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Math Games

Modern Burr Puzzles

Ed Pegg Jr., August 2, 2004

In 1803, the Bestelmeier Toy catalog listed a 6-piece burr puzzle. In 1899, Scientific American introduced a 3-piece burr puzzle by Wilhelm Segerblom. In 1917, US patent 1225760 described a 6-piece burr puzzle. All of these puzzles were slightly difficult to take apart -- interlocking pieces held the puzzle together. Over the next 60 years, millions of similar puzzles were made. Burr designs became so overused that they were considered somewhat trite, as a puzzle type. Just in case you haven't seen one, here is a sample -- the [Aluminum Rainbow Brainteaser Puzzle](#) by Paul Eibe.

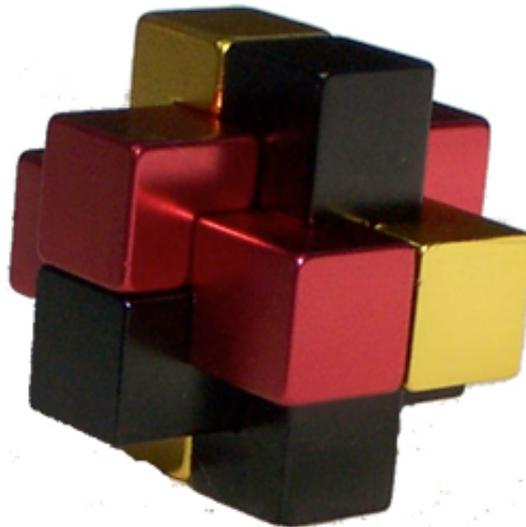


Figure 1. A 6-piece burr puzzle, available from [Bits&Pieces](#).

The rebirth of interlocking puzzles began with columns in *Scientific American*, in particular about [Miguel Berrocal](#) and [Burr puzzles](#). One burr puzzle, by Bill Cutler, appeared in the October 1985 issue. Due to a printing error, [Bill's Baffling Burr](#) was impossible to solve, which prompted many letters. The [Bill Cutler Puzzles](#) site contains more of this history, available puzzles, books, and software. The [burr puzzles site by IBM Research](#) explains some the method of computer analysis undertaken by Bill Cutler.

Another person involved in the rebirth of puzzles was Stewart Coffin. His book, [The Puzzling World of](#)

[Polyhedral Dissections](#), is available online at John Rausch's [PuzzleWorld](#), and should be considered a must-read for any recreational mathematician. Although Stewart has put many of his designs into the public domain, his works are the most sought after of all modern puzzles. I highly encourage the reader to build one of his best puzzles - [The Three Piece Block](#). All it requires is 10 cubes. I built one myself with a \$1 set of wooden cubes from a craft store and some wood glue during a wait at mechanics shop. I first built 10 side-2 cubes, then followed the directions. Easy. But not easy to solve.

Through Bill Cutler's systemized search, various "best-possible" puzzles were found. For example, disassembling a 6-piece puzzle apart might take considerable fiddling. Bill's Baffling Burr, for example, requires 5 moves to remove the first piece, and is thus considered an level-5 puzzle. There are also 24 assemblies that might work. In other words, you could take a block of wood and carve the 6 distinct pieces in a certain configuration, but only one of these assemblies could be taken apart. Hence, the solution is unique. After the analysis was completed, the Burr Puzzle was considered settled, for a few years.

In 1991, [Junichi Yananose](#) investigated 4-piece burr puzzles with a frame, and found one with a unique level-9 solution. Minimizing the pieces while maximizing complexity is considered a good thing. Juno followed up with a 17-move 6-piece framed burr with a unique solution, and then the search was on again for new burr puzzles. Two are shown below.

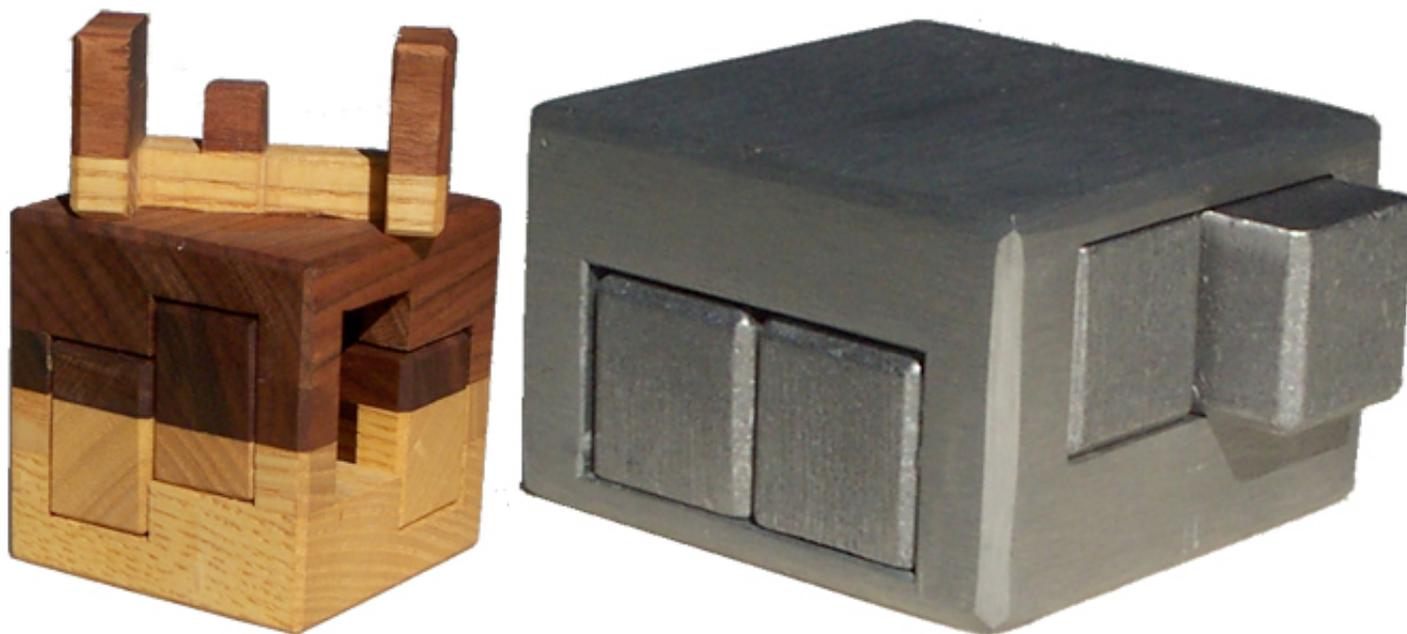


Figure 2. Boxed burrs. Life at 21 (level-21) and Internal Combustion (level-12).

In 1999, Dic Sonneveld and Frans de Vreugd used Bill Cutler's program to analyze a class of 12-piece burrs. The "Dic's Dozen" analysis found an level-60 puzzle. In 2001, they looked at framed burrs, and found a 4-piece puzzle with a level-47 solution. "It has baffled both Dic and myself that such extremely high levels can be reached with only so few pieces." One of these extreme puzzles is available very inexpensively at Bits&Pieces, the [Boxed Burr](#). In 2002, Dic found an [level-98 framed burr](#) with 6 pieces.

In 2001, Bill Cutler and Frans de Vreugd got stuck in traffic in Tokyo, and discussed an attack on the 6-board burr. Their programs shifted through billions of possible assemblies. They found an level-13 puzzle, and the level-11 puzzle below, which has a unique assembly.

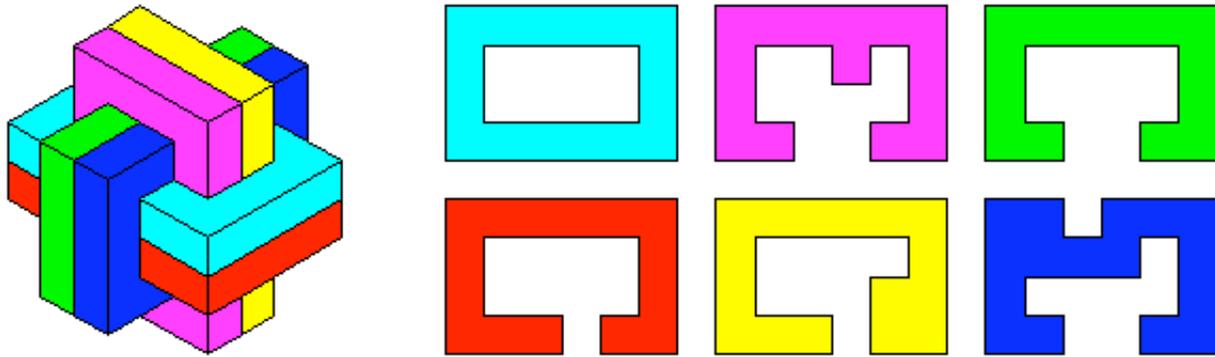


Figure 3. Frans de Vreugd's Irregular Board Burr, with an level-11.3.3.2.3 solution.

Everything is now settled, right? Well, Jim Gooch suggested spacing the boards one unit apart. Frans had the programs look at this and many very interesting solutions were found. He found the level-10 Zigzag configuration ([1](#), [2](#)) rather quickly in his analysis. After that, he discovered the level-17 Torture puzzle ([1](#), [2](#)). Several sets of Torture were made, as a kind of ultimate puzzle -- but the computer search wasn't finished yet. At the end of the search, the Extreme Torture ([1](#), [2](#)) configuration was found. Extreme Torture requires 28 moves to remove the first piece, then 21 moves to remove the next piece, for an incredible level-28.21 solution. This is at the far-limits of human solvability. After finding these unexpected complexities within simple pieces, the whole field is opening up to more searches.

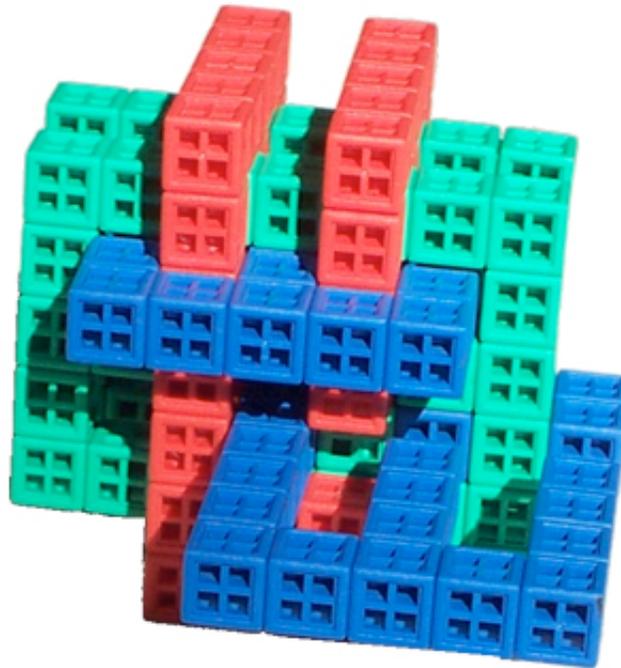


Figure 4. Frans de Vreugd's Extreme Torture, after 11 moves. Made with [LiveCube](#).

The above version of Extreme Torture was built with the [LiveCube system](#), which has been a great boon to puzzle designers. In particular, 2-piece burrs have gotten a lot of recent study. An unsolved question: two polycubes fit inside an order-5 cube. What is the maximum number of moves required to take the two pieces apart?

If you'd like to collect some of these, start with the [Boxed Burr](#) -- it's a bargain. Other excellent burrs can be obtained from [Josef Pelikan](#), [Puzzle Palace](#), [Puzzle Craft](#), [Cubic Dissection](#), [GarE Maxton](#), and [Mr. Puzzle](#). If you run across a puzzle design that isn't available, one of the [PuzzleWorld designers](#) might make it for you. Understand that craftspeople usually make puzzles for the sheer enjoyment of building them, and not for money. The puzzles are cut and assembled by hand, often from exotic materials, and thus can be expensive.

Hundreds of excellent designs have been chronicled at Ishino Keiichiro's [Puzzle will be played](#) site, and in the pages of [Cubism For Fun](#), the leading magazine for mechanical puzzles. Due to the number of unexpected but brilliant designs that have come out just in the past two years, I fully expect that Burr Puzzles will continue to keep surprising us.

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