MICROCHESS

A CHESS PLAYING PROGRAM

FOR THE 6502 MICROCOMPUTER

BY PETER JENNINGS

MICROCHESS is available on KIM cassette for $5.00.

M I C R O C H E S S

KIM Cassette Loading Instructions

1 Enter (RS) to reset KIM.
2 Enter (AD) 0 0 F 1 (DA) 0 0 to reset decimal flag.
3 Enter (AD) 1 7 F 9 (DA) C 1 to enter tape ID.
4 Enter (AD) 1 8 7 3 (GO) to begin read routine.
5 Start your cassette player.
6 When you see: 0000 D8 stop your cassette player.
7 Enter (RS) (AD) 1 8 7 3 (GO) to read block 2.
8 Start your cassette player.
9 When you see: 0000 D8 stop your cassette player.
10 Enter (RS) (GO) to start program execution.

If you wish KIM to play a specific opening, enter the ID in address 17F9 and load the opening data. Enter (RS) before and after each tape load.

Data for Openings

Microchess plays white	black	Opening
A0	A1	Four Knights
A2	A3	French Defence
A4	A5	Ruy Lopez
A6	A7	Queen's Indian
A8	A9	Guioco Piano

Remember to always press (RS) between each tape load. Otherwise, data at 0100 and 0101 may be overwritten by the stack. Verify these locations against the program listing if you have trouble executing the program.

A second copy of the two main programs can be found after the openings.

M I C R O C H E S S

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.

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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 [0F 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	F8	10 seconds
NORMAL	08	F8	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	006E
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.

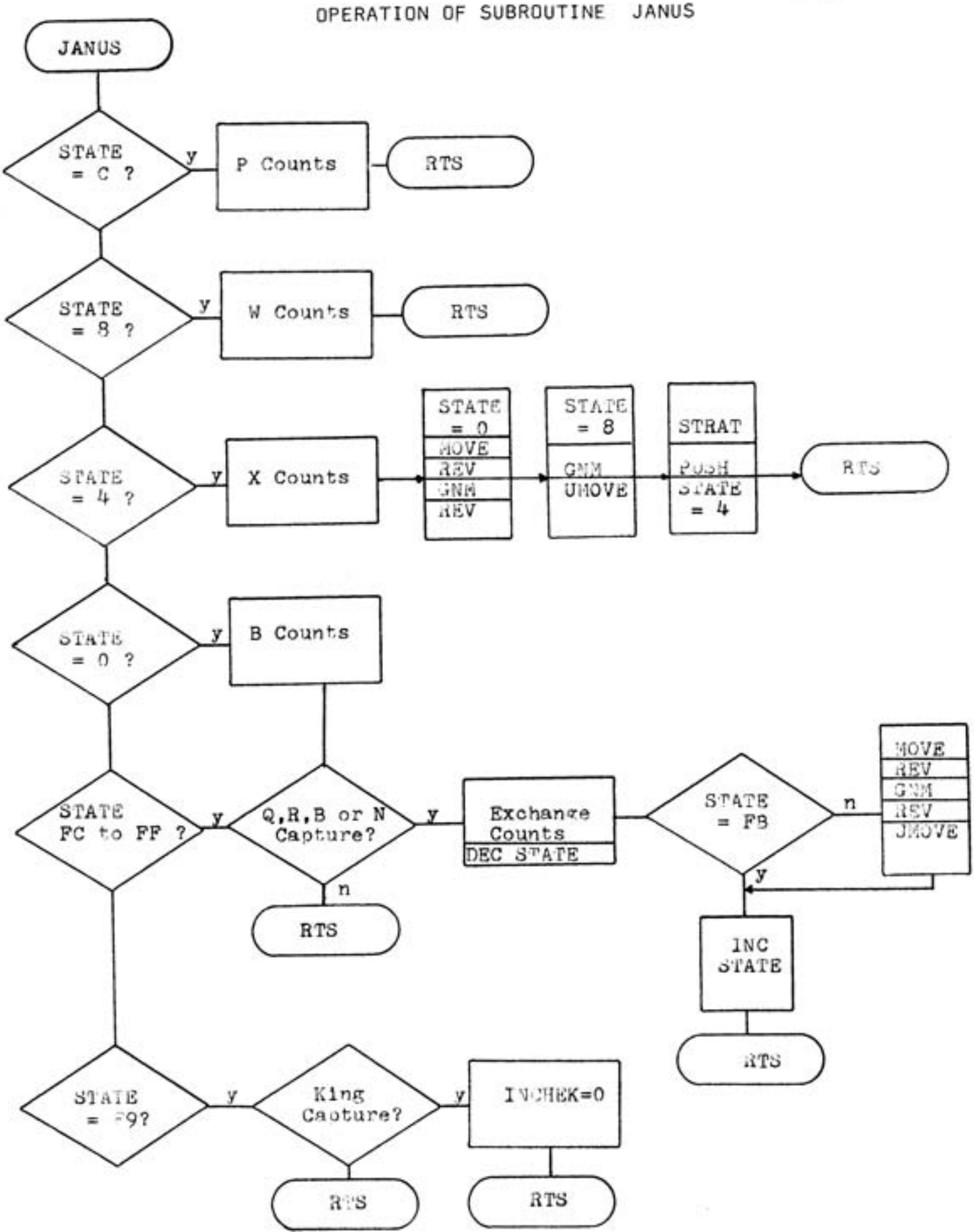
SOURCE LISTING

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 WCAP0 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 C5 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 C5 0F D0 06 20 4B 03 4C 5D 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 C5 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 A5 00 85 B5 20 4B 03 20 B2 02 20 00 02
0150: 20 B2 02 A9 08 85 B5 20 05 02 20 31 03 4C 80 17
0160: E0 F9 D0 0B A5 60 C5 B1 D0 04 A5 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 A5 EB 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 C0

0200: A2 10 A9 00 95 DE CA 10 FB A5 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 A5 77 F5 50 95 60 94 50 38
02C0: A5 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 C5 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 A5 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 A5 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

M I C R O C H E S S


```
 2                      ;       EXECUTION BEGINS AT ADDRESS 0000
 3                      ;
 4                              +++
 5  0000 D8             CHESS     CLD                             INITIALIZE
 6  0001 A2 FF                    LDXIM     FF                    TWO STACKS
 7  0003 9A                       TXS
 8  0004 A2 C8                    LDXIM     C8
 9  0006 86 B2                    STXZ      .SP2
10                      ;
11                      ;       ROUTINES TO LIGHT LED
12                      ;       DISPLAY AND GET KEY
13                      ;       FROM KEYBOARD.
14                      ;
15  0008 20 1F 1F       OUT       JSR       *OUT                  DISPLAY AND
16  000B 20 6A 1F                 JSR       *GETKEY               GET INPUT
17  000E C5 F3                    CMPZ      .OLDKY                KEY IN ACC
18  0010 F0 F6                    BEQ       OUT                   (DEBOUNCE)
19  0012 85 F3                    STAZ      .OLDKY
20                      ;
21  0014 C9 0C                    CMPIM     0C                    [C]
22  0016 D0 0F                    BNE       NOSET                 SET UP
23  0018 A2 1F                    LDXIM     1F                    BOARD
24  001A B5 70          WHSET     LDAZX     .SETW                 FROM
25  001C 95 50                    STAZX     .BOARD                SETW
26  001E CA                       DEX
27  001F 10 F9                    BPL       WHSET
28  0021 86 DC                    STXZ      .OMOVE
29  0023 A9 CC                    LDAIM     CC
30  0025 D0 12                    BNE       CLDSP
31                      ;
32  0027 C9 0E          NOSET     CMPIM     0E                    [E]
33  0029 D0 07                    BNE       NOREV                 REVERSE
34  002B 20 B2 02                 JSR       REVERSE               BOARD AS
35  002E A9 EE                    LDAIM     EE                       IS
36  0030 D0 07                    BNE       CLDSP
37                      ;
38  0032 C9 14          NOREV     CMPIM     14                    [PC]
39  0034 D0 0B                    BNE       NOGO                  PLAY CHESS
40  0036 20 A2 03                 JSR       GO
41                      ;
42  0039 85 FB          CLDSP     STA       .DIS1                 DISPLAY
43  003B 85 FA                    STAZ      .DIS2                 ACROSS
44  003D 85 F9                    STAZ      .DIS3                 DISPLAY
45  003F D0 BF                    BNE       CHESS
46                      ;
47  0041 C9 0F          NOGO      CMPIM     0F                    [F]
48  0043 D0 06                    BNE       NOMV                  MOVE MAN
49  0045 20 4B 03                 JSR       MOVE                  AS ENTERED
50  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   0F              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)
```

```
101  013E 60           XRT      RTS
102                    ;
103                    ;       GENERATE FURTHER MOVES FOR COUNT
104                    ;       AND ANALYSIS
105                    ;
106  013F A5 E8        ON4        LDAZ     .XMAXC        SAVE ACTUAL
107  0141 85 DD                   STAZ     .WCAPO         CAPTURE
108  0143 A9 00                   LDAIM    00            STATE=0
109  0145 85 B5                   STAZ     .STATE
110  0147 20 4B 03                JSR      MOVE          GENERATE
111  014A 20 B2 02                JSR      REVERSE       IMMEDIATE
112  014D 20 00 02                JSR      GNMZ          REPLY MOVES
113  0150 20 B2 02                JSR      REVERSE
114                    ;
115  0153 A9 08                   LDAIM    08            STATE=8
116  0155 85 B5                   STAZ     .STATE        GENERATE
117  0157 20 09 02                JSR      GNM           CONTINUATION
118  015A 20 31 03                JSR      UMOVE         MOVES
119                    ;
120  015D 4C 80 17                JMP      STRATGY       FINAL EVALUATION
121  0160 E0 F9        NOCOUNT    CPXIM    F9
122  0162 D0 0B                   BNE      TREE
123                    ;
124                    ;       DETERMINE IF THE KING CAN BE
125                    ;       TAKEN, USED BY CHKCHK
126                    ;
127  0164 A5 60                   LDAZ     .BK           IS KING
128  0166 C5 B1                   CMPZ     .SQUARE       IN CHECK?
129  0168 D0 04                   BNE      RETJ          SET INCHEK=0
130  016A A9 00                   LDAIM    00            IF IT IS
131  016C 85 B4                   STAZ     .INCHEK
132  016E 60           RETJ       RTS
133                    ;
134                    ;       IF A PIECE HAS BEEN CAPTURED BY
135                    ;       A TRIAL MOVE, GENERATE REPLIES &
136                    ;       EVALUATE THE EXCHANGE GAIN/LOSS
137                    ;
138  016F 50 FD        TREE       BVC      RETJ          NO CAP
139  0171 A0 07                   LDYIM    07            (PIECES)
140  0173 A5 B1                   LDAZ     .SQUARE
141  0175 D9 60 00     LOOPX      CMPAY    .BK
142  0178 F0 05                   BEQ      FOUNX
143  017A 88                      DEY
144  017B F0 F1                   BEQ      RETJ          (KING)
145  017D 10 F6                   BPL      LOOPX         SAVE
146  017F B9 A0 00     FOUNX      LDAAY    .POINTS       BEST CAP
147  0182 D5 E2                   CMPZX    .BCAPO        AT THIS
148  0184 90 02                   BCC      NOMAX         LEVEL
149  0186 95 E2                   STAZX    .BCAPO
150  0188 C6 B5        NOMAX      DEC      .STATE
```

```
151  018A A9 FB                    LDAIM   FB              IF STATE=FB
152  018C C5 B5                    CMPZ    .STATE          TIME TO TURN
153  018E F0 03                    BEQ     UPTREE          AROUND
154  0190 20 25 03                 JSR     GENRM           GENERATE FURTHER
155  0193 E6 B5          UPTREE    INC     .STATE          CAPTURES
156  0195 60                       RTS
157                      ;
158                      ;        THE PLAYER'S MOVE IS INPUT
159                      ;
160  0196 C9 08          INPUT     CMPIM   08              NOT A LEGAL
161  0198 B0 12                    BCS     ERROR           SQUARE #
162  019A 20 EA 03                 JSR     DISMV
163  019D A2 1F          DISP      LDXIM   1F
164  019F B5 50          SEARCH    LDAZX   .BOARD
165  01A1 C5 FA                    CMPZ    .DIS2
166  01A3 F0 03                    BEQ     HERE            DISPLAY
167  01A5 CA                       DEX                     PIECE AT
168  01A6 10 F7                    BPL     SEARCH          FROM
169  01A8 86 FB          HERE      STXZ    .DIS1           SQUARE
170  01AA 86 B0                    STXZ    .PIECE
171  01AC 4C 00 00       ERROR     JMP     CHESS
172                      ;
173                      ;        GENERATE ALL MOVES FOR ONE
174                      ;        SIDE, CALL JANUS AFTER EACH
175                      ;        ONE FOR NEXT STEP
176                      ;
177                               +++
178  0200 A2 10          GNMZ      LDXIM   10              CLEAR
179  0202 A9 00          GNMX      LDAIM   00              COUNTERS
180  0204 95 DE          CLEAR     STAZX   .COUNT
181  0206 CA                       DEX
182  0207 10 FB                    BPL     CLEAR
183                      ;
184  0209 A9 10          GNM       LDAIM   10              SET UP
185  020B 85 B0                    STAZ    .PIECE          PIECE
186  020D C6 B0          NEWP      DECZ    .PIECE          NEW PIECE
187  020F 10 01                    BPL     NEX             ALL DONE?
188  0211 60                       RTS                        -YES
189                      ;
190  0212 20 1E 03       NEX       JSR     RESET          READY
191  0215 A4 B0                    LDYZ    .PIECE          GET PIECE
192  0217 A2 08                    LDXIM   08
193  0219 86 B6                    STXZ    .MOVEN          COMMON START
194  021B C0 08                    CPYIM   08              WHAT IS IT?
195  021D 10 41                    BPL     PAWN            PAWN
196  021F C0 06                    CPYIM   06
197  0221 10 2E                    BPL     KNIGHT          KNIGHT
198  0223 C0 04                    CPYIM   04
199  0225 10 1F                    BPL     BISHOP          BISHOP
200  0227 C0 01                    CPYIM   01
```

```
201  0229 F0 09          BEQ     QUEEN       QUEEN
202  022B 10 0E          BPL     ROOK        ROOK
203                      ;
204  022D 20 8E 02  KING  JSR     SNGMV       MUST BE KING!
205  0230 D0 FB          BNE     KING        MOVES
206  0232 F0 D9          BEQ     NEWP        8 TO 1
207  0234 20 9C 02  QUEEN JSR     LINE
208  0237 D0 FB          BNE     QUEEN       MOVES
209  0239 F0 D2          BEQ     NEWP        8 TO 1
210                      ;
211  023B A2 04  ROOK    LDXIM   04
212  023D 86 B6          STXZ    .MOVEN      MOVES
213  023F 20 9C 02  AGNR  JSR     LINE        4 TO 1
214  0242 D0 FB          BNE     AGNR
215  0244 F0 C7          BEQ     NEWP
216                      ;
217  0246 20 9C 02  BISHOP JSR    LINE
218  0249 A5 B6          LDAZ    .MOVEN      MOVES
219  024B C9 04          CMPIM   04          8 TO 5
220  024D D0 F7          BNE     BISHOP
221  024F F0 BC          BEQ     NEWP
222                      ;
223  0251 A2 10  KNIGHT  LDXIM   10
224  0253 86 B6          STXZ    .MOVEN      MOVES
225  0255 20 8E 02  AGNN  JSR     SNGMV       16 TO 9
226  0258 A5 B6          LDAZ    .MOVEN
227  025A C9 08          CMPIM   08
228  025C D0 F7          BNE     AGNN
229  025E F0 AD          BEQ     NEWP
230                      ;
231  0260 A2 06  PAWN    LDXIM   06
232  0262 86 B6          STXZ    .MOVEN
233  0264 20 CA 02  P1    JSR     CMOVE       RIGHT CAP?
234  0267 50 05          BVC     P2
235  0269 30 03          BMI     P2
236  026B 20 00 01       JSR     JANUS       YES
237  026E 20 1E 03  P2    JSR     RESET
238  0271 C6 B6          DECZ    .MOVEN       LEFT CAP?
239  0273 A5 B6          LDAZ    .MOVEN
240  0275 C9 05          CMPIM   05
241  0277 F0 EB          BEQ     P1
242  0279 20 CA 02  P3    JSR     CMOVE       AHEAD
243  027C 70 8F          BVS     NEWP         ILLEGAL
244  027E 30 8D          BMI     NEWP
245  0280 20 00 01       JSR     JANUS
246  0283 A5 B1          LDAZ    .SQUARE      GETS TO
247  0285 29 F0          ANDIM   F0           3RD RANK?
248  0287 C9 20          CMPIM   20
249  0289 F0 EE          BEQ     P3           DO DOUBLE
250  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
```

```
351  02F9 85 B5              STAZ    .STATE          GENERATE
352  02FB 85 B4              STAZ    .INCHEK         ALL REPLY
353  02FD 20 4B 03           JSR     MOVE            MOVES TO
354  0300 20 B2 02           JSR     REVERSE         SEE IF KING
355  0303 20 09 02           JSR     GNM             IS IN
356  0306 20 2E 03           JSR     RUM             CHECK
357  0309 28                 PLP
358  030A 68                 PLA
359  030B 85 B5              STAZ    .STATE
360  030D A5 B4              LDAZ    .INCHEK
361  030F 30 04              BMI     RETL            NO - SAFE
362  0311 38                 SEC                     YES - IN CHK
363  0312 A9 FF              LDAIM   FF
364  0314 60                 RTS
365                  ;
366  0315 18         RETL    CLC                     LEGAL
367  0316 A9 00              LDAIM   00              RETURN
368  0318 60                 RTS
369                  ;
370  0319 A9 FF      ILLEGAL LDAIM   FF
371  031B 18                 CLC                     ILLEGAL
372  031C B8                 CLV                     RETURN
373  031D 60                 RTS
374                  ;
375                  ;       REPLACE .PIECE ON CORRECT .SQUARE
376                  ;
377  031E A6 B0      RESET   LDXZ    .PIECE          GET LOCAT.
378  0320 B5 50              LDAZX   .BOARD          FOR PIECE
379  0322 85 B1              STAZ    .SQUARE         FROM BOARD
380  0324 60                 RTS
381                  ;
382                  ;
383                  ;
384  0325 20 4B 03   GENRM   JSR     MOVE            MAKE MOVE
385  0328 20 B2 02   GENR2   JSR     REVERSE         REVERSE BOARD
386  032B 20 09 02           JSR     GNM             GENERATE MOVES
387  032E 20 B2 02   RUM     JSR     REVERSE         REVERSE BACK
388                  ;
389                  ;       ROUTINE TO UNMAKE A MOVE MADE BY
390                  ;                 MOVE
391                  ;
392  0331 BA         UMOVE   TSX                     UNMAKE MOVE
393  0332 86 B3              STXZ    .SP1
394  0334 A6 B2              LDXZ    .SP2            EXCHANGE
395  0336 9A                 TXS                     STACKS
396  0337 68                 PLA                     MOVEN
397  0338 85 B6              STAZ    .MOVEN
398  033A 68                 PLA                     CAPTURED
399  033B 85 B0              STAZ    .PIECE          PIECE
400  033D AA                 TAX
```

```
401  033E 68                        PLA                    FROM SQUARE
402  033F 95 50                     STAZX     .BOARD
403  0341 68                        PLA                    PIECE
404  0342 AA                        TAX
405  0343 68                        PLA                    TO SQUARE
406  0344 85 B1                     STAZ      .SQUARE
407  0346 95 50                     STAZX     .BOARD
408  0348 4C 70 03                  JMP       STRV
409                          ;
410                          ;      THIS ROUTINE MOVES .PIECE
411                          ;      TO .SQUARE,  PARAMETERS
412                          ;      ARE SAVED IN A STACK TO UNMAKE
413                          ;      THE MOVE LATER
414                          ;
415  034B BA                 MOVE   TSX
416  034C 86 B3                     STXZ      .SP1           SWITCH
417  034E A6 B2                     LDXZ      .SP2           STACKS
418  0350 9A                        TXS
419  0351 A5 B1                     LDAZ      .SQUARE
420  0353 48                        PHA                      TO SQUARE
421  0354 A8                        TAY
422  0355 A2 1F                     LDXIM     1F
423  0357 D5 50              CHECK  CMPZX     .BOARD         CHECK FOR
424  0359 F0 03                     BEQ       TAKE           CAPTURE
425  035B CA                        DEX
426  035C 10 F9                     BPL       CHECK
427  035E A9 CC              TAKE   LDAIM     CC
428  0360 95 50                     STAZX     .BOARD
429  0362 8A                        TXA                      CAPTURED
430  0363 48                        PHA                      PIECE
431  0364 A6 B0                     LDXZ      .PIECE
432  0366 B5 50                     LDAZX     .BOARD
433  0368 94 50                     STYZX     .BOARD         FROM
434  036A 48                        PHA                         SQUARE
435  036B 8A                        TXA
436  036C 48                        PHA                      PIECE
437  036D A5 B6                     LDAZ      .MOVEN
438  036F 48                        PHA                      MOVEN
439  0370 BA                 STRV   TSX
440  0371 86 B2                     STXZ      .SP2           SWITCH
441  0373 A6 B3                     LDXZ      .SP1           STACKS
442  0375 9A                        TXS                      BACK
443  0376 60                        RTS
444                          ;
445                          ;      CONTINUATION OF SUB STRATGY
446                          ;      -CHECKS FOR CHECK OR CHECKMATE
447                          ;      AND ASSIGNS VALUE TO MOVE
448                          ;
449  0377 A6 E4              CKMATE   LDXZ      .BMAXC         CAN BLK CAP
450  0379 E4 A0                       CPXZ      .POINTS        MY KING?
```

```
                        BNE     NOCHEK
                        LDAIM   00              GULP!
                        BEQ     RETV            DUMB MOVE!
                ;
NOCHEK          LDXZ    .BMOB           IS BLACK
                BNE     RETV            UNABLE TO
                LDXZ    .WMAXP          MOVE AND
                BNE     RETV            KING IN CH?
                LDAIM   FF              YES! MATE
                ;
RETV            LDXIM   04              RESTORE
                STXZ    .STATE          STATE=4
                ;
                ;       THE VALUE OF THE MOVE (IN ACC)
                ;       IS COMPARED TO THE BEST MOVE AND
                ;       REPLACES IT IF IT IS BETTER
                ;
PUSH            CMPZ    .BESTV          IS THIS BEST
                BCC     RETP            MOVE SO FAR?
                BEQ     RETP
                STAZ    .BESTV          YES!
                LDAZ    .PIECE          SAVE IT
                STAZ    .BESTP
                LDAZ    .SQUARE
                STAZ    .BESTM          FLASH DISPLAY
RETP            JMP     *OUT            AND RTS
                ;
                ;       MAIN PROGRAM TO PLAY CHESS
                ;       PLAY FROM OPENING OR THINK
                ;
GO              LDXZ    .OMOVE          OPENING?
                BPL     NOOPEN              -NO
                LDAZ    .DIS3           -YES WAS
                CMPZX   .OPNING          OPPONENT'S
                BNE     END              MOVE OK?
                DEX
                LDAZX   .OPNING         GET NEXT
                STAZ    .DIS1           CANNED
                DEX                     OPENING MOVE
                LDAZX   .OPNING
                STAZ    .DIS3           DISPLAY IT
                DEX
                STXZ    .OMOVE          MOVE IT
                BNE     MV2             (JMP)
                ;
END             STAZ    .OMOVE          FLAG OPENING
NOOPEN          LDXIM   0C              FINISHED
                STXZ    .STATE          STATE=C
                STXZ    .BESTV          CLEAR BESTV
                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
```

```
551  178E E5 F0           SBCZ    .PMAXC
552  1790 E5 F1           SBCZ    .PCC
553  1792 E5 E2           SBCZ    .BCAP0
554  1794 E5 E0           SBCZ    .BCAP1
555  1796 E5 DE           SBCZ    .BCAP2
556  1798 E5 EF           SBCZ    .PMOB
557  179A E5 E3           SBCZ    .BMOB
558  179C B0 02           BCS     POS             UNDERFLOW
559  179E A9 00           LDAIM   00              PREVENTION
560  17A0 4A      POS     LSRA
561  17A1 18              CLC                     **************
562  17A2 69 40           ADCIM   40
563  17A4 65 EC           ADCZ    .WMAXC          PARAMETERS
564  17A6 65 ED           ADCZ    .WCC            WITH WEIGHT
565  17A8 38              SEC                     OF 0.5
566  17A9 E5 E4           SBCZ    .BMAXC
567  17AB 4A              LSRA                    ************
568  17AC 18              CLC
569  17AD 69 90           ADCIM   90
570  17AF 65 DD           ADCZ    .WCAP0          PARAMETERS
571  17B1 65 DD           ADCZ    .WCAP0          WITH WEIGHT
572  17B3 65 DD           ADCZ    .WCAP0          OF 1.0
573  17B5 65 DD           ADCZ    .WCAP0
574  17B7 65 E1           ADCZ    .WCAP1
575  17B9 38              SEC                     [UNDER OR OVER-
576  17BA E5 E4           SBCZ    .BMAXC           FLOW MAY OCCUR
577  17BC E5 E4           SBCZ    .BMAXC           FROM THIS
578  17BE E5 E5           SBCZ    .BCC             SECTION]
579  17C0 E5 E5           SBCZ    .BCC
580  17C2 E5 E0           SBCZ    .BCAP1
581  17C4 A6 B1           LDXZ    .SQUARE         ************
582  17C6 E0 33           CPXIM   33
583  17C8 F0 16           BEQ     POSN            POSITION
584  17CA E0 34           CPXIM   34              BONUS FOR
585  17CC F0 12           BEQ     POSN            MOVE TO
586  17CE E0 22           CPXIM   22              CENTRE
587  17D0 F0 0E           BEQ     POSN               OR
588  17D2 E0 25           CPXIM   25              OUT OF
589  17D4 F0 0A           BEQ     POSN            BACK RANK
590  17D6 A6 B0           LDXZ    .PIECE
591  17D8 F0 09           BEQ     NOPOSN
592  17DA B4 50           LDYZX   .BOARD
593  17DC C0 10           CPYIM   10
594  17DE 10 03           BPL     NOPOSN
595  17E0 18      POSN    CLC
596  17E1 69 02           ADCIM   02
597  17E3 4C 77 03 NOPOSN JMP     CKMATE              CONTINUE
598                       ;
599                       ;
600                       ;
```

SYMBOL TABLE

SYMBOL	ADDR	DEF	CROSS REFERENCES
CHESS	0000	5	1 45 171 519
OUT	0008	15	18
WHSET	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

```
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
NOOPEN    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.

Micro-ADE 6502

ASSEMBLER

This flexible two pass assembler can be used to assemble small programs directly in memory, or with up to two computer controlled cassettes for easy handling of large programs. The allocation of memory to the source, object, and symbol table is user defined. The symbol table may be listed at any time in alphabetical or address order. Efficient packed ASCII coding reduces the memory required by the symbol table. Error messages warn you of mistakes before the program crashes the system.

DISASSEMBLER

The disassembler translates object code into assembler source language. Symbolic arguments and labels are defined from the symbol table. The assembler symbol table can be saved at assembly time for use with the disassembler for easy debugging. Relocation of undocumented programs becomes a snap. Use this disassembler once, and you'll never look at a hex dump again!

EDITOR

Quick edit features include the FIX, INSERT, MOVE, and DELETE commands. Lines are automatically numbered. Cassette commands: GET, SAVE, and REPRODUCE simplify the editing of multiple file source programs on cassettes. A page mode formats the output for CRT terminals to allow easy viewing of long listings.

Micro-ADE is a well documented package of programs which may be used with any 6502 microcomputer system. The comprehensive 56 page user manual includes the full source listing for all input/output and KIM cassette I/O routines enabling you to interface your own peripheral devices with ease. All programs and utility routines coreside in 4K. Schematics are included for automatic control of two cassette recorders.

Full documentation is available from Micro-Ware Limited. The User Manual, hex dump, and object program on paper tape or KIM cassette costs only $25.00. The complete annotated source listing is also available for an additional $25.00. This is the program development tool that you have been waiting for. Send today to:

Micro-Ware Ltd 27 FIRSTBROOKE ROAD, TORONTO, ONTARIO, CANADA. M4E 2L2.

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