



## Oral History of Ken Thompson

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Q: Actually I'm a trustee at the Computer History Museum. It's my pleasure to interview Ken Thompson about his involvement with computer chess over the years. So Ken, welcome to the museum.

**Ken Thompson:** Oh thank you very much, thanks for inviting me.

Q: Oh sure. So let's start at the beginning. Where are you from, where did you go to school, and how much game playing did you do before you got to college?

**Ken Thompson:** Oh, going way back.

Q: Yes, all the way.

**Ken Thompson:** My father was military and the technical term for that is Navy brat, so I was a Navy brat for the first 20 years of my life. And we moved all over, I never spent more than a year or two any one place. So that was high school and then I graduated high school in Chula Vista, California and went to school in Berkley and that's essentially my education.

Q: Okay. So in high school or before, or in college, what sort of involvement with games did you have, whether chess or other games?

**Ken Thompson:** I was always interested in games. I had written game books and crosswords, things like that. Chess in particular, I took up kind of the year that Bobby Fisher was mopping up in the U.S. when he was – he's about one month different age than I. And you know you get this feeling that you know, you know why aren't you any good? You know he's on the cover of Look Magazine you know at 14 and I'm going to school in Texas. So my parents played bridge and – the whole family actually played bridge, I played bridge a lot. Never liked the game and they would take me to this hotel once a week where they played duplicate bridge, in this little town in Texas. And there were a couple of old men there that played chess in the lobby. And when I didn't play bridge I'd go and watch them play chess. And eventually I started playing and then I read a couple books on it with all of Bobby Fisher, you know, hullabaloo going on. Then I played for about six months, like on the team in school. This is – I believe it was 7<sup>th</sup> grade; it might have been 6<sup>th</sup> grade. And I guess nobody in 6<sup>th</sup> grade ever read a chess book before because as soon as you read a chess book you're better than everybody else.

Q: Everybody else.

**Ken Thompson:** And then I quit it and then essentially never played after that. I was always a fan of chess, always followed it, always read the games, read the books, followed the tournaments. But after that 6<sup>th</sup> or 7<sup>th</sup> grade I never played personally.

Q: Okay. So how about other games? Any other ones that you were interested in before college?

**Ken Thompson:** I was interested in college, interested in three dimensional tic-tac-toe, four by four, by four. And I had a gamer for a teacher, Burlicamp; very nice man. And I used to get midnight computer time. Basically, when it was idle I'd go in and take over the machine.

Q: What machine was this?

**Ken Thompson:** 7094.

Q: A 7094, okay.

**Ken Thompson:** And I wrote some game playing programs, one of them being, 3D tic-tac-toe. And Burlicamp is still the strongest person I've ever known at that game. And I used to – and you know wake him up in the middle of the night, like two in the morning, and he'd come out of the computer room and play this game with me and beat it. You know and I'd go lick my wounds and go back and try to do better, and try to do better. But that's – I did that. Also, there was a game called Bridgette which is an N by N array where N can be; somewhere around 19, 20 something like that. And one player connects, you know, red lines on the screen and the other player connects blue lines. And the red player tries to connect the bottom row, you know, wiggling up to the top row. And the blue player tries to block and connect left to right or right to left. And the first person to make a connection wins. And again, there were some people at school that were very, very good at this, and this was my first game at cheating. Basically, the screens in those days were kind of round and they kind of bulged. And at one point I had an idea I couldn't beat this guy so I made it 19 x 18, which is a real advantage, especially if you go first. And he didn't notice and he actually got beat a couple times before he figured out that the screen wasn't square.

Q: Yeah, I think that's a little harder to get away with that in competitive chess, yeah?

**Ken Thompson:** It is.

Q: Okay, so –

**Ken Thompson:** \_\_\_\_\_.

Q: Yes, yeah. So then how did you end up at Bell Labs?

**Ken Thompson:** My teachers recommended me. I wasn't looking for a job I was just hanging around. I was having a good time. I kind of almost ran the school, you know, as far as computers go. I was into every nook and corner, and they sicked a Bell Labs recruiter on me, who tried to get me down for an interview the entire week he was there. And finally on the last night before he was going home he called me at home and came over, actually came over to my house to interview me. And disappeared, then I got a letter inviting me for an interview on the East Coast. And I had a lot of old friends that were spread all over the U.S. from the Navy brat kind of days and so I told him, you know, that you know I wasn't interested in a job but I'd take their interview just to, you know, get a free ride to the East Coast to visit some of my friends. And they said anything you want, you know, that's fine; and went to the East Coast, I interviewed two days out there; one day at Wippanee, one day at Murray Hill. Wippanee was grim and Murray Hill there were actually two departments that looked very good. And when I got home there was a letter saying, you know, if you want as job you can have it, just rank the departments in order. And I thought about it for a week or so and then ranked them, sent them in and I got offers from the top two that I'd ranked, and thought about that for another couple weeks and said, okay.

Q: Okay; now an interesting testament to the persistence of that recruiter, yes. Okay, so anyway, you moved to Bell Labs and when was that?

**Ken Thompson:** '66.

Q: '66, okay. And what did you start doing when you were there?

**Ken Thompson:** I was hired to work on Multex.

Q: On Multex, yeah.

**Ken Thompson:** And you know it was just a big monstrous project with GE, Bell Labs and MIT to build a – the time sharing system that was going to end all time sharing systems. And it was hugely over-designed and wildly uneconomical. It had very unique hardware. It was a research project on about four fronts, when you know – and you could research project but you'd only have one front. Bell Labs quit the project and it decided that it wasn't going to satisfy their needs. And then I was almost like out of a job at that point and I kind of had these old Multex computers lying around before they disappeared. And the only thing to do so I just did what I wanted to do from them on.

Q: Which was?

**Ken Thompson:** Games and operating systems and – I don't know anything that crossed my mind. I did some positional astronomy, some audio, some – I don't know, anything; absolutely anything that I wanted to do.

Q: So we were looking at the Deck PDP1 in space war. So let's talk about that. I guess that was one of your first applications on mini computers as I recall.

**Ken Thompson:** Well PDP1 – the only PDP1 I ever programmed or had access to was at Stanford when I was at school in Berkley. And at Stanford and Berkley had co-op arrangements, and at some point we were moving out our 7090 for a 7094 and we had no computer for an extended period. And we got Stanford to loan us there 7090 and 7094 at night. So I'd come down to Stanford at night with jobs to run and stuff like that and take the stuff back in the morning. It was like you know midnight to 8:00 and in the computer center there was their PDP1. And I'm sure I played a lot. So that was my only actual contact with the PDP1 and the real space war. After that Dennis Gritchie and I found a PDP7 with a 340 display, the same, roughly the same display.

Q: What kind of display is that?

**Ken Thompson:** It's a vector display. It'll move to and draw lines and it runs a vector list. The display runs an instruction list that says draw this, draw this, draw this and at the bottom it'll stop and then you wait a 60 of those cycle and then start it again at the top. And one of the games we wrote for that was Space War, you know we pulled up various copies of it and then copied it over and made it, you know, run on the PDP7. And got it running, you know, it was always very popular. And then I did a bunch of other programs. Like there was a – there was a three dimensional space where this machine, this PDP7 was remote job entry station for circuit analysis. And it had a real high speed disc; it had a 2000 bond data center on it that was used to send the real computation task to a big central computer. Well there was several of these satellite computers around and we'd have them call each other up and exchange coordinates, game coordinates. And you could play somebody else on some other computer. And this computer had a big hood that you could put over the screen that would – that was partitioned so that one eye saw half the screen and one eye saw the other half of the screen. And so I wrote a three dimensional space game where you'd travel around in a cube and find the other guy who was on the other machine doing the same thing, and shoot him and kill him. You know, all the games are shoot and kill.

Q: Yeah, yeah.

**Ken Thompson:** So I did some of that and then there was a simulation of the solar system that I did.

Q: This is the space travel game?

**Ken Thompson:** This is space travel.

Q: Yeah, okay.

**Ken Thompson:** That you would take off and go to someplace else. You'd go into orbit around something, dock with something, those kinds of things. It had all the solar system objects that – it was two dimensional it wasn't three, you know, that we knew and loved then. They're more now \_\_\_\_\_. But anyway that was a fun game. And that got us into the PDP7 and to really running it. And then on the PDP7 we wrote the first version of UNIX.

Q: Sure, of course, yeah. Now were there – was there any chess on that or was that later?

**Ken Thompson:** There was an MIT chess program that you could just load stand alone and then play. And I played maybe one or two games of it. I think it was a variety of the Kotoc.

Q: Okay.

**Ken Thompson:** But I'm not that sure what its origination was. It was – but it did come from MIT for the PDP7.

Q: Okay. So then there was a move over to the PDP11, right, someplace in there?

**Ken Thompson:** Yes. But we bought a PDP11 to – the excuse was text processing but the real thing was to play more, you know, to play.

Q: Right. As I recall this – once upon a time weren't you trying to get a PDP10 or something like that for the lab?

**Ken Thompson:** Yes, we were arguing that the Multex machine should be replaced with a PDP10. And there was such a huge backlash from Multex that it was pretty soundly turned down. It was probably a good idea, the ten is kind of a trashy machine with 36 bits at – the future just left it behind.

Q: Yeah.

**Ken Thompson:** It –

Q: The world would have been a little different perhaps if that happened. Okay. But in any case you got off onto PDP11's and so when did the sort of chess emphasis get restarted in your mind there? Or when did you start getting serious writing chess software on that?

**Ken Thompson:** Oh there was a display on the first PDP7 and I wrote a set of display programs and then that moved onto the 11, and they were just kind of parlor games to increase, you know, interest in it. I wrote a pool program where you know you'd like up and shoot pool balls and they'd strike and break and bounce over the screen. And I wrote a chess program; and chess program was actually – I took it out and I actually competed it a couple times. I took it the New Jersey open in about '72 or '73 and won one game and drew a couple games and lost the rest. It was a very, very weak program and it was then distributed on the first versions of the UNIX as chess.

Q: Chess, yes.

**Ken Thompson:** I did a better job of it in software and took it to the big national chess tournament. There were two sets of chess tournaments going on in those days. One was American, which was run by the ACM and it was routinely called either the ACM Chess Championships, the U.S. Chess Championships, Computer Chess Championships or the North American Computer Chess Championships, as it got broader, and it ran every year. And I was typically at the ACM conference. And then there was one every three years which was called the World Championship and that was actually weaker. It had a bigger title but it was weaker because they would try to not keep it dominated by the U.S. teams. And they'd throw out the bottom of the U.S. teams and invite essentially everybody else in the world, and that actually weakened the pot. And then that was run every three years.

Q: So in that era, could you sort of talk about the competition and the general caliber of play? What sorts of things could the programs do at that point?

**Ken Thompson:** I think they played well. They were probably – when I started, my program was probably 1200.

Q: So you might want to explain that a little bit.

**Ken Thompson:** Okay.

Q: Talk about USCF ratings and –

**Ken Thompson:** Ratings are where one sigma is 100 – is 200 points. And the classes are every 200 points and they draw a line and they say the class. And if you and I play and I beat you a lot and I steal some of your points, and if you beat me, you steal some of my points. So this is kind of a big point pool, called the ELA Rating System, of all the chess players in the United States; and also other places too, not just the United States. It was originally designed that 1500 is the average tournament chess player. And then if you're good you go to like 1800, that's Class A, 2000 is expert, 2200 is Master, 2400 Senior Master, 2600 is Grand Master, roughly. So that's every 200 points and then below – 1800 and below is like 1816 is A, 1614 is B, 1412 is C, so this was low C; quite a bit below average for chess players. If you play at home with your parents or your friends quite a lot and you go to a real tournament, you'll probably end up around 1200 or 1300. If you play tournaments for a lot and are kind of average, you don't actually study it, but you play a lot, you go once a week to a tournament, then you'll be 1500. And then if you show real talent and start winning then you're in the 2000 to 2200. And then if you're World Class you're finally up around 2600, 2700.

Q: Okay. Yeah I thought that was worth getting in because – to give people context for these – if they're not – if those numbers are not ones that they happen to know.

**Ken Thompson:** That's an exponential scale too. That a logarithmic scale.

Q: Yeah.

**Ken Thompson:** It represents exponential growth that each one is a sigma better than the other. And a sigma means that you're going to beat the other person 70% of the time.

Q: Okay.

**Ken Thompson:** And so somebody 1200 is going to be beat by somebody 1400, 70% of the time and then 1400 to 1600 is another 70%.

Q: Seventy percent then, yeah.

**Ken Thompson:** Yeah. And so when you go out and you play this, there's – and you're rated and all of this, you kind of think of it – well numbers that you can just kind of increase. And you don't realize the vast difference between playing skill, that the difference between 1200 and 2600 means. You know, how much better Bobby Fisher is than me. And you just work for that next notch, and the next notch and you don't realize that you're, you know, that you're climbing mole hill before Everest.



Q: Yeah. There certainly is quite a difference. I actually played Bobby Fisher once and it's simultaneous, I didn't last that long. So I know that feeling, yeah. So I guess your take is that the programs of that era were 1200, 1300 kinds of things? Is that –

**Ken Thompson:** They were probably slightly better than that. Computers were expanding quickly there and the Northwestern Program was the perennial champion all during that era. And they broke like 1800 towards the end of that era, towards the late 70's, probably middle 70's. They won a Class B tournament which is limited at 1800. They actually came in first at, somewhere in the valley here.

Q: So okay, you were running around with basically a pure software solution at this point, running what, PDP11's?

**Ken Thompson:** PDP11, yes.

Q: Okay.

**Ken Thompson:** Yes.

Q: Okay. So then how did you get going on doing Bell, and getting into hardware as well as software?

**Ken Thompson:** It just came naturally; that you find out that, you know, you profile trying to make this thing go better. You know, the algorithm is where you start off with a current board position, you try all the moves and then you turn the board around and let the opponent play for each of those moves he plays all of his moves, and then for each of those you play. And so this is – this grows exponentially and you plot. All this stuff is in the literature. You plot how many ply you can look ahead.

Q: A ply is?

**Ken Thompson:** A half a move.

Q: Half a move, yeah.

**Ken Thompson:** Where you turn the board around and play yourself, turn the board around and play yourself for each of those. So there's 20 or so moves on a board so two ply will be 400 and three ply will be, you know, bigger and bigger and bigger. That you profile what you're doing and find out all your time is

in the mechanics of chess, it's not in the algorithms or the thinking or the evaluation. It's all mechanics, you know, finding the legal moves. And so the very first thing you think of is, you know, an accelerator to make those legal moves a lot faster. And you say, ah ha, one more ply. And so I made a little tiny chess move accelerator that essentially did what software does is – it finds a piece and then walks the – looks for blank squares, you know, wherever the piece would move, radiating out from that piece and lays down those moves. And then what happens is it presents these moves to the software and the software has to pull it out of the hardware. And then it's kind of hard to go into, but you have to sort those moves before you actually play them. You can't play them in the order, in some random order, that they come out of the hardware, you must sort them. So the hardware generates these moves fairly fast and then you pull them out meticulously and laboriously into the software. And then you sort them and by the time you do that the hardware is swamped by the sort and the – so it did speed things up, but not by what you'd normally think of as a hardware solution. It sped it up by, you know, two or three, something like that, instead of 100 which you'd expect out of hardware. So that was the first solution. I took some –

Q: So now – sorry. Quick question here, so how many plies deep would your original software solution go and then how – did this give you what another ply?

**Ken Thompson:** No, it probably did nothing more. It was probably four ply, it was software, and then four ply.

Q: Okay.

**Ken Thompson:** Still with hardware. And that competed in exactly one tournament which was the 1977 World Championships, which was in Toronto I believe. And I came in roughly at the center of the field, maybe a little higher. I was a point higher than the center of the field. So it was a wash, you know, but it was fun. These tournaments in those days, especially, you'd sit across the table from somebody who, you know, who knows chess just like you do. And the computers would sit there and play and you're bored. You know, you watch the game but you know it doesn't take all that much time. And you'd talk about algorithms and you'd talk about ideas on what you're going to do about chess. And then that would actually fuel you. You'd play six or eight of these people over the course of four or five days. Then you go back home, kind of absorb everything you learned, and try it for the – you know for the next year for the next tournament and then come back and it all happens again. So that's how it was sustaining.

Q: Are there any particular people or – that come to mind in terms of having interesting exchanges with?

**Ken Thompson:** Oh yeah, essentially all of them. Hatkins and Slate were the perennial champions; they were running on the fastest machines. They were running on control data, 66 and 7600's, and they were sponsored by control data. And then Bob Hiatt –

Q: Which program was that?

**Ken Thompson:** They were Chess X.Y for two –

Q: Sure.

**Ken Thompson:** - 3.0, 4.0, 4.5, 4.6. Hiatt and Blower from Hattiesburg, Mississippi were sponsored by Cray when Cray came out, and they were the champions for a while. Berliner is an amazing man; he won the human, the individual World Correspondence Chess Championship, just an amazing feat. It – and he sat down and at one of these meetings told me what he went through personally to win this championship; and against whom, and you know, against these – and this is the epitome of chess is the Correspondence Championship and he was the best by far.

Q: You might want to explain that because not everyone knows what that is.

**Ken Thompson:** Correspondence Chess is where you are given days instead of minutes to make your move. And you do it at home with open books and open chess boards and you move pieces. And when you make your move you write it on a postcard and you send it to your opponent and your opponent logs it when he gets it and starts his clock. I mean a calendar instead of a clock and sends it back. And so you get so many moves and so many days, and you carry on simultaneous games. You know, you're playing the whole field at the same time. And then there's the – a lot of the strategy is that where you're playing – if you want to stagger your clock, you play; you know you play one move and send it, come back. But if there's obviously replies and you want to dump your opponent without the ability to think during the postage time, what you do is you lay out a big – it's like a contract. If you move here I move here, if you move here I move here, if you move here. So you lay down six kind of forced moves or the best moves and dump him right in a position that is coming, and he knows he's coming and instead he gets two or three days per move to do it rather than nearly double or triple that time if you count in the postage time, because there's just one postal exchange. So that kind of strategy, playing people's best lines, their own lines, the research involved, it was just a massive toll on his personal life, his professional life it took to do this, he just – it became a full job, more than full job. You know, 20 hour a day kind of job for the duration of this tournament which is several years.

Q: Wow that is hard, yes. So perhaps before get into the further hardware work that happened, talk about the structure of the software that you were using at that point in terms of how things like opening book and the middle game and the end game. You know, what were its abilities in these areas?

**Ken Thompson:** It was really run of the mill. All of the computer programs were roughly the same. There were a couple of outliers, a couple of people who tried to do real planning kind of things. But the other ones were progressively – became strong enough that they never made a bad mistake, and all of

the planning type of programs maybe played better and looked better, but they always made some horrible mistake, somewhere along the game. You just have to make 20 moves in a row with no mistakes and if you make one mistake, you know, you get your head handed to you. So they can't – they can play chess better probably, but they can't win games and win the tournaments better. So they – Darwin pretty much pulled those guys out. All of the other ones were brute force or semi-brute force. And what they would do is start at the opening position, play all the moves for each of those moves, play all the moves for each of those moves, play all the moves. And most of them – at first they played to a fixed depth and then evaluated. And then they started playing to varying depths where they would play to some minimum depth and then extend based on what they found along those depths. You know, like if their king was in trouble, they'd move again, or if their – but basically they would never skip to very shallow depths any move. They looked at everything and therefore they'd avoid the really bad mistakes. And then at the bottom they'd evaluate. And an evaluation involved an exchange analysis on of what happened and then turn back. And then there's this marvelous algorithm called alpha beta that is based upon the idea that if it's your – if you find a move that beats – if – it's you and I, I'm sorry. You make a bad move and I show its bad by taking your queen. You put the queen on \_\_\_\_\_, I take it. I don't have to find the best way to take it, I don't have to find the best move against you, all I have to do is wipe that out and to the point where it looks worse than some other alternative that you have. And so as soon as I refute one of your moves I don't have to find the best refutation, I can quit at that point. And if you sort the moves, this is what I was getting at earlier, if you sort the moves, you want to make the best move first so the refutation comes you know statistically higher on the list and then you throw – you don't look at the rest of them. And so typically if there's a – 35 moves on the board, very typical, one side makes 35 moves, it's on the offense, and it's trying to find the best move, and the one on the defense has to just prove that's a bad move, he makes one move. And then the offense makes 35 moves to try to count that. So it's – the tree looks like 35:1, 35:1, 35:1 and so it grows as the exponential of the depth over two rather than the exponential of the depth. Means you look twice as far with this algorithm as you can without it. And it's just immensely powerful.

Q: So when did that start to get widely used?

**Ken Thompson:** It was used before I got into chess.

Q: Okay.

**Ken Thompson:** There – in history, if you look at the books, there are three or four people who invented it. Samuel says he invented it in his chess/checkers program but if you look at the records of the games he played, I doubt that very seriously. Simon and Shaussy they invented it. Canuth has a claim to some portion of it and writing about it, but not in a real program. And there was another chess program that they – said they invented it. So you know it's sort of lost in history who actually invented or maybe it was invented more than once. But there's two forms of it. There's a so called deep cut off version and a shallow cut off version and I think that the two versions came about separately.

Q: Okay. But it was widespread and used then in the 70's, was that \_\_\_\_\_?

**Ken Thompson:** Yes it was.

Q: Yeah, okay. So that had gotten in – I think that's certainly one of the things we've been interested in for the chess exhibit was to show the power of such algorithms and why they do make a difference. So that's good to hear that extra commentary on it. Okay, so then after doing mostly software with a little bit of hardware, somewhere in there you really got going on doing Bell with some help from Joe Cann then and I guess some other folks?

**Ken Thompson:** Right. Joe Cann and I teamed up and we built a small chess machine, which is in a display case in the lobby of Bell Labs now that is maybe a cubic foot. It had a LSI11 in it and three cards, which is about a square foot each. One card was a move generator. It would generate the moves and sort them, and play them. It would actually – it had a micro-machine that would actually play. It had another card that would evaluate the board and then it had a third one which was made out of memory chips, 64K bit memory chips, that was the transposition table to like a big cache so that when you found the position you've seen before you can just cough up the answer instead of re-evaluating it, and cut off the search. That machine made its debut in the U.S. Championships in Washington, D.C. in '78 and it won them essentially for the first time, cutting off chess X.Y's dynasty.

Q: Okay, and sort of what kind of depth of search?

**Ken Thompson:** It was searching about eight ply.

Q: Eight ply at that point?

**Ken Thompson:** Yeah.

Q: Okay.

**Ken Thompson:** Six to eight.

Q: Okay. All right, so then where did you go from there?

**Ken Thompson:** We played it again the next year in – I can't remember where, Minneapolis and we tied for first, because of course they were on general purpose – monster general purpose computers that

were getting faster all the time. And Joe and I then went off and designed another machine after that. So it played those two tournaments. We – the next one was about the size of a small refrigerator, you know, a hip high refrigerator. It was built on the exact same principals but was much more parallel. It had three sections; one section was four boards which was move generation. One section was evaluation, which was four more boards. There was one more board that was – Micro Code ran the whole thing. It was conducted by a PDP11 and LSI11 and it had commercial memory at this point at 1 megabyte; monster, of transposition memory that was run by a micro-controller. It was approximately – it was probably 100 times faster than the other one. It ran about a 160,000 positions per second. A typical software ran about 6,000 positions per second; that's on a fast machine.

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**Ken Thompson:** ...anyway I took this off to its very first-- it went to the chess club a couple of times and I actually became the Westfield Chess Club champ <laugh>. It was clearly playing in the master level, it-- we had probably four or five masters and one or two senior masters and then a couple of visiting IMs, International Masters, at this chess club, it was a very strong local chess club and Bill had been a since the early 70s Bill was a member and a frequent sponsor and things, I'm going to digress for second. There was a hostility about computers and chess and humans and chess I mean you know in the same tournament and whether they cheated or not and it was all big philosophical flesh, some people were just adamant and mostly they were just apprehensive and afraid and so I made a very, very slow inroads into the chess club and built my relationships and things like that sponsored you know tournaments and always refused prizes, always moved the prizes down if I ever won prizes and then played friendly games and played simultaneous exhibitions with the computer and then pass out you know analysis that the computer would print during its game with the people score, it-- you know it built an end so it was a part of the structure of a-- of the club and new people it was just there and they always played it and everything, everybody played it while other people would go into a club and demand that they had the right and generate lots of bad feelings so if you have a chess machine like this or a program and you're trying to find out how well you're doing the best way to do that is to take it and play it and get it rated, and the rating is a nice number how well you're doing and if you haven't got a nice friendly place to do that, first off if you're getting rating points from fear factor which I don't think is fair and secondly you're generating more heat than necessary in doing it so anyway I had this local chess club, Westfield Chess Club that I cultivated as a resource to play and I went nearly every week for ten years.

Q: And how did its ratings improve in that period?

**Ken Thompson:** From twelve hundred to 22 something in a period of about six years. So anyway this monster machine went to the world championship in Lionsault Australia Linz that was...

Q: Which year was that?

**Ken Thompson:** That was '80...

Q: 1980?

**Ken Thompson:** Yeah and that was I-- I don't know that was a lot of fun. It was too important to actually take the machine although it was portable enough to do that most of the computers were big main frames, were also called up by phone and after four rounds there was a tie; and so they ran out of money for phones after that <laugh> and so what they did is they had both the winners-- co-winners were in the United States, one was Bell and one was Kaos [ph?] was their names and had them call each other up in the United States and then once every five or six moves they'd called us and read the moves off to us and we'd pretend like it was real time <laugh>. So anyway it was-- and Bell won that, won the play-off. These are Swiss tournaments, very short Swiss tournaments so actually who wins is remarkably close to the notion of who I thought was the strongest, even though they're pretty random events because of the very short tournaments and one loss and you're out kind of thing.

Q: Okay so then I guess where did things go from there, because Bell was certainly a force in chess for a number of years?

**Ken Thompson:** Yeah I played him in a bunch of tournaments, a bunch of exhibitions we took it to Moscow that was that famous...

Q: The famous infamous trip, yes since you mentioned it, why don't you describe this?

**Ken Thompson:** This is a hard thing to describe; I got invited by Botvinnik in case you don't know who Botvinni was, he was a world champion, the grandfather of chess. He was the-- he was actually the span across the war, he was a strong player before the war and a strong player after the war, well all the other world champions who had been real strong players were ever pre-war or post-war, he spanned it; he was kind of the inventor of the Soviet school of chess and a Soviet dominance of chess. His institute set up camps for finding chess talent and building it and everything, he's just-- he's just the Soviet chess player of the old time. He invited-- mostly invited my computer because he had a chess program and he was having trouble funding it and it was largely regarded as a-- computer chess was largely regarded as a fraud and he wanted to generated some publicity that this was really was working and that it really was you know for his own personal benefit you for know for his own fall out and I was allowed to go along with my computer <laugh> so I show up at Moscow and I had arranged-- I had brought the computer out all packaged to be in the hold of this plane that I was going in and made sure-- you know made all the arrangements and all-- everything so that when I arrived it would be there and I could take it out and have-- it wasn't separately shipped so I had to go out to Kennedy twice; once to package it the day before and everything and then everything and once for myself and so I landed and I go to the you know while they're undoing this plane and it's not there; I don't now why, it's just not there, disappeared and so we

make a trace on it and the trace comes back in a few hours and I get it back in the hotel and they say 'it missed the plane, it'll be on the next plane' so I tell my sponsors and we go out to the airport and we meet the next plane and wait and it doesn't come off, don't know what happened and we call and they say 'we don't understand, it should've been on that-- it must be on the next one' you know. So we meet the next one, it wasn't on the next one - it's like two days now and there's a bunch of-- there is a massive schedule, I'm there for a week and there's a massive schedule of where I'm supposed to take this machine every day and then there's like little pieces of touristy stuff in between these chess schedules and they keep pushing the schedule back and making it all tourist but you know so I'm touristy and at some point I get a call from Joe Condom from Belab and he says 'I had a-- I hand carried a bunch of spare parts for this machine' I had a disc and a CPU and you know a whole bunch of spare parts and Joe called me up and said 'don't bring the spare parts back, throw them away' and I said 'why?' And he says 'because you're probably going to be arrested when you get back in the United States' <laugh> 'oh great you know' and I says 'what for?' 'For smuggling computers into Russia' and I said 'oh God' <laugh> so what happened and-- what happened is that an ex-Belabs guard was working as a night guard at Kennedy and happened to notice that a Belab's package that said 'computer' on it was cordoned off by you know the security police, the Feds from Washington and that n body at Kennedy, none of the local customs people were allowed to touch it, it was just you know roped off, it was like another world you know and he called up his friends in the guard department at Belabs and said 'you know maybe you'll want to know about this' and that rippled around and finally got to Joe Condom who found out that this thing was confiscated out of the hold and what had happened is the day before I left, Ronald Reagan gave his famous hemorrhage of technology speech to congress saying 'we're just bleeding our lifeblood out to these you know these commie you know pingo bastards' you know and so the customs department they just jump up and they run out to all the airports and what do they see? They see computer, destination Moscow, they just grab it <laugh> and they \_\_\_\_\_ in a corner and don't tell anybody about it, there's nothing so I-- next day I call a meeting of all my sponsors you know the and it's-- it was the most uncomfortable position I've ever been in my life, it was in a-- it was the chess club and it was a very long dark drapery laddened you know deep purple red under lit room, it was where the table you know an oak table probably this thick that was maybe you know ten yards long and the head of the Society guy his name is Grototies [ph?] he was a grand master was at the far end and I was at the far end, I'm sitting all alone and he's got like four minions, you know clustered him and then there's about 20 spare seats and I'm sitting at the other end at the head of the table and he says-- I explained to him that it's not going to come, it's confiscated and then he said something very, very strange he said 'uh you know Ayatullah Klomeini?' And I says 'yeah I've heard of him, I'm not a good friend.' <laugh> He says 'well Klomeini has outlawed chess in Iran because it you know it's against God and do you suppose Reagan did this to outlaw chess in the United States?' And I-- <laugh> I can just see the headlines now you know 'no I don't think so, I think this is some low level custom guy who probably didn't even know how to play chess' <laugh> and he says 'oh okay then' that was the end of this meeting, you know this meeting and then I was a tourist and they wouldn't talk to me, they-- I mean I was pariah, you know but I-- you know you can't leave except on the you know the reservations are like you know forever, you have to have them months in advance to go in and out of there and you can't-- don't change them so I was there for another half a week as a complete pariah you know these guys you know just didn't want to talk to me and finally went home and I stopped off in Germany and dumped all my spare parts <laugh> and then flew back to the United States and after that I tried to get the computer back and you could go out to Kennedy and it



was there, but nobody knew who had it, what they wanted, what they were hoping for, what it was all about and so we had this import/export company that kind of worked with Belabs for going to shows and things like that and they worked full time on it, couldn't find anything about it and so at one of the chess club meetings, this Westfield Chess Club I was telling the story about how it's taken and you can't get it back, you don't know who wants it, you call and there's this telephone number on it, it says 'for information call' right on the computer, and you call this number and they take your name and address and say 'they'll call you back', and they don't and that's it, that's all you can get out of these people you know, this telephone number and so I relayed this story in the frustrations of trying to get this back, this was about six weeks after it was taken, still sitting at Kennedy and one of the guys there worked part time in one of these weekly throw away magazines on Long Island, you know the ones that you know you get you know little local community newspaper, he says 'you mind if write this?' And I said 'no, go ahead write it, it's true' and so he wrote it and it came out in one of these magazines and a clipping service got it and some guy from the Washington Post called me by way of this magazine and I told them the whole story and he says 'well let me look into it' and I said 'well good luck you know, I've been looking for six weeks, I've been trying very hard for six weeks' <laugh> and he says so he hung up and 15 minutes later, 15 minutes later he called me back and he knew who had it, what they wanted, everything about it, you know, he had contacts. Somehow he figured it out you know from what I told him, and he says- he says that they claim that if customs has it and they claim that it can be used for weapons research and I said, 'you know there's no way it can be used, you know maybe if you threw it out of a plane it could kill somebody but you' <laugh> and he says 'can I quote you?' <laugh> and I said 'sure I said it you know' and so the next day there as a Washington Post article, fairly large one about this, with this quote about you know killing somebody by throwing it out of a plane and the next day it was picked up by nearly every newspaper source you know and the day after that the customs called me, they finally called me you know, I'm sure it had nothing to do with these newspaper articles, made them look foolish, and they said 'what is it worth?' I said 'technically' they said to me 'technically you're in violation of the Export Act.' The HP terminal that I was taking with this to run the computer was on their list of bad things that you can't take overseas right, and thier list is so old I mean this was an obsolete you know terminal you know the computers were not on the list <laugh> you know all the chips weren't on the list but you know this lousy HP terminal was on the list and they said 'so technically you're in violation and typically what has to be done is you have to pay a fine that's a percentage of the worth of the equipment, so how much is the equipment worth?' And I didn't understand what he was saying but you know I said 'oh well we-- the budget that you know we kept a budget for it and it was seventeen thousand dollars to build this thing' he says 'well you don't seem to understand it was probably used parts now right and they probably weren't worth their full weight, and you must realize that we're going to have to fine you a percentage <laugh> of your \_\_\_\_\_' and I said 'oh well yeah they were used <laugh>, it's probably only worth a thousand dollars' he says 'okay, well we have to charge you 50 percentage, so a five hundred fine' you know and so Belab sent them five hundred dollars and they sent the computer back <laugh>, that happened in the next day so suddenly it just all broke loose and so anyway that's the Moscow story.

Q: So that's where the origin of the quote is, I had heard that quote of course but I had thought that it was earlier in the sequence, not at the end.

**Ken Thompson:** No, no it's actually-- there was the what broke it loose otherwise it would probably still be at Kennedy <laugh>.

Q: Which year was that?

**Ken Thompson:** Probably '82 or '83 - '83 - it was June-- it was-- there was-- while I was there it was VE day for-- which is a big, big holiday in Moscow because of the war and it was later than our VE day by one day because good news didn't travel, it was a day late getting there

Q: But you seemed to have lived through that experience with a good story of it anyway. So then after that let's see I think as I recall Bell won a number of additional times in the Oceania...

**Ken Thompson:** Yeah, yeah it sort of dominated; it had a hardware problem that I could never fix, the-- it was wire-wrapped and a batch of wires that we got were nicked, what they do is they pre-cut the-- their in links with pre-cut insulation on the ends and their machine was ill-calibrated and it actually nicked the wire when it stripped the wires and so when you put it in a gun and wrap it on the post it would stretch it, that's how wire wrap works and it would break inside the insulation and if you didn't notice it, if it didn't actually separate the wire so it could cause an error, you'd have these nicked wires under stress on these posts and they-- if they failed you could find them but if they were intermittent which one of them turned out to be, and I never found it, then it would sometimes run on and sometimes not run and when you're chasing down it would start to work and it would be catastrophic during a game because it would fail in the middle of a game so it stopped working around '85 or '86; and actually one of the last time it won was at the '86 US championship; it won '80, '81, '82 didn't win '83 and '86.

Q: So at that stage how many plies was it going and what kind of rating did it have?

**Ken Thompson:** It was going eight full ply easier, the other one was probably going six and was easily mastered, probably 2300, I never worked for rating you know you can squeeze rating points out by studying your opponents and booking up and taking away-- put a punch of crap kind of stuff in but I wanted to play, you know, just play dice solid chess and so it was probably 2300.

Q: And I think at some point I recall you talking about sort of the ratings compared to compute power as you I think extrapolated for about what kinds of compute power it would take to get certain improvements and ratings

**Ken Thompson:** Yeah...

Q: I can't remember when that was, it must have been early '80s or something...

**Ken Thompson:** Yeah it was early '80s. The-- it was Astintotick [ph?] but it was in the high rise part of the Astintot so you can't really tell whether-- where it rolled over but it would certainly in the era that era you were gaining for every doubling of horse power you'd gain a hundred points and I came with some really \_\_\_\_\_ back of the envelope calculations it set it around 12 or 13 ply, it'd be well world class, maybe not-- you'd compete for the world title, you may not win it but you'd be comparable.

Q: I mean presumably the ratings in some sense get a little less accurate at the very top I would think...

**Ken Thompson:** Yes, yes.

Q: So the last one in '86 and then at that point did you retire it or were you using it internally for things, what were you doing with it then? There was a period as I recall when you were doing a lot of work on 'n games, maybe it's worth talking about the n games'.

**Ken Thompson:** Okay the n games I did it under the name 'Bell' but I didn't really use any hardware, that was all software...

Q: So why don't you talk about that because I recall that's been an area where computers have certainly augmented our understanding of chess.

**Ken Thompson:** It started-- it's a very long story, goes back-- the first tournament I was in was in-- you know, the second tournament I was in was in San Diego in about '75 or '74, '75 and in that tournament David Leivich [ph?] who's a famous chess personality was the tournament director and we were-- after the games we were in the bar talking and he was saying that computers can't play n games, even simple n games and they never will and he says 'I'm an expert in the rook and rook and pawn against an n game and a computer will never play a rook and pawn against a rook n game' so I went to my room in the-- you know that evening and I was calculating the numbers and came to the conclusion that this was doable, that you could solve that game, absolutely solve it by a different mechanism but not you know not by you know normal computer chess but by a different mechanism, you could just have the answer and look it up, didn't make a table for everything that you're supposed to do, and I came back the next day and told him about it and he says 'no, takes too many plies' you know and I said 'it's ply independences different method' you know to 'oh no' so he just poo pooped me and I got sort of angry is not the right word but I got you know, you know so I went home and I worked probably for after that ten years on n games <laugh> from that point encounter one evening after the bar and so the method is to lay out a chess board that has two kings on it and then look for all the positions that two kings can all combinations of positions of the kings can be there and find which one's are mates and you know surprise you'll find none of them are mates, right so then you put a king and a queen against the king and you find all the mates

are there, so then you have a list of all the mates in one and then you build instead of a move generator you build an unmoved arise from that and a move is like an unmove except check is a little different, uncaptures a very strange move, sometimes you know uncastling and stuff like that so but basically it's just a move generator with different rules and so you find all positions that you can force the mates that you found in the last pass in two ply and then you do that again and again and again and again and when you find no more everything you didn't find is a draw so you do it by exhausted search, one ply at a time back from the terminal positions, from the end positions and it's called retrograde analysis, these \_\_\_\_\_ chess problems like this and so I worked on it and the computers weren't just big enough to really-- this was a \_\_\_\_\_ manipulation problem, it wasn't a computation problem, you just couldn't hold the answers; the biggest disc was like 5 megabytes at the time and this was-- each of these positions of three pieces had a king, a king and a thing were megabytes and then you had another piece on it, it becomes you know it gets bigger and bigger and then when you add a pawn which implies that it can promote which implies that it can be any number so anyway I saw a bunch of these three and four piece n games and some of them turned out to be very, very tricky and actually overturned conventional wisdom.

Q: Say some more about that.

**Ken Thompson:** Well the hardest one of the four piece n games is king and queen against king and rook and as the conventional wisdom that the rook cowers like a chicken <laugh> and the queen comes over eventually separates it and takes it-- checks it, checks it and takes the rook but the defense it comes up with is not cowering, it's very active and very pro-active and it kind of keeps the rook a-- it keeps the opponent king away from the-- your king by an empty square, an empty row and no one's every seen this defense before so I played this at the local chess club against the masters and then I played it at the '77 world championship against some very strong Canadian masters and then there were a US championship going on in Chicago at the Park Hotel and a friend of mine was there playing, called him and he arranged and had a bunch of the real strong masters from the US championship-- US Open play the computer simultaneously queen against rook play either the you know the and it held them all to a draw. They couldn't win with a queen and then he said 'well let's find a really-- a real strong grand master' and the US champion at the time was Walter Brown and a friend knew Walter and says 'you know you can't get him to play this, he'll think it's stupid, but if you bet him money you know' cause he's a better <laugh> 'then you've got it'...

Q: ...human ego yes comes through for the machine.

**Ken Thompson:** So we bet him fifty bucks he couldn't win queen against rook and so we set up a date and he had friends over and he was going to you know-- he allocated 30 minutes you know he was just going to just blow it away you know in 30 minutes and you could-- he had people over to watch and-- but half way through he kicked the people out you know <laugh> he was silent, he started going over on time but we didn't call him one time and then at some point you know we knew exactly how far we were to mate at every point and we knew he wasn't going to win because you know it was going to take him more

time than we had and we said that the rules were 50 moves, he has to win to the 50<sup>th</sup> move or less and you know computer chips-- this is human rules 50 moves.

Q: Sure, that's the 50 moves that required a piece to be taken right?

**Ken Thompson:** Computer taken or a pawn to be moved if there's no pawns here and he lost and so he wanted a rematch - 50 more bucks and I thought you know 'I'll give you your 50 bucks back I've made my point' <laugh>, 'no, no 50 bucks sounds' <laugh> and so he-- we gave him from the current-- there are two best positions, or worst positions whatever you call these things maximal positions and we gave him one and kept the other one a secret and from the one we gave him we gave him perfect play to capture and he went home and studied for a week on perfect play and I-- and he's a studier you know and he studied I think the whole week and the next week cause it was a Saturday and the next Saturday we set up again and it was much more serious and we played the second maximal position and he attacked like you know and the computer when it had equal moves it would play them at random and anyway he got-- he said he wanted uh he made some more conditions to, 50 moves he wins. 50 to 55 it's a draw and more than 55-- some number like that I can't remember the exact conditions so you know lose, and so anyway he actually he did it-- he actually did it first time he did it over the board, did it in exactly 50 moves right on the nose, one more move and it would've been a draw by the rules and there's one point right around 18 moves to the win where he-- it's like a wall where people just hit it and bounce, they just don't know how to cope with this defense and the computer makes like two or three random moves-- selections and one of them turned into repeating move you know where he could move the whole thing down a notch by doing a set of checks or-- it wasn't optimal but it was human and that's how he got through that wall so. Anyway it was fun, it was written up in the Minnesota Chess Magazine that-- there was an article called \_\_\_\_\_ <laugh> very, very well written.

Q: So interesting, so it sounds like-- what's the current state of n games and how-- it sounds like we've gotten there with a lot of software.

**Ken Thompson:** Well Vig Row exponentially with a number of pieces on a board and so this was four pieces; five pieces were done after that and then right now state out of six and six generates gigabytes of data and every ply-- every more piece after that goes up by a factor of 64 so if you think that something-- you've got to wait for the computer industry to \_\_\_\_\_ to give you a 64 in order to try the next step and we're between steps from between six and seven.

Q: As I recall, unless I misheard this, I thought at some stage did you not discover that there were cases I guess that it was impossible to do it in the 50 moves, it was still a win, were there cases like that?

**Ken Thompson:** Well there are tons and tons of them. The computer-- the human rules were 50 moves to-- but they didn't want to outlaw wins that were real wins and there were like two known positions; one

was two knights against a pawn I think that might have been the only exception, two knights against the pawn which is the old what's his name, gee I can't think of his name, the guy worked this out human, where two knights alone can't win because they can't mate a king without stalemating him first and so that's why the king has the pawn and the pawn is there just so that when you stalemate the king the pawn moves and then you go through.

Q: Yeah, yeah okay.

**Ken Thompson:** \_\_\_\_\_ and so that was an exception to the rule where for that game if you reached that game you had a 100 moves \_\_\_\_\_ and the idea was that you got to you know demonstrate that you're going towards a solution but they don't want to take the win away from you if you are in fact winning in the \_\_\_\_\_ position and you just don't have enough time they don't want to take that away from you so this was their theory is that anyone that was proved to be more than 50 moves they'd add to the list of exceptions and so I started publishing all these lists of exceptions and the list got longer and longer and longer and they were all in-human I mean they were just amazing solutions...

Q: But you said they were inhuman...

**Ken Thompson:** <laugh> these were just-- they're just crazy. The hardest one is a queen and pawn against queen and people avoid this like the plague because it's-- the queens are just wild on the board and they're interpolated with million checks before every pawn move so the-- in the '60s n game there's one that-- this runs about-- depending on where the pawn is, this can run up to about a hundred moves so they put in a hundred and fifty move exception for a couple of these very long positions pawn against queen and anyway they started putting in more and more exceptions and finally they just canned it and so they change these rules about four times adding exceptions and then they said 'that's it, 50 moves and if you can't win tough' <laugh> so they're back now to no exceptions 50 moves. Okay, and the current record is in a six game-- six it's king and two rooks against the king and a knight-- a king, a rook and a knight and it's like two hundred and fifty moves, I'll give you exact numbers sometimes

Q: I just find that's an interesting interaction between the software finding these things and human-- extra human play were...

**Ken Thompson:** Enough of these now are in the literature are on the web or they're databases around where you can go find the answers that they become celebrities. When they show up in a famous human game and a human doesn't do them right, suddenly everybody on the web's an expert and they you know <inaudible> and there was a one of the Fischer \_\_\_\_\_ games that ended up in a draw with \_\_\_\_\_ based on...

Q: ...on these cases yeah interesting. So let's see so I guess an interesting question looking back on this is to what extent did the structure of your software change from you know when you had a program that was playing something that 12 or 1300 to Bell at the end, the parts where you replaced software by the sort of equivalent hardware. Were there other particular structural changes that went on?

**Ken Thompson:** Oh the first ones I didn't really understand alpha beta and it was kind of a mess you know and you'd compare things and quit and you know it was just really not under control. But then as soon as I really boiled down the essence of alpha beta and got that then they were all the same after that. They had little different extension rules you know where you search deeper and keep track of how deep you've gone and stuff.

Q: How about evaluation functions, has that changed over time?

**Ken Thompson:** They just got more and more-- when you have a 1200 program there's certain material dominates \_\_\_\_\_ hardly anything else, anything else is if it plays roughly 1200 points as far as tactically goes, it just doesn't matter whether you understand \_\_\_\_\_ square complexes and <laugh> so as the computer plays deeper things, that we'll just learn like forks and pens and stuff like that learn but things that are just outside of its range you know you want to teach it and you put those in the evaluation option. Search does a lot for you know it amplifies the evaluation function and so subtle things mean more at bigger depths and there's also another thing that there's a randomness involved-- there's a famous experiment I'll-- it's not well-- well-- not many people know it but suppose you have a chess program that plays you now everything except the evaluation function, okay and you put in some terms like you know materials good you know, whatever you want all right. Suppose you replace that with a random number just rant is-- will that outplay a program that has some weak evaluation real function-- or zero will it outplay a program that has zero? If it has a big random number generator as opposed to little random number generator you know will it outplay it and the answer is yes. Random number generators are good evaluation function and the reason is, it amplified its-- if there's only one way to play right, you're going to get a random number evaluation back right? You're going to play-- this guy must play this, this guy must play this, this guy must play this random numbers so you've got like zero to one that's you're random number and you bring it back, that's going to be your function at the end right? But if you had like two or three ways to play what you're going...

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**Ken Thompson:** So anyway if you have this random number generators in fact are good evaluations in shape of the tree. And that if you have -- there's various technical reasons, but if you have some real evaluation function, if you throw some little random number generator on, it'll make it better. It will take the shape of the tree into the account of the position and it will give you more flexibility in the tree. You know, it's the way of breaking ties in certain cases. And that shows up in fact that it -- if a four ply search

can have like four co-efficients; four patterns, whatever you call them. Four is good for deeper things because it'll find different ways to find those four. What you want to do is the deeper you go you want more and more subtleties in your random number generator – in your evaluation function. And so yeah, I guess the question was as you go deeper and deeper and deeper, you must keep you with a valuation function.

Q: So now as I recall I think at some point didn't you have instances of bell playing itself or something like that? Or instances of the earlier software?

**Ken Thompson:** That was to get the – out of the curves that we talked about earlier about what apply means. Why you'd have bell playing at four-ply against bell at five-ply, and four against six, and six against four and five. And then you pretend like these different bells, at different ply's, are in a tournament and you'd rate the tournament, and you'd get a rating per ply for each of the – and then you'd get this typical lasimtodic thing. And the range that we were doing was 100 points per \_\_\_\_\_.

Q: Okay. That's where that came from, okay. So actually, some of that brings me to one of the more Meta questions in here which is the brute force versus artificial intelligence thing. So, you were clearly on one side of this, perhaps it's worth talking about how you came to believe that was the right thing to do.

**Ken Thompson:** Because you can't afford to make a mistake. And the deeper you go, the more you can't. Plus, alpha beta is so good that it takes you one unit of time to evaluate one move if think is the best move, right? It takes you one more unit of time to – with that as a basis value in the alpha beta, the alpha value; in the alpha beta search it takes you one more unit of time to prove that all the rest are less at the same depth. So I mean it's so – this algorithm is so dominating that it just doesn't make sense to try to do better than that because once you have a good move and on evaluation it's so much – so easy in computation to use that value to prove, you know bounds proof, on all the other moves that you don't have. And you never have to you're sorry when you do that. So it's, the truth is that there is a melding of these two ways now. The current method is to do massive extensions down the main lines and then search the – with some different kind of proof. There's these no move generators is the big algorithm now. That, if in this exchange, this you know, inside the computer you're playing yourself, you know, you make these moves and the idea is that if at some point you think you're doing okay and so you just pass and let the opponent have a move without you doing anything. It's like testing for the position for a threat. And if he can't do anything, if he can't exceed this alpha value with two moves in a row, then he's got a lousy position.

Q: He's got a lousy –

**Ken Thompson:** And so you don't have to search that one very deep because you know, with two moves in a row the idea is that with, if you really took your move you can't do better than that. If you can't do it



with two moves in a row, he can't do with it – you know after you move, which is not true in these \_\_\_\_ zone positions. But you try to avoid the pitfalls. And so this gives you a place where you can severely cut down – what you do is if you can do a no move and get away with it then you don't search that to a big depth. And if you do a no move and you don't get away with it, either he has a threat then you search back to the depth.

Q: You have to work for it.

**Ken Thompson:** And so you can take and throw away most of these positions and search them at, like two ply less. And so computers now, if they applied the horsepower to the – today's horsepower to the algorithms of the 80's they'd be doing eight or nine ply. That now these PC's are doing ten and twelve plies with this no move threat analysis.

Q: So that's interesting. That's another, yet another algorithmic efficiency approach to this.

**Ken Thompson:** Yes.

Q: Yeah. So, as I recall, once upon a time, like chess was viewed as sort of the great AI thing, right? But that seemed to have died off fairly early in the chess playing game, is that fair or is that –?

**Ken Thompson:** No, it was always touted as the drosophila I guess. That was the word they always used, it's a drosophila of AI. And the – you know Idgki and all of those still – they talk about the computer chess, you know, being waged over there in brute force. But from afar, they just look at the results so they're getting, they're getting better, they're getting better as proof that AI is working without looking at what they're doing. And the – as soon as it became very clear that they're just brute force, plus they're getting very good and that no AI program ever competed. They slowly drop the drosophila. Now they're talking about Go.

Q: Go, okay.

**Ken Thompson:** Where brute force doesn't work on Go.

Q: Have you ever tried the Go turf at all?

**Ken Thompson:** No, I never got into the game. I guess you have to wire your brain at an early age to – you know I certainly understand the – I mean it's –

Q: The rules are simple.

**Ken Thompson:** You know it's a trivial game.

Q: Yeah.

**Ken Thompson:** In some \_\_\_\_\_ yes. But no I never got into the game. And I tried to, you know, read and understand the game but this was you know in my 20's and I think it's too late then.

Q: So sort of finishing up here. Any particular moments in these matches where there were surprises, either positive or negative, where the bell surprised you or the opponent surprised you? Any particular things that stand out?

**Ken Thompson:** Oh there's some – oh yeah, almost every match, nearly every game had some monster surprise. When it was flaky and it would just throw away a piece in the middle of – you know, it had – it was an attacker. I mean I tuned the evaluation function to, you know, weigh king, safe king really high, you know and it would just go for the throat. I loved the way it played. And I did it mostly for entertainment not for results. And so it would be, you know, just tearing this guy's king apart, you know, just going in there and laying waste and then suddenly drop a piece and announce that it mated you. And he's looking where's the mate, you know. And – no those are horrible. And then the – all the missed opportunities, you know, where you upgrade a program or hardware that's like maybe ten or 100 times faster. And then you go look at the tournament that the previous program played and you say, oh no how did I miss that? And then there's a game – I'll show it to you if there's a chess porter out, but it's a 20 move game that is just spectacular that it played. This was in Washington D.C.; it beat – because I was paired – I was a dark horse there you know and I was paired in the center. And so the first round I was paired in the, you know, in the Swiss tournaments I was paired against the top player. I was playing with \_\_\_\_\_ and I beat him, first round. And the second round I was paired against the second player and beat him. And the third round I beat somebody in the middle and had won the tournament, because they'd all lost and couldn't catch up. And so I'd won the tournament after the fourth round. After the fourth round I'd already won the tournament, I had another game to go. I was more than a point ahead. And this last game I played and it was just – and it was one of the most beautiful games I've ever seen. And you know to watch that on top of the, you know, coasting to a win and watch it play this marvelous rook sack right out of the opening, where nobody saw it on the board, it was just beautiful. It was a – there was a move in it that was – his move was pawn takes queen, my queen, which was a sack discovering a check.

Q: Okay.

**Ken Thompson:** And the reply was a double checkmate. You know, block the check and deliver double checkmate.

Q: Deliver check –

**Ken Thompson:** Double checkmate. It was just – I've never seen anything like that on the board.

Q: Interesting. Well it is – I guess when I was watching all this the thing that struck me was that the funny things that happened where this was supposed to be artificial intelligence but it was more partnership between human designers of chess programs and the programs. Again, sometimes generating surprises or spending all this analysis of N game to find the cases.

**Ken Thompson:** There's very – the N game stuff, almost every program now that competes has those N games just buried in their tables, so that if they run into them they get the answer. Have – they're actually rarely useful, you never run into the N games in a real game.

Q: Now how is that? How usually you have an N game sooner or later, correct?

**Ken Thompson:** No. Not – computer chess games are won in the middle game. They're – rarely – I'm not –

Q: Okay.

**Ken Thompson:** Not never, but rarely. They're – everybody has them because they think they have to have them. But they're not that useful. Opening book is useful but unfortunately it can be used a weapon against you. If somebody knows your opening book they can book against you and essentially win the game before you –

Q: Get out of book, yeah.

**Ken Thompson:** - before you're computer starts to play.

Q: Yeah, okay.

**Ken Thompson:** And the – these commercial programs, you know the ones that are – sell at Christmas you know for – it's a big feather to be the best of the commercial programs.

Q: Sure, of course, yes.

**Ken Thompson:** And so the – and of course the commercially – the opening books are commercially available. So somebody who comes out a week later has an anti-book to the everything on the markets. So anybody who goes and plays these two programs A beats B a 100% of the time because B has A's book. And so I mean there's, you know, there's all of this stuff – well in real play, except to not fall into opening book traps, opening books are not that useful. If you want to play real high level chess you need to have them. You've got to save the time. They save a lot of time and they avoid a lot of –

Q: Traps.

**Ken Thompson:** - traps and stuff. And they can direct you into the kind of positions that computers are good at. Computers are still good at wide open tactical positions and they're pretty lousy at block positions. So the combination of saving time, avoiding traps, and steering the game into the types of positions that computers are good at make them really good for, you know, like cast prof against deep blue. Those kinds of positions.

Q: So let's see. Okay, so sort of the current state of the world then, I don't know, what sort of size of opening book do the typical programs have?

**Ken Thompson:** I don't know. I honestly don't know.

Q: Well what size did you have when you \_\_\_\_\_?

**Ken Thompson:** Mine was monstrous. I had essentially all of ECL.

Q: Okay.

**Ken Thompson:** And the reason is, is because I would play everybody's favorite opening. Again, if you open E4, because that's your book, your book says E4, you've wasted maybe 80% of your book by not having, by also having D4 and you know and C4 might have three in there right that don't transpose. And that's exactly the same proportion that alpha beta cuts off. Do you understand? If you're going to make this move you don't have to analyze the other ones.

Q: Sure, sure.

**Ken Thompson:** And so I had an opening book during that era. It was an order magnitude larger than the next – but mainly because it was – it had all the openings and I really loved to mix it up and especially in \_\_\_\_\_ I'd play with random openings.

Q: Oh okay. And how many different ones would be in the mix of the random opening if you had white? Let's see, there's not that many.

**Ken Thompson:** I'd probably – I had where I'd tell it to make a random choice, maybe 20 or 30 places.

Q: Okay.

**Ken Thompson:** Real early in the book.

Q: Okay.

**Ken Thompson:** So it really – it rarely played the same game twice or near it.

Q: Oh interesting, okay.

**Ken Thompson:** And then I put the weird stuff in. You know I put, you know, counter and gambits and king gambits. And, you know, just weird, weird stuff, loved it.

Q: Yeah. Now how much storage did that take at that point?

**Ken Thompson:** Not much at all.

Q: Not too much, yeah.

**Ken Thompson:** If you store it by tree it takes a byte per move.

Q: Okay.

**Ken Thompson:** And – but I started by position and hashed into the positions and it took maybe 50 bytes per position.

Q: Okay. All right.

**Ken Thompson:** It would also – on one game it would always convert every position it stored into white, you know. It would rotate – if it was black to move – every position in the book was white to move.

Q: Okay.

**Ken Thompson:** And so if I wanted – if I had a position that was black to move I'd rotate the board and flip it and flip the colors and then look it up white to move. And there's many instances in the opening books where the same position occurs.

Q: Okay.

**Ken Thompson:** Black to white to move.

Q: Okay.

**Ken Thompson:** Where essentially somebody's – white's lost half a move.

Q: Okay, yeah.

**Ken Thompson:** And if you follow the analysis it's completely different. And the reason is, is because there's a psychological point of view that you're white, you attack.

Q: Okay.

**Ken Thompson:** If you're black you defend.

Q: Oh I –

**Ken Thompson:** And so you'd have the exact same position, where the moves, where one side would be attacking and the other side would be defending in the same, you know, the same side would have attacked and the same side would defend. And once in a game I actually transposed into a black side of a Sicilian that turned into a white side of a English and started attacking. It was beautiful.

Q: Okay. So I guess the question is, are there any other particular things that come to mind about this whole experience that are worth talking about? Or any other particular high points that we haven't caught already sort of as closing words?

**Ken Thompson:** Oh gosh I don't know. I don't know it was a – I miss those days and I miss the tournaments and I miss the people. I don't know if you know it, Valvo passed away –

Q: No I haven't heard that.

**Ken Thompson:** - last year, the end of last year, not long ago at all. They – it was just fun. I don't know, you know, serious chess is pretty serious.

Q: Yes.

**Ken Thompson:** And you know you can't talk and you know – you know nothing. But these chess tournaments is nothing but talking you know. And you know the chess is almost an aside, it's almost like a symposium with some little chess on the side. And that has actually changed; it's much more cut throat now. And they hide their algorithms and the programmers don't talk. They typically have heavy commercial concerns and you saw that changing in the 80's. And now it's really changed. I miss the way it used to be. It was almost like a fraternity or something. It was, you know, people who knew – I don't know how to describe it.

Q: Well I think that'll make an interesting center point then for actually the – some of this for the chess exhibit. Because there's certainly a phase in there when a lot of knowledge comes out and the exact sort of thing you're talking about was happening. So...

**Ken Thompson:** Well there was – I have a – maybe I shouldn't say this, but there – you know in a Washington tournament, this guy, a chess programmer, Schwartz, Fred Schwartz, got up from the table to go pee, all right. And he doesn't come back and he doesn't come back, and he doesn't come back, and he doesn't come back, and everyone's worried about it. So we go look in the bathroom and he's in this bathroom in his underwear. And what happened is he got robbed at gunpoint in downtown Washington. And the guy took all of his clothes and his money and then ran out.

Q: With that – so there are probably more surprises than one can possibly describe. But I think that's a – and that's an interesting one. Okay, any other last words on this?

**Ken Thompson:** No.

Q: You're done, okay.

**Ken Thompson:** Thank you sir.

Q: Thank you sir.

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