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CRAY CHANNELS

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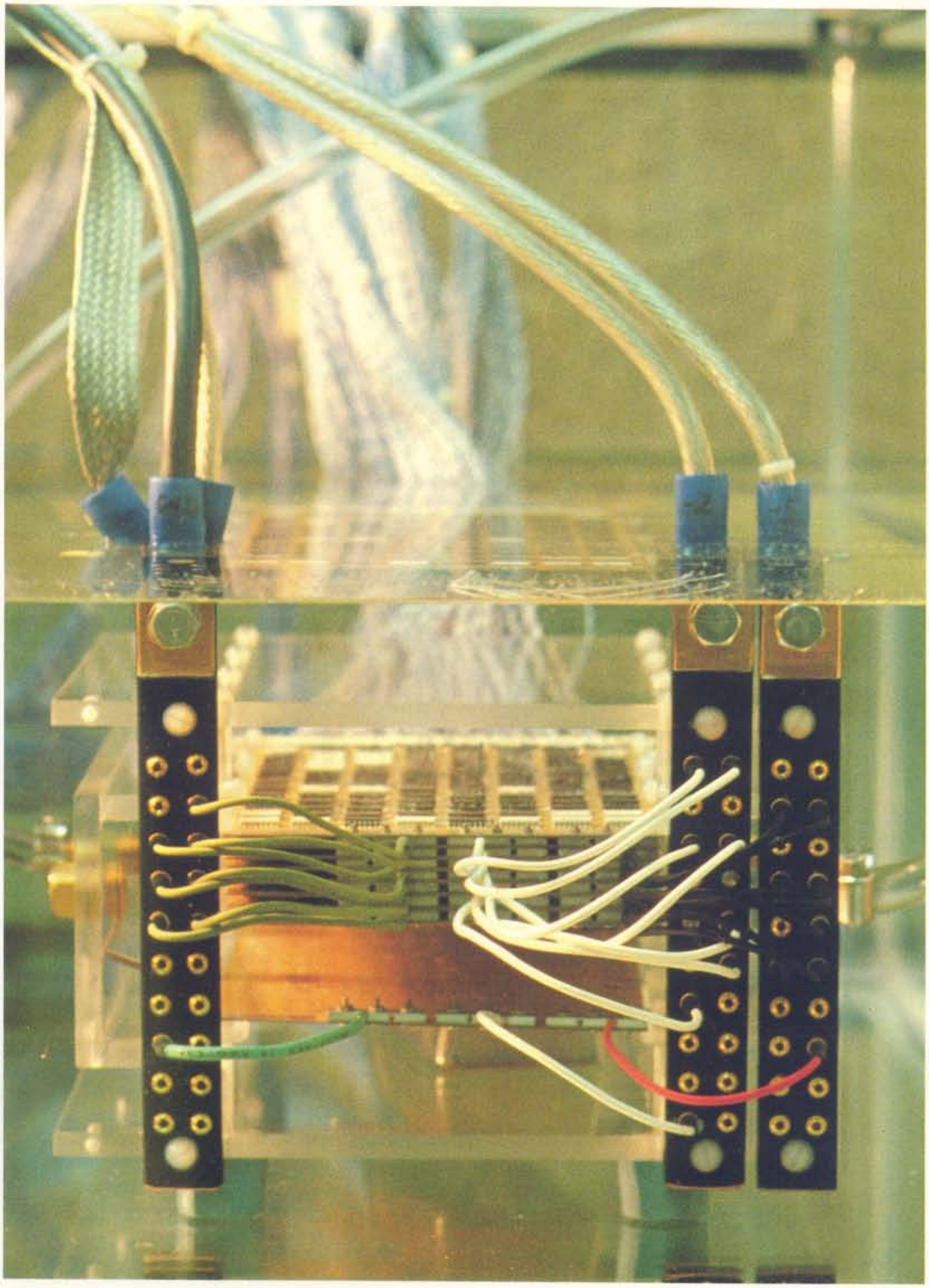
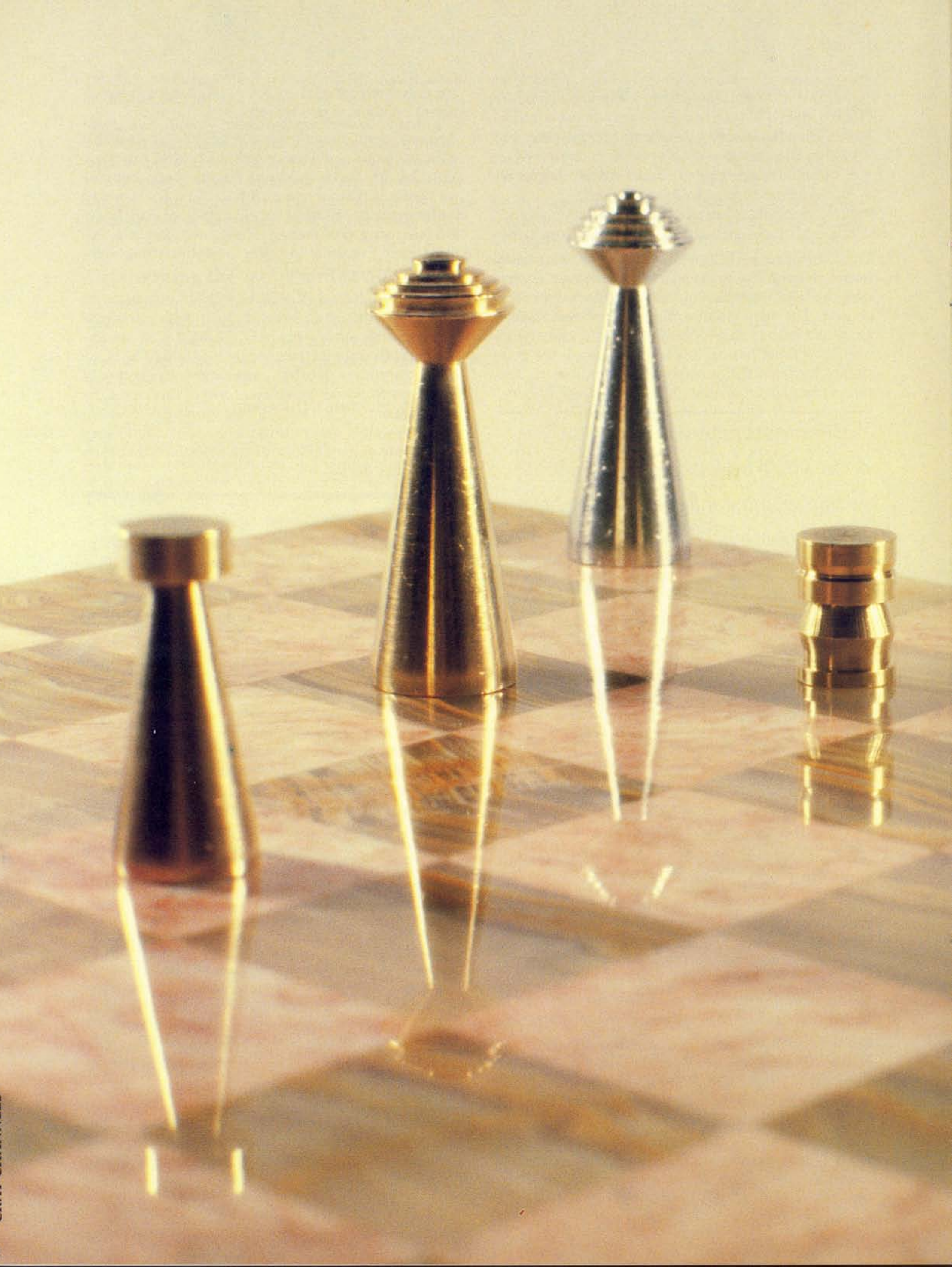
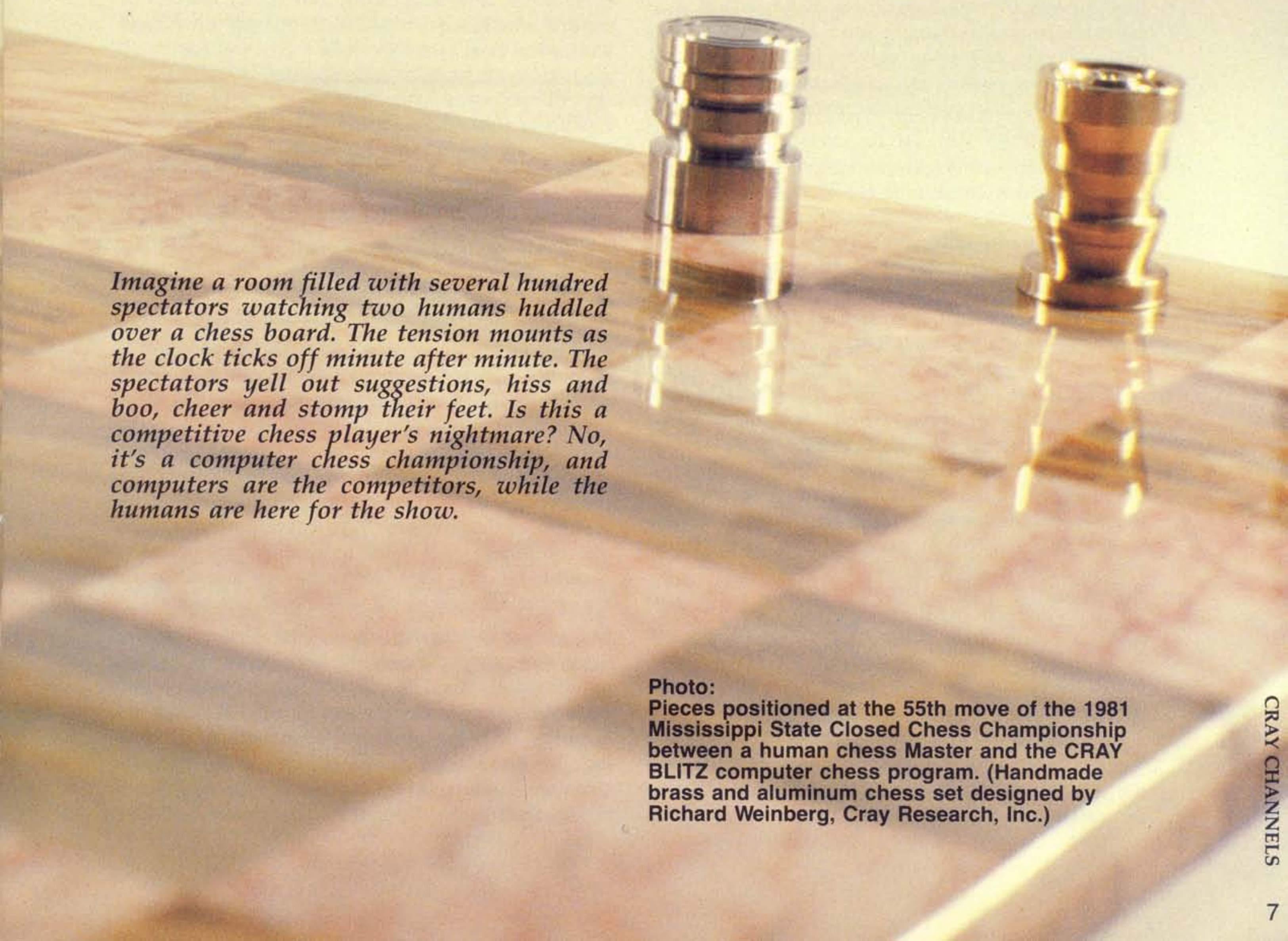




CHECKMATE— An electronic chess champion

Robert Hyatt
University of Southern Mississippi, Hattiesburg

Part two of a two-part series



Imagine a room filled with several hundred spectators watching two humans huddled over a chess board. The tension mounts as the clock ticks off minute after minute. The spectators yell out suggestions, hiss and boo, cheer and stomp their feet. Is this a competitive chess player's nightmare? No, it's a computer chess championship, and computers are the competitors, while the humans are here for the show.

Photo:
Pieces positioned at the 55th move of the 1981 Mississippi State Closed Chess Championship between a human chess Master and the CRAY BLITZ computer chess program. (Handmade brass and aluminum chess set designed by Richard Weinberg, Cray Research, Inc.)

Improvements in computer hardware and software design over the years have enabled computer chess programs to become more competitive with top human chess players. CRAY BLITZ's recent tournament victory in Mississippi is evidence of this fact—never before has a computer chess program won a state chess championship. And while no one can predict when a computer will become world chess champion, very few people will deny that one day the computer will be unbeatable.

Testing a program under competition

Developers of computer chess programs have two choices for testing a program under competition. They can enter open chess tournaments, where most, if not all, of the opponents are human. Alternatively, they can participate in computer chess championships, where only programs are allowed to enter. These two types of tournaments provide very different tests for computer chess programs of today.

The most notable difference between strong computer chess programs and strong human players is that human players sometimes make tactical mistakes but programs usually don't. However, the tactical fallibility of human players is generally offset by the deeper positional understanding humans exhibit, so if human players can avoid tactical errors, they will usually win.

In tournaments pitting human players against computers, the test conditions are ideal: the strengths of one competitor are matched by the weaknesses of the other. In entering both BLITZ and CRAY BLITZ in tournaments against human players, I have demonstrated that the computer is indeed a formidable opponent. The tactical expertise of the computer chess program, along with its "Mr. Spock"-like lack of emotion, are advantages the program holds over the human opponent. A program simply doesn't become unnerved when it is losing or when it is being attacked, and it never gets careless when it is ahead (a particular weakness of human players). Playing the best moves it can find, the program plays evenly, waiting for the human opponent to make a tactical mistake. This mistake is almost always forthcoming, and it often results in another victory for the computer. Fortunately, the human player can salve a damaged ego by thinking about the moves that would have beaten the computer, had they been played.

A chess game between two computers seems to be a non-optimal test condition, because the strong and weak points of the two programs may be quite similar. It is for this reason that luck generally plays an important role in deciding the victor of a contest between two programs. In an extended (multi-game) match, the better program will triumph, because play over a number of games should eliminate the factor of luck (or at least reduce it). Unfortunately, tournament play precludes two opponents meeting more than once.

Computer chess competitions

Each year, the Association for Computing Machinery (ACM) organizes and sponsors a tournament to measure progress in computer chess. An impressive array of computers participates: last year's tournament included two CRAY-1 computers, several AMDAHL 470/V7s and 470/V8s, and a Control Data Corporation CYBER 176. Rarely is that much computing power concentrated in one small room, especially to play chess! In addition to the yearly ACM tournament, a world computer chess tournament is held every three years to determine the best computer chess program in the world.

Computer chess tournaments are great crowd pleasers. Because computers don't mind noise, the spectators can actively participate by booing, hissing, applauding, and suggesting moves. As interest in the outcome reaches a peak, attendance can exceed 500 for the final two rounds of a tournament.

Playing the best moves it can find, the program plays evenly, waiting for the human opponent to make a tactical mistake.

Each side in a computer chess game has a fixed amount of time to make a predetermined number of moves. The requirement is usually that 40 moves must be made in two hours, for an average of three minutes per move. Time is measured precisely by two clocks at the tournament site, one for each program. When it is one program's turn to move, that program's clock is started and the opponent's clock is stopped. Because time is so important in a match, the computers used in the tournament are normally dedicated during play. Dedicated time allows for the maximum amount of computer time per move.

In addition to playing regular tournament chess at three minutes per move, the better chess programs are extremely good at playing speed chess, where the entire game lasts only five minutes. The tactical accuracy of these programs seems to offset their lack of knowledge to the extent that even the strongest human players in the world have a difficult time winning. No human has ever beaten CRAY

BLITZ in over-the-board speed chess, including several chess Masters. Even David Levy, who established himself as the arch-nemesis of computer chess programs and programmers, fell to BLITZ in speed chess. Five years ago, this record would have been labeled science fiction; today it is a demonstrable fact.

While no one can predict when a computer will become world chess champion, very few people will deny that one day the computer will be unbeatable.

ACM has sponsored the computer chess tournament annually as a controlled experiment. Since the first tournament in 1970, the time allowed per move has remained the same. Thus, increases in playing strength can be directly attributed to improvements in hardware and software.

In 1970, the best program entered in the ACM tournament was barely a United States Chess Federation (USCF) class C player with a rating of approximately 1500. In 1981, the best programs are rapidly approaching the Master rating (USCF rating of 2200 or better). CRAY BLITZ is the first (and only) program to have achieved this status to date, with a rating of 2258. In speed class, the better programs are currently rated at over 2400, and steady improvements are being seen in longer timed events.

CRAY BLITZ's performance

CRAY BLITZ has been playing chess for almost two years. Before being implemented on the CRAY-1, BLITZ had been playing chess for about four years. Needless to say, the CRAY-1 greatly improved the strength of the program, due to the depth of search made possible by the tremendous speed of the machine.

At a rate of one move every three minutes, CRAY BLITZ generally performs an exhaustive search to a depth of seven plies in the middle game. In the end game, CRAY BLITZ has performed searches exceeding 35 plies. While a depth of seven half-moves might not sound very impressive at first, it is deep enough to find some extremely clever tactics. Research has shown that as depth increases, the accuracy of move selection in a human lessens. In a program using exhaustive searching, however, inaccuracy is not a problem because every move is considered.

Tournament action

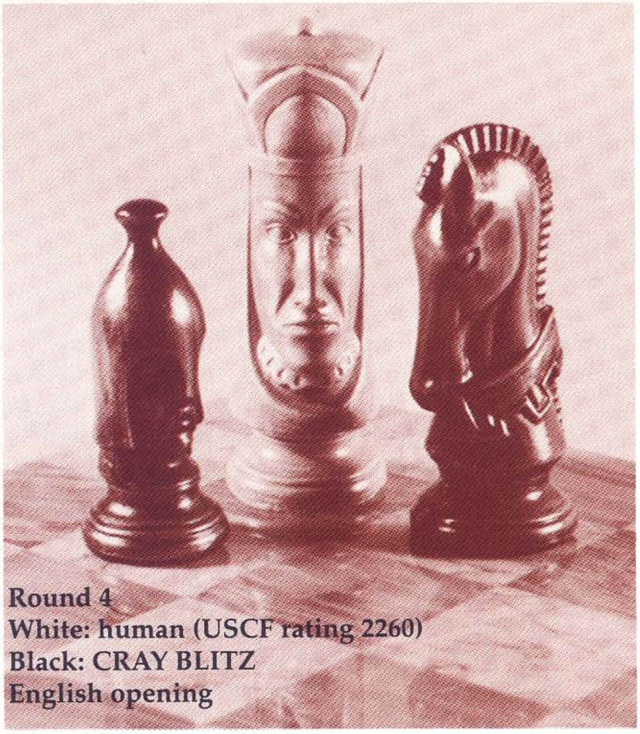
To appreciate what goes on at a tournament, join me in playing the following game. This game was played by CRAY BLITZ in the 1981 Mississippi State Closed Chess Championship. CRAY BLITZ won with a perfect score of 5 wins, 0 losses. The program's performance earned it the title of "Mississippi State Chess Champion" for 1981, making CRAY BLITZ the first computer program ever to win a state chess championship tournament. The opponent is a USCF chess Master and state champion for the previous two years. CRAY BLITZ played black. I am including the number of nodes the program examined, the position evaluation (where +1.2 means the program is 1.2 pawns ahead, for example), and the program's analysis (the moves it anticipates being played). I am also including the time elapsed per move for each side so that it is possible to determine how much time each side has left at any point. The time rules for the tournament require 50 moves every two hours. Also included are my remarks and (in quotes) those that came directly from CRAY BLITZ.

We are sitting across the board from our human opponent. A terminal connected to the CRAY-1 is facing us so that the opponent cannot see. Whenever our opponent makes a move, we enter the move via the terminal and wait for CRAY BLITZ's response. While BLITZ performs the search, it periodically displays on the terminal the current evaluation and expected sequence of moves. These values are updated whenever BLITZ's evaluation changes. Because the program is a much stronger evaluator than any human present, we rely on its analysis to let us know how the game is going.

Because computers don't mind noise, the spectators can actively participate by booing, hissing, applauding, and suggesting moves.

The only problem is time. We must sit patiently, waiting for a clue from CRAY BLITZ to let us know how the game is going. If the opponent takes 15 minutes for a move, we sweat it out until the move is made and the program starts displaying its analysis. As the evaluation climbs, we smile; as it drops sharply, we worry. It is very much like watching one's children play in a competitive event.

Remember that while the tournament is in progress, we can't turn the page to check the evaluation 10 moves from now! We have to wait (and worry).



Round 4
White: human (USCF rating 2260)
Black: CRAY BLITZ
English opening

1. c4 (0:15) — **Nf6 (0:00)**

2. Nc3 (0:21) — **c6 (0:00)**

3. Nf3 (0:16) — **d5 (2:17) 408,258 nodes −0.048**
d5 e3 e6 d4 Nbd7 Qa4 Bd6 Program is temporarily "out of book"

4. cxd5 (0:28) — **cxd5 (2:17) 558,670 nodes +0.000**
cxd5 d4 Nc6 e3 e6 Bb5 Bb4

5. d4 (0:50) — **Nc6 (0:00)**
"Back in book"

6. g3 (0:14) — **Ne4 (2:19) 384,099 nodes +0.183**
Ne4 Bg2 Nxc3 bxc3 Qa5 Qd3 e6 "Out of book" again

7. Bg2 (1:14) — **Nxc3 (3:23) 877,648 nodes +0.085**
Nxc3 bxc3 e6 0-0 Be7 e3 0-0

8. bxc3 (0:11) — **e6 (3:06) 565,507 nodes +0.129**
e6 0-0 Bd6 Qd3 0-0 e4 f5 exd5 exd5

9. 0-0 (0:28) — **Bd6 (2:36) 509,561 nodes +0.127**
Bd6 Rb1 0-0 Qa4 f5 Bg5 Qd7

10. Qc2 (2:15) — **0-0 (2:55) 508,413 nodes +0.117**
0-0 Rb1 f5 Bd2 Re8 e3 e5

11. Ng5 (5:10) — **f5 (2:43) 433,129 nodes +0.167**
f5 f4 Na5 Rb1 Nc4 e3...

12. f4 (2:58) — **Na5 (0:00) 493,756 nodes +0.148**
Na5 e3 Nc4 Nf3 Qf6 Ne5 Bxe5 fxe5 Notice CRAY BLITZ used no time to select this move since it had correctly predicted the opponent's move (f4, see previous analysis for move 11).

13. Qd3 (3:55) — **Qd7 (2:27) 381,838 nodes +0.138**
Qd7 Nf3 Nc4 Nd2 Nxd2 Bxd2

14. Bd2 (6:13) — **Nc4 (2:18) 348,683 nodes +0.147**
Nc4 e3 Qc6 Rfb1 b5 Rb3

15. Bc1 (2:22) — **Qa4 (2:18) 355,534 nodes +0.220**
Qa4 e3 Bd7 Rb1 b5... At this point I was happy! White's C pawn is backward, Black's knight is well placed, and the program thinks it is nearly ¼ pawn ahead. Little did we realize what was coming.

16. g4! (30:55) — **h6 (2:18) 378,020 nodes +1.243**
h6 gxf5 hxg5 fxg5 Ba3 Bd2 Nxd2 Qxd2 CRAY BLITZ is a pawn up! Watch the evaluation slip for the next few moves, because the human opponent used 30 minutes to calculate deeper than the program.

17. gxf5 (1:08) — **hxg5 (1:09) 326,700 nodes +1.193**
hxg5 fxg5 Qe8 f6 Qh5 Bh3

18. fxg5 (0:27) — **Ba3 (1:52) 320,602 nodes +1.068**
Ba3 Bxa3 Qxa3 e4 exf5 exf5

19. g6! (1:50) — **Bxc1 (2:21) 403,760 nodes +1.212**
Bxc1 Rfxc1 Rxf5 Qh3 Rg5 Qh7+ Kf8 Rf1+ Ke7 Qxg7+ Kd8 It's getting complicated! Note how far ahead the program is analyzing.

20. Raxc1 (0:26) — **Nd6 (2:21) 362,642 nodes +0.891**
Nd6 Qh3 Rxf5 Qh7+ Kf8 Qh8+ Ke7 Qxg7+ Kd8 Rxf5 Nxf5 Note the evaluation. I now thought the program was lost. How can it stop the g pawn from queening? Watch...

21. Qh3 (0:36) — **Rxf5 (2:21) 408,459 nodes +0.557**
Rxf5 Qh7+ Kf8 Bh3 Rxf1+ Rxf1+ Ke7 Qxg7+ Kd8 Rf8+ Ne8 Help! We're now only one-half pawn up!

22. Qh7+ (2:59) — **Kf8 (0:00) 426,135 nodes +0.557**
Kf8 Bh3 Rxf1+ Rxf1+ Ke7 Qxg7+ Kd8 Rf8+ Ne8 At least the evaluation held steady for one move!

23. Qh8+ (1:52) — **Ke7 (0:00) 349 nodes**
No analysis, because move is forced.

24. Qxg7+ — **Kd8 (2:01) 358,566 nodes −0.431**
Kd8 Qh8+ Kc7 g7 Nf7 Rxf5 exf5 Bxd5 At this point, the program sees trouble ahead. However, the Master has used a lot of time and can't afford to carefully analyze each move now, and he soon begins to falter.

25. Rxf5 (6:33) — **Nxf5 (2:29) 419,712 nodes +0.413**
Nxf5 Qf8+ Qe8 g7 Ne7 c4 Bd7 Qxe8+ Kxe8 cxd5 exd5 Now we are ahead again. Rxf5 was not best, as can be seen from the program's prior analysis. Qh8+ was better.

26. Qf6+ (0:32) — **Ne7 (2:29) 417,621 nodes +0.455**
Ne7 g7 Qe8 c4 Kd7 cxd5 exd5 Now the pawn is finally stopped. CRAY BLITZ is threatening Ng8, blockading it further.

27. g7 (2:27) — **Qe8 (0:15) 383,644 nodes +0.266**
Qe8 e4 Kd7 exd5 Nxd5 Qf8 Ne7 Qxe8+ Kxe8 The pawn looks dangerous, but we have defended well. For the time being, everything is held together.

28. Bf3 (3:01) — **Kd7 (2:35) 385,273 nodes +0.451**
Kd7 e4 Rb8 Kh1 dxe4 Qe5 Nc6 Qxe4 So far, so good...

29. Rf1 — **Ng8 (2:35) 382,522 nodes +0.306**
Ng8 Qg5 Qe7 Qxe7 Kxe7 e4 Nf6 exd5 exd5 Trading queens saves everything! However, the pawn is now threatening again via Rf8 Rxf8 gxf8=Q. Can we survive this last rush?

30. Qg5 (3:27) — **Qe7 (0:00) 515,188 nodes +0.209**
Qe7 Qg6 Kd6 e4 dxe4 Bxe4 Kd7 Rf7 Now the opponent has only 34 minutes for the final 20 moves, while the program has over one hour left.

31. Qg6 (0:53) — **Kd6 (1:49) 351,300 nodes +0.278**
Kd6 Qg3+ Kc6 c4 Qd8 Qg6 Kc7 cxd5 exd5

32. e4 (10:08) — **dxe4 (2:45) 385,266 nodes −0.219**
dxe4 Qg3+ e5 Bxe4 Qe6 Bf5 Qd5 dxe5+ Kc7 Oops! There goes the evaluation again. However, material is even. Time is really serious for the Master now.

33. Bxe4 (1:18) — **Qh4 (2:46) 391,722 nodes −0.713**
Qh4 Bg2 Bd7 Bxb7 Rb8 Qg2 Bb5 Now we are losing a pawn if the opponent plays correctly.

34. Qg3 (6:23) — **Qxg3+ (2:46) 610,609 nodes −1.459**
Qxg3+ hxg3 Bd7 Rf8 Rc8 Rxc8 Bxc8 Bh7 Ne7 g8=Q Nxg8 Bxg8 Now we are over a pawn behind. BLITZ is analyzing deeper than the Master, however, and the Master doesn't find the best moves.

35. hxg3 (0:37) — **Bd7 (2:08) 470,710 nodes −1.359**
Bd7 Rf8 Rc8 Rxc8 Bxc8 Bh7 Ne7 g8=Q Nxg8 Bxg8 The opponent has 15 minutes left. Note that the program's evaluation is climbing now, as it will for the remainder of the game.

36. Rf8 (7:31) — **Rc8 (0:00) 1,395,040 nodes −1.311**
Rc8 Rxc8 Bxc8 Bh7 Ne7 g8=Q Nxg8 Rxc8 is the Master's only chance. However, he is almost out of time.

37. Bh7 (1:56) — **Rxc3 (3:00) 604,912 nodes +0.000**
Rxc3 Kh2 Rc1 Rf2 Rc8 Rf8 Rc1 Bh7 looks good to drive the knight away, but it is too late. CRAY BLITZ thinks everything is exactly even.

38. Rxg8 (4:14) — **Rxg3+! (3:00) 610,779 nodes −0.090**
Rxg3+ Kf2 Rg4 Be4 b5 Ra8 Rxg7 Rxa7 The move Rxg8 is too late!

39. Kf2 (0:07) — **Rg5 (2:52) 615,741 nodes −0.010**
Rg5 Be4 e5 dxe5 Kxe5 Bxb7 Be6 Re8 Rxg7 Looking better every move. Just one more inexact move, and...

40. Be4 (0:46) — **b6 (2:14) 568,593 nodes −0.009**
b6 Ke3 e5 a3 Be6 Rd8+ Ke7 Ra8 Now it is our turn!

41. Ke3 (0:35) — **e5 (2:30) 616,227 nodes +0.004**
e5 Ra8 Rxg7 Rxa7 Rg3+ Kf2 Rc3 dxe5+ Kxe5 Rxd7 Kxe4 Evaluation has (finally) gone positive!

42. Ra8 (1:37) — **Rg3+! (1:32) 702,663 nodes +0.636**
Rg3+ Bf3 exd4+ Kxd4 Be6 Bb7 Rg4+ Ke3 Bxa2 Rxa7 Rxg7 We're a pawn up!

43. Kf2 (0:08) — **Rxg7 (3:22) 787,876 nodes +0.764**
Rxg7 Rxa7 exd4 Rb7 b5 Bd3 Rg5 a3 Rd5

44. dxe5 (0:07) — **Kxe5 (3:22) 708,164 nodes +0.785**
Kxe5 Bf3 Be6 a3 Rc7 Re8 Rc2+ Kg3 Kd6 Getting better!

45. Bf3 (0:07) — **Be6 (3:07) 675,932 nodes +0.761**
Be6 Re8 ...

46. a4 (0:07) — **Rf7 (3:25) 732,838 nodes +1.665**
Rf7 Re8 Rf4 a5 bxa5 Ke3 Rf7 Be4 Two pawns ahead looks good, but watch this...

47. Ke3? (0:11) — **Rxf3! (3:26) 760,544 nodes +4.093**
Rxf3 Kd2 Rf7 Ke3 Rh7 Kd2 Rh2+ Ke3 Rh3+ Kd2 If Kxf3, then Bd5+ wins the rook as in the game. "Be careful."

48. Kxf3 (0:06) — **Bd5+ (2:00) 703,217 nodes +5.071**
Bd5+ Ke2 Bxa8 Kd3 Bc6 a5 bxa5 Kc4 a4 Kc3 Be4 I will drop the analysis as the game is basically over.

49. Kc3 (0:05) — **Bxa8 (0:40) 266,098 nodes +5.079**
"That was easy."

50. a5 (0:06) — **Be4! (1:53) 722,217 nodes +7.694**

51. Kd2 (1:04) — **Kd4 (2:00) 774,460 nodes +10.866**
"Be careful."

52. Kc1 (0:25) — **b5 (2:00) 752,079 nodes +11.151**

53. Kb2 (1:57) — **Kc4 (0:00) 834,892 nodes +11.319**

54. a6 (0:16) — **b4 (2:00) 912,576 nodes +20.412**
"Be careful."

55. Ka2 (1:28) — **Kc3, and BLITZ announced mate in 6.**

That was a wild game that could have gone either way. I have some general comments on the game. First, the worst thing CRAY BLITZ saw was coming out a pawn down, but even being a pawn down was not critical because the opponent was so short on time. Second, the opponent was behind on time because the program came up with some surprising defensive moves and generally presented the opponent with a lot of tactical problems.

In winning the other four games in the tournament, the program never found itself with a negative evaluation; that is, it was ahead all the way. In winning the state championship title, the program achieved a rating of 2258, placing CRAY BLITZ in the *Guinness Book of World Records* as the first computer chess Master.

It should be noted that, to date, only three programs have beaten chess Masters in tournament play: BELLE of Bell Laboratories, Control Data Corporation's CHESS 4.9, and CRAY BLITZ. Three years ago, no one thought a program would ever beat a human. Now it is becoming commonplace. Watch out, Bobby!

The future for CRAY BLITZ

Performance against other programs is the next testing phase for CRAY BLITZ. The annual "computer only" tournament sponsored by ACM takes place in November in Los Angeles, California. CRAY BLITZ will be there to defend its "World Computer Speed Chess Champion" title and to try to wrest the regular world title from BELLE.

The current version of CRAY BLITZ has only played one other computer program, BELLE. In a four-game match played in August, BELLE and CRAY BLITZ split at two games each, which gives an indication of how close they really are. Remember that tactical errors don't really exist in games between top-class programs, so Lady Luck has a chance to enter into the fray, sometimes at the most embarassing times.

CRAY BLITZ is anxiously awaiting the successor to the CRAY-1 for additional hardware advantages, while human opponents have resigned themselves to the fact that computer chess programs can only improve.

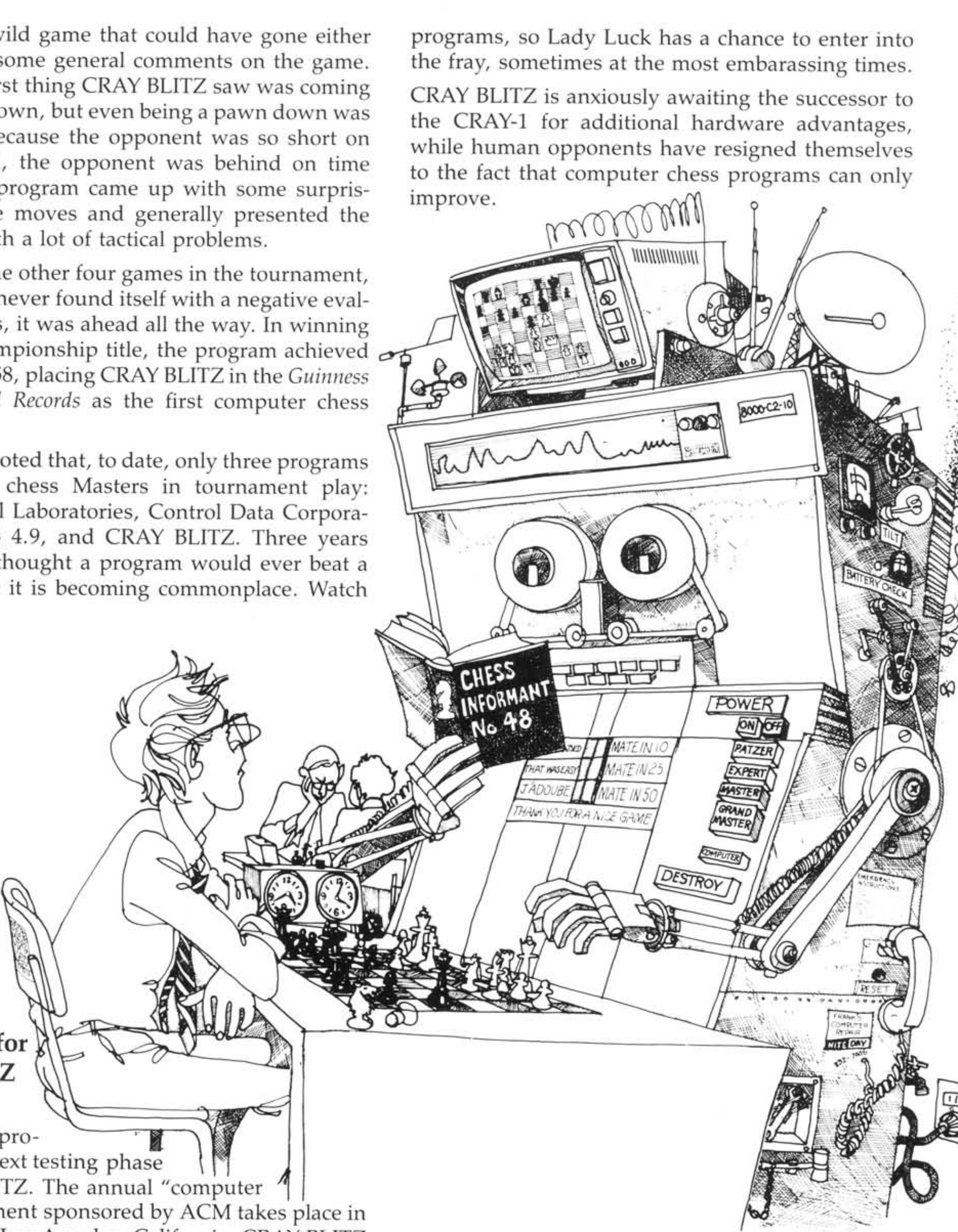


Illustration by Bob Walker, courtesy of the U.S. Chess Federation.

—ABOUT the AUTHOR—

Robert Hyatt *is an Instructor and Chief of Systems at the University of Southern Mississippi in Hattiesburg. He received his B.S. in Computer Science from USM in 1970 and has remained there to teach and do research. Bob has been competing in computer chess tournaments with BLITZ since 1976. He has had CRAY-1 support from Cray Research since April of 1980.*