSG,    LAM
001 351     240                                 NDA
001 352     053                                 RTZ
001 353     106 200 004                         CAL PRINT
001 356     060                                 INL
001 357     110 350 001                         JFZ MSG
001 362     050                                 INH
001 363     104 350 001                         JMP MSG

001 370     000                                 000
001 371     000                                 000
001 372     000                                 000
001 373     000                                 000
```

```
001 374    000                                    000
001 375    000                                    000
001 376    000                                    000
001 377    000                                    000

002 000    056 000                    START,      LHI 000
002 002    066 000                                LLI 000
002 004    106 350 001                            CAL MSG

002 007    056 000                    OVER,       LHI 000
002 011    066 325                                LLI 325
002 013    106 350 001                            CAL MSG

002 016    106 000 004                INAGN,      CAL CKINP
002 021    240                                    NDA
002 022    122 020 004                            CFS INPUTN
002 025    060                                    INL
002 026    074 316                                CPI 316
002 030    110 043 002                            JFZ NOTNO
002 033    056 000                                LHI 000
002 035    066 350                                LLI 350
002 037    106 350 001                            CAL MSG
002 042    000                                    HLT

002 043    074 331                    NOTNO,      CPI 331
002 045    110 016 002                            JFZ INAGN
002 050    306                                    LAL
002 051    044 007                                NDI 007
002 053    004 001                                ADI 001
002 055    056 001                                LHI 001
002 057    066 372                                LLI 372
002 061    370                                    LMA
002 062    060                                    INL
002 063    370                                    LMA
002 064    066 377                                LLI 377
002 066    044 007                                NDI 007
002 070    002                                    RLC
002 071    064 260                                ORI 260
002 073    370                                    LMA
002 074    056 001                                LHI 001
```

```
002 076   066 376                  LLI 376
002 100   076 020                  LMI 020
002 102   056 003                  LHI 003
002 104   066 300                  LLI 300
002 106   006 377                  LAI 377

002 110   370             FILOOP,  LMA
002 111   060                      INL
002 112   110 110 002              JFZ FILOOP

002 115   056 000         PLAYIN,  LHI 000
002 117   066 367                  LLI 367
002 121   106 350 001              CAL MSG
002 124   056 001                  LHI 001
002 126   066 372                  LLI 372
002 130   307                      LAM
002 131   064 260                  ORI 260
002 133   106 200 004              CAL PRINT
002 136   056 001                  LHI 001
002 140   066 026                  LLI 026
002 142   106 350 001              CAL MSG
002 145   056 001                  LHI 001
002 147   066 373                  LLI 373
002 151   307                      LAM
002 152   064 260                  ORI 260
002 154   106 200 004              CAL PRINT
002 157   106 002 003              CAL TRYMOV
002 162   056 001                  LHI 001
002 164   066 376                  LLI 376
002 166   317                      LBM
002 167   011                      DCB
002 170   371                      LMB
002 171   110 206 002              JFZ CONTIN

002 174   056 001         PHASOR,  LHI 001
002 176   066 125                  LLI 125
002 200   106 350 001              CAL MSG
002 203   104 007 002              JMP OVER

002 206   056 001         CONTIN,  LHI 001
```

```
002 210   066 036                      LLI 036
002 212   106 350 001                  CAL MSG

002 215   106 020 004        INX,      CAL INPUTN
002 220   074 261                      CPI 261
002 222   160 215 002                  JTS INX
002 225   074 271                      CPI 271
002 227   120 215 002                  JFS INX
002 232   056 001                      LHI 001
002 234   066 370                      LLI 370
002 236   044 017                      NDI 017
002 240   370                          LMA
002 241   056 001                      LHI 001
002 243   066 026                      LLI 026
002 245   106 350 001                  CAL MSG

002 250   106 000 004        INY,      CAL CKINP
002 253   240                          NDA
002 254   122 020 004                  CFS INPUTN
002 257   060                          INL
002 260   074 261                      CPI 261
002 262   160 250 002                  JTS INY
002 265   074 271                      CPI 271
002 267   120 250 002                  JFS INY
002 272   316                          LBL
002 273   056 001                      LHI 001
002 275   066 371                      LLI 371
002 277   044 017                      NDI 017
002 301   370                          LMA
002 302   301                          LAB
002 303   044 007                      NDI 007
002 305   002                          RLC
002 306   064 260                      ORI 260
002 310   056 001                      LHI 001
002 312   066 377                      LLI 377
002 314   370                          LMA

002 315   056 001        HITEST,       LHI 001
002 317   066 370                      LLI 370
002 321   307                          LAM
```

```
002 322    060                            INL
002 323    060                            INL
002 324    277                            CPM
002 325    110 352 002                    JFZ ZERSEC
002 330    061                            DCL
002 331    307                            LAM
002 332    060                            INL
002 333    060                            INL
002 334    277                            CPM
002 335    110 352 002                    JFZ ZERSEC

002 340    056 001              BOMB,     LHI 001
002 342    066 072                        LLI 072
002 344    106 350 001                    CAL MSG
002 347    104 007 002                    JMP OVER

002 352    066 370            ZERSEC,     LLI 370
002 354    307                            LAM
002 355    024 001                        SUI 001
002 357    002                            RLC
002 360    002                            RLC
002 361    002                            RLC
002 362    330                            LDA
002 363    060                            INL
002 354    307                            LAM
002 365    024 001                        SUI 001
002 367    203                            ADD
002 370    064 300                        ORI 300
002 372    360                            LLA
002 373    056 003                        LHI 003
002 375    076 000                        LMI 000
002 377    104 115 002                    JMP PLAYIN

003 002    056 001            TRYMOV,     LHI 001
003 004    066 377                        LLI 377
003 006    307                            LAM
003 007    026 010                        LCI 010

003 011    360                TRYSEC,     LLA
003 012    310                            LBA
```

```
003 013    056 003                          LHI 003
003 015    307                              LAM
003 016    056 001                          LHI 001
003 020    066 372                          LLI 372
003 022    207                              ADM
003 023    074 001                          CPI 001
003 025    160 125 003                      JTS NOGDX
003 030    074 011                          CPI 011
003 032    120 125 003                      JFS NOGDX
003 035    056 001                          LHI 001
003 037    066 374                          LLI 374
003 041    370                              LMA
003 042    010                              INB
003 043    361                              LLB
003 044    056 003                          LHI 003
003 046    307                              LAM
003 047    056 001                          LHI 001
003 051    066 373                          LLI 373
003 053    207                              ADM
003 054    074 001                          CPI 001
003 056    160 126 003                      JTS NOGDY
003 061    074 011                          CPI 011
003 063    120 126 003                      JFS NOGDY
003 066    056 001                          LHI 001
003 070    066 375                          LLI 375
003 072    370                              LMA

003 073    061                     CHECK,   DCL
003 074    307                              LAM
003 075    024 001                          SUI 001
003 077    002                              RLC
003 100    002                              RLC
003 101    002                              RLC
003 102    330                              LDA
003 103    060                              INL
003 104    307                              LAM
003 105    024 001                          SUI 001
003 107    203                              ADD
003 110    064 300                          ORI 300
003 112    360                              LLA
```

```
003 113    056 003                     LHI 003
003 115    307                         LAM
003 116    240                         NDA
003 117    110 152 003                 JFZ SAVPOS
003 122    104 126 003                 JMP NOGDY

003 125    010             NOGDX,      INB
003 126    010             NOGDY,      INB
003 127    301                         LAB
003 130    044 017                     NDI 017
003 132    064 260                     ORI 260
003 134    021                         DCC
003 135    110 011 003                 JFZ TRYSEC
003 140    056 001                     LHI 001
003 142    066 201                     LLI 201
003 144    106 350 001                 CAL MSG
003 147    104 007 002                 JMP OVER

003 152    056 001         SAVPOS,     LHI 001
003 154    066 374                     LLI 374
003 156    337                         LDM
003 157    060                         INL
003 160    347                         LEM
003 161    066 372                     LLI 372
003 163    373                         LMD
003 164    060                         INL
003 165    374                         LME
003 166    007                         RET


003 260    377                         377
003 261    001                         001
003 262    000                         000
003 263    001                         001
003 264    001                         001
003 265    001                         001
003 266    377                         377
003 267    000                         000
003 270    001                         001
003 271    000                         000
```

003 272	377		377
002 273	377		377
003 274	000		000
003 275	377		377
003 276	001		001
003 277	377		377
004 000		CKINP,	
004 020		INPUTN,	
004 200		PRINT,	

Do not forget that the program as presented will be using locations 300 through 377 on page 03 as a sector map. The reader should also make sure that the user provided I/O routines are loaded into memory at the indicated locations before attempting to operate the program!

OPERATING THE SPACE CAPTURE PROGRAM

Once the program has been loaded into memory it is ready for operation. The program is started by executing a jump to location 000 on page 02 for the illustrated program, and placing the computer in the normal program execution run mode. From there on the program effectively guides the player. The program will continue to operate, playing game after game, until the player responds with a N for NO to the WANT TO PLAY? query.

The player will want to have a supply of paper with 8 by 8 grids marked out to keep track of the space ship's movements and sectors in which shots have been fired as the games progresses. If the game is to be used frequently, it is probably worthwhile to make up a good supply of the grid forms using a mimeograph or duplicating machine.

In case the reader has any doubts as to how the game is played, the following illustrates an actual game played using the program. At the end of the illustration showing the dialogue between the computer and the player is a grid illustrating how the game progressed. The progress of the space ship is shown as a series of arrows indicating the direction of each movement. The phasor shots fired by the player are shown as a circled number in various sectors. The number refers to the actual shot number as the game progressed.

```
SPACESHIP CAPTURE. YOU HAVE 15 PHASOR
SHOTS WITH WHICH TO DESTROY MY TRAVEL
SECTORS. IF ALL MY ADJACENT SECTORS ARE
DESTROYED, I AM CAPTURED. IF YOU HIT ME
OR RUN OUT OF PHASOR ENERGY, THEN
YOU LOSE!

WANT TO PLAY?          Y

MY LAST POSITION WAS:    X= 7,    Y = 7

YOU ARE FIRING TO:    X = 7,    Y = 7

MY LAST POSITION WAS:    X = 8,    Y = 6

YOU ARE FIRING TO:    X = 6,    Y = 6

MY LAST POSITION WAS:    X = 8,    Y = 7

YOU ARE FIRING TO:    X = 6,    Y = 8

MY LAST POSITION WAS:    X = 8,    Y = 6

YOU ARE FIRING TO:    X = 6,    Y = 5

MY LAST POSITION WAS:    X = 8,    Y = 5

YOU ARE FIRING TO:    X = 6,    Y = 4

MY LAST POSITION WAS:    X = 7,    Y = 6
```

YOU ARE FIRING TO: X = 6, Y = 7

MY LAST POSITION WAS: X = 8, Y = 7

YOU ARE FIRING TO: X = 7, Y = 4

MY LAST POSITION WAS: X = 7, Y = 6

YOU ARE FIRING TO: X = 8, Y = 4

MY LAST POSITION WAS: X = 8, Y = 6

YOU ARE FIRING TO: X = 8, Y = 6

MY LAST POSITION WAS: X = 7, Y = 5

YOU ARE FIRING TO: X = 8, Y = 7

MY LAST POSITION WAS: X = 7, Y = 6

YOU ARE FIRING TO: X = 7, Y = 6

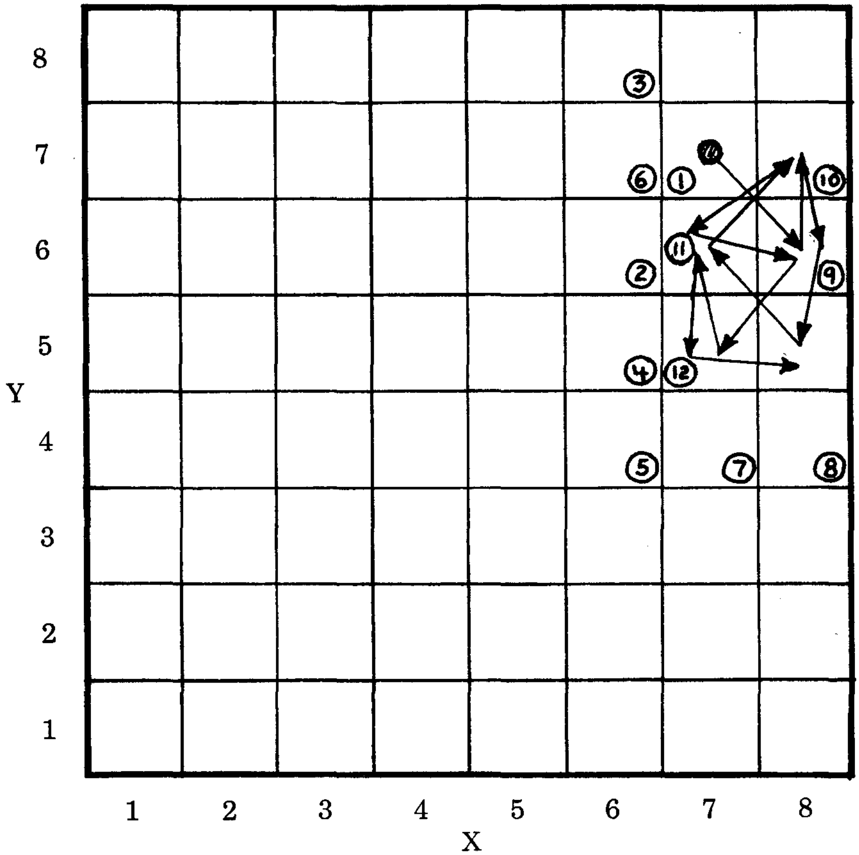
MY LAST POSITION WAS: X = 7, Y = 5

YOU ARE FIRING TO: X = 7, Y = 5

MY LAST POSITION WAS: X = 8, Y = 5

#!0#! DARN! YOU HAVE ME CAPTURED!!

WANT TO PLAY?



PICTORIAL OF THE MOVES MADE IN THE ILLUSTRATIVE SPACE CAPTURE GAME

The following is a listing of the program for an 8080 system. Only a few minor changes have been made in the program. Notably, the inclusion of stack pointer initializing instructions (required by the 8080 since it does not have a program counter stack on the CPU chip) at the labels START and OVER. Additionally, the double register (H and L) load instruction has been utilized when applicable instead of the individual commands required in an 8008 unit. Several other minor changes have been made to make use of the more powerful 8080 instruction set, but the basic structure of the program has not been altered so that the explanations of the various routines made earlier need not be elaborated upon.

```
001 350    176                       MSG,    LAM
001 351    247                               NDA
001 352    310                               RTZ
001 353    315 200 004                       CAL PRINT
001 356    043                               INXH
001 357    303 350 001                       JMP MSG

001 370    000                               000
001 371    000                               000
001 372    000                               000
001 373    000                               000
001 374    000                               000
001 375    000                               000
001 376    000                               000
001 377    000                               000

002 000    061 350 001             START,    LXS 350 001
002 003    041 000 000                       LXH 000 000
002 006    315 350 001                       CAL MSG

002 011    061 350 001              OVER,    LXS 350 001
002 014    041 325 000                       LXH 325 000
002 017    315 350 001                       CAL MSG
```

```
002 022    315 000 004          INAGN,   CAL CKINP
002 025    247                           NDA
002 026    364 020 004                   CFS INPUTN
002 031    054                           INL
002 032    376 316                       CPI 316
002 034    302 046 002                   JFZ NOTNO
002 037    041 350 000                   LXH 350 000
002 042    315 350 001                   CAL MSG
002 045    166                           HLT

002 046    376 331              NOTNO,   CPI 331
002 050    302 022 002                   JFZ INAGN
002 053    175                           LAL
002 054    346 007                       NDI 007
002 056    306 001                       ADI 001
002 060    041 372 001                   LXH 372 001
002 063    167                           LMA
002 064    054                           INL
002 065    167                           LMA
002 066    056 377                       LLI 377
002 070    346 007                       NDI 007
002 072    007                           RLC
002 073    366 260                       ORI 260
002 075    167                           LMA
002 076    041 376 001                   LXH 376 001
002 101    066 020                       LMI 020
002 103    041 300 003                   LXH 300 003
002 106    076 377                       LAI 377

002 110    167                  FILOOP,  LMA
002 111    054                           INL
002 112    302 110 002                   JFZ FILOOP

002 115    041 367 000          PLAYIN,  LXH 367 000
002 120    315 350 001                   CAL MSG
002 123    041 372 001                   LXH 372 001
002 126    176                           LAM
002 127    366 260                       ORI 260
002 131    315 200 004                   CAL PRINT
```

```
002 134   041 026 001              LXH 026 001
002 137   315 350 001              CAL MSG
002 142   041 373 001              LXH 373 001
002 145   176                      LAM
002 146   366 260                  ORI 260
002 150   315 200 004              CAL PRINT
002 153   315 363 002              CAL TRYMOV
002 156   041 376 001              LXH 376 001
002 161   065                      DCM
002 162   302 176 002              JFZ CONTIN

002 165   041 125 001    PHASOR,   LXH 125 001
002 170   315 350 001              CAL MSG
002 173   303 011 002              JMP OVER

002 176   041 036 001    CONTIN,   LXH 036 001
002 201   315 350 001              CAL MSG

002 204   315 020 004       INX,   CAL INPUTN
002 207   376 261                  CPI 261
002 211   372 204 002              JTS INX
002 214   376 271                  CPI 271
002 216   362 204 002              JFS INX
002 221   041 370 001              LXH 370 001
002 224   346 017                  NDI 017
002 226   167                      LMA
002 227   041 026 001              LXH 026 001
002 232   315 350 001              CAL MSG

002 235   315 000 004       INY,   CAL CKINP
002 240   247                      NDA
002 241   364 020 004              CFS INPUTN
002 244   054                      INL
002 245   376 261                  CPI 261
002 247   372 235 002              JTS INY
002 252   376 271                  CPI 271
002 254   362 235 002              JFS INY
002 257   105                      LBL
002 260   041 371 001              LXH 371 001
002 263   346 017                  NDI 017
```

```
002 265    167                          LMA
002 266    170                          LAB
002 267    346 007                      NDI 007
002 271    007                          RLC
002 272    366 260                      ORI 260
002 274    041 377 001                  LXH 377 001
002 277    167                          LMA

002 300    041 370 001       HITEST,    LXH 370 001
002 303    176                          LAM
002 304    054                          INL
002 305    054                          INL
002 306    276                          CPM
002 307    302 333 002                  JFZ ZERSEC
002 312    055                          DCL
002 313    176                          LAM
002 314    054                          INL
002 315    054                          INL
002 316    276                          CPM
002 317    302 333 002                  JFZ ZERSEC

002 322    041 072 001       BOMB,      LXH 072 001
002 325    315 350 001                  CAL MSG
002 330    303 011 002                  JMP OVER

002 333    056 370           ZERSEC,    LLI 370
002 335    176                          LAM
002 336    326 001                      SUI 001
002 340    007                          RLC
002 341    007                          RLC
002 342    007                          RLC
002 343    127                          LDA
002 344    054                          INL
002 345    176                          LAM
002 346    326 001                      SUI 001
002 350    202                          ADD
002 351    366 300                      ORI 300
002 353    157                          LLA
002 354    046 003                      LHI 003
002 356    066 000                      LMI 000
```

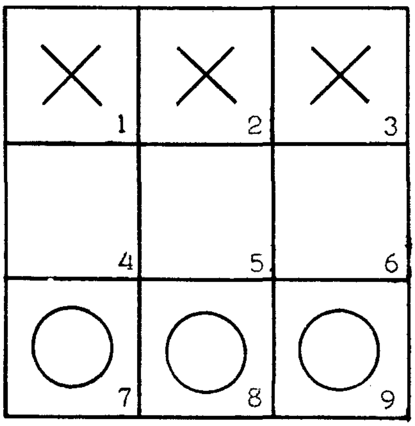
```
002 360   303 115 002            JMP PLAYIN

002 363   041 377 001   TRYMOV,  LXH 377 001
002 366   176                    LAM
002 367   016 010                LCI 010

002 371   157           TRYSEC,  LLA
002 372   107                    LBA
002 373   046 003                LHI 003
002 375   176                    LAM
002 376   041 372 001            LXH 372 001
003 001   206                    ADM
003 002   376 001                CPI 001
003 004   372 101 003            JTS NOGDX
003 007   376 011                CPI 011
003 011   362 101 003            JFS NOGDX
003 014   041 374 001            LXH 374 001
003 017   167                    LMA
003 020   004                    INB
003 021   150                    LLB
003 022   046 003                LHI 003
003 024   176                    LAM
003 025   041 373 001            LXH 373 001
003 030   206                    ADM
003 031   376 001                CPI 001
003 033   372 102 003            JTS NOGDY
003 036   376 011                CPI 011
003 040   362 102 003            JFS NOGDY
003 043   041 375 001            LXH 375 001
003 046   167                    LMA

003 047   055           CHECK,   DCL
003 050   176                    LAM
003 051   326 001                SUI 001
003 053   007                    RLC
003 054   007                    RLC
003 055   007                    RLC
003 056   127                    LDA
003 057   054                    INL
003 060   176                    LAM
```

```
003 061   326 001                  SUI 001
003 063   202                      ADD
003 064   366 300                  ORI 300
003 066   157                      LLA
003 067   046 003                  LHI 003
003 071   176                      LAM
003 072   247                      NDA
003 073   302 125 003              JFZ SAVPOS
003 076   303 102 003              JMP NOGDY

003 101   004             NOGDX,   INB
003 102   004             NOGDY,   INB
003 103   170                      LAB
003 104   346 017                  NDI 017
003 106   366 260                  ORI 260
003 110   015                      DCC
003 111   302 371 002              JFZ TRYSEC
003 114   041 201 001              LXH 201 001
003 117   315 350 001              CAL MSG
003 122   303 011 002              JMP OVER

003 125   041 374 001     SAVPOS,  LXH 374 001
003 130   126                      LDM
003 131   054                      INL
003 132   136                      LEM
003 133   056 372                  LLI 372
003 135   162                      LMD
003 136   054                      INL
003 137   163                      LME
003 140   311                      RET



003 260   377                      377
003 261   001                      001
003 262   000                      000
003 263   001                      001
003 264   001                      001
003 265   001                      001
003 266   377                      377
```

003 267	000			000
003 270	001			001
003 271	000			000
003 272	377			377
003 273	377			377
003 274	000			000
003 275	377			377
003 276	001			001
003 277	377			377
004 000			CKINP,	
004 020			INPUTN,	
004 200			PRINT,	

The possibility of playing a game of chess against a computer has undoubtably crossed the minds of most people that have had exposure to computers in one way or another. However, the game's near-limitless number of possible board configurations and moves makes it impossible to program on a small computer system. An alternative is to simplify the game to allow it to be programmed for the small computer system. Hexpawn is one such game.

Hexpawn consists of a 3 x 3 playing board and six pawns, three pawns for each player. The starting configuration is illustrated below. The pawns move in a manner similar to their moves in chess. A pawn can move one square forward, provided the square it is moving to is vacant, or one square diagonally to capture an opponent's pawn. A diagonal move cannot be made if an opponent's pawn is not captured by the move. The object of the game is to move a pawn to the opponent's side of the board while blocking the opponent from doing so, or capture all of the opponent's pawns. A game is a draw when no one can make a legal move.



The game starts by the current board configuration being printed followed by a request for a human to enter the first move. Each move is made by entering the number of the square which contains the pawn to be moved, followed by the number of the square to which the pawn is to be moved. The computer then makes its move, and prints the new board configuration. It then waits for the human's next move. After each move by the human and by the computer, the board is examined to determine if the game has been won by either side. When this occurs, an appropriate message is printed to indicate the end of the current game, and a new game is started. Should the human make an illegal move, the computer rejects the move and requests a new one.

As one can see, the game is fairly simple and requires no more than three or four moves by each side to complete. Thus, to make the game interesting, the program is written to provide the computer with ARTIFICIAL INTELLIGENCE. The computer is given the ability to decide which move it should make in an effort to win the game. That is, after each move is made by the human player, the computer examines the board and decides which, of all possible moves, it will make. If a move is made by the computer which results in the computer losing the game, that move is noted as an undesired move which should not be made again when that same board configuration if encountered. Thus, the computer learns from its mistakes, and eventually becomes so efficient in its ability to play the game that the best one can hope for is to play to a draw with the computer.

This version of Hexpawn is written to reside in five pages (256 bytes per page) of an 8008 or 8080 microcomputer system. The program may be reduced somewhat be revising or removing some of the text messages, if the user is limited in the amount of memory available. There are also several portions of the program which could be rearranged into subroutines, allowing for further compression of the program. Also, the table which is used to restore the program to its initial state of ignorance may be deleted along with the associated restoration program steps. If this is done, the program can be restored by simply reloading the program into memory. Making such changes to the program can reduce the memory required to less than four pages. The program was written to make it easy to follow the logic rather than minimize the amount of memory required. The reader can see that the memory required is, however, considerably less than that needed to duplicate the same game using a higher level language.

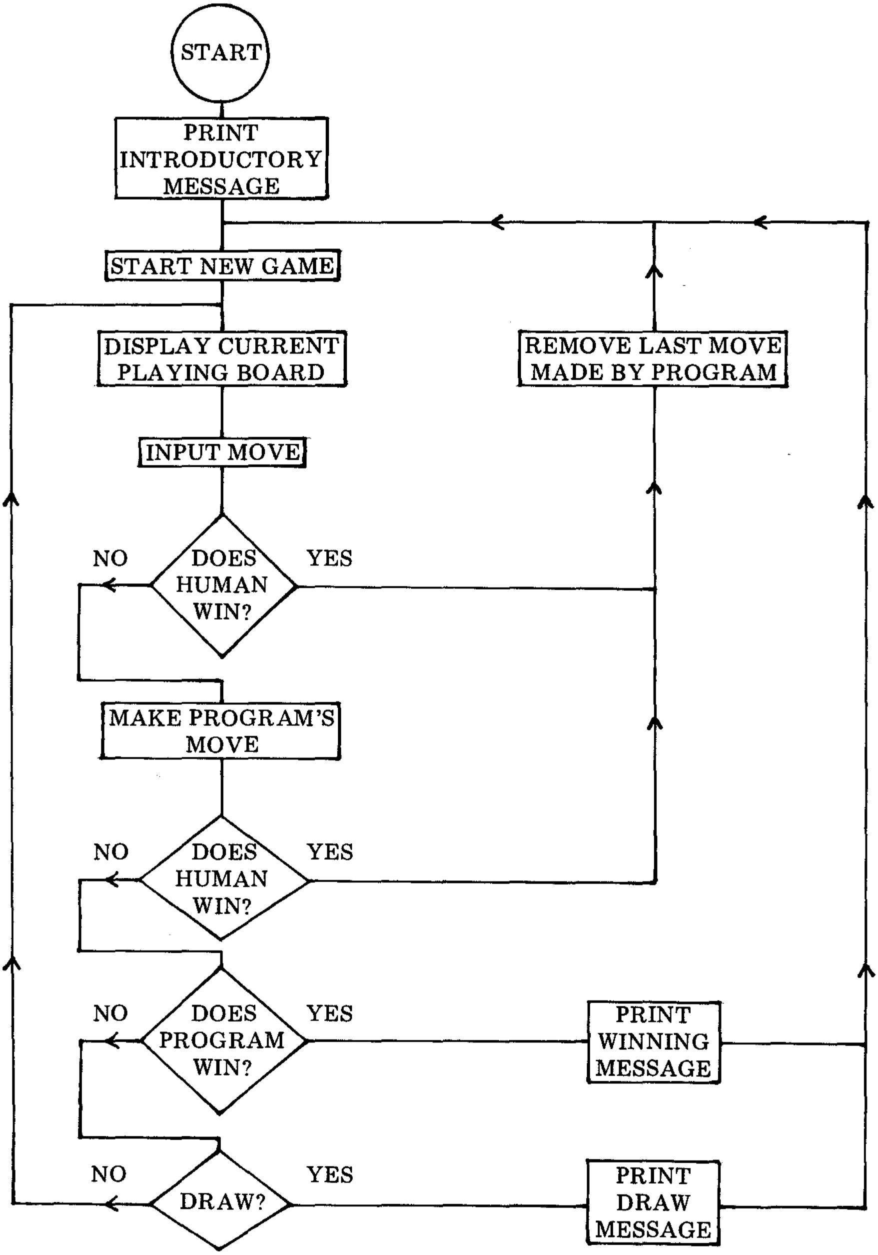
The flow chart on the following page illustrates the basic flow of the program. As one may observe, the game progresses in the same manner as a chess game. Each side makes one move at a time, and checks the board at the completion of each move to determine whether there is a winner. A verbal description of the flow chart will now be presented.

FUNDAMENTAL OPERATION OF THE HEXPAWN PROGRAM

The program starts by printing an introductory message which describes the operation of the game for a person that is playing the game for the first time. A game is then started by displaying the playing board along with the opening positions of the pawns for the human player to examine.

The program next requests the human to input a move. When the move has been received, it is checked to determine whether the player's move was to the opposite side of the board. That would indicate the challenger had won the game. If not, the move is entered on the current board. The program then examines the board and determines which move it will make in response to the player's move. If the human's move was a winning move, the program will remove the last move that it made from its list of possible moves. Since the last move that the computer made resulted in a win by the human, it does not want to make the same mistake twice. One may note that it requires at least two moves by a human to win a game, so that there will always be an initial move by the program which can be deleted.

When the program examines the current playing board, it selects a move from a list of possible moves which it may make for the current board configuration. If this list has had all of its entries removed, because the human has won as a result of making those moves, the game is conceded to the human and the move that the program just made will be removed. Otherwise, the program makes the move indicated in the list. It then determines whether its move has won the game or has resulted in a draw (all remaining pawns are blocked from making a move). If the game is a win or draw, an appropriate message is printed. A new game is then started. If not, the game is continued and the program returns to print the current



START
PRINT INTRODUCTORY MESSAGE
START NEW GAME
DISPLAY CURRENT PLAYING BOARD
REMOVE LAST MOVE MADE BY PROGRAM
INPUT MOVE
NO
DOES HUMAN WIN?
YES
MAKE PROGRAM'S MOVE
NO
DOES HUMAN WIN?
YES
NO
DOES PROGRAM WIN?
YES
PRINT WINNING MESSAGE
NO
DRAW?
YES
PRINT DRAW MESSAGE

playing board for the player to examine.

TABLES USED BY THE HEXPAWN PROGRAM

The most important portion of a program such as Hexpawn is that which decides what move is to be made for a specific board configuration. This operation is performed through the use of four tables in this program. These tables are used to: Find the matching board configuration, direct the program to the list of possible moves for each configuration, select the move to be made, and provide the actual codes for making the move. Each of these tables are presented in the listing at the end of this chapter. Due to the size of these tables, only sample entries of each will be presented in the following discussion.

The MODEL table is a table used by the program to determine the current board configuration. It consists of 33 pairs of bytes which define all the possible board configurations immediately following a human's move. The first byte of each pair indicates the positions of the program's pawns on the board. For each pawn in a square, the bit corresponding to that square is set to '1.' If a pawn is not in a square, the bit corresponding to that square is '0.' The squares of the board defined in the first byte are as follows:

BIT POSITION	B7	B6	B5	B4	B3	B2	B1	B0
BOARD POSITION	1	2	3	4	5	6	X	X

The reader may note that bits B1 and B0 do not have any position on the playing board defined for them. The reason for this is that if any of the program's pawns reach position 7, 8, or 9, the game will be over with the computer winning. It will not be necessary to store the fact that the program's pawn has reached the last row. Consequently, bits B1 and B0 will always be set to a zero. The same is true for the human's pawns, which are defined by the following bit definitions in the second byte of the model pair.

BIT POSITION	B7	B6	B5	B4	B3	B2	B1	B0
BOARD POSITION	X	X	4	5	6	7	8	9

Bits B7 and B6 are not defined for any position on the board, since a move to position 1, 2, or 3 is a winning move for the human. Bits B7 and B6 of the second byte are always a zero.

For example, suppose the first move made by the human was from square 7 to square 4. The current board configuration would be represented by the following byte pair (using octal notation):

PGM'S PAWNS	340
HUMAN'S PAWNS	043

This corresponds to a physical board configuration of:

```
X|X|X
O| |
 |O|O
```

When the program finds the byte pair in the model table that matches the current board, it sets up a pointer to the MODEL-TO-MOVE INDEX table. The model-to-move index table consists of a list of pointers. Each entry in this table points of a list of possible moves for the current board configuration. The list of moves is contained in the MOVE INDEX table.

The move index table contains a list of moves which may be made for each of the 33 models in the model table. Each list contains from one to three numbers which indicate a possible move. Each list is terminated by a 200 octal entry. The move numbers range in value from 1 to 15, and indicate possible moves taken from the list on the following page.

The move number is a number which is contained in the move index table. The number in the FROM column is the square on the playing board that the program's pawn is to be moved from. The TO column contains the square that the program's pawn is to be moved to. The result of the move is indicated in the last column. When a number of a move is read from the move index table, it is used to set up a pointer to the MOVE table.

The move table contains a four byte grouping for each of the

MOVE NO.	FROM	TO	RESULT
1	1	4	---
2	1	5	CAPTURE
3	2	4	CAPTURE
4	2	5	---
5	2	6	CAPTURE
6	3	5	CAPTURE
7	3	6	---
8	4	7	COMPUTER WINS
9	4	8	COMPUTER WINS
10	5	7	COMPUTER WINS
11	5	8	COMPUTER WINS
12	5	9	COMPUTER WINS
13	6	8	COMPUTER WINS
14	6	9	COMPUTER WINS
15	-	-	DRAW

moves in the table above. The first byte has one bit set. This bit represents the original position of the program's pawn which is to be moved (as discussed previously). The second byte has a bit set to represent the position to which the program's pawn will be moved. The third byte indicates the position of the player's pawn which will be captured by the move, if the move results in a capture. If no capture will be made, the third byte will be all zeros. The fourth byte depicts the result of the move. If the fourth byte is zero, the program will continue with the game by requesting a move by the human. If the move results in the computer winning, the fourth byte will contain the ASCII code for the number of the square the computer will move into to win the game. This code is used in setting up the winning message. If the move will result in a draw, the fourth byte will contain the octal value 100. The following example contains the four byte group used to define move number three. The reader may note that bytes 2 and 3 both correspond to square 4 of the playing board. Byte 2 indicates the program's pawn moving to square 4, and byte 3 indicates the human's pawn at square 4 being captured by the move.

MOVE NO. 3	BYTE NO. 1	100
	BYTE NO. 2	020
	BYTE NO. 3	040
	BYTE NO. 4	000

The move index table is the means by which the program learns to play the game. Each time a move is selected from the move index table that location in the table is saved. After every move, a test for a possible win by the human is made. If the human wins, the location in the move index table which was saved by the program is zeroed. Once zeroed, the program will not be able to make the same move. The program will skip that location and make the next move indicated in the list. For example, suppose in the first game the player's first move was from 7 to 4. The program would find the first model in the model table as a match. It would fetch the pointer from the first location in the model-to-move index table and select move 7 as its first move. This sequence is illustrated below.

MODEL TABLE	MODEL-TO-MOVE TABLE	MOVE INDEX TABLE	MOVE TABLE
340 →	000 →	007	.
043	003	004	.
.	.	003	040
.	.	200	004
.	.	.	000
.	.	.	000
.	.	.	.

From this sequence it may be observed that the program has moved from square 3 to 6. This move allows the human to win easily by moving from square 4 to 2 thus capturing the program's pawn. The program then removes 007 from the list of moves for the first model by loading a 000 in the first location of that list. Now, if the human makes the same opening move of square 7 to square 4, the program will skip the first location in the list of moves for the first model, since it is zero. It will then make the second move, which is move number 4. Thus, the program has learned that move number 7 was not the proper move to make for that particular board model.

Another manner in which the program learns is when all the moves for a specific model have been zeroed. When the program searches the move index table for a move, and it reaches the 200 byte, which terminates the list, it concedes the game to the human. The program knows that on the next move, no matter what move it makes, it will lose the game. At this point the program will go back to the previous move that it made before getting into the predicament and zero it in the move index table. In this way, the program is prevented from making the same move which brought it to the point of having to concede the game.

TEXT MESSAGES USED IN HEXPAWN

There are several messages used in Hexpawn to inform the human player of the setup of the game, to indicate when the human has input an illegal move, to display the current board configuration, and to signify the outcome of the game. These messages are of variable length, and may require more than one line of output. The content of these messages may be altered by the reader, if desired, to reflect greater emotion by the program at winning and losing. The messages presented here were kept fairly low key to conserve memory space, since the operating program and associated tables alone require almost 1K bytes of memory. The message strings are presented next.

```
"HERE'S THE BOARD
 1!2!3
 4!5!6
 7!8!9
I'M X, YOU'RE O
MOVE ONE SQUARE FORWARD IF VACANT
OR ONE SQUARE DIAGONALLY TO CAPTURE
YOU START."

"NO ! NO !"
```

"I CONCEDE!"

"YOU WIN."

"NO GOOD! MUST START AGAIN"

"DRAW, NO ONE WINS."

"I MOVE TO .
I WIN! YOU LOSE!"

"I WIN! YOU HAVE NO PAWNS."

These text messages are stored as a continuous string of ASCII characters with each message terminated by a zero byte. The playing board, however, is stored on the same page as the model table and temporary data, as it is updated after each move by the program. The board output, FROM and TO messages are stored as shown next.

```
"X ! X ! X
   !   !
 O ! O ! O
 FM  "  "  TO  "
```

The program uses a common subroutine to output these messages to the user's output device. This subroutine is called with memory pointer registers H and L set to the starting address of a message. It fetches each character from the storage area and presents it to the user's output routine in the accumulator. When it encounters the zero byte, it returns to the calling program. The listing for this routine is presented next. It is labeled MSG.

```
MSG,    LAM          Fetch character to print
        NDA          End of message?
        RTZ          Yes, return
        CAL PRINT    No, print character
        INL          Incr low addr msg pointer
        JFZ MSG      If non-0, continue output
        INH          Else, incr page addr pointer
        JMP MSG
```

As one can see, the MSG subroutine is quite straight-forward. It simply fetches characters from memory starting at the location set up by the calling program in the H and L registers, and calls the user provided subroutine PRINT to output the character to the system output device. The PRINT subroutine must take the character in the accumulator and perform whatever is required to output that character to the printer or display device. This routine is free to use registers B through E in outputting the character. The only requirement is that if registers H and L must be used, they must be restored to their initial value before returning to the MSG subroutine.

The MSG subroutine is called to output every message by this program. Therefore, in order to change the messages, the reader simply stores the ASCII codes for the messages desired in a continuous string in memory, and then stores a zero byte to terminate the message. To output a message, the program sets the pointer to the starting address of the message and calls the MSG subroutine.

THE HEXPAWN PROGRAM

The reader may refer to the flow chart presented previously during the following discussion of the operating portion of the program.

The first part of the Hexpawn program outputs the introductory message and resets the move index table to its initial state of intelligence. The move index table is initialized by transferring the contents of the RESTORE MOVE list into the ACTIVE MOVE list. The restore move list is a copy of the move index table with all the possible moves contained in it. The active move list is actually the move index table, which will have its contents zeroed as the program learns to play the game. This restore routine transfers the upper half of page 04, which contains the restore list and the beginning of the text messages, down to the lower half of page 04, which contains the active move list, or move index table. The actual list, however, only requires approximately 3/8 of the page. This should be noted so that one does not try to store messages in the area from 137 through 177 on page 04.

This restore routine is performed only when the program is started at the beginning. After each game is completed, the program returns to the next section, starting at the label AGAIN so that the move index table will not be reset. The only way that the move index table can be reset is for the operator to restart the program.

The listing for the initial portion of the Hexpawn program is presented below.

```
START,    LLI 076     Set pointer to intro. msg
          LHI 005
          CAL MSG     Print introduction
          LHI 004     Set pointer to move index pg
          LDI 000     Init. actv move list pointer
          LEI 200     Init. rstr move list pointer
 RSTR,    LLE         Set restore list pointer
          LAM         Fetch restore list entry
          LLD         Set pointer to active list
          LMA         Store entry in active list
          IND         Increment active list pointer
          INE         Increment restore list pointer
          JFZ RSTR    Done? No, cont. transfer
```

The next section of the program is the one which prepares the board output to display the current setup of the playing board. There are two points at which the program enters this routine. The first is at the instruction labeled AGAIN. This entry point resets the playing board, as stored in locations 03 000 for the X pawns, and 03 001 for the O pawns. This is the starting setup as shown in the figure on the first page of this chapter. It then proceeds to the other entry point of this routine. The second entry point is labeled PBD. This point is entered when the program is in the middle of a game. This portion of the routine sets up the board output message to display the current positions of the pawns in the following manner.

First, the board output message is cleared by storing space characters, ASCII code 240, at the locations in the board output that represent the possible pawn positions. The current positions of the X pawns and O pawns are then determined by the subroutines STX and STO.

When the STX subroutine is first called, the accumulator contains the current X board as stored in location 03 000. This is rotated left one bit to load the CARRY with the condition of square 1 with respect to the presence of an X pawn. If the carry is set to 1, the ASCII code for an X is stored in the location of square 1 in the board output message. If the carry is reset to 0, the routine simply returns and the contents of square 1 remain a space character. The next time STX is called, the accumulator contains the current X board rotated to the left one bit so that when it is rotated to the left again the carry will indicate the presence, or absence, of an X pawn for square 2. Each time the STX routine is called, the memory pointer registers H and L are set to indicate the location in the board output message where the X is to be stored if it is present at that location. The STO subroutine stores the ASCII code for the 0 character in the locations in the board output message where there are 0 pawns present in a manner similar to the STX subroutine. When the board output message is set to reflect the current board set up, the MSG subroutine is called to display the board for the player to examine. The following is the listing of this board set up and display routine.

```
AGAIN,   LLI 000     Set pointer to current board
         LHI 003
         LMI 340     Set board to starting setup
         INL
         LMI 007
PBD,     LLI 302     Set pointer to brd printout
         LBI 240     Set space char to clear board
         LMB         Store space in '1'
         LLI 304
         LMB         Store space in '2'
         LLI 306
         LMB         Store space in '3'
         LLI 311
         LMB         Store space in '4'
         LLI 313
         LMB         Store space in '5'
         LLI 315
         LMB         Store space in '6'
         LLI 320
         LMB         Store space in '7'
         LLI 322
```

```
LMB         Store space in '8'
LLI 324
LMB         Store space in '9'
LLI 000     Set pointer to current X board
LAM         Fetch X board
INL         Advance to O board
LBM         Fetch current O board
LLI 302     Set pointer to 1 position
CAL STX     If X here, store character
LLI 304     Set pointer to 2 position
CAL STX     If X here, store character
LLI 306     Set pointer to 3 position
CAL STX     If X here, store character
LLI 311     Set pointer to 4 position
CAL STX     If X here, store character
LCA         Save X board
LAB         Fetch O board
RLC         Position to 4
RLC
CAL STO     If O here, store character
LBA         Save O board
LLI 313     Set pointer to 5 position
LAC         Fetch X board
CAL STX     If X here, store character
LCA         Save X board
LAB         Fetch O board
CAL STO     If O here, store character
LBA         Save O board
LLI 315     Set pointer to 6 position
LAC         Fetch X board
CAL STX     If X here, store character
LAB         Fetch O board
CAL STO     If O here, store character
LLI 320     Set pointer to 7 position
CAL STO     If O here, store character
LLI 322     Set pointer to 8 position
CAL STO     If O here, store character
LLI 324     Set pointer to 9 position
CAL STO     If O here, store character
LLI 300     Set pointer to board printout
```

```
        CAL MSG      Print current board

STX,    RLC          Bit set?
        RFC          No, return
        LMI 330      Yes, put X in board
        RET

STO,    RLC          Bit set?
        RFC          No, return
        LMI 317      Yes, put O in board
        RET
```

After the current board is outputted, the program requests the player to enter a move by first entering the number of the square which contains the pawn to be moved, and then the number of the square to which the pawn is to be moved. The input request is indicated by the output of the message FM which is output as part of the board output message. The program then calls the user supplied input routine to accept a character from the system input device.

The input subroutine is a user provided routine which must input a character from the keyboard device and return with the ASCII code for that character in the accumulator. This subroutine is free to use registers A through E in inputting the character. If registers H and L are required to be used, they must be restored to their original contents before returning to the calling program. If the system's input device does not provide automatic echo of the inputted character to the output device, this input routine should include some provision for echoing the character received to the output device. This subroutine is called only in the move input routine being presented here.

When the FROM square is received, it is checked first to determine whether it is a valid number from 1 to 9, since these are the only valid entries expected. This is checked by calling the FNUM subroutine. If the input is not within these limits, the ERROR routine is entered. The error routine is called at several points in the next group of routines whenever the move which has been input is found to be illegal. The error routine prints the message "NO! NO!"

and then jumps to the PBD entry point of the program to request a new input.

If the FROM input is valid, the 260 portion of the ASCII code is removed, and the binary value of the number entered is stored in location 03 002. The current O board is then checked to determine whether an O pawn does reside in the square designated by the input. The binary value of the FROM square is used as a counter by the RTAL subroutine which rotates the current O board until the carry bit indicates the presence or absence of an O pawn in that position. If there is no O pawn, the error routine is entered.

The message TO is then output and the INPUT routine is called to input the square to which the pawn is to be moved. This input is also checked by calling the FNUM routine to determine whether it is within the limits of the expected input. If it is valid, it is changed to its binary value and stored in location 03 003. The program then proceeds to the next routine which checks that the move is legal.

The listing for this portion of the program is presented below.

```
LLI 002       Set pointer to input storage
CAL INPUT     Input FM move
LMA           Save input
CAL FNUM      Number valid?
JTS ERROR     No, error
LAM           Fetch number
NDI 017       Delete ASCII code
LMA           Save FM location
LBA           Save bit count for RTAL
DCL           Set pointer to O board
LAM           Fetch O board
CAL RTAL      Is pawn in FM position?
JFC ERROR     No, illegal move
LLI 333       Set pointer to TO msg
CAL MSG       Print TO
LLI 003       Set pointer to input storage
CAL INPUT     Input TO move
LMA           Save TO input
```

```
            CAL FNUM      Input valid?
            JTS ERROR     No, error
            LAM           Fetch number
            NDI 017       Delete ASCII code
            LMA           Save TO location

ERROR,      LLI 364       Set pointer to error message
            LHI 005
            CAL MSG       Print error message
            LHI 003
            JMP PBD       Print current board

RTAL,       DCB           Decrement bit count
            RTZ           If zero, return
            RLC           Else, rotate left
            JMP RTAL

FNUM,       LAM           Fetch ASCII number
            CPI 261       Is number valid?
            RTS           No, return with S flag set
            SUI 272       If number is valid, return
            ADI 200       With S flag set
            RET
```

Once the FROM and TO values are received, the move must be checked to determine whether it is legal. First, a move forward is checked by subtracting 3 from the FROM value and checking it with the value stored for the TO value. If the move is forward one square, the position of the X pawns must be checked to make sure an X pawn is not blocking the move. The BLK routine is entered to check the forward move. BLK sets the TO value as a counter and fetches the current X board, which is then rotated left by the RTAL subroutine, placing the bit corresponding to the location the O pawn is to be moved, to the sign position in the accumulator. If this bit is set, the move is blocked by an X pawn and the error routine is entered. If not, the BLK routine returns to the mainstream of the program at the HMV label to make the move as entered.

If the move is not forward, a diagonal move to the left or right is examined. By adding 1 to the forward move, the new value indicates a diagonal move to the right. If this matches the TO value, and is not equal to 7, which would be an illegal move from 9 to 7, the capture of an X pawn is checked, since a diagonal move must capture an opponent's pawn. If the move is not to the right, 2 is subtracted from the forward move and a diagonal move to the left is tested. If this matches and it is not equal to 3, indicating an illegal move from 7 to 3, an X pawn capture will be checked. If any of the above illegal conditions occur, the error routine is entered. When a capture move is indicated, the bit position in the current X board of the bit to be deleted is set up by the RTLP subroutine. The presence of an X pawn is checked, and if not there, the error routine is entered.

Once the preliminaries are complete, the move is checked for a win by the human player. If the move is to square 1, 2, or 3, the human has won the game. The HWIN routine is then entered to perform the required steps to teach the program. This is accomplished by zeroing the last move made by the program in the move index table. The HWIN routine then outputs a congratulatory message and starts a new game.

If the move does not result in a win, the move is entered in the current O board by resetting the bit indicating the FROM position and setting the bit indicating the TO position. If a capture was made, the bit in the current X board in the TO position is reset.

The listing for this routine is shown below.

```
DCL          Set FM pointer
LAM          Fetch FM
SUI 003      Is move forward?
INL          Check against TO
CPM
JTZ BLK      Yes, check if legal
ADI 001      No, move right 1 square
CPM          Is TO here
JTZ CKCAP    Yes, check for capture
SUI 002      No, move left 1 square
CPI 003      Is move from 7 to 3?
```

```
        JTZ ERROR     Yes, illegal
        CPM           Is TO here?
        JFZ ERROR     No, illegal move
CKCAP,  CPI 007       Is move to 7?
        JTZ ERROR     Yes, error
        LBM           Fetch TO move
        LAI 200       Set up to calculate capture
        CAL RTLP      Bit by rotating right
        LEA           Save capture bit
        LLI 000       Set X board pointer
        NDM           Capture?
        JTZ ERROR     No, illegal move
HMV,    LLI 002       Set pointer to FM
        LAM           Fetch FM location
        CAL RTAR      Set up FM bit
        LDA           Save FM bit
        INL           Set pointer to TO
        LAM           Fetch TO location
        CPI 004       Human wins?
        JTC HWIN      Yes, zero last move
        CAL RTAR      Set up TO bit
        LCA           Save TO bit
        LLI 001       Set pointer to current O board
        LAM           Fetch current board
        XRD           Clear old set
        ORC           Set new position
        LCA           Save new O board
        LMA           Save current board
        DCL
        LAE           Fetch capture bit
        NDA           Capture?
        JTZ NOCP      No, skip
        XRM           Yes, delete piece
        LMA           Save current X board

RTAR,   LBA           Set bit count
        LAI 001       Set bit to rotate
RTLP,   DCB           Decrement bit count
        RTZ           If zero, return
        RRC           Else, rotate right
```

```
          JMP RTLP

BLK,      LBM            Fetch TO move
          LLI 000        Set pointer to X board
          LAM            Fetch X board
          CAL RTAL       Check for blocked move
SET,      NDA            Is move blocked?
          JTS ERROR      Yes, illegal move
          LEI 000        Set for no capture
          JMP HMV        Return to make human move

HWIN,     LLI 004        Set pointer to last move
          LHI 003
          LLM            Fetch last move address
          LHI 004
          LMI 000        Zero last move
          LLI 315        Set pointer to lose message
          LHI 005
          CAL MSG        Print lose message
          JMP AGAIN      Start new game
```

Now that the human's move has been entered, it is time for the program to show what it knows about the game. This is the portion of the program which performs the table search and makes the resultant move that the program believes correct at the time for the given board configuration. The program first searches the model table for a matching model. If none is found, it is assumed that the move just input by the human is invalid. Some of the conditions which were not checked in the move input routine include a move forward into a square already occupied by an O pawn. (This results in the human eliminating one of his own pawns.) Or, a move from square 6 to square 4 in which an X pawn is captured. These moves will slip through the initial validity tests, but they do result in illegal board setups which are caught here. The only recourse for the program at this time is to start the game over again because the current board is unrecognizible.

When a model is found where the current X board and current O board match a byte pair in the model table, a pointer is calculated from the relative position in the model table to the model-to-move index table. This pointer is calculated by dividing the low address of the X byte of the matching model by 2 and adding 106 to the result. The pointer is used to fetch the starting address of the list of possible moves in the move index table from the model-to-move index table.

The designated list of moves is then examined, and the first non-zero entry is used as the move the program will make in response to the current board model. If the program encounters a 200 byte in searching the table, it jumps to the ONO (OH! NO!) routine. Reaching a 200 byte indicates the program has made every move it can for the model, and they all lead to defeat. The ONO routine concedes defeat and also goes to the HWIN routine to eliminate the previous move with the intent that this model will not be encountered again.

When a move is found, a pointer is set up using the move number and the four bytes of the move are fetched from the move table. The last byte of this group is examined first to determine whether the program has won the game, indicated by the sign bit set in the last byte. Or, if the game is a draw, indicated by a 100 stored in the last byte. If the game is won by the computer, the WIN routine is entered to print the winning message and start a new game. If the game is a draw, the DRAW routine is entered, to print the draw message and start a new game. If the last byte is zero, the move is made as indicated by the first three bytes. The first byte has the bit set which is the FROM location of the X move, the second byte has the bit set which is the TO location of the X board and the third byte has the bit set which indicates which location in the O board has been captured. If the third byte is zero, the move does not capture any O pawn, and the game is continued by jumping to PBD.

When a capture is made, the O board is checked to determine whether all the O pawns have been captured. If so, the program has won the game. At this point, the program deletes the move that it has just made from the move table because it knows that if there was only one O pawn on the board, the program has a move open which will allow it to win by moving to the opponent's side rather than gobbling up the last pawn. The program will then print a message to inform the human that he has no more pawns!

The listing for this final routine of the Hexpawn program is presented next. The reader will note the common MSG call followed by a jump to AGAIN which starts a new game. This instruction pair, labeled CMSG, was set up to conserve program space, as it is a common sequence used by several routines to print game concluding messages and then begin a new game.

```
NOCP,   LDM          Save new X board
        LLI 010      Set pointer to model table
SMDL,   LAD          Fetch X board
        CPM          X board match model?
        JTZ OHLF     Yes, try O half
        INL          Advance table pointer
SMD1,   INL
        LAL          Check for end of table
        CPI 112      End of table?
        JFZ SMDL     No, continue search
        LLI 340      No match, illegal move made
        LHI 004      Print "NO GOOD!"
CMSG,   CAL MSG      Print message
        JMP AGAIN    Start new game

OHLF,   INL          Advance pointer to O board
        LAC          Fetch current O board
        CPM          O boards match?
        JFZ SMD1     No, continue search

        DCL          Move pointer to X board
        LAL          Set up to calculate pointer
        RRC          Divide by 2
        ADI 106      Add to start of mdl index tbl
        LLA          Set pointer to mdl index tbl
        LLM          Fetch pntr to move index tbl
        LHI 004      Set pntr to move index table
MFD1,   LAM          Fetch move number
        NDA          Move number here?
        JTS ONO      No move avail. Human wins
        JFZ MOVE     Move found, make it
        INL          Move zeroed, try next location
```

```
          JMP MFD1

MOVE,     LEL           Save move location
          LLI 004       Set pointer to last move
          LHI 003
          LME           Save location as last move
          RLC           Set up pointer to move
          RLC           Storage table
          ADI 174
          LLA           Set pointer
          LDM           Fetch FM bit
          INL           Advance pointer
          LCM           Fetch TO bit
          INL           Advance pointer
          LEM           Fetch capture bit
          INL           Advance pointer
          LAM           Fetch contest bit
          NDA           Is game over?
          JTS WIN       Yes, computer wins
          JFZ DRAW      Yes, draw
          LLI 000       Set pointer to X board
          LAM           Fetch current X board
          XRD           Clear old position
          ORC           Set new position
          LMA           Save new X board
          INL           Advance pointer to O board
          LAE           Fetch capture bit
          NDA           Capture?
          JTZ PBD       No, print new board
          XRM           Yes, delete piece
          LMA           Save new O board
          JFZ PBD       Non-0, continue game

          LLI 004       Set pointer to last move
          LLM           Fetch last move location
          LHI 004       Set pointer to active move list
          LMI 000       Cancel last move
          LHI 005       Set pointer to msg "I WIN
          LLI 330       YOU HAVE NO PAWNS!"
          CAL CMSG      Print msg and start again
```

```
WIN,    LLI 025      Set pointer to store win move
        LHI 005
        LMA          Store win move in message
        LLI 011      Print "I MOVE TO  ."
        JMP CMSG     "I WIN, YOU LOSE"

DRAW,   LLI 052      Prnt 'DRAW, NO ONE WINS'
        LHI 005
        JMP CMSG     Print draw message

ONO,    LLI 374      Print "I CONCEDE!"
        LHI 004
        CAL MSG      Then zero last move
```

Well! That's it! Now the Hexpawn program is presented in its final assembled form to be loaded into an 8008 based microcomputer system. The operating portion of the program resides on pages 01 and 02 and the tables and messages are on pages 03 through 05. Due to the length of assembled listings for the tables and messages, they will be presented as an octal dump.

```
001 000   066 076          START,  LLI 076
001 002   056 005                  LHI 005
001 004   106 171 002              CAL MSG
001 007   056 004                  LHI 004
001 011   036 000                  LDI 000
001 013   046 200                  LEI 200
001 015   364              RSTR,   LLE
001 016   307                      LAM
001 017   363                      LLD
001 020   370                      LMA
001 021   030                      IND
001 022   040                      INE
001 023   110 015 001              JFZ RSTR
001 026   066 000          AGAIN,  LLI 000
001 030   056 003                  LHI 003
001 032   076 340                  LMI 340
```

```
001 034    060                           INL
001 035    076 007                       LMI 007
001 037    066 302                 PBD,  LLI 302
001 041    016 240                       LBI 240
001 043    371                           LMB
001 044    066 304                       LLI 304
001 046    371                           LMB
001 047    066 306                       LLI 306
001 051    371                           LMB
001 052    066 311                       LLI 311
001 054    371                           LMB
001 055    066 313                       LLI 313
001 057    371                           LMB
001 060    066 315                       LLI 315
001 062    371                           LMB
001 063    066 320                       LLI 320
001 065    371                           LMB
001 066    066 322                       LLI 322
001 070    371                           LMB
001 071    066 324                       LLI 324
001 073    371                           LMB
001 074    066 000                       LLI 000
001 076    307                           LAM
001 077    060                           INL
001 100    317                           LBM
001 101    066 302                       LLI 302
001 103    106 157 002                   CAL STX
001 106    066 304                       LLI 304
001 110    106 157 002                   CAL STX
001 113    066 306                       LLI 306
001 115    106 157 002                   CAL STX
001 120    066 311                       LLI 311
001 122    106 157 002                   CAL STX
001 125    320                           LCA
001 126    301                           LAB
001 127    002                           RLC
001 130    002                           RLC
001 131    106 164 002                   CAL STO
001 134    310                           LBA
001 135    066 313                       LLI 313
```

```
001 137    302                             LAC
001 140    106 157 002                     CAL STX
001 143    320                             LCA
001 144    301                             LAB
001 145    106 164 002                     CAL STO
001 150    310                             LBA
001 151    066 315                         LLI 315
001 153    302                             LAC
001 154    106 157 002                     CAL STX
001 157    301                             LAB
001 160    106 164 002                     CAL STO
001 163    066 320                         LLI 320
001 165    106 164 002                     CAL STO
001 170    066 322                         LLI 322
001 172    106 164 002                     CAL STO
001 175    066 324                         LLI 324
001 177    106 164 002                     CAL STO
001 202    066 300                         LLI 300
001 204    106 171 002                     CAL MSG
001 207    066 002                         LLI 002
001 211    106 000 006                     CAL INPUT
001 214    370                             LMA
001 215    106 303 002                     CAL FNUM
001 220    160 207 002                     JTS ERROR
001 223    307                             LAM
001 224    044 017                         NDI  017
001 226    370                             LMA
001 227    310                             LBA
001 230    061                             DCL
001 231    307                             LAM
001 232    106 223 002                     CAL RTAL
001 235    100 207 002                     JFC ERROR
001 240    066 333                         LLI 333
001 242    106 171 002                     CAL MSG
001 245    066 003                         LLI 003
001 247    106 000 006                     CAL INPUT
001 252    370                             LMA
001 253    106 303 002                     CAL FNUM
001 256    160 207 002                     JTS ERROR
001 261    307                             LAM
```

```
001 262    044 017                      NDI 017
001 264    370                          LMA
001 265    061                          DCL
001 266    307                          LAM
001 267    024 003                      SUI 003
001 271    060                          INL
001 272    277                          CPM
001 273    150 242 002                  JTZ BLK
001 276    004 001                      ADI 001
001 300    277                          CPM
001 301    150 317 001                  JTZ CKCAP
001 304    024 002                      SUI 002
001 306    074 003                      CPI 003
001 310    150 207 002                  JTZ ERROR
001 313    277                          CPM
001 314    110 207 002                  JFZ ERROR
001 317    074 007              CKCAP,  CPI 007
001 321    150 207 002                  JTZ ERROR
001 324    317                          LBM
001 325    006 200                      LAI 200
001 327    106 234 002                  CAL RTLP
001 332    340                          LEA
001 333    066 000                      LLI 000
001 335    247                          NDM
001 336    150 207 002                  JTZ ERROR
001 341    066 002              HMV,    LLI 002
001 343    307                          LAM
001 344    106 231 002                  CAL RTAR
001 347    330                          LDA
001 350    060                          INL
001 351    307                          LAM
001 352    074 004                      CPI 004
001 354    140 323 002                  JTC HWIN
001 357    106 231 002                  CAL RTAR
001 362    320                          LCA
001 363    066 001                      LLI 001
001 365    307                          LAM
001 366    253                          XRD
001 367    262                          ORC
001 370    320                          LCA
```

```
001 371    370                       LMA
001 372    061                       DCL
001 373    304                       LAE
001 374    240                       NDA
001 375    150 002 002               JTZ NOCP
002 000    257                       XRM
002 001    370                       LMA
002 002    337              NOCP,    LDM
002 003    066 010                   LLI 010
002 005    303              SMDL,    LAD
002 006    277                       CPM
002 007    150 034 002               JTZ OHLF
002 012    060                       INL
002 013    060              SMD1,    INL
002 014    306                       LAL
002 015    074 112                   CPI 112
002 017    110 005 002               JFZ SMDL
002 022    066 340                   LLI 340
002 024    056 004                   LHI 004
002 026    106 171 002      CMSG,    CAL MSG
002 031    104 026 001               JMP AGAIN
002 034
002 034    060              OHLF,    INL
002 035    302                       LAC
002 036    277                       CPM
002 037    110 013 002               JFZ SMD1
002 042
002 042    061                       DCL
002 043    306                       LAL
002 044    012                       RRC
002 045    004 106                   ADI 106
002 047    360                       LLA
002 050    367                       LLM
002 051    056 004                   LHI 004
002 053    307              MFD1,    LAM
002 054    240                       NDA
002 055    160 314 002               JTS ONO
002 060    110 067 002               JFZ MOVE
002 063    060                       INL
002 064    104 053 002               JMP MFD1
```

```
002 067    346                    MOVE,  LEL
002 070    066 004                       LLI 004
002 072    056 003                       LHI 003
002 074    374                           LME
002 075    002                           RLC
002 076    002                           RLC
002 077    004 174                       ADI 174
002 101    360                           LLA
002 102    337                           LDM
002 103    060                           INL
002 104    327                           LCM
002 105    060                           INL
002 106    347                           LEM
002 107    060                           INL
002 110    307                           LAM
002 111    240                           NDA
002 112    160 262 002                   JTS WIN
002 115    110 274 002                   JFZ DRAW
002 120    066 000                       LLI 000
002 122    307                           LAM
002 123    253                           XRD
002 124    262                           ORC
002 125    370                           LMA
002 126    060                           INL
002 127    304                           LAE
002 130    240                           NDA
002 131    150 037 001                   JTZ PBD
002 134    257                           XRM
002 135    370                           LMA
002 136    110 037 001                   JFZ PBD
002 141
002 141    066 004                       LLI 004
002 143    367                           LLM
002 144    056 004                       LHI 004
002 146    076 000                       LMI 000
002 150    056 005                       LHI 005
002 152    066 330                       LLI 330
002 154    106 026 002                   CAL CMSG
002 157
002 157    002                    STX,   RLC
```

```
002 160    003                        RFC
002 161    076 330                    LMI 330
002 163    007                        RET
002 164
002 164    002                  STO,  RLC
002 165    003                        RFC
002 166    076 317                    LMI 317
002 170    007                        RET
002 171
002 171    307                  MSG,  LAM
002 172    240                        NDA
002 173    053                        RTZ
002 174    106 100 006                CAL PRINT
002 177    060                        INL
002 200    110 171 002                JFZ MSG
002 203    050                        INH
002 204    104 171 002                JMP MSG
002 207
002 207    066 364            ERROR,  LLI 364
002 211    056 005                    LHI 005
002 213    106 171 002                CAL MSG
002 216    056 003                    LHI 003
002 220    104 037 001                JMP PBD
002 223
002 223    011                 RTAL,  DCB
002 224    053                        RTZ
002 225    002                        RLC
002 226    104 223 002                JMP RTAL
002 231
002 231    310                 RTAR,  LBA
002 232    006 001                    LAI 001
002 234    011                 RTLP,  DCB
002 235    053                        RTZ
002 236    012                        RRC
002 237    104 234 002                JMP RTLP
002 242
002 242    317                  BLK,  LBM
002 243    066 000                    LLI 000
002 245    307                        LAM
002 246    106 223 002                CAL RTAL
```

```
002 251   240                    SET,   NDA
002 252   160 207 002                   JTS ERROR
002 255   046 000                       LEI 000
002 257   104 341 001                   JMP HMV
002 262
002 262   066 025                WIN,   LLI 025
002 264   056 005                       LHI 005
002 266   370                           LMA
002 267   066 011                       LLI 011
002 271   104 026 002                   JMP CMSG
002 274
002 274   066 052                DRAW,  LLI 052
002 276   056 005                       LHI 005
002 300   104 026 002                   JMP CMSG
002 303
002 303   307                    FNUM,  LAM
002 304   074 261                       CPI 261
002 306   063                           RTS
002 307   024 272                       SUI 272
002 311   004 200                       ADI 200
002 313   007                           RET
002 314
002 314   066 374                ONO,   LLI 374
002 316   056 004                       LHI 004
002 320   106 171 002                   CAL MSG
003 323
002 323   066 004                HWIN,  LLI 004
002 325   056 003                       LHI 003
002 327   367                           LLM
002 330   056 004                       LHI 004
002 332   076 000                       LMI 000
002 334   066 315                       LLI 315
002 336   056 005                       LHI 005
002 340   106 171 002                   CAL MSG
002 343   104 026 001                   JMP AGAIN
002 346
```

TEMPORARY DATA

```
003 000          000  000  000  000  000
```

MODEL TABLE

003 010	340	043	340	016	340	025	260	021
003 020	150	041	240	062	300	051	150	014
003 030	160	034	260	012	304	061	140	054
003 040	140	021	140	024	240	041	070	010
003 050	200	070	120	030	104	060	230	010
003 060	240	014	210	042	054	040	060	020
003 070	110	040	110	010	220	020	044	020
003 100	200	060	240	032	100	020	250	052
003 110	040	070						

MODEL-TO-MOVE INDEX TABLE

003 112			000	004	010	013	017	023
003 120	027	033	036	041	043	046	051	054
003 130	057	061	063	065	070	073	075	077
003 140	101	103	107	112	115	120	123	125
003 150	131	133	135					

MOVE TABLE

003 200	200	020	000	000	200	010	020	000
003 210	100	020	040	000	100	010	000	000
003 220	100	004	010	000	040	010	020	000
003 230	040	004	000	000	020	000	000	267
003 240	020	000	000	270	010	000	000	267
003 250	010	000	000	270	010	000	000	271
003 260	004	000	000	270	004	000	000	271
003 270	000	000	000	100				

BOARD OUTPUT MESSAGE

003 300	215	212	330	336	330	336	330	215
003 310	212	240	336	240	336	240	215	212
003 320	317	336	317	336	317	215	212	306
003 330	315	240	000	240	324	317	240	000

MOVE INDEX TABLE

004 000	007	004	003	200	001	004	005	200
004 010	001	002	200	007	006	010	200	007
004 020	003	013	200	007	002	006	200	003
004 030	004	017	200	005	012	200	005	006
004 040	200	010	200	002	003	200	005	017
004 050	200	006	017	200	006	007	200	017
004 060	200	010	200	002	200	005	010	200
004 070	003	016	200	013	200	017	200	017
004 100	200	016	200	007	006	010	200	003
004 110	013	200	005	013	200	002	010	200
004 120	006	016	200	002	200	001	006	017
004 130	200	017	200	017	200	006	200	

RESTORE LIST

004 200	007	004	003	200	001	004	005	200
004 210	001	002	200	007	006	010	200	007
004 220	003	013	200	007	002	006	200	003
004 230	004	017	200	005	012	200	005	006
004 240	200	010	200	002	003	200	005	017
004 250	200	006	017	200	006	007	200	017
004 260	200	010	200	002	200	005	010	200
004 270	003	016	200	013	200	017	200	017
004 300	200	016	200	007	006	010	200	003
004 310	013	200	005	013	200	002	010	200
004 320	006	016	200	002	200	001	006	017
004 330	200	017	200	017	200	006	200	

MESSAGE STORAGE

004 340	215	212	316	317	240	307	317	317
004 350	304	241	240	315	325	323	324	240
004 360	323	324	301	322	324	240	301	307
004 370	301	311	316	000	215	212	311	240
005 000	303	317	316	303	305	304	305	241

005	010	000	215	212	311	240	315	317	326
005	020	305	240	324	317	240	240	254	215
005	030	212	311	240	327	311	316	241	240
005	040	331	317	325	240	314	317	323	305
005	050	241	000	215	212	304	322	301	327
005	060	254	316	317	240	317	316	305	240
005	070	327	311	316	323	256	000	215	212
005	100	310	305	322	305	247	323	240	324
005	110	310	305	240	302	317	301	322	304
005	120	215	212	261	336	262	336	263	215
005	130	212	264	336	265	336	266	215	212
005	140	267	336	270	336	271	215	212	311
005	150	247	315	240	330	254	240	331	317
005	160	325	247	322	305	240	317	215	212
005	170	315	317	326	305	240	317	316	305
005	200	240	323	321	325	301	322	305	240
005	210	306	317	322	327	301	322	304	240
005	220	311	306	240	326	301	303	301	316
005	230	324	215	212	317	322	240	317	316
005	240	305	240	323	321	325	301	322	305
005	250	240	304	311	301	307	317	316	301
005	260	314	314	331	240	324	317	240	303
005	270	301	320	324	325	322	305	215	212
005	300	331	317	325	240	323	324	301	322
005	310	324	256	215	212	000	215	212	331
005	320	317	325	240	327	311	316	256	000
005	330	215	212	311	240	327	311	316	241
005	340	240	331	317	325	240	310	301	326
005	350	305	240	316	317	240	320	301	327
005	360	316	323	256	000	215	212	316	317
005	370	241	240	316	317	241	000		

006	000	000	INPUT
006	100	000	PRINT

After loading the Hexpawn program into memory, the program execution is begun by jumping to the start address of the program which is at location 000 on page 01. The program will print the introductory message followed by the starting position of the playing board. When the FM is displayed, the player enters the number of the square from which the pawn is to be moved. The program then prints TO, and the player enters the number of the square to which the pawn is to go. The program then makes its move, and the new board configuration is displayed. When the outcome of the game is evident to the program, a message is printed to indicate win, lose, or draw. A sample of three consecutive games is listed below. Note how the program goes through its learning process as the human player makes the same sequence of moves in each game.

```
HERE'S THE BOARD
1|2|3
4|5|6
7|8|9
I'M X, YOU'RE O
MOVE ONE SQUARE FORWARD IF VACANT
OR ONE SQUARE DIAGONALLY TO CAPTURE
YOU START.

X|X|X
 | |
O|O|O
FM 8 TO 5
 |X|X
X|O|
O| |O
FM 9 TO 6
 | |X
X|O|X
O| |
FM 5 TO 2
YOU WIN.
```

```
X|X|X
 | |
O|O|O
FM 8 TO 5
 |X|X
X|O|
O| |O
FM 9 TO 6
 |X|
X|X|O
O| |
FM 7 TO 5
 | |
X|O|X
 | |
FM 5 TO 2
YOU WIN.
X|X|X
 | |
O|O|O
FM 8 TO 5
 |X|X
X|O|
O| |O
FM 9 TO 6
 |X|
X|X|O
O| |
FM 7 TO 5
I MOVE TO 7,
I WIN!  YOU LOSE!
```

AN 8080 LISTING OF THE HEXPAWN PROGRAM

This final listing is the operating portion of the Hexpawn program written for an 8080 based system. The 8080 version makes use of the more powerful instruction set of the 8080 mainly in setting up pointers, and includes instructions to set up the stack pointer, a function not required by the 8008. The operating portion of the 8080 version resides on pages 01 and 02 with the stack beginning at location 377 on page 02. The tables and messages are located on pages 03, 04, and 05 exactly as defined for the 8008 version. The user defined I/O routines should be set up as defined previously. The functional operation of the program is exactly as described in the text, and, therefore, need not be expanded upon. So, for those readers with 8080 based systems, here is the listing for the Hexpawn program.

```
001 000   061 000 003      START,  LXS 000 003
001 003   041 076 005              LXH 076 005
001 006   315 165 002              CAL MSG
001 011   041 000 004              LXH 000 004
001 014   021 200 004              LXD 200 004
001 017   032               RSTR,  LDAD
001 020   167                      LMA
001 021   054                      INL
001 022   034                      INE
001 023   302 017 001              JFZ RSTR
001 026   041 000 003      AGAIN,  LXH 000 003
001 031   066 340                  LMI 340
001 033   054                      INL
001 034   066 007                  LMI 007
001 036   056 302           PBD,   LLI 302
001 040   006 240                  LBI 240
001 042   160                      LMB
001 043   056 304                  LLI 304
001 045   160                      LMB
001 046   056 306                  LLI 306
001 050   160                      LMB
001 051   056 311                  LLI 311
001 053   160                      LMB
001 054   056 313                  LLI 313
001 056   160                      LMB
001 057   056 315                  LLI 315
001 061   160                      LMB
001 062   056 320                  LLI 320
001 064   160                      LMB
001 065   056 322                  LLI 322
```

```
001 067    160                   LMB
001 070    056 324               LLI 324
001 072    160                   LMB
001 073    056 000               LLI 000
001 075    176                   LAM
001 076    054                   INL
001 077    106                   LBM
001 100    056 302               LLI 302
001 102    315 153 002           CAL STX
001 105    056 304               LLI 304
001 107    315 153 002           CAL STX
001 112    056 306               LLI 306
001 114    315 153 002           CAL STX
001 117    056 311               LLI 311
001 121    315 153 002           CAL STX
001 124    117                   LCA
001 125    170                   LAB
001 126    007                   RLC
001 127    007                   RLC
001 130    315 160 002           CAL STO
001 133    107                   LBA
001 134    056 313               LLI 313
001 136    171                   LAC
001 137    315 153 002           CAL STX
001 142    117                   LCA
001 143    170                   LAB
001 144    315 160 002           CAL STO
001 147    107                   LBA
001 150    056 315               LLI 315
001 152    171                   LAC
001 153    315 153 002           CAL STX
001 156    170                   LAB
001 157    315 160 002           CAL STO
001 162    056 320               LLI 320
001 164    315 160 002           CAL STO
001 167    056 322               LLI 322
001 171    315 160 002           CAL STO
001 174    056 324               LLI 324
001 176    315 160 002           CAL STO
001 201    056 300               LLI 300
```

```
001 203    315 165 002              CAL MSG
001 206    056 002                  LLI 002
001 210    315 000 006              CAL INPUT
001 213    167                      LMA
001 214    315 270 002              CAL FNUM
001 217    372 177 002              JTS ERROR
001 222    176                      LAM
001 223    346 017                  NDI 017
001 225    167                      LMA
001 226    107                      LBA
001 227    055                      DCL
001 230    176                      LAM
001 231    315 212 002              CAL RTAL
001 234    322 177 002              JFC ERROR
001 237    056 333                  LLI 333
001 241    315 165 002              CAL MSG
001 244    056 003                  LLI 003
001 246    315 000 006              CAL INPUT
001 251    167                      LMA
001 252    315 270 002              CAL FNUM
001 255    372 177 002              JTS ERROR
001 260    176                      LAM
001 261    346 017                  NDI 017
001 263    167                      LMA
001 264    055                      DCL
001 265    176                      LAM
001 266    326 003                  SUI 003
001 270    054                      INL
001 271    276                      CPM
001 272    312 231 002              JTZ BLK
001 275    306 001                  ADI 001
001 277    276                      CPM
001 300    312 316 001              JTZ CKCAP
001 303    326 002                  SUI 002
001 305    376 003                  CPI 003
001 307    312 177 002              JTZ ERROR
001 312    276                      CPM
001 313    302 177 002              JFZ ERROR
001 316    376 007         CKCAP,   CPI 007
001 320    312 177 002              JTZ ERROR
```

```
001 323   106                          LBM
001 324   076 200                      LAI 200
001 326   315 223 002                  CAL RTLP
001 331   137                          LEA
001 332   056 000                      LLI 000
001 334   246                          NDM
001 335   312 177 002                  JTZ ERROR
001 340   056 002               HMV,   LLI 002
001 342   176                          LAM
001 343   315 220 002                  CAL RTAR
001 346   127                          LDA
001 347   054                          INL
001 350   176                          LAM
001 351   376 004                      CPI 004
001 353   332 307 002                  JTC HWIN
001 356   315 220 002                  CAL RTAR
001 361   117                          LCA
001 362   056 001                      LLI 001
001 364   176                          LAM
001 365   252                          XRD
001 366   261                          ORC
001 367   117                          LCA
001 370   167                          LMA
001 371   055                          DCL
001 372   173                          LAE
001 373   247                          NDA
001 374   312 001 002                  JTZ NOCP
001 377   256                          XRM
002 000   167                          LMA
002 001   126                   NOCP,  LDM
002 002   056 010                      LLI 010
002 004   172                   SMDL,  LAD
002 005   276                          CPM
002 006   312 032 002                  JTZ OHLF
002 011   054                          INL
002 012   054                   SMD1,  INL
002 013   175                          LAL
002 014   376 112                      CPI 112
002 016   302 004 002                  JFZ SMDL
002 021   041 340 004                  LXH 340 004
```

```
002 024    315 165 002      CMSG,   CAL MSG
002 027    303 026 001              JMP AGAIN
002 032
002 032    054              OHLF,   INL
002 033    171                      LAC
002 034    276                      CPM
002 035    302 012 002              JFZ SMD1
002 040
002 040    055                      DCL
002 041    175                      LAL
002 042    017                      RRC
002 043    306 106                  ADI 106
002 045    157                      LLA
002 046    156                      LLM
002 047    046 004                  LHI 004
002 051    176              MFD1,   LAM
002 052    247                      NDA
002 053    372 301 002              JTS ONO
002 056    302 065 002              JFZ MOVE
002 061    054                      INL
002 062    303 051 002              JMP MFD1
002 065
002 065    135              MOVE,   LEL
002 066    041 004 003              LXH 004 003
002 071    163                      LME
002 072    007                      RLC
002 073    007                      RLC
002 074    306 174                  ADI 174
002 076    157                      LLA
002 077    126                      LDM
002 100    054                      INL
002 101    116                      LCM
002 102    054                      INL
002 103    136                      LEM
002 104    054                      INL
002 105    176                      LAM
002 106    247                      NDA
002 107    372 251 002              JTS WIN
002 112    302 262 002              JFZ DRAW
002 115    056 000                  LLI 000
```

```
002 117     176                          LAM
002 120     252                          XRD
002 121     261                          ORC
002 122     167                          LMA
002 123     054                          INL
002 124     173                          LAE
002 125     247                          NDA
002 126     312 036 001                  JTZ PBD
002 131     256                          XRM
002 132     167                          LMA
002 133     302 036 001                  JFZ PBD
002 136
002 136     056 004                      LLI 004
002 140     156                          LLM
002 141     046 004                      LHI 004
002 143     066 000                      LMI 000
002 145     041 330 005                  LXH 330 005
002 150     315 024 002                  CAL CMSG
002 153
002 153     007                  STX,    RLC
002 154     320                          RFC
002 155     066 330                      LMI 330
002 157     311                          RET
002 160
002 160     007                  STO,    RLC
002 161     320                          RFC
002 162     066 317                      LMI 317
002 164     311                          RET
002 165
002 165     176                  MSG,    LAM
002 166     247                          NDA
002 167     310                          RTZ
002 170     315 100 006                  CAL PRINT
002 173     043                          INXH
002 174     303 165 002                  JMP MSG
002 177
002 177     041 364 005          ERROR,  LXH 364 005
002 202     315 165 002                  CAL MSG
002 205     046 003                      LHI 003
002 207     303 036 001                  JMP PBD
```

```
002 212     005                             RTAL,   DCB
002 213     310                                     RTZ
002 214     007                                     RLC
002 215     303 212 002                             JMP RTAL
002 220
002 220     107                             RTAR,   LBA
002 221     076 001                                 LAI 001
002 223     005                             RTLP,   DCB
002 224     310                                     RTZ
002 225     017                                     RRC
002 226     303 223 002                             JMP RTLP
002 231
002 231     106                             BLK,    LBM
002 232     056 000                                 LLI 000
002 234     176                                     LAM
002 235     315 212 002                             CAL RTAL
002 240     247                             SET,    NDA
002 241     372 177 002                             JTS ERROR
002 244     036 000                                 LEI 000
002 246     303 340 001                             JMP HMV
002 251
002 251     062 025 005                     WIN,    STA 025 005
002 254     041 011 005                             LXH 011 005
002 257     315 024 002                             CAL CMSG
002 262
002 262     041 052 005                     DRAW,   LXH 052 005
002 265     303 024 002                             JMP CMSG
002 270
002 270     176                             FNUM,   LAM
002 271     376 260                                 CPI 260
002 273     370                                     RTS
002 274     326 272                                 SUI 272
002 276     306 200                                 ADI 200
002 300     311                                     RET
002 301
002 301     041 374 004                     ONO,    LXH 374 004
002 304     315 165 002                             CAL MSG
002 307
002 307     041 004 003                     HWIN,   LXH 004 003
002 312     156                                     LLM
```

```
002 313    046 004                          LHI 004
002 315    066 000                          LMI 000
002 317    041 315 005                      LXH 315 005
002 322    315 165 002                      CAL MSG
002 325    303 026 001                      JMP AGAIN
002 330

006 000    000                  INPUT,

006 100    000                  PRINT,
```

HANGMAN is a word game with which most readers are probably well acquainted. The object of the game is to determine what word a player is thinking of by guessing the letters that make up the word. When characters contained in the word are correctly identified, the positions of the letters that have been ascertained are disclosed. The goal of the game is to ascertain all the letters making up the concealed word with the least amount of incorrect guesses. The game in the form to be presented traditionally received its name from the practice of creating a sketch of a stick figure being hung from a hangman's scaffold. A portion of the stick figure, such as a head, arms, torso, or legs, would be drawn in each time an incorrect letter guess was made. If the stick figure was completed before the entire word had been correctly identified, the player lost.

In the computerized version of the game to be presented here, the computer will select a word from a list of words (which may be created by the reader if desired). The computer will then allow a player to enter guesses as to the letters contained in the word selected. Each time the player correctly identifies a letter contained in the word, the characters that have been ascertained will be displayed in their proper location within the word. Each time a guess is incorrect, the computer will add a letter towards the spelling of Hangman! A game is finished when a player correctly identifies the word selected by the computer. Or, when eight incorrect letter guesses result in the complete spelling of Hangman!

The game is relatively simple to implement on a computer. However, despite its relative simplicity programming wise, the game can be surprisingly fun and challenging. This is due primarily to the nature of the game, augmented by the fact that the programmer has a virtually unlimited reservoir of alternatives to use when creating a list of words for the computer to select from when playing a game.

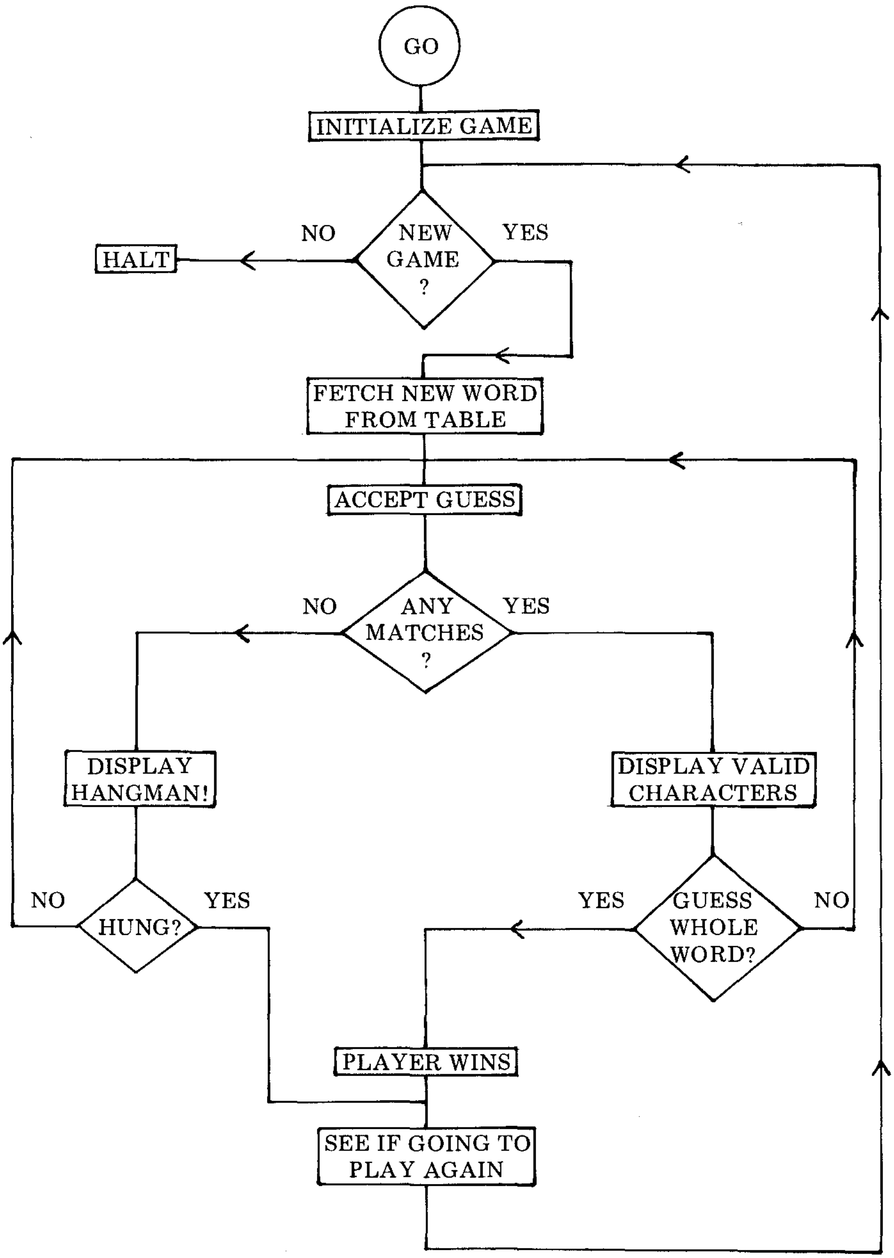
Besides its use as a pure fun game, the program can also be applied to more serious considerations such as making it a learning or teaching tool. Since the level of the vocabulary that is placed in the computer memory may be set as desired by the programmer, the game can be applied towards helping students develop vocabularies in virtually any subject. Additionally, one may readily change the language with which the game is played! French, Spanish, German, Maylasian! The computer will not care at all! The human player, though, may be suitably impressed with such variations!

FUNDAMENTAL STRUCTURE OF THE PROGRAM

The structure of the program is straightforward. Essentially, the computer is directed to select a word from a list of words in memory. A selected word is transferred to a buffer storage area. The player is asked to guess the letters in the selected word. Each time the player makes an entry, the buffer is scanned for any matches with the letter entered by the player. Appropriate matches are transferred to a working buffer that keeps track of all correct letter entries made by the player. Correct entries result in the contents of the working buffer being displayed to show the correct locations of letters properly identified by the player. Incorrect guesses by the player result in successive portions of the dreaded HANGMAN! being displayed. The overall flow of the program to be described here is illustrated in the flow chart on the following page.

DETAILS OF THE PROGRAM

The operating portion of the program described here fits easily into less than 1 K of memory excluding a variable length word table. The word table is simply a list of words. The list may extend as far as the user desires in available memory. A sample word table is included in this article. However, the reader may create a new list of words for the game. The word list provided uses about four pages of memory if the entire list is used. However, the list may be shortened if memory space is at a premium. A version of the program assembled to reside on pages 02 through 04 (operating portion) with the word table starting on page 05 will be provided as part of this article.


GO
INITIALIZE GAME
NEW GAME ?
NO
YES
HALT
FETCH NEW WORD FROM TABLE
ACCEPT GUESS
ANY MATCHES ?
NO
YES
DISPLAY HANGMAN!
DISPLAY VALID CHARACTERS
HUNG?
NO
YES
GUESS WHOLE WORD?
YES
NO
PLAYER WINS
SEE IF GOING TO PLAY AGAIN

The first several routines in the program are used to initialize pointer storage locations and display a WANT A NEW WORD message to the system operator. Messages to be displayed by the program are stored as text strings in memory terminated by a zero byte. Text strings are displayed by calling a subroutine labeled MSG. MSG will output a string of characters pointed to by the H and L registers until a zero byte is detected. The actual MSG subroutine will be presented later. Suffice it to say at this point that one need only set up the H & L CPU registers to the starting address of a text string stored in memory, then call the MSG subroutine when it is desired to display such messages.

Following the WANT A NEW WORD message display, the program waits for a response from the operator by calling a user defined input subroutine labeled INPUTN. INPUTN should be designed by the reader to accept a character from the system's imput device (such as a keyboard) and return the character in the accumulator to the calling program. The INPUTN subroutine should also perform an echo display function so that the operator may verify the input character. The subroutine is free to utilize CPU registers A through E as far as this program is concerned. The user should note that this program expects the eighth bit in the accumulator to be in a '1' condition when the remaining seven bits represent an ASCII encoded character.

If the operator responds to the WANT A NEW WORD query by entering the letter N for no, the program terminates after displaying an appropriate response. If a Y for yes is entered, the program continues by calling upon a subroutine called MOVTAB. This subroutine will fetch a word from the program's word table. It will then transfer the word into a buffer. The buffer it is transferred into will be referred to as the word buffer in this article. The actual operation of the MOVTAB subroutine will be presented later. Suffice it to note at this time that upon return from the MOVTAB subroutine, a new word will be residing in the word buffer. The program will then be ready to start the playing of a game of Hangman!

```
START,     LHI 003        Set pointer to
           LLI 350        Number of guesses counter
           LMI 001        Initialize counter
```

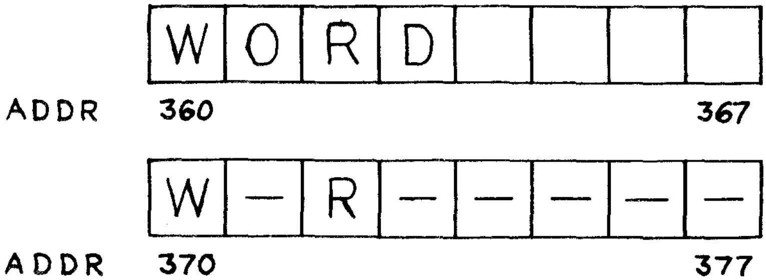
```
            LLI 356         Pointer to word table pointer
            LMI 000         Initialize to
            INL             Start of
            LMI 005         Word table
NEWONE,     LHI 004         Pointer to WANT A
            LLI 000         NEW WORD? message
            CAL MSG         Display message
            CAL INPUTN      Fetch answer
            CPI 316         Was it NO?
            JTZ NOMORE      Say GOODBYE if no
            CPI 331         Else was it a YES?
            JFZ NEWONE      Ignore input otherwise
            CAL MOVTAB      If Y, fetch a word
            JMP GUESS       Go play the game

NOMORE,     LHI 004         Pointer to GOODBYE
            LLI 025         Message
            CAL MSG         Display message
            HLT             End of playing session
```

The next portion of the program begins by sending a message telling the operator to GUESS A LETTER. The program then accepts an input from the player. The input is expected to be any alphabetical character.

The program will then scan the word buffer to see if the letter received from the player matches with any of the letters in the word. Whenever a match is detected, the letter is stored in the same position in a second buffer called the guesses buffer.

It should be pointed out that the word buffer and the guesses buffer are identical in length. (Eight bytes in this program.) In the example program, the word buffer starts at location 360 on page 03. The guesses buffer starts at location 370 on page 03. At the start of each game, the word buffer, as previously mentioned, will be loaded with a word taken from the word table. A word may be up to eight letters in length. If there are not eight letters in a word, the balance of the word buffer will be filled with zero bytes. Furthermore, at the time the word buffer obtains a new word, the guesses buffer is filled with hyphens.

It thus becomes an easy matter to keep a record of correct guesses as the Hangman game progresses. Each time a position in the word buffer matches with the letter guessed by the player, the identical position in the guesses buffer is changed from a hyphen to the actual letter! The addressing scheme used in the program makes it easy to accomplish the objective. When a match is found in the word buffer, it is only necessary to add 010 (octal) to the buffer pointer to reach the corresponding position in the guesses buffer. The pictorial below should clarify the relationship.



If there is a match between the character inputted and any position in the word buffer, a flag is set (using register B). The word in the word buffer is scanned for a matching character until a zero byte is detected or the buffer pointer reaches the last address allocated for the buffer.

```
GUESS,      LHI 004         Pointer to GUESS A
            LLI 037         LETTER message
            CAL MSG         Display message
            CAL INPUTN      Fetch a letter
            LCA             Save letter in C

SCAN,       LBI 000         Clear B for a flag register
            LHI 003         Set pointer to
            LLI 360         Word buffer

CKMTCH,     CPM             Look for a match
            JFZ NOMTCH      Skip ahead if not a match
            INB             Set B as a flag
```

```
          LAI 010        Advance pointer
          ADL            To the guesses
          LLA            Buffer
          LMC            And deposit character
          LAL            Decrease pointer
          SUI 010        Back to
          LLA            Word buffer

NOMTCH,   INL            Advance buffer pointer
          LAM            See if next character
          NDA            Is a zero byte
          JTZ EOWORD     End of word if so
          LAI 007        See if at
          NDL            End of word buffer
          JTZ EOWORD     End of word if so
          LAC            Restore character to ACC
          JMP CKMTCH     Check next position
```

When the entire word buffer has been searched, the program checks the flag mentioned previously (in CPU register B) to determine if the player had made a correct letter guess. The flag will be set (have a value) if such was the case. It will still be zero if no match was detected.

If the flag was set during the SCAN operation, then the player has correctly determined a letter that exists in the word that the player is trying to identify. The program must now show the player how much of the word has been correctly identified. Thus, the program will first display an encouraging message. Then, the routine simply outputs the contents of the guesses buffer. The guesses buffer will contain all the locations of the letters that have been correctly identified during the game. Unidentified locations will still contain a hyphen. Thus, if a player had correctly identified the letters W and R in the spelling of WORD, the computer would output: W-R-.

As the program outputs the contents of the guesses buffer, it checks to see if any hyphens (referred to in the listing as dashes) are displayed. A software flag mechanism is used for this purpose. At the end of the guesses buffer outputting operation, the flag is tested. If it is zero, then the player has identified the entire word. The program will then display a congratulations message and go back to see if the player wants to continue the game with a new word. If there are any hyphens left in the guesses buffer as indicated by the software flag being set, then the program loops back to allow the player to guess another letter.

The reader may note that the routine examines the word buffer to determine when to stop outputting the contents of the guesses buffer. This is because the word buffer will contain a zero byte at the end of the word if the word is less than eight characters in length. The guesses buffer does not contain such an indicator.

The portion of the program just discussed is presented next.

```
EOWORD,     INB            At end of word, exercise
            DCB            The MATCH flag
            JTZ HANGIT     If = 0, no matches
            LHI 004        If match(es), set pointer
            LLI 074        To GOOD. YOU HAVE: msg
            CAL MSG        Display message
            LHI 003        Set pointer to
            LLI 353        Dashes counter storage
            LMI 000        Clear dashes counter
            LLI 370        Pointer to guesses buffer

NOTEND,     LAM            Fetch a character
            CPI 255        See if it is a dash
            JFZ AHEAD2     Skip next instruction if not
            LEL            Save pointer temporarily
            LLI 353        Set pointer to dashes counter
            LBM            Fetch dashes value
            INB            Increment
            LMB            Restore to memory
            LLE            Restore saved pointer

AHEAD2,     CAL PRINT      Print the character
            INL            Advance the buffer pointer
            LAL            Decrease pointer
            SUI 010        To word buffer
```

```
            LLA             Here
            LAM             Fetch data from word buffer
            NDA             And see if it is
            JTZ ENDAGN      Zero byte, jump if so
            LAL             Fetch pointer
            NDI 007         See if at end of word
            JTZ ENDAGN      Buffer, jump if so
            LAI 010         Else restore pointer
            ADL             Ahead to
            LLA             The guesses buffer
            JMP NOTEND      Do next character in buffer

ENDAGN,     LLI 353         Pointer to dashes counter
            LBM             Fetch value
            INB             Exercise the dashes
            DCB             Flag register
            JFZ GUESS       Word not completed
            LHI 004         If reach here, set pointer
            LLI 120         To congratulations message
            CAL MSG         Display message
            JMP NEWONE      Go play with a new word
```

For the case when the player has inputted a letter that does not exist in the word in the word buffer, the program must take a different course of action. This case is handled by a portion of the program that starts at the label HANGIT. Here the operator is informed of the incorrect guess by the display of the message NOPE. This message is then followed by the display of a portion or all of the HANGMAN! message.

Each time the player guesses incorrectly during a game, a letter is added to the message spelling out the word HANGMAN! In order to do this properly, the program maintains a counter of the number of incorrect guesses made. Then, the computer is simply used to determine how many letters of the HANGMAN! message to display. (The HANGMAN! message is simply stored in a buffer, starting at location 340 on page 03 in the example program.) If the entire HANGMAN! statement is not displayed, the balance of the message is shown as dash signs (hyphens). The number of dash signs to display is calculated by subtracting the value of the counter (of incorrect guesses made) from 10 (octal) which is the number of characters in the HANGMAN! message. Thus, as the game progresses, the message HANGMAN! will appear more and more complete with each incorrect guess as illustrated below.

```
H------        (First incorrect guess)
HA-----        (Second incorrect guess)
HAN----        (Third incorrect guess)
   .
   .
HANGMAN!       (Eighth incorrect guess)
```

When eight incorrect guesses have been made in a game, the entire HANGMAN! message will be displayed. The player then loses the game. The program will then go back and see if the player wants to start with a new word.

The listing for the portion of the program that displays the dreaded HANGMAN! message is shown next.

```
HANGIT,     LHI 004       Pointer to NOPE
            LLI 062       Message
            CAL MSG       Display message
            LHI 003       Set pointer to
            LLI 350       Number of guesses in counter
            LBM           Fetch counter
            INB           Increment it
            LMB           Restore the counter
            INL           Advance pointer
            LMB           Save it again
            LAI 010       Calculate number of
            SUB           Dashes left in HANGMAN!
            INL           Advance pointer
            LMA           Save the value in memory
            LEI 340       Init. pntr. to HANGMAN bfr

HANGMR,     LLE           Set pntr to HANGMAN bfr
            LAM           Fetch a character from buffer
            CAL PRINT     Display it
```

```
            INL             Advance the buffer pointer
            LEL             Save temporarily in E
            LLI 351         Pointer to counter in memory
            LBM             Fetch counter value
            DCB             Decrement
            LMB             Restore to memory
            JFZ HANGMR      Continue if counter not zero
            LLI 352         Pntr to second cntr in memory
            LCM             Fetch counter value
            INC             Exercise counter value
            DCC             To see if it is zero
            JTZ NEWONE      Start new game if so
            LAI 255         Else load code for "-"

MRDASH,     CAL PRINT       Display a dash
            LCM             Fetch counter
            DCC             Decrement
            LMC             Restore
            JFZ MRDASH      Until counter is zero
            JMP GUESS       Then continue game
```

The next portion of the program is a subroutine mentioned previously called MOVTAB. The primary function of this subroutine is to fetch a new word from a list or table of words stored in memory. However, the subroutine also performs a few other functions that need to be performed each time a new word (actually representing the start of a new game) is obtained.

The first thing the subroutine does is fetch the value of the counter used for keeping track of how many incorrect guesses were made during the last game played. This value will be used to determine how many words in the word table to skip over when selecting a new word. This method is used so that words will be selected from the table in a rather arbitrary fashion rather than simply taking the next word in the list. If the next word in the list was always taken, players might soon start remembering certain words or sequences of words which would soon make the game somewhat boring!

The program then initializes the guesses buffer to the all hyphens condition by loading the ASCII code for the dash sign (255 octal) into all the locations in the buffer. In a similar fashion, the word buffer is cleared to the all zeroes condition in preparation for its receiving a new word from the word table.

These initial functions of the subroutine are shown below.

```
MOVTAB,     LHI 003         Pointer to number
            LLI 350         Of guesses counter
            LBM             Fetch and save in B
            LLI 370         Pointer to guesses buffer
            LCI 010         Set a loop counter
            LAI 255         Set code for "-"

DASHFL,     LMA             Fill guesses buffer
            INL             With dashes
            DCC             Until counter
            JFZ DASHFL      Is zero

NXWORD,     LLI 360         Set pointer to word buffer
            LCI 010         Set a loop counter
            XRA             Clear the accumulator

ZEROFL,     LMA             Fill word buffer
            INL             With zero bytes
            DCC             Until counter
            JFZ ZEROFL      Is zero
```

Before explaining the operation of the portion of the subroutine that extracts a new word from the word table, it will be beneficial to explain the organization of the table.

The table consists of a list of words stored in memory in the following format.

A	1st letter of a word
A+1	2nd letter of a word
A+2	3rd letter of a word

.	.
.	.
A+N	Nth letter of a word
A+N+1	000 word terminator code
B	1st letter of a word
B+1	2nd letter of a word
.	.
.	.
B+N	Nth letter of a word
B+N+1	000 word terminator code
C	1st letter of a word
.	.
.	.
C+N+1	000 word terminator code
D	000 end of table terminator

The reader should notice that each word in the list must be terminated by a zero byte. Words must also be limited to eight or less letters in length (or they would overflow the word buffer). The table is terminated by placing an additional zero byte immediately following the zero byte word terminator after the last word in the table. The word table in the program provided in this manual starts on page 05 at location 000. The table may extend for as long as the user desires within available memory. (In the sample word list about 100 words are provided. These require about three pages of memory. Of course, the list may be shortened if necessary. Or the user may provide a completely original table of words.)

A word is extracted from the word table through the following procedure. First, a word table pointer is extracted from its storage location in memory and loaded into CPU registers H and L. This pointer will initially point to the first letter of a word in the table. Next, a character is extracted from the word table. The character obtained is first tested to see if it is a zero byte. A zero byte in place of an expected letter (as the first letter in a word) indicates that the end of the table has been reached. In that case, the pointer in H and L is reset back to the start of the word table.

Next, a second pointer is established in CPU registers D and E.

This pointer will be used to point to the word buffer during transfer operations from the word table. Now a character is fetched from the word table. Then the pointers in H and L and D and E are swapped and the character is transferred into the word buffer. (Unless a zero byte indicating the end of a word is detected. In that case no transfer takes place.) Next, the two sets of pointers are advanced. The process is then repeated until a whole word has been loaded into the word buffer.

When an entire word has been transferred into the word buffer, the routine advances the word table pointer once more. (This is so it will be advanced over the end of word terminator and be pointing at the first letter in the next word in the table.) Then the pointer is restored to its storage location in memory. Next, the routine fetches the number of guesses counter. It decrements the value of that counter. If the value is not zero after the decrement operation, then the routine loops back (to the label NXWORD), and proceeds to read the next word in the word table into the word buffer. (The reason for following this procedure was presented earlier.) When the counter reaches zero, it is stored in memory (at its 000 value) for use during the next game. The subroutine is then exited.

```
            LLI 356       Set pointer to word table pntr
            LAM           Fetch the low address
            INL           Advance pointer
            LHM           Set the page address
            LLA           And low address
            XRA           Clear the accumulator
            CPM           See if first entry is zero
            JFZ AHEAD3    Skip ahead if not
            LHI 005       Reset pointer to start
            LLI 000       Of word table if so

AHEAD3,     LDI 003       Set pointer to word
            LEI 360       Buffer in D and E

BUFFMR,     LAM           Fetch a character from table
            NDA           Exercise flags
            JTZ NEXT      If zero, have whole word
```

```
            CAL SWITCH     Else swap pointers
            LMA            Dep character in word buffer
            INL            Advance word buffer pointer
            CAL SWITCH     Swap pointers
            INL            Advance word table low pntr
            JFZ NOHIGH     If not zero, skip next
            INH            Advance table high pointer

NOHIGH,     JMP BUFFMR     Continue transfer from table

NEXT,       INL            Advance table pointer
            JFZ NOTHI      Low address
            INH            And high address if required

NOTHI,      CAL SWITCH     Save pointer in D and E
            LLI 356        Set pointer to table pointer
            LME            Save table pointer low
            INL            Address and
            LMD            High address
            DCB            Decr number guesses counter
            JFZ NXWORD     If not zero, get next word
            LLI 350        Else set pointer to guesses
            LMI 000        Counter and zero counter
            RET            Then exit subroutine
```

That completes the discussion of the major routines in the program. There are two more minor utility subroutines used in the program. One of these is simply a subroutine called SWITCH that is used to exchange the contents of CPU registers H and L with D and E. During this operation, CPU register C is used as a temporary register.

```
SWITCH,     LCH            Put H into C temporarily
            LHD            Load D into H
            LDC            Now orig H from C to D
            LCL            Put L into C temporarily
            LLE            Load E into L
            LEC            Now orig L from C to E
            RET            Swapping oper. completed
```

The other is the subroutine mentioned earlier called MSG. MSG simply outputs a string of characters from memory to an output device until it detects a zero byte.

```
MSG,    LAM           Fetch a character
        NDA           See if a zero byte
        RTZ           Indicating end of string
        CAL PRINT     If not, display character
        INL           Increment low address pointer
        JFZ MSG       Get next character unless
        INH           Need to advance page address
        JMP MSG       Then get next character
```

The MSG subroutine above calls on another subroutine which has been termed PRINT. The PRINT subroutine must be an actual device operating subroutine that will cause the ASCII character in the accumulator to be transmitted to the output device being used by the system. The PRINT subroutine, which must be provided by the user, may use the CPU registers B through E if required. It should not alter the contents of the H and L CPU registers (unless the subroutine is able to restore those registers to their original values at the conclusion of the process).

ASSEMBLED LISTING OF THE "HANGMAN!" PROGRAM FOR AN '8008'

An assembled listing of the program for operation on an 8008 system is presented next. The operating portion of the program has been assembled to reside in pages 02 and 03. Page 04 is reserved for the various message strings used by the program plus the user provided I/O subroutines. The word table for the program is assumed to start on page 05. A sample list of words for use with the program is provided in ASCII form at the end of the assembled listing.

```
002 000    056 003              START,   LHI 003
002 002    066 350                       LLI 350
002 004    076 001                       LMI 001
002 006    066 356                       LLI 356
002 010    076 000                       LMI 000
002 012    060                           INL
002 013    076 005                       LMI 005

002 015    056 004             NEWONE,   LHI 004
002 017    066 000                       LLI 000
002 021    106 110 003                   CAL MSG
002 024    106 200 004                   CAL INPUTN
002 027    074 316                       CPI 316
002 031    150 047 002                   JTZ NOMORE
002 034    074 331                       CPI 331
002 036    110 015 002                   JFZ NEWONE
002 041    106 347 002                   CAL MOVTAB
002 044    104 057 002                   JMP GUESS
002 047    056 004             NOMORE,   LHI 004
002 051    066 025                       LLI 025
002 053    106 110 003                   CAL MSG
002 256    000                           HLT

002 057    056 004              GUESS,   LHI 004
002 061    066 037                       LLI 037
002 063    106 110 003                   CAL MSG
002 066    106 200 004                   CAL INPUTN
002 071    320                           LCA

002 072    016 000               SCAN,   LBI 000
002 074    056 003                       LHI 003
002 076    066 360                       LLI 360

002 100    277                CKMTCH,    CPM
002 101    110 116 002                   JFZ NOMTCH
002 104    010                           INB
002 105    006 010                       LAI 010
002 107    206                           ADL
002 110    360                           LLA
002 111    372                           LMC
```

```
002 112    306                          LAL
002 113    024 010                      SUI 010
002 115    360                          LLA

002 116    060              NOMTCH,     INL
002 117    307                          LAM
002 120    240                          NDA
002 121    150 136 002                  JTZ EOWORD
002 124    006 007                      LAI 007
002 126    246                          NDL
002 127    150 136 002                  JTZ EOWORD
002 132    302                          LAC
002 133    104 100 002                  JMP CKMTCH

002 136    010              EOWORD,     INB
002 137    011                          DCB
002 140    150 253 002                  JTZ HANGIT
002 143    056 004                      LHI 004
002 145    066 074                      LLI 074
002 147    106 110 003                  CAL MSG
002 152    056 003                      LHI 003
002 154    066 353                      LLI 353
002 156    076 000                      LMI 000
002 160    066 370                      LLI 370

002 162    307              NOTEND,     LAM
002 163    074 255                      CPI 255
002 165    110 177 002                  JFZ AHEAD2
002 170    346                          LEL
002 171    066 353                      LLI 353
002 173    317                          LBM
002 174    010                          INB
002 175    371                          LMB
002 176    364                          LLE

002 177    106 300 004      AHEAD2,     CAL PRINT
002 202    060                          INL
002 203    306                          LAL
002 204    024 010                      SUI 010
002 206    360                          LLA
```

```
002 207   307                        LAM
002 210   240                        NDA
002 211   150 231 002                JTZ ENDAGN
002 214   306                        LAL
002 215   044 007                    NDI 007
002 217   150 231 002                JTZ ENDAGN
002 222   006 010                    LAI 010
002 224   206                        ADL
002 225   360                        LLA
002 226   104 162 002                JMP NOTEND

002 231   066 353          ENDAGN,   LLI 353
002 233   317                        LBM
002 234   010                        INB
002 235   011                        DCB
002 236   110 057 002                JFZ GUESS
002 241   056 004                    LHI 004
002 243   066 120                    LLI 120
002 245   106 110 003                CAL MSG
002 250   104 015 002                JMP NEWONE

002 253   056 004          HANGIT,   LHI 004
002 255   066 062                    LLI 062
002 257   106 110 003                CAL MSG
002 262   056 003                    LHI 003
002 264   066 350                    LLI 350
002 266   317                        LBM
002 267   010                        INB
002 270   371                        LMB
002 271   060                        INL
002 272   371                        LMB
002 273   006 010                    LAI 010
002 275   221                        SUB
002 276   060                        INL
002 277   370                        LMA
002 300   046 340                    LEI 340

002 302   364              HANGMR,   LLE
002 303   307                        LAM
002 304   106 300 004                CAL PRINT
```

```
002 307   060                           INL
002 310   346                           LEL
002 311   066 351                       LLI 351
002 313   317                           LBM
002 314   011                           DCB
002 315   371                           LMB
002 316   110 302 002                   JFZ HANGMR
002 321   066 352                       LLI 352
002 323   327                           LCM
002 324   020                           INC
002 325   021                           DCC
002 326   150 015 002                   JTZ NEWONE
002 331   006 255                       LAI 255

002 333   106 300 004         MRDASH,   CAL PRINT
002 336   327                           LCM
002 337   021                           DCC
002 340   372                           LMC
002 341   110 333 002                   JFZ MRDASH
002 344   104 057 002                   JMP GUESS

002 347   056 003             MOVTAB,   LHI 003
002 351   066 350                       LLI 350
002 353   317                           LBM
002 354   066 370                       LLI 370
002 356   026 010                       LCI 010
002 360   006 255                       LAI 255

002 362   370                 DASHFL,   LMA
002 363   060                           INL
002 364   021                           DCC
002 365   110 362 002                   JFZ DASHFL

002 370   066 360             NXWORD,   LLI 360
002 372   026 010                       LCI 010
002 374   250                           XRA

002 375   370                 ZEROFL,   LMA
002 376   060                           INL
002 377   021                           DCC
```

```
003 000   110 375 002              JFZ ZEROFL
003 003   066 356                  LLI 356
003 005   307                      LAM
003 006   060                      INL
003 007   357                      LHM
003 010   360                      LLA
003 011   250                      XRA
003 012   277                      CPM
003 013   110 022 003              JFZ AHEAD3
003 016   056 005                  LHI 005
003 020   066 000                  LLI 000

003 022   036 003         AHEAD3,  LDI 003
003 024   046 360                  LEI 360

003 026   307             BUFFMR,  LAM
003 027   240                      NDA
003 030   150 053 003              JTZ NEXT
003 033   106 101 003              CAL SWITCH
003 036   370                      LMA
003 037   060                      INL
003 040   106 101 003              CAL SWITCH
003 043   060                      INL
003 044   110 050 003              JFZ NOHIGH
003 047   050                      INH

003 050   104 026 003     NOHIGH,  JMP BUFFMR

003 053   060               NEXT,  INL
003 054   110 060 003              JFZ NOTHI
003 057   050                      INH

003 060   106 101 003      NOTHI,  CAL SWITCH
003 063   066 356                  LLI 356
003 065   374                      LME
003 066   060                      INL
003 067   373                      LMD
003 070   011                      DCB
003 071   110 370 002              JFZ NXWORD
003 074   066 350                  LLI 350
```

```
003 076    076 000                              LMI 000
003 100    007                                  RET

003 101    325                       SWITCH,    LCH
003 102    353                                  LHD
003 103    332                                  LDC
003 104    326                                  LCL
003 105    364                                  LLE
003 106    342                                  LEC
003 107    007                                  RET

003 110    307                          MSG,    LAM
003 111    240                                  NDA
003 112    053                                  RTZ
003 113    106 300 004                          CAL PRINT
003 116    060                                  INL
003 117    110 110 003                          JFZ MSG
003 122    050                                  INH
003 123    104 110 003                          JMP MSG

003 340    310                                  310
003 341    301                                  301
003 342    316                                  316
003 343    307                                  307
003 344    315                                  315
003 345    301                                  301
003 346    316                                  316
003 347    241                                  241

003 350    000                                  000
003 351    000                                  000
003 352    000                                  000
003 353    000                                  000

003 356    000                                  000
003 357    000                                  000

003 360    000                                  000
003 361    000                                  000
003 362    000                                  000
```

003	363	000	000
003	364	000	000
003	365	000	000
003	366	000	000
003	367	000	000
003	370	255	255
003	371	255	255
003	372	255	255
003	373	255	255
003	374	255	255
003	375	255	255
003	376	255	255
003	377	255	255

004	000	215	212	212	327	301	316	324	240
004	010	301	240	316	305	327	240	327	317
004	020	322	304	277	240	000	215	212	307
004	030	317	317	304	302	331	241	000	215
004	040	212	307	325	305	323	323	240	301
004	050	240	314	305	324	324	305	322	272
004	060	240	000	215	212	316	317	320	305
004	070	241	240	240	000	215	212	307	317
004	100	317	304	256	240	331	317	325	240
004	110	310	301	326	305	272	240	240	000
004	120	215	212	303	317	316	307	322	301
004	130	304	325	314	301	324	311	317	316
004	140	323	241	000					

004 200 INPUTN,

004 300 PRINT,

005	000	310	305	314	314	317	000	301	322
005	010	322	317	327	000	303	317	315	320
005	020	325	324	305	322	000	320	322	305
005	030	315	311	325	315	000	316	317	324
005	040	311	303	305	000	306	325	316	000

005	050	310	305	301	326	331	000	322	325
005	060	302	302	305	322	000	322	325	323
005	070	324	314	305	000	324	310	327	301
005	100	322	324	000	317	331	323	324	305
005	110	322	000	317	330	311	304	311	332
005	120	305	000	317	323	323	311	306	331
005	130	000	317	320	311	316	311	317	316
005	140	000	317	317	332	331	000	317	316
005	150	305	322	317	325	323	000	316	317
005	160	315	301	304	000	316	317	303	324
005	170	325	322	316	305	000	316	317	315
005	200	311	316	301	324	305	000	316	325
005	210	315	323	313	325	314	314	000	304
005	220	301	306	306	317	304	311	314	000
005	230	323	311	304	305	322	305	301	314
005	240	000	303	322	311	303	313	305	324
005	250	000	303	317	325	322	311	305	322
005	260	000	303	317	323	315	317	323	000
005	270	303	310	305	315	311	323	324	000
005	300	303	310	305	315	311	303	301	314
005	310	000	303	310	311	303	317	322	331
005	320	000	303	310	314	317	322	311	316
005	330	305	000	303	311	324	311	332	305
005	340	316	000	303	311	324	322	325	323
005	350	000	303	314	317	323	305	324	000
005	360	303	317	307	305	316	324	000	302
005	270	311	322	304	000	302	305	305	324
006	000	314	305	000	302	305	314	311	305
006	010	326	305	000	302	301	324	310	324
006	020	325	302	000	302	301	323	313	305
006	030	324	000	302	301	316	321	325	305
006	040	324	000	302	301	302	302	311	324
006	050	324	000	302	301	303	313	302	317
006	060	316	305	000	301	325	304	311	302
006	070	314	305	000	301	323	320	311	322
006	100	311	316	000	301	323	324	305	322
006	110	317	311	304	000	301	320	320	322
006	120	317	326	301	314	000	301	320	317
006	130	307	305	305	000	301	316	316	325
006	140	311	324	331	000	301	316	317	304

006	150	311	332	305	000	301	314	325	315
006	160	311	316	325	315	000	301	311	322
006	170	000	301	311	323	314	305	000	301
006	200	304	312	317	311	316	000	301	302
006	210	331	323	323	000	301	302	317	314
006	220	311	323	310	000	321	325	305	325
006	230	305	000	321	325	311	326	305	322
006	240	000	321	325	301	314	315	000	321
006	250	325	311	324	305	000	321	325	311
006	260	330	317	324	311	303	000	321	325
006	270	317	311	316	000	321	325	317	311
006	300	324	000	321	325	317	324	311	305
006	310	316	324	000	322	301	304	311	317
006	320	000	322	301	311	323	311	316	000
006	330	322	301	320	324	000	322	301	324
006	340	311	317	000	322	301	325	303	317
006	350	325	323	000	322	301	331	317	316
006	360	000	322	301	332	317	322	000	322
006	370	305	301	314	315	000	322	305	305
007	000	313	000	322	305	307	311	323	324
007	010	305	322	000	322	311	326	305	324
007	020	000	323	303	310	317	317	316	305
007	030	322	000	323	301	325	316	301	000
007	040	323	301	324	311	316	000	323	303
007	050	305	320	324	305	322	000	323	303
007	060	311	305	316	303	305	000	323	303
007	070	322	311	302	302	314	305	000	302
007	100	305	310	311	316	304	000	304	311
007	110	307	316	311	306	331	000	305	314
007	120	314	311	320	324	311	303	000	305
007	130	314	317	321	325	305	316	324	000
007	140	305	314	325	323	311	326	305	000
007	150	306	305	301	324	310	305	322	000
007	160	307	301	314	314	317	327	323	000
007	170	307	301	322	304	305	316	000	307
007	200	301	332	305	314	314	305	000	315
007	210	301	303	301	302	322	305	000	326
007	220	301	314	311	301	316	324	000	326
007	230	305	316	311	323	317	316	000	326
007	240	311	326	311	304	000	327	305	311

007	250	307	310	324	000	327	305	311	322
007	260	304	000	327	311	323	305	000	332
007	270	305	322	317	000	332	317	317	314
007	300	317	307	331	000	332	305	316	311
007	310	324	310	000	331	301	327	316	000
007	320	331	317	314	313	000	331	305	314
007	330	314	317	327	000	331	325	314	305
007	340	000	324	322	311	303	313	314	305
007	350	000	305	316	304	000	000		

A list of the messages used in the game (which reside on page 04 in the assembled listing just presented) is shown below in the order in which they appear in the messages table.

WANT A NEW WORD?

GOODBYE!

GUESS A LETTER:

NOPE!

GOOD. YOU HAVE:

CONGRATULATIONS!

For those that want to use the word list supplied as an example, (pages 05 through 07 in the listing just presented) the list on the following page will serve as a reference. The words appear in the same order as they are stored in the list. (Remember, however, that the program will skip around the list as it selects the next word that will be played!)

HELLO
ARROW
COMPUTER
PREMIUM
NOTICE
FUN
HEAVY
RUBBER
RUSTLE
THWART
OYSTER
OXIDIZE
OSSIFY
OPINION
OOZY
ONEROUS
NOMAD
NOCTURNE
NOMINATE
NUMSKULL
DAFFODIL
SIDEREAL
CRICKET
COURIER
COSMOS
CHEMIST
CHEMICAL
CHICORY
CHLORINE
CITIZEN
CITRUS
CLOSET
COGENT
BIRD
BEETLE
BELIEVE
BATHTUB
BASKET
BANQUET
BABBITT
BACKBONE
AUDIBLE
ASPIRIN
ASTEROID
APPROVAL
APOGEE
ANNUITY
ANODIZE
ALUMINUM
AIR
AISLE
ADJOIN
ABYSS
ABOLISH
QUEUE
QUIVER
QUALM
QUITE
QUIXOTIC
QUOIN
QUOIT
QUOTIENT
RADIO
RAISIN
RAPT
RATIO
RAUCOUS
RAYON
RAZOR
REALM
REEK
REGISTER
RIVET
SCHOONER
SAUNA
SATIN
SCEPTER
SCIENCE
SCRIBBLE
BEHIND
DIGNIFY
ELLIPTIC
ELOQUENT
ELUSIVE
FEATHER
GALLOWS
GARDEN
GAZELLE
MACABRE
VALIANT
VENISON
VIVID
WEIGHT
WEIRD
WISE
ZERO
ZOOLOGY
ZENITH
YAWN
YOLK
YELLOW
YULE
TRICKLE
END

OPERATING THE PROGRAM

Once the program has been loaded into memory (along with the user provided I/O routines!) the program is ready to operate. Simply start program execution at page 02 location 000. Operation from then on is directed by the program. A sample of the program's operation is illustrated below.

```
WANT A NEW WORD?   Y
GUESS A LETTER:    A
NOPE!  H------
GUESS A LETTER:    E
GOOD. YOU HAVE:  -E---
GUESS A LETTER:    R
NOPE!  HA-----
GUESS A LETTER:    L
GOOD. YOU HAVE:  -ELL-
GUESS A LETTER:    B
NOPE!  HAN----
GUESS A LETTER:    S
NOPE!  HANG---
GUESS A LETTER:    O
GOOD. YOU HAVE:  -ELLO
GUESS A LETTER:    H
GOOD. YOU HAVE:  HELLO
CONGRATULATIONS!

WANT A NEW WORD?   Y
GUESS A LETTER:    A
NOPE!  H------
GUESS A LETTER:    E
GOOD. YOU HAVE:  -----E
GUESS A LETTER:    I
GOOD. YOU HAVE:  ---I-E
GUESS A LETTER:    O
GOOD. YOU HAVE:  -O-I-E
GUESS A LETTER:    U
NOPE!  HA-----
```

```
GUESS A LETTER:    R
NOPE!  HAN- - - -
GUESS A LETTER:    T
GOOD. YOU HAVE:  - OTI - E
GUESS A LETTER:    N
GOOD. YOU HAVE:  NOTI - E
GUESS A LETTER:    C
GOOD. YOU HAVE:  NOTICE
CONGRATULATIONS!


WANT A NEW WORD?  Y
GUESS A LETTER:    W
NOPE!  H- - - - - -
GUESS A LETTER:    Y
NOPE!  HA- - - - -
GUESS A LETTER:    P
NOPE!  HAN- - - -
GUESS A LETTER:    N
NOPE!  HANG- - -
GUESS A LETTER:    G
NOPE!  HANGM- -
GUESS A LETTER:    V
NOPE!  HANGMA-
GUESS A LETTER:    C
NOPE!  HANGMAN-
GUESS A LETTER:    X
NOPE!  HANGMAN!


WANT A NEW WORD?  N
GOODBYE!
```

The program will continue to operate until a player responds with a N for NO to the WANT A NEW WORD query. At that time, the program will halt. If it is desired to continue playing after a NO response to that question, the program may simply be restarted at the starting address (page 02 location 000).

ASSEMBLED LISTING OF THE PROGRAM FOR AN 8080 SYSTEM

The following is an assembled listing of the HANGMAN! program designed to run on an 8080 system. Only minor changes have been made in the program to take advantage of some of the special capabilities of the 8080 instruction set. However, the basic organization of the program has not been altered so that the previous detailed discussion of the program's operation still applies. The message table and word list would be in the same format as the 8008 version. Of course, the user will need to provide the appropriate I/O routines for either version of the program. They can be placed in the same memory locations for the following 8080 version as was suggested for the 8008 example (on page 04 starting at locations 200 (input) and 300 (output)).

```
002 000   041 350 003      START,    LXH 350 003
002 003   066 001                    LMI 001
002 005   056 356                    LLI 356
002 007   066 000                    LMI 000
002 011   054                        INL
002 012   066 005                    LMI 005

002 014   061 200 004      NEWONE,   LXS 200 004
002 017   041 000 004                LXH 000 004
002 022   315 032 003                CAL MSG
002 025   315 200 004                CAL INPUTN
002 030   376 316                    CPI 316
002 032   312 050 002                JTZ NOMORE
002 035   376 331                    CPI 331
002 037   302 014 002                JFZ NEWONE
002 042   315 327 002                CAL MOVTAB
002 045   303 057 002                JMP GUESS

002 050   041 025 004      NOMORE,   LXH 025 004
002 053   315 032 003                CAL MSG
002 056   166                        HLT
```

```
002 057    041 037 004        GUESS,    LXH 037 004
002 062    315 032 003                  CAL MSG
002 065    315 200 004                  CAL INPUTN
002 070    117                          LCA

002 071    006 000            SCAN,     LBI 000
002 073    041 360 003                  LXH 360 003

002 076    276                CKMTCH,   CPM
002 077    302 114 002                  JFZ NOMTCH
002 102    004                          INB
002 103    076 010                      LAI 010
002 105    205                          ADL
002 106    157                          LLA
002 107    161                          LMC
002 110    175                          LAL
002 111    326 010                      SUI 010
002 113    157                          LLA

002 114    054                NOMTCH,   INL
002 115    176                          LAM
002 116    247                          NDA
002 117    312 134 002                  JTZ EOWORD
002 122    076 007                      LAI 007
002 124    245                          NDL
002 125    312 134 002                  JTZ EOWORD
002 130    171                          LAC
002 131    303 076 002                  JMP CKMTCH

002 134    004                EOWORD,   INB
002 135    005                          DCB
002 136    312 243 002                  JTZ HANGIT
002 141    041 074 004                  LXH 074 004
002 144    315 032 003                  CAL MSG
002 147    041 353 003                  LXH 353 003
002 152    066 000                      LMI 000
002 154    056 370                      LLI 370

002 156    176                NOTEND,   LAM
002 157    376 255                      CPI 255
```

```
002 161     302 171 002                 JFZ AHEAD2
002 164     135                         LEL
002 165     056 353                     LLI 353
002 167     064                         INM
002 170     153                         LLE

002 171     315 300 004     AHEAD2,     CAL PRINT
002 174     054                         INL
002 175     175                         LAL
002 176     326 010                     SUI 010
002 200     157                         LLA
002 201     176                         LAM
002 202     247                         NDA
002 203     312 223 002                 JTZ ENDAGN
002 206     175                         LAL
002 207     346 007                     NDI 007
002 211     312 223 002                 JTZ ENDAGN
002 214     076 010                     LAI 010
002 216     205                         ADL
002 217     157                         LLA
002 220     303 156 002                 JMP NOTEND
002 223     056 353         ENDAGN,     LLI 353
002 225     064                         INM
002 226     065                         DCM
002 227     302 057 002                 JFZ GUESS
002 232     041 120 004                 LXH 120 004
002 235     315 032 003                 CAL MSG
002 240     303 014 002                 JMP NEWONE

002 243     041 062 004     HANGIT,     LXH 062 004
002 246     315 032 003                 CAL MSG
002 251     041 350 003                 LXH 350 003
002 254     064                         INM
002 255     176                         LAM
002 256     054                         INL
002 257     167                         LMA
002 260     076 010                     LAI 010
002 262     226                         SUM
002 263     054                         INL
002 264     167                         LMA
```

```
002 265   036 340                    LEI 340

002 267   153             HANGMR,    LLE
002 270   176                        LAM
002 271   315 300 004                CAL PRINT
002 274   054                        INL
002 275   135                        LEL
002 276   056 351                    LLI 351
002 300   065                        DCM
002 301   302 267 002                JFZ HANGMR
002 304   056 352                    LLI 352
002 306   064                        INM
002 307   065                        DCM
002 310   312 014 002                JTZ NEWONE
002 313   076 255                    LAI 255

002 315   315 300 004     MRDASH,    CAL PRINT
002 320   065                        DCM
002 321   302 315 002                JFZ MRDASH
002 324   303 057 002                JMP GUESS

002 327   041 350 003     MOVTAB,    LXH 350 003
002 332   106                        LBM
002 333   056 370                    LLI 370
002 335   016 010                    LCI 010
002 337   076 255                    LAI 255

002 341   167             DASHFL,    LMA
002 342   054                        INL
002 343   015                        DCC
002 344   302 341 002                JFZ DASHFL

002 347   041 360 003     NXWORD,    LXH 360 003
002 352   016 010                    LCI 010
002 354   257                        XRA

002 355   167             ZEROFL,    LMA
002 356   054                        INL
002 357   015                        DCC
002 360   302 355 002                JFZ ZEROFL
```

```
002 363    052 356 003                LHLD 356 003
002 366    257                        XRA
002 367    276                        CPM
002 370    302 376 002                JFZ AHEAD3
002 373    041 000 005                LXH 000 005

002 376    021 360 003     AHEAD3,    LXD 360 003

003 001    176             BUFFMR,    LAM
003 002    247                        NDA
003 003    312 014 003                JTZ NEXT
003 006    022                        STAD
003 007    023                        INXD
003 010    043                        INXH
003 011    303 001 003                JMP BUFFMR

003 014    043               NEXT,    INXH
003 015    042 356 003                SHLD 356 003
003 020    005                        DCB
003 021    302 347 002                JFZ NXWORD
003 024    041 350 003                LXH 350 003
003 027    066 000                    LMI 000
003 031    311                        RET

003 032    176                MSG,    LAM
003 033    247                        NDA
003 034    310                        RTZ
003 035    315 300 004                CAL PRINT
003 040    043                        INXH
003 041    303 032 003                JMP MSG
```