

Introduction

Nearly everyone must have had at least a few amusements among his or her childhood treasures based on the simple principle of taking things apart and fitting them back together again. Indeed, many infants show a natural inclination to do this almost from birth. Constructing things out of wooden sticks or blocks of stone must surely be one of the most primitive and deeply rooted instincts of mankind. How many budding engineers do you suppose have been boosted gently along toward their careers by the everlasting fascination of a mechanical construction set? I know I certainly was. Even after life starts to become more complicated and most childhood amusements have long since been left by the wayside, the irrepressible urge to join things together never dies out.

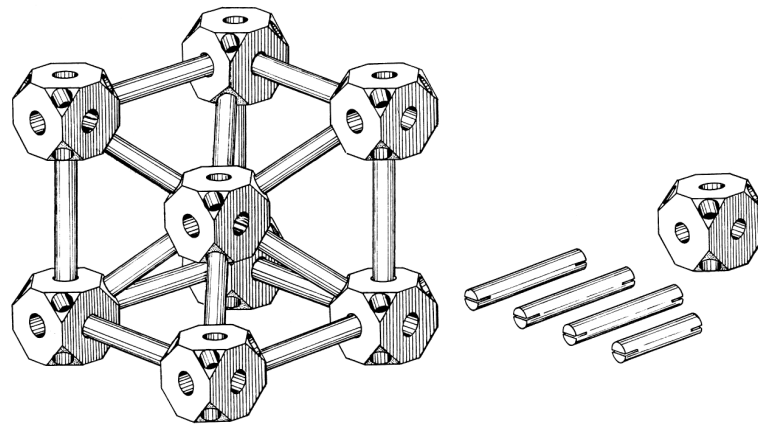


Figure 1. "He who wonders discovers that this is in itself a wonder."
—M. C. Escher

Construction pastimes in the form of geometric assembly puzzles have a universal appeal that transcends all cultural boundaries and practically all age levels. Young children catch on to them most quickly. One of the puzzle designs included in this book was the inspiration of an eight-year-old, and children younger than that have solved many of them. So much, then, for the presumptuous practice of rating the difficulty of puzzles according to age level, with adults of course always placing *themselves* at the top! Likewise, almost anyone from elementary school student to retiree having access to basic workshop facilities should be able to fabricate many of the puzzles to be described on the following pages.

On the other hand, this book is intended to be more than simply a collection of puzzle designs, plans, and instructions. This is a puzzle designer's guidebook. Some of the most rewarding recreations are neither in simply solving puzzles, nor in making them, but rather in discovering new ideas and crafting them into a form that others may enjoy too. Equally satisfying is discovering surprises long overlooked in traditional puzzles. It is amazing how many of these lie scattered about just beneath the surface waiting to be uncovered. Keep in mind that the systematic investigation of many types of problems covered in this book has taken place only within the last few decades. Throughout these pages, unsolved problems are mentioned, or at least implied, that should keep mathematicians and analysts, tinkers and inventors occupied for a long time to come. A few gems have even been purposely reburied so that the reader may have the joy of unearthing them again. But watch out for traps!

Life in general is a puzzle, is it not? Examples abound: trying to fathom the mysterious rules of English grammar and wondering if the spelling of some words was someone's idea of a joke! The engineer who dreamed up the assembly procedure for my car's transmission passed up a promising career as a puzzle inventor. Anyone who writes poetry or composes music knows the satisfaction that comes when all of the parts finally fit together properly, or the frustrations when they decline to do so. Almost any undertaking may become turned into a puzzle, intentionally or otherwise.

This book is devoted mostly to a broad and vaguely defined classification of geometric recreations that might be described as burrs and polyhedral dissections. Polyhedra are by definition any solids bounded by plane surfaces. One often associates the term polyhedra with the iso-

metrically symmetrical Platonic solids and their relatives. It is used here in a broader sense to include practically any solid or assemblage of parts having some sort of symmetry, including burrs. In puzzle nomenclature, burrs are assemblies of interlocking notched sticks. They are traditionally square sticks, but all sorts will be considered here. And for good measure, some puzzles will be included in this edition that do not fit in either category.

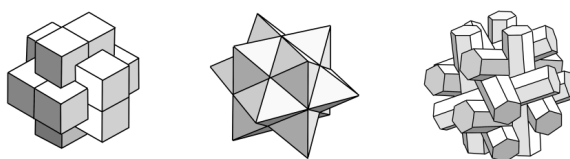


Figure 2. Burrs.

For convenience, the term *puzzle* is used throughout this book to include just about any sort of geometric recreation having pieces (actual or imagined) that come apart and fit back together again. Probably many readers associate the word puzzle with some task that is purposely confusing or difficult. That notion may be rather misleading when applied to many of the recreations described in this book. I much prefer to regard them as being fascinating and intriguing. Discovering the myriad amazing ways in which geometric solids fit together in space is in itself a marvelous revelation. If they also have the potential for challenging puzzle problems, so much the better. But let us not make the common mistake of assuming that the more satisfactory puzzle is one that is fiendishly difficult or complicated—a tendency more often than not counterproductive in any creative endeavor.

A proper treatise on geometric puzzles should probably begin with a historical overview. Here we have a problem. If you search long enough, you can usually find at least a brief written history on just about any possible subject, but apparently not so for geometric puzzles. Likewise, a search through the major anthropological museums of the world turns up practically nothing of ancient origin. (Added note: That could change. As we go to press, the definitive Slocum Puzzle Collection is being installed at Indiana University, Bloomington.) The conclusion to be

drawn from this is that most geometric puzzle designs must not be very old—not many over 200 years old. A popular marketing ploy of puzzle manufacturers is to invent stories of their ancient origins. One favorite theme is that they came down to us from the Orient. Some authors have called the six-piece burr the *Chinese Cross* puzzle. Conversely, perhaps puzzles sold in China are touted as products of Yankee ingenuity, and if so, they may be just as close to the truth.

Patent files are one of our most important historical resources on puzzles. As of 1980, there were about 1,000 patents of bona fide puzzles filed in the U.S. Patent Office and about the same number in the British Patent Office. The oldest U.S. patent is dated 1863. If the filing of patents is any accurate indication, then many of the classic designs familiar to us today, including various burrs and dissected blocks, date from the late 1800s. Starting around 1920, there is a decline in puzzle interest and patent activity (which, by the way, just happens to coincide with the phenomenal rise in popularity of the automobile). Puzzle interest picks up again after World War II and has been going strong ever since.

Many games and pastimes are known to be quite ancient, so why not three-dimensional puzzles too? We can only speculate, but here is one thought: of all three-dimensional puzzles, the so-called burr or notched square stick types are certainly the most familiar, the easiest to make, and probably the earliest to have become popular. To be entirely satisfactory, such puzzles should be made to close tolerances, and the only practical mass-production method is with specialized power woodworking machinery and suitable jigs. Power woodworking tools did not come into common use until the mid-nineteenth century. Note that most ancient games and pastimes use pebbles, beans, scratch marks on the ground, and other such things readily at hand.

To say that most geometric puzzles are less than 200 years old requires qualification. They are all based on mathematical principles known ages ago, which in turn have roots going even further back, finally fading away into the unknown of the past. To give credit where it is most due, the fascinating world of geometric dissections, and indeed of mathematical recreations in general, is utterly and profoundly Greek in origin. Behind every geometric model illustrated in this book, the shadow of the Acropolis looms dimly in the background, and within every tortuous puzzle solution lurks the ghost of the fabulous labyrinth of King Minos, brooding over its next victim!

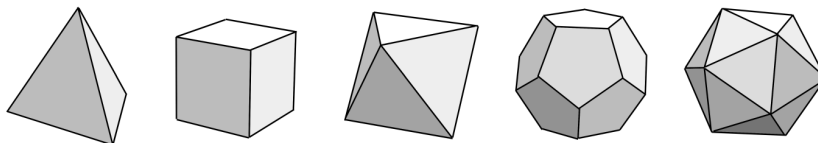
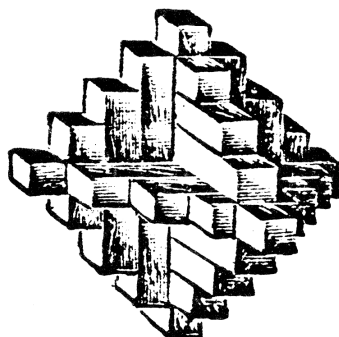


Figure 3. The Platonic solids.

The term *mathematical recreation* is in itself rather a misnomer, for every geometric puzzle worthy of consideration has non-mathematical aspects that are just as important if not more so. Most of the puzzle ideas described in this book were conceived by someone who was not a mathematician by either training or profession, but rather more of an inventor and craftsman, with perhaps a whimsical or artistic bent. Conversely, many creative endeavors that we certainly do not regard as geometric puzzles involve essentially the fitting together of discrete parts artistically into a logical and harmonious interlocking whole. The aspiring puzzle inventor seeking inspiration in the art of invention may be just as likely to find it in the classical arts as in mathematical textbooks.

Except for this edition's predecessors, *Puzzle Craft* and *The Puzzling World of Polyhedral Dissections*, there have been virtually no books published specifically on geometric puzzles. Many books on mathematical recreations have touched on the subject. There have been several compendia of mechanical puzzles in general that have included some burrs and geometric dissections. Likewise, a few woodworking books have included a chapter or two on puzzles. The closely related subjects such as polyhedra, symmetry, combinatorial theory, and design science all have extensive literature. Perhaps it is inherent in the very nature of dissection puzzles that even their literature is thus so scattered in bits and pieces. Trying to fit all of them together for the first time was quite a puzzle in itself!

Until recently, puzzles were regarded as little more than novelties and certainly not as a subject worthy of university-level study or museum exhibits. Before World War II, many wooden puzzles were mass-produced in the Orient, using the same few simple designs year after year. Typical were those found in the illustrious Johnson Smith & Co. mail-order catalog of the 1930s (Figure 4), priced at 10 cents or 15 cents postpaid! Then, cheap plastic versions in injection-molded styrene started flooding



Wood Puzzle

A unique wood puzzle imported from the orient. Will test your skill and patience. Each bar is a separate piece of wood and they can all be taken apart. Your job is to take them apart and put them back together again.
No. 3880. Price Postpaid 15c

Figure 4. Product from the Johnson Smith & Co. catalog.

the market, perpetuating the image of puzzles as expendable toys and trinkets. But all that is changing. There is a growing interest in geometric recreations at all levels, from educational materials for preschoolers to university courses and seminars, arts and crafts exhibits, articles in scientific journals, and hopefully even a few good books!

One reason that geometric dissections have so much potential for recreation is the wide range of skills and talents that may be brought into play, from the theoretical to the practical and from the mathematical to the artistic. At the practical level, a complex interlocking puzzle well crafted in fine wood can be a challenging and rewarding project for the skilled woodworker. On another level, some persons are more intrigued by the geometric shapes themselves, and a sort of Greek renaissance sub-culture has sprung up in the field of architecture and decorative design having to do with the adoration of polyhedra. On yet another level, there is what I call, for lack of a better term, the psycho-aesthetics of puzzle design. This gets into the puzzling question of what it is that makes certain puzzles appeal to certain persons but not others. So far as I know, almost nothing has previously been written on this pregnant subject.

Most of the designs described in this book are for puzzles that can, in theory at least, be made in wood. Directions and helpful hints for doing so are given. Some are much easier to make than others. You can start with the easy ones and gradually work upward, depending upon your woodworking skills and workshop facilities. But what about the reader with no such inclination or no workshop? Do not despair. Many of the designs have been or are being produced commercially, and probably many more will be in the future. Furthermore, the reader with good spatial perception ought to be able to solve many of them visually or on paper, without the need for physical models.

We might carry this notion a step further and suggest that the essence of an intriguing geometric puzzle is really the idea behind it. The physical model of the puzzle then becomes more of a tool to aid the thinking process and help convey the idea. Crude models may suffice for this purpose. As you become more adept with these skills, you may find that the actual models assume less importance than the principles involved. Some designers and solvers of geometric puzzles work almost entirely in the abstract, using pencil and paper or a computer, plus the amazing imaginative powers of the human mind. Consider all the advantages: the parts always fit perfectly and, unlike their wooden counterparts, never swell or shrink, crack or break. And for the apartment dweller with limited space, just think how many designs can be created and stored inside the recesses of one's head, using spaces that might otherwise have remained vacant!

Most of those who invent puzzles like to be given credit when their ideas are published, and some even hope to profit from them. Mention is made of the originators or patent grantees for a few of the puzzles described in this book when known, especially for some of the older classics. Well over half of all the designs included in this book were conceived and published only within the past 35 years. Although the origins of most of them are known to the author, credit is purposely omitted for these reasons: Some of the ideas are so obvious that they probably have been discovered independently by more than one person. Others may be just minor variations of someone else's ideas. For example, one of the puzzles described in this book is the author's variation on a design picked up from a now deceased puzzle craftsman in Florida, who reported getting the idea from someone in California, who in turn reports getting it from a puzzle company in Europe. But the idea is said to have originated

in Japan, although it too is but a variation on a familiar theme. An analysis of its solutions came to me from yet another source, and he reports learning that someone else had done it independently. Trying to unravel something like that would perplex even a patent attorney. So, some of the puzzles in this book are in the public domain, some are patented, some are copyrighted, and some are none of these. But the author cannot say in all cases which are which, so will avoid misunderstandings by not trying to define all origins. Anyone planning to manufacture or publish any of them should undertake the research necessary to make certain that no one's rights or sense of pride are being overlooked.