SARGON

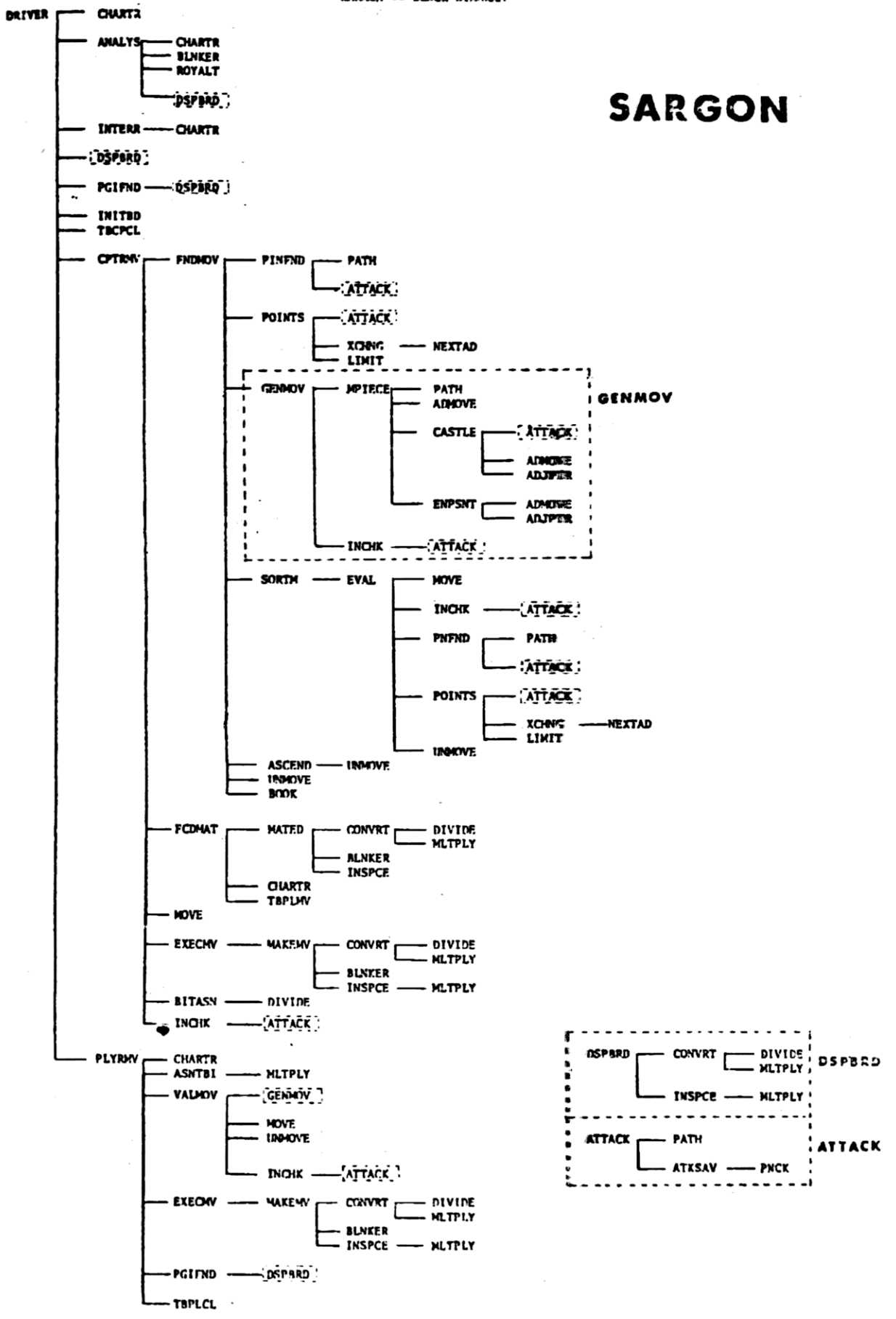
A COMPUTER CHESS PROGRAM

DAN AND KATHE SPRACKLEN

Winner — 1978 West Coast Computer Faire

IN Z-80 ASSEMBLY LANGUAGE

SARGON -- BLOCK DIAGRAM



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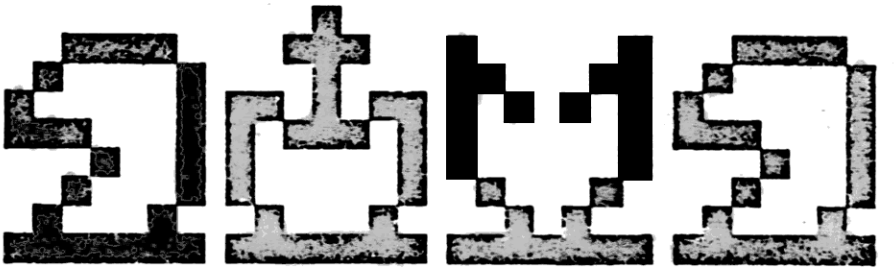

HAYDEN BOOK COMPANY, INC.
Rochelle Park, New Jersey

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MEET SARGON

SARGON is a computer chess program by Dan and Kathe Spracklen. In March 1978 it took first place in the first chess tournament held strictly for microcomputers. The tournament took place during the 2½ days of the 1978 West Coast Computer Faire and drew large crowds each day. When the last battle ended, SARGON had won 5 games of 5 played. A tie existed for second place, with 3 programs scoring a total of 3 points in the 5 rounds.

SARGON is written in Z-8Ø assembly language using the TDL Macro Assembler. The program occupies 8K of RAM, which includes 2K of data areas, 2K graphics display and user interface, and 4K move logic. The move logic is the heart of SARGON. It is displayed in the block diagram as the set of routines called by FNDMOV (Find Move). FNDMOV controls the search for the computer's best move by performing a depth first-tree search using the techniques of alpha beta pruning. Listed first under FNDMOV's calls on the block diagram is PINFND (Pin Find Routine). PINFND produces a list of all pieces pinned against the king or queen for both white and black. Pinned pieces must be treated carefully when analyzing battles engaged on the chess board, since their attacking power may be an illusion. FNDMOV also calls POINTS (Point Evaluation Routine). POINTS performs a static evaluation and derives a score for a given board position. POINTS takes factors of material, board control, and development into account. Predominant in the evaluation is material. Material scores must be adjusted to reflect unresolved battles on the chess board. It is the function of XCHNG (Exchange Evaluation Routine) to judge the outcome of these unresolved battles. The factors of development and board control are not allowed to dominate the move choice. LIMIT is called to truncate the contribution of those factors to the score.

FNDMOV controls the generation of legal moves by GENMOV (Generate Move Routine). GENMOV produces the move set for all of the pieces of a given color. For each piece in turn, GENMOV calls MPIECE (Piece Mover Routine), which generates all the possible legal moves for a given piece. MPIECE itself calls a series of routines. PATH generates a single possible move for a given piece along its current path of motion. ADMOVE adds a move to the move list. CASTLE and ENPSNT (En Passant Pawn Capture Routine) handle the special moves. After MPIECE has produced all legal moves, GENMOV calls INCHK, which determines whether or not the king is in check.

Basic to the success of alpha beta pruning is the sorting of moves generated at each ply level. FNDMOV calls SORTM (Sort Routine) to accomplish this task. A sort is dependent on an evaluation, so SORTM calls EVAL (Evaluation Routine). To evaluate a given move on the move list, EVAL first makes the move on the board by calling MOVE. It is determined if the move is legal by calling INCHK. Then, if the move is legal, it is evaluated by calling PNFND and POINTS. Finally, EVAL restores the board position by calling UNMOVE.

The bookkeeping required by alpha beta pruning is for the most part coded in line in FNDMOV. However, FNDMOV calls ASCEND (Ascend Tree Routine)

to adjust all the parameters in transferring the parameters up one ply in the tree.

At the bottom of FNDMOV's call list on the block diagram is BOOK. BOOK provides an opening book of a single move. If white, SARGON will play P-K4 or P-Q4 at random. If black, SARGON replies to any opening move with P-K4 or P-Q4, whichever is most appropriate.

The move selection logic of FNDMOV is embedded in a whole network of routines that forms SARGON's interface to the outside world. The DRIVER routine initiates and coordinates the entire game. First on the block diagram in DRIVER's list of calls is CHARTR (Accept Input Character). CHARTR is a totally machine-dependent input routine whose sole purpose is to accept a single character input from the keyboard. All machine-dependent aspects of SARGON have been isolated in this manner to simplify conversion to Z-80 machines running under different operating systems. Machine-dependent code appears in only two other places. The first is the macro definition area, where all the output functions are listed, and the second is in the routine DSPBRD (Display Graphics Board and Pieces), where machine-dependent lines of code are clearly marked.

Next on the block diagram is ANALYS (Set Up Position for Analysis). ANALYS allows the user to set the board to any position of his choosing. The routine blinks the graphics board squares in turn, allowing the user to input a piece of his choice or leave the contents unchanged. When the board has been set to the desired arrangement of pieces, play of the game may be resumed. ANALYS also provides a handy means of correcting a move entered by mistake.

As a part of game initialization, DRIVER calls INTERR (Interrogate for Ply and Color). INTERR questions the player for his choice of white or black, and allows him to select the depth of search. DSPBRD and INITBD complete initialization by setting up the graphics board display and internal board array. PGIFND (New Page if Needed) and TBCPCL (Tab to Computer's Column) are used to control spacing in the move list. The move list is displayed to the left of the graphics board on the video screen.

The most important routines called by DRIVER are, of course, CPTRMV and PLYRMV, which are control routines for the computer's and player's moves, respectively. Central to CPTRMV is FNDMOV, the logic to select the computer's move, which has already been discussed. Below FNDMOV on the block diagram is FCDMAT (Forced Mate Handling). If the computer is checkmated, it acknowledges the fact with a message displayed in the move list and by tipping over its king. Assuming the computer is not mated, MOVE makes the chosen move on the board array and EXECMV displays it on the graphics board. In displaying the move, the piece first blinks a few times, moves to its new location, and then blinks a few times again. The function of BITASN (Board Index to ASCII Square Name) is to convert the internal move into a representation in algebraic chess notation on the move list, then INCHK determines whether or not the computer should call "Check."

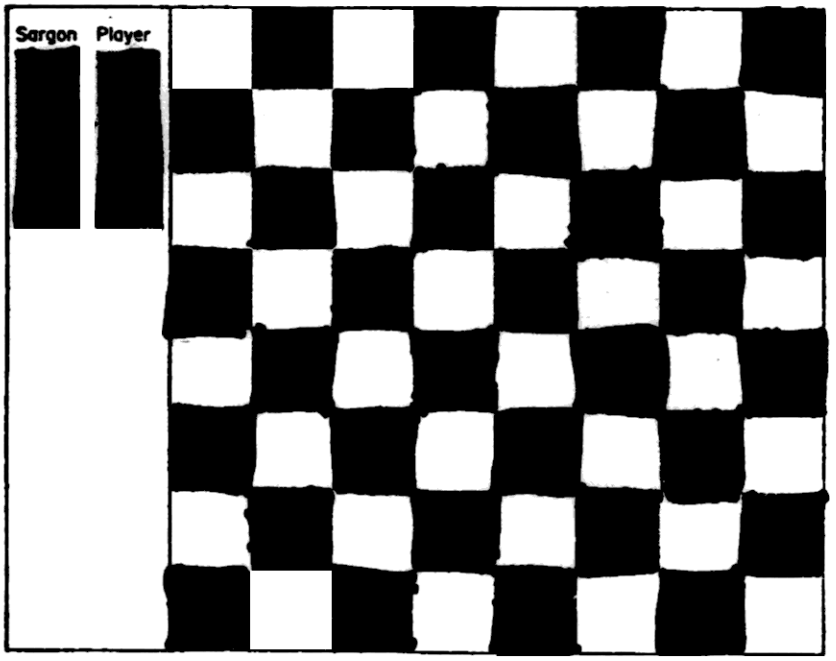
When the opponent is on the move, PLYRMV controls the events. It calls CHARTR to accept the move entry. ASNTBI (ASCII Square Name to Board Index) converts the move to internal representation. Then VALMOV checks the

player's move for validity. If the move is legal, EXECMV displays it on the graphics board as in CPTRMV. PGIFND (New Page if Needed) and TBPLCL (Tab to Player's Column) control spacing in the move list.

The Chess Board in Computer Graphics

A graphics display is an eye-catching addition to a chess program. For the human player, a visual display of the board is far easier to relate to than a scheme which creates an array using purely alphabetic characters. Graphics display requires specialized hardware, and degree of resolution varies with existing displays. The SARGON program features a complete graphics board display. The video screen of the Jupiter III microcomputer, on which it is implemented, has a 96 × 128 dot graphics matrix. The screen display is controlled by a 2k area of static RAM. Information may be displayed on the screen by storing the desired values in that 2k area. So only *move* instructions are required for graphics display.

The SARGON display utilizes 96 × 96 dots for the graphics chess board. The remaining area is used to list the moves of the game in algebraic chess notation. The display is arranged as follows:



The empty board and move list area are displayed using the block move feature of the Z-80. It requires no stored data. The memory required to store the piece shapes has been kept to a minimum through use of the concept of boundary and kernel dots.

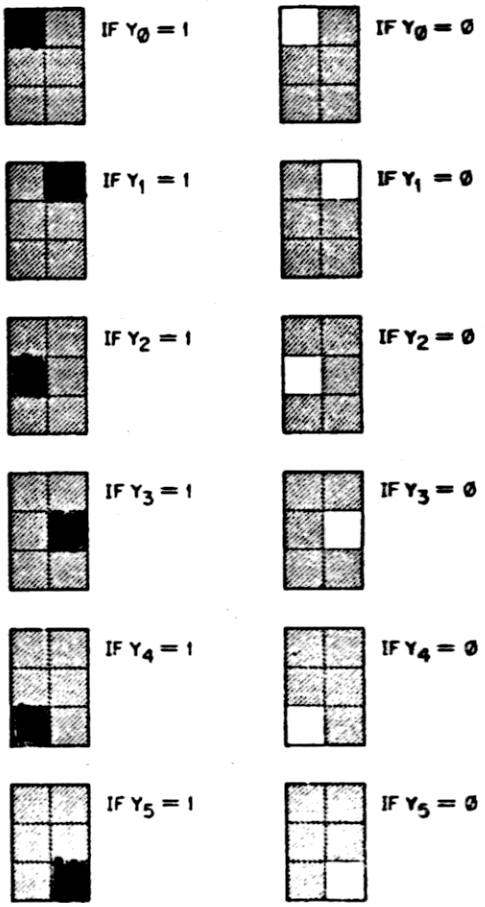
Graphics Control

On the Jupiter III System, every graphics byte is of the form:

$$1X_5Y_4 \qquad Y_3\,Y_2Y_1Y_0$$

where: 1 — Indicates a graphics character

X—Is unimportant, may be Ø or 1 with no effect on the resultant graphics character.



Graphics Characters

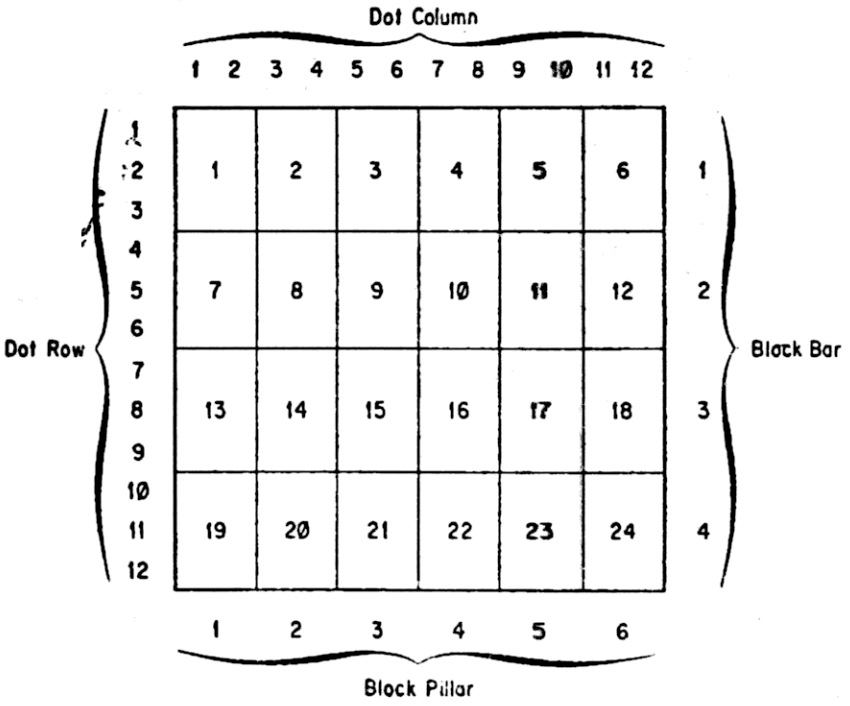
By varying and combining bits that are turned on, a total of 64 different graphics characters may be produced. For example:

1Ø1Ø ØlØl gives 

Now, 1Ø1Ø ØlØl = 165 in decimal, which can be used as the ASCII code for this character.

Pillar and Bar Formating

We've seen how individual dots are grouped into blocks of six dots each. The blocks are then laid out like tiles to cover the display area. So a dot matrix that is 12 × 12 would look like:



CHESS PIECE SUMMARY

Each square is 12 × 12 graphics dots, and 6 × 4 bytes.

No piece affects the 1 byte pillar at each side of the square. So the true region involved is 8 × 12 dots or 4 × 4 bytes.

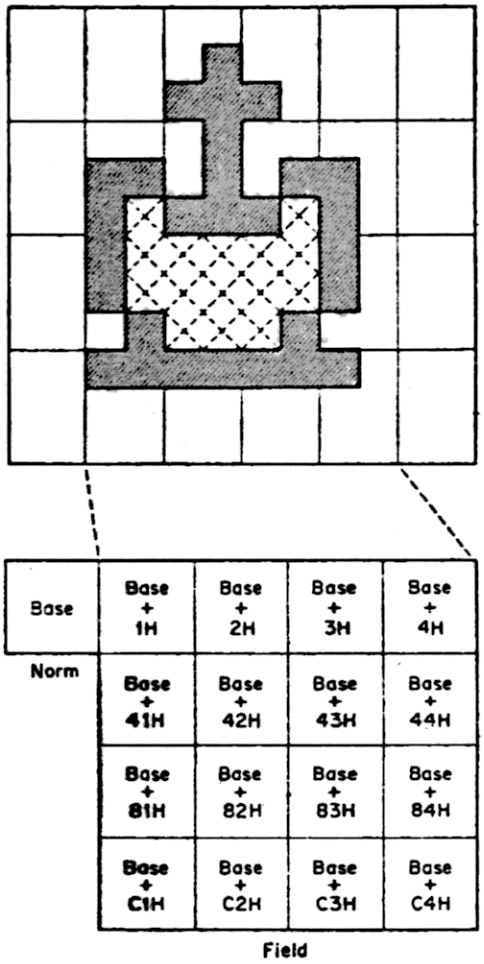
Boundary dots are the color opposite that of the square.

Kernel dots are the color of the piece.

The top left corner of a square is the norm of the square.

80H—White square
BFH—Black square

It is also the base address of the square. Addresses of the alterable portions of the square relative to the base address are on the chart. The alterable portions of the square are referred to as the field.



For each type of piece the tables on the following pages will give the piece shape and four field configurations:

Black on White
Black on Black
White on Black
White on White

All field values are in hexadecimal. Only the black on white configuration is stored in the graphics data base.

KING

Black on White

8Ø	B8	9Ø	8Ø
BC	BA	B8	94
AF	BF	BF	85
83	83	83	81

White on Black

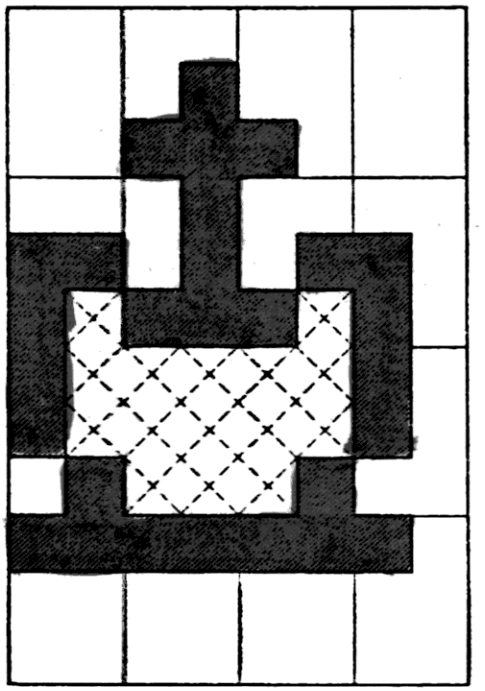
BF	87	AF	BF
83	85	87	AB
9Ø	8Ø	8Ø	BA
BC	BC	BC	BE

Black on Black

BF	87	AF	BF
A3	85	A7	AB
9A	BF	9F	BA
BC	BC	BC	BE

White on White

8Ø	B8	9Ø	8Ø
9C	BA	98	94
A5	8Ø	AØ	85
83	83	83	81



QUEEN

Black on White:

9Ø	8Ø	8Ø	9Ø
BF	B4	BE	95
8B	BF	9F	81
83	83	83	81

White on Black

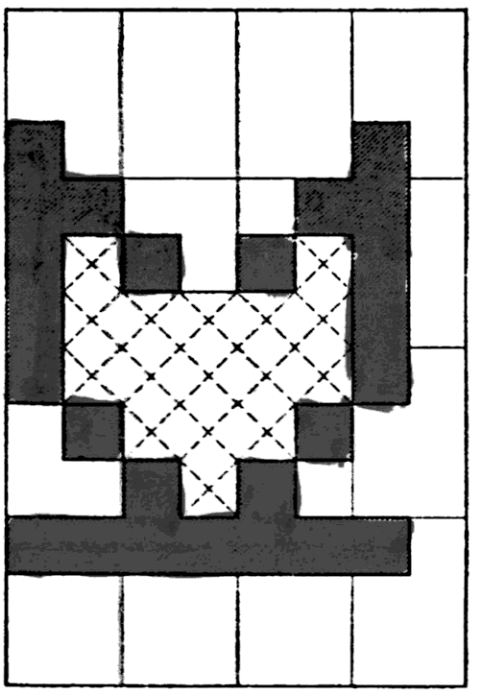
AF	BF	BF	AF
8Ø	8B	81	AA
B4	8Ø	AØ	BE
BC	BC	BC	BE

Black on Black

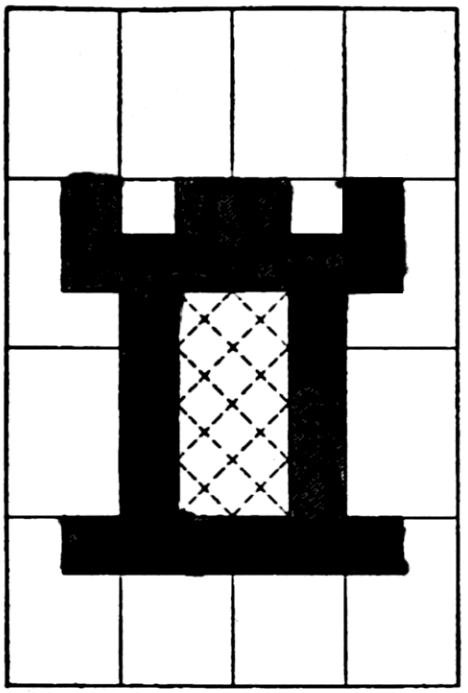
AF	BF	BF	AF
A8	9B	B9	AA
B6	AF	A7	BE
BC	BC	BC	BE

White on White

9Ø	8Ø	8Ø	9Ø
97	A4	86	95
89	9Ø	98	81
83	83	83	81



ROOK



Black on White

80	80	80	80
8A	BE	BD	85
80	BF	BF	80
82	83	83	81

White on Black

BF	BF	BF	BF
B5	81	82	BA
BF	80	80	BF
BD	BC	BC	BE

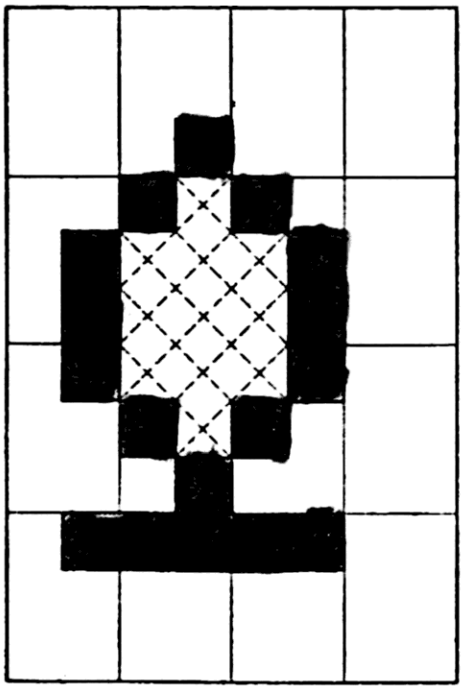
Black on Black

BF	BF	BF	BF
B5	A1	92	BA
BF	AA	95	BF
BD	BC	BC	BE

White on White

80	80	80	80
8A	9E	AD	85
80	95	AA	80
82	83	83	81

BISHOP



Black on White

80	A0	80	80
A8	BF	BD	80
82	AF	87	80
82	83	83	80

White on Black

BF	9F	BF	BF
97	80	82	BF
BD	90	B8	BF
BD	BC	BC	BF

Black on Black

BF	9F	BF	BF
97	BE	96	BF
BD	9B	B9	BF
BD	BC	BC	BF

White on White

80	A0	80	80
A8	81	A9	80
82	A4	86	80
82	83	83	80

KNIGHT

Black on White

80 B0 B0 80
BE BF BF 95
A0 BF BF 85
83 83 83 81

White on Black

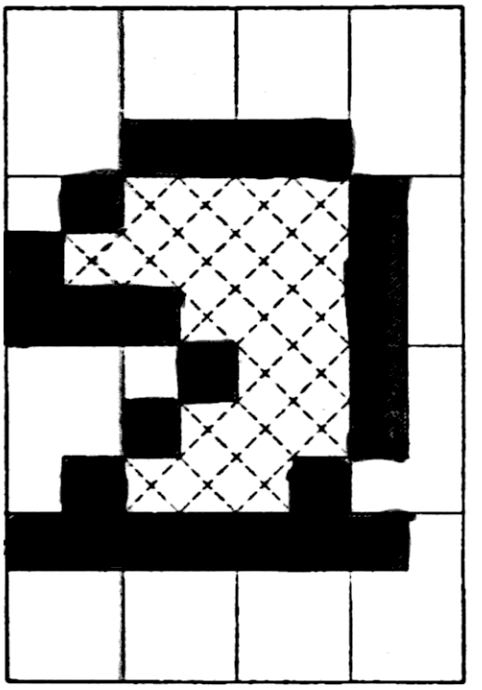
BF 8F 8F BF
81 80 80 AA
9F 81 BF BA
BC BC BC BE

Black on Black

BF 8F 8F BF
89 AF BF AA
9F B9 9F BA
BC BC BC BE

White on White

80 B0 B0 80
B6 90 80 95
A0 86 A0 85
83 83 83 81



PAWN

Black on White

80 80 80 80
80 A0 90 80
80 AF 9F 80
80 83 83 80

White on Black

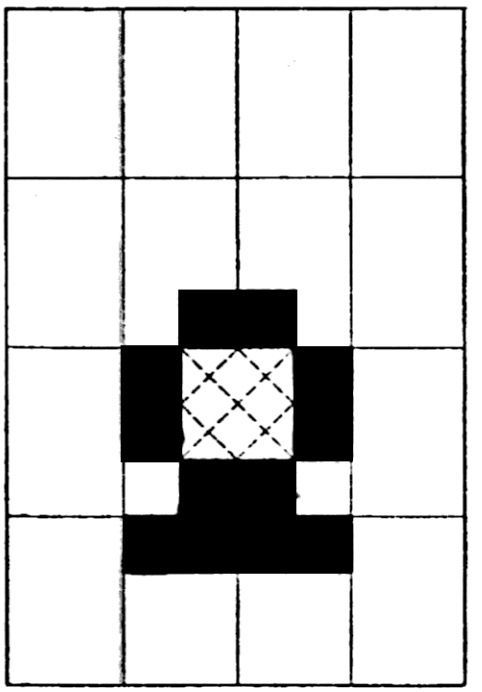
BF BF BF BF
BF 9F AF BF
BF 90 A0 BF
BF BC BC BF

Black on Black

BF BF BF BF
BF 9F AF BF
BF 9A A5 BF
BF BC BC BF

White on White

80 80 80 80
80 A0 90 80
80 A5 9A 80
80 83 83 80



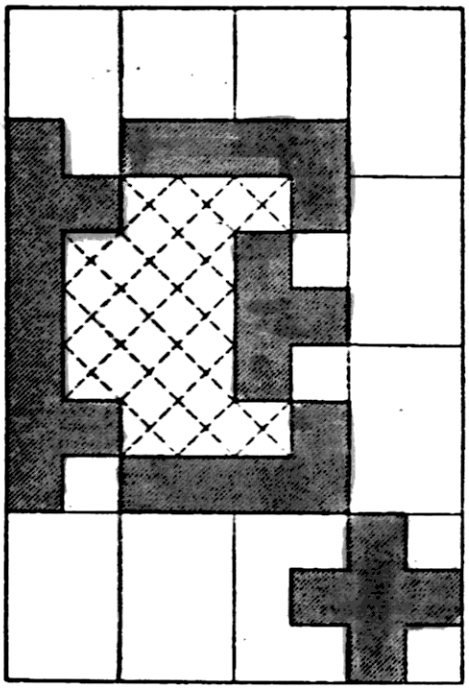
TOPPLED KING

Black on White

9Ø	BØ	BØ	8Ø
BF	BF	B7	8Ø
9F	BF	BD	8Ø
8Ø	8Ø	88	9D

Black on Black

AF	8F	8F	BF
A8	BF	89	BF
A2	8F	86	BF
BF	BF	B7	A2



For any byte the 1Ø in bits 6 and 7 must remain.

Boundary bytes are complemented if a piece moves to another color square.

Kernel bytes must be moved in from a table in memory. Only one color need be stored, since the other color is the complement. For each piece, the kernel will be composed of 6 bytes to be transferred to base plus 41H, 42H, 43H, 81H, 82H, and 83H. Only the black on black values are stored in the graphics data base.

Black	*on White*						*on Black*					
KING	BC	BA	B8	AF	BF	BF	A3	85	A7	9A	BF	9F
QUEEN	BF	B4	BE	8B	BF	9F	A8	9B	B9	B6	AF	A7
ROOK	8A	BE	BD	8Ø	BF	BF	B5	A1	92	BF	AA	95
BISHOP	A8	BF	BD	82	AF	87	97	BE	96	BD	9B	B9
KNIGHT	BE	BF	BF	AØ	BE	BF	89	AF	BF	9F	B9	9F
PAWN	8Ø	AØ	9Ø	8Ø	AF	9F	BF	9F	AF	BF	9A	A5

Thus, the entire data base required for all pieces to be displayed occupies only 154 bytes of storage.

User's Guide to SARGON

1. To begin execution:

   The start address of SARGON will vary depending on the load address. It will always be the address of DRIVER. Once execution has begun, SARGON will ask you a series of questions:

   "Welcome to Chess. Care for a Game?"

   To play a game of chess respond with "y." An answer of "n" will get you to the routine that allows you to set up a board position. (See Item 5.)

   "Would you like to play white (w) or black (b)?"

   The player selects white by entering "w" or black by "b." Any other key defaults to black. White always moves first.

   "Select look ahead (1-6)."

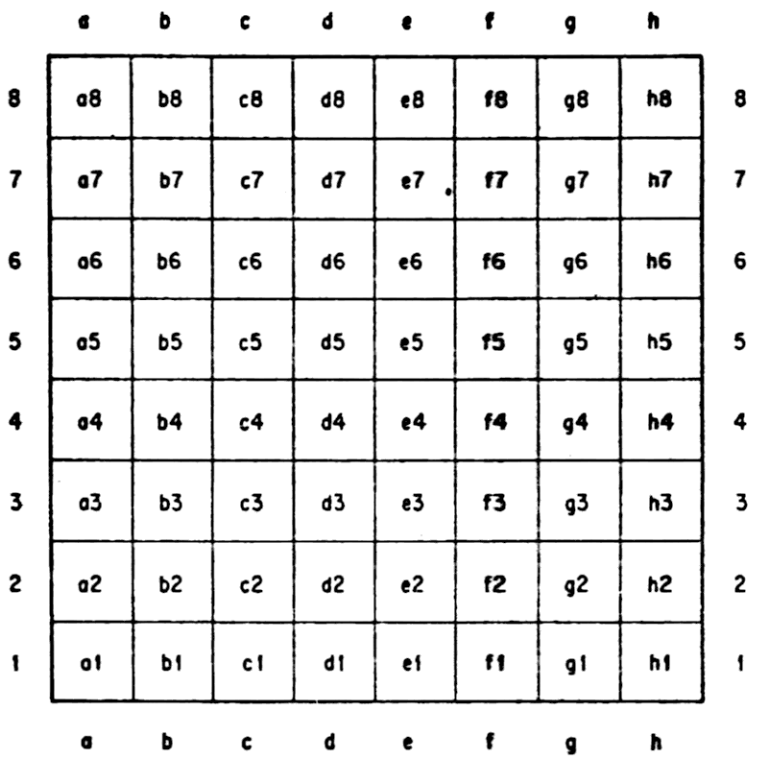
   This allows the player to select the depth of search. For example, if you select 3 ply, SARGON will consider:

   1. All of his possible moves.
   2. All of your responses to those moves.
   3. All of his possible replies to your responses.

   At this point, the board display will appear on the screen. If you choose white, SARGON will be waiting for your move entry. If you choose black, SARGON will make its move on the board, print it in the move list, and then wait for your move entry.

2. To enter a move:

   Moves must be entered in algebraic chess notation. This means you must tell SARGON the file and rank coordinates of the squares you are moving from and to. The files are lettered a-h and the ranks are numbered 1-8. So the coordinates of the board are:



The move itself is entered as ff-tt, so to play the king's pawn up two squares you would enter:

"e2-e4"

If SARGON responded with the same move, it would print:

"e7-e5"

To Castle

Just enter the king's move. The rook will tag along. For example, if you are white and you wish to castle king's side, enter:

"e1-g1"

You will see both your king and rook move. When SARGON castles, he lists it as 0-0 or 0-0-0 as in normal chess notation.

To Capture En Passant

If you wish to capture one of SARGON's pawns using the en passant privilege, enter your pawn's move. After your pawn move is displayed, SARGON's pawn will blink and then vanish. When SARGON captures en passant,

his move is displayed on the graphics board in the same way. SARGON prints it in the move list as PxPep.

3. To play another game after checkmate:

   If either you or SARGON is checkmated, and you wish to play again, just hit any key. The screen will blank out and SARGON will ask:

   "Care for Another Game?"

   Replies to this question are just like those to the original "Care for a Game?"

4. To resign a hopeless game or take back a move:

   If you decide your position is hopeless, or you wish to change a move entered in error, first wait until it is your turn to move. Then enter "~~control-R~~." You will immediately get the "Care for Another Game?" question. If you want to start over, type "y," but if you want to correct the board display, type "n." You will then get the routine that allows you to set up a board position.

5. To set up or correct a board position:

   If you typed "n" to a "Care for a Game" question, SARGON will now ask:

   "Would you like to analyze a position?"

   If you answer "n" to this one, you will be out of SARGON entirely and back in the computer's monitor state. An answer of "y" will display the board just as you left it. The lower left-hand corner will blink. That's your signal that you can change the contents of that square, using one of the analysis commands.

Summary of Analysis Commands

<CR> →

A carriage return leaves the contents of the square unchanged and blinks the next square. If you are already at the upper right-hand corner, it wraps around to the lower left-hand corner and blinks that square.

Backspace

A backspace leaves the contents of the square unchanged and blinks a square in the other direction. It's the opposite of a <CR>, so you can go either direction.

Clear Clear →

An entry of ~~0, or of the space bar, or any key not listed in these commands~~ will empty the square.

"Enter a Piece"
To enter a piece, type in piece-code, color-code, moved-code.

Piece-code is a letter indicating the desired piece (upper or lower case):

K — King
Q — Queen
R — Rook
B — Bishop
N — Knight
P — Pawn

Color-code is a letter indicating the side the piece belongs to (also upper or lower case):

w — white
b — black

Moved-code is a number indicating whether the piece has moved or not:

0 — piece has never moved
1 — piece has moved

Some examples:

To enter a black pawn on its original square type:

"P, b, 0"

A white knight in the middle of the board would be:

"N, w, 1"

A black king on its original square which has, however, moved:

"K, b, 1"

Escape
The [redacted] key will terminate the blinking cycle. SARGON will ask:

"Is this right?"

An answer of "n" will go back to setting up the board. If you say "y" then SARGON will ask for the information it needs to resume play from this point. The color choice and search depth questions are the same as in Section 1. In addition SARGON must be given the answer to:

"Whose move is it?"

6. To terminate execution:

   The way out of the SARGON program depends on whether you're at the end of a game, in the middle of a game, or setting up a board position.

   At the end of a game:

   1. Depress any key.
   2. SARGON responds with: "Care for Another Game?"
   3. Answer with "n."
   4. SARGON responds with: "Would you like to analyze a position?"
   5. Answer with "n" and you're out.

   In the middle of a game:

   1. Wait until it's your turn.
   2. Enter "Control-R."
   3. SARGON responds with: "Care for Another Game?"
   4. Follow 3-5 as for the end of a game.

   Setting up a board:

   1. Depress the BREAK key.
   2. SARGON answers: "Is this right?"
   3. Respond with "ywlw," answering four questions at once.
   4. Follow 2-4 as for the middle of a game.

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Notes on the Implementation of SARGON

1. SARGON was assembled using the TDL Macro Assembler, which does not use the ZILOG mnemonics. Conversion to ZILOG mnemonics can be performed on an instruction for instruction basis using the conversion chart included with this listing.

2. I/O is based on the JOVE operation system which runs on the Wave-Mate Jupiter III computer. For ease in conversion all I/O has been isolated to the following areas: Accept Input Character (p. 82), I/O Macro Definitions (p. 68), and Set Up Empty Board (p. 89).

3. SARGON must be loaded at a start address which is an even 256 byte page boundary (that is, at an address of the form XXØØ hexadecimal).

4. Graphics routines assume a 96 by 128 dot matrix with black characters on a white background. To convert to a display with white characters on a black background, only six lines of code need be changed:

Location	Is		Change to	
DBØ4	MVI	M,8ØH	MVI	M,ØBFH
DBØ8	MVI	M,ØBFH	MVI	M,8ØH
2 lines above IPØ4	JRZ	IPØ4	JRNZ	IPØ4
4 lines above IP18	JRNZ	IP18	JRZ	IP18
2 lines above IP18	JRNZ	IP2C	JRZ	IP2C
1 line below IP18	JRZ	IP2C	JRNZ	IP2C

5. SARGON requires a minimum of 8K bytes of memory available for user programs.

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```
;*************************************************************
;
;                    SARGON
;
;       Sargon is a computer chess playing program designed
; and coded by Dan and Kathe Spracklen.  Copyright 1978. All
; rights reserved.  No part of this publication may be
; reproduced without the prior written permission.
;
;*************************************************************
; EQUATES
;*************************************************************
;
PAWN    =       1
KNIGHT  =       2
BISHOP  =       3
ROOK    =       4
QUEEN   =       5
KING    =       6
WHITE   =       0
BLACK   =       80H
BPAWN   =       BLACK+PAWN


;*************************************************************
; TABLES SECTION
;*************************************************************
START:.
        .LOC    START+80H
TBASE   =       START+100H
;*************************************************************
;  DIRECT --  Direction Table.  Used to determine the dir-
;             ection of movement of each piece.
;*************************************************************
DIRECT  =       .-TBASE
        .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
```

```
;*****************************************************************
; DPOINT  --  Direction Table Pointer.  Used to determine
;             where to begin in the direction table for any
;             given piece.
;*****************************************************************
DPOINT  =       .-TBASE
        .BYTE   20,16,8,0,4,0,0
;*****************************************************************
; DCOUNT  --  Direction Table Counter.  Used to determine
;             the number of directions of movement for any
;             given piece.
;*****************************************************************
DCOUNT  =       .-TBASE
        .BYTE   4,4,8,4,4,8,8


;*****************************************************************
; PVALUE  --  Point Value.  Gives the point value of each
;             piece, or the worth of each piece.
;*****************************************************************
PVALUE  =       .-TBASE-1
        .BYTE   1,3,3,5,9,10
;*****************************************************************
; PIECES  --  The initial arrangement of the first rank of
;             pieces on the board.  Use to set up the board
;             for the start of the game.
;*****************************************************************
PIECES  =       .-TBASE
        .BYTE   4,2,3,5,6,3,2,4
```

```
;*****************************************************
; BOARD   --  Board Array.  Used to hold the current position
;             of the board during play.  The board itself
;             looks like:
;             FFFFFFFFFFFFFFFFFFFF
;             FFFFFFFFFFFFFFFFFFFF
;             FF0402030506030204FF
;             FF0101010101010101FF
;             FF0000000000000000FF
;             FF0000000000000000FF
;             FF0000000000000000FF
;             FF0000000000000000FF
;             FF8181818181818181FF
;             FF8482838586838284FF
;             FFFFFFFFFFFFFFFFFFFF
;             FFFFFFFFFFFFFFFFFFFF
;             The values of FF form the border of the
;             board, and are used to indicate when a piece
;             moves off the board.  The individual bits of
;             the other bytes in the board array 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
;               Bit 3 -- Piece has moved flag
;               Bits 2-0 Piece type
;                        1 -- Pawn
;                        2 -- Knight
;                        3 -- Bishop
;                        4 -- Rook
;                        5 -- Queen
;                        6 -- King
;                        7 -- Not used
;                        0 -- Empty Square
;*****************************************************
BOARD   =       .-TBASE
BOARDA: .BLKB   120
```

```
;*************************************************************
; ATKLIST -- Attack List.  A two part array, the first
;            half for white and the second half for black.
;            It is used to hold the attackers of any given
;            square in the order of their value.
;
; WACT    --  White Attack Count.  This is the first
;            byte of the array and tells how many pieces are
;            in the white portion of the attack list.
;
; BACT    --  Black Attack Count.  This is the eighth byte of
;            the array and does the same for black.
;*************************************************************
WACT    =       ATKLST
BACT    =       ATKLST+7
ATKLST: .WORD   0,0,0,0,0,0,0,0


;*************************************************************
; PLIST   --  Pinned Piece Array.  This is a two part array.
;            PLISTA contains the pinned piece position.
;            PLISTD contains the direction from the pinned
;            piece to the attacker.
;*************************************************************
PLIST   =       .-TBASE-1
PLISTD  =       PLIST+10
PLISTA: .WORD   0,0,0,0,0,0,0,0,0,0


;*************************************************************
; POSK    --  Position of Kings.  A two byte area, the first
;            byte of which hold the position of the white
;            king and the second holding the position of
;            the black king.
;
; POSQ    --  Position of Queens.  Like POSK,but for queens.
;*************************************************************
POSK:   .BYTE   24,95
POSQ:   .BYTE   14,94
        .BYTE   -1
```

```
;*****************************************************************
; SCORE   --  Score Array.  Used during Alpha-Beta pruning to
;             hold the scores at each ply.  It includes two
;             "dummy" entries for ply -1 and ply 0.
;*****************************************************************

WHITE:  .WORD   0,0,0,0,0,0
;*****************************************************************
; PLYIX   --  PIy Table.  Contains pairs of pointers, a pair
;             for each ply.  The first pointer points to the
;             top of the list of possible moves at that ply.
;             The second pointer points to which move in the
;             list is the one currently being considered.
;*****************************************************************

BLIX:   .WORD   0,0,0,0,0,0,0,0,0,0
        .WORD   0,0,0,0,0,0,0,0,0,0
;*****************************************************************
; STACK   --  Contains the stack for the program.
;*****************************************************************
        .LOC    START+2FFH
```

```
;*****************************************************************
; TABLE INDICES SECTION
;
; 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    --  General working indices.  Used for various
; INDX2        purposes.
;
; NPINS    --  Number of Pins.  Count and pointer into the
;              pinned piece list.
;
; MLPTRI   --  Pointer into the ply table which tells
;              which pair of pointers are in current use.
;
; MLPTRJ   --  Pointer into the move list to the move that is
;              currently being processed.
;
; SCRIX    --  Score Index.  Pointer to the score table for
;              the ply being examined.
;
; BESTM    --  Pointer into the move list for the move that
;              is currently considered the best by the
;              Alpha-Beta pruning process.
;
; MLLST    --  Pointer to the previous move placed in the move
;              list.  Used during generation of the move list.
;
; MLNXT    --  Pointer to the next available space in the move
;              list.
;
;*****************************************************************
         .LOC    START+0
M1:      .WORD   TBASE
M2:      .WORD   TBASE
M3:      .WORD   TBASE
M4:      .WORD   TBASE
T1:      .WORD   TBASE
T2:      .WORD   TBASE
T3:      .WORD   TBASE
INDX1:   .WORD   TBASE
INDX2:   .WORD   TBASE
NPINS:   .WORD   TBASE
MLPTRI:  .WORD   PLYIX
MLPTRJ:  .WORD   0
SCRIX:   .WORD   0
BESTM:   .WORD   0
MLLST:   .WORD   0
MLNXT:   .WORD   MLIST
```

```
;*****************************************************************
; VARIABLES SECTION
;
; KOLOR   --  Indicates computer's color.  White is 0, and
;             Black is 80H.
;
; COLOR   --  Indicates color of the side with the move.
;
; P1-P3   --  Working area to hold the contents of the board
;             array for a given square.
;
; PMATE   --  The move number at which a checkmate is
;             discovered during look ahead.
;
; MOVENO  --  Current move number.
;
; PLYMAX  --  Maximum depth of search using Alpha-Beta
;             pruning.
;
; NPLY    --  Current ply number during Alpha-Beta
;             pruning.
;
; CKFLG   --  A non-zero value indicates the king is in check.
;
; MATEF   --  A zero value indicates no legal moves.
;
; VALM    --  The score of the current move being examined.
;
; BRDC    --  A measure of mobility equal to the total number
;             of squares white can move to minus the number
;             black can move to.
;
; PTSL    --  The maximum number of points which could be lost
;             through an exchange by the player not on the
;             move.
;
; PTSW1   --  The maximum number of points which could be won
;             through an exchange by the player not on the
;             move.
;
; PTSW2   --  The second highest number of points which could
;             be won through a different exchange by the player
;             not on the move.
;
; MTRL    --  A measure of the difference in material
;             currently on the board.  It is the total value of
;             the white pieces minus the total value of the
;             black pieces.
;
; BC0     --  The value of board control(BRDC) at ply 0.
```

```
;
; MV0      --  The value of material(MTRL) at ply 0.
;
; PTSCK    --  A non-zero value indicates that the piece has
;              just moved itself into a losing exchange of
;              material.
;
; BMOVES   --  Our very tiny book of openings. Determines
;              the first move for the computer.
;
;*************************************************************
KOLOR:   .BYTE   0
COLOR:   .BYTE   0
P1:      .BYTE   0
P2:      .BYTE   0
P3:      .BYTE   0
PMATE:   .BYTE   0
MOVENO:  .BYTE   0
PLYMAX:  .BYTE   2
NPLY:    .BYTE   0
CKFLG:   .BYTE   0
MATEF:   .BYTE   0
VALM:    .BYTE   0
BRDC:    .BYTE   0
PTSL:    .BYTE   0
PTSW1:   .BYTE   0
PTSW2:   .BYTE   0
MTRL:    .BYTE   0
BC0:     .BYTE   0
MV0:     .BYTE   0
PTSCK:   .BYTE   0
BMOVES:  .BYTE   35,55,10H
         .BYTE   34,54,10H
         .BYTE   85,65,10H
         .BYTE   84,64,10H
```

```
;*************************************************************
; MOVE LIST SECTION
;
; MLIST   --  A 2048 byte storage area for generated moves.
;             This area must be large enough to hold all
;             the moves for a single leg of the move tree.
;
; MLEND   --  The address of the last available location
;             in the move list.
;
; MLPTR   --  The Move List is a linked list of individual
;             moves each of which is 6 bytes in length.  The
;             move list pointer(MLPTR) is the link field
;             within a move.
;
; MLFRP   --  The field in the move entry which gives the
;             board position from which the piece is moving.
;
; MLTOP   --  The field in the move entry which gives the
;             board position to which the piece is moving.
;
; MLFLG   --  A field in the move entry which contains flag
;             information.  The meaning of each bit is as
;             follows:
;             Bit 7  --  The color of any captured piece
;                        0  --  White
;                        1  --  Black
;             Bit 6  --  Double move flag (set for castling and
;                        en passant pawn captures)
;             Bit 5  --  Pawn Promotion flag; set when pawn
;                        promotes.
;             Bit 4  --  When set, this flag indicates that
;                        this is the first move for the
;                        piece on the move.
;             Bit 3  --  This flag is set is there is a piece
;                        captured, and that piece has moved at
;                        least once.
;             Bits 2-0   Describe the captured piece.  A
;                        zero value indicates no capture.
;
; MLVAL   --  The field in the move entry which contains the
;             score assigned to the move.
;
;*************************************************************
```

```
        .LOC    START+300H
MLIST:  .BLKB   2048
MLEND   =       MLIST+2040
MLPTR   =       0
MLFRP   =       2
MLTOP   =       3
MLFLG   =       4
MLVAL   =       5


;*****************************************************************
; PROGRAM CODE SECTION
;*****************************************************************
; BOARD SETUP ROUTINE
;*****************************************************************
; FUNCTION:   To initialize the board array, setting the
;             pieces in their initial positions for the
;             start of the game.
;
; CALLED BY:  DRIVER
;
; CALLS:      None
;
; ARGUMENTS:  None
;
;*****************************************************************
INITBD: MVI     B,120           ; Pre-fill board with -1's
        LXI     H,BOARDA
        MVI     M,-1
        INX     H
        DJNZ    .-3
        MVI     B,8
        LXI     X,BOARDA
IB2:    MOV     A,-8(X)         ; Fill non-border squares
        MOV     21(X),A         ; White pieces
        SET     7,A             ; Change to black
        MOV     91(X),A         ; Black pieces
        MVI     31(X),PAWN      ; White Pawns
        MVI     81(X),BPAWN     ; Black Pawns
        MVI     41(X),0         ; Empty squares
        MVI     51(X),0
        MVI     61(X),0
        MVI     71(X),0
        INX     X
        DJNZ    IB2
        LXI     X,POSK          ; Init King/Queen position list
        MVI     0(X),25
        MVI     1(X),95
        MVI     2(X),24
        MVI     3(X),94
        RET
```

```
;*****************************************************************
; PATH ROUTINE
;*****************************************************************
; FUNCTION:   To generate a single possible move for a given
;             piece along its current path of motion including:
;
;                Fetching the contents of the board at the new
;                position, and setting a flag describing the
;                contents:
;                          0  --  New postion is empty
;                          1  --  Encountered a piece of the
;                                 opposite color
;                          2  --  Encountered a piece of the
;                                 same color
;                          3  --  New position is off the
;                                 board
;
; CALLED BY:  MPIECE
;             ATTACK
;             PINFND
;
; CALLS:      None
;
; ARGUMENTS:  Direction from the direction array giving the
;             constant to be added for the new position.
;*****************************************************************
PATH:   LXI     H,M2            ; Get previous position
        MOV     A,M
        ADD     C               ; Add diection constant
        MOV     M,A             ; Save new position
        LIXD    M2              ; Load board index
        MOV     A,BOARD(X)      ; Get contents of board
        CPI     -1              ; In boarder area ?
        JRZ     PA2             ; Yes - jump
        STA     P2              ; Save piece
        ANI     7               ; Clear flags
        STA     T2              ; Save piece type
        RZ                      ; Return if empty
        LDA     P2              ; Get piece encountered
        LXI     H,P1            ; Get moving piece address
        XRA     M               ; Compare
        BIT     7,A             ; Do colors match ?
        JRZ     PA1             ; Yes - jump
        MVI     A,1             ; Set different color flag
        RET                     ; Return
PA1:    MVI     A,2             ; Set same color flag
        RET                     ; Return
PA2:    MVI     A,3             ; Set off board flag
        RET                     ; Return
```

```
;*****************************************************************
; PIECE MOVER ROUTINE
;*****************************************************************
; FUNCTION:   To generate all the possible legal moves for a
;             given piece.
;
; CALLED BY:  GENMOV
;
; CALLS:      PATH
;             ADMOVE
;             CASTLE
;             ENPSNT
;
; ARGUMENTS:  The piece to be moved.
;*****************************************************************
MPIECE: XRA     M               ; Piece to move
        ANI     87H             ; Clear flag bit
        CPI     BPAWN           ; Is is a black Pawn ?
        JRNZ    .+3             ; No-Skip
        DCR     A               ; Decrement for black Pawns
        ANI     7               ; Get piece type
        STA     T1              ; Save piece type
        LIYD    T1              ; Load index to DCOUNT/DPOINT
        MOV     B,DCOUNT(Y)     ; Get direction count
        MOV     A,DPOINT(Y)     ; Get direction pointer
        STA     INDX2           ; Save as index to direct
        LIYD    INDX2           ; Load index
MP5:    MOV     C,DIRECT(Y)     ; Get move direction
        LDA     M1              ; From position
        STA     M2              ; Initialize to position
MP10:   CALL    PATH            ; Calculate next position
        CPI     2               ; Ready for new direction ?
        JRNC    MP15            ; Yes - Jump
        ANA     A               ; Test for empty square
        EXAF                    ; Save result
        LDA     T1              ; Get piece moved
        CPI     PAWN+1          ; Is it a Pawn ?
        JRC     MP20            ; Yes - Jump
        CALL    ADMOVE          ; Add move to list
        EXAF                    ; Empty square ?
        JRNZ    MP15            ; No - Jump
        LDA     T1              ; Piece type
        CPI     KING            ; King ?
        JRZ     MP15            ; Yes - Jump
        CPI     BISHOP          ; Bishop, Rook, or Queen ?
        JRNC    MP10            ; Yes - Jump
MP15:   INX     Y               ; Increment direction index
        DJNZ    MP5             ; Decr. count-jump if non-zero
        LDA     T1              ; Piece type
```

```
        CPI     KING            ; King ?
        CZ      CASTLE          ; Yes - Try Castling
        RET                     ; Return
; ***** PAWN LOGIC *****
MP20:   MOV     A,B             ; Counter for direction
        CPI     3               ; On diagonal moves ?
        JRC     MP35            ; Yes - Jump
        JRZ     MP30            ; -or-jump if on 2 square move
        EXAF                    ; Is forward square empty?
        JRNZ    MP15            ; No - jump
        LDA     M2              ; Get "to" position
        CPI     91              ; Promote white Pawn ?
        JRNC    MP25            ; Yes - Jump
        CPI     29              ; Promote black Pawn ?
        JRNC    MP26            ; No - Jump
MP25:   LXI     H,P2            ; Flag address
        SET     5,M             ; Set promote flag
MP26:   CALL    ADMOVE          ; Add to move list
        INX     Y               ; Adjust to two square move
        DCR     B
        LXI     H,P1            ; Check Pawn moved flag
        BIT     3,M             ; Has it moved before ?
        JRZ     MP10            ; No - Jump
        JMP     MP15            ; Jump
MP30:   EXAF                    ; Is forward square empty ?
        JRNZ    MP15            ; No - Jump
MP31:   CALL    ADMOVE          ; Add to move list
        JMP     MP15            ; Jump
MP35:   EXAF                    ; Is diagonal square empty ?
        JRZ     MP36            ; Yes - Jump
        LDA     M2              ; Get "to" position
        CPI     91              ; Promote white Pawn ?
        JRNC    MP37            ; Yes - Jump
        CPI     29              ; Black Pawn promotion ?
        JRNC    MP31            ; No- Jump
MP37:   LXI     H,P2            ; Get flag address
        SET     5,M             ; Set promote flag
        JMPR    MP31            ; Jump
MP36:   CALL    ENPSNT          ; Try en passant capture
        JMP     MP15            ; Jump
```

```
;*************************************************************
; EN PASSANT ROUTINE
;*************************************************************
; FUNCTION:    --  To test for en passant Pawn capture and
;                  to add it to the move list if it is
;                  legal.
;
; CALLED BY:   --  MPIECE
;
; CALLS:       --  ADMOVE
;                  ADJPTR
;
; ARGUMENTS:   --  None
;*************************************************************
ENPSNT: LDA     M1              ; Set position of Pawn
        LXI     H,P1            ; Check color
        BIT     7,M             ; Is it white ?
        JRZ     .+4             ; Yes - skip
        ADI     10              ; Add 10 for black
        CPI     61              ; On en passant capture rank ?
        RC                      ; No - return
        CPI     69              ; On en passant capture rank ?
        RNC                     ; No - return
        LIXD    MLPTRJ          ; Get pointer to previous move
        BIT     4,MLFLG(X)      ; First move for that piece ?
        RZ                      ; No - return
        MOV     A,MLTOP(X)      ; Get "to" postition
        STA     M4              ; Store as index to board
        LIXD    M4              ; Load board index
        MOV     A,BOARD(X)      ; Get piece moved
        STA     P3              ; Save it
        ANI     7               ; Get piece type
        CPI     PAWN            ; Is it a Pawn ?
        RNZ                     ; No - return
        LDA     M4              ; Get "to" position
        LXI     H,M2            ; Get present "to" position
        SUB     M               ; Find difference
        JP      .+5             ; Positive ? Yes - Jump
        NEG                     ; Else take absolute value
        CPI     10              ; Is difference 10 ?
        RNZ                     ; No - return
        LXI     H,P2            ; Address of flags
        SET     6,M             ; Set double move flag
        CALL    ADMOVE          ; Add Pawn move to move list
        LDA     M1              ; Save initial Pawn position
        STA     M3
        LDA     M4              ; Set "from" and "to" positions
                                ; for dummy move
```

```
        STA     M1
        STA     M2
        LDA     P3              ; Save captured Pawn
        STA     P2
        CALL    ADMOVE          ; Add Pawn capture to move list
        LDA     M3              ; Restore "from" position
        STA     M1


;*****************************************************************
; ADJUST MOVE LIST POINTER FOR DOUBLE MOVE
;*****************************************************************
; FUNCTION:    --  To adjust move list pointer to link around
;                  second move in double move.
;
; CALLED BY:   --  ENPSNT
;                  CASTLE
;                  (This mini-routine is not really called,
;                  but is jumped to to save time.)
;
; CALLS:       --  None
;
; ARGUMENTS:   --  None
;*****************************************************************
ADJPTR: LHLD    MLLST           ; Get list pointer
        LXI     D,-6            ; Size of a move entry
        DAD     D               ; Back up list pointer
        SHLD    MLLST           ; Save list pointer
        MVI     M,0             ; Zero out link, first byte
        INX     H               ; Next byte
        MVI     M,0             ; Zero out link, second byte
        RET                     ; Return
```

```
;*****************************************************************
;CASTLE ROUTINE
;*****************************************************************
; FUNCTION:    --  To determine whether castling is legal
;                  (Queen side, King side, or both) and add it
;                  to the move list if it is.
;
; CALLED BY:   --  MPIECE
;
; CALLS:       --  ATTACK
;                  ADMOVE
;                  ADJPTR
;
; ARGUMENTS:   --  None
;*****************************************************************
CASTLE: LDA     P1              ; Get King
        BIT     3,A             ; Has it moved ?
        RNZ                     ; Yes - return
        LDA     CKFLG           ; Fetch Check Flag
        ANA     A               ; Is the King in check ?
        RNZ                     ; Yes - Return
        LXI     B,0FF03H        ; Initialize King-side values
CA5:    LDA     M1              ; King position
        ADD     C               ; Rook position
        MOV     C,A             ; Save
        STA     M3              ; Store as board index
        LIXD    M3              ; Load board index
        MOV     A,BOARD(X)      ; Get contents of board
        ANI     7FH             ; Clear color bit
        CPI     ROOK            ; Has Rook ever moved ?
        JRNZ    CA20            ; Yes - Jump
        MOV     A,C             ; Restore Rook position
        JMPR    CA15            ; Jump
CA10:   LIXD    M3              ; Load board index
        MOV     A,BOARD(X)      ; Get contents of board
        ANA     A               ; Empty ?
        JRNZ    CA20            ; No - Jump
        LDA     M3              ; Current position
        CPI     22              ; White Queen Knight square ?
        JRZ     CA15            ; Yes - Jump
        CPI     92              ; Black Queen Knight square ?
        JRZ     CA15            ; Yes - Jump
        CALL    ATTACK          ; Look for attack on square
        ANA     A               ; Any attackers ?
        JRNZ    CA20            ; Yes - Jump
        LDA     M3              ; Current position
CA15:   ADD     B               ; Next position
        STA     M3              ; Save as board index
        LXI     H,M1            ; King position
        CMP     M               ; Reached King ?
```

```
        JRNZ    CA10            ; No - jump
        SUB     B               ; Determine King's position
        SUB     B
        STA     M2              ; Save it
        LXI     H,P2            ; Address of flags
        MVI     M,40H           ; Set double move flag
        CALL    ADMOVE          ; Put king move in list
        LXI     H,M1            ; Addr of King "from" position
        MOV     A,M             ; Get King's "from" position
        MOV     M,C             ; Store Rook "from" position
        SUB     B               ; Get Rook "to" position
        STA     M2              ; Store Rook "to" position
        XRA     A               ; Zero
        STA     P2              ; Zero move flags
        CALL    ADMOVE          ; Put Rook move in list
        CALL    ADJPTR          ; Re-adjust move list pointer
        LDA     M3              ; Restore King position
        STA     M1              ; Store
CA20:   MOV     A,B             ; Scan Index
        CPI     1               ; Done ?
        RZ                      ; Yes - return
        LXI     B,01FCH         ; Set Queen-side initial values
        JMP     CA5             ; Jump
```

```
;*****************************************************************
; ADMOVE ROUTINE
;*****************************************************************
; FUNCTION:    --  To add a move to the move list
;
; CALLED BY:   --  MPIECE
;                  ENPSNT
;                  CASTLE
;
; CALLS:       --  None
;
; ARGUMENT:    --  None
;*****************************************************************
ADMOVE: LDED    MLNXT           ; Addr of next loc in move li
        LXI     H,MLEND         ; Address of list end
        ANA     A               ; Clear carry flag
        DSBC    D               ; Calculate difference
        JRC     AM10            ; Jump if out of space
        LHLD    MLLST           ; Addr of prev. list area
        SDED    MLLST           ; Save next as previous
        MOV     M,E             ; Store link address
        INX     H
        MOV     M,D
        LXI     H,P1            ; Address of moved piece
        BIT     3,M             ; Has it moved before ?
        JRNZ    .+7             ; Yes - jump
        LXI     H,P2            ; Address of move flags
        SET     4,M             ; Set first move flag
        XCHG                    ; Address of move area
        MVI     M,0             ; Store zero in link address
        INX     H
        MVI     M,0
        INX     H
        LDA     M1              ; Store "from" move position
        MOV     M,A
        INX     H
        LDA     M2              ; Store "to" move position
        MOV     M,A
        INX     H
        LDA     P2              ; Store move flags/capt. piec
        MOV     M,A
        INX     H
        MVI     M,0             ; Store initial move value
        INX     H
        SHLD    MLNXT           ; Save address for next move
        RET                     ; Return
AM10:   MVI     M,0             ; Abort entry  on table ovflo
        INX     H
        MVI     M,0
        DCX     H
        RET
```

```
;*****************************************************************
; GENERATE MOVE ROUTINE
;*****************************************************************
; FUNCTION:    --  To generate the move set for all of the
;                  pieces of a given color.
;
; CALLED BY:   --  FNDMOV
;
; CALLS:       --  MIECE
;                  INCHK
;
; ARGUMENTS:   --  None
;*****************************************************************
GENMOV: CALL    INCHK           ; Test for King in check
        STA     CKFLG           ; Save attack count as flag
        LDED    MLNXT           ; Addr of next avail list space
        LHLD    MLPTRI          ; Ply list pointer index
        INX     H               ; Increment to next ply
        INX     H
        MOV     M,E             ; Save move list pointer
        INX     H
        MOV     M,D
        INX     H
        SHLD    MLPTRI          ; Save new index
        SHLD    MLLST           ; Last pointer for chain init.
        MVI     A,21            ; First position on board
GM5:    STA     M1              ; Save as index
        LIXD    M1              ; Load board index
        MOV     A,BOARD(X)      ; Fetch board contents
        ANA     A               ; Is it empty ?
        JRZ     GM10            ; Yes - Jump
        CPI     -1              ; Is it a boarder square ?
        JRZ     GM10            ; Yes - Jump
        STA     P1              ; Save piece
        LXI     H,COLOR         ; Address of color of piece
        XRA     M               ; Test color of piece
        BIT     7,A             ; Match ?
        CZ      MPIECE          ; Yes - call Move Piece
GM10:   LDA     M1              ; Fetch current board position
        INR     A               ; Incr to next board position
        CPI     99              ; End of board array ?
        JNZ     GM5             ; No - Jump
        RET                     ; Return
```

```
;*************************************************************
; CHECK ROUTINE
;*************************************************************
; FUNCTION:    --  To determine whether or not the
;                  King is in check.
;
; CALLED BY:   --  GENMOV
;                  FNDMOV
;                  EVAL
;
; CALLS:       --  ATTACK
;
; ARGUMENTS:   --  Color of King
;*************************************************************
INCHK:  LDA     COLOR           ; Get color
INCHK1: LXI     H,POSK          ; Addr of white King position
        ANA     A               ; White ?
        JRZ     .+3             ; Yes - Skip
        INX     H               ; Addr of black King position
        MOV     A,M             ; Fetch King position
        STA     M3              ; Save
        LIXD    M3              ; Load board index
        MOV     A,BOARD(X)      ; Fetch board contents
        STA     P1              ; Save
        ANI     7               ; Get piece type
        STA     T1              ; Save
        CALL    ATTACK          ; Look for attackers on King
        RET                     ; Return
```

```
;*****************************************************************
; ATTACK ROUTINE
;*****************************************************************
; FUNCTION:    --  To find all attackers on a given square
;                  by scanning outward from the square
;                  until a piece is found that attacks
;                  that square, or a piece is found that
;                  doesn't attack that square, or the edge
;                  of the board is reached.
;
;                      In determining which pieces attack
;                  a square, this routine also takes into
;                  account the ability of certain pieces to
;                  attack through another attacking piece. (For
;                  example a queen lined up behind a bishop
;                  of her same color along a diagonal.) The
;                  bishop is then said to be transparent to the
;                  queen, since both participate in the
;                  attack.
;
;                      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.
;
; CALLED BY:   --  POINTS
;                  PINFND
;                  CASTLE
;                  INCHK
;
; CALLS:       --  PATH
;                  ATKSAV
;
; ARGUMENTS:   --  None
;*****************************************************************
ATTACK: PUSH    B               ; Save Register B
        XRA     A               ; Clear
        MVI     B,16            ; Initial direction count
        STA     INDX2           ; Initial direction index
        LIYD    INDX2           ; Load index
AT5:    MOV     C,DIRECT(Y)     ; Get direction
        MVI     D,0             ; Init. scan count/flags
        LDA     M3              ; Init. board start position
        STA     M2              ; Save
AT10:   INR     D               ; Increment scan count
        CALL    PATH            ; Next position
        CPI     1               ; Piece of a opposite color ?
        JRZ     AT14A           ; Yes - jump
        CPI     2               ; Piece of same color ?
        JRZ     AT14B           ; Yes - jump
```

```
        ANA     A               ; Empty position ?
        JRNZ    AT12            ; No - jump
        MOV     A,B             ; Fetch direction count
        CPI     9               ; On knight scan ?
        JRNC    AT10            ; No - jump
AT12:   INX     Y               ; Increment direction index
        DJNZ    AT5             ; Done ?  No - jump
        XRA     A               ; No attackers
AT13:   POP     B               ; Restore register B
        RET                     ; Return
AT14A:  BIT     6,D             ; Same color found already ?
        JRNZ    AT12            ; Yes - jump
        SET     5,D             ; Set opposite color found flag
        JMP     AT14            ; Jump
AT14B:  BIT     5,D             ; Opposite color found already?
        JRNZ    AT12            ; Yes - jump
        SET     6,D             ; Set same color found flag
;
; ***** DETERMINE IF PIECE ENCOUNTERED ATTACKS SQUARE *****
AT14:   LDA     T2              ; Fetch piece type encountered
        MOV     E,A             ; Save
        MOV     A,B             ; Get direction counter
        CPI     9               ; Look for Knights ?
        JRC     AT25            ; Yes - jump
        MOV     A,E             ; Get piece type
        CPI     QUEEN           ; Is is a Queen ?
        JRNZ    AT15            ; No - Jump
        SET     7,D             ; Set Queen found flag
        JMPR    AT30            ; Jump
AT15:   MOV     A,D             ; Get flag/scan count
        ANI     0FH             ; Isolate count
        CPI     1               ; On first position ?
        JRNZ    AT16            ; No - jump
        MOV     A,E             ; Get encountered piece type
        CPI     KING            ; Is it a King ?
        JRZ     AT30            ; Yes - jump
AT16:   MOV     A,B             ; Get direction counter
        CPI     13              ; Scanning files or ranks ?
        JRC     AT21            ; Yes - jump
        MOV     A,E             ; Get piece type
        CPI     BISHOP          ; Is it a Bishop ?
        JRZ     AT30            ; Yes - jump
        MOV     A,D             ; Get flags/scan count
        ANI     0FH             ; Isolate count
        CPI     1               ; On first position ?
        JRNZ    AT12            ; No - jump
        CMP     E               ; Is it a Pawn ?
        JRNZ    AT12            ; No - jump
        LDA     P2              ; Fetch piece including color
```

```
        BIT     7,A             ; Is it white ?
        JRZ     AT20            ; Yes - jump
        MOV     A,B             ; Get direction counter
        CPI     15              ; On a non-attacking diagonal ?
        JRC     AT12            ; Yes - jump
        JMPR    AT30            ; Jump
AT20:   MOV     A,B             ; Get direction counter
        CPI     15              ; On a non-attacking diagonal ?
        JRNC    AT12            ; Yes - jump
        JMPR    AT30            ; Jump
AT21:   MOV     A,E             ; Get piece type
        CPI     ROOK            ; Is is a Rook ?
        JRNZ    AT12            ; No - jump
        JMPR    AT30            ; Jump
AT25:   MOV     A,E             ; Get piece type
        CPI     KNIGHT          ; Is it a Knight ?
        JRNZ    AT12            ; No - jump
AT30:   LDA     T1              ; Attacked piece type/flag
        CPI     7               ; Call from POINTS ?
        JRZ     AT31            ; Yes - jump
        BIT     5,D             ; Is attacker opposite color ?
        JRZ     AT32            ; No - jump
        MVI     A,1             ; Set attacker found flag
        JMP     AT13            ; Jump
AT31:   CALL    ATKSAV          ; Save attacker in attack list
AT32:   LDA     T2              ; Attacking piece type
        CPI     KING            ; Is it a King ?
        JZ      AT12            ; Yes - jump
        CPI     KNIGHT          ; Is it a Knight ?
        JZ      AT12            ; Yes - jump
        JMP     AT10            ; Jump
```

```
;*************************************************************
; ATTACK SAVE ROUTINE
;*************************************************************
; FUNCTION:    --  To save an attacking piece value in the
;                  attack list, and to increment the attack
;                  count for that color piece.
;
;                  The pin piece list is checked for the
;                  attacking piece, and if found there, the
;                  piece is not included in the attack list.
;
; CALLED BY:   --  ATTACK
;
; CALLS:       --  PNCK
;
; ARGUMENTS:   --  None
;*************************************************************
ATKSAV: PUSH    B               ; Save Regs BC
        PUSH    D               ; Save Regs DE
        LDA     NPINS           ; Number of pinned pieces
        ANA     A               ; Any ?
        CNZ     PNCK            ; Yes - check pin list
        LIXD    T2              ; Init index to value table
        LXI     H,ATKLST        ; Init address of attack list
        LXI     B,0             ; Init increment for white
        LDA     P2              ; Attacking piece
        BIT     7,A             ; Is it white ?
        JRZ     .+4             ; Yes - jump
        MVI     C,7             ; Init increment for black
        ANI     7               ; Attacking piece type
        MOV     E,A             ; Init increment for type
        BIT     7,D             ; Queen found this scan ?
        JRZ     .+4             ; No - jump
        MVI     E,QUEEN         ; Use Queen slot in attack list
        DAD     B               ; Attack list address
        INR     M               ; Increment list count
        MVI     D,0
        DAD     D               ; Attack list slot address
        MOV     A,M             ; Get data already there
        ANI     0FH             ; Is first slot empty ?
        JRZ     AS20            ; Yes - jump
        MOV     A,M             ; Get data again
        ANI     0F0H            ; Is second slot empty ?
        JRZ     AS19            ; Yes - jump
        INX     H               ; Increment to King slot
        JMPR    AS20            ; Jump
AS19:   RLD                     ; Temp save lower in upper
        MOV     A,PVALUE(X)     ; Get new value for attack list
        RRD                     ; Put in 2nd attack list slot
        JMPR    AS25            ; Jump
AS20:   MOV     A,PVALUE(X)     ; Get new value for attack list
        RLD                     ; Put in 1st attack list slot
```

```
1525:   POP     D               ; Restore DE regs
        POP     B               ; Restore BC regs
        RET                     ; Return


;*****************************************************************
; PIN CHECK ROUTINE
;*****************************************************************
; FUNCTION:    --  Checks to see if the attacker is in the
;                  pinned piece list.  If so he is not a valid
;                  attaçker unless the direction in which he
;                  attacks in the same as the direction along
;                  which he is pinned.  If the piece is
;                  found to be invalid as an attacker, the
;                  return to the calling routine is aborted
;                  and this routine returns directly to ATTACK.
;
; CALLED BY:   --  ATKSAV
;
; CALLS:       --  None
;
; ARGUMENTS:   --  The direction of the attack.
;                  The pinned piece counnt.
;*****************************************************************
PSCK:   MOV     D,C             ; Save attack direction
        MVI     E,0             ; Clear flag
        MOV     C,A             ; Load pin count for search
        MVI     B,0
        LDA     M2              ; Position of piece
        LXI     H,PLISTA        ; Pin list address
PC1:    CCIR                    ; Search list for position
        RNZ                     ; Return if not found
        EXAF                    ; Save search paramenters
        BIT     0,E             ; Is this the first find ?
        JRNZ    PC5             ; No - jump
        SET     0,E             ; Set first find flag
        PUSH    H               ; Get corresp index to dir list
        POP     X
        MOV     A,9(X)          ; Get direction
        CMP     D               ; Same as attacking direction ?
        JRZ     PC3             ; Yes - jump
        NEG                     ; Opposite direction ?
        CMP     D               ; Same as attacking direction ?
        JRNZ    PC5             ; No - jump
PC3:    EXAF                    ; Restore search parameters
        JPE     PC1             ; Jump if search not complete
        RET                     ; Return
PC5:    POP     PSW             ; Abnormal exit
        POP     D               ; Restore regs.
        POP     B
        RET                     ; Return to ATTACK
```

```
;*************************************************************
; PIN FIND ROUTINE
;*************************************************************
; FUNCTION:    --  To produce a list of all pieces pinned
;                  against the King or Queen, for both white
;                  and black.
;
; CALLED BY:   --  FNDMOV
;                  EVAL
;
; CALLS:       --  PATH
;                  ATTACK
;
; ARGUMENTS:   --  None
;*************************************************************
PINFND: XRA     A               ; Zero pin count
        STA     NPINS
        LXI     D,POSK          ; Addr of King/Queen pos list
PF1:    LDAX    D               ; Get position of royal piece
        ANA     A               ; Is it on board ?
        JZ      PF26            ; No - jump
        CPI     -1              ; At end of list ?
        RZ                      ; Yes return
        STA     M3              ; Save position as board index
        LIXD    M3              ; Load index to board
        MOV     A,BOARD(X)      ; Get contents of board
        STA     P1              ; Save
        MVI     B,8             ; Init scan direction count
        XRA     A
        STA     INDX2           ; Init direction index
        LIYD    INDX2
PF2:    LDA     M3              ; Get King/Queen position
        STA     M2              ; Save
        XRA     A
        STA     M4              ; Clear pinned piece saved
        MOV     C,DIRECT(Y)     ; Get direction of scan
PF5:    CALL    PATH            ; Compute next position
        ANA     A               ; Is it empty ?
        JRZ     PF5             ; Yes - jump
        CPI     3               ; Off board ?
        JZ      PF25            ; Yes - jump
        CPI     2               ; Piece of same color found
        LDA     M4              ; Load pinned piece position
        JRZ     PF15            ; Yes - jump
        ANA     A               ; Possible pin ?
        JZ      PF25            ; No - jump
        LDA     T2              ; Piece type encountered
        CPI     QUEEN           ; Queen ?
        JZ      PF19            ; Yes - jump
        MOV     L,A             ; Save piece type
```

```
        MOV     A,B             ; Direction counter
        CPI     5               ; Non-diagonal direction ?
        JRC     PF10            ; Yes - jump
        MOV     A,L             ; Piece type
        CPI     BISHOP          ; Bishop ?
        JNZ     PF25            ; No - jump
        JMP     PF20            ; Jump
PF18:   MOV     A,L             ; Piece type
        CPI     ROOK            ; Rook ?
        JNZ     PF25            ; No - jump
        JMP     PF20            ; Jump
PF15:   ANA     A               ; Possible pin ?
        JNZ     PF25            ; No - jump
        LDA     M2              ; Save possible pin position
        STA     M4
        JMP     PF5             ; Jump
PF19:   LDA     P1              ; Load King or Queen
        ANI     7               ; Clear flags
        CPI     QUEEN           ; Queen ?
        JRNZ    PF20            ; No - jump
        PUSH    B               ; Save regs.
        PUSH    D
        PUSH    Y
        XRA     A               ; Zero out attack list
        MVI     B,14
        LXI     H,ATKLST
        MOV     M,A
        INX     H
        DJNZ    .-2
        MVI     A,7             ; Set attack flag
        STA     T1
        CALL    ATTACK          ; Find attackers/defenders
        LXI     H,WACT          ; White queen attackers
        LXI     D,BACT          ; Black queen attackers
        LDA     P1              ; Get queen
        BIT     7,A             ; Is she white ?
        JRZ     .+3             ; Yes - skip
        XCHG                    ; Reverse for black
        MOV     A,M             ; Number of defenders
        XCHG                    ; Reverse for attackers
        SUB     M               ; Defenders minus attackers
        DCR     A               ; Less 1
        POP     Y               ; Restore regs.
        POP     D
        POP     B
        JP      PF25            ; Jump if pin not valid
PF20:   LXI     H,NPINS         ; Address of pinned piece count
        INR     M               ; Increment
        LIXD    NPINS           ; Load pin list index
        MOV     PLISTD(X),C     ; Save direction of pin
```

```
        LDA     M4              ; Position of pinned piece
        MOV     PLIST(X),A      ; Save in list
PF25:   INX     Y               ; Increment direction index
        DJNZ    PF27            ; Done ?  No - Jump
PF26:   INX     D               ; Incr King/Queen pos index
        JMP     PF1             ; Jump
PF27:   JMP     PF2             ; Jump
```

```
;*************************************************************
; EXCHANGE ROUTINE
;*************************************************************
; FUNCTION:    --  To determine the exchange value of a
;                  piece on a given square by examining all
;                  attackers and defenders of that piece.
;
; CALLED BY:   --  POINTS
;
; CALLS:       --  NEXTAD
;
; ARGUMENTS:   --  None.
;*************************************************************
XCHNG:  EXX                         ; Swap regs.
        LDA     P1                  ; Piece attacked
        LXI     H,WACT              ; Addr of white attkrs/dfndrs
        LXI     D,BACT              ; Addr of black attkrs/dfndrs
        BIT     7,A                 ; Is piece white ?
        JRZ     .+3                 ; Yes - jump
        XCHG                        ; Swap list pointers
        MOV     B,M                 ; Init list counts
        XCHG
        MOV     C,M
        XCHG
        EXX                         ; Restore regs.
        MVI     C,0                 ; Init attacker/defender flag
        MVI     E,0                 ; Init points lost count
        LIXD    T3                  ; Load piece value index
        MOV     D,PVALUE(X)         ; Get attacked piece value
        SLAR    D                   ; Double it
        MOV     B,D                 ; Save
        CALL    NEXTAD              ; Retrieve first attacker
        RZ                          ; Return if none
XC16:   MOV     L,A                 ; Save attacker value
        CALL    NEXTAD              ; Get next defender
        JRZ     XC18                ; Jump if none
        EXAF                        ; Save defender value
        MOV     A,B                 ; Get attacked value
        CMP     L                   ; Attacked less than attacker ?
        JRNC    XC19                ; No - jump
        EXAF                        ; Restore defender
XC15:   CMP     L                   ; Defender less than attacker ?
        RC                          ; Yes - return
        CALL    NEXTAD              ; Retrieve next attacker value
        RZ                          ; Return if none
        MOV     L,A                 ; Save attacker value
        CALL    NEXTAD              ; Retrieve next defender value
        JRNZ    XC15                ; Jump if none
XC18:   EXAF                        ; Save Defender
        MOV     A,B                 ; Get value of attacked piece
```

```
XC19:   BIT     0,C             ; Attacker or defender ?
        JRZ     .+4             ; Jump if defender
        NEG                     ; Negate value for attacker
        ADD     E               ; Total points lost
        MOV     E,A             ; Save total
        EXAF                    ; Restore previous defender
        RZ                      ; Return if none
        MOV     B,L             ; Prev attckr becomes defender
        JMP     XC10            ; Jump


;*************************************************************
; NEXT ATTACKER/DEFENDER ROUTINE
;*************************************************************
; FUNCTION:    --  To retrieve the next attacker or defender
;                  piece value from the attack list, and dele:
;                  that piece from the list.
;
; CALLED BY:   --  XCHNG
:
: CALLS:       --  None
;
; ARGUMENTS:   --  Attack list addresses.
;                  Side flag
;                  Attack list counts
;*************************************************************
NEXTAD: INR     C               ; Increment side flag
        EXX                     ; Swap registers
        MOV     A,B             ; Swap list counts
        MOV     B,C
        MOV     C,A
        XCHG                    ; Swap list pointers
        XRA     A
        CMP     B               ; At end of list ?
        JRZ     NX6             ; Yes - jump
        DCR     B               ; Decrement list count
        INX     H               ; Increment list pointer
        CMP     M               ; Check next item in list
        JRZ     .-2             ; Jump if empty
        RRD                     ; Get value from list
        ADD     A               ; Double it
        DCX     H               ; Decrement list pointer
NX6:    EXX                     ; Restore regs.
        RET                     ; Return
```

```
;*****************************************************************
; POINT EVALUATION ROUTINE
;*****************************************************************
;FUNCTION:    --  To perform a static board evaluation and
;                 derive a score for a given board position
;
; CALLED BY:  --  FNDMOV
;                 EVAL
;
; CALLS:      --  ATTACK
;                 XCHNG
;                 LIMIT
;
; ARGUMENTS:  --  None
;*****************************************************************
POINTS: XRA     A               ; Zero out variables
        STA     MTRL
        STA     BRDC
        STA     PTSL
        STA     PTSW1
        STA     PTSW2
        STA     PTSCK
        LXI     H,T1            ; Set attacker flag
        MVI     M,7
        MVI     A,21            ; Init to first square on board
PT5:    STA     M3              ; Save as board index
        LIXD    M3              ; Load board index
        MOV     A,BOARD(X)      ; Get piece from board
        CPI     -1              ; Off board edge ?
        JZ      PT25            ; Yes - jump
        LXI     H,P1            ; Save piece, if any
        MOV     M,A
        ANI     7               ; Save piece type, if any
        STA     T3
        CPI     KNIGHT          ; Less than a Knight (Pawn) ?
        JRC     PT6X            ; Yes - Jump
        CPI     ROOK            ; Rook, Queen or King ?
        JRC     PT6B            ; No - jump
        CPI     KING            ; Is it a King ?
        JRZ     PT6AA           ; Yes - jump
        LDA     MOVENO          ; Get move number
        CPI     7               ; Less than 7 ?
        JRC     PT6A            ; Yes - Jump
        JMP     PT6X            ; Jump
PT6AA:  BIT     4,M             ; Castled yet ?
        JRZ     PT6A            ; No - jump
        MVI     A,+6            ; Bonus for castling
        BIT     7,M             ; Check piece color
        JRZ     PT6D            ; Jump if white
        MVI     A,-6            ; Bonus for black castling
```

```
        JMP     PT6D            ; Jump
PT6A:   BIT     3,M             ; Has piece moved yet ?
        JRZ     PT6X            ; No - jump
        JMP     PT6C            ; Jump
PT6B:   BIT     3,M             ; Has piece moved yet ?
        JRNZ    PT6X            ; Yes - jump
PT6C:   MVI     A,-2            ; Two point penalty for white
        BIT     7,M             ; Check piece color
        JRZ     .+4             ; Jump if white
        MVI     A,+2            ; Two point penalty for black
PT6D:   LXI     H,BRDC          ; Get address of board control
        ADD     M               ; Add on penalty/bonus points
        MOV     M,A             ; Save
PT6X:   XRA     A               ; Zero out attack list
        MVI     B,14
        LXI     H,ATKLST
        MOV     M,A
        INX     H
        DJNZ    .-2
        CALL    ATTACK          ; Build attack list for square
        LXI     H,BACT          ; Get black attacker count addr
        LDA     WACT            ; Get white attacker count
        SUB     M               ; Compute count difference
        LXI     H,BRDC          ; Address of board control
        ADD     M               ; Accum board control score
        MOV     M,A             ; Save
        LDA     P1              ; Get piece on current square
        ANA     A               ; Is it empty ?
        JZ      PT25            ; Yes - jump
        CALL    XCHNG           ; Evaluate exchange, if any
        XRA     A               ; Check for a loss
        CMP     E               ; Points lost ?
        JRZ     PT23            ; No - Jump
        DCR     D               ; Deduct half a Pawn value
        LDA     P1              ; Get piece under attack
        LXI     H,COLOR         ; Color of side just moved
        XRA     M               ; Compare with piece
        BIT     7,A             ; Do colors match ?
        MOV     A,E             ; Points lost
        JRNZ    PT20            ; Jump if no match
        LXI     H,PTSL          ; Previous max points lost
        CMP     M               ; Compare to current value
        JRC     PT23            ; Jump if greater than
        MOV     M,E             ; Store new value as max lost
        LIXD    MLPTRJ          ; Load pointer to this move
        LDA     M3              ; Get position of lost piece
        CMP     MLTOP(X)        ; Is it the one moving ?
        JRNZ    PT23            ; No - jump
        STA     PTSCK           ; Save position as a flag
        JMP     PT23            ; Jump
```

```
PT20:   LXI     H,PTSW1         ; Previous maximum points won
        CMP     M               ; Compare to current value
        JRC     .+4             ; Jump if greater than
        MOV     A,M             ; Load previous max value
        MOV     M,E             ; Store new value as max won
        LXI     H,PTSW2         ; Previous 2nd max points won
        CMP     M               ; Compare to current value
        JRC     PT23            ; Jump if greater than
        MOV     M,A             ; Store as new 2nd max lost
PT23:   LXI     H,P1            ; Get piece
        BIT     7,M             ; Test color
        MOV     A,D             ; Value of piece
        JRZ     .+4             ; Jump if white
        NEG                     ; Negate for black
        LXI     H,MTRL          ; Get addrs of material total
        ADD     M               ; Add new value
        MOV     M,A             ; Store
PT25:   LDA     M3              ; Get current board position
        INR     A               ; Increment
        CPI     99              ; At end of board ?
        JNZ     PT5             ; No - jump
        LDA     PTSCK           ; Moving piece lost flag
        ANA     A               ; Was it lost ?
        JRZ     PT25A           ; No - jump
        LDA     PTSW2           ; 2nd max points won
        STA     PTSW1           ; Store as max points won
        XRA     A               ; Zero out 2nd max points won
        STA     PTSW2
PT25A:  LDA     PTSL            ; Get max points lost
        ANA     A               ; Is it zero ?
        JRZ     .+3             ; Yes - jump
        DCR     A               ; Decrement it
        MOV     B,A             ; Save it
        LDA     PTSW1           ; Max points won
        ANA     A               ; Is it zero ?
        JRZ     .+11            ; Yes - jump
        LDA     PTSW2           ; 2nd max points won
        ANA     A               ; Is it zero ?
        JRZ     .+5             ; Yes - jump
        DCR     A               ; Decrement it
        SRLR    A               ; Divide it by 2
        SUB     B               ; Subtract points lost
        LXI     H,COLOR         ; Color of side just moved
        BIT     7,M             ; Is it white ?
        JRZ     .+4             ; Yes - jump
        NEG                     ; Negate for black
        LXI     H,MTRL          ; Net material on board
        ADD     M               ; Add exchange adjustments
        LXI     H,MV0           ; Material at ply 0
```

```
SUB     M               ; Subtract from current
MOV     B,A             ; Save
MVI     A,30            ; Load material limit
CALL    LIMIT           ; Limit to plus or minus value
MOV     E,A             ; Save limited value
LDA     BRDC            ; Get board control points
LXI     H,BC0           ; Board control at ply zero
SUB     M               ; Get difference
MOV     B,A             ; Save
LDA     PTSCK           ; Moving piece lost flag
ANA     A               ; Is it zero ?
JRZ     .+4             ; Yes - jump
MVI     B,0             ; Zero board control points
MVI     A,6             ; Load board control limit
CALL    LIMIT           ; Limit to plus or minus value
MOV     D,A             ; Save limited value
MOV     A,E             ; Get material points
ADD     A               ; Multiply by 4
ADD     A
ADD     D               ; Add board control
LXI     H,COLOR         ; Color of side just moved
BIT     7,M             ; Is it white ?
JRNZ    .+4             ; No - jump
NEG                     ; Negate for white
ADI     80H             ; Rescale score (neutral = 80
STA     VALM            ; Save score
LIXD    MLPTRJ          ; Load move list pointer
MOV     MLVAL(X),A      ; Save score in move list
RET                     ; Return
```

```
;*************************************************************
; LIMIT ROUTINE
;*************************************************************
; FUNCTION:    --  To limit the magnitude of a given value
;                  to another given value.
;
; CALLED BY:   --  POINTS
;
; CALLS:       --  None
;
; ARGUMENTS:   --  Input  - Value to be limited in the B
;                           register.
;                         - Value to limit to in the A register.
;              Output - Limited value in the A register.
;*************************************************************
LIMIT:  BIT     7,B             ; Is value negative ?
        JZ      LIM10           ; No - jump
        NEG                     ; Make positive
        CMP     B               ; Compare to limit
        RNC                     ; Return if outside limit
        MOV     A,B             ; Output value as is
        RET                     ; Return
LIM10:  CMP     B               ; Compare to limit
        RC                      ; Return if outside limit
        MOV     A,B             ; Output value as is
        RET                     ; Return
        .END
```

```
;*****************************************************************
; MOVE ROUTINE
;*****************************************************************
; FUNCTION:    --  To execute a move from the move list on the
;                  board array.
;
; CALLED BY:   --  CPTRMV
;                  PLYRMV
;                  EVAL
;                  FNDMOV
;                  VALMOV
;
; CALLS:       --  None
;
; ARGUMENTS:   --  None
;*****************************************************************
MOVE:   LHLD    MLPTRJ          ; Load move list pointer
        INX     H               ; Increment past link bytes
        INX     H
MV1:    MOV     A,M             ; "From" position
        STA     M1              ; Save
        INX     H               ; Increment pointer
        MOV     A,M             ; "To" position
        STA     M2              ; Save
        INX     H               ; Increment pointer
        MOV     D,M             ; Get captured piece/flags
        LIXD    M1              ; Load "from" pos board index
        MOV     E,BOARD(X)      ; Get piece moved
        BIT     5,D             ; Test Pawn promotion flag
        JRNZ    MV15            ; Jump if set
        MOV     A,E             ; Piece moved
        ANI     7               ; Clear flag bits
        CPI     QUEEN           ; Is it a queen ?
        JRZ     MV20            ; Yes - jump
        CPI     KING            ; Is it a king ?
        JRZ     MV30            ; Yes - jump
MV5:    LIYD    M2              ; Load "to" pos board index
        SET     3,E             ; Set piece moved flag
        MOV     BOARD(Y),E      ; Insert piece at new position
        MVI     BOARD(X),0      ; Empty previous position
        BIT     6,D             ; Double move ?
        JRNZ    MV40            ; Yes - jump
        MOV     A,D             ; Get captured piece, if any
        ANI     7
        CPI     QUEEN           ; Was it a queen ?
        RNZ                     ; No - return
        LXI     H,POSQ          ; Addr of saved Queen position
        BIT     7,D             ; Is Queen white ?
        JRZ     MV10            ; Yes - jump
        INX     H               ; Increment to black Queen pos
```

```
MV10:   XRA     A           ; Set saved position to zero
        MOV     M,A
        RET                 ; Return
MV15:   SET     2,E         ; Change Pawn to a Queen
        JMP     MV5         ; Jump
MV20:   LXI     H,POSQ      ; Addr of saved Queen position
MV21:   BIT     7,E         ; Is Queen white ?
        JRZ     MV22        ; Yes - jump
        INX     H           ; Increment to black Queen pos
MV22:   LDA     M2          ; Get new Queen position
        MOV     M,A         ; Save
        JMP     MV5         ; Jump
MV30:   LXI     H,POSK      ; Get saved King position
        BIT     6,D         ; Castling ?
        JRZ     MV21        ; No - jump
        SET     4,E         ; Set King castled flag
        JMP     MV21        ; Jump
MV40:   LHLD    MLPTRJ      ; Get move list pointer
        LXI     D,8         ; Increment  to next move
        DAD     D
        JMP     MV1         ; Jump (2nd part of dbl move)
```

```
;*************************************************************
; UN-MOVE ROUTINE
;*************************************************************
; FUNCTION:    --  To reverse the process of the move routine
;                  thereby restoring the board array to its
;                  previous position.
;
; CALLED BY:   --  VALMOV
;                  EVAL
;                  FNDMOV
;                  ASCEND
;
; CALLS:       --  None
;
; ARGUMENTS:   --  None
;*************************************************************
UNMOVE: LHLD    MLPTRJ          ; Load move list pointer
        INX     H               ; Increment past link bytes
        INX     H
UM1:    MOV     A,M             ; Get "from" position
        STA     M1              ; Save
        INX     H               ; Increment pointer
        MOV     A,M             ; Get "to" position
        STA     M2              ; Save
        INX     H               ; Increment pointer
        MOV     D,M             ; Get captured piece/flags
        LIXD    M2              ; Load "to" pos board index
        MOV     E,BOARD(X)      ; Get piece moved
        BIT     5,D             ; Was it a Pawn promotion ?
        JRNZ    UM15            ; Yes - jump
        MOV     A,E             ; Get piece moved
        ANI     7               ; Clear flag bits
        CPI     QUEEN           ; Was it a Queen ?
        JRZ     UM20            ; Yes - jump
        CPI     KING            ; Was it a King ?
        JRZ     UM30            ; Yes - jump
UM5:    BIT     4,D             ; Is this lst move for piece
        JRNZ    UM16            ; Yes - jump
UM6:    LIYD    M1              ; Load "from" pos board index
        MOV     BOARD(Y),E      ; Return to previous board
        MOV     A,D             ; Get captured piece, if any
        ANI     8FH             ; Clear flags
        MOV     BOARD(X),A      ; Return to board
        BIT     6,D             ; Was it a double move ?
        JRNZ    UM40            ; Yes - jump
        MOV     A,D             ; Get captured piece, if any
        ANI     7               ; Clear flag bits
        CPI     QUEEN           ; Was it a Queen ?
        RNZ                     ; No - return
```

```
        LXI     H,POSQ          ; Address of saved Queen pos
        BIT     7,D             ; Is Queen white ?
        JRZ     UM10            ; Yes - jump
        INX     H               ; Increment to black Queen pos
UM10:   LDA     M2              ; Queen's previous position
        MOV     M,A             ; Save
        RET                     ; Return
UM15:   RES     2,E             ; Restore Queen to Pawn
        JMP     UM5             ; Jump
UM16:   RES     3,E             ; Clear piece moved flag
        JMP     UM6             ; Jump
UM20:   LXI     H,POSQ          ; Addr of saved Queen position
UM21:   BIT     7,E             ; Is Queen white ?
        JRZ     UM22            ; Yes - jump
        INX     H               ; Increment to black Queen pos
UM22:   LDA     M1              ; Get previous position
        MOV     M,A             ; Save
        JMP     UM5             ; Jump
UM30:   LXI     H,POSK          ; Address of saved King pos
        BIT     6,D             ; Was it a castle ?
        JRZ     UM21            ; No - jump
        RES     4,E             ; Clear castled flag
        JMP     UM21            ; Jump
UM40:   LHLD    MLPTRJ          ; Load move list pointer
        LXI     D,8             ; Increment to next move
        DAD     D
        JMP     UM1             ; Jump (2nd part of dbl move)
```

```
;*****************************************************
; SORT ROUTINE
;*****************************************************
; FUNCTION:    --  To sort the move list in order of
;                  increasing move value scores.
;
; CALLED BY:   --  FNDMOV
;
; CALLS:       --  EVAL
;
; ARGUMENTS:   --  None
;*****************************************************
SORTM:  LBCD    MLPTRI          ; Move list begin pointer
        LXI     D,0             ; Initialize working pointers
SR5:    MOV     H,B
        MOV     L,C
        MOV     C,M             ; Link to next move
        INX     H
        MOV     B,M
        MOV     M,D             ; Store to link in list
        DCX     H
        MOV     M,E
        XRA     A               ; End of list ?
        CMP     B
        RZ                      ; Yes - return
SR10:   SBCD    MLPTRJ          ; Save list pointer
        CALL    EVAL            ; Evaluate move
        LHLD    MLPTRI          ; Begining of move list
        LBCD    MLPTRJ          ; Restore list pointer
SR15:   MOV     E,M             ; Next move for compare
        INX     H
        MOV     D,M
        XRA     A               ; At end of list ?
        CMP     D
        JRZ     SR25            ; Yes - jump
        PUSH    D               ; Transfer move pointer
        POP     X
        LDA     VALM            ; Get new move value
        CMP     MLVAL(X)        ; Less than list value ?
        JRNC    SR30            ; No - jump
SR25:   MOV     M,B             ; Link new move into list
        DCX     H
        MOV     M,C
        JMP     SR5             ; Jump
SR30:   XCHG                    ; Swap pointers
        JMP     SR15            ; Jump
```

```
;*************************************************************
; EVALUATION ROUTINE
;*************************************************************
; FUNCTION:    --  To evaluate a given move in the move list.
;                  It first makes the move on the board, then if
;                  the move is legal, it evaluates it, and then
;                  restores the boaard position.
;
; CALLED BY:   --  SORT
;
; CALLS:       --  MOVE
;                  INCHK
;                  PINFND
;                  POINTS
;                  UNMOV
;
; ARGUMENTS:   --  None
;*************************************************************
EVAL:   CALL    MOVE            ; Make move on the board array
        CALL    INCHK           ; Determine if move is legal
        ANA     A               ; Legal move ?
        JRZ     EV5             ; Yes - jump
        XRA     A               ; Score of zero
        STA     VALM            ; For illegal move
        JMP     EV10            ; Jump
EV5:    CALL    PINFND          ; Compile pinned list
        CALL    POINTS          ; Assign points to move
EV10:   CALL    UNMOVE          ; Restore board array
        RET                     ; Return
```

```
;*************************************************************
; FIND MOVE ROUTINE
;*************************************************************
; FUNCTION:    --  To determine the computer's best move by
;                  performing a depth first tree search using
;                  the techniques of alpha-beta pruning.
;
; CALLED BY:   --  CPTRMV
;
; CALLS:       --  PINFND
;                  POINTS
;                  GENMOV
;                  SORTM
;                  ASCEND
;                  UNMOV
;
; ARGUMENTS:   --  None
;*************************************************************
FNDMOV: LDA     MOVENO          ; Currnet move number
        CPI     1               ; First move ?
        CZ      BOOK            ; Yes - execute book opening
        XRA     A               ; Initialize ply number to ze
        STA     NPLY
        LXI     H,0             ; Initialize best move to ze
        SHLD    BESTM
        LXI     H,MLIST         ; Initialize ply list pointe
        SHLD    MLNXT
        LXI     H,PLYIX-2
        SHLD    MLPTRI
        LDA     KOLOR           ; Initialize color
        STA     COLOR
        LXI     H,SCORE         ; Initialize score index
        SHLD    SCRIX
        LDA     PLYMAX          ; Get max ply number
        ADI     2               ; Add 2
        MOV     B,A             ; Save as counter
        XRA     A               ; Zero out score table
        MOV     M,A
        INX     H
        DJNZ    .-2
        STA     BC0             ; Zero ply 0 board control
        STA     MV0             ; Zero ply 0 material
        CALL    PINFND          ; Complie pin list
        CALL    POINTS          ; Evaluate board at ply 0
        LDA     BRDC            ; Get board control points
        STA     BC0             ; Save
        LDA     MTRL            ; Get material count
        STA     MV0             ; Save
FM5:    LXI     H,NPLY          ; Address of ply counter
        INR     M               ; Increment ply count
```

```
        XRA     A               ; Initialize mate flag
        STA     MATEF
        CALL    GENMOV          ; Generate list of moves
        LDA     NPLY            ; Current ply counter
        LXI     H,PLYMAX        ; Address of maximum ply number
        CMP     M               ; At max ply ?
        CC      SORTM           ; No - call sort
        LHLD    MLPTRI          ; Load ply index pointer
        SHLD    MLPTRJ          ; Save as last move pointer
FM15:   LHLD    MLPTRJ          ; Load last move pointer
        MOV     E,M             ; Get next move pointer
        INX     H
        MOV     D,M
        MOV     A,D
        ANA     A               ; End of move list ?
        JRZ     FM25            ; Yes - jump
        SDED    MLPTRJ          ; Save current move pointer
        LHLD    MLPTRI          ; Save in ply pointer list
        MOV     M,E
        INX     H
        MOV     M,D
        LDA     NPLY            ; Current ply counter
        LXI     H,PLYMAX        ; Maximum ply number ?
        CMP     M               ; Compare
        JRC     FM18            ; Jump if not max
        CALL    MOVE            ; Execute move on board array
        CALL    INCHK           ; Check for legal move
        ANA     A               ; Is move legal ?
        JRZ     .+8             ; Yes - jump
        CALL    UNMOVE          ; Restore board position
        JMP     FM15            ; Jump
        LDA     NPLY            ; Get ply counter
        LXI     H,PLYMAX        ; Max ply number
        CMP     M               ; Beyond max ply ?
        JRNZ    FM35            ; Yes - jump
        LDA     COLOR           ; Get current color
        XRI     80H             ; Get opposite color
        CALL    INCHK1          ; Determine if King is in check
        ANA     A               ; In check ?
        JRZ     FM35            ; No - jump
        JMP     FM19            ; Jump (One more ply for check)
FM18:   LIXD    MLPTRJ          ; Load move pointer
        MOV     A,MLVAL(X)      ; Get move score
        ANA     A               ; Is it zero (illegal move) ?
        JRZ     FM15            ; Yes - jump
        CALL    MOVE            ; Execute move on board array
FM19:   LXI     H,COLOR         ; Toggle color
        MVI     A,80H
        XRA     M
        MOV     M,A             ; Save new color
```

```
        BIT     7,A             ; Is it white ?
        JRNZ    .+6             ; No - jump
        LXI     H,MOVENO        ; Increment move number
        INR     M
        LHLD    SCRIX           ; Load score table pointer
        MOV     A,M             ; Get score two plys above
        INX     H               ; Increment to current ply
        INX     H
        MOV     M,A             ; Save score as initial value
        DCX     H               ; Decrement pointer
        SHLD    SCRIX           ; Save it
        JMP     FM5             ; Jump
FM25:   LDA     MATEF           ; Get mate flag
        ANA     A               ; Checkmate or stalemate ?
        JRNZ    FM30            ; No - jump
        LDA     CKFLG           ; Get check flag
        ANA     A               ; Was King in check ?
        MVI     A,80H           ; Pre-set stalemate score
        JRZ     FM36            ; No - jump (stalemate)
        LDA     MOVENO          ; Get move number
        STA     PMATE           ; Save
        MVI     A,0FFH          ; Pre-set checkmate score
        JMP     FM36            ; Jump
FM30:   LDA     NPLY            ; Get ply counter
        CPI     1               ; At top of tree ?
        RZ                      ; Yes - return
        CALL    ASCEND          ; Ascend one ply in tree
        LHLD    SCRIX           ; Load score table pointer
        INX     H               ; Increment to current ply
        INX     H
        MOV     A,M             ; Get score
        DCX     H               ; Restore pointer
        DCX     H
        JMP     FM37            ; Jump
FM35:   CALL    PINFND          ; Compile pin list
        CALL    POINTS          ; Evaluate move
        CALL    UNMOVE          ; Restore board position
        LDA     VALM            ; Get value of move
FM36:   LXI     H,MATEF         ; Set mate flag
        SET     0,M
        LHLD    SCRIX           ; Load score table pointer
FM37:   CMP     M               ; Compare to score 2 ply ab
        JRC     FM40            ; Jump if less
        JRZ     FM40            ; Jump if equal
        NEG                     ; Negate score
        INX     H               ; Incr score table pointer
        CMP     M               ; Compare to score 1 ply ab
        JC      FM15            ; Jump if less than
        JZ      FM15            ; Jump if equal
```

```
        MOV     M,A             ; Save as new score 1 ply above
        LDA     NPLY            ; Get current ply counter
        CPI     1               ; At top of tree ?
        JNZ     FM15            ; No - jump
        LHLD    MLPTRJ          ; Load current move pointer
        SHLD    BESTM           ; Save as best move pointer
        LDA     SCORE+1         ; Get best move score
        CPI     0FFH            ; Was it a checkmate ?
        JNZ     FM15            ; No - jump
        LXI     H,PLYMAX        ; Get maximum ply number
        DCR     M               ; Subtract 2
        DCR     M
        LDA     KOLOR           ; Get computer's color
        BIT     7,A             ; Is it white ?
        RZ                      ; Yes - return
        LXI     H,PMATE         ; Checkmate move number
        DCR     M               ; Decrement
        RET                     ; Return
FM40:   CALL    ASCEND          ; Ascend one ply in tree
        JMP     FM15            ; Jump
```

```
;*************************************************************
; ASCEND TREE ROUTINE
;*************************************************************
; FUNCTION:    --  To adjust all necessary parameters to
;                  ascend one ply in the tree.
;
; CALLED BY:   --  FNDMOV
;
; CALLS:       --  UNMOV
;
; ARGUMENTS:   --  None
;*************************************************************
ASCEND: LXI     H,COLOR         ; Toggle color
        MVI     A,80H
        XRA     M
        MOV     M,A             ; Save new color
        BIT     7,A             ; Is it white ?
        JRZ     .+6             ; Yes - jump
        LXI     H,MOVENO        ; Decrement move number
        DCR     M
        LHLD    SCRIX           ; Load score table index
        DCX     H               ; Decrement
        SHLD    SCRIX           ; Save
        LXI     H,NPLY          ; Decrement ply counter
        DCR     M
        LHLD    MLPTRI          ; Load ply list pointer
        DCX     H               ; Load pointer to move list to
        MOV     D,M
        DCX     H
        MOV     E,M
        SDED    MLNXT           ; Update move list avail ptr
        DCX     H               ; Get ptr to next move to undo
        MOV     D,M
        DCX     H
        MOV     E,M
        SHLD    MLPTRI          ; Save new ply list pointer
        SDED    MLPTRJ          ; Save next move pointer
        CALL    UNMOVE          ; Restore board to previous pl
        RET                     ; Return
```

```
;*************************************************************
; ONE MOVE BOOK OPENING
;*************************************************************
; FUNCTION:    --  To provide an opening book of a single
;                  move.
;
; CALLED BY:   --  FNDMOV
;
; CALLS:       --  None
;
; ARGUMENTS:   --  None
;*************************************************************
BOOK:   POP     PSW             ; Abort return to FNDMOV
        LXI     H,SCORE+1       ; Zero out score
        MVI     M,0             ; Zero out score table
        LXI     H,BMOVES-2      ; Init best move ptr to book
        SHLD    BESTM
        LXI     H,BESTM         ; Initialize address of pointer
        LDA     KOLOR           ; Get computer's color
        ANA     A               ; Is it white ?
        JRNZ    BM5             ; No - jump
        LDAR                    ; Load refresh reg (random no)
        BIT     0,A             ; Test random bit
        RZ                      ; Return if zero (P-K4)
        INR     M               ; P-Q4
        INR     M
        INR     M
        RET                     ; Return
BM5:    INR     M               ; Increment to black moves
        INR     M
        INR     M
        INR     M
        INR     M
        INR     M
        LIXD    MLPTRJ          ; Pointer to opponents lst move
        MOV     A,MLFRP(X)      ; Get "from" position
        CPI     22              ; Is it a Queen Knight move ?
        JRZ     BM9             ; Yes - Jump
        CPI     27              ; Is it a King Knight move ?
        JRZ     BM9             ; Yes - jump
        CPI     34              ; Is it a Queen Pawn ?
        JRZ     BM9             ; Yes - jump
        RC                      ; If Queen side Pawn opening -
                                ; return (P-K4)
        CPI     35              ; Is it a King Pawn ?
        RZ                      ; Yes - return (P-K4)
BM9:    INR     M               ; (P-Q4)
        INR     M
        INR     M
        RET                     ; Return to CPTRMV

;*************************************************************
```

```
;*********************************************************
; GRAPHICS DATA BASE
;*********************************************************
; DESCRIPTION: The Graphics Data Base contains the
;              necessary stored data to propuce the piece
;              on the board.  Only the center 4 x 4 blocks are
;              stored and only for a Black Piece on a White
;              square.  A White piece on a black square is
;              produced by complementing each block, and a
;              piece on its own color square is produced
;              by moving in a kernel of 6 blocks.
;*********************************************************
        .LOC    START+384
BLBASE  =       START+512
BLOCK   =       .-BLBASE
        .RADIX  16
        .BYTE   80,80,80,80     ; Black Pawn on White square
        .BYTE   80,0A0,90,80
        .BYTE   80,0AF,9F,80
        .BYTE   80,83,83,80
        .BYTE   80,0B0,0B0,80   ; Black Knight on White squar
        .BYTE   0BE,0BF,0BF,95
        .BYTE   0A0,0BE,0BF,85
        .BYTE   83,83,83,81
        .BYTE   80,0A0,80,80    ; Black Bishop on White squar
        .BYTE   0A8,0BF,0BD,80
        .BYTE   82,0AF,87,80
        .BYTE   82,83,83,80
        .BYTE   80,80,80,80     ; Black Rook on White square
        .BYTE   8A,0BE,0BD,85
        .BYTE   80,0BF,0BF,80
        .BYTE   82,83,83,81
        .BYTE   90,80,80,90     ; Black Queen on White squar
        .BYTE   0BF,0B4,0BE,95
        .BYTE   8B,0BF,9F,81
        .BYTE   83,83,83,81
        .BYTE   80,0B8,90,80    ; Black King on White square
        .BYTE   0BC,0BA,0B8,94
        .BYTE   0AF,0BF,0BF,85
        .BYTE   83,83,83,81
        .BYTE   90,0B0,0B0,80   ; Toppled Black King
        .BYTE   0BF,0BF,0B7,80
        .BYTE   9F,0BF,0BD,80
        .BYTE   80,80,88,9D
KERNEL  =       .-BLBASE
        .BYTE   0BF,9F,0AF,0BF,9A,0A5   ; Pawn Kernel
        .BYTE   89,0AF,0BF,9F,0B9,9F    ; Knight Kernel
        .BYTE   97,0BE,96,0BD,9B,0B9    ; Bishop Kernel
        .BYTE   0B5,0A1,92,0BF,0AA,95   ; Rook Kernel
        .BYTE   0A8,9B,0B9,0B6,0AF,0A7  ; Queen Kernel
        .BYTE   0A3,85,0A7,9A,0BF,9F    ; King Kernel
        .BYTE   0A8,0BF,89,0A2,8F,86    ; Toppled King Ker
        .RADIX  10
```

```
;*********************************************************
; STANDARD MESSAGES
;*********************************************************
        .LOC    START+1800H
GRTTNG: .ASCII  "WELCOME TO CHESS! CARE FOR A GAME?"
ANAMSG: .ASCII  "WOULD YOU LIKE TO ANALYZE A POSITION?"
CLRMSG: .ASCII  "DO YOU WANT TO PLAY WHITE(w) OR BLACK(b)?"
TITLE1: .ASCII  "SARGON"
TITLE2: .ASCII  "PLAYER"
SPACE:  .ASCII  "          "     ; For output of blank area
MVENUM: .ASCII  "01 "
TITLE3: .ASCII  "  "
        .ASCII  [^H83]           ; Part of TITLE 3 - Underlines
        .ASCII  [^H83]
        .ASCII  [^H83]
        .ASCII  [^H83]
        .ASCII  [^H83]
        .ASCII  [^H83]
        .ASCII  " "
        .ASCII  [^H83]
        .ASCII  [^H83]
        .ASCII  [^H83]
        .ASCII  [^H83]
        .ASCII  [^H83]
        .ASCII  [^H83]
        .ASCII  " "
MVEMSG: .ASCII  "a1-a1"
O.O:    .ASCII  "O-O  "
O.O.O:  .ASCII  "O-O-O"
CKMSG:  .ASCII  "CHECK"
MTMSG:  .ASCII  "MATE IN "
MTPL:   .ASCII  "2"
PCS:    .ASCII  "KQRBNP"         ; Valid piece characters
UWIN:   .ASCII  "YOU WIN"
IWIN:   .ASCII  "I WIN"
AGAIN:  .ASCII  "CARE FOR ANOTHER GAME?"
CRTNES: .ASCII  "IS THIS RIGHT?"
PLYDEP: .ASCII  "SELECT LOOK AHEAD (1-6)"
TITLE4: .ASCII  "                "
WSMOVE: .ASCII  "WHOSE MOVE IS IT?"
BLANKR: .ASCII  [^H1C]                   ; Control-\
P.PEP:  .ASCII  "PxPep"
INVAL1: .ASCII  "INVALID MOVE"
INVAL2: .ASCII  "TRY AGAIN"
```

```
;*********************************************************
; VARIABLES
;*********************************************************
BRDPOS: .BLKB   1       ; Index into the board array
ANBDPS: .BLKB   1       ; Additional index required for ANALYS
INDXER: .WORD   BLBASE  ; Index into graphics data base
NORMAD: .BLKW   1       ; The address of the upper left hand
                        ; corner of the square on the board
LINECT: .BYTE   0       ; Current line number


;*********************************************************
; MACRO DEFINITIONS
;*********************************************************
; All input/output to SARGON is handled in the form of
; macro calls to simplify conversion to alternate systems.
; All of the input/output macros conform to the Jove monitor
; of the Jupiter III computer.
;*********************************************************
;*** OUTPUT <CR><LF> ***
        .DEFINE CARRET=
        [RST    7
        .BYTE   92H,1AH
        .WORD   0]
;*** CLEAR SCREEN ***
        .DEFINE CLRSCR=
        [RST    7
        .BYTE   0B2H,1AH
        .WORD   BLANKR,1]
;*** PRINT ANY LINE (NAME, LENGTH) ***
        .DEFINE PRTLIN[NAME,LNGTH]=
        [RST    7
        .BYTE   0B2H,1AH
        .WORD   NAME,LNGTH]
;*** PRINT ANY BLOCK (NAME, LENGTH) ***
        .DEFINE PRTBLK[NAME,LNGTH]=
        [RST    7
        .BYTE   0B3H,1AH
        .WORD   NAME,LNGTH]
;*** EXIT TO MONITOR ***
        .DEFINE EXIT=
        [RST    7
        .BYTE   01FH]
```

```
;*****************************************************************
; MAIN PROGRAM DRIVER
;*****************************************************************
; FUNCTION:    --  To coordinate the game moves.
;
; CALLED BY:   --  None
;
; CALLS:       --  INTERR
;                  INITBD
;                  DSPBRD
;                  CPTRMV
;                  PLYRMV
;                  TBCPCL
;                  PGIFND
;
; MACRO CALLS:     CLRSCR
;                  CARRET
;                  PRTLIN
;                  PRTBLK
;
; ARGUMENTS:       None
;*****************************************************************
        .LOC    START+1A00H     ; Above the move logic
DRIVER: LXI     SP,STACK        ; Set stack pointer
        CLRSCR                  ; Blank out screen
        PRTLIN  GRTTNG,34       ; Output greeting
DRIV01: CALL    CHARTR          ; Accept answer
        CARRET                  ; New line
        CPI     59H             ; Is it a 'Y' ?
        JNZ     ANALYS          ; Yes - jump
        SUB     A               ; Code of White is zero
        STA     COLOR           ; White always moves first
        CALL    INTERR          ; Players color/search depth
        CALL    INITBD          ; Initialize board array
        MVI     A,1             ; Move number is 1 at at start
        STA     MOVENO          ; Save
        STA     LINECT          ; Line number is one at start
        LXI     H,MVENUM        ; Address of ascii move number
        MVI     M,30H           ; Init to '01 '
        INX     H
        MVI     M,31H
        INX     H
        MVI     M,20H
        CALL    DSPBRD          ; Set up graphics board
        PRTLIN  TITLE4,15       ; Put up player headings
        PRTLIN  TITLE3,15
DRIV04: PRTBLK  MVENUM,3        ; Display move number
        LDA     KOLOR           ; Bring in computer's color
        ANA     A               ; Is it white ?
        JRNZ    DR08            ; No - jump
```

```
        CALL    PGIFND          ; New page if needed
        CPI     1               ; Was page turned ?
        CZ      TBCPCL          ; Yes - Tab to computers col.
        CALL    CPTRMV          ; Make and write computers mo.
        PRTBLK  SPACE,1         ; Output a space
        CALL    PLYRMV          ; Accept and make players mo.
        CARRET                  ; New line
        JMPR    DR0C            ; Jump
DR08:   CALL    PLYRMV          ; Accept and make players mo.
        PRTBLK  SPACE,1         ; Output a space
        CALL    PGIFND          ; New page if needed
        CPI     1               ; Was page turned ?
        CZ      TBCPCL          ; Yes - Tab to computers col.
        CALL    CPTRMV          ; Make and write computers mo.
        CARRET                  ; New line
DR0C:   LXI     H,MVENUM+2      ; Addr of 3rd char of move
        MVI     A,20H           ; Ascii space
        CMP     M               ; Is char a space ?
        MVI     A,3AH           ; Set up test value
        JRZ     DR10            ; Yes - jump
        INR     M               ; Increment value
        CMP     M               ; Over Ascii 9 ?
        JRNZ    DR14            ; No - jump
        MVI     M,30H           ; Set char to zero
DR10:   DCX     H               ; 2nd char of Ascii move no.
        INR     M               ; Increment value
        CMP     M               ; Over Ascii 9 ?
        JRNZ    DR14            ; No - jump
        MVI     M,30H           ; Set char to zero
        DCX     H               ; 1st char of Ascii move no.
        INR     M               ; Increment value
        CMP     M               ; Over Ascii 9 ?
        JRNZ    DR14            ; No - jump
        MVI     M,31H           ; Make 1st char a one
        MVI     A,30H           ; Make 3rd char a zero
        STA     MVENUM+2
DR14:   LXI     H,MOVENO        ; Hexadecimal move number
        INR     M               ; Increment
        JMP     DRIV04          ; Jump
```

```
;*****************************************************************
; INTERROGATION FOR PLY & COLOR
;*****************************************************************
; FUNCTION:    --  To query the player for his choice of ply
;                  depth and color.
;
; CALLED BY:   --  DRIVER
;
; CALLS:       --  CHARTR
;
; MACRO CALLS:     PRTLIN
;                  CARRET
;
; ARGUMENTS:   --  None
```

```
;*************************************************************
INTERR: PRTLIN  CLRMSG,41       ; Request color choice
        CALL    CHARTR          ; Accept response
        CARRET                  ; New line
        CPI     57H             ; Did player request white ?
        JRZ     IN04            ; Yes - branch
        SUB     A               ; Set computers color to white
        STA     KOLOR
        LXI     H,TITLE1        ; Prepare move list titles
        LXI     D,TITLE4+2
        LXI     B,6
        LDIR
        LXI     H,TITLE2
        LXI     D,TITLE4+9
        LXI     B,6
        LDIR
        JMPR    IN08            ; Jump
IN04:   MVI     A,80H           ; Set computers color to black
        STA     KOLOR
        LXI     H,TITLE2        ; Prepare move list titles
        LXI     D,TITLE4+2
        LXI     B,6
        LDIR
        LXI     H,TITLE1
        LXI     D,TITLE4+9
        LXI     B,6
        LDIR
IN08:   PRTLIN  PLYDEP,23       ; Request depth of search
        CALL    CHARTR          ; Accept response
        CARRET                  ; New line
        LXI     H,PLYMAX        ; Address of ply depth variable
        MVI     M,2             ; Default depth of search
        CPI     31H             ; Under minimum of 1 ?
        RM                      ; Yes - return
        CPI     37H             ; Over maximum of 6 ?
        RP                      ; Yes - return
        SUI     30H             ; Subtract Ascii constant
        MOV     M,A             ; Set desired depth
        RET                     ; Return
```

```
;*****************************************************************
; COMPUTER MOVE ROUTINE
;*****************************************************************
; FUNCTION:    --  To control the search for the computers move
;                  and the display of that move on the board
;                  and in the move list.
;
; CALLED BY:   --  DRIVER
;
; CALLS:       --  FNDMOV
;                  FCDMAT
;                  MOVE
;                  EXECMV
;                  BITASN
;                  INCHK
;
; MACRO CALLS:     PRTBLK
;                  CARRET
;
; ARGUMENTS:   --  None
;*****************************************************************
CPTRMV: CALL    FNDMOV          ; Select best move
        LHLD    BESTM           ; Move list pointer variable
        SHLD    MLPTRJ          ; Pointer to move data
        LDA     SCORE+1         ; To check for mates
        CPI     1               ; Mate against computer ?
        JRNZ    CP0C            ; No - jump
        MVI     C,1             ; Computer mate flag
        CALL    FCDMAT          ; Full checkmate ?
CP0C:   CALL    MOVE            ; Produce move on board array
        CALL    EXECMV          ; Make move on graphics board
                                ; and return info about it
        MOV     A,B             ; Special move flags
        ANA     A               ; Special ?
        JRNZ    CP10            ; Yes - jump
        MOV     D,E             ; "To" position of the move
        CALL    BITASN          ; Convert to Ascii
        SHLD    MVEMSG+3        ; Put in move message
        MOV     D,C             ; "From" position of the move
        CALL    BITASN          ; Convert to Ascii
        SHLD    MVEMSG          ; Put in move message
        PRTBLK  MVEMSG,5        ; Output text of move
        JMPR    CP1C            ; Jump
CP10:   BIT     1,B             ; King side castle ?
        JRZ     .+11            ; No - jump
        PRTBLK  O.O,5           ; Output "O-O"
        JMPR    CP1C            ; Jump
        BIT     2,B             ; Queen side castle ?
        JRZ     .+11            ; No - jump
```

```
        PRTBLK  O.O.O,5         ; Output "O-O-O"
        JMPR    CP1C            ; Jump
        PRTBLK  P.PEP,5         ; Output "PxPep" - En passant
CP1C:   LDA     COLOR           ; Should computer call check ?
        MOV     B,A
        XRI     80H             ; Toggle color
        STA     COLOR
        CALL    INCHK           ; Check for check
        ANA     A               ; Is enemy in check ?
        MOV     A,B             ; Restore color
        STA     COLOR
        JRZ     CP24            ; No - return
        CARRET                  ; New line
        LDA     SCORE+1         ; Check for player mated
        CPI     0FFH            ; Forced mate ?
        CNZ     TBCPMV          ; No - Tab to computer column
        PRTBLK  CKMSG,5         ; Output "check"
        LXI     H,LINECT        ; Address of screen line count
        INR     M               ; Increment for message
CP24:   LDA     SCORE+1         ; Check again for mates
        CPI     0FFH            ; Player mated ?
        RNZ                     ; No - return
        MVI     C,0             ; Set player mate flag
        CALL    FCDMAT          ; Full checkmate ?
        RET                     ; Return
```

```
;*************************************************************
; FORCED MATE HANDLING
;*************************************************************
; FUNCTION:    --  To examine situations where there exits
;                  a forced mate and determine whether or
;                  not the current move is checkmate.  If it is,
;                  a losing player is offered another game,
;                  while a loss for the computer signals the
;                  King to tip over in resignation.
;
; CALLED BY:   --  CPTRMV
;
; CALLS:       --  MATED
;                  CHARTR
;                  TBPLMV
;
; ARGUMENTS:   --  The only value passed in a register is the
;                  flag which tells FCDMAT whether the computer
;                  or the player is mated.
;*************************************************************
FCDMAT: LDA     MOVENO          ; Current move number
        MOV     B,A             ; Save
        LDA     PMATE           ; Move number where mate occurs
        SUB     B               ; Number of moves till mate
        ANA     A               ; Checkmate ?
        JRNZ    FM0C            ; No - jump
        BIT     0,C             ; Check flag for who is mated
        JRZ     FM04            ; Jump if player
        CARRET                  ; New line
        PRTLIN  CKMSG,9         ; Print "CHECKMATE"
        CALL    MATED           ; Tip over King
        PRTLIN  UWIN,7          ; Output "YOU WIN"
        JMPR    FM08            ; Jump
FM04:   PRTLIN  MTMSG,4         ; Output "MATE"
        PRTLIN  IWIN,5          ; Output "I WIN"
FM08:   POP     H               ; Remove return addresses
        POP     H
        CALL    CHARTR          ; Input any char to play again
FM09:   CLRSCR                  ; Blank screen
        PRTLIN  AGAIN,22        ;  "CARE FOR ANOTHER GAME?"
        JMP     DRIV01          ; Jump (Rest of game init)
FM0C:   BIT     0,C             ; Who has forced mate ?
        RNZ                     ; Return if player
        CARRET                  ; New line
        ADI     30H             ; Number of moves to Ascii
        STA     MTPL            ; Place value in message
        PRTLIN  MTMSG,9         ; Output "MATE IN x MOVES"
        CALL    TBPLMV          ; Tab to players column
        RET                     ; Return
```

```
;*************************************************************
; TAB TO PLAYERS COLUMN
;*************************************************************
; FUNCTION:    --  To space over in the move listing to the
;                  column in which the players moves are being
;                  recorded.  This routine also reprints the
;                  move number.
;
; CALLED BY:   --  PLYRMV
;
; CALLS:       --  None
;
; MACRO CALLS:     PRTBLK
;
; ARGUMENTS:   --  None
;*************************************************************
TBPLCL: PRTBLK  MVENUM,3        ; Reproduce move number
        LDA     KOLOR           ; Computers color
        ANA     A               ; Is computer white ?
        RNZ                     ; No - return
        PRTBLK  SPACE,6         ; Tab to next column
        RET                     ; Return


;*************************************************************
; TAB TO COMPUTERS COLUMN
;*************************************************************
; FUNCTION:    --  To space over in the move listing to the
;                  column in which the computers moves are
;                  being recorded.  This routine also reprints
;                  the move number.
;
; CALLED BY:   --  DRIVER
;                  CPTRMV
;
; CALLS:       --  None
;
; MACRO CALLS:     PRTBLK
;
; ARGUMENTS:   --  None
;*************************************************************
TBCPCL: PRTBLK  MVENUM,3        ; Reproduce move number
        LDA     KOLOR           ; Computer's color
        ANA     A               ; Is computer white ?
        RZ                      ; Yes - return
        PRTBLK  SPACE,6         ; Tab to next column
        RET                     ; Return
```

```
;*************************************************************
; TAB TO PLAYERS COLUMN W/O MOVE NO.
;*************************************************************
; FUNCTION:    --  Like TBPLCL, except that the move number
;                  is not reprinted.
;
; CALLED BY:   --  FCDMAT
;*************************************************************
TBPLMV: PRTBLK  SPACE,3
        LDA     KOLOR
        ANA     A
        RNZ
        PRTBLK  SPACE,6
        RET


;*************************************************************
; TAB TO COMPUTERS COLUMN W/O MOVE NO.
;*************************************************************
; FUNCTION:    --  Like TBCPCL, except that the move number
;                  is not reprinted.
;
;CALLED BY:   --  CPTRMV
;*************************************************************
TBCPMV: PRTBLK  SPACE,3
        LDA     KOLOR
        ANA     A
        RZ
        PRTBLK  SPACE,6
        RET
```

```
;*****************************************************************
; BOARD INDEX TO ASCII SQUARE NAME
;*****************************************************************
; FUNCTION:    --  To translate a hexadecimal index in the
;                  board array into an ascii description
;                  of the square in algebraic chess notation.
;
; CALLED BY:   --  CPTRMV
;
; CALLS:       --  DIVIDE
;
; ARGUMENTS:   --  Board index input in register D and the
;                  Ascii square name is output in register
;                  pair HL.
;*****************************************************************
BITASN: SUB     A               ; Get ready for division
        MVI     E,10
        CALL    DIVIDE          ; Divide
        DCR     D               ; Get rank on 1-8 basis
        ADI     60H             ; Convert file to Ascii (a-h)
        MOV     L,A             ; Save
        MOV     A,D             ; Rank
        ADI     30H             ; Convert rank to Ascii (1-8)
        MOV     H,A             ; Save
        RET                     ; Return
```

```
;*****************************************************
; PLAYERS MOVE ANALYSIS
;*****************************************************
; FUNCTION:   --  To accept and validate the players move
;                 and produce it on the graphics board.  Also
;                 allows player to resign the game by
;                 entering a control-R.
;
; CALLED BY:  --  DRIVER
;
; CALLS:      --  CHARTR
;                 ASNTBI
;                 VALMOV
;                 EXECMV
;                 PGIFND
;                 TBPLCL
;
; ARGUMENTS:  --  None
;*****************************************************
PLYRMV: CALL    CHARTR          ; Accept "from" file letter
        CPI     12H             ; Is it instead a Control-R ?
        JZ      FM09            ; Yes - jump
        MOV     H,A             ; Save
        CALL    CHARTR          ; Accept "from" rank number
        MOV     L,A             ; Save
        CALL    ASNTBI          ; Convert to a board index
        SUB     B               ; Gives board index, if valid
        JRZ     PL08            ; Jump if invalid
        STA     MVEMSG          ; Move list "from" position
        CALL    CHARTR          ; Accept separator & ignore it
        CALL    CHARTR          ; Repeat for "to" position
        MOV     H,A
        CALL    CHARTR
        MOV     L,A
        CALL    ASNTBI
        SUB     B
        JRZ     PL08
        STA     MVEMSG+1        ; Move list "to" position
        CALL    VALMOV          ; Determines if a legal move
        ANA     A               ; Legal ?
        JNZ     PL08            ; No - jump
        CALL    EXECMV          ; Make move on graphics board
        RET                     ; Return
PL08:   LXI     H,LINECT        ; Address of screen line count
        INR     M               ; Increase by 2 for message
        INR     M
        CARRET                  ; New line
        CALL    PGIFND          ; New page if needed
        PRTLIN  INVAL1,12       ; Output "INVALID MOVE"
        PRTLIN  INVAL2,9        ; Output "TRY AGAIN"
        CALL    TBPLCL          ; Tab to players column
        JMP     PLYRMV          ; Jump
```

```
;*****************************************************************
; ASCII SQUARE NAME TO BOARD INDEX
;*****************************************************************
; FUNCTION:    --  To convert an algebraic square name in
;                  Ascii to a hexadecimal board index.
;                  This routine also checks the input for
;                  validity.
;
; CALLED BY:   --  PLYRMV
;
; CALLS:       --  MLTPLY
;
; ARGUMENTS:   --  Accepts the square name in register pair HL
;                  and outputs the board index in register A.
;                  Register B = 0 if ok.  Register B = Register
;                  A if invalid.
;*****************************************************************
ASNTBI: MOV     A,L             ; Ascii rank
        SUI     30H             ; Rank 1 - 8
        CPI     1               ; Check lower bound
        JM      AT04            ; Jump if invalid
        CPI     9               ; Check upper bound
        JRNC    AT04            ; Jump if invalid
        INR     A               ; Rank 2 - 9
        MOV     D,A             ; Ready for multiplication
        MVI     E,10
        CALL    MLTPLY          ; Multiply
        MOV     A,H             ; Ascii file letter (a - h)
        SUI     40H             ; File 1 - 8
        CPI     1               ; Check lower bound
        JM      AT04            ; Jump if invalid
        CPI     9               ; Check upper bound
        JRNC    AT04            ; Jump if invalid
        ADD     D               ; File+Rank(20-90)=Board index
        MVI     B,0             ; Ok flag
        RET                     ; Return
AT04:   MOV     B,A             ; Invalid flag
        RET                     ; Return
```

```
;*****************************************************************
; VALIDATE MOVE SUBROUTINE
;*****************************************************************
; FUNCTION:    --  To check a players move for validity.
;
; CALLED BY:   --  PLYRMV
;
; CALLS:       --  GENMOV
;                  MOVE
;                  INCHK
;                  UNMOVE
;
; ARGUMENTS:   --  Returns flag in register A, Ø for valid
;                  and 1 for invalid move.
;*****************************************************************
VALMOV: LHLD    MLPTRJ          ; Save last move pointer
        PUSH    H               ; Save register
        LDA     KOLOR           ; Computers color
        XRI     80H             ;Toggle color
        STA     COLOR           ; Store
        LXI     H,PLYIX-2       ; Load move list index
        SHLD    MLPTRI
        LXI     H,MLIST+1024    ; Next available list pointer
        SHLD    MLNXT
        CALL    GENMOV          ; Generate opponents moves
        LXI     X,MLIST+1024    ; Index to start of moves
VA5:    LDA     MVEMSG          ; "From" position
        CMP     MLFRP(X)        ; Is it in list ?
        JRNZ    VA6             ; No - jump
        LDA     MVEMSG+1        ; "To" position
        CMP     MLTOP(X)        ; Is it in list ?
        JRZ     VA7             ; Yes - jump
VA6:    MOV     E,MLPTR(X)      ; Pointer to next list move
        MOV     D,MLPTR+1(X)
        XRA     A               ; At end of list ?
        CMP     D
        JRZ     VA10            ; Yes - jump
        PUSH    D               ; Move to X register
        POP     X
        JMPR    VA5             ; Jump
VA7:    SIXD    MLPTRJ          ; Save opponents move pointer
        CALL    MOVE            ; Make move on board array
        CALL    INCHK           ; Was it a legal move ?
        ANA     A
        JRNZ    VA9             ; No - jump
VA8:    POP     H               ; Restore saved register
        RET                     ; Return
VA9:    CALL    UNMOVE          ; Un-do move on board array
VA10:   MVI     A,1             ; Set flag for invalid move
        POP     H               ; Restore saved register
        SHLD    MLPTRJ          ; Save move pointer
        RET                     ; Return
```

```
;*************************************************************
; ACCEPT INPUT CHARATER
;*************************************************************
; FUNCTION:    --  Accepts a single character input from the
;                  console keyboard and places it in the A
;                  register.  The character is also echoed on
;                  the video screen, unless it is a carrage
;                  return, line feed, or backspace.
;                  Lower case alphabetic characters are folded
;                  to upper case.
;
; CALLED BY:   --  DRIVER
;                  INTERR
;                  PLYRMV
;                  ANALYS
;
; CALLS:       --  None
;
; ARGUMENTS:   --  Character input is output in register A.
;
; NOTES:       --  This routine contains a reference to a
;                  monitor function of the Jove monitor, there-
;                  for the first few lines of this routine are
;                  system dependent.
;*************************************************************
CHARTR: RST     7               ; Jove monitor single char inpt
        .BYTE   81H,0
        CPI     0DH             ; Carriage return ?
        RZ                      ; Yes - return
        CPI     0AH             ; Line feed ?
        RZ                      ; Yes - return
        CPI     08H             ; Backspace ?
        RZ                      ; Yes - return
        RST     7               ; Jove monitor single char echo
        .BYTE   81H,1AH
        ANI     7FH             ; Mask off parity bit
        CPI     7BH             ; Upper range check (z+1)
        RP                      ; No need to fold - return
        CPI     61H             ; Lower range check (a)
        RM                      ; No need to fold - return
        SUI     20H             ; Change to one of A-Z
        RET                     ; Return
```

```
;************************************************************
; NEW PAGE IF NEEDED
;************************************************************
; FUNCTION:    --  To clear move list output when the column
;                  has been filled.
;
; CALLED BY:   --  DRIVER
;                  PLYRMV
;                  CPTRMV
;
; CALLS:       --  DSPBRD
:
; ARGUMENTS:   --  Returns a 1 in the A register if
;                  a  new page was turned.
;************************************************************
PGIFND: LXI     H,LINECT        ; Addr of page position counter
        INR     M               ; Increment
        MVI     A,1BH           ; Page bottom ?
        CMP     M
        RNC                     ; No - return
        CALL    DSPBRD          ; Put up new page
        PRTLIN  TITLE4,15       ; Re-print titles
        PRTLIN  TITLE3,15
        MVI     A,1             ; Set line count back to 1
        STA     LINECT
        RET                     ; Return
```

```
;*************************************************************
; DISPLAY MATED KING
;*************************************************************
; FUNCTION:    --  To tip over the computers King when
;                  mated.
;
; CALLED BY:   --  FCDMAT
;
; CALLS:       --  CONVRT
;                  BLNKER
;                  INSPCE   (Abnormal Call to IP04)
;
; ARGUMENTS:   --  None
;*************************************************************
MATED:  LDA     KOLOR           ; Computers color
        ANA     A               ; Is computer white ?
        JRZ     .+9             ; Yes - skip
        MVI     C,2             ; Set black piece flag
        LDA     POSK+1          ; Position of black King
        JMPR    MA08            ; Jump
        MOV     C,A             ; Clear black piece flag
        LDA     POSK            ; Position of white King
MA08:   STA     BRDPOS          ; Store King position
        STA     ANBDPS          ; Again
        CALL    CONVRT          ; Getting norm address in HL
        MVI     A,7             ; Piece value of toppled King
        MVI     B,10            ; Blink parameter
        CALL    BLNKER          ; Blink King position
        LXI     Y,MA0C          ; Prepare for abnormal call
        PUSH    Y
        PUSH    H
        PUSH    B
        PUSH    D
        PUSH    X
        PUSH    PSW
        JMP     IP04            ; Call INSPCE
MA0C:   MVI     B,10            ; Blink again
        LDA     ANBDPS
        STA     BRDPOS
        CALL    BLNKER
        RET                     ; Return
```

```
;*************************************************************
; SET UP POSITION FOR ANALYSIS
;*************************************************************
; FUNCTION:    --  To enable user to set up any position
;                  for analysis, or to continue to play
;                  the game.  The routine blinks the board
;                  squares in turn and the user has the option
;                  of leaving the contents unchanged by a
;                  carriage return, emptying the square by a 0,
;                  or inputting a piece of his chosing.  To
;                  enter a piece, type in piece-code,color-code,
;                  moved-code.
;                  .
;                  Piece-code is a letter indicating the
;                  desired piece:
;                       K  -  King
;                       Q  -  Queen
;                       R  -  Rook
;                       B  -  Bishop
;                       N  -  Knight
;                       P  -  Pawn
;
;                  Color code is a letter, W for white, or
;                  B for black.
;
;                  Moved-code is a number. 0 indicates the piece
;                  has never moved.  1 indicates the piece has
;                  moved.
;
;                  A backspace will back up in the sequence of
;                  blinked squares.  An Escape will terminate
;                  the blink cycle and  verify that the
;                  position is correct, then procede with game
;                  initialization.
;
; CALLED BY:   --  DRIVER
;
; CALLS:       --  CHARTR
;                  DPSBRD
;                  BLNKER
;                  ROYALT
;                  PLYRMV
;                  CPTRMV
;
; MACRO CALLS:     PRTLIN
;                  EXIT
;                  CLRSCR
;                  PRTBLK
;                  CARRET
;
; ARGUMENTS:   --  None
;*************************************************************
```

```
ANALYS: PRTLIN  ANAMSG,37       ; "CARE TO ANALYSE A POSITION?"
        CALL    CHARTR          ; Accept answer
        CARRET                  ; New line
        CPI     4EH             ; Is answer a "N" ?
        JRNZ    AN04            ; No - jump
        EXIT                    ; Return to monitor
AN04:   CALL    DSPBRD          ; Current board position
        MVI     A,21            ; First board index
AN08:   STA     ANBDPS          ; Save
        STA     BRDPOS
        CALL    CONVRT          ; Norm address into HL register
        STA     M1              ; Set up board index
        LIXD    M1
        MOV     A,BOARD(X)      ; Get board contents
        CPI     0FFH            ; Boarder square ?
        JRZ     AN19            ; Yes - jump
        MVI     B,4H            ; Ready to blink square
        CALL    BLNKER          ; Blink
        CALL    CHARTR          ; Accept input
        CPI     1BH             ; Is it an escape ?
        JRZ     AN1B            ; Yes - jump
        CPI     08H             ; Is it a backspace ?
        JRZ     AN1A            ; Yes - jump
        CPI     0DH             ; Is it a carriage return ?
        JRZ     AN19            ; Yes - jump
        LXI     B,7             ; Number of types of pieces + 1
        LXI     H,PCS           ; Address of piece symbol table
        CCIR                    ; Search
        JRNZ    AN18            ; Jump if not found
        CALL    CHARTR          ; Accept and ignore separator
        CALL    CHARTR          ; Color of piece
        CPI     42H             ; Is it black ?
        JRNZ    .+4             ; No - skip
        SET     7,C             ; Black piece indicator
        CALL    CHARTR          ; Accept and ignore separator
        CALL    CHARTR          ; Moved flag
        CPI     31H             ; Has piece moved ?
        JRNZ    AN18            ; No - jump
        SET     3,C             ; Set moved indicator
AN18:   MOV     BOARD(X),C      ; Insert piece into board array
        CALL    DSPBRD          ; Update graphics board
AN19:   LDA     ANBDPS          ; Current board position
        INR     A               ; Next
        CPI     99              ; Done ?
        JRNZ    AN08            ; No - jump
        JMPR    AN04            ; Jump
AN1A:   LDA     ANBDPS          ; Prepare to go back a square
```

```
        SUI     3               ; To get around boarder
        CPI     20              ; Off the other end ?
        JNC     AN08            ; No - jump
        MVI     A,98            ; Wrap around to top of screen
AN0B:   JMP     AN08            ; Jump
AN1B:   PRTLIN  CRTNES,14       ; Ask if correct
        CALL    CHARTR          ; Accept answer
        CPI     4EH             ; Is it "N" ?
        JZ      AN04            ; No - jump
        CALL    ROYALT          ; Update positions of royalty
        CLRSCR                  ; Blank screen
        CALL    INTERR          ; Accept color choice
AN1C:   PRTLIN  WSMOVE,17       ; Ask whose move it is
        CALL    CHARTR          ; Accept response
        CALL    DSPBRD          ; Display graphics board
        PRTLIN  TITLE4,15       ; Put up titles
        PRTLIN  TITLE3,15
        CPI     57H             ; Is is whites move ?
        JZ      DRIV04          ; Yes - jump
        PRTBLK  MVENUM,3        ; Print move number
        PRTBLK  SPACE,6         ; Tab to blacks column
        LDA     KOLOR           ; Computer's color
        ANA     A               ; Is computer white ?
        JRNZ    AN20            ; No - jump
        CALL    PLYRMV          ; Get players move
        CARRET                  ; New line
        JMP     DR0C            ; Jump
AN20:   CALL    CPTRMV          ; Get computers move
        CARRET                  ; New line
        JMP     DR0C            ; Jump
```

```
;*************************************************************
; UPDATE POSITIONS OF ROYALTY
;*************************************************************
; FUNCTION:    --  To update the positions of the Kings
;                  and Queen after a change of board position
;                  in ANALYS.
;
; CALLED BY:   --  ANALYS
;
; CALLS:       --  None
;
; ARGUMENTS:   --  None
;*************************************************************
ROYALT: LXI     H,POSK          ; Start of Royalty array
        MVI     B,4             ; Clear all four positions
        MVI     M,0
        INX     H
        DJNZ    .-3
        MVI     A,21            ; First board position
RY04:   STA     M1              ; Set up board index
        LXI     H,POSK          ; Address of King position
        LIXD    M1
        MOV     A,BOARD(X)      ; Fetch board contents
        BIT     7,A             ; Test color bit
        JRZ     .+3             ; Jump if white
        INX     H               ; Offset for black
        ANI     7               ; Delete flags, leave piece
        CPI     KING            ; King ?
        JRZ     RY08            ; Yes - jump
        CPI     QUEEN           ; Queen ?
        JRNZ    RY0C            ; No - jump
        INX     H               ; Queen position
        INX     H               ; Plus offset
RY08:   LDA     M1              ; Index
        MOV     M,A             ; Save
RY0C:   LDA     M1              ; Current position
        INR     A               ; Next position
        CPI     99              ; Done.?
        JRNZ    RY04            ; No - jump
        RET                     ; Return
```

```
;*************************************************************
; SET UP EMPTY BOARD
;*************************************************************
; FUNCTION:    --  Diplay graphics board and pieces.
;
; CALLED BY:   --  DRIVER
;                  ANALYS
;                  PGIFND
;
; CALLS:       --  CONVRT
;                  INSPCE
;
; ARGUMENTS:   --  None
;
; NOTES:       --  This routine makes use of several fixed
;                  addresses in the video storage area of
;                  the Jupiter III computer, and is therefor
;                  system dependent.  Each such reference will
;                  be marked.
;*************************************************************
DSPBRD: PUSH    B               ; Save registers
        PUSH    D
        PUSH    H
        PUSH    PSW
        CLRSCR                  ; Blank screen
        LXI     H,0C000H        ; System Dependent-First video
                                ; address
        MVI     M,80H           ; Start of blank border
        LXI     D,0C001H        ; Sys Dep- Next boarder square
        LXI     B,15            ; Number of bytes to be moved
        LDIR                    ; Blank boarder bar
        MVI     M,0AAH          ; First black boarder box
        INR     L               ; Next block address
        MVI     B,6             ; Number to be moved
DB04:   MVI     M,80H           ; Create white block
        INR     L               ; Next block address
        DJNZ    DB04            ; Done ?  No - jump
        MVI     B,6             ; Number of repeats
DB08:   MVI     M,0BFH          ; Create black box
        INR     L               ; Next block address
        DJNZ    DB08            ; Done ?  No - jump
        XCHG                    ; Get ready for block move
        LXI     B,36            ; Bytes to be moved
        LDIR                    ; Move - completes first bar
        LXI     H,0C000H        ; S D - First addr to be copied
        LXI     B,0D0H          ; Number of blocks to move
        LDIR                    ; Completes first rank
        LXI     H,0C016H        ; S D - Start of copy area
        LXI     B,6             ; Number of blocks to move
```

```
        LDIR                    ; First black square done
        LXI     H,0C010H        ; S D - Start copy area
        LXI     B,42            ; Bytes to be moved
        LDIR                    ; Rest of bar done
        LXI     H,0C100H        ; S D - Start of copy area
        LXI     B,0C0H          ; Move three bars
        LDIR                    ; Next rank done
        LXI     H,0C000H        ; S D - Copy rest of screen
        LXI     B,600H          ; Number of blocks
        LDIR                    ; Board done
BSETUP: MVI     A,21            ; First board index
BSET04: STA     BRDPOS          ; Ready parameter
        CALL    CONVRT          ; Norm addr into HL regtisters
        CALL    INSPCE          ; Insert that piece onto board
        INR     A               ; Next square
        CPI     99              ; Done ?
        JRC     BSET04          ; No - jump
        POP     PSW             ; Restore registers
        POP     H
        POP     D
        POP     B
        RET
```

```
;*****************************************************************
; INSERT PIECE SUBROUTINE
;*****************************************************************
; FUNCTION:    --  This subroutine places a piece onto  a
;                  given square on the video board.  The piece
;                  inserted is that stored in the board array
;                  for that square.
;
; CALLED BY:   --  DPSPRD
;                  MATED
;
; CALLS:       --  MLTPLY
;
; ARGUMENTS:   --  Norm address for the square in register
;                  pair HL.
;*****************************************************************
INSPCE: PUSH    H                ; Save registers
        PUSH    B
        PUSH    D
        PUSH    X
        PUSH    PSW
        LDA     BRDPOS           ; Get board index
        STA     M1               ; Save
        LIXD    M1               ; Index into board array
        MOV     A,BOARD(X)       ; Contents of board array
        ANA     A                ; Is square empty ?
        JRZ     IP2C             ; Yes - jump
        CPI     0FFH             ; Is it a boarder square ?
        JRZ     IP2C             ; Yes - jump
        MVI     C,0              ; Clear flag register
        BIT     7,A              ; Is piece white ?
        JRZ     IP04             ; Yes - jump
        MVI     C,2              ; Set black piece flag
IP04:   ANI     7                ; Delete flags, leave piece
        DCR     A                ; Piece on a 0 - 5 basis
        MOV     E,A              ; Save
        MVI     D,16             ; Multiplier
        CALL    MLTPLY           ; For loc of piece in table
        MOV     A,D              ; Displacement into block table
        STA     INDXER           ; Low order index byte
        LIXD    INDXER           ; Get entire index
        BIT     0,M              ; Is square white ?
        JRZ     IP08             ; Yes - jump
        INR     C                ; Set compliment flag
IP08:   INR     L                ; Address of first alter block
        PUSH    H                ; Save
        MVI     D,0              ; Bar counter
IP0C:   MVI     B,4              ; Block counter
IP10:   MOV     A,BLOCK(X)       ; Bring in source block
        BIT     0,C              ; Should it be complemented ?
```

```
        JRZ     IP14            ; No - jump
        XRI     3FH             ; Graphics complement
IP14:   MOV     M,A             ; Store block
        INR     L               ; Next block
        INX     X               ; Next source block
        DJNZ    IP10            ; Done ?  No - jump
        MOV     A,L             ; Bar increment
        ADI     3CH
        MOV     L,A
        INR     D               ; Bar counter
        BIT     2,D             ; Done ?
        JRZ     IP0C            ; No - jump
        POP     H               ; Address of Norm + 1
        BIT     0,C             ; Is square white ?
        JRNZ    IP18            ; No - jump
        BIT     1,C             ; Is piece white ?
        JRNZ    IP2C            ; No - jump
        JMPR    IP1C            ; Jump
IP18:   BIT     1,C             ; Is piece white ?
        JRZ     IP2C            ; Yes - jump
IP1C:   MVI     D,6             ; Multiplier
        CALL    MLTPLY          ; Multiply for displacement
        MOV     A,D             ; Kernel table displacement
        STA     INDXER          ; Save
        LIXD    INDXER          ; Get complete index
        MOV     A,L             ; Start of Kernel
        ADI     40H
        MOV     L,A
        MVI     D,0             ; Bar counter
IP20:   MVI     B,3             ; Block counter
IP24:   MOV     A,KERNEL(X)     ; Kernel block
        BIT     1,C             ; Need to complement ?
        JRNZ    IP28            ; No - jump
        XRI     3FH             ; Graphics complement
IP28:   MOV     M,A             ; Store block
        INR     L               ; Next target block
        INX     X               ; Next source block
        DJNZ    IP24            ; Done ?  No - jump
        MOV     A,L             ; Bar increment
        ADI     3DH
        MOV     L,A
        INR     D               ; Bar counter
        BIT     1,D             ; Done ?
        JRZ     IP20            ; Repeat bar move
IP2C:   POP     PSW             ; Restore registers
        POP     X
        POP     D
        POP     B
        POP     H
        RET
```

```
;*************************************************************
; BOARD INDEX TO NORM ADDRESS SUBR.
;*************************************************************
; FUNCTION:    --  Converts a hexadecimal board index into
;                  a Norm address for the square.
;
; CALLED BY:   --  DSPBRD
;                  INSPCE
;                  ANALYS
;                  MATED
;
; CALLS:       --  DIVIDE
;                  MLTPLY
;
;ARGUMENTS:    --  Returns the Norm address in register pair
;                  HL.
;*************************************************************
CONVRT: PUSH    B               ; Save registers
        PUSH    D
        PUSH    PSW
        LDA     BRDPOS          ; Get board index
        MOV     D,A             ; Set up dividend
        SUB     A
        MVI     E,10            ; Divisor
        CALL    DIVIDE          ; Index into rank and file
                                ; file (1-8) & rank (2-9)
        DCR     D               ; For rank (1-8)
        DCR     A               ; For file (0-7)
        MOV     C,D             ; Save
        MVI     D,6             ; Multiplier
        MOV     E,A             ; File number is multiplicand
        CALL    MLTPLY          ; Giving file displacement
        MOV     A,D             ; Save
        ADI     10H             ; File norm address
        MOV     L,A             ; Low order address byte
        MVI     A,8             ; Rank adjust
        SUB     C               ; Rank displacement
        ADI     0C0H            ; Rank Norm address
        MOV     H,A             ; High order addres byte
        POP     PSW             ; Restore registers
        POP     D
        POP     B
        RET                     ; Return
```

```
;*****************************************************************
; POSITIVE INTEGER DIVISION
;*****************************************************************
DIVIDE: PUSH    B
        MVI     B,8
DD04:   SLAR    D
        RAL
        SUB     E
        JM      .+6
        INR     D
        JMPR    .+3
        ADD     E
        DJNZ    DD04
        POP     B
        RET


;*****************************************************************
; POSITIVE INTEGER MULTIPLICATION
;*****************************************************************
MLTPLY: PUSH    B
        SUB     A
        MVI     B,8
ML04:   BIT     0,D
        JRZ     .+3
        ADD     E
        SRAR    A
        RARR    D
        DJNZ    ML04
        POP     B
        RET
```

```
;*************************************************************
; SQUARE BLINKER
;*************************************************************
; FUNCTION:    --  To blink the graphics board square to signal
;                  a piece's intention to move, or to high-
;                  light the square as being alterable
;                  in ANALYS.
;
; CALLED BY:   --  MAKEMV
;                  ANALYS
;                  MATED
;
; CALLS:       --  None
;
; ARGUMENTS:   --  Norm address of desired square passed in
;                  register pair HL.  Number of times to
;                  blink passed in register B.
;*************************************************************
BLNKER: PUSH    PSW             ; Save registers
        PUSH    B
        PUSH    D
        PUSH    H
        PUSH    X
        SHLD    NORMAD          ; Save Norm address
BL04:   MVI     D,0             ; Bar counter
BL08:   MVI     C,0             ; Block counter
BL0C:   MOV     A,M             ; Fetch block
        XRI     3FH             ; Graphics complement
        MOV     M,A             ; Replace block
        INR     L               ; Next block address
        INR     C               ; Increment block counter
        MOV     A,C
        CPI     6               ; Done ?
        JRNZ    BL0C            ; No - jump
        MOV     A,L             ; Address
        ADI     3AH             ; Adjust square position
        MOV     L,A             ; Replace address
        INR     D               ; Increment bar counter
        BIT     2,D             ; Done ?
        JRZ     BL08            ; No - jump
        LHLD    NORMAD          ; Get Norm address
        PUSH    B               ; Save register
        LXI     B,3030H         ; Delay loop, for visibility
BL10:   DJNZ    BL10
        DCR     C
        JRNZ    BL10
```

```
POP     B               ; Restore register
DJNZ    BL04            ; Done ?  No - jump
POP     X               ; Restore registers
POP     H
POP     D
POP     B
POP     PSW
RET                     ; Return
```

```
;*************************************************************
; EXECUTE MOVE SUBROUTINE
;*************************************************************
; FUNCTION:    --  This routine is the control routine for
;                  MAKEMV.  It checks for double moves and
;                  sees that they are properly handled.  It
;                  sets flags in the B register for double
;                  moves:
;                        En Passant  -- Bit 0
;                        O-O         -- Bit 1
;                        O-O-O       -- Bit 2
;
; CALLED BY:   --  PLYRMV
;                  CPTRMV
;
; CALLS:       --  MAKEMV
;
; ARGUMENTS:   --  Flags set in the B register as described
;                  above.
;*************************************************************
EXECMV: PUSH    X               ; Save registers
        PUSH    PSW
        LIXD    MLPTRJ          ; Index into move list
        MOV     C,MLFRP(X)      ; Move list "from" position
        MOV     E,MLTOP(X)      ; Move list "to" position
        CALL    MAKEMV          ; Produce move
        MOV     D,MLFLG(X)      ; Move list flags
        MVI     B,0
        BIT     6,D             ; Double move ?
        JRZ     EX14            ; No - jump
        LXI     D,6             ; Move list entry width
        DADX    D               ; Increment MLPTRJ
        MOV     C,MLFRP(X)      ; Second "from" position
        MOV     E,MLTOP(X)      ; Second "to" position
        MOV     A,E             ; Get "to" position
        CMP     C               ; Same as "from" position ?
        JRNZ    EX04            ; No - jump
        INR     B               ; Set en passant flag
        JMPR    EX10            ; Jump
EX04:   CPI     1AH             ; White O-O ?
        JRNZ    EX08            ; No - jump
        SET     1,B             ; Set O-O flag
        JMPR    EX10            ; Jump
EX08:   CPI     60H             ; Black O-O ?
        JRNZ    EX0C            ; No - jump
        SET     1,B             ; Set O-O flag
        JMPR    EX10            ; Jump
EX0C:   SET     2,B             ; Set O-O-O flag
EX10:   CALL    MAKEMV          ; Make 2nd move on board
EX14:   POP     PSW             ; Restore registers
        POP     X
        RET                     ; Return
```

```
;*************************************************************
; MAKE MOVE SUBROUTINE
;*************************************************************
; FUNDTION:    --  Moves the piece on the board when a move
;                  is made.  It blinks both the "from" and
;                  "to" positions to give notice of the move.
;
; CALLED BY:   --  EXECMV
;
; CALLS:       --  CONVRT
;                  BLNKER
;                  INSPCE
;
; ARGUMENTS:   --  The "from" position is passed in register
;                  C, and the "to" position in register E.
;*************************************************************
MAKEMV: PUSH    PSW             ; Save register
        PUSH    B
        PUSH    D
        PUSH    H
        MOV     A,C             ; "From" position
        STA     BRDPOS          ; Set up parameter
        CALL    CONVRT          ; Getting Norm address in HL
        MVI     B,10            ; Blink parameter
        CALL    BLNKER          ; Blink "from" square
        MOV     A,M             ; Bring in Norm block
        INR     L               ; First change block
        MVI     D,0             ; Bar counter
MM04:   MVI     B,4             ; Block counter
MM08:   MOV     M,A             ; Insert blank block
        INR     L               ; Next change block
        DJNZ    MM08            ; Done ?  No - jump
        MOV     C,A             ; Saving norm block
        MOV     A,L             ; Bar increment
        ADI     3CH
        MOV     L,A
        MOV     A,C             ; Restore Norm block
        INR     D
        BIT     2,D             ; Done ?
        JRZ     MM04            ; No - jump
        MOV     A,E             ; Get "to" position
        STA     BRDPOS          ; Set up parameter
        CALL    CONVRT          ; Getting Norm address in HL
        MVI     B,10            ; Blink parameter
        CALL    INSPCE          ; Inserts the piece
        CALL    BLNKER          ; Blinks "to" square
        POP     H               ; Restore registers
        POP     D
        POP     B
        POP     PSW

        RET                     ; Return
```

TDL/ZILOG Mnemonics Conversion

Symbols Used

SYMBOL	OPERATION
r	one of the 8-bit registers A,B,C,D,E,H,L
n	any 8-bit absolute value
ii	an index register reference, either X or Y
d	an 8-bit index displacement, where -128< d< 127
zz	B for the BC register pair, D for the DE pair
nn	any 16-bit value, absolute or relocatable
rr	B for the BC register pair, D for the DE pair, H for the HL pair, SP for the stack pointer
qq	B for the BC register pair, D for the DE pair, H for the HL pair, PSW for the A/Flag pair
s	any of r (defined above), M, or d(ii)
IFF	interrupt flip-flop
CY	carry flip-flop
ZF	zero flag
tt	B for the BC register pair, D for the DE pair, SP for the stack pointer, X for index register IX
uu	B for the BC register pair, D for the DE pair, SP for the stack pointer, Y for index register IY
b	a bit position in an 8-bit byte, where the bits are numbered from right to left Ø to 7
PC	program counter
b{n}	bit n of the 8-bit value or register v
vv/H	the most significant byte of the 16-bit value or register vv
vv/L	the least significant byte of the 16-bit value or register vv

Iv	an input operation on port v
Ov	an output operation on port v
w ← v	the value of w is replaced by the value of v
w ↔ v	the value of w is exchanged with the value of v

8 Bit Load Group

TDL MNEMONIC	OPERATION	ZILOG MNEMONIC	# OF BYTES	# OF T STATES
MOV r,r'	r ← r'	LD r,r'	1	4
MOV r,M	r ← (HL)	LD r,(HL)	1	7
MOV r,d(ii)	r ← (ii+d)	LD r,(Iii+d)	3	19
MOV M,r	(HL) ← r	LD (HL),r	1	7
MOV d(ii),r	(ii+d) ← r	LD (Iii+d),r	3	19
MVI r,n	r ← n	LD r,n	2	7
MVI M,n	(HL) ← n	LD (HL),n	2	1Ø
MVI d(ii),n	(ii+d) ← n	LD (Iii+d),n	4	19
LDA nn	A ← (nn)	LD A,(nn)	3	13
STA nn	(nn) ← A	LD (nn),A	3	13
LDAX zz	A ← (zz)	LD A,(zz)	1	7
STAX zz	(zz) ← A	LD (zz),A	1	7
LDAI	A ← I	LD A,I	2	9
LDAR	A ← R	LD A,R	2	9
STAI	I ← A	LD I,A	2	9
STAR	R ← A	LD R,A	2	9

16 Bit Load Group

TDL MNEMONIC	OPERATION	ZILOG MNEMONIC	# OF BYTES	# OF T STATES
LXI rr,nn	rr ← nn	LD rr,nn	3	10
LXI ii,nn	ii ← nn	LD ii,nn	4	14
LBCD nn	B ← (nn+1) C ← (nn)	LD BC,(nn)	4	20
LDED nn	D ← (nn+1) E ← (nn)	LD DE,(nn)	4	20
LHLD nn	H ← (nn+1) L ← (nn)	LD HL,(nn)	3	16
LIXD nn	IX/H ← (nn+1) IX/L ← (nn)	LD IX,(nn)	4	20
LIYD nn	IY/H ← (nn+1) IY/L ← (nn)	LD IY,(nn)	4	20
LSPD nn	SP/H ← (nn+1) SP/L ← (nn)	LD SP,(nn)	4	20
SBCD nn	(nn+1) ← B (nn) ← C	LD (nn),BC	4	20
SDED nn	(nn+1) ← D (nn) ← E	LD (nn),DE	4	20
SHLD nn	(nn+1) ← H (nn) ← L	LD (nn),HL	3	16
SIXD nn	(nn+1) ← IX/H (nn) ← IX/L	LD (nn),IX	4	20
SIYD nn	(nn+1) ← IY/H (nn) ← IY/L	LD (nn),IY	4	20
SSPD nn	(nn+1) ← SP/H (nn) ← SP/L	LD (nn),SP	4	20
SPHL	SP ← HL	LD SP,HL	1	6
SPIX	SP ← IX	LD SP,IX	2	10
SPIY	SP ← IY	LD SP,IY	2	10

PUSH qq	(SP-1) ← qq/H (SP-2) ← qq/L SP ← SP-2	PUSH qq	1	11
PUSH ii	(SP-1) ← ii/H (SP-2) ← ii/L SP ← SP-2	PUSH ii	2	15
POP qq	qq/H ← (SP-1) qq/L ← (SP) SP ← SP-2	POP qq	1	1Ø
POP ii	ii/H ← (SP+1) ii/L ← (SP) SP ← SP+2	POP ii	2	14

Exchange, Block Transfer, and Search Group

TDL MNEMONIC	OPERATION	ZILOG MNEMONIC	# OF BYTES	# OF T STATES
XCHG	HL ↔DE	EX DE,HL	1	4
EXAF	PSW ↔PSW'	EX AF,AF'	1	4
EXX	BCDEHL ↔BCDEHL'	EXX	1	4
XTHL	H ↔(SP+1) L ↔(SP)	EX (SP),HL	1	19
XTIX	IX/H ↔(SP+1) IX/L ↔(SP)	EX (SP),IX	2	23
XTIY	IY/H ↔(SP+1) IY/L ↔(SP)	EX (SP),IY	2	23
LDI	(DE) ← (HL) DE ← DE+1 HL ← HL+1 BC ← BC-1	LDI	2	16
LDIR	repeat LDI until BC=Ø	LDIR	2	21/16
LDD	(DE) ← (HL) DE ← DE-1 HL ← HL-1 BC ← BC-1	LDD	2	16
LDDR	repeat LDD until BC=Ø	LDDR	2	21/16
CCI	A - (HL) HL ← HL+1 BC ← BC-1	CPI	2	16
CCIR	repeat CCI until A=(HL) or BC=Ø	CPIR	2	21/16
CCD	A - (HL) HL ← HL-1 BC ← BC-1	CPD	2	16
CCDR	repeat CCD until A=(HL) or BC=Ø	CPDR	2	21/16

8 Bit Arithmetic and Logical

TDL MNEMONIC	OPERATION	ZILOG MNEMONIC	# OF BYTES	# OF T STATES
ADD r	A ← A + r	ADD A,r	1	4
ADD M	A ← A + (HL)	ADD A,(HL)	1	7
ADD d(ii)	A ← A + (ii+d)	ADD A,(Iii+d)	3	19
ADI n	A ← A + n	ADD A,n	2	7
ADC s	A ← A + s + CY	ADC A,s	As shown for ADD instruction	
ACI n	A ← A + n + CY	ADC A,n		
SUB s	A ← A - s	SUB s		
SUI n	A ← A - n	SUB n		
SBB s	A ← A - s - CY	SBC A,s		
SBI n	A ← A - n - CY	SBC A,n		
ANA s	A ← A ∧ s	AND s		
ANI n	A ← A ∧ n	AND n		
ORA s	A ← A ∨ s	OR s		
ORI n	A ← A ∨ n	OR n		
XRA s	A ← A ⊕ s	XOR s		
XRI n	A ← A ⊕ n	XOR n		
CMP s	A - s	CP s		
CPI n	A - n	CP n		
INR r	r ← r + 1	INC r		
INR M	(HL) ← (HL) + 1	INC (HL)		
INR d(ii)	(ii+d) ← (ii+d) + 1	INC (Iii+d)		
DCR r	r ← r - 1	DEC r		
DCR M	(HL) ← (HL) - 1	DEC (HL)		
DCR d(ii)	(ii+d) ← (ii+d) - 1	DEC (Iii+d)		

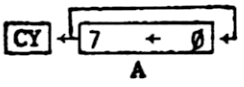
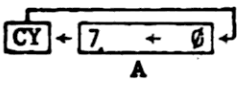
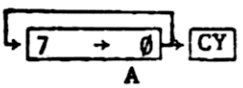
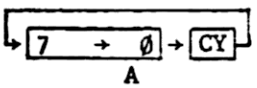
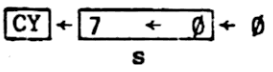
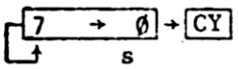
General Purpose Arithmetic and Control Group

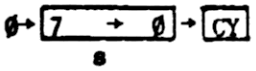
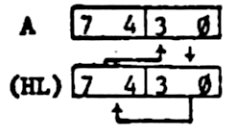
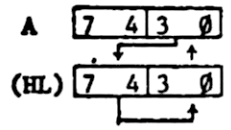
TDL MNEMONIC	OPERATION	ZILOG MNEMONIC	# OF BYTES	# OF T STATES
DAA	convert A to packed BCD after an add or subtract of packed BCD operands	DAA	1	4
CMA	A ← ∿A	CPL	1	4
NEG	A ← -A	NEG	2	8
CMC	CY ← ∿CY	CCF	1	4
STC	CY ← 1	SCF	1	4
NOP	no operation	NOP	1	4
HLT	halt	HALT	1	4
DI	IFF ← Ø	DI	1	4
EI	IFF ← 1	EI	1	4
IMØ	interrupt mode Ø	IM Ø	2	8
IM1	interrupt mode 1	IM 1	2	8
IM2	interrupt mode 2	IM 2	2	8

16 Bit Arithmetic Group

TDL MNEMONIC	OPERATION	ZILOG MNEMONIC	# OF BYTES	# OF T STATES
DAD rr	HL ← HL + rr	ADD HL,rr	1	11
DADC rr	HL ← HL + rr + CY	ADC HL,rr	2	15
DSBC rr	HL ← HL - rr - CY	SBC HL,rr	2	15
DADX tt	IX ← IX + tt	ADD IX,tt	2	15
DADY uu	IY ← IY + uu	ADD IY,uu	2	15
INX rr	rr ← rr + 1	INC rr	1	6
INX ii	ii ← ii + 1	INC ii	2	1Ø
DCX rr	rr ← rr - 1	DEC rr	1	6
DCX ii	ii ← ii - 1	DEC ii	2	1Ø

Rotate and Shift Group

TDL MNEMONIC	OPERATION	ZILOG MNEMONIC	# OF BYTES	# OF T STATES
RLC		RLCA	1	4
RAL		RLA	1	4
RRC		RRCA	1	4
RAR		RRA	1	4
RLCR r	Same diagram as for RLC	RLC r	2	8
RLCR M	"	RLC (HL)	2	15
RLCR d(ii)	"	RLC (Iii+d)	4	23
RALR s	Same diagram as for RAL	RL s	Same as for RLCR instruction	
RRCR s	Same diagram as for RRC	RRC s		
RARR s	Same diagram as for RAR	RR s		
SLAR s		SLA s		
SRAR s		SRA s		

SRLR s		2	18
RLD		2	18
RRD			

Bit Set, Reset, and Jump Group

TDL MNEMONIC.	OPERATION	8106 MNEMONIC	# OF BYTES	# OF T STATES
BIT b,r	ZF ← ∿r{b}	BIT b,r	2	8
BIT b,M	ZF ← ∿(HL){b}	BIT b,(HL)	2	12
BIT b,d(ii)	ZF ← ∿(Iii+d){b}	BIT b,(Iii+d)	4	20
SET b,r	r{b}← 1	SET b,r	2	8
SET b,m	(HL){b} ← 1	SET b,(HL)	2	15
SET b,d(ii)	(Iii+d){b} ← 1	SET b,(Iii+d)	4	23
RES b,s	S{b} ← Ø	RES b,s	Same as for SET instruction	

Jump Group

TDL MNEMONIC	OPERATION	ZILOG MNEMONIC	# OF BYTES	# OF T STATES
JMP nn	PC ← nn	JP nn	3	1Ø
JZ nn	if zero, then JMP else continue	JP Z,nn	3	1Ø
JNZ nn	if not zero	JP NZ,nn	3	1Ø
JC nn	if carry	JP C,nn	3	1Ø
JNC nn	if not carry	JP NC,nn	3	1Ø
JPO nn	if parity odd	JP PO,nn	3	1Ø
JPE nn	if parity even	JP PE,nn	3	1Ø
JP nn	if sign positive	JP P,nn	3	1Ø
JM nn	if sign negative	JP M,nn	3	1Ø
JO nn	if overflow	JP PE,nn	3	1Ø
JNO nn	if no overflow	JP PO,nn	3	1Ø
JMPR nn	PC ← PC + e where e = nn - PC -126< e< 129	JR e	2	12
JRZ nn	if zero, then JMPR else continue	JR Z,e	2	7/12
JRNZ nn	if not zero	JR NZ,e	2	7/12
JRC nn	if carry	JR C,e	2	7/12
JRNC nn	if not carry	JR NC,e	2	7/12
DJNZ nn	B ← B - 1 if B=Ø then continue else JMPR	DJNZ e	2	8/13
PCHL	PC ← HL	JP (HL)	1	4
PCIX	PC ← IX	JP (IX)	2	8
PCIY	PC ← IY	JP (IY)	2	8

Call and Return Group

TDL MNEMONIC	OPERATION	ZILOG MNEMONIC	# OF BYTES	# OF T STATES
CALL nn	(SP-1) ← PC/H (SP-2) ← PC/L SP ← SP-2 PC ← nn	CALL nn	3	17
CZ nn	if zero, then CALL else continue	CALL Z,nn	3	1Ø/17
CNZ nn	if not zero	CALL NZ,nn	3	1Ø/17
CC nn	if carry	CALL C,nn	3	1Ø/17
CNC nn	if not carry	CALL NC,nn	3	1Ø/17
CPO nn	if parity odd	CALL PO,nn	3	1Ø/17
CPE nn	if parity even	CALL PE,nn	3	1Ø/17
CP nn	if sign positive	CALL P,nn	3	1Ø/17
CM nn	if sign negative	CALL M,nn	3	1Ø/17
CO nn	if overflow	CALL PE,nn	3	1Ø/17
CNO nn	if no overflow	CALL PO,nn	3	1Ø/17
RET	PC/H ← (SP+1) PC/L ← (SP) SP ← SP+2	RET	1	1Ø
RZ	if zero, then RET else continue	RET Z	1	5/11
RNZ	if not zero	RET NZ	1	5/11
RC	if carry	RET C	1	5/11
RNC	if not carry	RET NC	1	5/11
RPO	if parity odd	RET PO	1	5/11
RPE	if parity even	RET PE	1	5/11
RP	if sign positive	RET P	1	5/11
RM	if sign negative	RET M	1	5/11

RO	if overflow	RET PE	1	5/11
RNO	if no overflow	RET PO	1	5/11
RETI	return from interrupt	RETI	2	14
RETN	return from non-maskable interrupt	RETN	2	14
RST n	(SP-1) ← PC/H (SP-2) ← PC/L PC ← 8 * n where 0≤ n< 8	RST n	1	11

Input and Output Group

TDL MNEMONIC	OPERATION	ZILOG MNEMONIC	# OF BYTES	# OF T STATES
IN n	A ← In	IN A,(n)	2	11
INP r	r ← I(C)	IN r,(C)	2	12
INI	(HL) ← I(C) B ← B - 1 HL ← HL + 1	INI	2	16
INIR	repeat INI until B=Ø	INIR	2	16/21
IND	(HL) ← I(C) B ← B - 1 HL ← HL - 1	IND	2	16
INDR	repeat IND until B=Ø	INDR	2	16/21
OUT n	On ← A	OUT (n),A	2	11
OUTP r	O(C) ← r	OUT (C),r	2	12
OUTI	O(C) ← (HL) B ← B - 1 HL ← HL + 1	OUTI	2	16
OUTIR	repeat OUTI until B=Ø	OTIR	2	16/21
OUTD	O(C) ← (HL) B ← B - 1 HL ← HL - 1	OUTD	2	16
OUTDR	repeat OUTD until B=Ø	OTDR	2	16/21

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