

# Beyond the 3000 Elo barrier

## A glance behind the scenes of the Rybka chess engine

by **HARALD FIETZ**

**A**t the end of 2005, the world of chess computers suddenly changed when an engine with the name of Rybka appeared from virtually nowhere. At the prestigious International Paderborn Computer Chess Championship the new program by the American developer Vaclav Rajlich – whom everybody simply calls Vasik or Vas as his first name – won a clear point ahead of established machines such as Zappa, Spike, Shredder, Fruit or Jonny. Out of the blue, Rybka skyrocketed to the top of the Swedish computer rating list, which had been regarded for a long time as the equivalent of the FIDE rating list in the chess computer sector ([cp.http://web.telia.com/~u85924109/ssdf/](http://web.telia.com/~u85924109/ssdf/)). However, chess computer experts now regard the results of other test teams as more reliable (e.g. <http://www.husvankempen.de/nunn/> or <http://www.computerchess.org.uk/ccr/4040/>). Depending on hardware, Rybka surpasses every other program by 60 rating points at least, and is the first engine which has established itself beyond the 3000 Elo rating barrier. Among top players, Rybka is increasingly regarded as an added value to the engines they traditionally use; Alexander Morozevich even gave Rybka the highest score in his voting for the Chess Oscar 2005 and put forward allegations that the ‘Topalov team’ might have used this tool for cheating activities.

Therefore, it is high time to get first-hand information from the man behind the machine. The place to meet Rajlich was the Hungarian capital of Budapest, and the visit also offered a unique opportunity to peek over the shoulder of his team in order to watch the man-machine interaction during a freestyle qualification tournament.

### **From computer freak to chess couple**

In a few years time Rajlich’s career might be described as a typical American rise from rags to riches. However, this time the American has left the States to try his luck in ‘old’ Europe. He describes his life-long shuttle across the Atlantic: “I was born in Cleveland in 1971 where my Czech parents were studying at the time. My father is a mathematician and later

worked in the computer field. My mother is also a trained mathematician. I have two younger brothers. We moved back to Prague when I was three weeks old and stayed in the Czech Republic until I was 11. The whole family moved back to the USA at that time. I studied computer science at MIT (Massachusetts Institute of Technology) near Boston and worked as a software developer at Texas Instruments (Dallas, USA), Triada, a company specialized in data compression, (Ypsilanti, USA), Ford (Detroit, USA), at the Environmental Research Institute of Michigan, which was developing radar imaging systems (Ann Arbor, USA), and Option, a leading company in the field of wireless communication technology (Adelsried, Germany), over the last thirteen years. Now, I am working full-time on Rybka in Budapest, Hungary.” He came over to Europe mainly in order to pursue his chess career after he was fascinated by the royal game comparatively late: “Chess was quite big in my family, mainly thanks to my grandfather on my father’s side, who was a very enthusiastic chess player in the Czech city of Tabor. I started to play tournaments quite casually at first, when I was about 20, and then went through a big chess phase in the period 1997 through 2003 or so. Now I am an international master.” Like most other ‘chess travellers’ he chose Budapest as a hot-spot for ambitious chess players. However, this also turned out to be the place to find his private future: “Around 5 years ago I met Iweta Radziewicz at a tournament in Budapest, and we got married on August 19, 2006 in Piaseczno near Warsaw.”

The now 26 year old Polish international used her years of study to continue her junior achievements at the top of the world ranking. Besides finishing her diploma in psychology in 2005 (with a thesis on “Risk perception and assessment among chess players”) she got the male IM title and one GM norm so far. Now the five times Polish women champion, who won her latest title in March 2007 in Barlinek (Emanuel Lasker’s place of birth), is ‘the main tester’ of the Rybka program and assesses its values from the tournament player’s point of view: “Rybka is quite an objective analysis tool and tends to defend very well, so perhaps I learnt to sacrifice more correctly. Many times my sacrifices

looked very promising and scary for the opponent when I played them, but in a post-mortem Rybka sometimes revealed them as crazy blunders. I believe that using Rybka can help to develop an intuition about which sacrifices actually work. For sure using Rybka has some influence on my openings – I think that my repertoire is getting much stronger thanks to my work with the engine.”

### **A programmer’s everyday life and visions**

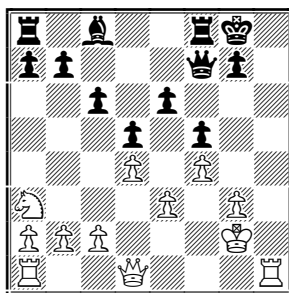
However, the improvement of a sophisticated program also requires a lot of support from other sources: “There are tons of people who are involved in the project in various ways. My partner Convekta Ltd. handles the business and marketing and develops graphic user interfaces on which Rybka runs. Jeroen Noomen from the Netherlands writes the Rybka opening book – this is an extremely competitive sub-discipline of computer chess which has quite an impact on engine results. My wife Iweta uses Rybka constantly and gives me feedback which I use to improve the engine. The Polish GM Michal Krasenkov is a member of our team in the freestyle events. Christoph and Felix Kling from Germany have developed the Rybka web site ([www.rybkachess.com](http://www.rybkachess.com)). In addition, there are dozens of other testers and test groups around the world who give me useful ideas and test results, and who create the objective test environments for chess engines, without which computer chess itself would not exist. The Rybka project would hardly be possible, at least in its current form, without all of this help.” The fundamentals can be traced back to his teenage years: “I’ve been programming my whole life, I wrote hundreds of programs before I even got to college. These programs included a Connect-4 program (a two-player board game in which players take turns dropping discs into a vertical grid, with the objective of getting four of one’s own discs in a line), this was my first experience with game-playing algorithms.” The idea of creating a chess program for professionals combined Rajlich’s hobby and skills he learnt at university. Nevertheless, it is not easy for him to define a chess programmer’s profile: “The main qualification is kind of

vague – it’s a sort of semi-mathematical thinking ability which is hard to pin down exactly. Some people just have it, others haven’t. Of course, it also helps to have software development skills and chess skill. My main interest in computer science has always been artificial intelligence, for instance, at ERIM we developed algorithms to identify features on radar images, etc. It had always been in the back of my mind that some day I would write a chess program. Finally, in January 2003, I got started, and immediately stopped doing everything else.”

Now the daily life of this Washington Redskins fan – and of the NFL in general – looks pretty much all the same in their small two room-flat in the centre of the Hungarian capital, some 200 meters away from the Danube and the famous Liberty bridge: “It very much depends, but Rybka development goes through cycles which are roughly as follows: 1) get a new idea; 2) refine the idea, maybe make some preliminary experiments; 3) initial implementation of the idea and 4) testing. If you put a camera in my work area, mostly you’d find me sitting in front of my computer.” Rajlich knows that there is still a lot of work to do: “Rybka still lacks a few concepts which come naturally to humans. For example, Rybka lacks a true idea of contempt – that is, preventing a weaker opponent from achieving an easy draw due to too much simplification or blocking the position. Rybka will play against a peer the same way as it would against a patzer. So, yes, there are ways for a weaker player to play for a draw which are more effective than they should be. However, there are no especially good ways to play for a win.”

Optimization is one issue, integration of new functions is another area. As in other fields of chess learning, an instructive combination between didactic methods and user friendliness is required. Rybka as a ‘chess teacher’ should reveal more than an ordinary assessment by a single numerical value in the display. Implementation of a visual function is not an easy task, says Rajlich: “This is probably too complicated to get into in a short time. I’ve put together a preliminary design which involves for example the engine giving a score to each piece on the board. The graphic user interface would then display this score to the user, perhaps using some sort of colour coding scheme, etc. Other elements which would be scores are squares or predefined themes. Once we actually start working on this, a lot of things are likely to change, so it’s probably better to wait a year or two until we are ready for implementation. Who knows how everything will look once it is all implemented. Nevertheless, I can show

you a model position in order to demonstrate this function.



The above position is meant to illustrate the idea that positional evaluations change as the search gets deeper. Rybka’s static evaluation has no trouble understanding that the bishop on c8 is a bad piece, so this bishop will be consistently reported as a bad piece, regardless of how much searching is done. This will be indicated to the user via some sort of colour coding of the piece or the square it sits on. The knight on a3, on the other hand, is very difficult for Rybka’s evaluation to handle properly. There are potential outposts, but figuring out whether the knight can reach them and with what significance can only be properly determined via a search. So Rybka would give this knight higher and higher scores as the search proceeds, and the user would see the colour coding of the knight improve as the search gets deeper.”

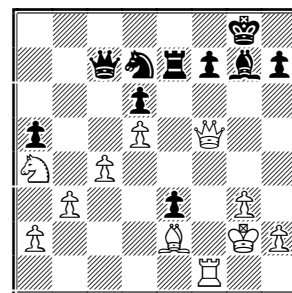
Besides such dynamic functions, the main attention is targeted towards improvements in every phase of the game. So-called ‘freestyle’ tournaments, which are played man-machine versus man-machine, offer valuable insights on how to tackle these areas.

### Tournament games as test fields

Iweta Rajlich describes how the ‘man-machine interface’ is organized when the heat of a one-hour game is on: “GM Michal Krasenkov is our team captain and he decides which move we play. He sometimes asks about our opinions. Vasik and I try to discover an interesting route and ask Michal what he thinks about it, or he comments on the ideas which we can see on his screen. Each of us has his own Rybka (with different hardware: 4 processors plus 2 parallel 1 processor machines for Michal, 2 processors for myself and 1 processor for Vasik). In addition to analyzing, Vasik is responsible for technical staff and avoiding mouse slips, and it is my responsibility to have in mind that we need to eat from time to time. To sum up, we work pretty individually on positions and then we summarize ours ideas; sometimes Michal divides up work and we test

what he suggests. In the opening and early middle game as well as in the endgame we tend more to overrule the Rybka engine more often than in the middle game. White’s moves g6! and h5 in the game Rajlich-Intragrand are human discoveries (included below as part of the analysis of Rajlich-Kingscrusher).

Furthermore, we are using Rybka to go deeply into tactical lines. If the position is rather strategic (I mean with little tactics) we try to choose a plan. For instance, in the game of Poweronoff with the white pieces against Rajlich in the final of the 3<sup>rd</sup> freestyle competition, we had a very difficult position, and in order to save the game Michal came up with a clever idea of exchanging knights for the cost of another pawn. The game transposed into opposite-colour bishop endgame where Poweronoff (who played as an unattended Rybka) had two pawns more. I don’t have to mention that sacrificing a pawn for an idea which appears in 20 moves later in a drawn endgame is even beyond the reach of Rybka.”



33 ♖e1 ♜c5

A human GM move – the idea is to exchange knights and defend the opposite-coloured bishop endgame being two pawns down.

34 ♜xc5 ♞xc5 35 ♜f1 ♞c7 36 ♙d3 h6 37 ♞g4 ♜c5 38 ♙e2 ♜f8 39 ♜f4

The e3-pawn will be lost but more pieces will be exchanged and the black square blockade will remain.

39 ... ♙e5 40 ♜e4 ♙f6 41 ♜xe7 ♙xe7 42 ♞e4+ ♜f8 43 ♞h7 ♙g7 44 ♞f5 ♙e5 45 ♙h5 ♞a7 46 ♜f3 ♞e7 47 ♙e2 ♙b2 48 ♞f4 ♙g7 49 ♞xe3 ♞xe3+ 50 ♜xe3 f5 51 h3 ♙a3 52 ♙e8 ♜f6 53 ♙d7 ♙c5+ 54 ♜f3 ♙a3 1/2-1/2

It looks as if the subtleties of endgame strategy are still a domain where human intuition is superior as more long-term thinking is required. A game against the Australian Fredi\_Z demonstrated that engines sometimes follow rules which human would not really consider. Rajlich tries to explain this phenomenon: “Engines, Rybka included, are relatively weak compared to humans in the area of understanding the chances of drawing in endgames where one side stands nominally better.

They will often fail to simplify to the right kind of inferior endgame (i.e. one that is defensible), or they will be too happy to allow such a simplification. This second case is what happened in the game with Fredi\_Z, who was using an automated Rybka. Rybka stood better, but needlessly allowed a trade of the white b-pawn for the black e-pawn, after which there is no serious danger of us losing. Of course, Rybka understands that it is not good to trade those pawns in general, but for Rybka in the position here this was overruled – incorrectly – by other considerations.”

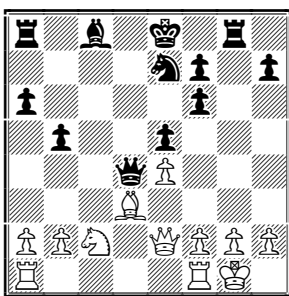
### Fredi\_Z – Rajlich

4th Freestyle (Qualification) 2006

1 e4 c5 2 ♘f3 ♘c6 3 ♘c3 e6 4 d4 cxd4 5 ♗xd4 ♗f6 6 ♗db5 d6 7 ♙f4 e5 8 ♙g5 a6 9 ♗a3 b5 10 ♗d5 ♙e7 11 ♙xf6 ♙xf6 12 c3 ♗e7 13 ♗xf6+ gxf6 14 ♙d3 d5 15 ♙e2 d4 16 cxd4 ♗xd4 17 0-0!

It is time to take a crucial decision as White deviated from a previous game by Krasenkov. After White castled kingside, Black has the option to castle kingside or to play ♗g8. The Rajlich team took its time to scan the position in order to identify drawish lines. In this process they overlooked the unexpected move ♗c2 which leaves the b2-pawn en prise. Maybe this was caused by Vasik’s statement that 18 ♙h1 is the most likely move or their search was mainly influenced by the stem game with 17 0-0-0 ♙b6 18 ♙e3 ♙xe3+ 19 fxe3 ♗g8 20 ♗d2 ♙b7 21 ♗f1 ♗g6 22 ♗c2 ♗c8 23 ♗b4 ♗d6 24 ♗d5 ♗c8+ 25 ♙b1 f5 26 exf5 ♗h6 27 e4 ♙xd5 28 exd5 ♗xh2 29 f6 ♙d7, and Black won in Socko-Krasenkov, Bundesliga 2003.

17 ... ♗g8 18 ♗c2!



The engine excels at top level!

18 ... ♙b6

18 ... ♙xb2 19 ♙d2 ♙h3 (19 ... b4 20 ♗ab1 ♙c3 21 ♙e3 a5 22 ♗fc1 ♙e6 23 ♗xb4 ♙d4±) 20 ♗fb1 ♙xg2 21 f3 ♙h3+ 22 ♙h1 ♙g2+ 23 ♙xg2 ♗xg2 24 ♗xb2 ♗d2 25 ♗b3 ♗d8 26 ♗e1 would be a worst case scenario for Black.

19 a4!

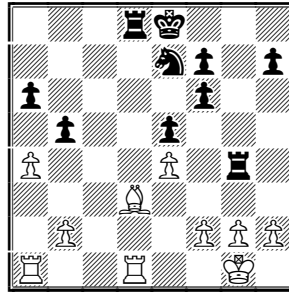
The human players expected this move and started to search for paths to split the point (in particular, in a forced endgame with a white passed pawn in

the b-line). In addition, they received information that their opponent was using hardware with two processors which compared to the second best computer among the four machines in the Rajlich team.

19 ... ♙g4 20 ♙e3 ♙xe3 21 ♗xe3 ♗d8 22 ♗xg4 ♗xg4

The difference on the clock was striking: so far White had used 10 minutes whereas Black had already spent 45 minutes (of an hour’s total)!

23 ♗fd1



23 ... bxa4

This line was as early as move 19 at the screens in Budapest and the alternative was 23 ... ♙f8 24 axb5 (24 f3 ♗g6 25 axb5 axb5 26 ♙xb5 ♗b8) 24 ... axb5 25 ♙xb5 ♗b8, which should save the game.

24 ♗xa4 f5 25 ♗xa6 ♙f8 26 f3 ♗g6

Krasenkov stated categorically: “We should no longer trust Rybka.”

27 ♗a1

They expected 27 ♗xg6 hxg6 28 exf5 ♗xf5 29 ♙f2 ♗d4.

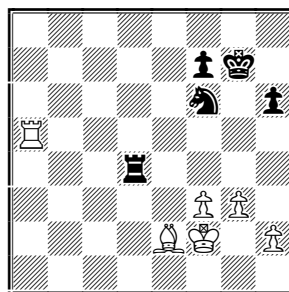
27 ... ♗gd6 28 ♙e2 ♗xd1+ 29 ♗xd1 ♗b8 30 exf5 ♗xf5 31 ♗d5 ♗xb2 32 ♗xe5 h6

Played without any hesitation as all endgames are likely to reach the draw haven.

33 ♙d3 ♗d6 34 ♙f1 ♗d2 35 ♙e2 ♙g7 36 ♙e1 ♗d4

“If we want a draw it is immaterial if we play the rook to d4 or b2.” (Krasenkov)

37 ♙f2 ♗c4 38 ♗b5 ♗d6 39 ♗a5 ♗e8 40 g3 ♗f6



Krasenkov was already looking to the future: “Do we have the tablebase installed in case it will be rook versus rook and bishop?”

41 ♙e3 ♗d5 42 ♗xd5

The human player knows that this facilitates Black’s task. However, an engine implements the rule that it has to

exchange if it has extra material. This position illustrates the danger of playing a freestyle competition with an engine in automatic mode.

42 ... ♗xd5+ 43 ♙d4 ♗e7 44 ♙d3 ♙f6 45 f4 ♗c8 46 g4 ♗d6 47 ♙d5 ♙e7 48 h4 f6 49 ♙d4 ♗f7

Although White can no longer make any progress the game lasted 192 moves. White repeated moves and shortly before the 50 moves rule applied, the player advanced pawns to h5 and f5 Nevertheless, it was inevitable that the point would be shared.

½-½

However, such ‘slips of the pen’ help to rethink endgame themes as in this case the rook versus minor pieces with pawns on one side. Rajlich concludes: “Well, we were discussing some endgames over breakfast with Michal Krasenkov, and I found out that there are certain things that I (and Rybka too) don’t really understand. For example, if both sides have 3 pawns on the f-, g- and h-files, and White has a rook while Black has two minors, Michal claims that Black’s winning chances are better if the minors are a bishop and a knight than if the minors are two bishops. You can easily convince yourself that Rybka thinks the opposite by setting up such positions and asking Rybka to evaluate them. Anyway, I haven’t had a chance to investigate this as it usually takes between two or three weeks to check something like this – nevertheless, I’ll need to see if this heuristic passes my tests.”

King security is the other field which still reveals impressive capacities of human brain. The g4-attack in the Shabalov line of the Slav has to be regarded as a model opening to put this issue to the test.

### Rajlich – Kingscrusher

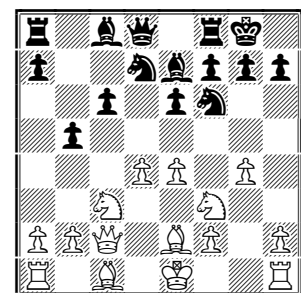
4th Freestyle (Qualification) 2006

1 d4 ♗f6 2 c4 e6 3 ♗f3 d5 4 ♗c3 c6 5 e3 ♗bd7 6 ♙c2 ♙d6 7 g4 dxc4 8 ♙xc4 b5 9 ♙e2 0-0 10 e4

Krasenkov: “Should we play 10 e4?” Vasik Rajlich: “He might have prepared it, but not for us. And his analysis might be not so deep.”

10 ... ♙e7

10 ... e5?! 11 g5 ♗h5? 12 ♗xe5!+-

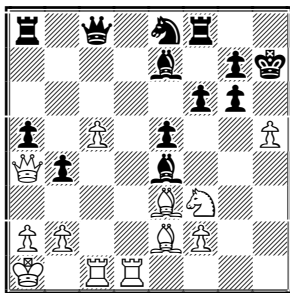


**11 g5**

After a previous encounter against Intragrand in the 3<sup>rd</sup> Freestyle final, Michal Krasenkov explored the alternative 11 e5 in detail (cp. www.rybkachess.com). This piece of analysis makes plain the difference between decision-making as a centaur and over-the-board in a fight between human players. On-going interaction between man and machine enables the human player to delve far deeper into positions. If a top player properly shares out responsibilities for sub-variations and more risky lines in his team, he can assess the potential direction of the game and reliability of promising candidate moves: 11 e5 d5 12 dxd5 cxd5 13 d3 (13 dxb5? a5+ +-) 13 ... h6 14 h4 b7 15 h5 f6 16 d4 c8 17 b1 (17 h7+ h8 (17 ... f7?? 18 g6 mate) 18 d6+ xh7 19 xxf8+ g8 20 h7+ xf8 21 xh6 a5+ 22 f1 gxh6 23 xh6+ e8 24 g6+ d8 25 h6!? (25 g8+ c7 26 c1+ c5!! 27 xe6 c6 28 dxc5 d2!, Black's king is safe. At a particular moment White will be in great danger! Although White has a nice material advantage he is in trouble.) 25 ... d2 26 h7 c7 27 h8= xh8 28 xh8 xd4 29 c1+ c5y 30 c2 b6 31 b4!? xxb4 32 exf6 xg4 (32 ... xxf6 33 xc5+ xc5 34 xc5 xg4 (34 ... xc5 35 g5+-) 35 c3+-) 33 f7 c4± 17 ... xcl+ 18 xcl fxe5 19 d6 b4± offers a nice example of how a player has to be aware of counterplay in freestyle competitions.

**11 ... d8 12 f4 d6**

In the above-mentioned encounter against Intragrand the line 12 ... b7 13 0-0-0 b6 14 b1 a5 15 h4 b4 16 a4 xa4 17 xa4 c5 18 dxc5 xe4+ 19 a1 c8 20 c1 f6 was played. As in the main game, the machine weakened its kingside with an f6-advance. 21 g6 In retrospect Vasik concluded: "We sacrificed a pawn against Rybka's wish. Although I opposed this action during the game, I now believe that this was the correct approach." The motif also appeared in the main game against Kingscrusher. 21 ... hxg6 22 hd1! e5 23 e3 h7 24 h5!!



A strange but extremely efficient pawn sacrifice. Usually one would

expect White to put his heavy pieces into the g- and h-file and then he "opens the gates" by removing the pawns. 24 ... gxh5 (24 ... g5? 25 d7 f7 26 cd1 c6 (26 ... g8 27 h6! c6 28 b3 xd7 29 h7+ +-) 27 b3+-) 25 d7 f7 26 c4 c6 (26 ... c6 27 c2+ e4 28 d4 f8 29 xe4+-) 27 b5 e6 28 d1 f8 (28 ... g4 29 e2 h3 30 d3 xd3 (30 ... f5 31 h4) 31 xd3+ g8 32 xe7 xe7 33 d5+ +-) 29 d4 exd4 (29 ... xd7 30 xd7 xd7 31 xh5+ g8 32 g4+-) 30 xh5+ g8 31 xf7 d8 32 c4 d5 33 d3 e4 34 xe4 xe4 35 d2 e6 36 a7 d5 37 f3 xc5 38 xc5 xc5 39 xa5 e7 40 d5, and White later won in Rajlich-Intagrand.

**13 0-0-0 b6**

Iweta checked 13 ... a5 14 b1 b4 15 e5!= which is a surprising silicon solution!

**14 d3 d4 15 h4**

15 h4 f6 16 g6 hxg6 17 hg1 g5 (When the Rajlich trio analyzed the advance of the h-pawn they concluded that 17 ... e8 18 e5 f5 19 g3 with the idea dg1 is unlikely to happen, as it isn't a good strategy. However, this appeared at the board later!) 18 e3 b4 Krasenkov as "team leader" analysed 18 ... a6 19 hxg5 b4 20 e2 xe3 21 fe3 xd3 22 xd3 fxg5 23 e5 c5 24 d6 c4 25 c2 f2 26 h1 f7 27 e5+ g8.

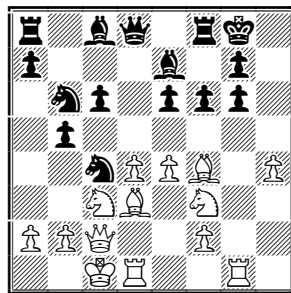
**15 ... f6**

Krasenkov: "A human player would know that you do not play such a move at the side where you are being attacked."

**16 g6 hxg6**

16 ... h6 Vasik: "Rybka hates moves like this."

**17 hg1**



**17 ... e8?!**

Instead of putting the queen on e8, a lot of the human players' analysis focused on 17 ... g5 18 e3 b4 (18 ... a6 19 xc4 xc4 20 e5 b4 21 e4 f5 22 c5 xc5 23 dxc5 a5 24 b1 g4 25 d5s) 19 a4 xa4 20 xa4 xe3 21 fe3 c5 22 c4±.

**18 e5 f5 19 g3 b4**

Chat from Kingscrusher: "I'm aware of this line but forgot to fix it ..." 19 ... c5 20 dg1 b7 21 xg6 f7

22 dxc5 xf3 23 cxb6± was Iweta's analysis.

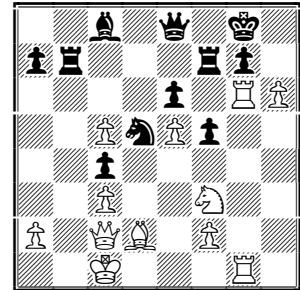
**20 dg1 xc3**

Vasik: "I'm pretty sure that Rybka will play this move."

**21 bxc3 d5**

"Black has a nice knight but what else besides this?" (Iweta)

**22 d2 f7 23 xg6 b8 24 xc4 bxc4 25 h5 c5 26 h6 bb7 27 dxc5**



**27... e7**

A panic move which one can expect from a human, but not from an engine (Krasenkov).

**28 xg7+ xg7 29 xg7+ h8**

Everything runs smoothly – Rybka has +2.42 on the display.

**30 g5 d5 31 xb7 xb7 32 b2 c6 33 d4 g8 34 d2 a8 35 f4**

"We should play normal stuff. Rybka will go for the win of the c4-pawn." (Vasik)

**35 ... h7 36 e2 c8 37 xc4**

Or 37 h5 d7 38 c6 xc6 39 dxc6 dxc3.

**37 ... c6 38 a3**

Just for fun a "Zugzwang" move

**38 ... d7 39 d3 a4 40 g3 e8 41 h4 f8 42 c4 1-0**

Concerning the learning effect Rajlich points out: "Yes, these games were quite similar. In both of them, Black tried to free his position and get counterplay by playing f6, expecting an exchange of our g5 pawn for Black's f-pawn, and in both cases we played the speculative but apparently strong pawn sacrifice g5-g6. In both cases, Rybka evaluates the situation similarly – it thinks that White is better after the pawn sacrifice, but considers the advantage less than if Black hadn't provoked the sacrifice in the first place with f6 It's hard to give any general rules for this – these sacrifices certainly can't be said to work 'just in principle', the positions are far too complex for that. It does seem, though, that these are two examples where Rybka's sense of balance between material and king safety turns out to be not quite correct." Although the advertising phrase 'Rybka is a revolution in computer chess' correctly hits the mark, human players still take comfort from having some creative scope for development – at least.