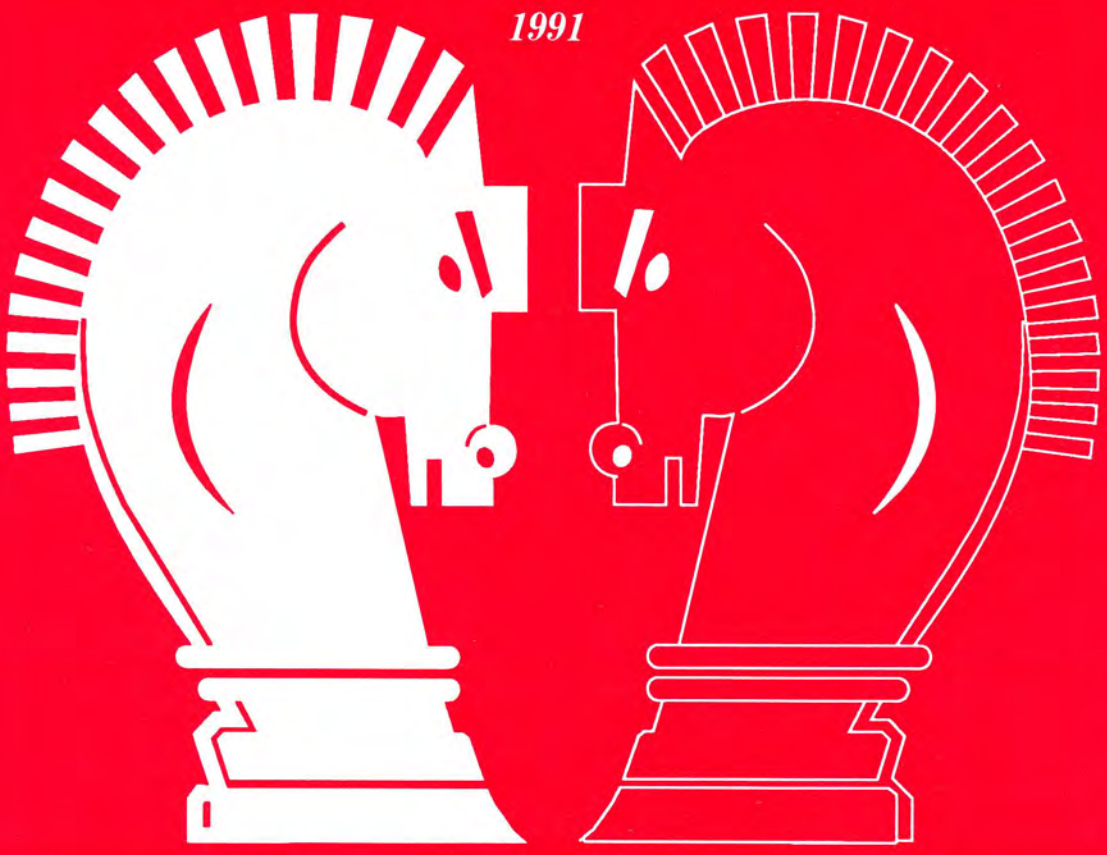
THE 22nd ANNUAL

ACM International Computer Chess Championship

Doubletree Hotel
Albuquerque, New Mexico
November 17-20
1991



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The 22nd ACM International Computer Chess Championship

Albuquerque, New Mexico
November 17-20, 1991
A Special Event at the Supercomputing '91 Conference

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1970 New York: CHESS 3.0.....1971 Chicago: CHESS 3.0.....1972 Boston: CHESS 3.0.....
.....1973 Atlanta: CHESS 3.5.....1974 San Diego: RIBBIT.....1975 Minneapolis: CHESS 4.4..
..1976 Houston: CHESS 4.5.....1977 Seattle: CHESS 4.6.....1978 Washington: BELLE.....
....1979 Detroit: CHESS 4.9.....1980 Nashville: BELLE.....1981 Los Angeles: BELLE.....
..1982 Dallas: BELLE.....1983 New York: CRAY BLITZ.....1984 San Fransisco: CRAY BLITZ.....
.....1985 Denver: HITECH.....1986 Dallas: BELLE.....1987 Dallas: CHIPTEST-M.....
.....1988 Orlando: DEEP THOUGHT.....1989 Reno: HITECH and DEEP THOUGHT (Tied for 1st Place)
.....1990 New York: MEPHISTO and DEEP THOUGHT (Tied for 1st Place)

Welcome and Overview

When will a computer defeat the human world chess champion? Will it be next year, by the year 2000 or will it take much longer. It's not clear to most of us, but the 22nd ACM International Computer Chess Championship should shed some light on this question. What is clear is that the best programs are now playing at the Grandmaster level. With greater computer speeds on the immediate horizon, with improved approaches to parallel search and with continued refinement of the process of encoding chess knowledge efficiently into a search program, there is no reason not to expect significant improvement in the near future.

The strength of the participants in this year's tournament is quite remarkable. The authors of the programs all submitted rating for their programs in their entry forms and the "weakest" rating was submitted by BEBE's programmers. They rated their program as an Expert at 2150. The fourteen participants include the current would champion DEEP THOUGHT II as well as a number of other programs playing near the Grandmaster level: HITECH, MEPHISTO, CHESS MACHINE/SCHROEDER. Last year's ACM championship ended in a tie between DEEP THOUGHT/88 and MEPHISTO.

The size of the trees searched by the programs continues to grow. This year DEEP THOUGHT II will search approximately 5,000,000 chess positions per second while the new multiprocessor program HIERTECH will search approximately 2,000,000 chess positions per second while running on the new THINK CM-5 computer. Two CRAY computers will participate, four programs will run on multiprocessors, and four programs will compete using simple microcomputers.

The rules of the tournament were changed las year so that all games would last at most four hours. Each side was given two hours of playing time. While such a format is fine for human games, at this current time in history, the mechanics of entering moves into the computers requies too much time when moves must be made in several seconds or even less. Furthermore, the rules for deciding upon how and when to terminate games must be established very carefully. Thus, this year the format has returned to the usual 40 moves in two hours and 20 moves per hour thereafter. Hpoefully, the games will not continue into the early hours of the mornings.

Robert Levinson, of the University of California at Santa Cruz, will give a demonstration of a chess program that learns. His demonstration will be in the tournament hall and run for the length of the championship.

The ACM Computer Chess Committee has invited Professor Jaap van den Herik to attend the championship as our Honoured Guest. Jaap is currently the Editor of the Journal of the International Computer Chess Association, the leading journal devoted to the subject of computer chess. It is quite likely the most important chess journal as well. Jaap is a professor of computer science at the University of Limburg in the Netherlands. His programs competed successfully in a number of major tournaments in the 1980's, including the 1980, 1983 and 1986 world championships.

Mike Valvo will serve as Tournament Director. Mike has served in this capacity for a decade. As one of America's leading players, one of its best blindfold players, and as a consultant in the computer field, Mike combines the two areas needed to take command of this event.

Attending the championship will be the two best junior high school chess teams in America. Adam Clayton Powell Junior High School from New York and Masterson Junior High School from Philadelphia finished in a tie earlier this year for the junior high school championship of the United States. They will play a match with one another on Sunday beginning at 3:00 PM to resolve the tie.

The Awards Presentation will be held on Thursday at Noon. At that time the trophies and the $8000 in prizes will be awarded. In addition, the winner of the 1990-91 MEPHISTO AWARD for the paper that makes the biggest contribution to computer chess during this time period will be announced.

We would like to thank Supercomputing '91 for including us on their program. This is the fourth year that we have been a part of their program. We would also like to thank IBM for their partial support of this event. Don Nowak and Jim Adams of the ACM deserve a special thanks for their help with the arrangements. Jim, of course, has helped out for 22 years!

We wish all the competitors the best of luck. For the audience, we point out (for the second year running) that those commenting on the games sound more and more like weather forecasters every year.

Monty Newborn
Chairman
ACM Computer Chess Committee

Hans Berliner
Tony Marsland
Kathe Spracklen
Ken Thompson
Committee Members

Important Times and Places

1. Schedule of Rounds

Round 1:	1:00 PM	Sunday	November 17
Round 2:	7:30 PM	Sunday	November 17
Round 3:	7:00 PM	Monday	November 18
Round 4:	7:00 PM	Tuesday	November 19
Round 5:	7:00 PM	Wednesday	November 20

Note: all participants must attend a meeting at 12:00 noon on the 17th at which time the rules will be finalized.

2. **Playoff for US Junior High School Championship:** Sunday November 17, 3:00 PM. Adam Clayton Powell JHS, New York versus Masterson JHS, Philadelphia.

3. **Experiment in machine learning:** given by Robert Levinson, beginning Sunday November 17 through Wednesday November 20.

4. **ICCA Meeting** Monday November 18, 6:00-7:00 PM.

5. **ACM Computer Chess Committee Meeting** Tuesday November 19, 12:00-12:45 PM.

6. **Panel Discussion: Where is computer chess going?** Wednesday November 19, 3:30-5:00 PM. Chair: Tony Marsland.

7. **Going away wine and cheese party for the participants:** Wednesday following the final round.

8. **Awards Presentation:** Thursday November 21, 12:00 PM.

Awards:	First Place.....	$4000 and Trophy
	Second Place.....	$2000 and Trophy
	Third Place.....	$1000 and Trophy
	Best Small Computing System.....	$1000 and Trophy
	Mephisto Award	

Tournament Director: Mike Valvo.

Tournament Officials: Monty Newborn, Tony Marsland and Danny Kopec.

Note: All activities will take place in the Doubletree Ballroom.

Information on Participants

BEBE	Tony Scherzer and Linda Scherzer, SYS-10 Inc., 2117 Stonington Avenue, Hoffman Estates, Illinois 60195.
BP	Robert D. Cullum, PO Box 111, Prospect Heights, Illinois 60070.
CHESS MACHINE/ SCHROEDER	Ed Schroeder, Jan Loumann, c/o JL, Bing Crosby Street #5, 3069 XN, Rotterdam, The Netherlands.
CRAY BLITZ	Robert Hyatt, Harry Nelson, Albert Gower, c/o RH, Computer and Information Science Department, Campbell Hall, University of Alabama at Birmingham, Birmingham, Alabama, 35124.
DEEP THOUGHT II	Feng-hsiung Hsu, Murray Campbell, (with contributions from Joe Hoane and Jerry Brody), c/o FH, IBM T. J. Watson Research Center, PO Box 704, Yorktown Heights, NY 10598.
DELICATE BRUTE	Don Beal, Department of Comp. Science, Queen Mary & Westfield College, University of London, Mile End Rd, London E1 4N5 England.
HIERTECH	with involvement from (in alphabetical order):Hans Berliner, Mark Bromley, Richard Karp, Bradley Kuzmaul, Charles Leiserson, Chris McConnell, David Slate, Guy Steele, Kurt Thearling, Richard Title, David Waltz, and Skef Wholey., c/o HB, Dept. of Computer Science, Carnegie-Mellon Univ., Pittsburgh, PA 15213.
HITECH	Carl Ebeling, Hans Berliner, Chris McConnell, c/o HB, Dept. of Computer Science, Carnegie-Mellon Univ., Pittsburgh, PA 15213.
LACHEX	Tony Warnock, Burton Wendroff, c/o BW, MS 284, Los Alamos National Laboratory, Los Alamos, New Mexico 87544.
M CHESS	Marty Hirsch, M CHESS, PO Box 9388, San Fafael, California, 94912.
MEPHISTO	Richard Lang, 31 Clifton Road, Poole, Dorset, BH14 9PW, England.
QUESTX	Hans Morsch and Don Maddox, c/o DM, ChessBase USA, 75 Main Street, Manasquan, NJ, 08736.
SOCRATES	Don Dailey, Larry Kaufman, Mark Leski, c/o Julio Kaplan, Heuristic Software, 2550 Nineth Street, #204, Berkeley, CA 94710.
ZARKOV	John Stanbeck, 4237 Cape Cod Circle, Ft. Collins, Colorado 80525.

Computing System Information

Program	Computing system,language, etc. (* indicates computer at site)	Nodes/ sec.	Rating estimate
BEBE	SYS-10 Chess Engine, assmbler, special-purpose chess circuitry, 64Kb, 16 bits,10 mips, 3 Meg hash table.*	40000	2150
BP	486/33 Clone, C & assmebler, 20 Mips, 4 Meg, 32 bits, 1 Meg hash table.* (Highly selective search)	1600	2250
CHESS MACHINE/ SCHROEDER	ARM-2 Risc Processor (Archimedas) 31 mhertz*	NA	NA
CRAY BLITZ	Cray YMP-8, Fortran+C+assembler 1330 Mips, 64 Mw, 64 bits, 8 processors 60 Megaword hash table, (Cray Research Comp Center, Eagen MN).	200K-500K	2200+
DEEP THOUGHT II	RS/6000 550 (host) & 24 custom chess processors C+microassembler, 44 mips (host), 192 Mbytes (host) 32 bits (host), 2 million entry hash table (IBM T. J. Watson Research Center, Hawthorne, NY).	5M	2550+
DELICATE BRUTE	SUN 4 (or equivalent) unclear at this time	6K	2200
HIERTECH	CM-5 Multiprocessor (512 or 1024 processors) 40 * #Proc Mips, 8Meg * #Proc , 32 bits 128K * #Proc hash table (New Mexico)	2M	NA
HITECH	SUN 4 with special chess hardware, microcode + assembler, 1 M hash table, (Carnegie-Mellon University).	100K	2400
LACHEX	CRAY YMPZE, FORTRAN + Assembler 4 million position hash table	50K	2328
M CHESS	IBM PC or clone, 80486, C + Assembler 5 mips, 640Kbytes, 32 bits, 16K position hash table*	5K	2450
MEPHISTO	68030 Mephisto machine, assmbler 128K ROM, 32bit, 45 mh.,1M hash table.*	10K	2350
QUESTX	IBM PC or clone 486, 33 Mhz	NA	NA
SOCRATES	IBM PC or clone, 486 33 Mhz or 50 Mhz	NA	NA
ZARKOV	HP 9000/732, C 67 mips, 32 Meg, 32 bits, 64K position hash table (HP, Fort Collins, Colorado)	10K	2400

Score Table

Team	Rounds 1	2	3	4	5	Total Points	Final Place
1. BEBE							
2. BP							
3. CHESS MACHINE/ SCHROEDER							
4. CRAY BLITZ							
5. DEEP THOUGHT II							
6. DELICATE BRUTE							
7. HIERTECH							
8. HITECH							
9. LACHEX							
10. M CHESS							
11. MEPHISTO							
12. QUESTX							
13. SOCRATES							
14. ZARKOV							

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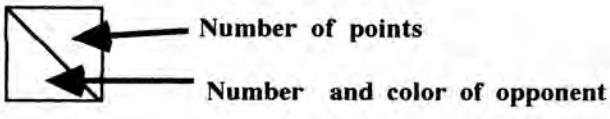

Tournament Rules

1. Each entry is a computing system and one or more human operators. A listing of all chess-related programs running on the system must be available on demand to the TD. Each entry requires at least one full-time operator (i.e., one operator cannot assist with more than one entry).

2. Participants are required to attend an orgaizational meeting at 12 noon on November 17 for the purpose of officially registering for the tournament. Rules will be finalized at that meeting.

3. The tournament is a five round Swiss style tournament. The first and second rounds will be played Sunday November 17 at 1:00 PM and 7:30 PM respectively. The third round is scheduled for Monday, November 18 at 7:00 PM, the fourth round for Tuesday November 19 at 7:00 PM, and the final round for Wednesday November 20 at 7:00 PM.

4. Trophies and prizes will be awarded to the first three finishers. The order of finish will be determined by the total number of points earned. If two or more teams have an equal number of points, they will be considered as tied, and the trophies and prizes divided accordingly. A prize of $4000 will be awarded to the program which finishes the tournament with the most points, $2000 to the second most, and $1000 to the third most. A trophy and $1000 prize will be awarded to the "Best Small Computing System."

5. Unless otherwise specified, rules of play are identical to those of "human" tournament play. If a point is in question, the TD has the right to make the final decision.

6. Games are played at a speed of 40 moves per player in the first two hours and 20 moves per player per hour thereafter.

7. The TD has the right to adjudicate a game after six hours of total clock time. The adjudication will be made on the premise that perfect chess will be played by both sides from the final position. Every effort will be made by the TD to avoid adjudication. In particular, the second round will not begin until 8:00 p.m. on Sunday, if necessary to avoid adjudicating a first-round game. A game will be adjudicated in the final round after 8 hours of play if it can be established that the result of the game has no bearing on the order of the top three finishers.

10. An operator may ask that the TD stop the clock at most twice during the course of a game because of technical difficulties. The clock must be restarted each time after at most 15 minutes. If an operator using a remote computer can clearly establish that his problems are not in his own computing system but in the communication network, the TD can permit additional time-outs.

11. If a program experiences technical difficulties, the operator can ask the TD for permission to restart the program. When restarting a program after a failure of any kind, the operator must reset all parameters to their values at the time the game was interupted. An operator error made when starting a game or in the middle of a game can be corrected only with the approval of the TD.

12. If an operator types in an incorrect move, the TD must be immediately notified. Both clocks will be stopped. The game must then be backed up to the point where the error occurred. The TD will back up the clocks to their settings when the error occurred using whatever information is available. Both sides may adjust program parameters after such an error with the approval of the TD. The TD may not allow certain parameters to be changed, e.g., the contempt factor.

13. Terminals located at the tournament site must communicate directly with remote computers, i.e., there cannot be any human intermediary at the remote location.

14. Each team that uses a terminal must position the terminal on the game table in such a way that the opponent has a good view of it. An operator can only (1) type in moves and (2) respond to request from the computer for clock information. If an operator must type in any other information, it must be approved ahead of time by the TD. (This might happen if there is noise on the communication line and, for example, a CR must be typed to clear the line.) The operator cannot querry the system to see if it alive without permission of the TD.

15. A team must receive the approval of the TD to change from one computing system to another.

16. Each game is officially played on a chess board provided by the Tournament Committee. The official clock is also provided by the Tournament Committee.

17. At the end of each game, each team is required to turn in a game listing to the TD.

History of Major Tournaments

ACM North American Computer Chess Championships

Year	City	Winner	Runner-up
1970	New York	CHESS 3.0; Slate, Atkin, Gorlen, CDC 6400	DALY CHESS PROGRAM; Daly,King, Varian 620/i
1971	Chicago	CHESS 3.5; Slate, Atkin, Gorlen, CDC 6400	TECH; Gillogly, PDP 10
1972	Boston	CHESS 3.6; Slate, Atkin, Gorlen, CDC 6400	OSTRICH; Arnold, Newborn, DG Supernova
1973	Atlanta	CHESS 4.0; Slate, Atkin, Gorlen, CDC 6400	TECH II; Baisley, PDP 10
1974	San Diego	RIBBIT; Hansen, Crook, Parry, Honeywell 6050	CHESS 4.0; Slate, Atkin, CDC 6400
1975	Minneapolis	CHESS 4.4; Slate, Atkin, CDC Cyber 175	TREEFROG; Hansen, Calnek, Crook, Honeywell 6080
1976	Houston	CHESS 4.5; Slate, Atkin, CDC Cyber 176	CHAOS; Swartz, Berman, ALexander Ruben, Toikka, Winograd, Amdahl 470
1977	Seattle	CHESS 4.6; Slate, Atkin, CDC Cyber 176	DUCHESS; Truscott, Wright, Jensen, IBM 370/168
1978	Washington	BELLE; Thompson, Condon, PDP 11/70 with chess hardware	CHESS 4.7; Slate, Atkin, CDC Cyber 176
1979	Detroit	CHESS 4.9; Slate, Atkin, CDC Cyber 176	BELLE; Thompson, Condon, PDP 11/70 with chess hardware
1980	Nashville	BELLE; Thompson, Condon, PDP 11/70 with chess hardware	CHAOS; Alexander, O'Keefe, Swartz, Berman, Amdahl 470
1981	Los Angeles	BELLE; Thompson, Condon, PDP 11/23 with chess hardware	NUCHESS; Blanchard, Slate, CDC Cyber 176
1982	Dallas	BELLE; Thompson, Condon, PDP 11/23 with chess hardware	CRAY BLITZ; Hyatt, Gower, Nelson, Cray 1

1983 Not held as the ACM NACCC that year but as the Fourth World Championship. See World Championships.

1984	San Fransisco	CRAY BLITZ; Hyatt, Gower, Nelson, Cray XMP/4	BEBE; Scherzer, Chess Engine, and FIDELITY EXPERIMENTAL; Sparcklen, Spracklen, Fidelity machine
1985	Denver	HITECH; Ebeling, Berliner, Goetsch, Paley Campbell, Slomer, SUN w/ chess hardware	BEBE; Scherzer, Chess engine

1986 Dallas	BELLE; Thompson, Condon, PDP 11/23 with chess hardware	LACHEX; Wendroff, Cray X-MP
1987 Dallas	CHIPTEST-M; Anantharaman, Hsu Campbell, SUN 3 with VLSI chess hardware	CRAY BLITZ; Hyatt, Nelson, Gower Cray XMP 4/8
1988 Orlando	DEEP THOUGHT 0.02; Hsu Anatharaman, Browne, Campbell, Nowatzyk, SUN 3 w/ VLSI circuitry	CHESS CHALLENGER EXP; Spracklen, Spracklen, Nelson, Fidelity machine with Motorola 68030 microprocessor
1989 Reno	HITECH*; Ebeling, Berliner, Goetsch, Paley, Campbell, Slomer, SUN w/ chess hardware (* denotes 1st-place tie)	DEEP THOUIGHT*; Hsu, Anantharaman, Browne, Campbell, Nowatzyk, 3 SUN 4s w/ VLSI chess hardware
1990 New York	DEEP THOUGHT/88; Hsu, Anantharaman, Jensen, Campbell, Nowatzyk, SUN 4 with two special VLSI chess circuits	MEPHISTO; Lang, 68030 microprocessor MEPHISTO machine

World Championships

Year City	Winner	Runner-up
1974 Stockholm	KAISSA; Donskoy, Arlazarov, ICL 4/70	CHESS 4.0; Slate, Atkin, CDC 6600
1977 Toronto	CHESS 4.6; Slate, Atkin, CDC Cyber 176	DUCHESS; Truscott, Wright, Jensen, IBM 370/165
1980 Linz	BELLE; Thompson, Condon, PDP 11/23 with chess circuitry	CHAOS; Alexander, Swartz, Berman O'Keefe, Amdahl 470/V8
1983 New York	CRAY BLITZ; Hyatt, Gower, Nelson, Cray XMP 48	BEBE; Scherzer, Chess engine
1986 Cologne	CRAY BLITZ; Hyatt, Gower, Nelson, Cray XMP	HITECH; Berliner, et al., SUN workstaton with chess circuitry
1989 Edmonton	DEEP THOUGHT; Hsu, Anantharaman Browne, Campbell, Jansen, Nowatzyk, SUN with VLSI chess hardware	BEBE; Scherzer, Scherzer, Chess Engine

World Microcomputer Championships

Year City	Winner	Runner-up
1980 London	CHESS CHALLENGER	BORIS EXPERIMENTAL
1981 Travemunde	FIDELITY X	CHESS CHAMPION MARK V
1983 Budapest	ELITE A/S	MEPHISTO X
1984 Glasgow	Four way tie: ELITE X, MEPHISTO S/X, PRINCHESS, PSION CHESS	
1985 Amsterdam	MEPHISTO AMSTERDAM I	MEPHISTO AMSTERDAM II
1986 Dallas	MEPHISTO DALLAS 3	FIDELITY "2533"
1987 Rome	MEPHISTO	CYRUS 68K
1988 Almeria	MEPHISTO	FIDELITY
1989 Portoroz	MEPHISTO	FIDELITY
1990 Lyons	MEPHISTO	Tie: ECHEC 1.9 & GIDEON
1991 Vancouver	Tie: MEPHISTO & GIDEON	

A SHORT HISTORY OF COMPUTER CHESS PROGRAMS†

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Background

Of the early chess-playing machines the best known was exhibited by Baron von Kempelen of Vienna in 1769. As might be expected, they were all conjurer's tricks and grand hoaxes, as Bell [1978] and Levy & Newborn [1982] explain. In contrast, around 1890 a Spanish engineer, Torres y Quevedo, designed a true mechanical player for KRK (king and rook against king) endgames. A later version of that machine was displayed at the Paris Exhibition of 1914 and now resides in a museum at Madrid's Polytechnic University [Levy & Newborn 1982]. Despite the success of this electro-mechanical device, further advances on chess automata did not come until the 1940s. During that decade there was a sudden spurt of activity as several leading engineers and mathematicians, intrigued by the power of computers, began to express their ideas about computer chess. Some, like Tihamer Nemes of Budapest [Nemes 1951] and Konrad Zuse of Germany [Zuse 1945], tried a hardware approach, but their computer-chess works did not find wide acceptance. Others, like noted scientist Alan Turing, found success with a more philosophical tone, stressing the importance of the stored program concept [Turing *et al.* 1953].[1] Today, best recognized are Adriaan de Groot's 1946 doctoral dissertation [de Groot 1965] and the much referenced paper on algorithms for playing chess by Claude Shannon [1950]. Shannon's inspirational work was read and re-read by computer-chess enthusiasts, and provided a basis for most early chess programs. Despite the passage of time, that paper is still worthy of study.

Landmarks in Chess Program Development

The first computer-chess model in the 1950s was a hand simulation [Turing *et al.* 1953]. Programs for subsets of chess followed [Kister *et al.* 1957] and the first full working program was reported in 1958 [Bernstein *et al.* 1958]. By the mid 1960s there was an international computer-computer match, later reported by Mittman [1977], between a program backed by John McCarthy of Stanford (developed by Alan Kotok and a group of students from MIT) and one from the Institute for Theoretical and Experimental Physics (ITEP) in Moscow [Adelson-Velsky *et al.* 1970]. The ITEP group's program won the match, and the scientists involved went on to develop *Kaissa*,[2] which became the first World Computer Chess Champion in 1974 [Hayes & Levy 1976]. Meanwhile there emerged from MIT another program, *Mac Hack Six* [Greenblatt *et al.* 1967], which boosted interest in artificial intelligence. Firstly, *Mac Hack* was demonstrably superior not only to all previous chess programs, but also to most casual chess players. Secondly, it contained more sophisticated move-ordering and position-evaluation methods. Finally, the program incorporated a memory table to keep track of the values of chess positions that were seen more than once. In the late 1960s, spurred by the early promise of *Mac Hack*, several people began developing

† This article is a slightly revised version of the chapter "A Short History of Computer Chess", in T.A. Marsland and J. Schaeffer (eds.), *Computers, Chess, and Cognition*, Springer-Verlag, New York, 1990.

[1] The chess portion of that paper is normally attributed to Turing, the draughts (checkers) part to Strachey, and the balance to the other co-authors.

[2] Descriptions of *Kaissa*, and older chess programs not discussed here, can be found elsewhere, e.g., in the books by Hayes & Levy [1976], and by Welsh & Baczynskyj [1985].

chess programs and writing proposals. Most substantial of the proposals was the twenty-nine point plan by Jack Good [1968]. By and large experimenters did not make effective use of these works; at least nobody claimed a program based on those designs, partly because it was not clear how some of the ideas could be addressed. Even so, by 1970 there was enough progress that Monroe Newborn was able to convert a suggestion for a public demonstration of chess-playing computers into a competition that attracted eight participants [Newborn 1975]. Due mainly to Newborn's careful planning and organization this event continues today under the title "The ACM International Computer Chess Championship."[3]

World Computer Chess Championships

In a similar vein, under the auspices of the International Computer Chess Association, a worldwide computer-chess competition has evolved. Initial sponsors were the IFIP triennial conference at Stockholm in 1974 and Toronto in 1977, and later independent backers such as the Linz (Austria) Chamber of Commerce for 1980, ACM New York for 1983, the city of Cologne in West Germany for 1986 and AGT/CIPS for 1989 in Edmonton, Canada. In the first World Championship for computers *Kaissa* won all its games, including a defeat of *Chaos* program that had beaten the favorite, *Chess 4.0*. An exhibition match between the new champion, *Kaissa*, and the eventual second place finisher, *Chess 4.0* the 1973 North American Champion, was drawn [Mittman 1977]. *Kaissa* was at its peak, backed by a team of outstanding experts on tree-searching methods [Adelson-Velsky *et al.* 1988]. In the second Championship at Toronto in 1977, *Chess 4.6* finished first with *Duchess* and *Kaissa* tied for second place. Meanwhile both *Chess 4.6* and *Kaissa* had acquired faster computers, a Cyber 176 and an IBM 370/165 respectively. The exhibition match between *Chess 4.6* and *Kaissa* was won by the former, indicating that in the interim it had undergone far more development and testing [Frey 1983]. The 3rd World Championship at Linz in 1980 finished in a tie between *Belle* and *Chaos*. In the playoff *Belle* won, providing convincing evidence that a deeper search more than compensates for an apparent lack of knowledge. In the past, this counter-intuitive idea had not found ready acceptance in the artificial intelligence community.

At the 4th World Championship (1983 in New York) yet another new winner emerged, *Cray Blitz* [Hyatt *et al.* 1985, 1990]. More than any other, that program drew on the power of a fast computer, here a Cray XMP. Originally Blitz was a selective search program, in the sense that it used a local evaluation function to discard some moves from every position, but often the time saved was not worth the attendant risks. The availability of a faster computer made it possible for *Cray Blitz* to switch to a purely algorithmic approach and yet retain much of the expensive chess knowledge. Although a mainframe program won the 1983 event, small machines made their mark and were seen to have a great future [Levy & Newborn 1982]. For instance, *Bebe* [Scherzer *et al.* 1990] with special-purpose hardware finished second, and even experimental versions of commercial products did well. The 5th World Championship (1986 in Cologne) was especially exciting. At that time *Hitech* [Berliner & Ebeling 1990] seemed all powerful, but faltered in a better position against *Cray Blitz* allowing a four-way tie for first place. As a consequence, had an unknown microprocessor system, *Rebel*, capitalized on its advantages in the final round game, it would have been the first micro-system to win an open championship. Finally we come to the most recent event of this type, the 6th World Championship (1989 in Edmonton). Here the Carnegie Mellon favorite, *Deep Thought* won convincingly, even though the program exhibited several programming errors. Still luck favors the strong, as the full report of the largest and strongest computer chess event ever held shows [Schaeffer 1990]. Although *Deep Thought* dominated the world championship, at the 20th North American Tournament that followed a bare six months later it lost a game against *Mephisto*, and so only tied for first place with its deadly rival and stable-mate *Hitech*.

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[3] Sponsored by the Association for Computing Machinery, New York.

Far and Wide

From the foregoing one might reasonably assume that most computer chess programs have been developed in the USA, and yet for the past two decades Canadian and European participation has also been active and successful. Two programs, *Ostrich* and *Wita*, were at the inauguration of computer-chess tournaments at New York in 1970, and their authors went on to produce fundamental research in parallel game-tree search [Marsland & Campbell 1982] [Newborn 1985] [Marsland & Popowich 1985] [Newborn 1988] Before its retirement, *Ostrich* (McGill University) participated in more championships than any other program. Its contemporary, renamed *Awit* (University of Alberta), had a checkered career as a Shannon type-B (selective search) program, finally achieving its best result with a second place tie at New York in 1983. Other active programs included *Ribbit* (University of Waterloo), which tied for second at Stockholm in 1974. Currently the strongest Canadian program is *Phoenix* (University of Alberta), a multiprocessor-based system using workstations [Schaeffer 1989], which tied for first place with three others at Cologne in 1986.

While the biggest and highest performing computers were being used in North America, European developers concentrated on microcomputer systems. Especially noteworthy are now the Hegener & Glaser products with the *Mephisto* program developed by Richard Lang of England, and the *Rebel* program by Ed Schröder from the Netherlands. An introductory book on how chess programs work has also recently appeared [Levy & Newborn 1991].

The Champion's Road

All this leads to the common question: When will a computer be the unassailed expert on chess? This issue was discussed at length during a panel discussion at the ACM 1984 National Conference in San Francisco. At that time it was too early to give a definitive answer, since even the experts could not agree. Their responses covered the whole range of possible answers with different degrees of optimism. Monty Newborn enthusiastically supported "in five years," while Tony Scherzer and Bob Hyatt held to "about the end of the century." Ken Thompson was more cautious with his "eventually, it is inevitable," but more pessimistic was Tony Marsland who said "never, or not until the limits on human skill are known." Even so, there was a sense that production of an artificial Grandmaster was possible, and that a realistic challenge would occur during the first quarter of the 21st century. As added motivation, Edward Fredkin (MIT professor and well-known inventor) has created a special incentive prize for computer chess. The trustee for the Fredkin Prize is Carnegie Mellon University and the fund is administered by Hans Berliner. Much like the Kremer prize for man-powered flight, awards are offered in three categories. The smallest prize of $5000 was presented to Ken Thompson and Joe Condon, when their *Belle* program earned a US Master rating in 1983. The second prize of $10,000 for the first program to achieve a USCF 2500 rating (players who attain this rating may reasonably aspire to becoming Grandmasters) was awarded to *Deep Thought* [Hsu *et al.* 1990] in August 1989, but the $100,000 for attaining world-champion status remains unclaimed. To sustain interest in this activity, Fredkin funds are available each year for a prize match between the currently best computer and a comparably rated human.

Implications

One might well ask whether such a problem is worth all this effort, but when one considers some of the emerging uses of computers in important decision-making processes, the answer must be positive. If computers cannot even solve a decision-making problem in an area of perfect knowledge (like chess), then how can we be sure that computers make better decisions than humans in other complex domains—especially in domains where the rules are ill-defined, or those exhibiting high levels of uncertainty? Unlike some problems, for chess there are well established standards against which to measure performance, not only through the Elo rating scale but also using standard tests [Kopec & Bratko 1982]

[Marsland 1990] and relative performance measures [Thompson 1982]. The ACM-sponsored competitions have provided twenty years of continuing experimental data about the effective speed of computers and their operating system support. They have also afforded a public testing ground for new algorithms and data structures for speeding the traversal of search trees. These tests have provided growing proof of the increased understanding about how to program computers for chess, and how to encode the wealth of expert knowledge needed.

Another potentially valuable aspect of computer chess is its usefulness in demonstrating the power of man-machine cooperation. One would hope, for instance, that a computer could be a useful adjunct to the decision-making process, providing perhaps a steadying influence, and protecting against errors introduced by impulsive short-cuts of the kind people might try in a careless or angry moment. In this and other respects it is easy to understand Donald Michie's support for the view that computer chess is the "*Drosophila melanogaster* (fruit fly) of machine intelligence" [Michie 1980].

What then has been the effect of computer chess on artificial intelligence (AI)? First, each doubter who dared assert the superiority of human thought processes over mechanical algorithms for chess has been discredited. All that remains is to remove the mysticism of the world's greatest chess players. Exactly why seemingly mechanical means have worked, when almost every method proposed by reputable AI experts failed, remains a mystery for some. Clearly hard work, direct application of simple ideas and substantial public testing played a major role, as did improvements in hardware/software support systems. More than anything, this failure of traditional AI techniques for selection in decision-making, leads to the unnatural notion that many "intellectual and creative" activities can be reduced to fundamental computations. Ultimately this means that computers will make major contributions to Music and Writing; indeed some will argue that they have already done so. Thus one contribution of computer chess has been to force an initially reluctant acceptance of "brute-force" methods as an essential component in "intelligent systems," and to encourage growing use of search in problem-solving and planning applications.

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Deep Thought 88
MEPHISTO
nyc
NEW YORK
Kf2 Rb6 65 R b6 cx
1 Kxh4 Be8 72 Kg4 Bd7+ 73 Kg5 Bh3 74
Rb5 Ra8 55 Rb2 Bf7 56 Kd2 Bh5 57 b6 30 Rc1 Bxd
d2 g5 32 Re3 Rf8 Kxg3 Bh5 51 Kf
Kd3 Bf7 45 Kd2 Be8 46 Ke2 a4
Be8 58 Rb1 Rb5 59 Rb2 Ra8 60 Rb7 Ra8 61 Kd2 Bf7 62 Ke1 Ra6 63 Rb8 Ke7
33 Rxf8+ Kxf8 34 Bc5 Ra8 35 Bb4 Ra8 36 Kd6 40 Rb7 Be8 41 Bg4 h5 42 Bf5 h4 43 a3 Bh5 44
Kh7 23 Bc3 24 Rx b6 fxg 25 Rf6 Be7 26 Rf3 gxf2+ 27 Rxf2 Bg5 28 Rf3 Kg8

THE 21st ACM NORTH AMERICAN Computer Chess Championship

New York, New York
November 11–14, 1990

Monty Newborn, McGill University
Danny Kopec, University of Maine

After twenty years of traveling from city to city across the United States, the ACM North American Computer Chess Championship came back to the place of its birth, the New York Hilton Hotel, where the competitions began in 1970. This latest five-round event ended in a two-way tie for first place between MEPHISTO and DEEP THOUGHT/88. Finishing in a two-way tie for third place were HITECH and M CHESS. A total of 10 teams participated, and the level of play was at the low grandmaster level. A special three-round endgame championship was won by MEPHISTO, who also captured the prize for the best Small Computing System. A total of $8000 in prizes was divided up among the winners.

DEEP THOUGHT/88, currently under development at IBM by researchers Feng-Hsiung Hsu, Murray Campbell, and Thomas Anantharaman along with two former associates at Carnegie Mellon University, Peter Jensen and Andreas Nowatzyk, outplayed MEPHISTO in the third round but lost to HITECH in the next round. It entered the final round of play one-half point behind HITECH, who had won all of its games with the exception of a first-round draw with ZARKOV. DEEP THOUGHT/88 defeated ZARKOV in the final round while HITECH lost on time to MEPHISTO in a dead-drawn game. MEPHISTO won all of its games with the exception of its third-round loss to DEEP THOUGHT/88.

MEPHISTO played solid chess throughout the event, but was fortunate to win its game against HITECH in the final round. MEPHISTO, developed by Richard Lang of Great Britain, is marketed by the German company of Hegener & Glaser A.G. The rules of the tournament required each side to play all of its moves within a two-hour period ensuring that the games would last at most four hours. MEPHISTO played slightly faster than HITECH in the middle game and entered the endgame with approximately five more minutes on its clock. HITECH, who played even with MEPHISTO, was unable to regain the lost time and eventually lost a dead-drawn game on move 145.

The tournament was marred by difficulties. This was the first time the tournament was played during the day, and Bob Hyatt was unable to make the necessary arrangements. DEEP THOUGHT/88 was used by Hsu and company when they found they did not have sufficient time to test out their latest version. ZERKER, a new entry developed by James Testa at the University of California, Berkeley, was forced to withdraw because its SUN computer was damaged on shipping. CRAY BLITZ, a former world champion, had to pass up the event because it was unable to gain access to a CRAY computer.

Ken Thompson's BELLE rejoined the competition after an absence of several years, but was unable to do better than seventh place. BELLE was the world champion program from 1980 to 1983, and was the first program awarded the title of Master by the United States Chess Federation. This title was formally awarded to BELLE in 1983 at the Fourth World Computer Chess Championship by the USCF on the very evening when it was dethroned by NUCHESS in its bid to repeat as world champion. Thompson has made some improvements to BELLE in recent years, but its seventh-place finish shows just how much stronger the programs are today than

ILLUSTRATION: DENNIS AHLGRIM

they were when BELLE was best.

Mike Valvo served as Tournament Director after a one year leave. He will return again as TD when the next championship takes place in Albuquerque, New Mexico on November 17–20, 1991 at Supercomputing '91. For further information on this upcoming event, write to Professor Monty Newborn, Department of Computer Science, McGill University, Montreal, Quebec, CANADA H3A 2A7.

THE MAIN CHAMPIONSHIP

The championship was highlighted by three "heavyweights" in the current world of computer chess: DEEP THOUGHT/88, HITECH, and MEPHISTO. DEEP THOUGHT/88, the reigning World Champion and defending ACM Cochampion, was the favorite with ACM Cochampion HITECH and MEPHISTO, World Microcomputer Champion, closely behind.

The first surprise of the tournament was in Round 1 when ZARKOV drew with HITECH. It was an exceptional case in point where too much opening preparation may have led directly to a program's difficulties. HITECH entered the fourth round with 2.5/3 trailing DEEP THOUGHT/88 3/3 by a half a point. After four rounds it seemed that rating probabilities had finally caught up in HITECH's favor. In its previous three head-to-head tournament encounters with DEEP THOUGHT/88, HITECH had lost (Sixth World Computer Chess Championship in Edmonton, 1989, 19th ACM North American Computer Chess Championship in Orlando, 1988, and 20th ACM North American Computer Chess Championship in Reno, 1989) with a rating difference of about 150 points (DEEP THOUGHT 2551, HITECH, 2413). HITECH would be expected to score in approximately one in four games.

When HITECH won its fourth-round game against DEEP THOUGHT/88, taking over sole possession of first place, the stage was set for the final round MEPHISTO-HITECH showdown. The only legitimate result for this game was a draw. However, due to the relative unfamiliarity of the participants, tournament director, and organizers coupled with the sudden death time control (all moves in 2 hours), the game ended bizarrely. During a meeting of the participants and organizers held just before the tournament began, Hans Berliner, the programmer of HITECH, voted in favor of games being played to the end (until a checkmate, draw, or time forfeit occurs) without intervention from the tournament director. In human chess tournaments with sudden death time controls the tournament director is expected to intervene when it is clear that either side's only hope of winning is on the clock and the chess moves become rather inconsequential.

Thus MEPHISTO finished tied for first with DEEP THOUGHT/88 with 4 points, and HITECH had to settle for a third place tie with M CHESS with 3.5 points.

GAMES FROM THE MAIN EVENT

Round 3, Board 1
White: DEEP THOUGHT/88 vs.
Black: MEPHISTO

In Reno (1989) Mephisto was the first program to ever defeat DEEP THOUGHT/88. Here DEEP THOUGHT/88 and MEPHISTO entered the third round as the only programs with perfect scores and DEEP THOUGHT/88 exacted revenge through straightforward positional pressure.

Here MEPHISTO plays 4 ...Nc6? which quickly lands it in trouble. This error, which incidently DEEP THOUGHT/88 is also prone to, breaks the simple heuristic that in Queen Pawn Openings the Queen Knight should not block the Queen Bishop's Pawn. This error was compounded with 5 ...Bb4+? trading off Black's theoretically better bishop. Without this move, White's Queen's Bishop may become a problem. After 9 ...Na5?! White attained the spatial advantage on the Queenside which was

maintained and exploited throughout the game. DEEP THOUGHT/88's various positional probes on the Queenside led nowhere in particular until they were capped brilliantly with the stroke 32 Nde5+! which led to the gain of a pawn and a winning Knight Ending. DEEP THOUGHT/88 played very logically and consistently by advancing its king to the critical Queenside sector until the decisive breakthrough there became feasible. MEPHISTO's Kingside pawn advances may have eased DEEP THOUGHT /88's task.

1 Nf3 d5 2 e3 Nf6 3 c4 e6 4 Be2 Nc6 5 d4 Bb4+ 6 Bd2 O-O 7 Bxb4 Nxb4 8 a3 Nc6 9 O-O Na5 10 c5 b6 11 b4 Nc6 12 Nc3 bxc5 13 bxc5 Qe7 14 Rb1 Bd7 15 Bb5 Rfb8 16 Qa4 Nd8 17 Bxd7 Nxd7 18 Qa5 Rc8 19 Nb5 a6 20 Nc3 Qf6 21 Rb3 Qg6 22 Rfb1 f6 23 R1b2 h6 24 Kh1 Qd3 25 Ne2 Qd1+ 26 Nfg1 Nc6 27 Qa4 Ndb8 28 Nf4 Kf7 29 Nd3 Rh8 30 Rb1 Qd2 31 Nf3 Qa5 32 Nde5+ fxe5 33 Nxe5+ Kf6 34 Qxa5 Nxa5 35 Rxb8 Rhxb8 36 Rxb8 Rxb8 37 Nd7+ Ke7 38 Nxb8 Nc4 39 Nxa6 Kd8 40 a4 Nb2 41 Kg1 Nxa4 42 Kf1 Kd7 43 f3 Nc3 44 Nb8+ Kc8 45 Nc6 Kd7 46 Ne5+ Ke7 47 Ke1 g5 48 Kd2 Nb5 49 Kc2 Kf6 50 Kb3 Na7 51 Kb4 h5 52 Ka5 Nc8 53 g4 hxg4 54 fxg4

COMPUTING SYSTEM INFORMATION
21st ACM NACCC

Program, Authors	Computing system, language, etc. (*indicates computer at site)	Book size	Nodes/ sec.	Rating estimate
BEBE Tony Scherzer, Linda Scherzer	SYS-10 Chess Engine, assembler, special-purpose chess circuitry, 64Kb, 16 bits, 10 mips, 3Meg hash table*	5K	40K	2150
BELLE Ken Thompson	PDP 11/23, C Special-purpose chess hardware (Bell Laboratories)	400K	150K	2250
DEEP THOUGHT/88 Thomas Anantharaman, Peter Jensen, Murray Campbell, Feng-Hsiung Hsu, Andreas Nowatzyk	1 SUN 4 with two special processors, C+microcode, 1 M hash table, (Carnegie Mellon University)	5K	800K	2551
HITECH Carl Ebeling, Hans Berliner, Gordon Goetsch, Andy Gruss	SUN 4 with special chess hardware, microcode + assembler, 1 M hash table, (Carnegie Mellon University)	NA	100K	2400
M CHESS Marty Hirsch	80386 microprocessor*	NA	NA	NA
MEPHISTO Richard Lang	68030 Mephisto machine, assembler 128K ROM, 32bit, 45 mh., 1M hash table*	60K	10K	2350 FIDE
NIGHTMARE Reinhold Gellner, Gaby von Rekowski	80386, C + assembler, 250K hash table*	15K (moves)	700	1750
NOW Mark Lefler	80386, Pascal + assembler*	5K (moves)	3K	1950
ZARKOV John Stanbeck	MIPS 6000, C 32 bits, 55 mips, 16K hash table (HP, Fort Collins, Colorado)	5K	2.5K	2200
ZERKER James Testa	Sun Sparkstation, C, 16 Meg, 32 bits, 12 mips, 100Mb hash table, 200,000 transistor VLSI chess microprocessor* (University of California, Berkeley)	9K	7000K (moves)	2300

Ne7 55 Ka6 Ng8 56 Kb7 Ke7 57 Kxc7 Nf6 58 c6 Ne8 59 Kc8 Kd6 60 Kb7 Black resigns.

Round 4, Board 1
White: HITECH vs.
Black: DEEP THOUGHT/88

Hitech's victory in the fourth round against DEEP THOUGHT/88 was a truly magnificent example of fine positional play converted to an explosive tactical finish.

1 e4 c5 2 Nf3 Nc6 3 Bb5
The Rossolimo Variation against the Sicilian Defense avoids most popular and complex lines of the Sicilian.

3 ...g6 4 O-O Bg7 5 c3 Nf6 6 Re1 O-O 7 d4 cxd4 8 cxd4 d5 9 e5 Ne4 10 Nc3 Nxc3 11 bxc3 Bg4
This is all considered "book" to this point and no doubt these moves were part of both program's Opening libraries. White has a big center but Black has two bishops and sufficient chances for counterplay.

12 h3 Bf5
This seems a quite playable idea, namely to retain the two bishops and to make it difficult for White to challenge the b-file in the event of the likely Bxc6, bxc6. etc. Normal is 12 ...Bxf3 13 Qxf3 Qa5! when 14 Qxd5 or 14 Qd3 can both be met strongly by Nxd4.

13 Bxc6 bxc6 14 Ba3 Rb8 15 Bc5
White's bishop is annoying because it has a target (P/e7) and cannot be contested. The Black plan ...e6, ...Bf8 is virtually impossible to organize with impunity.

15 ...Qc7 16 Qc1 Rb7 17 Nh4!
HITECH does very well to recognize that the only way to utilize its Kingside space advantage is by the pawn storm f4-f5.

17 ...Be4 18 Qe3 Rfb8 19 f3 Bc2 20 Rec1 Ba4?
It is imperative that Black obtain some relief through the simplifications which follow from 20 ...Rb1. Now this bishop becomes a mere spectator.

21 f4 Bb5 22 f5!
White's attack has gained full steam.

22 ...Kh8 23 e6!
Black's K-side is demolished!

23 ...Bf6 24 exf7 Kg7
Now if 24 ...Bxh4 25 Qh6 Qd8 (to stop f8 = Q+ and mate follows) 26 fxg6 wins.

SCORECARD FOR THE 21st ACM NACCC

#	Program	Round 1	Round 2	Round 3	Round 4	Round 5	Total Points	Place
1	DEEP THOUGHTS	6W 1	7B 2	2W 3	3B 3	5W 4	4	1
2	MEPHISTO	9W 1	4B 2	1B 2	5W 3	3W 4	4	1
3	HITECH	5B ½	8W 1½	7B 2½	1W 3½	2B 3½	3½	3
4	M CHESS	10B 12W	1 8B	2 7W	36B 3½	3½	3	
5	ZARKOV	3W ½	9B 1½	6W 2½	3B 2½	1B 2½	2½	5
6	BEBE	1B 0	10W 1	5B 1	9W 2	4W 2½	2½	5
7	BELLE	8B 1	1W 1	3W 1	4B 1	Bye 2	2	7
8	NIGHTMARE	4W 0	3B 0	4W 0	Bye 1	9B 2	2	7
9	NOW	2B 0	5W 0	Bye 1	6B 1	8W 1	1	9
10	ZERKER	4W 0	6B 0	Withdrew			0	10

Note: Each entry in the "Round" column denotes the opponent, the color played, and the cumulative points earned.

25 Nf3 gxf5 26 Re1
26 Ng5! forcing Bxg5 27 Qxg5+ Kxf7 28 Qxf5+ also looked very attractive.

26 ...Kxf7 27 Qh6
A most natural attacking move which also offers excellent prospects in an ending after the h-pawn goes if White's attack does not prove decisive. However 27 Ng5+ also deserved great scrutiny, e.g. 27 ...Bxg5 28 Qxg5 e6 29 Rxe6! Kxe6 30 Re1+ Kf7 (or 30 ...Be2!? 31 Rxe2+ Kf7 32 Re5 Rb1+ 33 Kf2 R8b2+ 34 Kf3 etc.) 31 Re5, but 31 ...Bd3 seems to refute White's attack. Then on 32 Re7+ Qxe7 33 Bxe7 Rxe7 Black has more than enough for the queen.

27 ...Qg3
The best chance.

28 Qxh7+ Ke8 29 Qxf5 Qg7 30 Re6 Bc4 31 Rxc6
At this point there are a number of decisive ways for White to proceed including 31 Rae1 or 31 Ne5. This second extra pawn is like tax-free money in the bank! Momentarily one thinks that HITECH does not have a "tactical eye" for a flashy finish, but ...

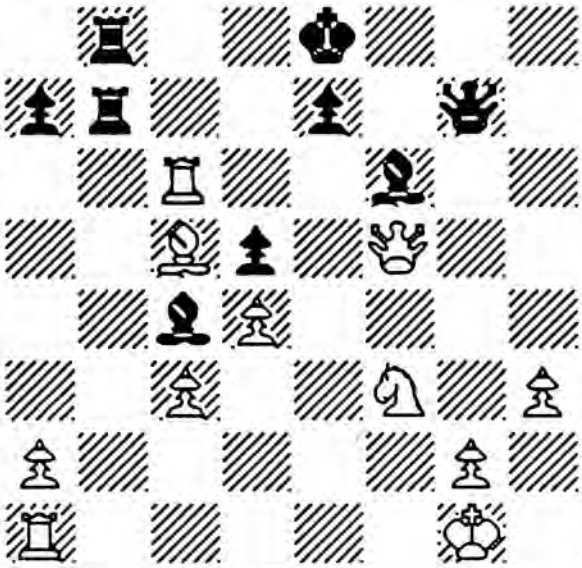

FIGURE 1
Position after 30 Rxc6

31 ...Kd8 32 Bd6!
On 32 ...exd6 34 Rxd6+ Rd7 35 Rxf6 wins easily. This move followed by White's next ...

32 ...Bb5 33 Ne5!!
...shows that HITECH has plenty of punch. If 33 ...Bxc6 34 Nxc6+ and 35 Nxb8 wins a whole piece. Or on 33 ...exd6 34 Rxd6+ Bd7 36 Nxd7 Bxd4+ 36 cxd4 Qxd4+ 37 Kh2 Qxa1 38 Nb8+ Kc7 39 Qd7+ Kxb8 40 Qd8 mate.

33 ...Bxe5 34 Bxe5 Qxe5
This was Black's best chance for longest survival. However, the rest of the game is of little interest as White has a decisive material edge.

35 Qxe5 Bxc6 36 Qe6 Rb1+ 37 Rxb1 Rxb1+ 38 Kh2 Rb6 39 g4 Bb7 40 Qg8+ Kc7 41 Qf7 Bc6 42 Qxe7+ Bd7 43 Qc5+ Rc6 44 Qxd5 Re6 45 Kg3 Re1 46 c4 Re2 47 Qa5+ Kb7 48 Qb4+ Kc8 49 Qa3 Kb8 50 d5 Re4 51 c5 Bxg4 Black resigns.
There are few humans who would not be proud of producing a game like this.

Round 5, Board 1
White: MEPHISTO vs. Black: HITECH
The Opening in MEPHISTO versus HITECH is undeniably to White's advantage, but it is hard to prove anything without opening the position up and entering some tactics, which is not MEPHISTO's wont. Instead, HITECH takes some action with 21 ...f5. The game looks like it might end in a quick draw after the ending is briskly reached from the sequence following 23 ...f4 24. Rxb6 fxg3 25 Rf6 etc. All the rooks might have even come off with 30 ...Rf8. Instead we have one of the longest drawn out affairs in ACM Championship history. Neither side deserved to win or lose this game. Had HITECH lasted a few more moves there may not even have been sufficient material left to mate.

1 d4 Nf6 2 c4 g6 3 Nc3 d5 4 Nf3 Bg7 5 cxd5 Nxd5 6 Bd2 O-O 7 Rc1 Nc6 8 e4 Nxc3 9 bxc3 Qd6 10 Be2 e5 11 d5 Nb8 12 c4 Nd7 13 O-O Nc5 14 Bb4 Qb6 15 Rb1 Re8 16 Qc2 h6 17 Rfc1 a6 18 h3 Rb8 19 Nd2 Bd7 20 Qc3 Bf8 21 Qe3 f5 22 Qg3 Kh7 23 Bc3 f4 24 Rxb6 fxg3 25 Rf6 Be7 26 Rf3 gxf2+ 27 Rxf2 Bg5 28 Rf3 Kg8 29 Bb4 b6 30 Rcf1 Bxd2 31 Bxd2 g5 32 Re3 Rf8

33 Rxf8+ Kxf8 34 Bc3 Re8 35 Bb4 Ra8 36 Bc5 bxc5 37 Rb3 Ke7 38 Kf2 a5 39 Ke3 Kd6 40 Rb7 Be8 41 Bg4 h5 42 Bf5 h4 43 a3 Bh5 44 Kd3 Bf7 45 Kd2 Be8 46 Ke2 a4 47 Kf3 Bh5+ 48 Kf2 Bf7 49 g3 hxg3+ 50 Kxg3 Bh5 51 Kf2 Bd1 52 Ke3 Bh5 53 Rb1 Rf8 54 Rb5 Ra8 55 Rb7 Bf7 56 Kd2 Bh5 57 Kd3 Be8 58 Rb1 Bh5 59 Rb2 Rd8 60 Rb7 Ra8 61 Kd2 Bf7 62 Ke1 Ra6 63 Rb8 Ke7 64 Kf2 Rb6 65 Rxb6 cxb6 66 Kg3 Bh5 67 Bg4 Be8 68 Be2 Bg6 69 Bd3 Bh5 70 h4 gxh4+ 71 Kxh4 Be8 72 Kg4 Bd7+ 73 Kg5 Bh3 74 Kh4 Bc8 75 Bf1 Kf6 76 Kg3 Ke7 77 Kf3 Kd7 78 Be2 Kd6 79 Ke3 Ke7 80 Kd2 Bh3 81Kc3 Bc8 82 Bd1 Bd7 83 Bc2 Kd6 84 Bd3 Be8 85 Be2 Bg6 86 Kd3 Be8 87 Kd2 Bg6 88 Bf3 Ke7 89 Bg2 Bh5 90 Ke3 Be8 91 Bf1 Kd7 92 Be2 Kd6 93 Kd3 Kd7 94 Kc3 Kd6 95 Bd3 Kd7 96 Kd2 Kd6 97 Bf1 Bg6 98 Ke3 Bh5 99 Bd3 Be8 100 Kf2 Bh5 101 Kg3 Bd1 102 Kg2 Bg4 103 Kf1 Bh5 104 Kf2 Be8 105 Kg3 Bd7 106 Be2 Ke7 107 Kh4 Bc8 108 Bd3 Kd6 109 Bf1 Ke7 110 Kg5 Kd6 111 Kf6 Bg4 112 Bd3 Bd7 113 Be2 Bh3 114 Kg5 Ke7 115 Kg6 Bg2 116 Kf5 Kd6 117 Bd3 Bh3+ 118 Kg5 Bd7 119 Bc2 b5 120 cxb5 Bxb5 121 Kg4 c4 122 Kf3 Bd7 123 Ke3 Kc5 124 Bd1 Be8 125 Bg5 Kd6 126 Kd2 Bg6 127 Bf3 Kc5 128 Kc3 Bh7 129 d6 Kxd6 130 Kxc4 Bg8+ 131 Kb5 Bb3 132 Bh5 Bc2 133 Bf3 Ke6 134 Kc5 Bd3 135 Bg2 Kf6 136 Kd6 Be6 137 Bf1 Bf7 138 Bb5 Bb3 139 Be8 Bc2 140 Bc6 Bd1 141 Kd5 Bb3+ 142 Kc5 Bd1 143 Kb4 Bc2 144 Bxa4 Bxe4 145 Bb5 Black loses on time.

THE ENDGAME CHAMPIONSHIP

The special Endgame Championship directed by Danny Kopec had four participants: MEPHISTO, M CHESS, ZARKOV and NOW. For many years there has been a general consensus among those observing computer chess progress that endgame play was rather weak. This special event was put together in an effort to shed some light on this issue. Time only permitted three rounds. Each round consisted of two games with each side taking turns as Black and White. A total of twenty minutes per game was given to each participant.

The three positions were selected based on involving play from well-known, documented, and top grandmaster competition. All three positions were theoretically drawn according to published sources. Therefore the expected score for each program in the tournament (with correct play by both sides) was 3/6 (six draws). However, even from this small sample it was possible to confirm that there are great differences among the programs' endgame abilities, which correspond to their overall rating differences. The participants were MEPHISTO, M CHESS, ZARKOV, and NOW.

ROUND 1: The test position in Round 1 was from Game 1 of Fischer-Spassky, Reykjavik, 1972. Fischer played ...Bxh2 around move 30 in this dead even Bishop Ending and lost. Much subsequent analysis by many people indicated that with very accurate play Fischer might still have been able to salvage a draw.

MEPHISTO is the only program which does not bite on h2. MEPHISTO wins from both sides of this position as does M CHESS against NOW.

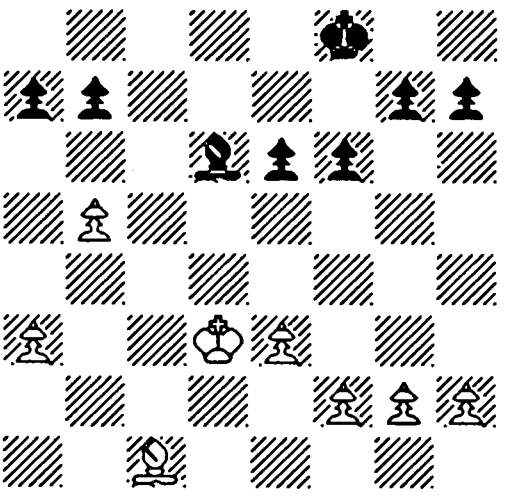

FIGURE 2
Endgame position 1 from Fischer-Spassky, Reykjavik, 1972

MEPHISTO-ZARKOV: 1 ...Bxh2? 2 g3 g5 3 Ke2 a6 4 bxa6 bxa6 5 Kf3 Kf7 6 Kg2 Bxg3 7 fxg3 g4 8 Kf2 h5 9 e4 Ke7 10 Bb2 e5 11 Ke3 Kf7 12 a4 Ke7 13 Kd3 Ke6 14 Bc3 Kd7 15 Kc4 Ke6 16 Kc5 f5 17 Bd2 fxe4 18 Be3 a5 19 Kc6 Kf6 20 Kd6 Kf5 21 Kd5 h4 22 gxh4 g3 23 h5 g2 24 h6 Kf6 25 Kxe4 Kg6 26 Kxe5 1:0.

ROUND 2: This is a famous endgame in which Capablanca beat Yates twice (!) over a short period of time (Hastings 1930–31). It almost led endgame theorists to mistakenly believe that this ending (Rook + 4 pawns vs. Rook + 3 pawns) is a win for White. Knowledge of Rook and Pawn endgame theory is critical to the correct play in this position. Basic theory is that after Black plays ...h5 it should be a draw because White cannot try to make progress without trading into drawn Rook and 3 Pawns vs. Rook and 2 Pawn endings. However, the correct defense still poses a number of hurdles for Black to overcome.

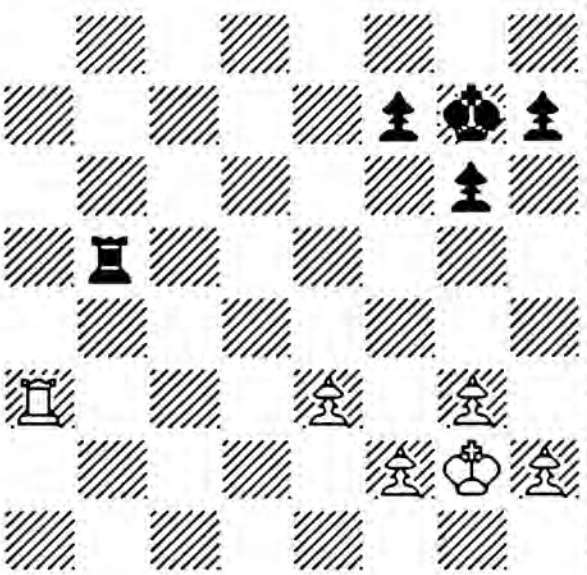

FIGURE 3
Endgame position 2 Capablanca-Yates, Hastings, 1930–31

Black may be already lost in the following continuation after 4 ...Ke6?. Black's best chance to hold a draw is 4 ...Rb6.

MEPHISTO-M CHESS: 1 h4 Kf6 2 f4 h5 3 Kf3 Rb2 4 e4 Ke6 5 Ra6+ Ke7 6 f5 gxf5 7 exf5 Rb4 8 Rh6 Rb3+ 9 Kg2 Rb4 10 Rxh5 Kf6 11 Rh7 Rc4 12 Kh3 Rc3 13 Kg4 Rb3 14 Rh6+ Ke5 15 Rc6 Rb8 16 Rc7 Kf6 17 Rc4 Ke5 18 Rc5+ Kf6 19 Kh3 Rb7 20 g4 Rb3+ 21 Kg2 Rb2+ 22 Kg3 Rb3 23 Kf4 Rb4+ 24 Kf3 Rb3+ 25 Ke2 Rh3 26 g5+ Kg7 27 Rc4 Rb3 28 Kf2 Rb5 29 Rf4 Rb2+ 30 Kg3 Rb1 31 Kg4 Rh1 32 Kh5 Rd1 33 f6+ Kh7 34 Re4 Rg1 35 Re7 Kg8 36 Kh6 Kf8 37 Rb7 Ke8 38 Kg7 Rg4 39 Re7+ 1:0. In the next example, with colors reversed, after White allows 8 ...Rg2 the game is fairly clearly drawn.

M CHESS-MEPHISTO: 1 Ra6 Rb2 2 Kf3 h5 3 h4 f5 4 Kf4 Rb4+ 5 Ke5 Re4+ 6 Kd5 Rb4 7 Rc6 Rb2 8 f3 Rg2 9 Rc4 Rxg3 10 Rf4 Rg2 11 e4 fxe4 12 fxe4 Rg4 13 Ke5 g5 14 hxg5 Rxg5+ 15 Ke6 Rg4 16 Rf7+ Kg6 17 e5 h4 18 Rf6+ Kg5 19 Rf5+ Kg6 20 Rf8 Kg5 21 Rg8+ Kf4 22 Rh8 Kg3 23 Kd5 h3 24 e6 h2 25 e7 Rh4 1/2:1/2.

Round 3: This double-edged position occured in Flohr-Keres, Semmering-Baden, 1937. The game ended in a draw after 1 Ng6 which, Fine praises (BCE #456). It seems that the programs' choice of 1 Ba4 steers the ending in White's favor.

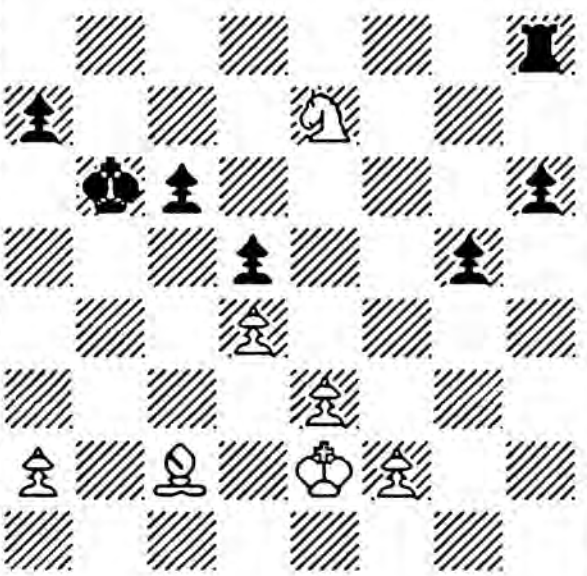

FIGURE 4
Endgame position 3 from Flohr-Keres, Semmering-Baden, 1937

Here both sides seem to squeeze the most out of the position.

MCHESS-ZARKOV: 1 Ba4 c5 2 Nxd5+ Ka5 3 Bb3 cxd4 4 exd4 h5 5 Kf3 h4 6 Kg2 h3+ 7 Kh2 Rh4 8 f3 Kb5 9 Nc3+ Kb4 10 Ne2 Ka3 11 d5 Kb4 12 d6 Kc5 13 d7 Rh8 14 Be6 Kd6 15 Bxh3 g4 16 fxg4 Kxd7 17 g5+ Kd6 18 Kg3 Re8 19 Nf4 Re3+ 20 Kg4 Ra3 21 g6 Ke7 22 Kg5 Ra6 23 Be6 Ra5+ 24 Bd5 Ra3 25 g7 Rg3+ 26 Kh6 a5 1:0

Brief observations: Patterns like the trapped bishop (1 ...Bxh2??) in Position 1 are particularly difficult for computers to comprehend. The fact that the bishop is trapped can be clouded with the horizon effect and a program often requires very deep search to see that the piece is or is not trapped. Where theory is established in certain endings, for example Position 2, there seems to be plenty for programs to learn from human experience. In more complex tactical endgames, i.e., Position 3, expect new contributions from programs. It can be said that MEPHISTO and M CHESS play the endgame quite well in general. ◘

SCORECARD FOR THE ENDGAME CHAMPIONSHIP

#	Program	Round 1	Round 2	Round 3	Total Points	Place
1	MEPHISTO	3 2	2 3½	4 5½	5½	1
2	M CHESS	4 2	1 2½	3 4	4	2
3	ZARKOV	1 0	4 1½	2 2	2	3
4	NOW	2 0	3 ½	1 ½	½	4

Note: Each entry in the "Round" column denotes the opponent, the color played, and the cumulative points earned.