Where KAISSA Founders on a Bug

and CHESS 4.6 Conquers All

The Second World Computer Chess Championships

About the Author

Peter Jennings is author of MICROCHESS, a 6502 chess playing program developed for the KIM-1, and seen in operation at the PC 77 show in Atlantic City NJ. MICROCHESS 1.5 versus DARK HORSE is a match that Peter expects to report upon in the near future to give personal computer users an idea about the prospects of entering small systems in international chess competition.

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The Second World Computer Chess Championships were held on August 7, 8, and 9 1977 at the Hotel Toronto in downtown Toronto Canada under the sponsorship of the International Federation for Information Processing (IFIP). 16 programs from the United States, Canada, USSR, United Kingdom, Switzerland, Netherlands, West Germany and Sweden competed in a 4 round Swiss style tournament for the world title.

The event drew large audiences of spectators including computer and chess experts from around the world. In attendance was Mikhail Botvinnik from the Soviet Union, world human chess champion during the period from 1948 to 1963. Also attending the event was Hans Berliner, former world correspondence chess champion and author of J Biit, an earlier chess playing program. Lively expert commentary was provided by international master and computer chess author, David Levy, who is watching computer chess developments very closely these days because his wager of 1968 that no computer chess program will beat him in a tournament before August 1978 is about to run out.

The trend evidenced by the competing programs seems to be toward larger programs running on faster machines. Three of the programs ran on Amdahl 470/V6 computers, and CHESS 4.6 was running on CDC's Cyber 176. At the other end of the spectrum, OSTRICH was the only program running on a computer at the tournament site. A Data General Supernova was used. Communications were provided to remote data centers as distant as England, Germany, and California for the nonportable programs.

The 16 entrants were initially ranked on the basis of previous play before the tournament. In the first round, the eight superior programs were played against the

CHESS 4.6

For the next three years CHESS 4.6 will be the reigning world champion computer chess program. CHESS 4.6 was written in the CDC assembly language by David Slate and Larry Atkin at Northwestern University in Illinois, and runs on the CDC Cyber 176 located at Arden Hills MN. Initial work on the program began in the spring of 1968 and revisions have followed almost continuously since that time. Different versions of the program have held the US Computer Chess Championship title in 1970, 1971, 1972, 1973 and 1975. The program placed second in 1974, and second at the First World Computer Chess Championships, also that year.

CHESS 4.6, like almost all chess programs, plays chess by generating the possible legal moves for each side and evaluating the resultant position. The evaluation of this resultant position usually requires the generation of subsequent moves until a value can be ascertained, or until the time allotted to the evaluation has expired. Because of the number of moves normally available in a chess position (average 42), the number of terminal positions which must be evaluated grows exponentially with the depth of the search. Many programs restrict the number of moves they examine as a means to extend the depth of search. CHESS 4.6, on the other hand, conducts a full width search but is consequently restricted in the maximum depth to which it can evaluate a position. It must also evaluate each terminal position as rapidly as possible.

The evaluation of each position is based upon the material and positional factors. The material factor is considered to be the most important as most chess players will agree. The positional factor is limited in importance to less than the value of 1½ pawns in material difference. The value of any given position is based on the material difference between the sides and on penalty and bonus points allocated for positional factors such as: the pieces under attack, the pawn structure (doubled, isolated, passed or backward pawns), the rock positions (squares controlled, enemy king tropism, doubling, file control and seventh rank), the bishop position (square control and development), the knights (king and center tropism, and development), the queen position (square control and king tropism) and the king position (safety, center and pawn tropism). Two different algorithms are used: one for positions involving an even material position, and a "mop up" algorithm for positions in which one side has a clear material advantage.

For further discussion of the evaluation routines the reader is directed to a chapter in reference 1 by David Slate and Larry Atkin in which they describe their program in some detail.

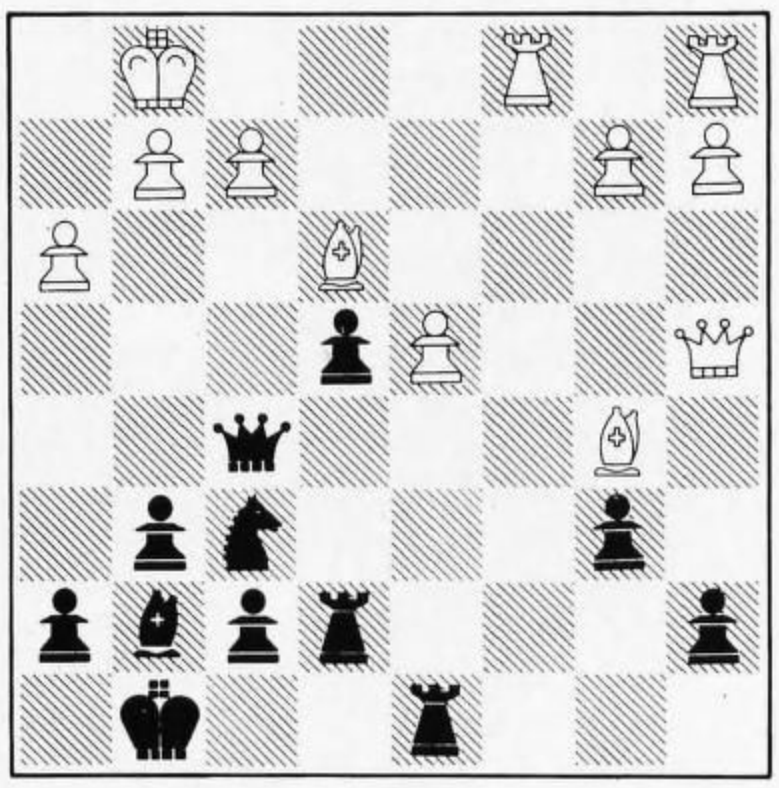
The CHESS 4.6 program plays extremely good chess. It is capable of beating 99.5 percent of all USCF rated players in the United States under tournament conditions. Perhaps even more remarkable is its play in blitz games. With restrictions of a five minute time limit for 60 moves, the program has already beaten many master players including David Levy, Hans Berliner and Lawrence Day. If any program has a chance to beat David Levy before next August, it will be CHESS 4.6. The authors will be working hard to improve the program between now and next summer.■

Game 1: White: DUCHESS. Black: KAISSA.
For the record, here is the full listing of the victory of DUCHESS over KAISSA. In the first round of play, KAISSA was unexpectedly defeated by DUCHESS in an upset which will long be remembered. Post game analysis fingered a bug in KAISSA introduced by a last minute "improvement" of the program.

	White: DUCHESS	Black: KAISSA
1.	P-K4	P-Q4
2.	PxP	N-KB3
3.	P-Q4	NxP
4.	N-KB3	P-KN3
5.	B-K2	B-N2
6.	P-QB4	N-N3
7.	N-B3	O-O
8.	B-K3	B-N5
9.	P-B5	N-Q4
10.	O-O	P-K3
11.	Q-N3	P-N3
12.	NxN	PxN
13.	B-KN5	Q-Q2
14.	P-KR3	B-B4
15.	Q-B3	R-K1
16.	R-K1	B-K5
17.	N-Q2	Q-B4
18.	B-K3	Q-K3
19.	NxB	PxN
20.	PxP	BPxP
21.	R(K1)-QB1	. . .

Better is R(R1)-QB1. White has a positional advantage due to the control of the open file and the weak placement of Black's knight.

21.		N-Q2
22.	B-N4	Q-Q4
23.	Q-B6	N-B3
24.	B-K2	R(R1)-Q1
25.	Q-R4	R-K2
26.	B-N5	Q-KB4



Position after 26. . . Q-KB4.

This is the move which was apparently caused by a bug in the KAISSA program.

27.	R-B2	N-Q4
28.	R(1)-QB1	B-B3
29.	Q-N3	P-QR4
30.	P-KN4	Q-K3

Black's queen is terribly restricted.

31.	R-B6	P-R5

KAISSA sacrifices the rook pawn in order to draw DUCHESS' queen away from the long diagonal.

32.	QxP	R-Q3

The KAISSA program rejected Q-R8 as an important threat, and had consequently not fully analyzed the continuation which follows.

33.	RxR	QxR
34.	Q-R8ch !	R-K1

If 34. . . . K-N2, then 35. Q-B8ch KxQ, 36. B-R6ch B-N2, 37. R-B8, and mate follows.

35.	QxRch	K-N2
36.	P-N5	B-Q1
37.	B-QB4	Q-K2
38.	QxQ	NxQ
39.	B-B4	N-B4
40.	B-Q5	K-B1
41.	R-B8	K-K2
42.	R-B4	N-N2
43.	BxP	N-K3
44.	B-K3	N-B2
45.	P-Q5	N-N4
46.	B-B3	K-Q2
47.	P-QR4	N-Q3
48.	R-B6	N-B4
49.	BxP	Resigns.

weaker or untried programs. The previous world champion, KAISSA, from the Institute for System Studies in Moscow, was paired with ninth ranked DUCHESS from Duke University in Durham NC. It was expected that KAISSA would have an easy win.

Both KAISSA and DUCHESS utilize an "opening book" computer chess strategy. KAISSA's book contains 10,000 possible opening positions, whereas DUCHESS' book contains only 3,000. The use of an opening book allows the programs to play rapidly for the first few moves of each game while maintaining a line of play previously determined to be the best by human chess masters. Only two of the programs entered in the tournament played without opening books.

After 25 moves, the DUCHESS program, playing white, was judged by David Levy to have only a marginal positional advantage over black. To this point, KAISSA had used only 14 minutes of its available time while DUCHESS had used 59 minutes.

Under the rules of the tournament, each side must complete 40 moves in the first two hours, and at least ten moves in each succeeding half hour. Several programs, including KAISSA, made use of their opponents' time by preparing replies to the most probable move expected. Very often, the expected move would be played, and the program could respond instantly.

On move 26, KAISSA unexpectedly moved its queen from Q4 to B4. Although this move appeared to be of little significance, four moves later it became apparent that black was in trouble. KAISSA's black queen was dangerously restricted and DUCHESS was threatening checkmate. A rook sacrifice was necessary to prevent the immediate loss, but a win for black was almost impossible from that point onward. After move 48, DUCHESS was declared the winner, and the previous world champion

Note: *At the last minute, we discovered that BYTE's "automatic" chessboard drawing algorithm had used inverted logic, so please note that the chessboard diagrams in this article are all drawn with Black's home squares at the bottom (Sometimes we think we could use a little artificial intelligence)...* CM

had been upset in the first round by a previously unknown program.

It was learned the following day that the disastrous move had been the result of a bug in the program introduced when the programmers made last minute changes the evening before the tournament. The complete score of this game is printed in game 1, along with commentary.

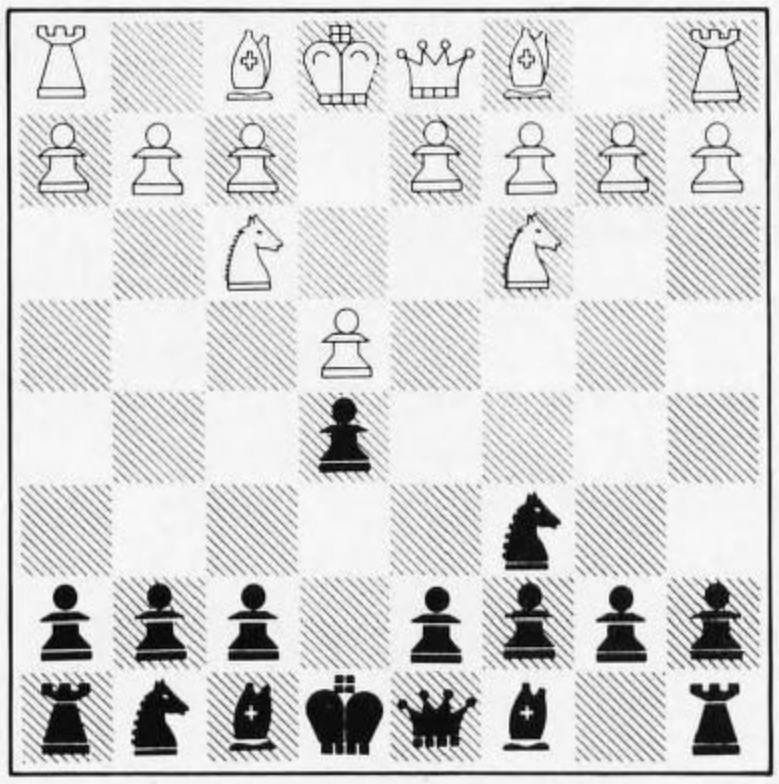


Figure 1: An interesting foible of the "opening book" strategy is revealed when a nonstandard opening occurs. In the game of DARK HORSE versus CHAOS, CHAOS was unable to recognize the transposed standard opening taken by DARK HORSE, and as a result it was thrown immediately into its middle game mode of operation. Here is the situation in DARK HORSE versus CHAOS after move 3, P-K4.

The tournament favorite, CHESS 4.6, met Don Beal's BCP in the first round of play. Due to a system failure, the CDC Cyber 176 used by CHESS 4.6 was not available at the scheduled start of play. Tournament rules allow each team up to 30 minutes of down time during which the chess clock may be stopped. When this period has expired, the clock must run and the time used is deducted from the two hours available for the first 40 moves.

CHESS 4.6 had almost an hour on their clock when service was restored. However, they wasted no time in defeating the English program in a rapid 27 move game which was the first game to end in the first round, despite the delays.

At the end of round one, CHESS 4.6, DUCHESS, CHAOS, MASTER, DARK HORSE, and OSTRICH had one point, BELLE, BLACK KNIGHT, ELSA, and BLITZ V had one half point, and the others had no points. For the second round, the programs all played against opponents with the same number of points from the first round.

KAISSA showed the strength it had not displayed in the first round, defeating TELL,

Results of the Second World Computer Chess Championships

n	Program	Round 1	Round 2	Round 3	Round 4	Total	Rank
1.	CHESS 4.6	1 (W,13)	1 (B,6)	1 (W,3)	1 (B,5)	4	1
2.	KAISSA	0 (B,3)	1 (W,16)	1 (B,4)	1 (B,7)	3	2
3.	DUCHESS	1 (W,2)	1 (B,11)	0 (B,1)	1 (B,6)	3	2
4.	CHAOS	1 (W,15)	½ (B,10)	0 (W,2)	1 (B,12)	2½	4
5.	BELLE	½ (W,7)	1 (B,12)	1 (W,10)	0 (W,1)	2½	4
6.	MASTER	1 (W,14)	0 (W,1)	1 (B,9)	0 (W,3)	2	6
7.	BLACK KNIGHT	½ (B,5)	½ (W,9)	1 (B,11)	0 (W,2)	2	6
8.	WITA	0 (B,11)	1 (B,13)	½ (W,15)	½ (W,10)	2	6
9.	ELSA	½ (W,12)	½ (B,7)	0 (W,6)	1 (B,15)	2	6
10.	DARK HORSE	1 (B,16)	½ (W,4)	0 (B,5)	½ (B,8)	2	6
11.	OSTRICH	1 (W,8)	0 (W,3)	0 (W,7)	½ (B,13)	1½	11
12.	BLITZ V	½ (B,9)	0 (W,5)	1 (B,14)	0 (W,4)	1½	11
13.	BCP	0 (B,1)	0 (W,8)	1 (B,16)	½ (W,11)	1½	11
14.	CHUTE 1.2	0 (W,6)	½ (B,15)	0 (W,12)	1 (B,16)	1½	11
15.	BS'66'76	0 (B,4)	½ (W,14)	½ (B,8)	0 (W,9)	1	15
16.	TELL	0 (W,10)	0 (B,2)	0 (W,13)	0 (W,14)	0	16

Table 1: The Second World Computer Chess Championships' results at a glance. In this table, each program's results in the four rounds of the tournament are summarized. A point (1) is awarded for each win, a half point (1/2) for each draw, and zero for each loss. In the notation of each round, the score color and opponent are given in the notation s (c,n) where s is the score for the round (1, 1/2 or 0), c is the color which the program played (B or W for black or white) and n is the number of the opponent in this list of programs.

from Switzerland, in a remarkable 16 moves, the shortest game of the tournament. TELL, written by Johann Joss, was European champion in 1975, and placed third in 1976.

In an interesting game, DARK HORSE, playing without the aid of an opening book, used a nonstandard opening against CHAOS, a program with an opening book of 7,500 positions. Since none of the book openings had prepared CHAOS for the very unusual N-QB3 move, it had to revert to its middle game analysis rather than responding instantly with a table lookup result. After three moves:

1. N-QB3 P-K4
2. N-B3 N-QB3
3. P-K4,

the position was transposed to a standard Four Knight's game usually obtained by:

1. P-K4 P-K4
2. N-KB3 N-QB3
3. N-B3.

CHAOS, having discarded its opening table, was now unable to recognize that this was a standard position, and wasted precious time analyzing the position to determine the correct response (see figure 1).

At the end of the first two rounds of

Technical Comparisons								Author Information		
Rank	Program	Computer	Language	Program Size	Word Length	Opening Book	Average Number of Positions Examined per Move	Author(s)	Affiliation	Location of Computer
1	CHESS 4.6	CDC Cyber 176	Assembly	7.5 K + external core	60	5,600 positions	400,000	David Slate Larry Atkin	Northwestern University Evanston IL	Arden Hills MN
2	KAISSA	IBM 370/168	Assembly	250 K	32	10,000 positions	90,000	Dr M V Donskoy Dr V Arlazarov	Institute for System Studies Moscow USSR	Canada Systems Group Toronto, Ontario CANADA
2	DUCHESS	IBM 370/165	PL/I and Assembly	300 K	32	3,000 positions	1,200	Tom Truscott Bruce Wright Eric Jensen	Duke University Durham NC	Triangle Universities C C Triangle Park NC
4	BELLE	PDP-11 with chess hardware	"C"	8 K	16	10,000 positions	30,000	Ken Thompson Joe Condon	Bell Telephone Labs Murray Hill NJ	Bell Telephone Labs Murray Hill NJ
4	CHAOS	AMDAHL 470 V/6	FORTRAN	3 megabytes	32	7,500 positions	30,000	Mike Alexander T McBride Fred Swartz Bill Toikka Vic Berman Joe Winograd	University of Michigan Ann Arbor MI	Amdahl Corporation Sunnyvale CA
6	BLACK KNIGHT	UNIVAC 1110	FORTRAN	30 K	36	70,000 positions	7,500	Ken Sogge Fred Prouse Gary Maltzen Lonny Lebahn Elliot Adams	Sperry Univac St Paul MN	Sperry Univac Roseville St Paul MN
6	DARK HORSE	CDC 6600	FORTRAN	24 K	60	NO BOOK	12,000	Ulf Rathsman	Telefon AB LM Ericsson Stockholm SWEDEN	Multiple Access Computer Group Toronto, Ontario CANADA
6	ELSA	Telefunken TR440	Assembly	100 K	48	500 positions	— —	Ludwig Zagler	Technischen Universitat Munchen WEST GERMANY	Technischen Universitat Munchen Munich WEST GERMANY
6	MASTER	IBM 370/168	PL/I	170 K	32	450 variations	100,000	J A Birmingham Peter Kent	Rutherford Lab and AERE Harwell, Oxfordshire UK	AERE Harwell UK
6	WITA	AMDAHL 470 V/6	ALGOL W	350 K	32	9,000 positions	250	Tony Marsland	University of Alberta Edmonton, Alberta CANADA	University of Alberta Edmonton, Alberta CANADA
11	BCP	CDC 6400	FORTRAN and Assembly	24 K	60	1,000 positions	1,000 per second	Don Beal	Queen Mary College London ENGLAND	McMaster University Hamilton, Ontario CANADA
11	BLITZ V	XEROX SIGMA 9	FORTRAN	24 K	32	5,000 positions	500	Robert Hyatt	University of Southern Mississippi Hattiesburg MS	University of Southern Mississippi Hattiesburg MS
11	CHUTE 1.2	AMDAHL 470 V/6	BPL (Extended XPL)	250 K	32	45 variations	900	Mike Valenti Zvonko Vranesic	University of Toronto Toronto, Ontario CANADA	Industrial Life Technical Services (IST) Montreal, Quebec CANADA
11	OSTRICH	Data General Supernova	Assembly	20 K	16	NO BOOK	10,000	Monroe Newborn George Arnold	McGill University Montreal, Quebec CANADA	At tournament site.
15	BS'66'76	IBM 370/168	FORTRAN	200 K	32	1,000 positions	150	Barend Swets	Private entry Tilborg NETHERLANDS	Datacrown Limited Toronto, Ontario CANADA
16	TELL	DEC KI10	ALGOL 60	15 K	36			Johann Joss	Eidgenossische Technische Hochschule Zurich SWITZERLAND	Dataline Systems Toronto, Ontario CANADA

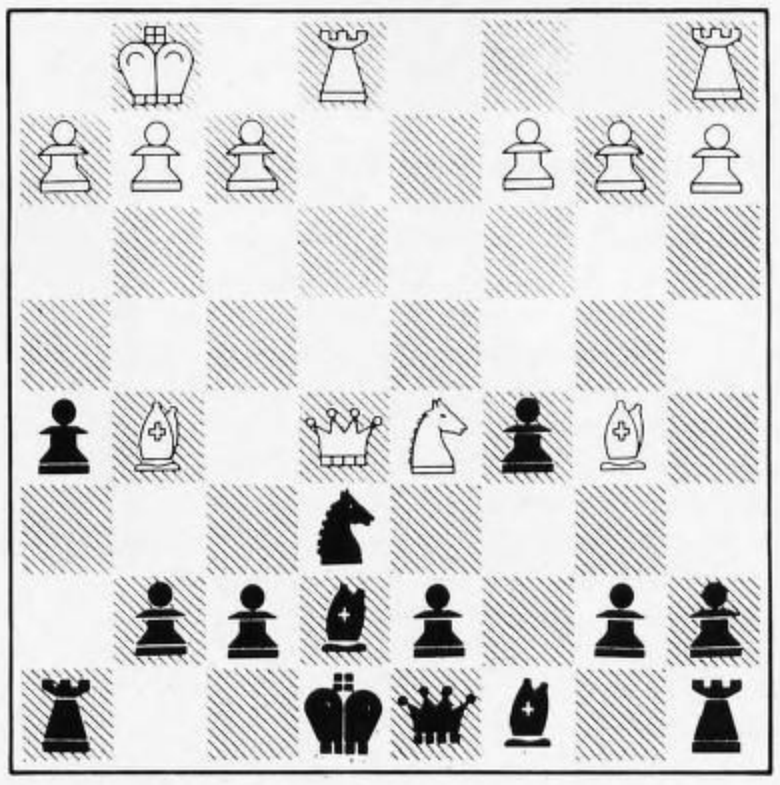
Table 2: Technical characteristics of contestants. This table lists the major characteristics and source of each program entered into the Second World Computer Chess Championships. A total of 33 people were actively involved in the design and programming of the 16 programs entered in the contest; while no personally owned microcomputers were entered in the 1977 championships, we expect some future editions of the contest to include contestants from the world of personal computers.

White: KAISSA Black: TELL

1.	P-K4	P-K4
2.	N-KB3	N-QB3
3.	B-N5	N-B3

The Berlin defense. As Fred Reinfeld pointed out, "The drawback of this once popular defense is that it leads to a weak pawn position for Black."

4.	O-O	NxP
5.	P-Q4	NxP
6.	NxN	PxN
7.	QxP	N-B4
8.	R-K1ch	N-K3
9.	N-QB3	P-QB4
10.	Q-K5	P-KR4?
11.	N-Q5	B-K2
12.	B-N5?	. . .



Position after 12. B-N5.

Game 2: The shortest game of the tournament was KAISSA's defeat of TELL in the second round.

12.	. . .	Q-R4
13.	BxB	P-QN3?
14.	QxNP	R-R3
15.	Q-N8ch	N-B1
16.	QxN mate	

play, only two programs, CHESS 4.6 and DUCHESS, had two wins to their credit. These two programs played each other in the third round. After a hard fought 50 move game, CHESS 4.6 extended its winning streak to three games.

Throughout the tournament, the moves of the OSTRICH program were punctuated by the familiar clatter of Monroe Newborn's ASR 33 Teletype, audible to the entire audience. On the sixteenth move of his game against BLACK KNIGHT, the Teletype began to clatter madly. It was obviously in an open loop. The cover was removed, and an urgent call was made for any ASR 33 experts in the audience. Unable to continue play, OSTRICH was forced to resign from the game. Later it was learned that, although the Teletype was making the noise, the fault lay with the serial IO interface of the minicomputer, and not with the terminal.

Problems were not confined to the on site minicomputer. In the final round of play, CHESS 4.6 was matched with BELLE, running on a PDP-11 located at the Bell Telephone Laboratories in Murray Hill NJ. The game was interrupted for several minutes because BELLE was experiencing communications difficulties.

An interesting aspect of the BELLE system was the use, for the first time, of a microprogrammed hardware move generator added to the PDP-11. This feature allowed a much faster generation of positions for analysis and is thought by many to be the route to better chess playing computers. In this case, it was not enough. After 52 moves, CHESS 4.6 mated BELLE to win the game, and the tournament.

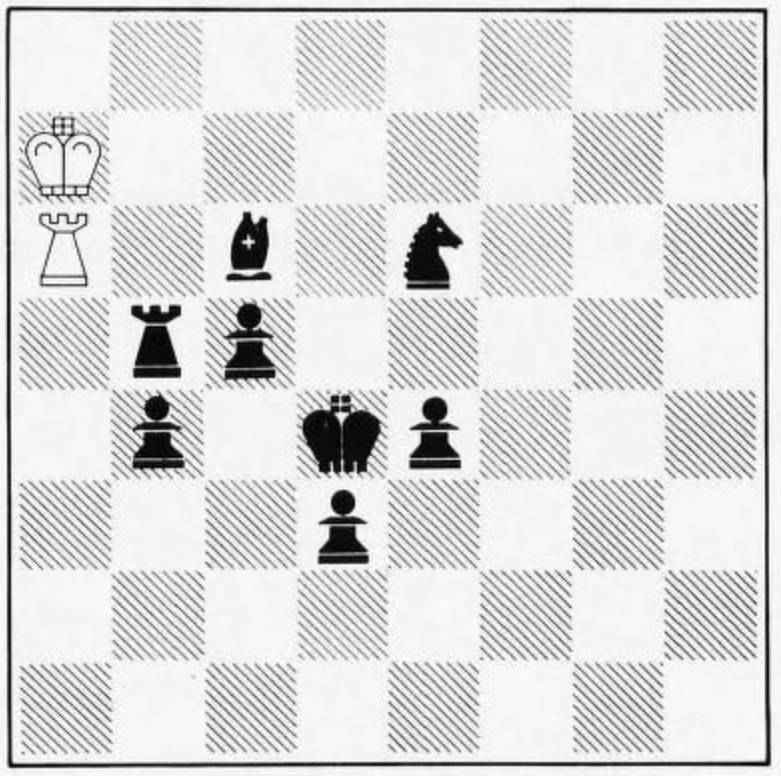
The final results, shown in table 2, show that CHESS 4.6 was the undisputed champion with four wins, KAISSA and DUCHESS tied for second with three wins each, and CHAOS and BELLE tied for third with two wins and a draw each.

Prizes of another sort went to the following programmers and their programs:

1. One programmer inserted (just for fun) a message into his program to print "POSSIBLE MATE IN x MOVES" each time a mate threat was discovered in the analysis. When the position became dangerous during round 1, the number of possible mate threats became enormous. The programmer was unable to interrupt the program as it listed page after page of possible mate combinations in 2, 3, 4, . . . 16 moves. As a result, the opponent's move could not be entered and the game was lost due to a time forfeit. None of the mate threats were irrefutable. By round 2, the message had been removed.
2. A bug in another program was not a new one. It had been in the program for nearly ten years. Unable to locate the exact cause of a fatal run time error which occurred sporadically during the program execution, the programmer devised a subtle solution to prevent the program from abending during a game by trapping the error code before the operating system could react to it and initiating an error recovery routine which would restart the program and skip the error prone analysis. A message was directed to the line printer to inform the programmer that the recovery routine had been called. This procedure had allowed the program to compete successfully in several tournaments without a single fatal abend. During

Game 3: The final game of the tournament was BELLE versus CHESS 4.6, listed here.

	White: BELLE	Black: CHESS 4.6
1.	P-K4	N-QB3
2.	N-KB3	P-K3
3.	P-Q4	P-Q4
4.	N-B3	B-N5
5.	P-K5	N/1-K2
6.	P-QR3	BxNch
7.	PxB	N-R4
8.	B-N5ch	B-Q2
9.	B-Q3	R-QB1
10.	N-N5	P-KR3
11.	N-B3	P-QB4
12.	PxP	RxP
13.	B-K3?	RxP
14.	BxQRP	N-B5
15.	O-O	RxRP
16.	RxR	NxR
17.	B-QB5	Q-R4
18.	B-Q6	N-B5
19.	Q-R1	N-B3
20.	QxQ	N/3xQ
21.	R-R1	B-B1
22.	P-B3	N-B3
23.	R-R4	NxB
24.	PxN	K-Q2
25.	R-KN4	P-KN4
26.	B-B2	KxP
27.	R-QR4	P-N4
28.	R-R1	P-QN5
29.	PxP	NxP
30.	B-N1	B-Q2
31.	K-R1?	P-B4
32.	N-Q4	R-QB1
33.	N-K2?	B-N4
34.	N-N1	R-B8
35.	R-R5	RxB
36.	P-B3?	B-B8
37.	P-R4?	R-N7
38.	PxP	BxPch
39.	K-R2	PxP
40.	R-R4?	BxPch
41.	K-N3	B-R4
42.	K-R3?	P-B5
43.	R-R8	B-N3
44.	K-N4	R-N7ch
45.	K-R3	RxN
46.	K-R2	R-N5
47.	R-Q8ch?	K-K4
48.	R-KN8?	B-K5
49.	R-N7?	B-B6
50.	R-KR7	N-Q6
51.	R-R3?	. . .



Position after 51. R-R3?

51.	. . .	R-N7ch
52.	K-R1	N-B7mate

round 1, the error recovery routine was called three times. In round 2, it was called ten times; in the third round, 20 times. But in round 4, the position of the game somehow triggered a tight loop around the patched code. The run time error was triggered 800,000 times. The error recovery routine was called 800,000 times, and 800,000 lines of printed output awaited the programmer at the data center the next day. The program did not abend, but it also did not win. It probably spent most of its time in the error recovery routines.

The standard of play evidenced by the programs competing in this tournament shows considerable improvement over that demonstrated three years ago in Stockholm at the First World Computer Chess Championships. Still, no program available at this time is capable of defeating a master ranked player in regular play. Room for improvement still lies in the need for the incorporation of long range plans into the computer chess algorithms. This is an aspect of chess play which is vital to good human strategy and yet completely lacking from all conventional computer chess programs.

Also needed are some fundamental improvements in the end game play of the programs. Most of the current algorithms suffer the consequences of the "horizon effect," a term coined to describe the blunders made when a program fails to see threats or opportunities one or more levels below the maximum number of plies it has searched. This is a particular problem in end game strategy, where short term heuristics are not necessarily relevant to the winning combination.

Current advances in artificial intelligence, pattern recognition and multiprocessors are likely to enable significant improvements in the chess ability of future computer systems over the next few years. It is now quite conceivable that master level play will be achieved within this decade, and yet it is still entirely possible (if not probable) that grand master play will not be achieved in this century.■

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