First Steps in Computer Chess Programming

Kathe and Dan Spracklen
10832 Macouba Pl
San Diego CA 92124

The fascination of chess gains a new dimension with microcomputer chess. No longer are the struggles confined to giant machines. With the advent of the Chess Mate, Chess Challenger, Boris, and Compuchess, as well as some custom software packages, the day of microcomputer chess has dawned. Writing a program to play chess on a small system is no small matter, though. Consider just for a start the challenge of meaningfully representing the board and its pieces in computer memory: there are 64 squares, 32 pieces, 6 piece types and 2 piece colors. Since the machine is a microcomputer, storage requirements must be kept to a minimum. Next comes the job of moving the pieces. Only when these first problems of piece representation and move generation have been solved can the chess programmer go on to consider strategy.

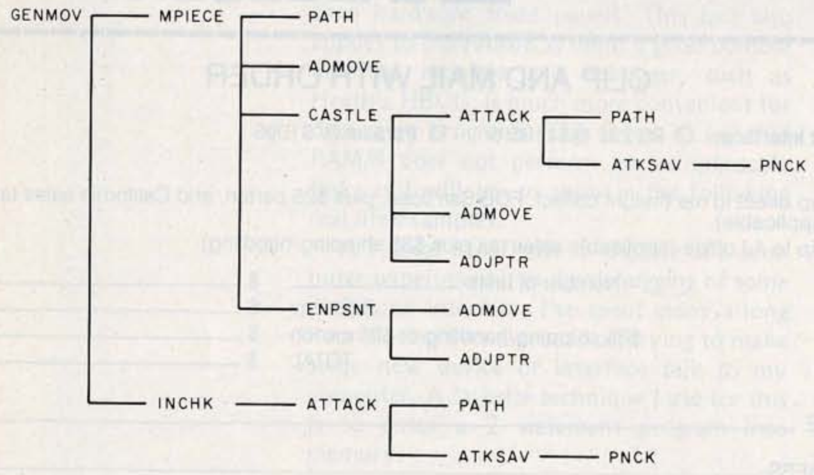

Figure 1: Block structure of the move generation routine of Sargon, the authors' chess playing program written for Z-80 assembler language.

Sargon, a chess playing program we developed for Z-80 machines, solves the representation problem through the use of a board array. Move generation is accomplished through a network of routines diagrammed in figure 1. The functions of the routines are as follows:

GENMOV	Generate move routine. Generates the move set for all of the pieces of a given color.
MPIECE	Piece mover routine. Generates the move set for a given piece.
INCHK	Check routine. Determines whether or not the King is in check.
PATH	Path routine. Generates a single possible move for a given piece along its current path of motion.
ADMOVE	Admove routine. Adds a move to the move list.
CASTLE	Castle routine. Determines whether castling is legal and adds it to the move list if it is.
ENPSNT	En passant routine. Tests for an en passant pawn capture and adds it to the move lists if it is legal.
ATTACK	Attack routine. Finds all the attackers on a given square.
ADJPTR	Adjust move list pointer. Links around the second move in a double move (ie: castle or en passant pawn capture).
ATKSAV	Attack save routine. Saves attacking piece value in the attack list and increments the attack count for that color piece.
PNCK	Pin check routine. Checks to see if an attacking piece is in the pinned piece list.

Several of the routines involved are multipurpose routines. Their involvement in move generation is incidental to a main function elsewhere in the move selection logic. The key routines in move generation are MPIECE, PATH, CASTLE and ENPSNT. Of these,

(a)

110	111	112	113	114	115	116	117	118	119
100	101	102	103	104	105	106	107	108	109
90	91	92	93	94	95	96	97	98	99
80	81	82	83	84	85	86	87	88	89
70	71	72	73	74	75	76	77	78	79
60	61	62	63	64	65	66	67	68	69
50	51	52	53	54	55	56	57	58	59
40	41	42	43	44	45	46	47	48	49
30	31	32	33	34	35	36	37	38	39
20	21	22	23	24	25	26	27	28	29
10	11	12	13	14	15	16	17	18	19
0	1	2	3	4	5	6	7	8	9

(b)

6E	6F	70	71	72	73	74	75	76	77
64	65	66	67	68	69	6A	6B	6C	6D
5A	5B	5C	5D	5E	5F	60	61	62	63
50	51	52	53	54	55	56	57	58	59
46	47	48	49	4A	4B	4C	4D	4E	4F
3C	3D	3E	3F	40	41	42	43	44	45
32	33	34	35	36	37	38	39	3A	3B
28	29	2A	2B	2C	2D	2E	2F	30	31
1E	1F	20	21	22	23	24	25	26	27
14	15	16	17	18	19	1A	1B	1C	1D
A	B	C	D	E	F	10	11	12	13
0	1	2	3	4	5	6	7	8	9

Figure 2: Decimal (a) and hexadecimal (b) representations of the chessboard used in the Sargon program. Each square of the board is represented by a single byte in memory. Border squares are assigned a flag value of hexadecimal FF. The use of the border simplifies move generation, since it becomes easy to determine when a piece moves off the board.

MPIECE and PATH will be discussed here. The routines will be described in a language independent narrative. The Z-80 assembler code in which they are implemented will also be presented and exhaustively commented.

The Board in Memory

The chessboard in memory is an array of 120 bytes that can be visualized as in figure 2. Each square of the board is represented in memory by a single byte. Border bytes are assigned a flag value of hexadecimal FF. The border simplifies move generation, since it becomes easy to determine when a piece moves off the board.

The Pieces in Memory

Each piece is represented in memory by one byte of data. The meaning and function of the bits are as follows:

Bit 7 –	color of the piece.
	1 – Black
	0 – White
Bit 6 –	not used.
Bit 5	not used.
Bit 4 –	castle flag for Kings only.
	Set if the King has castled.
Bit 3 –	moved flag.
	Set if the piece has moved.
Bits 2-0 –	Piece type.
	1 Pawn
	2 Knight
	3 Bishop
	4 Rook
	5 Queen
	6 King

The pieces in play occupy squares of the board. If a board square is empty, it has the value 00. Thus the board set up for play would be as shown in figure 3.

Piece Mover Data Base

In order to generate moves for the pieces on the board, data must be maintained to describe the possibilities for each piece. This is accomplished through the use of three tables. Values for the tables are given in table 1.

DIRECT	Direction Table. Used to determine the direction of movement of each piece.
DPOINT	Direction Table Pointer. Used to determine where to begin in the direction table for any given piece.
DCOUNT	Direction Table Counter. Used to determine the number of directions of movement for any given piece.

FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
FF	84	82	83	85	86	83	82	84	FF
FF	81	81	81	81	81	81	81	81	FF
FF	00	00	00	00	00	00	00	00	FF
FF	00	00	00	00	00	00	00	00	FF
FF	00	00	00	00	00	00	00	00	FF
FF	00	00	00	00	00	00	00	00	FF
FF	01	01	01	01	01	01	01	01	FF
FF	04	02	03	05	06	03	02	04	FF
FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
FF	FF	FF	FF	FF	FF	FF	FF	FF	FF

Figure 3: Representation of the pieces on their home squares. Pieces are identified by means of unique byte values.

About the Authors

Dan and Kathe Spracklen are the creators of Sargon, the microcomputer chess program that won the microcomputer chess tournament at the 1978 West Coast Computer Faire. Dan Spracklen is a 13 year programming veteran. His experience ranges from scientific simulation programs to real time commercial applications. He is currently a senior applications analyst for Sperry-Univac. Kathe Spracklen is a graduate student in computer science at San Diego State University. An experienced tournament player, Kathe provided the chess background for Sargon.

Listing 1: The Sargon move generation routine, written in Z-80 assembly language.

```
;**********************************
; EQUATES
;**********************************
PAWN     =     1
KNIGHT   =     2
BISHOP   =     3
ROOK     =     4
QUEEN    =     5
KING     =     6
WHITE    =     0
BLACK    =     80H
BPAWN    =     BLACK+PAWN
```

Equate statements supply symbolic equivalents for the piece types and colors.

```
;**********************************
;TABLES SECTION
;**********************************
START:
```

Start is the first address in Sargon and should lie on an even 256 byte page boundary.

```
         .LOC     START+80H
TBASE    =        START+100H
```

Indexing in the Z-80 makes use of an address, contained in either the IX or IY index registers, plus a displacement. The displacement is a signed number +127 to −128. Thus a 256 byte area of memory centered on the index address is accessible. For this reason TBASE is placed in the middle of the tables section.

```
;**********************************
;DIRECT – DIRECTION TABLE
;**********************************
DIRECT   =        .–TBASE
```

The value of "." is the current program counter. Direct is now the displacement of the direction table from the table base. So if the value of TBASE is loaded in the IY index register, "DIRECT(Y)" will reference the first element in the direction table.

```
                  .BYTE + 09,+ 11,–11,–09
                  .BYTE + 10,–10,+ 01,–01
                  .BYTE –21,–12,+ 08,+ 19
                  .BYTE + 21,+ 12,–08,–19
                  .BYTE + 10,+ 10,+ 11,+ 09

                  .BYTE –10,–10,–11,–09
```

Diagonal directions used for Bishop, Queen, and King.
Rank and file directions used for Rook, Queen, and King.
Knight move directions.

White pawn directions including two forward moves and two diagonal moves for captures.
Black pawn directions.

```
;**********************************
;DPOINT-DIRECTION TABLE POINTER
;**********************************
DPOINT   =        .–TBASE
         .BYTE  20,16,8,0,4,0,0
```

Displacement from table base.
Starting point in direction table. In the order BP, WP, N, B, R, Q, K.

```
;**********************************
;DCOUNT-DIRECTION TABLE COUNTER
;**********************************
DCOUNT   =       .–TBASE
         .BYTE  4,4,8,4,4,8,8
```

Number of directions to use from table. In the same order as DPOINT.

```
;**********************************
;BOARD – BOARD ARRAY
;**********************************
BOARD    =        –TBASE
BOARDA  .BLKB    120
```

The board array consists of 120 bytes in memory.

```
;**********************************
;TABLE INDICES SECTION
;**********************************
         .LOC     START+0
M1:      .WORD  TBASE
M2:      .WORD  TBASE
M3:      .WORD  TBASE
M4:      .WORD  TBASE
T1:      .WORD  TBASE
T2:      .WORD  TBASE
T3:      .WORD  TBASE
```

Uses the area of memory between START and START+80H. These indices are used to index into the various tables. Since TBASE is on an even boundary, its address is of the form XX00, where XX depends on the load address. The table address needed for a particular routine is formed by storing a one byte value in the 00 portion. Since addresses are stored in memory with the low order byte first, XX00 would be stored as 00XX. Then changing the 00 portion is simply a matter of storing a one byte value in the index.

```
;**********************************
;VARIABLES SECTION
;**********************************
P1:      .BYTE 0
P2:      .BYTE 0
P3:      .BYTE 0
```

Working storage area to hold the contents of the board array for a given square.

```
;**********************************
;PIECE MOVER ROUTINE
;**********************************
MPIECE:  XRA      M
```

Gets the piece to be moved into register A. In GENMOV, the routine which calls MPIECE, the piece value in register A, had been exclusive ORed with COLOR, the color of the piece to determine whether or not to call MPIECE. Another exclusive OR restores the piece.

```
         ANI      87H
```

This clears all the flag bits and leaves just piece type and color.

```
         CPI      BPAWN
```

Is it a Black pawn?

Listing 1, continued (Listing 1 is concluded on page 95):

```
        JRNZ    MP2             No—Skip.
        DCR     A               Decrement, making piece type a 0 for a Black pawn.
MP2:    ANI     7               Clears color bit and leaves just the piece type.
        STA     T1              This is the first step in forming the index into DPOINT and
                                DCOUNT. T1 contains the value of TBASE (XX00) stored
                                in low-high order (00XX). After storing the piece type
                                (0–6) in T1, it contains the address of TBASE + TYPE.
        LIYD    T1              This operation loads the entire TBASE + TYPE address into
                                the IY index register.
        MOV     B,DCOUNT(Y)     DCOUNT is the displacement from TBASE to the start
                                of the direction count table. So DCOUNT + TBASE is
                                the starting address of the direction count table. Then
                                DCOUNT(Y) is:
                                   DCOUNT + CONTENTS IY Register
                                =  DCOUNT + TBASE + TYPE (0–6)
                                =  START OF TABLE + TYPE (0–6)
                                This move instruction pulls the direction count for the given
                                piece type and places it in register B.
        MOV     A,DPOINT(Y)     Similarly, this instruction pulls the direction table pointer for
                                the given piece type and places it in register A.
        STA     INDX2           The direction table pointer will be used to index into the
        LIYD    INDX2           direction table.
MP5:    MOV     C,DIRECT(Y)     Gets the direction and places it in register C.
        LDA     M1              Gets the "from" position which was stored in M1 in
                                GENMOV.
        STA     M2              Save in M2 to form the address of the current position.
MP10:   CALL    PATH            Generate a single move in the given direction.
        CPI     2               Did the moving piece encounter a piece of the same color,
                                or is new position off the board?
        JRNC    MP15            Jump if yes to either question. No move to add to move
                                list. Ready for new direction.
        ANA     A               Was the square moved to empty?
        EXAF                    Save the answer to this question by swapping flag register
                                for alternate flag register.
        LDA     T1              Get type of moving piece.
        CPI     PAWN+1          Is it a pawn?
        JRC     MP20            If so, jump to special pawn handling logic. PAWN+1 is equal
                                to the number 2. A White pawn would be of type 1 while a
                                Black pawn would have type set to 0. In either case the
                                carry flag would be set upon a comparison to a value of 2.
        CALL    ADMOVE          Valid move, so add it to the move list.
        EXAF                    Restore the answer to the empty square question.
        JRNZ    MP15            If it is not empty, go get ready for next direction. No further
                                moves are possible in this direction.
        LDA     T1              Get piece type. Some pieces may only make one move in a
                                given direction.
        CPI     KING            The King is such a piece. Is this piece a King?
        JRZ     MP15            If so, go get ready for a new direction.
        CPI     BISHOP          Compare piece type to a Bishop.
        JRNC    MP10            If piece type is bishop or greater (ie: Bishop, Rook, or
                                Queen) go make another move in this same direction.
MP15:   INX     Y               Increment direction index for next direction in the direction
                                table.
        DJNZ    MP5             Decrement the direction count (in register B). If count is
                                not yet 0, go back and repeat this process for the new direc-
                                tion. Otherwise all of the directions have been considered.
        LDA     T1              Fetch piece type again.
        CPI     KING            Is it a King?
        CZ      CASTLE          If so, call castle to add it to the move list if legal.
        RET                     Return to GENMOV.
;***********PAWN LOGIC***********
MP20:   MOV     A,B             Get the number of move directions left to consider. If this
                                is the first direction, register A=4.
        CPI     3               Are there three directions left to look at?
        JRC     MP35            A carry on this compare indicates a diagonal move. If so,
                                branch to diagonal logic.
        JRZ     MP30            Equality on this compare indicates a forward move of two
                                squares.
                                Branch to check for legality.
        EXAF                    Otherwise this is a forward move of one square. Restore the
                                answer to the empty square question.
        JRNZ    MP15            If the square is not empty, this is not a valid move. Go check
                                the next direction.
        LDA     M2              Get the "to" position of the move.
        CPI     91              Is it on the last rank and therefore a promotion of a White
                                pawn?
        JRNC    MP25            If so, go set promotion flag.
        CPI     29              Otherwise, is it on the first rank and therefore a promotion
                                of a Black pawn?
        JRNC    MP26            If no, skip setting flag.
MP25:   LXI     H,P2            Load the address of the promotion flag.
        SET     5,M             Set the flag (bit 5 of P2).
```

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The subroutines in Sargon that handle the actual move generation rely heavily on the indexing capabilities of the Z-80 microprocessor. For this purpose several sets of indices are maintained to access elements of the tables. The piece mover routines depend especially on the following groups of indices.

M1–M4	Working indices used to index into the board array.
T1–T3	Working indices used to index into direction count, direction value, and piece value tables.
INDX1 INDX2	General working indices. Used for various purposes.

Variables and constants used in the routines PATH and MPIECE include:

PAWN	= 1	(Identification of the piece types is made through use of equate statements. Numbers are hexadecimal.)
KNIGHT	= 2	
BISHOP	= 3	
ROOK	= 4	
QUEEN	= 5	
KING	= 6	
WHITE	= 0	
BLACK	= 80	
BPAWN	= Black + pawn	
P1–P3	= Working area to hold the contents of the board array for a given square.	

DPOINT *(a)*

0	+09	+11	−11	−09
4	+10	−10	+01	−01
8	−21	−12	+08	+19
12	+21	+12	−08	−19
16	+10	+10	+11	+09
20	−10	−10	−11	−09

(b)

Piece Type	DPOINT	DCOUNT
Black Pawn	20	4
White Pawn	16	4
Knight	8	8
Bishop	0	4
Rook	4	4
Queen	0	8
King	0	8

Table 1: Direction table (a) and direction table pointer and counter (b). In order to generate moves for the chess pieces, data describing the possibilities for each piece is kept in table 1a. Table 1b shows the direction table pointer, which tells where to start in the table for a given piece, and the direction table counter, which determines the number of directions of movement for a given piece.

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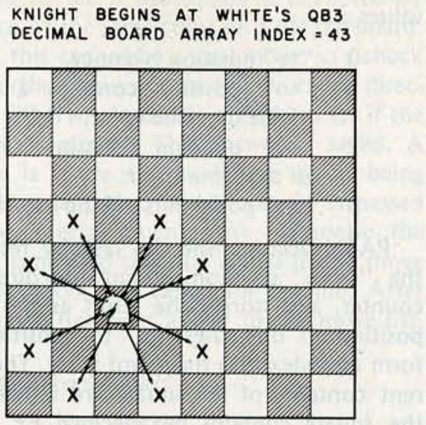

Direction Table Values	Direction Calculation	New Board Array Index	Resulting Square
−21	43 − 21	22	QN1
−12	43 − 12	31	QR2
+08	43 + 08	51	QR4
+19	43 + 19	62	QN5
+21	43 + 21	64	Q5
+12	43 + 12	55	K4
−08	43 − 08	35	K2
−19	43 − 19	24	Q1

Figure 4: Generating all the possible Knight moves from the Queen Bishop 3 (QB3) square. The Knight is piece type 2 (see text) and has a DPOINT (direction table pointer) value of 8 and a DCOUNT (direction table counter) value of 8 also. So in generating the Knight's moves, DIRECT+8 will be the starting point in the direction table, and 8 values will be used: −21, −12, +08, +19, +21, +12, −08 and −19. The Knight starts at White's QB3 square, which is square 43 (see figure 2a, decimal representation). Thus the first possible Knight move is 43 − 21 = 22 (QN1), and so on.

Sample Move Generation

Suppose a Knight occupies the QB3 square. A Knight is piece type 2 and has a DPOINT of 8 and a DCOUNT of 8 (see table 1b). So in generating the Knight's moves, DIRECT + 8 will be the starting point in the direction table and 8 values will be used. Those values are −21, −12, +08, +19, +21, +12, −08, and −19. The Knight starts at White's QB3, which is square 43 (see figure 2a, decimal representation). Thus the first possible Knight move is 43 − 21 = 22. Now 22 is QN1, so the first Knight move returns the Knight to its starting square. Figure 4 summarizes all possible Knight moves from QB3.

**Move Generation—
The Algorithms Explained**

Move generation is controlled by GENMOV, which scans the board array and calls MPIECE for each piece encountered.

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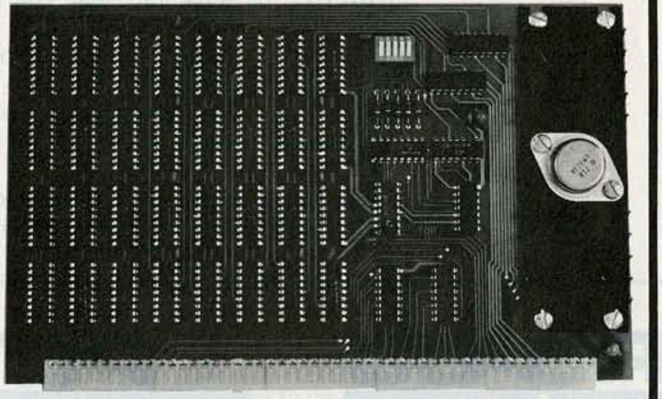

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Then MPIECE, the piece mover routine, generates all possible legal moves for that piece (moves that place the King in check are eliminated later in the program). The piece is brought in from memory. It is a one byte data value, as previously discussed, which contains piece type, flags and color. The flags are deleted from the piece before checking for type. Basic piece types are indicated by values from 1 to 6. Except for pawns, White and Black pieces move alike. So a special case is needed for the Black pawn. If the given piece is a Black pawn, the piece type is decremented, making it type 0.

The type of the piece, now one from 0 to 6, is used as an index into the DCOUNT, direction table count, and DPOINT, direction table pointer arrays. The values for the given piece are fetched. The direction table pointer is then used as an index into DIRECT, the direction table, and the first move direction is fetched. The "from" position of the piece is the square on which the piece currently stands. This "from" board index and the direction table value are passed as parameters to the routine PATH.

PATH generates the move indicated and returns a flag which describes the status of the "to" position of the piece. Flag values are:

0 "to" position is empty.
1 "to" position contains a piece of the opposite color.
2 "to" position contains a piece of the same color.
3 "to" position is off the board.

PATH accomplishes its task by fetching the "from" position, adding the direction counter, and storing the result as the "to" position. It then uses the "to" position to form an index into the board array. The current contents of the square are fetched. If the square contains hexadecimal FF, it is off the board. The off board flag is set and control is returned to MPIECE.

If the square is on the board, the contents of the square are saved in memory location P2. The color and flag bits are then cleared and the remaining piece type is saved in T2. If the square is empty, control is returned to MPIECE with the flag value still set to 0. Otherwise the color of the piece on the "to" square is compared with that of the moving piece. The appropriate flag is set to indicate whether or not the pieces are of the same color, and control is returned to MPIECE.

Upon return from PATH, piece mover

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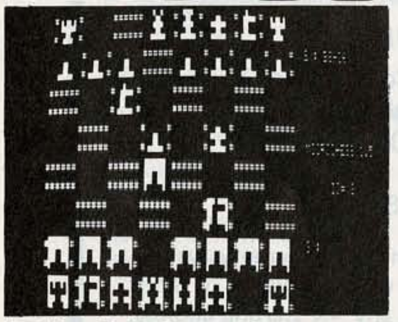
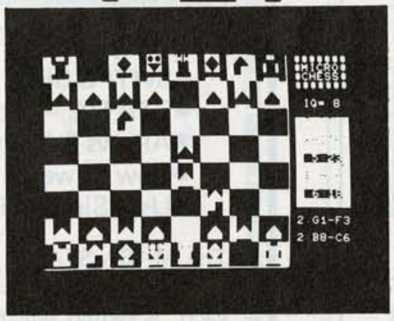

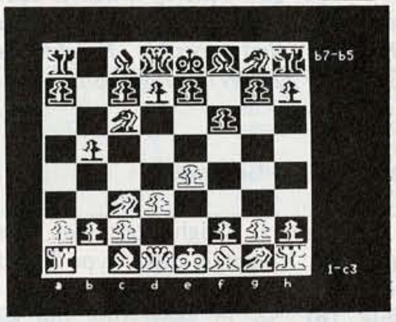

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checks to see if the square is occupied by a piece of the same color or is off the board. If so, this cannot be a legal move, so a check for further moves must follow a new direction. Otherwise a check is made to see if the square is empty. The answer is saved. A check is made to see if the piece being moved is a pawn. If so, control is passed to the special pawn logic. Otherwise the move generated must be added to the move list. ADMOVE is called for the job. After the move has been added to the move list, the answer to the empty square question is recovered. If the square is empty and the piece is a Bishop, Rook, or Queen, it is possible to continue moving in the same direction. In this case control passes back to the call to PATH for another move in that direction. Kings and Knights may make only one move in a given direction.

When the time comes to consider a new direction of movement for the piece, the index into the direction table is incremented. DCOUNT, the number of directions to con-

Listing 1, continued:

```
MP26:   CALL    ADMOVE          Add this move to the move list.
        INX     Y               Increment direction index for two square move direction.
        DCR     B               Decrement the direction count.
        LXI     H,P1            Load the address where the piece was saved.
        BIT     3,M             Check the flag in the piece which tells whether it has moved
                                before.
        JRZ     MP10            If the pawn has never moved, go generate a second forward
                                move. (The pawn can move two squares on the first move.)
        JMP     MP15            Otherwise go get new direction, skipping second forward
                                move.
;********MOVE OF 2 SQUARES********
MP30:   EXAF                    Restore the answer to the empty square question.
        JRNZ    MP15            If the square is not empty, this is not a valid move. Go check
                                the next direction.
MP31:   CALL    ADMOVE          Otherwise add this move to the move list.
        JMP     MP15            Go check the next direction.
;*********DIAGONAL MOVE**********
MP35:   EXAF                    Restore the answer to the empty square question.
        JRZ     MP36            If the square is empty, it is not a normal pawn capture.
                                Go try en passant.
        LDA     M2              Get the "to" position of the move.
        CPI     91              If the board index is 91 or greater, this is the last rank and
                                a White pawn promotion.
        JRNC    MP37            If so, go set promote flag.
        CPI     29              Otherwise, if the board index is less than 29, this is the first
                                rank and a Black pawn promotion.
        JRNC    MP31            If not, just go add the move to the move list.
MP37:   LXI     H,P2            Load the address of the promotion flag.
        SET     5,M             Set the flag (bit 5 of P2), and go add the move to the move
        JMPR    MP31            list.
;*****DIAGONAL SQUARE EMPTY*****
MP36:   CALL    ENPSNT          Check for possible en passant capture and add it to the
                                move list if legal.
        JMP     MP15            Go check the next direction.
;**********************************
;PATH ROUTINE
;**********************************
PATH:   LXI     H,M2            Get the address of the location where the "from" position
                                was stored.
        MOV     A,M             Get the "from" position from that memory location.
        ADD     C               Add in the direction from the direction table, giving the
                                "to" position.
        MOV     M,A             Use "to" position to form an index into the board array.
        LIXD    M2              Load the board index.
        MOV     A,BOARD(X)      Get the contents of the board at the "to" square.
        CPI     0FFH            Is the "to" position off the board?
        JRZ     PA2             If so, go set off-board flag.
        STA     P2              Save contents of the board at "to" square.
        ANI     7               Isolate piece type.
        STA     T2              Save piece type.
        RZ                      Return if the square is empty. The flag value is returned in
                                the A register and it is already 0.
        LDA     P2              Get piece again.
        LXI     H,P1            Load the address of the moving piece.
        XRA     M               Compare the pieces.
        BIT     7,A             Check to see if the colors match. If so, after the exclusive
                                OR the color bit will be 0.
        JRZ     PA1             If they match, go set match flag.
        MVI     A,1             Otherwise, set different color flag and return.
        RET
;***********SAME COLOR***********
        MVI     A,2             Set same color flag and return.
        RET
;***********OFF BOARD************
        MVI     A,3             Set off-board flag and return.
        RET
```

sider, is decremented. When DCOUNT reaches zero, all the moves for the piece have been generated. If the piece involved is the King, a call to castle will add any legal castling moves. Then control is returned to GENMOV.

All that remains is to discuss the special pawn logic. Pawns are peculiar in that they capture diagonally, but move straight ahead. They also have the option of moving one or two squares forward on their first move. Furthermore, if they reach the eighth and final rank, they may be promoted to another piece. Sargon always promotes its own pawns to Queens. A flag in variable P2 indicates pawn promotion.

The pawn logic in MPIECE first checks to see if the direction of movement is along a diagonal. If so, the square must be occu-

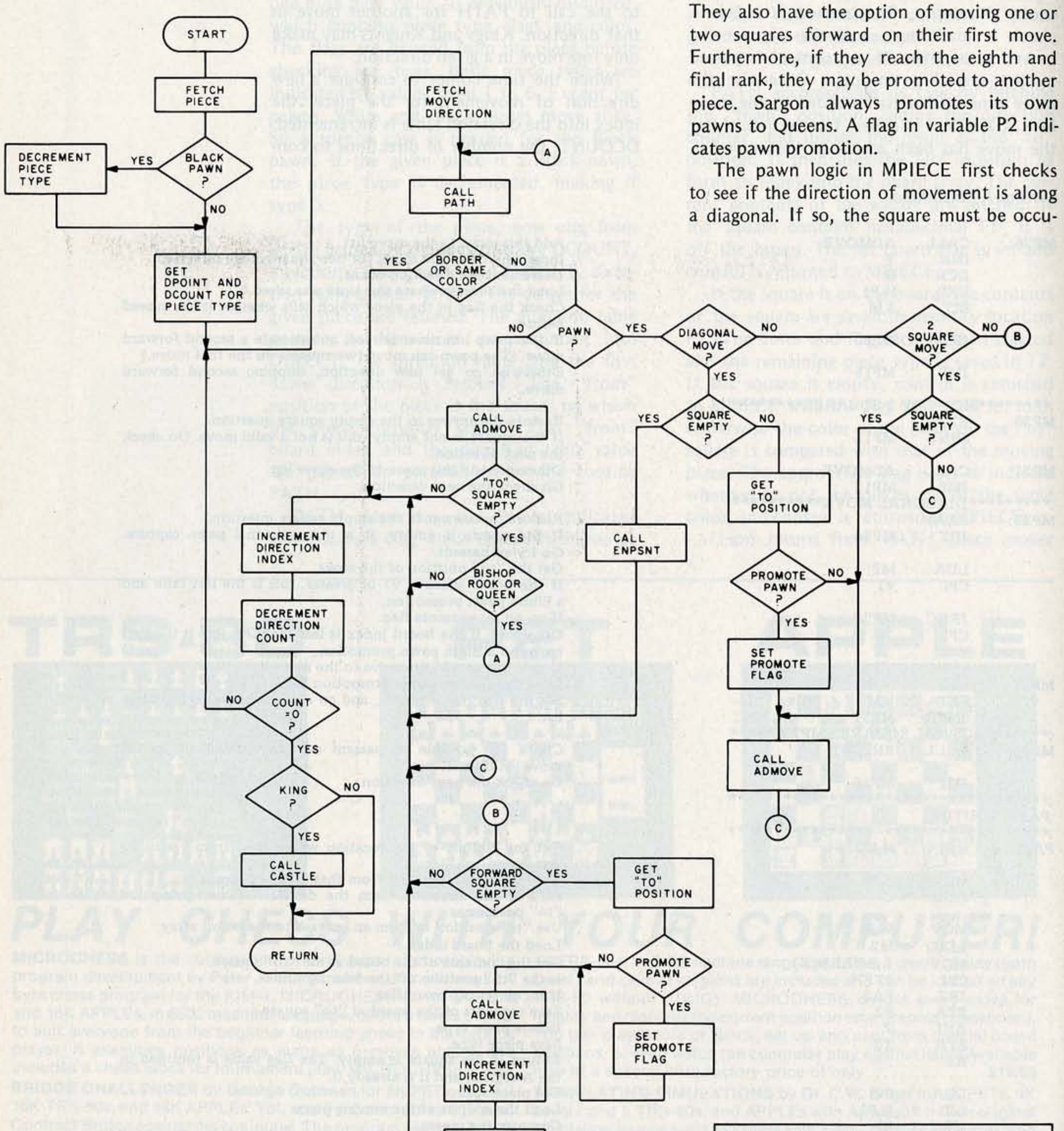

Figure 5: Flowchart of the piece mover routine, MPIECE.

Note: *The authors' complete Sargon chess playing program is available in book form. The documentation includes a complete Z-80 listing with detailed comments. The price is $15 from Dan and Kathe Spracklen, 10832 Macouba Pl, San Diego CA 92124, or from local computer stores for $17.95.*

pied by an enemy piece. It may also be possible to move to the eighth rank in capturing, so pawn promotion must be considered here as well. Another type of diagonal pawn move is the *en passant* capture. It must be considered by a call to ENPSNT. Finally it is time to consider a new direction, as is done for the other piece types.

If, however, the direction of movement is forward, the "to" square must be empty. Pawn promotion must be checked for on forward moves. If the piece has never moved before, another move in the same direction is a possibility. Otherwise it is time to consider a new direction. Figures 5 and 6 are flowcharts of MPIECE and PATH, respectively.

The Other Move Generation Routines

The move generation driver is GENMOV, the generate move routine. The basic function of GENMOV is to generate the move set for all pieces of a given color. It scans the board checking for a piece of the same color and calls MPIECE, the piece mover routine.

CASTLE and ENPSNT are also key routines in move generation. CASTLE checks the legality of both King side and Queen side castling. It adds them to the move list if legal. Basic checks must include:

Has King moved?
Is King in check?
Has Rook moved?
Are the intervening squares empty?
Are any squares that the King passes through under attack?

ENPSNT checks for any en passant pawn captures and adds them to the move list if legal. The tests must include:

On the fifth rank?
Was previous move the first move for the enemy pawn?
Is the enemy pawn on an adjacent file?

INCK, the check routine, performs the function of determining whether or not the King is in check. The basic method used is to scan outward from the King looking for attackers, by calling ATTACK.

The attack routine finds all attackers on a given square by scanning outward from the square until one of the following occurs:

A piece is found that attacks this square.
A piece is found that doesn't attack this square.
The edge of the board is reached.

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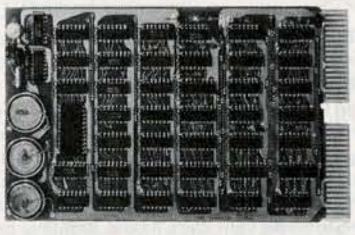

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Note: *Next month the authors discuss their Sargon Exchange Evaluator.*

In the case where this routine is called by CASTLE or INCHK, the routine is terminated as soon as an attacker of the opposite color is encountered.

ADMOVE adds a move to the move list. The move list is a linked list. Each move in the move list is stored in a 6 byte area. The meaning of each byte is as follows:

0&1	MLPTR – Move list pointer. A pointer to the next move in the move list. Used to facilitate sorting the list.
2	MLFRP – Move list from position. The board position from which the piece is moving.
3	MLTOP – Move list to position. The board position to which the piece is moving.
4	MLFLG – Move list flags.
5	MLVAL – Move list value. Contains the score assigned to the move in evaluation.

It is hoped that this introductory discussion will assist potential chess programmers in getting started. With the essentials of move generation out of the way, the fun part of evaluation can begin. ■

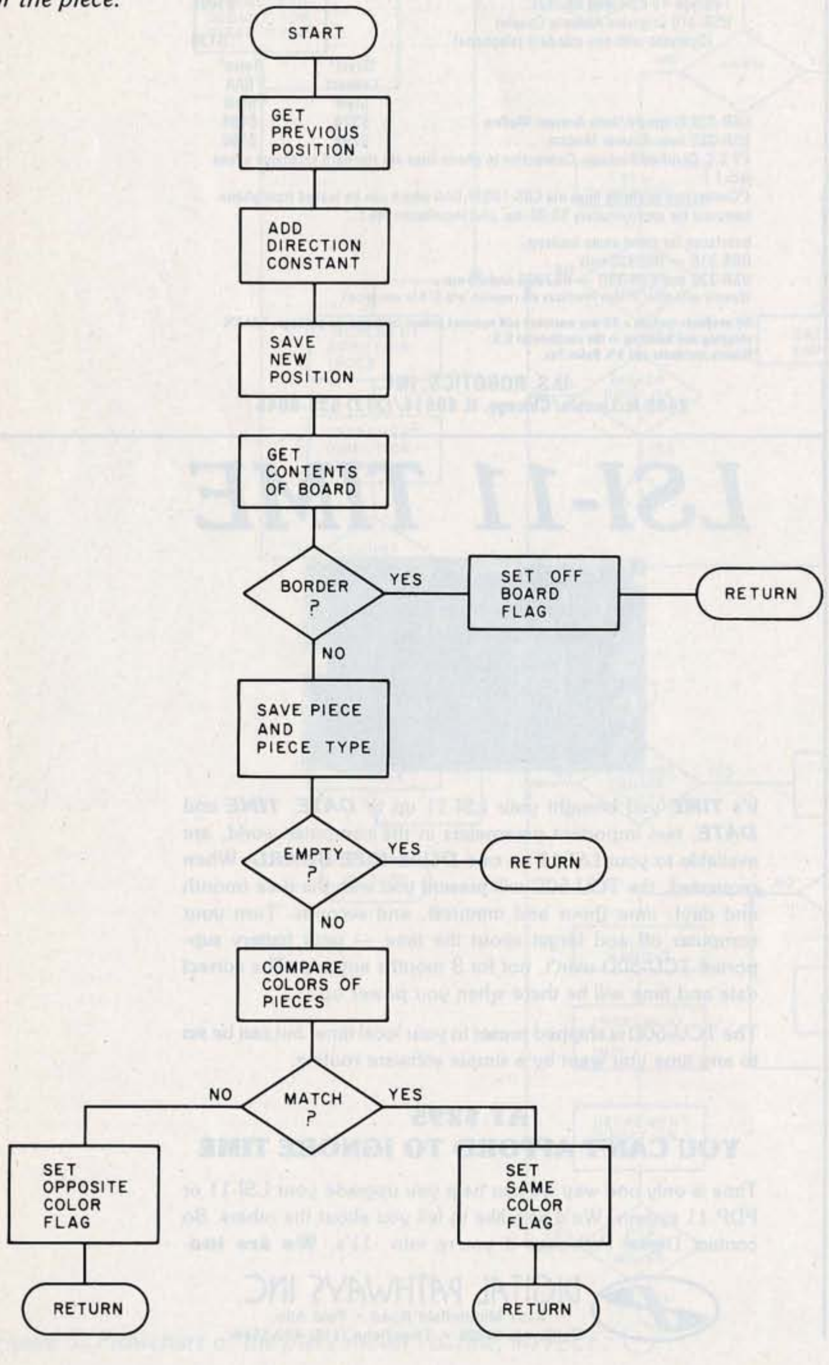

Figure 6: Flowchart of the PATH routine, which performs the actual move of the piece.

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In writing Sargon, it was our original intention to put together the first version without any research into the attempts made by others. In this respect Sargon is a unique creation. After competing in the Second West Coast Computer Faire, we began to investigate some of the literature. This bibliography presents some of the references we found most helpful, together with our evaluations.

1. Michie, Donald, *On Machine Intelligence,* Edinburg University Press, 1974.
Michie's book provides an excellent treatment of exchange evaluation. He uses the concept of an exchange polynomial for accurately determining the outcome of battles engaged on the board. The basic approach we used in XCHNG, the Sargon exchange evaluator, turned out to be surprisingly similar. Sargon's approach, however, is far less computationally complex. We highly recommend this reference to anyone planning to write a chess program without look-ahead.

2. Samuel, A L, "Some Studies in Machine Learning Using the Game of Checkers. 11-Recent Progress," *IBM Journal,* November 1967.
Samuel provides a complete though sometimes difficult treatment of alpha-beta pruning. One of the few articles we encountered before writing Sargon, Samuel's article is the basis for the tree search used in the Sargon program.

3. Fine, Reubin, *Ideas Behind the Chess Openings,* David McKay, New York, 1943.
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4. Chernev, Irving, *Practical Chess Endings,* Dover Publications, New York, 1961.
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5. Kmoch, Hans, *Pawn Power in Chess,* D McKay Company, New York, 1959.
Alas, too many microcomputer chess programs shoot out pawns like photon torpedoes. Kmoch provides an excellent introduction to what constitutes good pawn structure.