

# Rob's Puzzle Page

## Interlocking Puzzles

This section covers **interlocking puzzles** - wherein multiple pieces fit together such that the puzzle does not fall apart, and presents a challenge to disassemble and re-assemble. This is one of my favorite categories.

Here are my groupings:

- [Traditional 6-Piece Burrs](#)
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- [The Diagonal Burr and The Diagonal Star](#)
- [3-piece Burrs](#)
- [Boxed Burrs](#)
- [Kumiki Burrs](#)
- [Chuck and Pagoda Burrs](#) - a large number of similar notched pieces that must be built up into a symmetric structure
- [The Altekruse Puzzle and Variants](#)
- [Coordinate Motion Assemblies](#) - the solution relies on simultaneous (coordinate) motion of groups of pieces
- [Non-traditional Burrs](#) - including 6-piece "board" burrs
  - [Non-traditional Burrs in Plastic or Metal](#)
- [Interlocking Poly-cube Assemblies](#) - individual pieces are constructed from cubes joined in specific ways (e.g. by full faces)
- [Cube-and-Plank](#) (or Plate) Assemblies
- [Polyhedral Assemblies](#) - pieces made from regular shapes other than cubes - e.g. tetrahedrons
  - [Designs by Stewart Coffin](#)
  - [The 3M Hectix and The Geo-Logic Line](#)
- [Pinned Assemblies](#) - pieces include rods or pins that hold the structure together
- [Irregular Assemblies](#)
- [Keychain Puzzles](#)
- [Happy Cubes/Snafooz \(Foam Assemblies\)](#)
- [The Puzzle Sculptures of Miguel Berrocal](#)

## Traditional 6-Piece Burrs



**Any story about interlocking puzzles** has to start with the traditional **six-piece burr puzzle**. This puzzle is known by several names, including the "puzzle knot," the "Devil's Knot" ([Teufelsknoten](#) in German), the "Chinese Cross," the "Lock of Luban" ([Luban Suo](#) 鲁班鎖) or the "Lock of Kongming" (Kongming Suo 孔明鎖). The term "burr" is thought to have been first used by Edwin Wyatt in *Puzzles in Wood* (1928), but Wyatt seems to use the term as if it was already commonly understood to apply. Supposedly whoever coined the term did so because the puzzle resembles the clinging burrs of some plants.

Like other well-known vintage puzzles, the burr has acquired a probably-fanciful backstory, and details of its history are lost. Some say it is a Chinese invention, along with the Patience Tanglement, the Sliding Piece Puzzle known as "The Huarong Path," and the Tangram, and date it to ancient times (see [Wei Zhang's Chinese Puzzles Blog](#), and the website of the [Chinese Culture Center of San Francisco](#), for info about an exhibition). The earliest relevant U.S. Patent seems to be [1225760](#) - Brown 1917. However, a traditional six-piece burr appears in Hoffmann's 1893 book *Puzzles Old and New* in Chapter III as No. XXXVI "The Nut (or Six-piece) Puzzle." Jerry Slocum and Dieter Gebhardt put together a compendium of puzzle advertisements found in the 1785 catalogue of the merchant *Peter Friedrich Catel*, who established a retail store in Berlin in 1780. The 1785 catalogue contains an ad for a traditional six-piece burr puzzle called "The Small Devil's Hoof" (in addition to an ad for the Large Devil's Hoof which is a 24-piece cage burr).

In his 2007 book *Geometric Puzzle Design*, Stewart Coffin discusses the six-piece burr in chapter 7, and reports that Jerry Slocum's *New Findings on the History of the Six Piece Burr* traces the six-piece burr back to Germany in 1698. One early depiction of the six-piece burr puzzle and specific pieces occurs in a Spanish book from 1733 by Pablo Minguet y Irol (b. 1700 d. ca. 1775) with a rather lengthy title that begins *Engaños à Ojos Vistas*. Also see the 1728 [Cyclopedia of Ephraim Chambers](#) (online at the [University of Wisconsin Digital Collection](#); additional commentary at [www.cyclopedia.org](#)). You can see a six-piece burr in the lower left area of the [frontispiece](#) by John Sturt, which is a

modified and left-to-right inverted copy of a [1698 engraving](#) entitled "L'Académie des Sciences et des Beaux Arts" by Sébastien Leclerc (or Le Clerc). In his [Sources in Recreational Mathematics](#), David Singmaster says that James Dalgety was the first to note this picture. Read about this engraving, at the [University of Oxford](#).

Stewart Coffin's book [The Puzzling World of Polyhedral Dissections hosted on John Rausch's site](#) contains a good introduction to this type of puzzle. Martin Gardner discusses burrs briefly (as an introduction to the puzzle sculptures of Miguel Berrocal) in his 1989 book *Penrose Tiles to Trapdoor Ciphers*, and most of the key puzzle authors mention the puzzle. There have been sporadic fits of research into the six-piece burr, including an extensive analysis by hand by the Dutch mathematician J. H. de Boer, and work by Tom O'Beirne and Arthur Cross, but [Bill Cutler](#) has performed the definitive computer analysis, and the statistics cited below are based on his analysis.

There is a distinction made between burr puzzles that contain no internal "holes" or voids - termed "solid" burrs, and those that do contain one or more - termed "holey" burrs. Also, there is a distinction made among the pieces which can be produced without hard-to-manufacture blind (or internal) corners versus those that cannot. The 59 "easy" pieces are called "notchable" and there are only 25 of them that can be used to build solid burrs. Those 25 pieces can be put together in 314 ways. There are 369 general pieces that can be used to produce 119,979 solid burrs. Of those 369, 112 can be used in duplicate and 2 in triplicate, making a useful set of 485 pieces. The 59 notchable pieces can be used to make 13,354,991 assemblies, most of which are holey. Overall, there are 837 pieces that can be used to produce an estimated 5.95 billion constructible puzzles.

So, to make a traditional six-piece burr, six pieces, usually but not always distinct, are selected from the overall set of 837 possible such pieces, and interlocked in a characteristic 2x2x2 pattern along 3 orthogonal axes - see the photo at upper left. The burr shape is tricky to envision without an example in front of one, but it gets easier with practice.

Bill Cutler has done extensive analysis on both the ["holey" six-piece burr](#) and [all six-piece burrs in general](#), and Bill [offers several burrs for sale](#). Jurg von Kanel created the wonderful [Burr Puzzles Site](#) hosted at IBM Research. Jurg's site offers a [solution analyzer applet](#) and [historical info about burrs](#). [Bruno Curfs' site](#) offers additional analysis. Ed Pegg wrote a [good survey article about burrs](#). [Peter Roesler's site](#) also discusses burr puzzles, and has an interesting history of Willem van der Poel's Grandfather 6x6x6 burr. You can see some burrs at [John Rausch's Puzzleworld](#) and at [Wayne Daniel's site](#). You can use Andreas Roever's [Burr Tools](#) to model, solve, and design burr puzzles.

If you're interested in collecting 6-piece burrs, I suggest you first check out the ["Puzzle Will Be Played" site](#) to get some idea of the variety available. Look under "Interlocking (6 piece burr: traditional)." Though they may be sold under different names and by different vendors, burr puzzles that use the same set of six pieces are isomorphic and have identical solutions (although using pieces longer than six units might eliminate some solutions). That site also provides a comprehensive [catalogue of burr pieces](#).

The "level" of a burr puzzle is the number of distinct moves (a shift of one or more pieces as a unit, usually by one unit in one direction) that must be performed to remove the first piece or pieces - there can be a concatenation of figures usually separated by dots - these are the numbers of steps to remove successive pieces. All solid burrs are level 1 - they come apart without any preliminary shifting. Burrs with internal holes, of which there can be from 1 to 20, can achieve higher levels, and one goal of research has been to delimit what is possible in terms of level complexity.

I admit that, early on, I didn't like burr puzzles. But as I read more about them, and tried various designs, my appreciation for them grew. I put together the diagram below to try to summarize and organize some of the facts I learned about this category of puzzle.