MICROCHESS

A CHESS PLAYING PROGRAM

FOR THE 6502 MICROCOMPUTER

BY PETER JENNINGS

MICROCHESS

MICROCHESS was originally conceived as a program which would play chess using only a minimum hobbyist microcomputer system. The program designed will run on a KIM-1, 6502 based system, using only 1.1 Kbytes of RAM. Elimination of some unnecessary features would even allow an implementation in less than 1K.

Although MICROCHESS does not play an expert level of chess, it will play a reasonable game in most instances. In addition, it can provide a useful opponent for practising checkmates, learning openings, and sharpening general playing skills.

The program has been carefully designed to allow the average user to expand or modify the basic package to suit the requirements of his particular system configuration, or to experiment with his own ideas for improvement of the playing strategy.

User documentation supplied with the MICROCHESS program consists of a Player's Manual, a complete source program listing, and a Programmer's Manual, which explains the operation of the program and includes suggestions for expansion and modifications.

PETER JENNINGS,
MICROCHESS,
1612-43 THORNCLIFFE PK., DR.,
TORONTO, ONTARIO,
M4H 1J4, CANADA.

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MICROCHESS

PLAYER'S MANUAL

MICROCHESS was designed to play a game of chess using the KIM-1 microcomputer system with no additional memory or peripherals. The human player's moves are entered on the self contained keyboard and the computer's responses are flashed on the LED display. Slight program alterations will permit the user to run the program using a teletype, CRT terminal, or another 6502 based system, (see the Programmer's Manual for details). All references in this manual assume that the KIM keyboard and display are being used.

LOADING THE PROGRAMS

Since the KIM-1 memory is divided into two non-contiguous segments, the program must be loaded in two sections. The first section will contain the program and data for the lower 1K of available memory between addresses 0000 and 03FF. The second section will contain the program segment between locations 1780 and 17E6. In addition, short program loaders may be used to enter the data necessary to use different "canned openings", which are stored between 00C0 and 00DB. Since sections of program reside in page one, which is normally reserved for the program stack, it is advisable to reset the stack pointer using the [RS] key before each load. In addition, it is prudent to check locations 0100 and 0101 before executing the program to ensure that they have not been inadvertently altered.

MICROCHESS NOTATION

In order to keep memory requirements to a minimum, (an absolute necessity when programming chess in the 1K environment of the KIM-1), it has been necessary to use a special octal chess notation. Each square on the chess board is uniquely identified by a two digit octal number as shown below. The first digit specifies the rank (0 to 7) from the computer's end of the board. The second digit specifies the file (0 to 7) from the player's left. Moves are specified uniquely by the FROM square and the TO square using this notation.

COMPUTER

00	01	02	03	04	05	06	07
10	11	12	13	14	15	16	17
20	21	22	23	24	25	26	27
30	31	32	33	34	35	36	37
40	41	42	43	44	45	46	47
50	51	52	53	54	55	56	57
60	61	62	63	64	65	66	67
70	71	72	73	74	75	76	77

PLAYER

MICROCHESS COMMAND KEYS

The following keys are used as commands while playing chess with the MICROCHESS program.

[GO] This key is depressed immediately after loading the tape in order to start the program execution, or to restart the program after a temporary exit. No change occurs in the display after the [GO] key has been depressed. After execution begins the key has no effect on the system at all.

[ST] This key is used to leave the MICROCHESS program and enter the KIM monitor in order to examine or change memory contents while playing a game. Under no circumstances should this key be pressed when the computer is contemplating its move. Only when the system is displaying a move is it permissable to press the [ST] key.

[C] This key CLEARS the internal chessboard and resets it to begin another game. The board is set up with the computer playing white. CCCCCC is displayed to indicate that the board has been reset.

[E] This key EXCHANGES the computer's men with your men. The actual position of the board is unchanged. If [C] is pressed, followed immediately by [E], the board will be set up to begin a game with the computer playing black. By pressing [PC] followed by [E] followed by [PC] . . . the computer will play a game against itself, displaying the moves as it goes. EEEEEE is displayed immediately after the [E] key is pressed to verify operation.

[F] This key is used to move the piece on the FROM square to the TO square to register the player's move, or to move one of the computer's men if desired.

[PC] This key instructs the computer to PLAY CHESS. The computer analyses the current position and formulates its optimum move. The display will darken and flash until the move has been decided. When it relights the move is displayed.

THE COMPUTER'S MOVE

The computer moves are displayed in the format shown below:

[piece¦FROM square¦TO square]

[piece¦ The piece which the computer is indicating that it wishes to move is encoded according to the table below:

0 - KING	4 - King Bishop	8 - K R Pawn	C - K B Pawn
1 - Queen	5 - Queen Bishop	9 - Q R Pawn	D - Q B Pawn
2 - King Rook	6 - King Knight	A - K N Pawn	E - Q Pawn
3 - Queen Rook	7 - Queen Knight	B - Q N Pawn	F - K Pawn

¦FROM square¦ The FROM and TO squares are indicated using the micronotation shown above.

For example the display [OF 13 33] indicates that the King Pawn is to be moved from King Pawn 2 to King Pawn 4. (This assumes that the computer is playing white.)

ENTERING YOUR MOVE

Your moves are described to the computer using the same octal notation described above. It is not necessary to enter the type of piece being moved, just the FROM square and TO square locations.

The computer verifies the input by indicating in the left two digits the piece located on the FROM square. The first digit will be 0,1, or F. 0 indicates that the piece on the from square is one of the computer's men. 1 indicates that the piece is one of your men. F indicates that there is no piece on the FROM square.

The second digit indicates the type of piece located on the FROM square using the same hexadecimal code shown above.

If you have made an error in entering your move at this point just continue to press the appropriate keys. The numbers will scroll from right to left until the correct move is displayed.

For example, if you punch 6 3 4 3 and see the display [1F 63 43], the 1F indicates that the FROM square (63), contains the King Pawn and that you are preparing to move it to the square 43.

When you have entered and verified the move, depress the [F] key to register the move on the internal chess board. The first two digits of the display will be changed to FF to indicate that the FROM square is now unoccupied. If the TO square had been occupied, the previous occupant will have been captured automatically.

You may make as many moves in this manner as you wish, moving either your own men or the computer's. No verification of the legality of the moves is carried out. Illegal moves are accepted and executed as easily as legal moves, so care should be taken that you do not accidentally move in an illegal manner. Since the computer does not make a point of warning you if your king is in check, you must be careful not to leave this situation after your move. The computer will usually take off your king on its subsequent move if this is possible.

SPECIAL MOVES

CASTLING: You may make a castling move by making two moves in succession in the normal manner. First move the king to its new square, then move the rook. Remember to depress [F] after each move. The computer has no provision for castling during the middle game or end game, but may castle during the opening. If this occurs it will indicate a move of the king two squares over. You must complete the move for the computer by moving the rook for it. Just enter the appropriate TO and FROM square followed by [F] to make the move, then, go ahead and make your own move.

EN PASSANT: In order to capture en passant you must break the move into two separate components. First, move your pawn laterally to capture the computer's pawn. Then, move your pawn forward to its appropriate final square. Do not forget to depress [F] after each move to register it internally. Note that the computer cannot capture en passant itself and will not recognize the danger of your en passant captures in considering its double pawn moves.

QUEENING PAWNS: If you should succeed in pushing a pawn to the eighth rank (rank 7 in micronotation), it will be necessary for you to manually set up the queen on that square. Because of the internal representation of the position it is possible only to have one Queen per side at a time. Therefore, if you already have one, you will have to choose a rook, bishop, or knight instead. To replace the pawn with a Queen the following steps should be carried out.

1) Use the [ST] key to exit from the MICROCHESS program and return control to the KIM monitor.

2) Find the pawn using the table of piece locations below. Confirm by its position that it is the correct one. Remove it from the board by entering the data 'CC', which indicates a captured piece.

3) Enter the address of the queen (0061). This memory location should now contain 'CC', assuming the queen has been lost.

4) Press [DA] and enter the new location for the Queen, which is the square the pawn moved to. (e.g. 07)

5) Press [PC] followed by [GO] to reenter the MICROCHESS program. Continue in the normal manner from this point.

If the computer should push a pawn to the eighth rank, it will be necessary for you to replace the pawn with a Queen, or the highest piece available. Use the same procedure as above. The computer's Queen should be stored at address 0051.

LEVEL OF PLAY

There are several sections of the program which can be bypassed in order to reduce the computer's response time in a given situation. This will reduce the quality of play accordingly. The strategy levels and data changes are outlined below.

LEVEL	LOCATION 02F2	LOCATION 018B	AVGE TIME PER MOVE
SUPER BLITZ	00	FF	3 seconds
BLITZ	00	FB	10 seconds
NORMAL	08	FB	100 second

POSITION VERIFICATION

Occassionally, while playing a game, you will come to the sudden realization that the computer is seeing a different board setup from the one you have. This results from your misinterpretation of one of its moves, from entering one of your moves incorrectly, or from forgetting to press [F] to register your move.

It is possible in this situation to sneak a peek at the location of each piece as it is internally stored in order to verify its location on the board. To do this press [ST] to exit the MICROCHESS program and enter the KIM monitor. Then look at the addresses shown below to determine where the computer thinks each piece is. Afterwards, return to the chess program by pressing [PC] followed by [GO].

MEMORY LOCATIONS FOR THE PIECES

COMPUTER PIECES		YOUR PIECES
0050	King	0060
0051	Queen	0061
0052	King Rook	0062
0053	Queen Rook	0063
0054	King Bishop	0064
0055	Queen Bishop	0065
0056	King Knight	0066
0057	Queen Knight	0067
0058	K R Pawn	0068
0059	Q R Pawn	0069
006A	K N Pawn	006A
005B	Q N Pawn	006B
005C	K B Pawn	006C
005D	Q B Pawn	006D
005E	Q Pawn	005E
005F	K Pawn	006F

IMPORTANT NOTE:
Never depress the [ST] key while the computer is contemplating its move. Important parameters are stored in the same area of memory used by the KIM monitor programs. Reentry after these locations have been altered will probably destroy the board position.

NOTES

As mentioned above, there are three types of moves which the current version of MICROCHESS does not play. These are castling, en passant pawn captures, and queening of pawns. In order to make the game fair some players adopt one of the two following strategies. Recognizing that the computer cannot make these moves, some players choose not to make them themselves, thus both players suffer the same restrictions. On the other hand, other players have decided to help the computer by watching for appropriate castling or en passant situations and making the moves on the computer's behalf at that time. Of course, you may always play without regard to the computer's disadvantage, allowing it to fend for itself as best it can.

If you are an above average player, you may find that the MICROCHESS program is below your level of play and hence, always loses. You can add to the challenge of the game in the same way that you might against an inexperienced human player. Remove one or more of your pieces at the start of the game and see if you can come back from a position of disadvantage. The easiest way to remove a piece is to move one of the computer's men to the square of the piece you wish to remove, and then move it back to its original square.

MICROCHESS

PROGRAMMER'S MANUAL

The program can be divided into three basic functional units.

I — Control and Input/Output. This section comprises the initialization routines, the input and output routines, and the main entry into the move generation and evaluation routines.

II — Move Generation and Data Collection. This program group generates the moves available to the computer, one at a time. For each of these moves, data are collected regarding available continuation moves, the threats of possible reply moves, and the gain or loss from subsequent piece exchanges.

III — Strategic Analysis. The data collected by the move generation routines are analysed by a mathematical algorithm which assigns a value to each available move. The move with the highest assigned value will be the move that the computer selects.

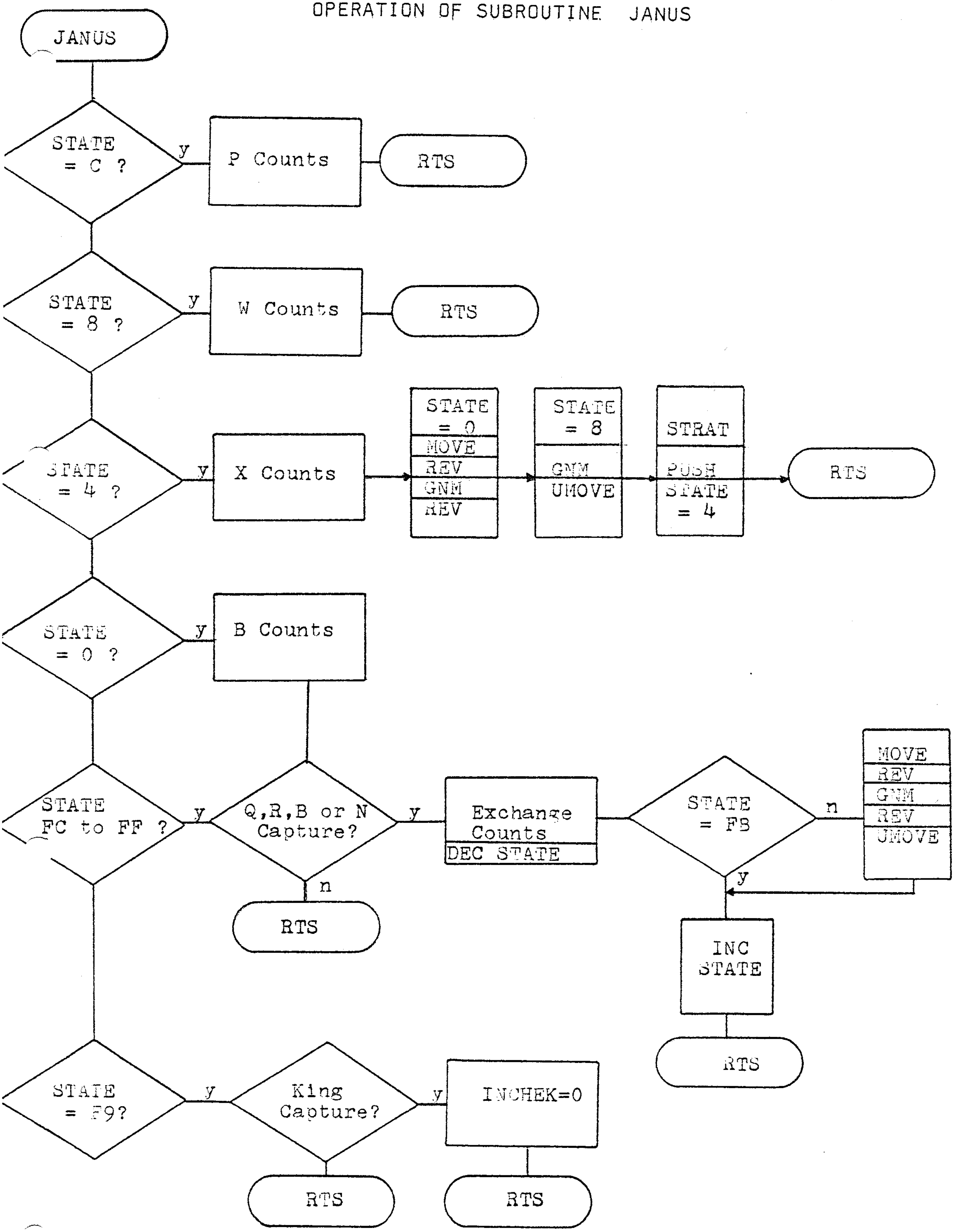
SOURCE LISTING

A complete listing of the program is included in source form. The average programmer should be able to use this document as a key to understanding the program's operation, and as a basis for further modifications. The complete cross reference table is included to assist in program relocation. As a convention in the listing, variables are preceded by a period to distinguish them from program labels, and external subroutines are preceded by an asterisk. Comment lines are preceded by a semicolon.

SUBROUTINES GNM AND JANUS

The key to the operation of the MICROCHESS program lies in the two subroutines GNM and JANUS. GNM calculates the available moves for one side with three nested loops: NEWP, which loops through the pieces from the pawns to the king; NEX, which loops through the four to eight directions through which each piece can move using the table MOVEX as pointed to by the move direction pointer MOVEN; and the individual loops for each piece which select the appropriate directions and distances to move.

OPERATION OF SUBROUTINE JANUS



After each move has been calculated by GNM, the subroutine JANUS is called. JANUS uses the value of STATE to determine which portion of the analysis the computer is working on and directs it to the appropriate continuation routines. As can be seen from the simplified flow chart of JANUS' operation, JANUS often alters the value of STATE and calls the subroutine GNM again. This series of recursive subroutine calls calculates approximately 20,000 moves per second-- over 2 million moves in a 100 second analysis. Most of these moves are repetitions generated from a slightly different board position.

PROGRAM FUNCTION FOR EACH VALUE OF .STATE

STATE	SET BY	FUNCTION
C	GO	Generate all available moves from the current position and analyse as a benchmark with which to compare the real moves, which are generated by STATE 4.
4	GO	Generate all available moves, evaluating each one and assigning a value to it as a possible selection.
8	JANUS	Having made one trial move, generate the possible second moves for analysis.
0	JANUS	Having made one trial move, generate the possible replies for analysis.
FF	JANUS	Since a reply move was a capture, reverse the board and evaluate the exchange that could result.
FE	JANUS	Stage two of the exchange evaluation started by STATE FF.
FD	JANUS	Stage three of the exchange evaluation.
FC	JANUS	Last stage of the exchange evaluation.
F9	CHKCHK	Look for a capture of the king which signifies that the move being calculated is illegal.

STRATEGY OPERATION

After each real available move is generated and the various counts have been performed, the following information is available for decision making purposes.

MOB Mobility. The total number of moves available for a given side from a given position. Each queen move is counted as two moves.

MAXC Maximum Capture. The number of points to be gained by capturing the most valuable piece currently under attack.

CC Capture Count. The total points of all opposing pieces under attack.

MAXP Maximum Capturable Piece. Identification of the opponent's piece under attack which is worth the most points.

PRIOR COUNTS (.PMOB, .PMAXC, .PCC, .PMAXP) reflect the status of the position as it exists for the computer before any move is made. This is a benchmark, against which further moves are to be compared.

CONTINUATION COUNTS (.WMOB, .WMAXC, .WCC, .WMAXP) are obtained for each move tested to determine the potential of the new position that would result if the move were made.

REPLY COUNTS (.BMOB, .BMAXC, .BCC, .BMAXP) are obtained for each move tested to determine the potential danger of the opponent's available replies.

EXCHANGE COUNTS (.WCAP0, .WCAP1, .WCAP2, .BCAP0, .BCAP1, .BCAP2) are used to analyse the effect of the potential exchange combinations. Each count reflects the maximum number of points capturable at each level of an exchange combination. Capture chains are halted by pawn captures, king captures, or by reaching a limit of three captures per side.

In addition, information regarding the moving piece and its TO and FROM squares can also be used by the STRATGY algorithm.

All information available is combined by the algorithm in the subprogram STRATGY to calculate a single strategic value for the move under analysis. The algorithm, a weighted sum of the count information, is shown below:

```
VALUE =  + 4.00 * WCAP0
         + 1.25 * WCAP1
         + 0.75 * (WMAXC + WCC)
         + 0.25 * (WMOB  + WCAP2)
         - 2.50 * BMAXC
         - 2.00 * BCC
         - 1.25 * BCAP1
         - 0.50 * BMAXC
         - 0.25 * (PMAXC + PCC + PMOB + BCAP0 + BCAP2 + BMOB)
```

VALUE = VALUE + 02, A position bonus if the move is to the centre or out of the back rank.

VALUE = 00, If the move is illegal because the king is in check.

VALUE = FF, If the move results in a checkmate.

The move with the highest value is selected by the computer as the best move available. This algorithm can easily be modified by changing the weights assigned to the various parameters. For example, the program can be made to play more aggressively by increasing the importance of BMAXC and WCAPO in the equation above. On the other hand, it can be made to play more defensively by increasing the importance of BMAXC in the equation.

Note that the algorithm above has not yet been optimized. Therefore, it may be possible to significantly improve the play of the program by empirical testing to optimize the form and weights used for the equation.

An alternative form of algorithm to the weighted average type above, which also works well, assigns a fixed number of points to the occurrence of certain conditions. For example, the condition WMOB > PMOB may be considered to be worth 3 points regardless of the difference in value between the two variables. Similarly, conditions which are unfavourable would be assigned negative points. This type of strategy can be easily implemented by keeping a running total of the value in the accumulator and using CPX and CPY instructions to control branches around the adddition and subtraction routines. In general, more memory is required to implement an equally complex strategy using this type of algorithm, but in the long run this strategy will be more flexible.

OPENING PLAY

The MICROCHESS program is designed in such a way that the opening can be played from memory, following established lines of play for up to nine moves per side. In order to conserve memory, only one opening is actually stored in the computer at a given time. The opening is stored in locations 00C0 through 00DB. By storing each of the openings provided on cassette tape with a different ID for each, it is possible to load the desired opening before beginning play. More openings can be added to the repertoire by coding them in the format shown below.

Users with expanded memory can set up all the openings in a set of tables, allowing the program to select the appropriate opening as long as its opponent is following a standard procedure.

The ability to load an opening by name and play it with the computer also provides an excellent method of rehearsing openings for a chessplayer who is attempting to memorize the standard plays.

Each move and expected reply is stored in 3 bytes. The program first checks that the expected reply TO square is the same as the one in the stored opening. If it matches, the piece and the TO square for the computer's move are loaded into the display and moved. For example, the following illustrates the GIUOCO PIANO Opening. The computer is playing white.

Address	Data	Move
00DB	CC	Expected display when computer is making its first move.
00DA	0F	King pawn.
00D9	33	To KP4.
00D8	43	Expected reply P-KP4.
00D7	06	Knight.
00D6	22	To KB3.
00D5	52	Expected reply: N-QB3.
00D4	04	Bishop.

The last line of the opening sequence must be 99, or any impossible position square, to cause the program to leave the opening routine and enter the normal strategy evaluation routines.

MODIFYING THE INPUT AND OUTPUT ROUTINES

In order to use the MICROCHESS program on 6502 microprocessor systems other than the KIM-1, the only modifications necessary are changes to the input and output subroutine calls. These subroutines appear in the program listing as *OUT and *GETKEY at locations 0008, 000B, and 039F.

*OUT is a subroutine in the KIM ROM at location 1F1F which displays, in hexadecimal format, the contents of memory locations 00FB, 00FA, and 00F9 on the 6 digit LED display. 00FB contains the coded piece identification and locations 00FA and 00F9 contain the FROM and TO squares respectively. These three locations are also used to display CCCCCC and EEEEEE as verification of the keyboard input. At address 039F, *OUT is called by CKMATE at the end of the move analysis to flash the display. This call is not necessary for operation of the program and may be eliminated by replacing the JMP instruction at that location with an RTS (60). The MICROCHESS program has been designed so that neither the X and Y registers, nor the accumulator contents need be preserved by a replacement output subroutine.

*GETKEY is a KIM subroutine which returns the value of the depressed key in the accumulator. Hexadecimal values are returned right justified (e.g. 0A). The only non-hex key used is [PC] which returns the value 14. This key is used only once, at location 0033, so is easy to replace with any other value. Once again, the X and Y registers need not be preserved by a replacement input subroutine.

EXPANDED INPUT AND OUTPUT ROUTINES

Users with CRT or teletype terminals and additional memory will probably want to customize the input and output features of the program.

A format which can be used for move entry and move display is shown by the example: N(KN1) - KB3. This format completely expresses the move, and also provides a check value in the piece descriptor. Translation from this notation to the internal octal FROM and TO square notation is easily accomplished with a simple table lookup program which contains the file descriptors and subtracts 01 from the rank value.

The board can be displayed by providing a routine which prints a layout such as the one illustrated below. Before printing each square, the program could search the piece tables to determine if the square is occupied, and by which piece. The table descriptor is then obtained from the same tables used by the I/O routines above. Users with graphic terminals will want to set up even more elaborate board display routines.

```
 ---------------------------------------------------------------
|       |       |       |       |       |       |       |       |
|  WR   |  WN   |  WB   |  WK   |  WQ   |  WB   |       |  WR   |
|_______|_______|_______|_______|_______|_______|_______|_______|
|       |       |       |       |       |       |       |       |
|  WP   |  WP   |  WP   |       |  WP   |  WP   |  WP   |  WP   |
|_______|_______|_______|_______|_______|_______|_______|_______|
|       |       |       |       |       |       |       |       |
|       |  **   |       |  **   |       |  WN   |       |  **   |
|_______|_______|_______|_______|_______|_______|_______|_______|
|       |       |       |       |       |       |       |       |
```

SPECIAL MOVES

Several types of moves are not included in the basic MICROCHESS program in order reduce the memory requirements. These moves, castling, en passant capture, and queening of pawns, can be added by expanding and modifying some of the subroutines which generate and execute moves. GNM must be modified to spot the occurrence of situations in which the moves are available. The actual move calculations must be added to CMOVE, and a flag to indicate the nature of the move set to allow MOVE and UMOVE to properly interpret them. The flag could use the two spare bits in .SQUARE. Additional parameters would be required to indicate when castling, or en passant moves are legal during the game, because these moves depend upon previous play for their legality. Expansion of the piece and point tables would allow the program to keep track of more than one queen per side.

STRATEGY IMPROVEMENTS

As you will soon discover when playing against the MICROCHESS program, it has a tendency to make ridiculous moves from time to time. These moves usually result from unusual positions, which point out deficiencies in the way the move value is calculated. A major problem in the analysis is that there is only one strategy which is used for the opening, the middle game, and the end game. This involves a considerable compromise of three different types of play. Users with memory expansion may wish to write three algorithms which can be switched in and out of the analysis at various points during the game.

Similarly, allowing more than 1K of memory enables the user to add more specialized evaluation routines. For example, a separate subroutine could be used to evaluate each of the following situations from both an offensive and defensive viewpoint, enabling a much more sophisticated level of play: 1- King in check. A major flaw in the current program causes the computer to minimize attacks by placing the opponent's king in check, even at the expense of a minor piece- a very short term solution to the problem! 2- En prise capture availability for either side. 3- Pawn development value: isolated pawns, passed pawns, doubled pawns, etc. 4- Xray analysis: the value of pins, discovered attack threats, etc. 5- Mating strategies: each of the major types of mates. 6- Positional development: utilization of open files, control of the centre, king position, pawn chains, etc.

With the exception of the capture tree, the MICROCHESS program analyses in full only one move for each side beyond the move it will make. It is possible to use the same recursive technique used by TREE to carry out a full analysis to a further depth. To do this would require a routine to analyse and evaluate each intermediate position arrived at. Sequences of possible positions with positive values for computer moves and negative values for opponent's moves can be summed to give the total long term value of each currently available move. In order to be time efficient, this analysis can be performed on a subset of the available continuations selected by a quick static analysis. In addition, a system of 'tree pruning' should be implemented to prevent long excursions down low valued branches. Programmers embarking on this type of program should bear in mind that from an average position with 50 available moves per side, a total of 15.625 billion sequences are generated in three moves per side.

As can be seen, MICROCHESS is only the beginning. However, it does demonstrate the capability of a small scale hobbyist microcomputer system to tackle the game of chess. It is hoped that this program will provide an inspiration and a stepping stone that chess playing programmers will expand and build upon. Let us know what you have done to improve the system. We will attempt to publish or distribute some of your ideas. It is hoped that a tournament of chess playing microcomputers can be arranged at a future microcomputer gathering. Expanded and modified versions of MICROCHESS will then have the opportunity to prove their playing ability against other programs in the same memory utilization class.

DATA FOR OPENINGS

The data below enables the computer to play the opening specified from memory. The data is in a block from 00C0 to 00DB. W specifies that the computer will play white, B specifies that the computer is black.

ADDR	W	FRENCH DEFENCE	B	W	GIUOCO PIANO	B	W	RUY LOPEZ	B	W	QUEEN'S INDIAN	B	W	FOUR KNIGHTS	B
DB	CC		44	CC		44	CC		44	CC		43	CC		44
DA	0F	P-K4	0F	0F	P-K4	0F	0F	P-K4	0F	0E	P-Q4	06	0F	P-K4	0F
D9	33	P-K3	24	33	P-K4	34	33	P-K4	34	34	N-KB3	25	33	P-K4	34
D8	53		43	43		55	43		55	52		42	43		55
D7	0E	P-Q4	0E	06	N-KB3	07	06	N-KB3	07	0D	P-QB4	0F	06	N-KB3	07
D6	34	P-Q4	33	22	N-QB3	22	22	N-QB3	22	35	P-K3	24	22	N-QB3	22
D5	44		52	55		42	55		31	53		55	55		52
D4	07	N-QB3	06	04	B-B4	04	04	B-N5	06	06	N-KB3	0B	07	N-B3	06
D3	25	N-KB3	25	35	B-B4	32	46	N-B3	25	22	P-QN3	21	25	N-B3	25
D2	52		36	45		52	52		75	56		56	52		31
D1	05	B-N5	04	0D	P-B3	06	00	O-O	06	0A	P-KN3	05	04	B-N5	04
D0	41	B-K2	14	25	N-B3	25	01	NxP	44	21	B-N2	11	46	B-N5	41
CF	63		34	52		43	33		43	66		66	36		75
CE	0F	P-K5	06	0E	P-Q4	0F	0E	P-Q4	04	04	B-N2	04	00	O-O	00
CD	43	KN-Q2	13	34	PxP	43	34	B-K2	14	11	B-K2	14	01	O-O	06
CC	64		14	34		43	63		64	63		75	72		53
CB	05	BxB	01	0D	PxP	04	01	Q-K2	06	00	O-O	00	0E	P-Q3	0E
CA	63	QxB	14	34	B-N5	41	13	N-Q3	23	01	O-O	06	24	P-Q3	23
C9	63		63	36		52	54		22	72		52	54		36
C8	01	Q-Q2	00	07	N-B3	06	04	BxN	0B	07	N-B3	06	05	B-N5	04
C7	14	O-O	06	25	NxKP	44	55	NPxB	22	25	N-K5	44	41	BxN	52
C6	72		45	33		75	55		34	33		62	25		52
C5	0C	P-B4	0D	00	O-O	06	0E	PxP	06	01	Q-B2	06	0B	PxB	01
C4	32	P-QB4	32	01	NxN	52	43	N-N2	11	15	NxN	52	25	Q-K2	14
C3	45		55	25		52	66		52	25		52	63		74
C2	06	N-B3	07	0B	PxN	04	07	N-B3	00	01	QxN	0C	02	R-K1	07
C1	22	N-QB3	22	25	BxP	52	25	O-O	06	25	P-KB4	35	03	N-Q1	03
C0	99		99	99		99	99		99	99		99	99		99

EXPLANATION OF SYMBOLS

ADDR	SYMBOL		EXPLANATION
0050	.BOARD	:	LOCATION OF PIECES
0060	.BK	:	OPPONENT'S PIECES
0070	.SETW	:	INITIAL PIECE LOCATIONS
008F	.MOVEX	:	TABLE OF MOVE DIRECTIONS
00A0	.POINTS	:	TABLE OF PIECE VALUES
00B0	.PIECE	:	CURRENT PIECE UNDER ANALYSIS
00B1	.SQUARE	:	TO SQUARE OF .PIECE
00B2	.SP2	:	STACK POINTER FOR STACK 2
00B3	.SP1	:	STACK POINTER FOR STACK 1
00B4	.INCHEK	:	MOVE INTO CHECK FLAG
00B5	.STATE	:	STATE OF ANALYSIS
00B6	.MOVEN	:	MOVE TABLE POINTER
00DC	.OMOVE	:	OPENING POINTER
00DC	.OPNING	:	OPENING MOVE TABLE
00DD	.WCAP0	:	COMPUTER CAPTURE 0
00DE	.COUNT	:	START OF COUNT TABLE
00DE	.BCAP2	:	OPPONENT CAPTURE 2
00DF	.WCAP2	:	COMPUTER CAPTURE 2
00E0	.BCAP1	:	OPPONENT CAPTURE 1
00E1	.WCAP1	:	COMPUTER CAPTURE 1
00E2	.BCAP0	:	OPPONENT CAPTURE 0
00E3	.MOB	:	MOBILITY
00E4	.MAXC	:	MAXIMUM CAPTURE
00E5	.CC	:	CAPTURE COUNT
00E6	.PCAP	:	PIECE ID OF MAXC
00E3	.BMOB	:	OPPONENT MOBILITY
00E4	.BMAXC	:	OPPONENT MAXIMUM CAPTURE
00E5	.BCC	:	OPPONENT CAPTURE COUNT
00E6	.BMAXP	:	OPPONENT MAXP
00E8	.XMAXC	:	CURRENT MAXIMUM CAPTURE
00EB	.WMOB	:	COMPUTER MOBILITY
00EC	.WMAXC	:	COMPUTER MAXIMUM CAPTURE
00ED	.WCC	:	COMPUTER CAPTURE COUNT
00EE	.WMAXP	:	COMPUTER MAXP
00EF	.PMOB	:	PREVIOUS COMPUTER MOB
00F0	.PMAXC	:	PREVIOUS COMPUTER MAXC
00F1	.PCC	:	PREVIOUS COMPUTER CC
00F2	.PCP	:	PREVIOUS COMPUTER MAXP
00F3	.OLDKY	:	KEY INPUT TEMPORARY
00FB	.BESTP	:	PIECE OF BEST MOVE FOUND
00FA	.BESTV	:	VALUE OF BEST MOVE FOUND
00F9	.BESTM	:	TO SQUARE OF BEST MOVE
00FB	.DIS1	:	DISPLAY POINT 1
00FA	.DIS2	:	DISPLAY POINT 2
00F9	.DIS3	:	DISPLAY POINT 3

```
       00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F

0000:  D8 A2 FF 9A A2 C8 86 B2 20 1F 1F 20 6A 1F C5 F3
0010:  F0 F6 85 F3 C9 0C D0 0F A2 1F B5 70 95 50 CA 10
0020:  F9 86 DC A9 CC D0 12 C9 0E D0 07 20 B2 02 A9 EE
0030:  D0 07 C9 14 D0 0B 20 A2 03 85 FB 85 FA 85 F9 D0
0040:  BF C9 0F D0 06 20 4B 03 4C 9D 01 4C 96 01 10 00

0070:  03 04 00 07 02 05 01 06 10 17 11 16 12 15 14 13
0080:  73 74 70 77 72 75 71 76 60 67 61 66 62 65 64 63
0090:  F0 FF 01 10 11 0F EF F1 DF E1 EE F2 12 0E 1F 21
00A0:  0B 0A 06 06 04 04 04 04 02 02 02 02 02 02 02 02

0100:  A6 B5 30 5C A5 B0 F0 08 E0 08 D0 04 C5 E6 F0 2E
0110:  F6 E3 C9 01 D0 02 F6 E3 50 1E A0 0F A5 B1 D9 60
0120:  00 F0 03 88 10 F8 B9 A0 00 D5 E4 90 04 94 E6 95
0130:  E4 18 08 75 E5 95 E5 28 E0 04 F0 03 30 31 60 A5
0140:  E8 85 DD A9 00 85 B5 20 4B 03 20 B2 02 20 00 02
0150:  20 B2 02 A9 08 85 B5 20 09 02 20 31 03 4C 80 17
0160:  E0 F9 D0 0B A5 60 C5 B1 D0 04 A9 00 85 B4 60 50
0170:  FD A0 07 A5 B1 D9 60 00 F0 05 88 F0 F1 10 F6 B9
0180:  A0 00 D5 E2 90 02 95 E2 C6 B5 A9 FB C5 B5 F0 03
0190:  20 25 03 E6 B5 60 C9 08 B0 12 20 EA 03 A2 1F B5
01A0:  50 C5 FA F0 03 CA 10 F7 86 FB 86 B0 4C 00 00 00

0200:  A2 10 A9 00 95 DE CA 10 FB A9 10 85 B0 C6 B0 10
0210:  01 60 20 1E 03 A4 B0 A2 08 86 B6 C0 08 10 41 C0
0220:  06 10 2E C0 04 10 1F C0 01 F0 09 10 0E 20 8E 02
0230:  D0 FB F0 D9 20 9C 02 D0 FB F0 D2 A2 04 86 B6 20
0240:  9C 02 D0 FB F0 C7 20 9C 02 A5 B6 C9 04 D0 F7 F0
0250:  BC A2 10 86 B6 20 8E 02 A5 B6 C9 08 D0 F7 F0 AD
0260:  A2 06 86 B6 20 CA 02 50 05 30 03 20 00 01 20 1E
0270:  03 C6 B6 A5 B6 C9 05 F0 EB 20 CA 02 70 8F 30 8D
0280:  20 00 01 A5 B1 29 F0 C9 20 F0 EE 4C 0D 02 20 CA
0290:  02 30 03 20 00 01 20 1E 03 C6 B6 60 20 CA 02 90
02A0:  02 50 F9 30 07 08 20 00 01 28 50 F0 20 1E 03 C6
02B0:  B6 60 A2 0F 38 B4 60 A9 77 F5 50 95 60 94 50 38
02C0:  A9 77 F5 50 95 50 CA 10 EB 60 A5 B1 A6 B6 18 75
02D0:  8F 85 B1 29 88 D0 42 A5 B1 A2 20 CA 30 0E D5 50
02E0:  D0 F9 E0 10 30 33 A9 7F 69 01 70 01 B8 A5 B5 30
02F0:  24 C9 08 10 20 48 08 A9 F9 85 B5 85 B4 20 4B 03
0300:  20 B2 02 20 09 02 20 2E 03 28 68 85 B5 A5 B4 30
0310:  04 38 A9 FF 60 18 A9 00 60 A9 FF 18 B8 60 A6 B0
0320:  B5 50 85 B1 60 20 4B 03 20 B2 02 20 09 02 20 B2
0330:  02 BA 86 B3 A6 B2 9A 68 85 B6 68 85 B0 AA 68 95
0340:  50 68 AA 68 85 B1 95 50 4C 70 03 BA 86 B3 A6 B2
0350:  9A A5 B1 48 A8 A2 1F D5 50 F0 03 CA 10 F9 A9 CC
0360:  95 50 8A 48 A6 B0 B5 50 94 50 48 8A 48 A5 B6 48
0370:  BA 86 B2 A6 B3 9A 60 A6 E4 E4 A0 D0 04 A9 00 F0
0380:  0A A6 E3 D0 06 A6 EE D0 02 A9 FF A2 04 86 B5 C5
0390:  FA 90 0C F0 0A 85 FA A5 B0 85 FB A5 B1 85 F9 4C
03A0:  1F 1F A6 DC 10 17 A5 F9 D5 DC D0 0F CA B5 DC 85
03B0:  FB CA B5 DC 85 F9 CA 86 DC D0 1A 85 DC A2 0C 86
03C0:  B5 86 FA A2 14 20 02 02 A2 04 86 B5 20 00 02 A6
03D0:  FA E0 0F 90 12 A6 FB B5 50 85 FA 86 B0 A5 F9 85
03E0:  B1 20 4B 03 4C 00 00 A9 FF 60 A2 04 06 F9 26 FA
03F0:  CA D0 F9 05 F9 85 F9 85 B1 60 00 00 00 00 00 00

1780:  18 A9 80 65 EB 65 EC 65 ED 65 E1 65 DF 38 E5 F0
1790:  E5 F1 E5 E2 E5 E0 E5 DE E5 EF E5 E3 B0 02 A9 00
17A0:  4A 18 69 40 65 EC 65 ED 38 E5 E4 4A 18 69 90 65
17B0:  DD 65 DD 65 DD 65 DD 65 E1 38 E5 E4 E5 E4 E5 E5
17C0:  E5 E5 E5 E0 A6 B1 E0 33 F0 16 E0 34 F0 12 E0 22
17D0:  F0 0E E0 25 F0 0A A6 B0 F0 09 B4 50 C0 10 10 03
17E0:  18 69 02 4C 77 03
```

MICROCHESS

MICROCHESS

```
                         ;       EXECUTION BEGINS AT ADDRESS 0000
                         ;
                                  +++
0000 D8                  CHESS    CLD                          INITIALIZE
0001 A2 FF                        LDXIM     FF                 TWO STACKS
0003 9A                           TXS
0004 A2 C8                        LDXIM     C8
0006 86 B2                        STXZ      .SP2
                         ;
                         ;       ROUTINES TO LIGHT LED
                         ;       DISPLAY AND GET KEY
                         ;       FROM KEYBOARD.
                         ;
0008 20 1F 1F            OUT      JSR       *OUT               DISPLAY AND
000B 20 6A 1F                     JSR       *GETKEY            GET INPUT
000E C5 F3                        CMPZ      .OLDKY             KEY IN ACC
0010 F0 F6                        BEQ       OUT                (DEBOUNCE)
0012 85 F3                        STAZ      .OLDKY
                         ;
0014 C9 0C                        CMPIM     0C                 [C]
0016 D0 0F                        BNE       NOSET              SET UP
0018 A2 1F                        LDXIM     1F                 BOARD
001A B5 70               WHSET    LDAZX     .SETW              FROM
001C 95 50                        STAZX     .BOARD             SETW
001E CA                           DEX
001F 10 F9                        BPL       WHSET
0021 86 DC                        STXZ      .OMOVE
0023 A9 CC                        LDAIM     CC
0025 D0 12                        BNE       CLDSP
                         ;
0027 C9 0E               NOSET    CMPIM     0E                 [E]
0029 D0 07                        BNE       NOREV              REVERSE
002B 20 B2 02                     JSR       REVERSE            BOARD AS
002E A9 EE                        LDAIM     EE                    IS
0030 D0 07                        BNE       CLDSP
                         ;
0032 C9 14               NOREV    CMPIM     14                 [PC]
0034 D0 0B                        BNE       NOGO               PLAY CHESS
0036 20 A2 03                     JSR       GO
                         ;
0039 85 FB               CLDSP    STA       .DIS1              DISPLAY
003B 85 FA                        STAZ      .DIS2              ACROSS
003D 85 F9                        STAZ      .DIS3              DISPLAY
003F D0 BF                        BNE       CHESS
                         ;
0041 C9 0F               NOGO     CMPIM     0F                 [F]
0043 D0 06                        BNE       NOMV               MOVE MAN
0045 20 4B 03                     JSR       MOVE               AS ENTERED
0048 4C 9D 01                     JMP       DISP
```

```
004B 4C 96 01    NOMV     JMP      INPUT
                 ;
                 ;        THE ROUTINE JANUS DIRECTS THE
                 ;        ANALYSIS BY DETERMINING WHAT
                 ;        SHOULD OCCUR AFTER EACH MOVE
                 ;        GENERATED BY GNM
                 ;
                 ;
                 ;
                          +++
0100 A6 B5       JANUS    LDXZ     .STATE
0102 30 5C                BMI      NOCOUNT
                 ;
                 ;        THIS ROUTINE COUNTS OCCURRENCES
                 ;        IT DEPENDS UPON STATE TO INDEX
                 ;        THE CORRECT COUNTERS
                 ;
0104 A5 B0       COUNTS   LDAZ     .PIECE
0106 F0 08                BEQ      OVER          IF STATE=8
0108 E0 08                CPXIM    08            DO NOT COUNT
010A D0 04                BNE      OVER          BLK MAX CAP
010C C5 E6                CMPZ     .BMAXP        MOVES FOR
010E F0 2E                BEQ      XRT           WHITE
                 ;
0110 F6 E3       OVER     INCZX    .MOB          MOBILITY
0112 C9 01                CMPIM    01            + QUEEN
0114 D0 02                BNE      NOQ           FOR TWO
0116 F6 E3                INCZX    .MOB
                 ;
0118 50 1E       NOQ      BVC      NOCAP
011A A0 0F                LDYIM    OF            CALCULATE
011C A5 B1                LDAZ     .SQUARE       POINTS
011E D9 60 00    ELOOP    CMPAY    .BK           CAPTURED
0121 F0 03                BEQ      FOUN          BY THIS
0123 88                   DEY                    MOVE
0124 10 F8                BPL      ELOOP
0126 B9 A0 00    FOUN     LDAAY    .POINTS
0129 D5 E4                CMPZX    .MAXC
012B 90 04                BCC      LESS          SAVE IF
012D 94 E6                STYZX    .PCAP         BEST THIS
012F 95 E4                STAZX    .MAXC         STATE
                 ;
0131 18          LESS     CLC
0132 08                   PHP                    ADD TO
0133 75 E5                ADCZX    .CC           CAPTURE
0135 95 E5                STAZX    .CC           COUNTS
0137 28                   PLP
                 ;
0138 E0 04       NOCAP    CPXIM    04
013A F0 03                BEQ      ON4
013C 30 31                BMI      TREE          (=00 ONLY)
```

```
013E 60             XRT       RTS
                    ;
                    ;       GENERATE FURTHER MOVES FOR COUNT
                    ;       AND ANALYSIS
                    ;
013F A5 E8          ON4       LDAZ      .XMAXC        SAVE ACTUAL
0141 85 DD                    STAZ      .WCAPO         CAPTURE
0143 A9 00                    LDAIM     00            STATE=0
0145 85 B5                    STAZ      .STATE
0147 20 4B 03                 JSR       MOVE          GENERATE
014A 20 B2 02                 JSR       REVERSE       IMMEDIATE
014D 20 00 02                 JSR       GNMZ          REPLY MOVES
0150 20 B2 02                 JSR       REVERSE
                    ;
0153 A9 08                    LDAIM     08            STATE=8
0155 85 B5                    STAZ      .STATE        GENERATE
0157 20 09 02                 JSR       GNM           CONTINUATION
015A 20 31 03                 JSR       UMOVE         MOVES
                    ;
015D 4C 80 17                 JMP       STRATGY       FINAL EVALUATION
0160 E0 F9          NOCOUNT   CPXIM     F9
0162 D0 0B                    BNE       TREE
                    ;
                    ;       DETERMINE IF THE KING CAN BE
                    ;       TAKEN, USED BY CHKCHK
                    ;
0164 A5 60                    LDAZ      .BK           IS KING
0166 C5 B1                    CMPZ      .SQUARE       IN CHECK?
0168 D0 04                    BNE       RETJ          SET INCHEK=0
016A A9 00                    LDAIM     00            IF IT IS
016C 85 B4                    STAZ      .INCHEK
016E 60             RETJ      RTS
                    ;
                    ;       IF A PIECE HAS BEEN CAPTURED BY
                    ;       A TRIAL MOVE, GENERATE REPLIES &
                    ;       EVALUATE THE EXCHANGE GAIN/LOSS
                    ;
016F 50 FD          TREE      BVC       RETJ          NO CAP
0171 A0 07                    LDYIM     07            (PIECES)
0173 A5 B1                    LDAZ      .SQUARE
0175 D9 60 00       LOOPX     CMPAY     .BK
0178 F0 05                    BEQ       FOUNX
017A 88                       DEY
017B F0 F1                    BEQ       RETJ          (KING)
017D 10 F6                    BPL       LOOPX         SAVE
017F B9 A0 00       FOUNX     LDAAY     .POINTS       BEST CAP
0182 D5 E2                    CMPZX     .BCAPO        AT THIS
0184 90 02                    BCC       NOMAX         LEVEL
0186 95 E2                    STAZX     .BCAPO
0188 C6 B5          NOMAX     DEC       .STATE
```

```
018A A9 FB                     LDAIM     FB           IF STATE=FB
018C C5 B5                     CMPZ      .STATE       TIME TO TURN
018E F0 03                     BEQ       UPTREE       AROUND
0190 20 25 03                  JSR       GENRM        GENERATE FURTHER
0193 E6 B5           UPTREE    INC       .STATE       CAPTURES
0195 60                        RTS
                     ;
                     ;      THE PLAYER'S MOVE IS INPUT
                     ;
0196 C9 08           INPUT     CMPIM     08           NOT A LEGAL
0198 B0 12                     BCS       ERROR        SQUARE #
019A 20 EA 03                  JSR       DISMV
019D A2 1F           DISP      LDXIM     1F
019F B5 50           SEARCH    LDAZX     .BOARD
01A1 C5 FA                     CMPZ      .DIS2
01A3 F0 03                     BEQ       HERE         DISPLAY
01A5 CA                        DEX                    PIECE AT
01A6 10 F7                     BPL       SEARCH       FROM
01A8 86 FB           HERE      STXZ      .DIS1        SQUARE
01AA 86 B0                     STXZ      .PIECE
01AC 4C 00 00        ERROR     JMP       CHESS
                     ;
                     ;      GENERATE ALL MOVES FOR ONE
                     ;      SIDE, CALL JANUS AFTER EACH
                     ;      ONE FOR NEXT STEP
                     ;
                               +++
0200 A2 10           GNMZ      LDXIM     10           CLEAR
0202 A9 00           GNMX      LDAIM     00           COUNTERS
0204 95 DE           CLEAR     STAZX     .COUNT
0206 CA                        DEX
0207 10 FB                     BPL       CLEAR
                     ;
0209 A9 10           GNM       LDAIM     10           SET UP
020B 85 B0                     STAZ      .PIECE       PIECE
020D C6 B0           NEWP      DECZ      .PIECE       NEW PIECE
020F 10 01                     BPL       NEX          ALL DONE?
0211 60                        RTS                       -YES
                     ;
0212 20 1E 03        NEX       JSR       RESET       READY
0215 A4 B0                     LDYZ      .PIECE       GET PIECE
0217 A2 08                     LDXIM     08
0219 86 B6                     STXZ      .MOVEN       COMMON START
021B C0 08                     CPYIM     08           WHAT IS IT?
021D 10 41                     BPL       PAWN         PAWN
021F C0 06                     CPYIM     06
0221 10 2E                     BPL       KNIGHT       KNIGHT
0223 C0 04                     CPYIM     04
0225 10 1F                     BPL       BISHOP       BISHOP
0227 C0 01                     CPYIM     01
```

```
0229 F0 09                   BEQ      QUEEN       QUEEN
022B 10 0E                   BPL      ROOK        ROOK
                   ;
022D 20 8E 02      KING      JSR      SNGMV       MUST BE KING!
0230 D0 FB                   BNE      KING        MOVES
0232 F0 D9                   BEQ      NEWP        8 TO 1
0234 20 9C 02      QUEEN     JSR      LINE
0237 D0 FB                   BNE      QUEEN       MOVES
0239 F0 D2                   BEQ      NEWP        8 TO 1
                   ;
023B A2 04         ROOK      LDXIM    04
023D 86 B6                   STXZ     .MOVEN      MOVES
023F 20 9C 02      AGNR      JSR      LINE        4 TO 1
0242 D0 FB                   BNE      AGNR
0244 F0 C7                   BEQ      NEWP
                   ;
0246 20 9C 02      BISHOP    JSR      LINE
0249 A5 B6                   LDAZ     .MOVEN      MOVES
024B C9 04                   CMPIM    04          8 TO 5
024D D0 F7                   BNE      BISHOP
024F F0 BC                   BEQ      NEWP
                   ;
0251 A2 10         KNIGHT    LDXIM    10
0253 86 B6                   STXZ     .MOVEN      MOVES
0255 20 8E 02      AGNN      JSR      SNGMV       16 TO 9
0258 A5 B6                   LDAZ     .MOVEN
025A C9 08                   CMPIM    08
025C D0 F7                   BNE      AGNN
025E F0 AD                   BEQ      NEWP
                   ;
0260 A2 06         PAWN      LDXIM    06
0262 86 B6                   STXZ     .MOVEN
0264 20 CA 02      P1        JSR      CMOVE       RIGHT CAP?
0267 50 05                   BVC      P2
0269 30 03                   BMI      P2
026B 20 00 01                JSR      JANUS       YES
026E 20 1E 03      P2        JSR      RESET
0271 C6 B6                   DECZ     .MOVEN       LEFT CAP?
0273 A5 B6                   LDAZ     .MOVEN
0275 C9 05                   CMPIM    05
0277 F0 EB                   BEQ      P1
0279 20 CA 02      P3        JSR      CMOVE       AHEAD
027C 70 8F                   BVS      NEWP         ILLEGAL
027E 30 8D                   BMI      NEWP
0280 20 00 01                JSR      JANUS
0283 A5 B1                   LDAZ     .SQUARE      GETS TO
0285 29 F0                   ANDIM    F0           3RD RANK?
0287 C9 20                   CMPIM    20
0289 F0 EE                   BEQ      P3           DO DOUBLE
028B 4C 0D 02                JMP      NEWP
```

```
                    ;
                    ;         CALCULATE SINGLE STEP MOVES
                    ;         FOR K, N
                    ;
028E 20 CA 02       SNGMV      JSR        CMOVE          CALC MOVE
0291 30 03                     BMI        ILL1            -IF LEGAL
0293 20 00 01                  JSR        JANUS           -EVALUATE
0296 20 1E 03       ILL1       JSR        RESET
0299 C6 B6                     DECZ       .MOVEN
029B 60                        RTS
                    ;
                    ;         CALCULATE ALL MOVES DOWN A
                    ;         STRAIGHT LINE FOR Q,B,R
                    ;
029C 20 CA 02       LINE       JSR        CMOVE          CALC MOVE
029F 90 02                     BCC        OVL             NO CHK
02A1 50 F9                     BVC        LINE            CH,NOCAP
02A3 30 07          OVL        BMI        ILL             RETURN
02A5 08                        PHP
02A6 20 00 01                  JSR        JANUS          EVALUATE POSN
02A9 28                        PLP
02AA 50 F0                     BVC        LINE           NOT A CAP
02AC 20 1E 03       ILL        JSR        RESET          LINE STOPPED
02AF C6 B6                     DECZ       .MOVEN          NEXT DIR
02B1 60                        RTS
                    ;
                    ;         EXCHANGE SIDES FOR REPLY
                    ;         ANALYSIS
                    ;
02B2 A2 0F          REVERSE    LDXIM      0F
02B4 38             ETC        SEC
02B5 B4 60                     LDYZX      .BK             SUBTRACT
02B7 A9 77                     LDAIM      77              POSITION
02B9 F5 50                     SBCZX      .BOARD          FROM 77
02BB 95 60                     STAZX      .BK
02BD 94 50                     STYZX      .BOARD             AND
02BF 38                        SEC
02C0 A9 77                     LDAIM      77              EXCHANGE
02C2 F5 50                     SBCZX      .BOARD          PIECES
02C4 95 50                     STAZX      .BOARD
02C6 CA                        DEX
02C7 10 EB                     BPL        ETC
02C9 60                        RTS
                    ;
                    ;
                    ;
                    ;
                    ;
                    ;
                    ;
```

```
                 ;        CMOVE CALCULATES THE TO SQUARE
                 ;        USING .SQUARE AND THE MOVE
                 ;       TABLE.  FLAGS SET AS FOLLOWS:
                 ;       N - ILLEGAL MOVE
                 ;       V - CAPTURE (LEGAL UNLESS IN CH)
                 ;       C - ILLEGAL BECAUSE OF CHECK
                 ;       [MY THANKS TO JIM BUTTERFIELD
                 ;        WHO WROTE THIS MORE EFFICIENT
                 ;        VERSION OF CMOVE]
                 ;
02CA A5 B1       CMOVE    LDAZ      .SQUARE        GET SQUARE
02CC A6 B6                LDXZ      .MOVEN         MOVE POINTER
02CE 18                   CLC
02CF 75 8F                ADCZX     .MOVEX         MOVE LIST
02D1 85 B1                STAZ      .SQUARE        NEW POS'N
02D3 29 88                ANDIM     88
02D5 D0 42                BNE       ILLEGAL        OFF BOARD
02D7 A5 B1                LDAZ      .SQUARE
                 ;
02D9 A2 20                LDXIM     20
02DB CA          LOOP     DEX                      IS TO
02DC 30 0E                BMI       NO             SQUARE
02DE D5 50                CMPZX     .BOARD         OCCUPIED?
02E0 D0 F9                BNE       LOOP
                 ;
02E2 E0 10                CPXIM     10             BY SELF?
02E4 30 33                BMI       ILLEGAL
                 ;
02E6 A9 7F                LDAIM     7F             MUST BE CAP!
02E8 69 01                ADCIM     01             SET V FLAG
02EA 70 01                BVS       SPX            (JMP)
                 ;
02EC B8          NO       CLV                      NO CAPTURE
                 ;
02ED A5 B5       SPX      LDAZ      .STATE         SHOULD WE
02EF 30 24                BMI       RETL           DO THE
02F1 C9 08                CMPIM     08             CHECK CHECK?
02F3 10 20                BPL       RETL
                 ;
                 ;       CHKCHK REVERSES SIDES
                 ;       AND LOOKS FOR A KING
                 ;       CAPTURE TO INDICATE
                 ;       ILLEGAL MOVE BECAUSE OF
                 ;       CHECK.  SINCE THIS IS
                 ;       TIME CONSUMING, IT IS NOT
                 ;       ALWAYS DONE.
                 ;
02F5 48          CHKCHK   PHA                      STATE
02F6 08                   PHP
02F7 A9 F9                LDAIM     F9
```

```
02F9 85 B5                  STAZ     .STATE        GENERATE
02FB 85 B4                  STAZ     .INCHEK       ALL REPLY
02FD 20 4B 03               JSR      MOVE          MOVES TO
0300 20 B2 02               JSR      REVERSE       SEE IF KING
0303 20 09 02               JSR      GNM           IS IN
0306 20 2E 03               JSR      RUM           CHECK
0309 28                     PLP
030A 68                     PLA
030B 85 B5                  STAZ     .STATE
030D A5 B4                  LDAZ     .INCHEK
030F 30 04                  BMI      RETL          NO - SAFE
0311 38                     SEC                    YES - IN CHK
0312 A9 FF                  LDAIM    FF
0314 60                     RTS
                   ;
0315 18            RETL     CLC                    LEGAL
0316 A9 00                  LDAIM    00            RETURN
0318 60                     RTS
                   ;
0319 A9 FF         ILLEGAL  LDAIM    FF
031B 18                     CLC                    ILLEGAL
031C B8                     CLV                    RETURN
031D 60                     RTS
                   ;
                   ;        REPLACE .PIECE ON CORRECT .SQUARE
                   ;
031E A6 B0         RESET    LDXZ     .PIECE        GET LOCAT.
0320 B5 50                  LDAZX    .BOARD        FOR PIECE
0322 85 B1                  STAZ     .SQUARE       FROM BOARD
0324 60                     RTS
                   ;
                   ;
                   ;
0325 20 4B 03      GENRM    JSR      MOVE          MAKE MOVE
0328 20 B2 02      GENR2    JSR      REVERSE       REVERSE BOARD
032B 20 09 02               JSR      GNM           GENERATE MOVES
032E 20 B2 02      RUM      JSR      REVERSE       REVERSE BACK
                   ;
                   ;        ROUTINE TO UNMAKE A MOVE MADE BY
                   ;                  MOVE
                   ;
0331 BA            UMOVE    TSX                    UNMAKE MOVE
0332 86 B3                  STXZ     .SP1
0334 A6 B2                  LDXZ     .SP2          EXCHANGE
0336 9A                     TXS                    STACKS
0337 68                     PLA                    MOVEN
0338 85 B6                  STAZ     .MOVEN
033A 68                     PLA                    CAPTURED
033B 85 B0                  STAZ     .PIECE        PIECE
033D AA                     TAX
```

```
033E 68                        PLA                        FROM SQUARE
033F 95 50                     STAZX     .BOARD
0341 68                        PLA                        PIECE
0342 AA                        TAX
0343 68                        PLA                        TO SQUARE
0344 85 B1                     STAZ      .SQUARE
0346 95 50                     STAZX     .BOARD
0348 4C 70 03                  JMP       STRV
                    ;
                    ;     THIS ROUTINE MOVES .PIECE
                    ;     TO .SQUARE,  PARAMETERS
                    ;     ARE SAVED IN A STACK TO UNMAKE
                    ;     THE MOVE LATER
                    ;
034B BA             MOVE       TSX
034C 86 B3                     STXZ      .SP1             SWITCH
034E A6 B2                     LDXZ      .SP2             STACKS
0350 9A                        TXS
0351 A5 B1                     LDAZ      .SQUARE
0353 48                        PHA                        TO SQUARE
0354 A8                        TAY
0355 A2 1F                     LDXIM     1F
0357 D5 50          CHECK      CMPZX     .BOARD           CHECK FOR
0359 F0 03                     BEQ       TAKE             CAPTURE
035B CA                        DEX
035C 10 F9                     BPL       CHECK
035E A9 CC          TAKE       LDAIM     CC
0360 95 50                     STAZX     .BOARD
0362 8A                        TXA                        CAPTURED
0363 48                        PHA                        PIECE
0364 A6 B0                     LDXZ      .PIECE
0366 B5 50                     LDAZX     .BOARD
0368 94 50                     STYZX     .BOARD           FROM
036A 48                        PHA                           SQUARE
036B 8A                        TXA
036C 48                        PHA                        PIECE
036D A5 B6                     LDAZ      .MOVEN
036F 48                        PHA                        MOVEN
0370 BA             STRV       TSX
0371 86 B2                     STXZ      .SP2             SWITCH
0373 A6 B3                     LDXZ      .SP1             STACKS
0375 9A                        TXS                        BACK
0376 60                        RTS
                    ;
                    ;     CONTINUATION OF SUB STRATGY
                    ;     -CHECKS FOR CHECK OR CHECKMATE
                    ;     AND ASSIGNS VALUE TO MOVE
                    ;
0377 A6 E4          CKMATE     LDXZ      .BMAXC           CAN BLK CAP
0379 E4 A0                     CPXZ      .POINTS          MY KING?
```

```
037B D0 04                   BNE      NOCHEK
037D A9 00                   LDAIM    00          GULP!
037F F0 0A                   BEQ      RETV        DUMB MOVE!
                   ;
0381 A6 E3         NOCHEK    LDXZ     .BMOB       IS BLACK
0383 D0 06                   BNE      RETV        UNABLE TO
0385 A6 EE                   LDXZ     .WMAXP      MOVE AND
0387 D0 02                   BNE      RETV        KING IN CH?
0389 A9 FF                   LDAIM    FF          YES! MATE
                   ;
038B A2 04         RETV      LDXIM    04          RESTORE
038D 86 B5                   STXZ     .STATE      STATE=4
                   ;
                   ;         THE VALUE OF THE MOVE (IN ACC)
                   ;         IS COMPARED TO THE BEST MOVE AND
                   ;         REPLACES IT IF IT IS BETTER
                   ;
038F C5 FA         PUSH      CMPZ     .BESTV      IS THIS BEST
0391 90 0C                   BCC      RETP        MOVE SO FAR?
0393 F0 0A                   BEQ      RETP
0395 85 FA                   STAZ     .BESTV      YES!
0397 A5 B0                   LDAZ     .PIECE      SAVE IT
0399 85 FB                   STAZ     .BESTP
039B A5 B1                   LDAZ     .SQUARE
039D 85 F9                   STAZ     .BESTM      FLASH DISPLAY
039F 4C 1F 1F      RETP      JMP      *OUT        AND RTS
                   ;
                   ;         MAIN PROGRAM TO PLAY CHESS
                   ;         PLAY FROM OPENING OR THINK
                   ;
03A2 A6 DC         GO        LDXZ     .OMOVE      OPENING?
03A4 10 17                   BPL      NOOPEN         -NO
03A6 A5 F9                   LDAZ     .DIS3       -YES WAS
03A8 D5 DC                   CMPZX    .OPNING      OPPONENT'S
03AA D0 0F                   BNE      END          MOVE OK?
03AC CA                      DEX
03AD B5 DC                   LDAZX    .OPNING     GET NEXT
03AF 85 FB                   STAZ     .DIS1       CANNED
03B1 CA                      DEX                  OPENING MOVE
03B2 B5 DC                   LDAZX    .OPNING
03B4 85 F9                   STAZ     .DIS3       DISPLAY IT
03B6 CA                      DEX
03B7 86 DC                   STXZ     .OMOVE      MOVE IT
03B9 D0 1A                   BNE      MV2         (JMP)
                   ;
03BB 85 DC         END       STAZ     .OMOVE      FLAG OPENING
03BD A2 0C         NOOPEN    LDXIM    0C          FINISHED
03BF 86 B5                   STXZ     .STATE      STATE=C
03C1 86 FA                   STXZ     .BESTV      CLEAR BESTV
03C3 A2 14                   LDXIM    14          GENERATE P
```

```
03C5 20 02 02                     JSR      GNMX           MOVES
                        ;
03C8 A2 04                        LDXIM    04             STATE=4
03CA 86 B5                        STXZ     .STATE         GENERATE AND
03CC 20 00 02                     JSR      GNMZ           TEST AVAILABLE
                        ;                                 MOVES
                        ;
03CF A6 FA                        LDXZ     .BESTV         GET BEST MOVE
03D1 E0 0F                        CPXIM    0F             IF NONE
03D3 90 12                        BCC      MATE           OH OH!
                        ;
03D5 A6 FB              MV2       LDXZ     .BESTP         MOVE
03D7 B5 50                        LDAZX    .BOARD          THE
03D9 85 FA                        STAZ     .BESTV         BEST
03DB 86 B0                        STXZ     .PIECE         MOVE
03DD A5 F9                        LDAZ     .BESTM
03DF 85 B1                        STAZ     .SQUARE        AND DISPLAY
03E1 20 4B 03                     JSR      MOVE             IT
03E4 4C 00 00                     JMP      CHESS
                        ;
03E7 A9 FF              MATE      LDAIM    FF             RESIGN
03E9 60                           RTS                     OR STALEMATE
                        ;
                        ;       SUBROUTINE TO ENTER THE
                        ;       PLAYER'S MOVE
                        ;
03EA A2 04              DISMV     LDXIM    04             ROTATE
03EC 06 F9              ROL       ASLZ     .DIS3           KEY
03EE 26 FA                        ROLZ     .DIS2          INTO
03F0 CA                           DEX                     DISPLAY
03F1 D0 F9                        BNE      ROL
03F3 05 F9                        ORAZ     .DIS3
03F5 85 F9                        STAZ     .DIS3
03F7 85 B1                        STAZ     .SQUARE
03F9 60                           RTS
                        ;
                        ;       THE FOLLOWING SUBROUTINE ASSIGNS
                        ;       A VALUE TO THE MOVE UNDER
                        ;       CONSIDERATION AND RETURNS IT IN
                        ;         THE ACCUMULATOR
                        ;
                                  +++
1780 18                 STRATGY   CLC
1781 A9 80                        LDAIM    80
1783 65 EB                        ADCZ     .WMOB          PARAMETERS
1785 65 EC                        ADCZ     .WMAXC         WITH WEIGHT
1787 65 ED                        ADCZ     .WCC           OF 0.25
1789 65 E1                        ADCZ     .WCAP1
178B 65 DF                        ADCZ     .WCAP2
178D 38                           SEC
```

```
178E E5 F0                SBCZ    .PMAXC
1790 E5 F1                SBCZ    .PCC
1792 E5 E2                SBCZ    .BCAP0
1794 E5 E0                SBCZ    .BCAP1
1796 E5 DE                SBCZ    .BCAP2
1798 E5 EF                SBCZ    .PMOB
179A E5 E3                SBCZ    .BMOB
179C B0 02                BCS     POS         UNDERFLOW
179E A9 00                LDAIM   00          PREVENTION
17A0 4A          POS      LSRA
17A1 18                   CLC                 **************
17A2 69 40                ADCIM   40
17A4 65 EC                ADCZ    .WMAXC      PARAMETERS
17A6 65 ED                ADCZ    .WCC        WITH WEIGHT
17A8 38                   SEC                 OF 0.5
17A9 E5 E4                SBCZ    .BMAXC
17AB 4A                   LSRA                ************
17AC 18                   CLC
17AD 69 90                ADCIM   90
17AF 65 DD                ADCZ    .WCAP0      PARAMETERS
17B1 65 DD                ADCZ    .WCAP0      WITH WEIGHT
17B3 65 DD                ADCZ    .WCAP0      OF 1.0
17B5 65 DD                ADCZ    .WCAP0
17B7 65 E1                ADCZ    .WCAP1
17B9 38                   SEC                 [UNDER OR OVER-
17BA E5 E4                SBCZ    .BMAXC       FLOW MAY OCCUR
17BC E5 E4                SBCZ    .BMAXC       FROM THIS
17BE E5 E5                SBCZ    .BCC         SECTION]
17C0 E5 E5                SBCZ    .BCC
17C2 E5 E0                SBCZ    .BCAP1
17C4 A6 B1                LDXZ    .SQUARE     ************
17C6 E0 33                CPXIM   33
17C8 F0 16                BEQ     POSN        POSITION
17CA E0 34                CPXIM   34          BONUS FOR
17CC F0 12                BEQ     POSN        MOVE TO
17CE E0 22                CPXIM   22          CENTRE
17D0 F0 0E                BEQ     POSN           OR
17D2 E0 25                CPXIM   25          OUT OF
17D4 F0 0A                BEQ     POSN        BACK RANK
17D6 A6 B0                LDXZ    .PIECE
17D8 F0 09                BEQ     NOPOSN
17DA B4 50                LDYZX   .BOARD
17DC C0 10                CPYIM   10
17DE 10 03                BPL     NOPOSN
17E0 18          POSN     CLC
17E1 69 02                ADCIM   02
17E3 4C 77 03    NOPOSN   JMP     CKMATE          CONTINUE
                 ;
                 ;
                 ;
```

```
SYMBOL TABLE
SYMBOL    ADDR DEF  CROSS REFERENCES

CHESS     0000   5     1  45 171 519
OUT       0008  15    18
CHSET     001A  24    27
NOSET     0027  32    22
NOREV     0032  38    33
CLDSP     0039  42    30  36
NOGO      0041  47    39
NOMV      004B  51    48
JANUS     0100  60   236 245 257 270
COUNTS    0104  67
OVER      0110  74    68  70
NOQ       0118  79    76
ELOOP     011E  82    85
FOUN      0126  86    83
LESS      0131  92    88
NOCAP     0138  98    79
XRT       013E 101    72
ON4       013F 106    99
NOCOUNT   0160 121    61
RETJ      016E 132   129 138 144
TREE      016F 138   100 122
LOOPX     0175 141   145
FOUNX     017F 146   142
NOMAX     0188 150   148
UPTREE    0193 155   153
INPUT     0196 160    51
DISP      019D 163    50
SEARCH    019F 164   168
HERE      01A8 169   166
ERROR     01AC 171   161
GNMZ      0200 178   112 505
GNMX      0202 179   501
CLEAR     0204 180   182
GNM       0209 184   117 355 386
NEWP      020D 186   206 209 215 221 229 243 244 250
NEX       0212 190   187
KING      022D 204   205
QUEEN     0234 207   201 208
ROOK      023B 211   202
AGNR      023F 213   214
BISHOP    0246 217   199 220
KNIGHT    0251 223   197
AGNN      0255 225   228
PAWN      0260 231   195
P1        0264 233   241
P2        026E 237   234 235
P3        0279 242   249
SNGMV     028E 255   204 225
ILL1      0296 258   256
LINE      029C 265   207 213 217 267 272
OVL       02A3 268   266
ILL       02AC 273   268
REVERSE   02B2 280    34 111 113 354 385 387
ETC       02B4 281   292
CMOVE     02CA 311   233 242 255 265
LOOP      02DB 321   324
NO        02EC 333   322
```

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SYMBOL    ADDR DEF  CROSS REFERENCES

SPX       02ED 335   331
CHKCHK    02F5 348
RETL      0315 366   336 338 361
ILLEGAL   0319 370   317 327 343
RESET     031E 377   190 237 258 273
GENRM     0325 384   154
GENR2     0328 385
RUM       032E 387   356
UMOVE     0331 392   118
MOVE      034B 415    49 110 353 384 518
CHECK     0357 423   426
TAKE      035E 427   424
STRV      0370 439   408
CKMATE    0377 449   597
NOCHEK    0381 455   451
RETV      038B 461   453 456 458
PUSH      038F 468
RETP      039F 476   469 470
GO        03A2 481    40
END       03BB 496   485
IOOPEN    03BD 497   482
MV2       03D5 512   494
MATE      03E7 521   510
DISMV     03EA 527   162
ROL       03EC 528   531
STRATGY   1780 543   120
POS       17A0 560   558
POSN      17E0 595   583 585 587 589
NOPOSN    17E3 597   591 594
.BOARD    0050 602    25 164 284 286 289 290 323 378 402 407
                     423 428 432 433 513 592
.BK       0060 603    82 127 141 282 285
.SETW     0070 604    24
.MOVEX    008F 605   314
.POINTS   00A0 606    86 146 450
.PIECE    00B0 607    67 170 185 186 191 377 399 431 472 515
                     590
.SQUARE   00B1 608    81 128 140 246 311 315 318 379 406 419
                     474 517 534 581
.SP2      00B2 609     9 394 417 440
.SP1      00B3 610   393 416 441
.INCHEK   00B4 611   131 352 360
.STATE    00B5 612    60 109 116 150 152 155 335 351 359 462
                     498 504
.MOVEN    00B6 613   193 212 218 224 226 232 238 239 259 274
                     312 397 437
.OMOVE    00DC 614    28 481 493 496
.OPNING   00DC 615   484 487 490
.WCAP0    00DD 616   107 570 571 572 573
.COUNT    00DE 617   180
.BCAP2    00DE 618   555
.WCAP2    00DF 619   549
.BCAP1    00E0 620   554 580
.WCAP1    00E1 621   548 574
.BCAP0    00E2 622   147 149 553
.MOB      00E3 623    74  77
.MAXC     00E4 624    87  90
.CC       00E5 625    94  95
```

```
SYMBOL    ADDR DEF  CROSS REFERENCES

.PCAP     00E6 626   89
.BMOB     00E3 627  455 557
.BMAXC    00E4 628  449 566 576 577
.BCC      00E5 629  578 579
.BMAXP    00E6 630   71
.XMAXC    00E8 631  106
.WMOB     00EB 632  545
.WMAXC    00EC 633  546 563
.WCC      00ED 634  547 564
.WMAXP    00EE 635  457
.PMOB     00EF 636  556
.PMAXC    00F0 637  551
.PCC      00F1 638  552
.PCP      00F2 639
.OLDKY    00F3 640   17  19
.BESTP    00FB 641  473 512
.BESTV    00FA 642  468 471 499 508 514
.BESTM    00F9 643  475 516
 DIS1     00FB 644   42 169 488
.DIS2     00FA 645   43 165 529
.DIS3     00F9 646   44 483 491 528 532 533
*OUT      1F1F 647   15 476
*GETKEY   1F6A 648   16
```

BLOCK DATA

```
.SETW     0070     03 04 00 07 02 05 01 06 10 17 11 16 12 15 14 13
                   73 74 70 77 72 75 71 76 60 67 61 66 62 65 64 63

.MOVEX    0090     F0 FF 01 10 11 0F EF F1 DF E1 EE F2 12 0E 1F 21

 POINTS   00A0     0B 0A 06 06 04 04 04 04 02 02 02 02 02 02 02 02

.OPNING   00C0     99 25 0B 25 01 00 33 25 07 36 34 0D 34 34 0E 52
                   25 0D 45 35 04 55 22 06 43 33 0F CC
```

NOTE THAT 00B7 TO 00BF, 00F4 TO 00F8, AND 00FC TO 00FF ARE AVAILABLE FOR USER EXPANSION AND I/O ROUTINES.